Aug. 17, 1937. F. H. CORNELIUS 2,090,287

AIR CONDITIONING APPARATUS AND METHOD

Filed May 12, 1931 3 Sheets-Sheet 1

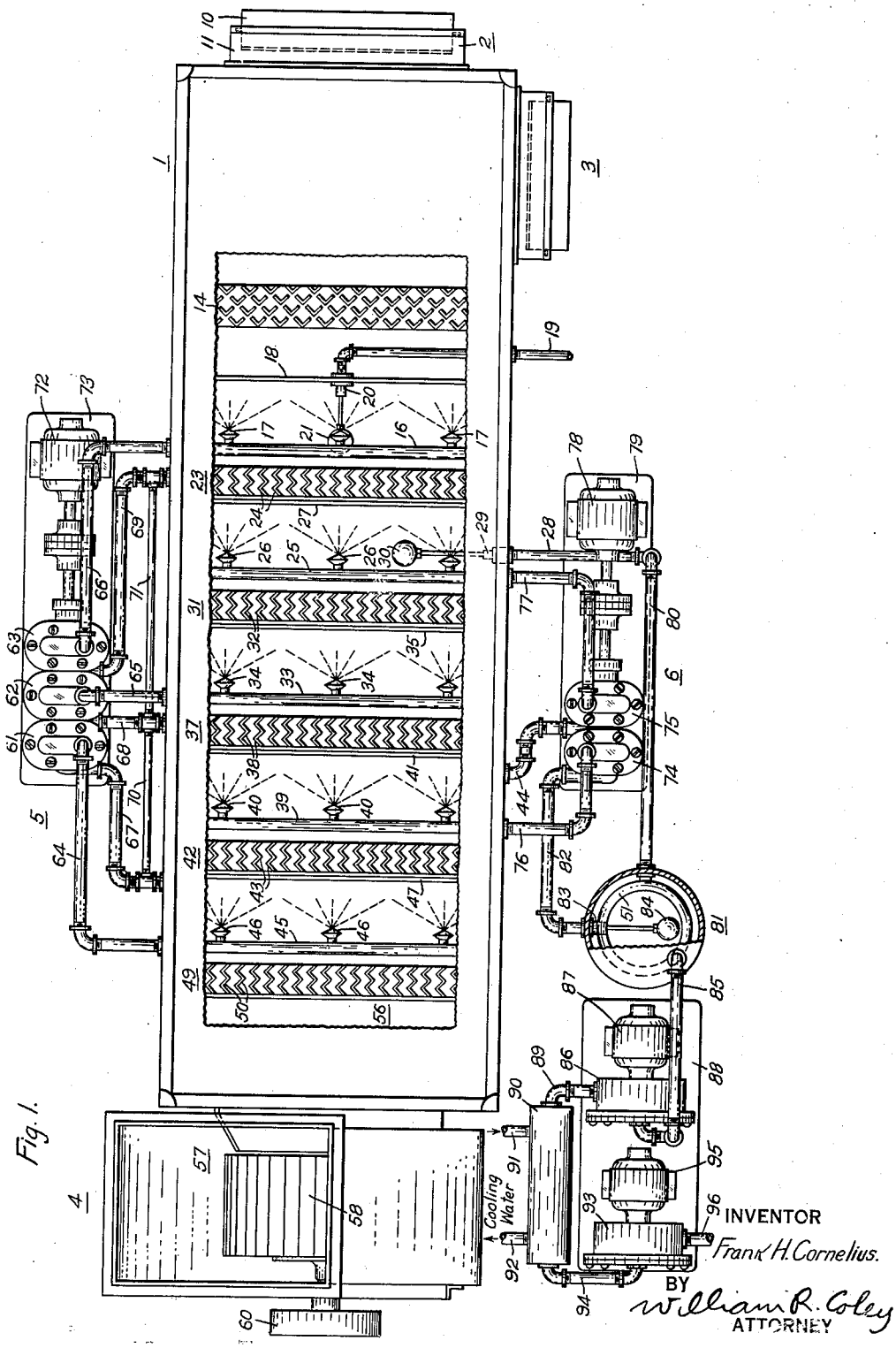


Fig. 1.

