United States Patent

Davis

[15] **3,703,814**

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[54] **COLD FINGER DEHUMIDIFICATION SYSTEM**

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[21] Appl. No.: **43,740**

[52] **U.S. Cl.** **62/95**, 62/93, 62/283

[51] **Int. Cl.**.....**F25d 17/06**

[58] **Field of Search**.....62/93, 95, 283, 176, 217

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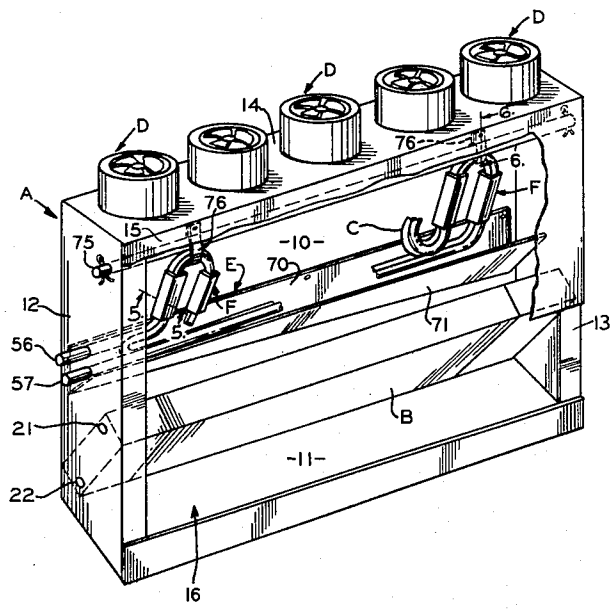
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[57] **ABSTRACT**

A dehumidification arrangement for air in a closed circulating system wherein the air is passed at a relatively high velocity over a first cooling coil having a surface area and temperature such as to cool the air to approximately the ultimate desired temperature and thence a portion only of the air is passed at a relatively low velocity past a second cooling coil at a temperature at or below the dew point temperature of the water vapor in the air. In one arrangement, the second cooling coil is baffled so that none of the air directly impinges thereon. A much greater amount of moisture is removed with a lower cooling load on the second coil.

