

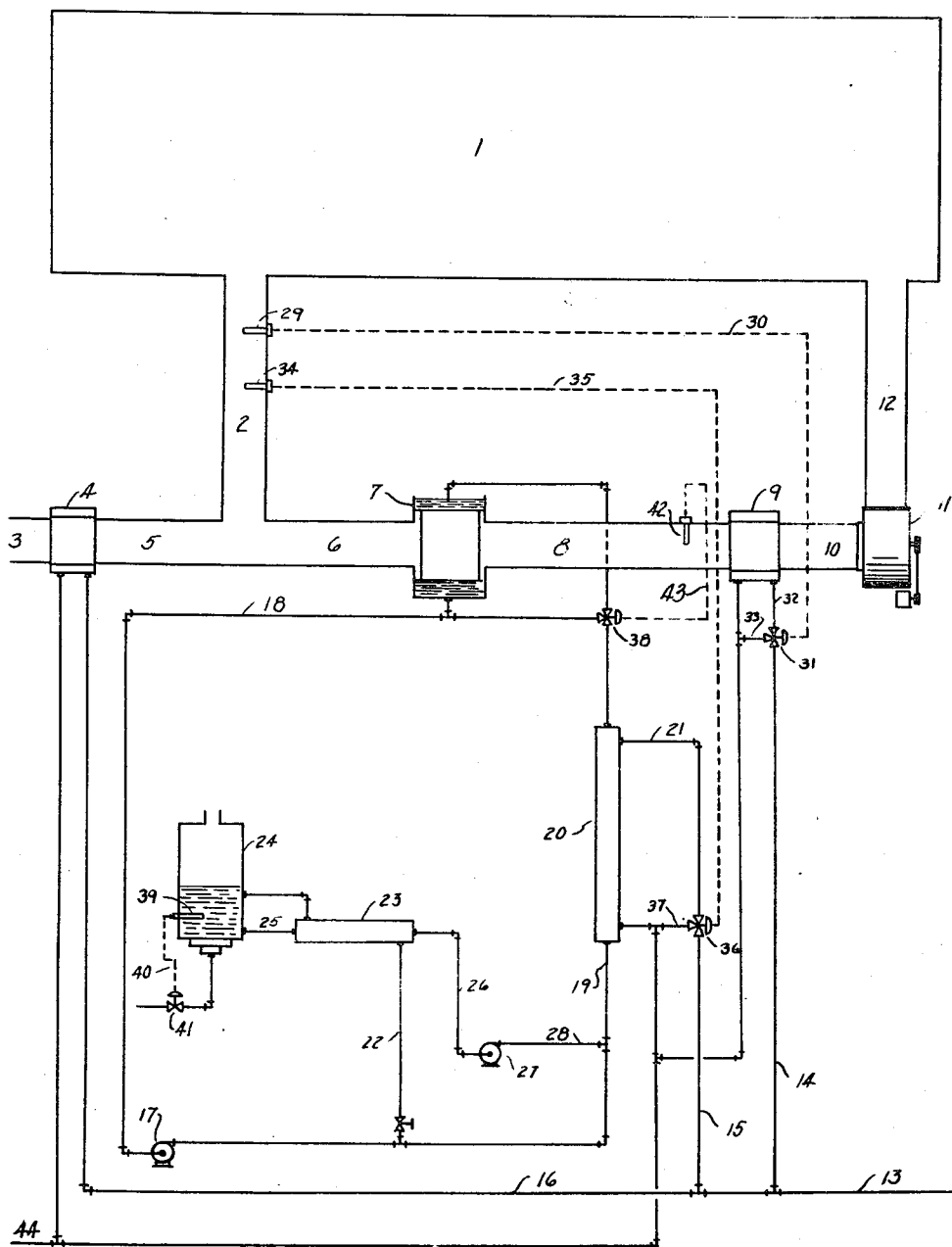
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AIR CONDITIONING SYSTEM

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AIR CONDITIONING SYSTEM

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This invention relates to air conditioning systems, and more particularly to air conditioning systems wherein the tempering and humidifying of the air is accomplished without the use of mechanical refrigeration.