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Fig. 2.

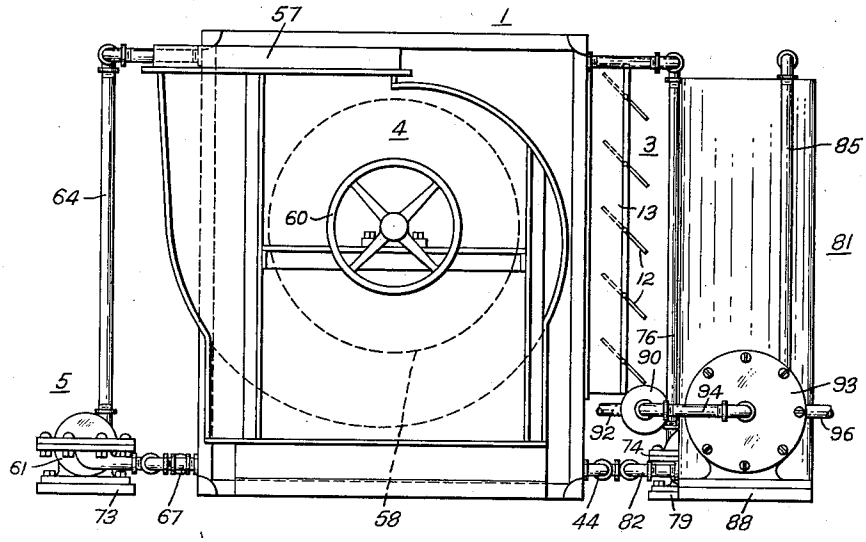
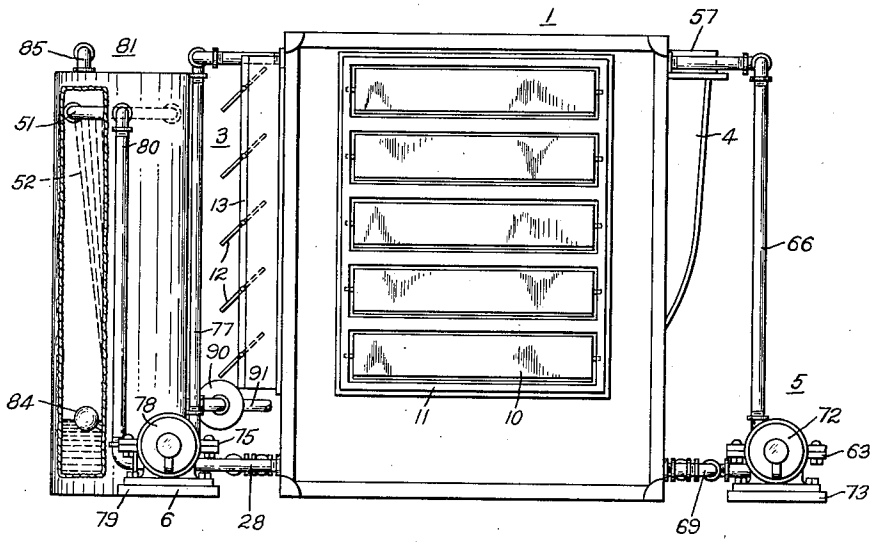


Fig. 3.



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AIR CONDITIONING APPARATUS AND METHOD