10 Claims, 7 Drawing Figures



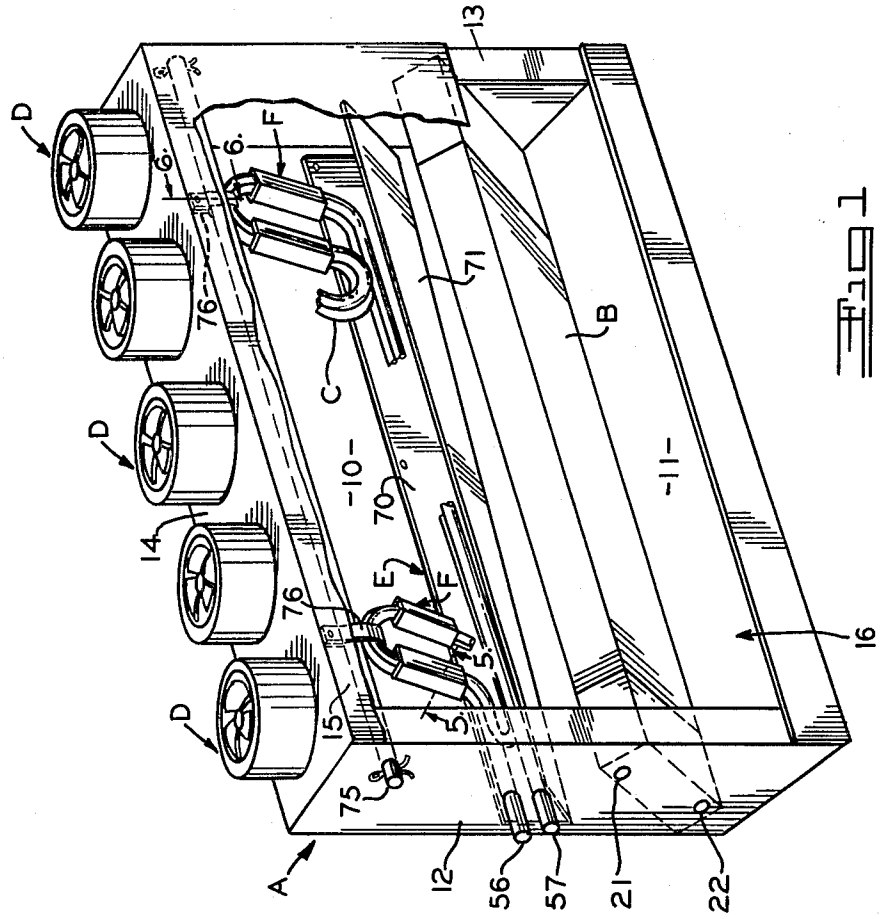


Fig 1

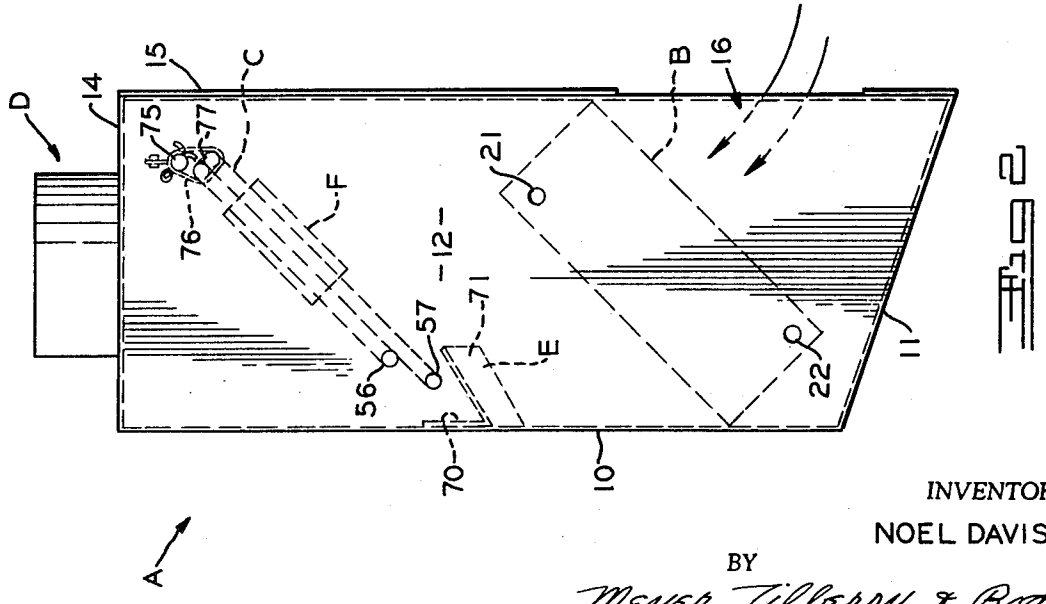


Fig 2

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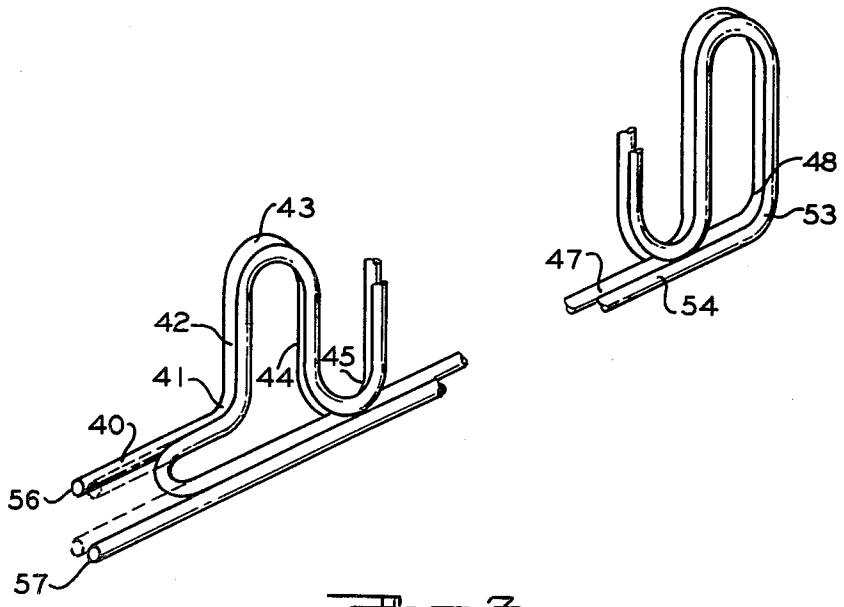


Fig 3

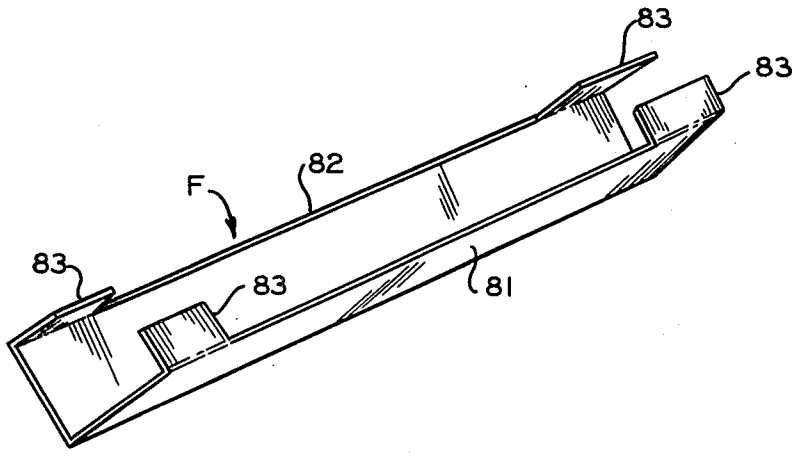


Fig 4

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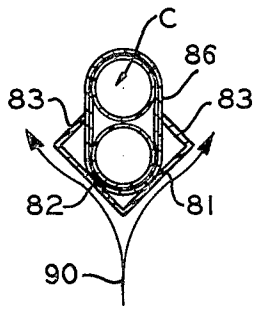