In its preferred embodiment the present invention comprises an air conditioning system wherein a primary air stream is precooled by passing it over coils containing circulating cold water, where it may also be dehumidified to some extent, and is then mixed with return air from the enclosure wherein desired conditions of temperature and humidity are to be maintained, and the mixed air stream is passed to a dehydrating chamber. In this chamber, the air is brought into intimate contact with a dehydrating solution to dehumidify the air. From the dehydrating chamber the dehumidified air is passed over a recooling coil and thence into the enclosure.

One of the main objects of the present invention is to effect dehumidification of the air without substantially changing its temperature. This is accomplished by the isothermal dehumidification produced in the dehydrating chamber. By passing the solution used in the dehydrating chamber through a solution cooler, the heat of condensation of the moisture from the air, and the heat of dilution of the solution, may be removed from the solution so that a substantially constant temperature is maintained in the dehydrating chamber.

In connection with the use of a dehydrating solution, it is another object of the present invention to provide means for maintaining this solution at a substantially constant concentration by passing the dilute solution through a boiler wherein the absorbed moisture is liberated from the solution and the concentrated solution is then returned, through a heat interchanger and the solution cooler, to the dehydrating chamber.

Another object of the present invention resides in the cooling of the fresh air stream and the mixed air stream without the use of mechanical refrigeration by passing the air streams over heat exchange means having cold water circulating therethrough, the circulation of the water being controlled in accordance with the temperature desired within the enclosure.

The system as a whole is provided with various controls, which effect operation of the cooling and the dehumidifying means in accordance with the temperature and humidity conditions which it is desired to maintain within the enclosure.

Another object of the present invention is the provision of an air conditioning system of simple

and compact arrangement, and of decidedly economical construction, since the refrigerating load ordinarily required in such a system is eliminated, and also, the heating means for reheating the air after dehumidification by lowering the temperature thereof, as has been the practice heretofore, is eliminated by the use of the isothermal dehumidifying means.

Other objects and advantages of the present invention will appear more fully from the following detailed description, which, taken in connection with the accompanying drawing will disclose to those skilled in the art a preferred embodiment of our invention.

The drawing discloses a substantially diagrammatic representation of the air conditioning system of the present invention.

Referring now in detail to the operation of the invention, in the drawing we have provided the enclosure or space 1 in which it is desired to maintain predetermined conditions of temperature and humidity. This enclosure is provided with the outlet 2, which communicates with a conduit containing fresh air admitted at the inlet opening 3 thereof.

The fresh primary air stream entering the inlet 3 passes over the precooling coil 4, which may comprise an extended surface cooling coil of finned construction, through which cold water is adapted to be circulated. The air leaving the coil 4 passes through the conduit 5 and is mixed with the return air from the conduit 2, the mixture passing through the conduit 6 to the dehydrating chamber 7.

This dehydrating chamber 7 may comprise any desired gas and liquid contact apparatus, in which the mixed air stream comes into contact with a concentrated solution of a dehydrating medium, such as calcium chloride, lithium chloride, or other hygroscopic salt solutions, preferably moving in counter-current relation to the flow of air. For example, the apparatus may comprise a series of spaced rotating discs adapted to present films of the solution to the passing air stream, cloth sheets or other means providing for capillary rise of the solution in the chamber, or spraying nozzles or the like for projecting the solution into the air stream. In fact, any suitable means providing intimate contact between the air stream and the dehydrating solution may be used.

In passing through the dehydrating chamber 7, the mixture of fresh and return air is dehydrated to the desired moisture content, but its

temperature is not greatly changed, the dehumidification being substantially isothermal.