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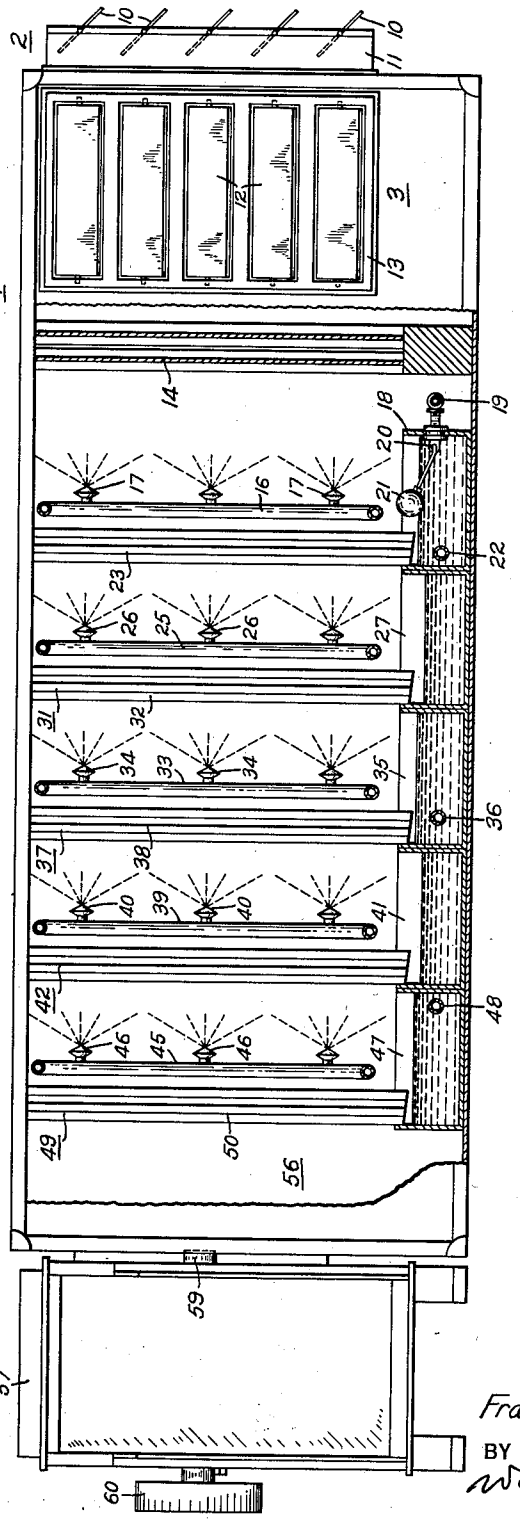


Fig. 4.

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UNITED STATES PATENT OFFICE

2,090,287

AIR CONDITIONING APPARATUS AND METHOD

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Application May 12, 1931, Serial No. 536,715

10 Claims. (Cl. 261—9)

My invention relates to heat pumps or gas or air-conditioning apparatus, and one object thereof is to add water, or the like, substantially adiabatically and subsequently apply glycerin, or the like, to a gas or air stream to effect cooling thereof.

In the prior art ice machines and auxiliary equipment have been utilized in cooling and conditioning air, requiring a large amount of energy to overcome the existing high pressures and temperatures, in order to provide the necessary gas expansion for effecting the cooling operation or the necessary absorption of heat.

In my apparatus, however, the physical laws relating to air, water and glycerin, or the like, are so co-ordinated and applied as to produce the desired heat transfer while utilizing very little outside energy, the horse-power required by my apparatus being only a fraction of that taken by the standard ice machine.

My apparatus is suitable for general process air conditioning in connection with cigars, cigarettes, textiles, candies, bakery products, etc., as well as for providing conditioned air for human comfort.

Another object of my invention is to provide an apparatus of the above-indicated character which is relatively simple, but durable, in construction, inexpensive in first and operating cost and capable of general application for conditioning purposes.

A further object of my invention is to add water or other fluid substantially adiabatically to an air or gas stream and subsequently remove water or other liquid therefrom substantially isothermally by applying glycerin, or the like.

Another object of my invention is to provide an air-conditioning apparatus, or the like, embodying successively arranged sprays of water and glycerin, or the like.

Another object of my invention is to provide apparatus for successively applying a self-imparting and an absorbent material to a gas stream to vary the heat contents thereof and thereby effect either a heating or a cooling action at a desired point.

A further object of my invention is to provide an air-conditioning apparatus of the type just set forth, the excess or entrained water and glycerin being eliminated from the air stream before it is circulated for use.

Another object of my invention is to provide an air-conditioning apparatus of the character in question utilizing continuous circulations of water and glycerin for the desired purpose.

A further object of my invention is to provide apparatus of this class with special devices for separating moisture from the glycerin after each exposure thereof to the air being conditioned.