Fig 5

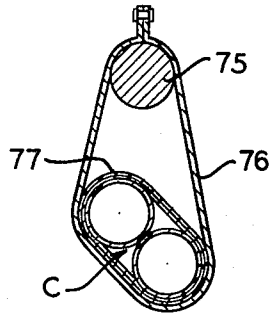


Fig 6

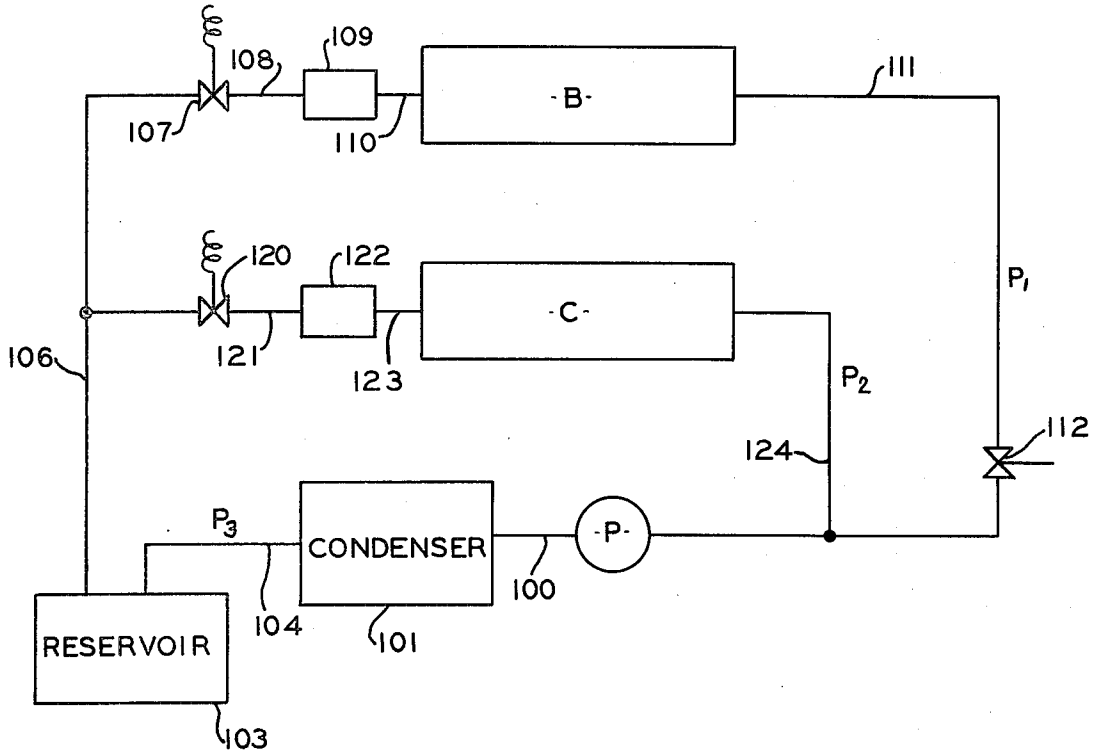


Fig 7

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COLD FINGER DEHUMIDIFICATION SYSTEM

This invention pertains to the art of gas treatment, and more particularly to method and apparatus for removing condensable vapors from an entraining gas.

The invention is particularly applicable to environmental growth chambers and will be described with particular reference thereto, although it will be appreciated that the invention has many and other applications enclosed gas recirculation systems such as air conditioning of homes or automobiles or in industry. Thus, the invention is usable in any closed recirculation system where portions of one gas must be removed from another gas by a process where both gases are cooled to a temperature below the condensation temperature of the gas to be removed and the ultimate mixture of gases are delivered to the point of use at a temperature above the condensation temperature of the gas to be removed. For the purposes of clarity hereinafter, the gas to be removed will be called a vapor (although it is in gaseous form, or when condensed, a liquid) to distinguish it from the vehicle or carrying gas. "Dew point" is that temperature of the gas mixture at which the vapor will commence to condense out and be deposited as a liquid on a cooling surface.

In the art of air conditioning, the carrying gas is an intimate mixture of the elements ordinarily found in the atmosphere e.g. oxygen and nitrogen together with water vapor. In the art of air conditioning, air at a high temperature and relative humidity is treated so as to be supplied at the end point of use at a lower temperature and a lower relative humidity. Relative humidity may be defined generally as the ratio of the weight of water vapor in a given weight of air to the maximum amount of water vapor which the given weight of air will carry. As the temperature of the air is varied, the maximum amount which a given weight of air will carry also varies. Thus, as a given weight of air at any initial relative humidity is cooled, the relative humidity increases until a temperature is reached where the relative humidity is 100 percent. This temperature is called the dew point temperature for air. Further decreases in the temperature of the air result in the water vapor condensing out as a liquid. If the same weight of air is then reheated to its original temperature, the relative humidity will be lower than it was to begin with and in proportion to the amount of water vapor removed.

