Feb. 23, 1932. A. D. KARR ET AL 1,846,875

AIR CONDITIONING

Filed March 4, 1931 2 Sheets-Sheet 1

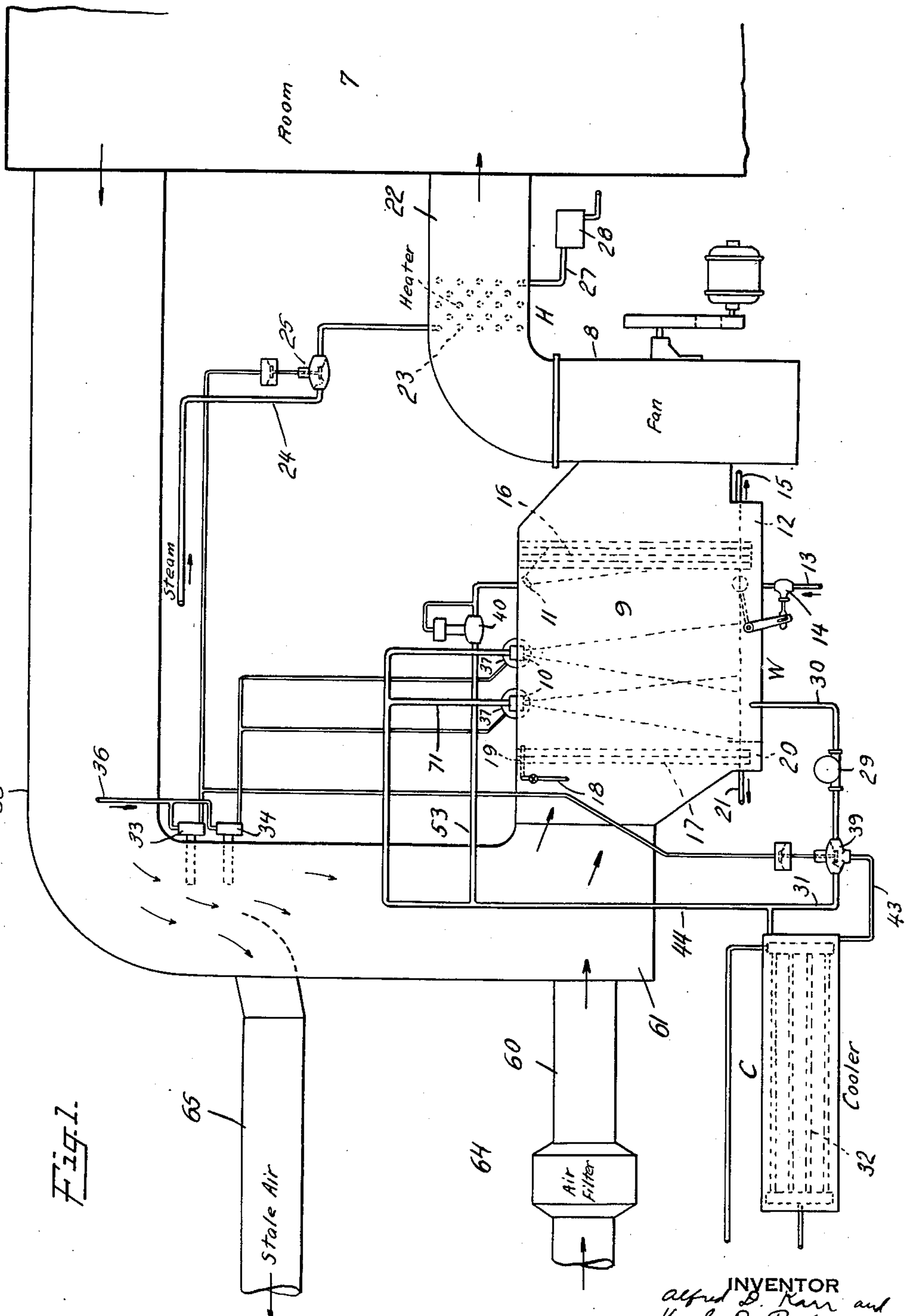


Fig. 1.

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Fig. 2.

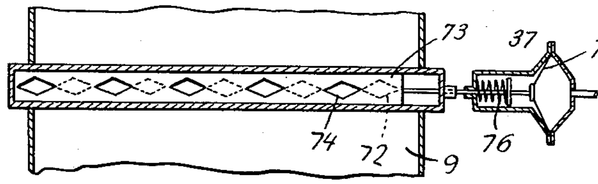



Fig. 4.

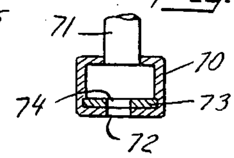



Fig. 3.

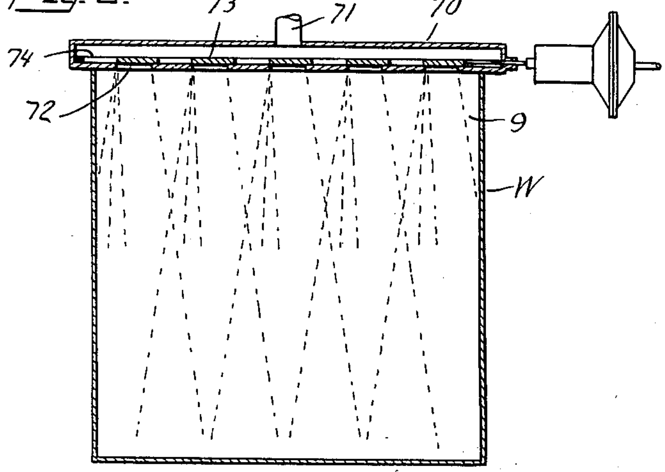



Fig. 5.