A further object of my invention is to provide apparatus for conditioning air for various purposes, by means of substantially adiabatically adding moisture and then removing water substantially isothermally by the use of glycerin, or the like.

Further objects of my invention will become evident from the following detailed description taken in conjunction with the accompanying drawings, wherein.

Figure 1 is a plan view, with parts broken away for clearness, of an apparatus constructed in accordance with my present invention,

Figs. 2 and 3 are views in elevation taken at the respective ends of the apparatus shown in Fig. 1, and

Fig. 4 is a view, partially in side elevation and partially in longitudinal section, of the apparatus shown in the other figures.

Referring to the drawings, the apparatus here shown comprises a suitable conditioning or treating chamber or main tank 1, which is provided with a fresh air inlet 2 and a return or recirculated air inlet 3, together with a fan or blower device 4 for circulating the conditioned air, pumping apparatus 5 for the water or moisture that is to be added to the air being conditioned, and pumping and treating apparatus 6 for the glycerin that is also added to the air stream being conditioned.

The treating tank or chamber 1 may be of any suitable heat-insulated type and needs no particular description here. At one end a rectangular frame 11 is secured, in which a plurality of louvres or shutters 10 are pivotally mounted. The adjustment of these louvres regulates the amount of fresh air that is delivered to the apparatus.

On one side of the tank 1, near the end where the fresh air inlet is located, is positioned a second rectangular frame 13, in which are pivotally mounted a plurality of louvres or shutters 12, which may be adjusted to regulate the amount of return or recirculated air that is admitted to the tank.

Beyond the air inlets is located a filter or eliminator 14 comprising a plurality of V-shaped sheet metal members extending from the top to the bottom of the chamber 1 and spaced apart laterally and located in rows, for the purpose of

eliminating dust, dirt and bacteria as the air is first admitted to the treating tank.

The air next encounters a spray of water emanating from a plurality of spray nozzles 17 fitted into a supply pipe 16 which extends across the top and down one side of the tank 1. The excess or unused water, that is, the water not absorbed or carried by the air stream, falls into a suitable small tank 18 at the bottom of the apparatus which is connected to a water supply pipe 19 by means of a valve 20 that is controlled by a float ball 21. Thus, the level of the water in the tank 18 is maintained substantially constant by means of the movement of the float ball 21 admitting more water from the supply pipe 19, as required. A drain or suction pipe 22 communicates with the tank 18 to provide a continuous circulation of water therethrough, as subsequently described.

Beyond the water spray pipe 16 is located a filter or eliminator 23 comprising a plurality of zigzag metal members 24 extending longitudinally of the tank and adapted to remove water entrained in the air stream. These members extend from the top to the bottom of the tank and are spaced apart laterally.

The air stream next encounters a spray of glycerin emanating at a temperature lower than that of the air stream from a plurality of spray nozzles 26 attached to a pipe 25 that extends across the top and down one side of the main tank 1. The excess or unused glycerin falls into a small tank 27 at the bottom of the main tank 1, and a continuous circulation is maintained by reason of withdrawal of the glycerin from the tank 27 through a pipe 28 by means of a valve 29 that is controlled by float ball 30, whereby a substantially constant level of glycerin in the tank 27 is maintained.

It should be understood that while I prefer glycerin in this connection any other liquid or solid having similar properties, insofar as air or gas conditioning is concerned, might be used in lieu thereof.

For example, sulphuric acid or a calcium chloride solution may be used as liquid absorbent material, whereas silica gel, kieselguhr or calcium chloride in solid form may be employed as solid material. The gas to be treated may be air, ether, ammonia, carbon dioxide or gasoline vapor depending on the pressures and temperatures within the apparatus and the applications for which the apparatus is used.

It will be seen that the air stream after leaving the first water spray enters the first glycerin spray at approximately a saturated condition, the water lowering its dry bulb temperature, while its original wet bulb temperature remains substantially constant. As the air passes through each glycerin spray, a large percentage of the moisture is removed, but the air stream dry bulb temperature remains nearly constant, while the wet bulb temperature is lowered, as the glycerin spray is of sufficient volume to absorb both the water and the latent heat of condensation. In other words, water has been added approximately adiabatically to the air stream, while the glycerin has removed water therefrom approximately isothermally.