It is known to cool all of the air of the dew point temperature for the desired relative humidity of the air at the desired living space or ultimate temperature, and then to reheat the air to this desired living space or ultimate temperature. Such an arrangement is wasteful of cooling capacity.

In a closed recirculating system it is known that if the amount of water vapor continually removed is greater than the amount of water vapor added to the air by sources in the living space, the relative humidity of the air will be gradually reduced and can ultimately be reduced to the desired value.

In a recirculating system, it is also known to provide as is described in my U.S. Pat. No. 3,434,530, issued Mar. 24, 1969, a first cooling coil which is at a temperature which will remove enough sensible heat from the air that the air leaves the coil at approximately the desired ultimate temperature. This air is then passed over a second cooling coil of a much lower capacity but

at a temperature substantially below the dew point of the air at the desired ultimate temperature which second coil removes substantial amounts of moisture from the air with a lesser effect on the sensible temperature of the air.

One problem observed with such a system has been that the cooling load on the second coil, that is the amount of heat absorbed from the passing air, was substantially greater than that necessary to remove the amount of water vapor actually condensed. Analysis of the problem indicated that substantial amounts of the air passing the coil were striking its cooling surfaces and were being cooled thereby, but in amounts insufficient to reduce the temperature of the air to the dew point temperature. Thus, if the entering air were 70° and the dew point temperature was 40°, unless the air striking the second coil was cooled to 40°, it would not give up its moisture even though it had given up a substantial amount of heat to the coil. Thus, there was a substantial cooling load from which no benefit was being derived.

Further analysis indicated the velocity of the air as it came into contact with the coil was so high that the air was in contact with the cold surfaces for too short a time to have its temperature reduced to the dew point temperature.

A further problem was that the velocity of air passing over the second cooling coil was high enough that the droplets of moisture condensing on the cooling surfaces were often times blown off of the surfaces and back into the air stream where they evaporated and again became water vapor.

THE INVENTION

The present invention contemplates method and apparatus which overcomes all of the above-referred to difficulties and enables greater amounts of vapor to be removed from an entraining gas with a lesser cooling load.

In accordance with the present invention, there is provided in a recirculating system, a first cooling coil having a cooling capacity to cool all of the gas stream to approximately the desired ultimate temperature and a second cooling coil at a temperature substantially below the dew point of the gas at the desired ultimate temperature and arranged so that less than 10 percent of the gas stream comes into "contact" therewith and for a time period sufficient to cool substantially all of said portion to below the dew point.

"Contact" as used herein is intended to connate actual physical contact of the gas molecules with the cooling surfaces or to be in such close physical relationship that there is a substantial heat transfer from the molecules to the surface.

The time period that this portion of the gas is in "-contact" with the second cooling coil is a function of the velocity of the gas and the length of the path in which the gas is in contact with the coil. If the path is long, the velocity can be higher.

The arrangement so that less than 10 percent comes into contact with the coil can be accomplished by diverting part of the gas stream to a separate compartment where the second coil is located or by locating the coil out of the main gas stream, preferably, however, the second cooling coil is located in the main gas

stream and is so constructed as to have a small frontal area relative to either the area of the gas stream or the frontal area of the first cooling coil such that only a small portion of the gas can impinge on the surfaces of the second coil. Further and preferably, the frontal area of the second coil is shielded from direct impingement of the gas thereon by means of a baffle, such that the coil surfaces are always in the lee of the baffle and velocity of the gas behind the baffle and thus in contact with the second cooling coil surfaces is substantially reduced. Furthermore, by providing a baffle, the gas behind the baffle follows a turbulent path such that the same molecules may come into contact with the cooling surfaces several times or will remain in contact for a sufficient period of time that a much greater ratio of the portion of gas coming into contact with the second cooling coil is reduced to the dew point temperature than would be the case if the baffles were not employed.

Further, in accordance with the invention, the frontal area of the second cooling coil is not greater than one-tenth (1/10) of the frontal area of the first cooling coil. As used in the specification and claims, the term "frontal area" means the area of the coil substantially perpendicular to the direction of air flow thereover.

It will be appreciated that the first cooling coil may or may not operate at a temperature below the dew point temperature. Thus, for example, if air at 80°F. and 100 percent relative humidity enters the coil and it is desired to have 70° air, the first cooling coil will have to be at a temperature somewhat below 70° and will, of course, be operating below the dew point temperature. The first cooling coil will thus remove some water vapor from the air.

However, if the air to be cooled to 70°F. enters the first coil at 80°F. and 50 percent relative humidity, so long as the temperature of the first cooling coil is above 51°F., it will be above the dew point of the air at the ultimate temperature.