The dehydrated air leaving the dehydrating chamber 7 passes through the duct 8 to a second cooling coil 9, preferably termed a "recooling coil", which is similar in construction to the coil 4, and which is adapted to cool the mixture of dehydrated air sufficiently to produce the proper temperature within the conditioned space or enclosure 1. From the recooling coil 9, the cooled conditioned air passes through the duct 10 to the fan 11, by which it is forced through the inlet duct 12 into the enclosure 1. Suitable manual or automatically controlled dampers may be provided adjacent the outlet conduit 2, the fresh air inlet conduit 3, and the connection of the conduit 2 and the conduit 5, for providing predetermined proportions of fresh and return air.

The water used in the precooling coil 4 and the recooling coil 9 is supplied through a water supply main 13, which may be connected to any desired source of cold water, and which is provided preferably with the branch supply lines 14, 15 and 16, which respectively supply the recooling coil 9, a solution cooler 20, and the precooling coil 4.

In order to provide circulation through the dehydrating chamber 7, a pump 17, which may be any desired type of pump, operated either by mechanical or electrical means, is connected between the suction or outlet pipe 18 of the dehydrating chamber and the discharge pipe 19 of the pump, which pipe 19 extends through the solution cooler 20 and conducts the pumped solution to the dehydrating chamber 7. The solution cooler 20 is supplied with cold water through the supply pipes 15 and 21. This cooler serves to remove the heat of condensation of moisture from the air, and the heat of dilution of the dehydrating solution which is contained in the solution, by heat transfer between the water and the solution, and is preferably a counter-current extended surface cooler of any well known type.

The absorbing or dehydrating solution used in the chamber 7 is constantly being diluted by the absorption of moisture from the air stream, and consequently, some means must be provided for removing the absorbed moisture. This is accomplished by conducting a portion of the solution from the discharge side of the pump 17 through the conduit 22 to a boiler 24, the pipe 22 extending through a heat interchanger 23, to be hereinafter described in more detail. In the boiler 24, the moisture is continually removed from the solution by evaporation, and the solution is thus concentrated. The concentrated solution is returned through the pipe 25, heat interchanger 23, conduit 26 and a pump 27 to a conduit 28 leading back into the main supply line 19 of the dehydrating chamber 7. In this manner, a constant concentrating of the solution is effected, and the concentrated solution is returned into the dilute solution being discharged from the pump 17. The heat interchanger 23 serves to impart a portion of the heat of the concentrated solution leaving the boiler 24 to the incoming solution entering through the pipe 22. By this interchanging of the heat from the concentrated solution to the incoming dilute solution, a considerable saving of heat energy is effected.

In order to effect automatic control of the temperature conditions desired within the enclosure 1, we preferably provide a thermostat 29, responsive either to dry bulb or wet bulb temperatures, which may be located in either the enclosure 1, or adjacent the outlet therefrom into the conduit

2, and which is connected through the tube 30 or the like, which may be a suitable compressed air pipe or other actuating means, to the diaphragm of a three-way valve 31 which controls the delivery of cold water from the branch supply line 14 to the recooling coil 9. The valve 31 is of any desired type, and is operated by the thermostat 29 in such manner that when the temperature within the enclosure 1 rises above the desired temperature conditions, the valve admits more cold water from the branch supply line 14 through the conduit 32 to the coil 9. However, when the temperature within the enclosure 1 drops below the predetermined desired condition, the valve is operated to pass the cooling water from the branch supply line 14 through the conduit 33 to the outlet side of the cooling coil 9, and thence to a suitable drain. If desired, the thermostat 29 may be of such character as to energize electrically operated means for controlling the valve 31.

The humidity desired within the enclosure 1 is controlled, preferably, by a humidostat or wet bulb thermostat 34, disposed in the conduit 2, or adjacent the enclosure 1, and which is connected, through the pressure line 35 to a valve 36 of the same construction as the valve 31. The valve 36 is adapted to control the flow of water to the solution cooler. Thus, if an increase in the absolute humidity is necessary to provide the proper humidity within the enclosure 1, the valve 36 throttles the flow of cooling water through the pipe 21, and causes the water from the branch supply main 15 to pass through the pipe 37 to the outlet side of the solution cooler 20. In this manner, the temperature and vapor pressure of the dehydrating solution is increased, resulting in less dehumidification being effected within the dehydrating chamber 7. When a decrease in the absolute humidity is desired, in order to maintain the proper humidity conditions within the enclosure 1, the valve 36 is actuated by the humidostat 34 to allow more cooling fluid to flow through the pipe 21 to the solution cooler 20, and thus produce a lowering of the temperature of the dehydrating solution, which results in a greater dehumidification being effected within the dehydrating chamber 7. In this manner, the control of the temperature of the dehydrating solution results in automatic control of the dehumidification effected, and thus results in control of the humidity within the enclosure 1.