Beyond the glycerin spray a filter or eliminator 31 containing zigzag metal members 32 similar to the members 24 is provided for removing entrained glycerin from the stream, which then passes into the next space where a water spray is again applied thereto. For this purpose a water pipe 33 extending across the top and down one side of the main tank 1 is provided with spray nozzles 34. The excess water drops into a small tank 35 at the bottom of the main tank 1, from which it may be withdrawn by means of a drain pipe 36. In this case also the water is added adiabatically, the air retaining approximately the same wet bulb temperature, although the dry bulb temperature is lowered.

After passing this water spray, eliminators 37 are encountered by the air stream, embodying zigzag metal plates 38 similar to those included in the eliminators 23 and 31.

Upon entering the next space another glycerin spray is added at a lower temperature to the air stream by means of a pipe 39 that runs across the top and down one side of the main tank 1 and is provided with suitable spray nozzles 40. The excess or unused glycerin drops into a small tank 41 at the botom of the main tank 1, from which it may be withdrawn by means of a drain pipe 44. In this glycerin spray the wet bulb temperature of the air stream is further lowered, while the dry bulb temperature remains practically constant, or, in other words, heat is removed from the air stream.

Beyond this glycerin spray eliminators 42 are again provided embodying zigzag metal plates similar to those illustrated in the other eliminators, such as 37, and after the air stream passes through this eliminator to remove entrained glycerin, it encounters the final adiabatic saturating water spray from a pipe 45 extending across the top and down one side of the main tank 1, this pipe being provided with suitable spray nozzles 46. The excess or unused moisture falls into a small tank 47 at the bottom of the main tank 1, from which it may be withdrawn by means of a suitable drain pipe 48.

In this final application of water adiabatically, the wet bulb temperature of the air stream remains substantially constant, while its dry bulb temperature is further lowered. There is thus a considerable decrease in the dry bulb temperature of the air stream between the two ends of the conditioning chamber 1.

The entrained moisture in the air stream is then removed by the filter or eliminator 49 which is provided with zigzag plates 50 similar to those of the preceding four eliminators.

The fully conditioned air stream then passes into the space 56 at the delivery end of the chamber or tank 1, whence it is drawn into the centrifugal fan or blower box 57. This box contains a centrifugal fan or blower 58 of any suitable type, the air being drawn into the center thereof through the short pipe or passage 59 between the main tank 1 and the centrifugal fan box 57. The centrifugal fan may be driven in any suitable way as by a motor (not shown) secured to a coupling or pulley 60.

This fan or blower may be a positive pressure pump, or a vacuum pump, as the application or characteristics of the installation demand.

When air passes through a water spray, the water being at the temperature of evaporation, the air becomes saturated, thereby adiabatically lowering the dry bulb temperature, while the wet bulb temperature remains constant. There is, however, no change in the total heat of the air stream. When such saturated air passes through a glycerin spray, some water is absorbed by the glycerin. Further, this passage liberates the latent heat of condensation, but if sufficient glycerin at a slightly lower temperature is used, it will absorb the latent heat and water without

changing the dry bulb temperature of the air, but lowering the wet bulb temperature. Thus, there is heat removed from the air in this glycerin spray operation. Consequently, it is evident that by a series of properly designed water and glycerin sprays arranged alternately, as hereinbefore described, it is possible to remove any desired amount of heat from the air stream for conditioning the air either for human comfort or for industrial processing.

In order to produce the desired continuous circulation of water through the three illustrated sprays, a plurality of pumps 61, 62 and 63 are provided with outlet or delivery pipes 64, 65 and 66, respectively, which in turn communicate with the spray pipes 45, 33 and 16, respectively. Pipes 67, 68 and 69, respectively, communicate with the drain pipes for the tanks 47, 35 and 18, these pipes in turn communicating with the return openings of the pumps 61, 62 and 63, respectively. In this way the desired continuous circulation from each of the three small tanks mentioned and the continuous spraying thereinto are maintained. In order to preserve an equal level of liquid in all three of these small tanks, thus preventing an overflow or a shortage of water therein, a small pipe 70 serves to connect the outlet or drain pipes 67 and 68, while the second small pipe 71 serves to connect the outlet or drain pipes 68 and 69. These small pipes also prevent convection currents between the three small tanks in question as the water temperatures therein differ in accordance with the temperature of adiabatic saturation in the respective spray temperatures.