Further in accordance with the invention, a method of dehumidifying gas and delivering it at a predetermined temperature and humidity is provided comprising the steps of: Cooling a stream of gas from a room or a chamber to a temperature approximately that of the ultimate desired temperature, and cooling less than a 10 percent portion of said stream of gas to a temperature below the dew point of the gas at the desired ultimate temperature and remixing said portion with the main stream of gas. In effect, 90 percent of the stream bypasses the second coil. However, on the next recirculation, some of the bypassed gas will be in the 10 percent portion and come into contact with the second coil and have its water vapor removed.

Further in accordance with the invention, an arrangement for supplying coolant to a sensible heat removing coil and a latent heat or dehumidifying coil functioning in series on an air stream is provided or wherein a single refrigerant compressor is employed and the temperature of the individual coils is controlled by exhausting the dehumidifying coil directly back to the intake of the refrigerant compressor and the temperature of the sensible heat removing coil is controlled by controlling and maintaining a higher pressure therein than in the dehumidifying coil.

OBJECTS

The principle object of this invention is the provision of a new and improved method of treating gases to remove a condensable vapor therefrom using a first and second cooling coil which places the minimum cooling load on the second coil while giving the maximum amount of vapor removal.

Another object of the invention is the provision of a new and improved apparatus for removing a vapor from an entraining gas which is simple in construction and which gives the maximum amount of vapor removal with a minimum cooling load.

Another object of the invention is the provision of a new and improved air dehumidification system wherein the maximum amount of water vapor can be removed from the air with a minimum cooling load on a cooling coil.

Another object of the invention is the provision of a new and improved air dehumidification system wherein a first coil cools the air to the approximate desired ultimate temperature and a second coil acts on only a small portion of the air to remove the moisture therefrom.

A further object of the invention is the provision of a new and improved method and means for removing water vapor from the air and delivering it at a desired ultimate temperature wherein the air in contact with the dehumidifying coil has a much lower velocity than the velocity in contact with the main cooling coil.

Another object of the invention is the provision of a new and improved apparatus for dehumidifying air wherein a maximum amount of moisture may be removed for a minimum amount of coolant supplied to the dehumidifying coil.

Another object of the invention is the provision of a new and improved apparatus for dehumidifying air wherein only a portion of the air stream is allowed to come in contact with the dehumidifying coil and the length of time that such portion is in contact with the dehumidifying coil is substantially increased whereby to give maximum dehumidification with minimum removal of heat from the air.

Another object of the invention is the provision of a new and improved method for dehumidifying air wherein all of the air is cooled to generally the desired ultimate temperature and then only small portions of the air are subjected to dehumidification but such portions are held in contact with the dehumidifying coils for a maximum period of time.

A further object of the invention is the provision of a new and improved arrangement for operating two cooling coils at different operating temperatures from a single refrigerant compressor which is simple in construction and effective in operation.

DRAWINGS

The invention may take physical form in certain parts and arrangements of parts preferred embodiments of which will be described in this specification in detail and illustrated in the accompanying drawings which form a part hereof and wherein;

FIG. 1 is a side perspective view of a dehumidification module such as may be employed in an environmental growth chamber and illustrating a preferred embodiment of the invention;

FIG. 2 is an end view thereof;

FIG. 3 is a perspective view of the second cooling coil showing details of its construction;

FIG. 4 is a perspective view of an air baffle showing details of construction;

FIGS. 5 and 6 are cross-sectional views of FIG. 1 taken approximately on the line 5—5 and 6—6 respectively thereof; and,

FIG. 7 is a schematic diagram of a refrigerant circuit for the preferred embodiment of the invention.

PREFERRED EMBODIMENT

Referring now to the drawings wherein the showings are for the purposes of illustrating a preferred embodiment of the invention only and not for the purposes of limiting same, FIG. 1 shows a cooling module of a type which can be used in the apparatus shown in my U.S. Pat. No. 3,434,530 comprised of a housing A, a first sensible heat removing coil B, a second dehumidifying coil C and a plurality of fans D for drawing the air or gases to be dehumidified across the coils B and C.

The housing A may take any desired shape or form, but in the embodiment shown, is made from sheet metal and includes a back panel **10**, a bottom panel **11**, left and right end panels **12**, and **13**, a top panel **14** and a front panel **15** which front panel **15** terminates short of the lower panel **11** so as to provide an air inlet opening **16**.

The fans D are conventional and are mounted in suitable openings formed in the top panel **14**. Any number can be employed. The fans D can be located separately from the module if desired.

The bottom panel **11** slopes to the front and terminates in an upwardly extending flange so as to direct any moisture which may fall thereon toward the front where it may flow to a drain opening (not shown).

The specific configuration of first cooling coil B forms no part of the present invention and is relatively conventional being comprised of copper tubing having inlets **21** and **22** extending outwardly through the end panel **12** and having a plurality of fins or webs thereon as is conventional.