The cooling coils 4 and 9, and the solution cooler 20 preferably have their discharge openings connected by suitable means to a common drain 44, and the warmed water is thus carried away to waste, or for use in other situations.

A supplemental control for the humidity within the enclosure may be provided by disposing a dewpoint thermostat 42 in the path of the dehydrated air stream, preferably in conduit 8, as shown. The thermostat 42 is connected, through line 43 to a suitable valve 38, corresponding to the valves 31 and 36. The valve 38 is adapted to control the flow of dehydrating solution to the chamber 7, and bypasses a portion of the solution when it is desired to effect less dehumidification within the dehydrating chamber 7. It is thus apparent that regulation of the amount of dehumidification taking place within the chamber 7 is controlled, either by the humidostat 34, or by the dewpoint thermostat 42. It is apparent that the control 34 may be used for throttling the flow of the solution, and the control 42 for determining the temperature of the solution, if desired.

To effect control of the concentration of the

solution produced within the boiler 24, a thermostat 39 is placed in direct contact with the solution in the boiler, and is set for a temperature corresponding to the boiling point of the solution at the desired concentration. The thermostat 39 is connected through suitable means 40 to the fuel supply valve 41 which admits fuel to the burner of the boiler. It is apparent, that, by the provision of the thermostatic control of the boiling point of the solution within the boiler 24, the desired concentration of the solution can be produced.

In connection with the controls 29, 34, 42 and 39, it is to be understood that any suitable type of control may be used, which may actuate either electrical, mechanical or pressure means for effecting control of the valves 31, 36, 38 and 41, respectively.

In the operation of the control shown for the boiler 24, a certain quantity of water is at all times being absorbed by the solution in the chamber 7. At the same time, a substantially equal quantity of the absorbed moisture is being evaporated in the boiler 24 at a temperature corresponding to the concentration desired. The pumps 17 and 27 are circulating substantially constant quantities of the solution. Now, if due to a change in the condition of the air passing through the duct 6 to the dehydrating chamber 7, the amount of moisture absorbed in the chamber 7 becomes less, the concentration of the solution in the boiler 24 will tend to increase. However, this will in effect, tend to raise the boiling point of the solution. The thermostat 39, in such instances, will throttle the valve 41 and reduce the amount of fuel supplied to the boiler, thus decreasing the amount of water removed from the solution, and thus maintaining the concentration constant.

It is therefore apparent that we have provided an air conditioning system wherein the air is dehumidified without substantially changing its temperature, thus eliminating the use of mechanical refrigerating means for lowering the temperature of the air stream to a point sufficient to produce the desired dehumidification. This effects a considerable saving by the elimination of the refrigerating load imposed upon such a system. Further, we have provided a system wherein the cooling of the air is accomplished by circulation of cold water through suitable cooling coils in direct heat exchange contact with the air stream. This eliminates the use of artificial refrigerating means. The controls for maintaining the desired conditions of temperature and humidity within the enclosure are automatic in operation, and need no attention other than initially setting them to the desired point.

While we have shown and described a preferred embodiment of our invention, we do not intend to be limited to the exact details disclosed, but only in so far as defined by the spirit and scope of the appended claims.

We claim:

1. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, mixing said precooled fresh air with return air from said enclosure, isothermally dehydrating said mixture with a dehydrating solution, controlling the temperature of said solution in accordance with the humidity of said return air, recooling said dehydrated air, and delivering said air to the enclosure.