The three pumps 61, 62 and 63 may be set up for multiple or gang operation, being driven by a suitable electric motor 72, the motor and the pumps being preferably mounted upon a suitable base plate 73 located at one side of the main tank 1.

With respect to maintaining the continual circulation of the glycerin sprays, the cycle is necessarily more complicated than that employed for the water, as just described, since the glycerin has to be suitably treated for the removal of water and correction of temperature before it can be circulated back into the sprays.

For this purpose two pumps 74 and 75 are provided with delivery pipes 76 and 77, respectively communicating with the glycerin spray pipes 39 and 25. These two pumps may be gang operated by a common electric motor 78, and the motor and pumps are preferably mounted on a suitable base plate 79 located on the opposite side of the main tank 1 from the water pumps 61, 62 and 63.

The first glycerin tank 27, as previously mentioned, is connected through float ball valve 29 to the drain pipe 28, whence the glycerin passes through pipe 80 to the top of a vacuum treating tank 81. The pipe 80 terminates in a perforated or spray ring 51 for downwardly spraying the glycerin and water mixture. As indicated at 52 in Fig. 3, this spraying of the mixture separates the glycerin, which descends to the bottom of the tank, from the water vapor, which remains at the top and is drawn out through pipe 85.

The reconditioned glycerin is permitted to flow from the bottom of the tank by means of a valve 83 controlled by a float ball 84, the glycerin being delivered through a pipe 82 to the suction end of the pump 74. By reason of the high surface tension of such liquids as glycerin, it is necessary to break up the liquid into small drops or balls by means of the spray ring illustrated in order to prevent the formation of large bubbles in the vacuum tank. It will be noted that the dehydration of the glycerin in the vacuum tank is also an adiabatic process and, therefore, the latent heat of evaporation is removed from the glycerin, which in turn reduces the temperature of the reconditioned glycerin at the bottom of the vacuum tank below that of the air stream.

This glycerin is then forced through the spray pipe 39, the cooled and dehydrated glycerin being first used in the cool-air end of the air-conditioning tank, so as to use it in counterflow relation to the air travel. That is to say, after the glycerin is sprayed from the pipe 39, it is withdrawn from the tank 41 through pipe 44 to the suction end of pump 75, whence it is delivered through pipe 77 to the other glycerin spray pipe 25 near the warm air end of the main tank 1. The glycerin spray thus again absorbs more heat and more vapor from the incoming air stream and then is drawn from the small tank 27 into the vacuum-treating tank 81.

The pumping equipment associated with pipe 85 for removing water vapor from the vacuum-treating tank 81 and creating a vacuum therein to cause the water-ladened glycerin to enter the tank, comprises a double or two-stage pumping device. In summer weather, water passing through a cooling tower is usually too high in temperature to condense the water vapor being removed from the glycerin in the vacuum tank. Consequently, I employ two vacuum pumps, the first pump 86 operating against a very low pressure, such as 0.5 pound, and handling water vapor and air, thus requiring a large displacement, but operating against a low pressure head, and a second pump 93 operating against atmospheric pressure and handling air and the condensate resulting from the condensation of the water vapor drawn through the first pump 86.

A suitable electric motor 87, completely sealed from atmospheric pressure to eliminate stuffing boxes on the shaft, is provided for driving the pump 86 and a second electric motor 95 for driving the pump 93, both pumps and both motors being preferably mounted on a suitable base plate 88 located in the vicinity of the centrifugal fan box 57.