The coil B is placed in the housing A generally at an angle and spaced from the bottom side **11** with its upper left-hand corner in engagement with the back panel **10** and its lower right-hand corner in engagement with the front panel **15**. The coil B has a longitudinal length so that its ends generally abut against the end panels **12** and **13**. Thus, all of the air entering the opening **16** passes over or through coil B. The cross-sectional area of the stream of air and the frontal area of the coil B have a ratio of approximately one to one. As this coil must remove substantial amounts of sensible heat from the air, the ratio of its depth to frontal area may be as low as desired e.g. less than 0.1 to 1.0.

The fans D suck air over the coil B. The coil B may be supplied with a cooling medium at a temperature such that, taking into consideration the surface area of the coil B and the rate of air flow therethrough, the temperature of the air leaving the coil B will be at or just slightly above the desired outlet temperature from the fans D. This outlet temperature may, of course, be controlled by either varying the rate of air flow through the coil B or by varying the temperature of the coolant supplied to the coil B or both. The temperature of the coolant to the coil B should preferably be above the dew point of the air at the temperature at which it leaves the coil B. It will be appreciated that in certain situations where the air enters the coil B at or approaching 100 percent relative humidity that if any cooling is to take place then the temperature of the coil B will have to be below the dew point temperature. Ordinarily, however, the air entering the coil B will have a substantially lower dew point temperature than its outlet temperature and the temperature of the coil B will then be at a temperature above the dew point temperature of the existing air.

The above is all relatively conventional and forms no part of the present invention except as it may function in combination with the dehumidifying coil C.

Coil C is constructed in accordance with the present invention and is so designed and arranged as to present a frontal surface area of approximately 10 percent of the coil B and a ratio of length in the direction of air flow to the frontal area of at least 1:1 and in the embodiment shown of approximately 2:1. In addition, as will appear, a substantial portion of the frontal area (perpendicular to the path of movement of the air stream) of coil C is comprised of baffle members which prevent direct impingement of the air leaving coil B on the cold surfaces of the coil C.

Since the frontal area of coil B is substantially coextensive with the cross sectional area of flow of air therethrough, the frontal area of coil C is seen to be not greater than one-tenth (1/10) of the cross-sectional area of the column of air moving therethrough.

The dehumidifying coil C may take a number of different forms so long as it presents a minimum frontal area to the flow of air through the housing A and a maximum depth in the direction of the air flow. In the embodiment shown, the coil C is comprised of two generally sinuous tubes in side-by-side relationship and aligned in the direction of air movement through which tubes coolant is to be circulated and these tubes are connected in series relationship to form the coil.

Thus, in the embodiment shown, the first coil consists of a horizontally extending inlet portion **40**, a 90° arcuate bend **41**, a vertically extending portion **42**, a 180° arcuate portion **43**, a vertically extending portion **44** and a 180° arcuate portion **45**. Such form continues through as many turns as is necessary to extend across the length of the housing A and at the end there is a 90° arcuate bend **48** where it extends through a horizontal portion **49** back toward the inlet end **40**. This horizontal portion **47** terminates in a 180° union which then connects to a second coil essentially identical to the first coil. These two coils are then placed in side-by-side relationship with the legs and bends exactly parallel and the tubes are soldered or brazed so as to hold them in this position.

The second coil then terminates in a 90° bend **53**, leading to a horizontally extending portion **54** which extends to the left and out through suitable openings provided in the left hand end panel **12**. Thus, coil C is provided with an inlet connection **56** and an outlet connection **57**. In the embodiment shown, the coil C is made from ½ inch outer diameter copper tubing with the radius of each bend being approximately 1 5/16 inch. The vertically extending legs **42**, **44** are thus spaced approximately 2 ⅝ inches. With this construction, the coil C presents a minimum of surface area to

the flow of air out of coil B, namely the area of a single length of ½ inch diameter copper tubing. However, the coil has a thickness in the direction of the air movement twice that of the frontal area. With this arrangement, a minimum amount of air passing through the coil C actually comes into physical contact with the coil C. The remainder is bypass air. The air that does come into contact with this coil C remains in contact therewith for a longer time than if only a single coil of copper tubing were provided. With this increased length of time of contact of the air with the coil, a greater amount of water can be removed from the coils.

In the embodiment shown, a drip pan E is provided in the form of a trough having a back **70** fastened to the back panel **10** and an upwardly inclined portion **71** which extends outwardly a distance far enough to shield or baffle the horizontally extending portions **47** and **54** of the coil C from the flow of air passing the coil C.

In the embodiment shown, the plane of the legs **42**, **44**, etc. extends at approximately 45° across the housing and the upper ends of the loops are supported in position by means of a rod **75** extending through suitable openings in the right and left hand panels **12** and **13** and by means of aluminum retaining straps **76** which extend around the loops **43** and over the rod **75**. In the preferred embodiment, thermal insulation in the form of adhesive foamed tape **77** is wrapped around the upper ends of the loops **43** so that the strap **76** is thermally insulated therefrom.