2. The method of conditioning air for an en-

closure which comprises precooling a stream of fresh air, mixing said precooled fresh air with return air from said enclosure, isothermally dehydrating said mixture by intimate contact with a dehydrating solution, controlling the quantity of said solution contacted in accordance with the humidity of the dehydrated air, recooling said dehydrated air, and delivering said air to the enclosure.

3. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, mixing said precooled fresh air with return air from said enclosure, isothermally dehydrating said mixture by intimate contact with a dehydrating solution, controlling the quantity of said solution contacted in accordance with the humidity of the dehydrated air, recooling said dehydrated air, controlling the recooling of said dehydrated air in accordance with the dry bulb temperature of the air in said enclosure, and delivering said dehydrated air to the enclosure.

4. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, passing said air into intimate contact with a dehydrating solution controlling the temperature of said solution in accordance with the wet bulb temperature of the air in said enclosure, subsequently cooling said dehydrated air in accordance with the temperature in said enclosure, and delivering said air to the enclosure.

5. The method of conditioning air for an enclosure which comprises precooling a stream of return air by admixture with cooled fresh air, passing said air into intimate contact with a dehydrating solution, controlling the quantity and temperature of said solution passed into contact with said air, subsequently recooling said dehydrated air in accordance with the temperature in said enclosure, and delivering said air to the enclosure.

6. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, mixing said air with return air, passing the mixture into intimate contact with a dehydrating solution, controlling the circulation of said dehydrating solution in accordance with the relative humidity of the air in said enclosure, and recooling said dehydrated air.

7. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, mixing said air with return air, passing the mixture into intimate contact with a dehydrating solution, controlling the circulation of said dehydrating solution in accordance with the relative humidity of the air in said enclosure, recooling said dehydrated air, and controlling the recooling of said air in accordance with the dry bulb temperature of said return air.

8. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, mixing said air with return air, passing the mixture into intimate contact with a dehydrating solution, controlling the temperature of said dehydrating solution in accordance with the relative humidity of the air in said enclosure, recooling said dehydrated air, and controlling the recooling of said air in accordance with the dry bulb temperature of said return air.

9. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, mixing said air with return air, passing the mixture into intimate contact with a dehydrating solution, controlling the circulation of said dehydrating solution in accordance with the relative humidity of the air in said enclosure, re-

cooling said dehydrated air, and controlling the recooling of said air in accordance with the wet bulb temperature of said return air.

10. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, mixing said air with return air, passing the mixture into intimate contact with a dehydrating solution to absorb moisture therefrom, controlling the temperature of said dehydrating solution in accordance with the wet bulb temperature of the air in said enclosure, and subsequently recooling the dehydrated air.

11. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, mixing said air with return air, passing the mixture into intimate contact with a dehydrating solution to absorb moisture therefrom, controlling the circulation of said dehydrating solution in accordance with the humidity conditions desired within said enclosure, and subsequently recooling the dehydrated air.

12. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, mixing said air with return air, passing the mixture into intimate contact with a dehydrating solution to absorb moisture therefrom, controlling the circulation of said dehydrating solution in accordance with the dewpoint temperature of the dehydrated air, and subsequently recooling said air.

13. The method of conditioning air for an enclosure which comprises precooling a stream of fresh air, passing said air into intimate contact with a dehydrating solution, circulating the solution through evaporating means to remove absorbed moisture therefrom, maintaining the concentration of said solution constant by controlling the temperature of said evaporating means, cooling said concentrated solution, controlling the quantity of said solution which passes into contact with the air stream in accordance with the dewpoint of the dehydrated air, and recooling said dehydrated air.

14. The method of conditioning air for an enclosure which comprises mixing fresh air with return air from said enclosure, intimately contacting said air with a dehydrating solution, maintaining said solution at a constant concentration, controlling the temperature of said solution in accordance with the humidity of said return air, recooling said dehydrated air, controlling the circulation of said solution in accordance with the dewpoint of the dehydrated air prior to the recooling thereof, and delivering said cooled dehydrated air to said enclosure.

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