The air and water vapor from the low pressure vacuum pump 86 are delivered through pipe 89 to a condenser 90, which is provided with inlet and outlet pipes 91 and 92 for connecting to a cooling tower or water supply of a familiar cooling water system, as indicated by the legend. The condensate resulting from this treatment is pumped through suction pipe 94 to the atmospheric pressure pump 93, whence the excess water is delivered from outlet pipe 96, being either allowed to drain away or being returned to the water supply system of my apparatus, if desired.

The condenser 90 may be either of the surface or the jet type, preferably the jet type, as it is small in construction and operates with a lower temperature difference between the water and water vapor than does the surface condenser.

As an example of the operation of the two-stage vacuum pump apparatus, if it be assumed that the temperature of the glycerin leaving the vacuum tank is 60° F., then the pressure in the tank would be .25 of a pound per square inch absolute, in order to remove the water vapor from the glycerin. It is evident that an assumed water temperature of 75° F. in the condenser circulating pipes 91 and 92 would not condense the vapor pumped from the vacuum tank 81.

The pump 86, therefore, handling the water vapor and air from the vacuum tank, raises the pressure from .25 of a pound per square inch absolute to .5 pound per square inch absolute, which raises the condensation temperature from 60° F. to 80° F., thus permitting the water in the cooling system at the temperature of 75° F. to condense the water vapor in the condenser 90. In this way the size and horsepower consumption of the high-pressure-head vacuum pump 93 may be greatly reduced, as it merely has to handle the entrained air and condensate against a pressure ranging from .5 pound per square inch absolute to atmospheric pressure of 14.7 pounds per square inch absolute.

If desired, the flow of water and glycerin for conditioning the air stream flowing through the main tank 1 may be controlled automatically in accordance with any known system, such, for example, as maintaining a constant dew-point temperature in the delivery end 56 of the main tank, the control apparatus being utilized to vary the amount of glycerin spray for this purpose. It will further be understood that both the glycerin and the water sprays may be varied either manually or automatically to produce any desired condition of temperature and humidity.

It will be seen that I have thus provided an air-conditioning equipment wherein any desired amount of heat may be removed from an air stream by means of alternately adding sprays of water and glycerin to the air until the desired reduced temperature is attained. The necessary water for humidifying the air is continuously circulated as required, as is also the glycerin, which in turn is subjected to a vacuum-treating process by means of a special highly efficient apparatus for removing the water from the glycerin and lowering the temperature of the latter.

However, it should be understood that my apparatus, broadly considered, is adapted for changing the heat energy of any suitable gas, such as ammonia, gasoline, carbon dioxide, or ether, using the Carnot cycle with maximum efficiency, as the heat transfer is by direct contact in all cases when using a cooling tower and a jet condenser. Thus my apparatus may be used for heating purposes, if desired, by using the heated water from the jet condenser.

Moreover, the air or gas stream in my apparatus may operate under various pressures other than atmospheric depending on the mediums or materials used and the characteristics of the application or use of the apparatus.

Broadly speaking, the materials or mediums used in the apparatus may be defined, within the scope of my invention, as follows:

The gas to be treated comprises any gas capable of absorbing a self-imparting liquid into a vapor state and later partially or wholly giving it up to another liquid or solid medium or absorbing material in the form of a liquid, under suitable conditions.

The self-imparting material comprises any liquid capable of partially or wholly saturating a gas stream in the form of a vapor and having the characteristics of being re-absorbed from the gas stream in the form of a liquid by a suitably absorbent liquid or solid, the self-imparting material being capable of removal from the latter by reducing the pressure thereof, for example.

The absorbent material comprises any solid or liquid capable of partially or wholly removing a vapor from a gas stream and retaining same in the form of a liquid until a suitable reduced pressure is applied, for example.

The type of self-imparting liquid used depends on the nature of the gas-conditioning application, particularly as to the temperatures encountered. It is also essential to select a liquid that requires a minimum of energy to remove the same from the absorbent liquid or solid through a condensing action taking into account the heat of condensation.

While I have shown my invention in its present preferred form, I do not wish to be restricted to the illustrated specific structural details or arrangement of parts, as various modifications thereof may be made without departing from the spirit and scope of my invention. I desire, therefore, that only such limitations shall be imposed as are indicated in the appended claims.