In addition, the lower portions of the coil C may be taped to the flange **71** of the drip pan E by means of insulating tape (not shown), with the tape extending between the coil and the flange **71** so as to keep the pan **71** from being in direct heat conducting relationship with the cooling coil C.

Further in accordance with the invention, baffle means F are provided to prevent the air flowing out of coil B from directly impinging on the tubing of the coil C. Such baffles may take a number of different forms but in the embodiment shown are comprised of an L-shaped member of aluminum having a pair of sides **81**, **82** at right angles to each other and with the free ends of the legs **81**, **82** and at the longitudinal ends thereof provided with tabs **83** extending at right angles therefrom. This baffle F is adapted to be slipped lengthwise over the vertical legs of the coils and the tabs **83** crimped inwardly to hold the baffle in place. However, before placing the baffle F in place, the coil members are wrapped with two layers of 1/32 inch thick double adhesive foam tape **86** at the point where the tabs **83** would normally contact the tubes, and the tabs **83** are then crimped into this foam tape. It will be appreciated that this foam tape **86** functions as an insulating medium to prevent metal to metal contact of the baffle F with the coils so that there is no direct conduction of heat from the coils to the baffle F. Also, it provides a space between the baffle F and coil surfaces so that air can circulate freely over the coil surfaces in the space condensed. Water can fall downwardly into the drip pan E.

It will thus be seen that the coil C presents a minimum frontal area to the flow of air there past, a high area parallel to the flow of air and that substantially all surfaces of the coil C are shielded from the direct impact of the air onto the coil itself. Thus, air flowing around the baffle F will have a substantially reduced velocity, will be in the form of eddy or turbulent currents which can contact the surfaces of the coil C and be in contact for a maximum length of time such that a greater percentage of air which comes into contact with the surfaces of the coil C will be reduced to a temperature below the dew point and will therefore give up its moisture which can then flow down the sides of the coil into the drip pan.

It will be appreciated that more than two coils in side-by-side relationship can be employed or in some instances only one. The coils B and C may be supplied from either a common source of coolant or from separate sources of coolant. In the event of separate sources of coolant, individual controls for each source may be employed so as to regulate the temperature of the coolant supplied to each coil. In the event a common source of coolant is employed, then controls must be provided which will control the amount of coolant supplied to each coil.

In either event, the coil B is supplied with coolant so that the air discharging therefrom is either at or just slightly above the desired air discharge temperature while the coils C are operated at a temperature at least below the dew point of the discharging air. The coil C having a small frontal area has a minimum effect on the temperature of the air flowing through the apparatus but is able to remove a maximum amount of moisture. Thus, using the invention, the ratio of moisture removed to the average temperature change of the air is relatively high. Stated otherwise, this means that for a given amount of moisture removed from the air, a minimum amount of coolant must be supplied to coil C.

The coil C may be operated at any temperature below the dew point down to 30°F. or if suitable defrosting arrangements are provided, then at temperatures below 32°F.

FIG. **7** shows a schematic diagram illustrating a preferred embodiment of a coolant circuit for use with the coils B and C above described. In this circuit a pump or compressor P compresses the spent or warm refrigerant gas, delivers it through conduit **100** to a condenser **101** of conventional construction. From condenser **101** the now liquid refrigerant is delivered at pressure P_3 to a reservoir **103** through conduit **104**. From reservoir **103**, the liquid refrigerant flows to coil B through conduit **106**, a solenoid control valve **107**, conduit **108** and an expansion chamber **109**. The liquid refrigerant vaporizes in the expansion chamber **109** and then passes through coil B and through conduit **111** to a pressure control valve **112**. This valve **112** is a standard valve known as a —crankcase pressure regulator" and acts to maintain the vaporized refrigerant in conduit **111** and coil B at pressure P_1. By regulating pressure P_1, the temperature in coil B can readily be controlled.

In a like manner, the liquid refrigerant flows to the dehumidifying coil C from conduit **106**, through a control valve **120**, conduit **121**, and expansion chamber **122**. The discharge from coil C at pressure P_2 is through conduit **124** which feeds directly back to the input of the pump or compressor P.

The pressure of P_2 is that as controlled by the compressor inlet or pump P.

As the temperature in coils B and C are controlled by the saturation pressures of the refrigerant, and as these pressures are controlled in both coils B and C, it will be seen that the temperatures in both coils B and C may readily be controlled and maintained at different temperatures even though both coils B and C are being supplied from a common pump or compressor.

In operation, the stream of air **90** impinges on the sides **81** and **82** of the baffle F and is deflected outwardly away from the surfaces of the copper tubing. The only air which will come into contact with the copper tubing is that which is in the lee of the baffle F and this air is turbulent and not moving at a substantial velocity. In fact, the air in its turbulence will swirl around and contact the surfaces of the copper tubes a number of different times thus insuring that substantially all of the air which comes into contact with the surfaces of the copper tubes will have its temperature reduced to the dew point. It should also be noted that any moisture which condenses on the surfaces of the copper tubing will be shielded from the direct impingement of the air and this moisture can flow under gravity down the tubes and into the drain pan **70**.

It will be appreciated that the coil C could be made of either oval or rectangularly shaped copper tubing with the long dimension to be disposed in a direction parallel to the direction of air flow.

The important things insofar as the present invention is concerned are that (1) only a portion of the total air stream comes into contact with the dehumidifying coil C, and (2) the velocity of the air which does come into contact with the coil in relation to the thickness of the coil measured in the direction of the air flow is such that a substantial portion, if not all of the portion, is in contact for a long enough period of time that it is cooled below its dew point. The invention contemplates a substantial amount of "bypass" air, that is air which never comes in "contact" with the coil C.

In the preferred embodiment, the coil is located in the main air stream but its frontal area is so small in relation to the area of the main stream that only a portion of the stream can come into contact with the coil. The rest is "bypass" air. Then the velocity of such portion is so reduced by the baffling that all of such portion, or at least a large portion thereof, is in contact with the coil for a long enough time to be cooled to its dew point temperature.

It will be appreciated that it is possible to divert a portion of the total air stream to an independent chamber wherein a conventional finned tube coil of any frontal area could be employed. In such instance, it will be appreciated that such a coil can only function on that portion of the air which is diverted to the auxiliary chamber. In such a situation, the only thing necessary is that the velocity of the air be insufficient to blow the droplets of condensation from the coil back into the air stream and low enough that all or substantially all of the air diverted to such chamber will be reduced to its dew point. Alternatively, the coil C may simply be located out of the main air stream such that the eddy currents created by the main air stream passing the opening to the coil will come into contact therewith.

Thus, it will be seen that embodiments of the invention have been described which accomplish all of the objectives heretofore set forth and others. The invention is not to be limited to the exact embodiments shown. Obviously, modifications and alternations will occur to others upon a reading and understanding of this specification, and it is my intention to include all such modifications and alterations insofar as they come within the scope of the appended claims or equivalents thereof.

Having thus described my invention, I claim:

1. Apparatus for treating a gas to a predetermined ultimate temperature and humidity including a compressor, the outlet of which is connected to a first coil and a second coil, said first coil and said second coil being arranged sequentially so that the gas to be treated flows in series over said first coil and said second coil, said second coil serving to dehumidify said gas and said second coil having a frontal area less than about one-tenth (1/10) of the frontal area of said first coil, said second coil further having baffle means disposed upstream of said second coil in the direction of gas flow whereby said second coil, or a portion thereof, is shielded by said baffle means from direct impingement of gas on said second coil.

2. A method of treating gas to a predetermined ultimate temperature and humidity comprising the steps of:

a. a continuously moving said gas over a first heat exchanger coil while maintaining said coil at a temperature to cool the gas discharging therefrom to approximately the desired ultimate temperature;

b. then passing said air over a second heat exchanger coil while maintaining said second heat exchanger coil at a temperature substantially below the dew point of the air at said humidity; and,

c. baffling the front area of said second coil so that the moving air does not directly impinge thereon.

3. The method of treating air to an ultimate predetermined temperature and humidity content comprising the steps of providing a first heat exchanger coil, maintaining said coil at a predetermined temperature at least above the dew point temperature of the ultimate air temperature and thereafter passing said air over a second heat exchanger coil maintained at a temperature substantially below the dew point temperature of the ultimate air, said second heat exchanger coil having a frontal area not greater than one-tenth (1/10) of the cross-sectional area of the column of moving air.

4. Apparatus for conditioning air comprising first and second heat exchanger coils and means for moving air to be conditioned past said first coil and then past second coil, means for supplying coolant to said first coil at a temperature above the dew point of the air exiting from said second coil, means for cooling said second coil to a temperature substantially below the dew point temperature of the air issuing from the first coil, said second coil having a frontal area not greater than one-tenth (1/10) the frontal area of the first coil.

5. The improvement of claim **3** wherein said air is deflected away from direct impingement on said second coil.

6. A method of cooling and lowering the humidity of air in a generally closed system comprising continuously circulating said air over a first heat exchanger coil maintained at a temperature at least above the dew

point temperature of the ultimate air temperature at a first velocity and passing a portion only of said air over a second heat exchanger coil maintained at a temperature substantially below the dew point temperature of the ultimate air, and reducing the velocity of the air in contact with said second coil substantially below the velocity of the air in contact with said first heat exchanger coil.

7. Apparatus for reducing the humidity of air comprising a heat exchanger coil having a frontal area transverse to the stream of air to be dehumidified substantially less than the cross-sectional area of the stream of air and baffle means positioned between the front of said coil for deflecting the stream of air away from the frontal surfaces of said coil.

8. The coil of claim 7 wherein said baffle means are in heat insulated relationship from said coil.

9. The improvement of claim 1 further including back pressure control means for controlling the back pressure imposed on said first coil, said back pressure control means being positioned between the discharge of said first coil and the inlet to said compressor.

10. The improvement of claim 9 wherein the back pressure on said second coil is controlled by the inlet to said compressor.

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