I claim as my invention:

1. An air-conditioning apparatus embodying successively-arranged means for adding water and glycerin to the air being conditioned, means for maintaining a continuous circulation of glycerin for this purpose, and means for separating moisture from said glycerin after each exposure to the air being conditioned, said last means including means for vacuum-treating the combined glycerin and moisture and means for condensing the aqueous vapor resulting from said treatment.

2. An air-conditioning apparatus embodying successively-arranged means for adding water and glycerin to the air being conditioned, means for maintaining a continuous circulation of glycerin for this purpose, and means for separating moisture from said glycerin after each exposure to the air being conditioned, said last means including means for vacuum-treating the combined glycerin and moisture, a condenser, means for transferring the aqueous vapor resulting from said treatment to said condenser.

3. An air-conditioning apparatus embodying successively-arranged means for adding water and glycerin to the air being conditioned, means for maintaining a continuous circulation of glycerin for this purpose, and means for separating moisture from said glycerin after each exposure to the air being conditioned, said last means including means for vacuum-treating the combined glycerin and moisture, a condenser, means for transferring the aqueous vapor resulting from said treatment to said condenser, and means for removing the condensate.

4. An air-conditioning apparatus embodying successively-arranged means for adding water and glycerin to the air being conditioned, means for maintaining a continuous circulation of glycerin for this purpose, and means for separating moisture from said glycerin after each exposure to the air being conditioned, said last means including means for vacuum-treating the combined glycerin and moisture, a condenser, a pump operating at relatively low pressure for transferring the aqueous vapor resulting from such treatment to said condenser, and a second pump operating at higher pressure for removing the condensate.

5. An air-conditioning apparatus embodying successively-arranged means for adding water and glycerin to the air being conditioned, means for maintaining a continuous circulation of glycerin for this purpose, and means for separating moisture from said glycerin after each exposure to the air being conditioned, said last means including means for vacuum-treating the combined glycerin and moisture, a condenser, a pump operating at sub-atmospheric pressure for transfer-

ring the aqueous vapor resulting from such treatment to said condenser, and a second pump operating at atmospheric pressure for removing the condensate.

6. An air-conditioning apparatus embodying successively-arranged sprays for adding water and glycerin to the air being conditioned, filters for eliminating entrained water and glycerin from such air, a fan for circulating the conditioned air, tanks for respectively receiving the unused and retrieved water and glycerin, pumps for respectively drawing water and glycerin from said tanks and returning them to the respective sprays, and float-controlled valves for respectively regulating the levels of water and glycerin in said tanks.

7. An air-conditioning apparatus embodying successively-arranged sprays for adding water and glycerin to the air being conditioned, filters for eliminating entrained water and glycerin from such air, a fan for circulating the conditioned air, tanks for respectively receiving the unused and retrieved water and glycerin, pumps for respectively drawing water and glycerin from said tanks and returning them to the respective sprays, float-controlled valves for respectively regulating the levels of water and glycerin in said tanks, a vacuum-treating device for separating moisture from said glycerin after withdrawing it from a tank, and a condenser for condensing the aqueous vapor resulting from said treatment.

8. A method of conditioning air which includes the steps of dehydrating said air by contacting said air with a circulated hygroscopic liquid of controlled concentration cooled to such an extent that said dehydration is effected substantially isothermally with respect to said air, and subsequently contacting said air with a spray of water and humidifying it to a desired degree substantially adiabatically, thereby imparting to said air desired conditions of temperature and humidity.

9. Means for conditioning air comprising heat pumping means employing a hygroscopic solution for removing latent heat of the vapor from said air above its dew point, means for adding latent heat to the air by removing an equal quantity of sensible heat from said air, and means whereby the liquid removed from said solution acts as the refrigerant therefor during such removal.

10. The method of conditioning air which consists in removing from said air a quantity of water, adding to a hygroscopic solution an amount of water whose latent heat is substantially equal to the total heat removed from said air, selectively dividing said total heat into predetermined amounts of sensible heat and latent heat, and reconditioning said hygroscopic solution with a heat pump.

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