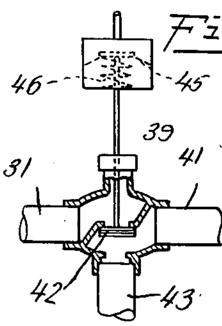



Fig. 6.

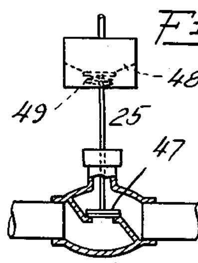



Fig. 9.

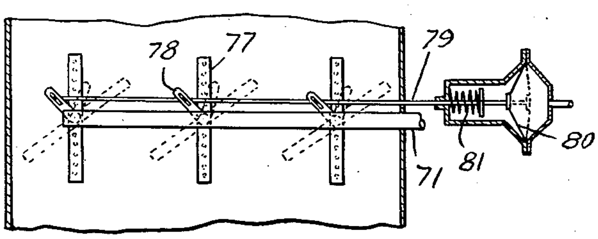



Fig. 8.

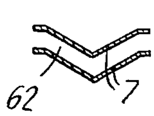
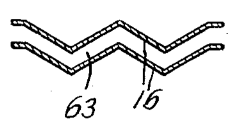



Fig. 7.

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# UNITED STATES PATENT OFFICE

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## AIR CONDITIONING

Application filed March 4, 1931. Serial No. 519,940.

This invention relates to the conditioning of air and more particularly concerns an improved method and means for maintaining desirable atmospheric conditions within rooms or other enclosures.

This application is a continuation in part of our copending application, Serial No. 505,478, filed December 30, 1930.

In maintaining desirable atmospheric conditions in enclosures such as auditoriums, factories, dwelling rooms, theaters, laboratories and the like, it is necessary to cool and dehumidify the air supplied to such enclosures during the warmer seasons and to heat and humidify such air during the colder seasons of the year.

Dehumidification, as heretofore effected, involves cooling a body of air to a temperature below its dewpoint whereby some of the moisture content thereof is condensed and removed therefrom, the cooling medium usually comprising a cold water spray which, in addition to cooling the air, washes it to remove foreign matter and odors therefrom. After being thus cooled and dehumidified, the air is substantially at the saturation point and is consequently at a temperature considerably below that required for comfort in the enclosure, and it is accordingly necessary to reheat the air after dehumidification and before its introduction to the enclosure. The cooling and subsequent reheating of large quantities of air such as those required in theater auditoriums and other large enclosures involves an expense which in most cases is prohibitive.

It has heretofore been proposed to effect economies in the amounts of energy consumed in the cooling and reheating of air which is incident to dehumidification by dehumidifying a small percentage of the air to be supplied to the enclosure and subsequently mixing the comparatively warm and moist untreated air with such treated air prior to its introduction to the enclosure. In most air conditioning and ventilating schemes, both fresh air and air withdrawn from the enclosure are supplied to the enclosure, and consequently the untreated portion of the air carries considerable heat which assists in raising the temperature of the dehumidified air to a comfortable value. Thus, in order to bring the air mixture to the desired temperature and relative humidity during the warmer seasons, it is necessary not only to cool the small proportion of treated air to its dewpoint or slightly below, but to carry the temperature of such air to an extremely low value far below its initial dewpoint whereby this small proportion of air may absorb sufficient heat from the large proportion of untreated air to give the desired temperature. It is obviously inefficient and wasteful of refrigeration effect to thus cool the treated air to a temperature far below that necessary for the extraction of the desired amount of moisture therefrom. Also, in the by-passing systems heretofore employed, a very large percentage of the air supplied to the room is not washed or otherwise treated to remove odors and dust or other foreign matter therefrom, and accordingly, the air in the enclosure soon becomes stale, odorous and dust-laden.

In order that an air conditioning system may be capable of supplying fresh and recirculated air at the proper temperature under the widely varying outdoor atmospheric conditions met with at different seasons of the year, and under the widely varying indoor conditions produced by changes in the number of people or in the amount of heat and moisture emanating from other sources in the enclosure, it is desirable that the system have an air treating capacity which is variable between very wide limits of cooling and dehumidification on the one hand and heating and humidification on the other hand. It is further desirable to provide a system so designed that its temperature and humidity altering functions may be quickly varied in response to slight changes in atmospheric conditions within the enclosure whereby appreciable variations in the desired room conditions may be effectively avoided.

With the above and other considerations in mind, it is proposed in accordance with the present invention to provide an improved air conditioning method and system capable of treating the air to be supplied to an enclosure in such a manner that a degree of economy heretofore unobtainable is effected in the energy expended in cooling and dehumidifying as well as in heating the air, while at the same time, all of the air supplied to the enclosure is subjected to a desirable washing and cleansing operation. Another important object of the invention resides in the provision of an air conditioning method and system having an air temperature and humidity altering capacity which is very rapidly variable over an extremely wide range, whereby atmospheric conditions in an enclosure may be maintained at the desired point without substantial variation regardless of the most extreme or rapid variations in outdoor atmospheric conditions or in indoor heat and moisture supply.

It is a further object of the invention to provide an air conditioning method in which the velocity of circulation of the air is maintained constant whereby the control of air conditions may be effected without the use of dampers or other means for varying the rate of flow of air at any point in the system.

The above and other objects of our invention are carried out by passing all of the air to be supplied to the enclosure in a single stream and condensing moisture from the air in such stream without reducing the total heat content of the air to such an extent as to bring the air stream down to or close to the desired dewpoint temperature. In general, this is accomplished by cooling different portions of the air in the stream to different temperatures, some of the air being cooled slightly below its dewpoint whereby moisture is condensed and removed therefrom, and the remaining air being cooled to various temperatures above the dewpoint, but the total remaining heat content of the air in the stream after treatment being sufficient to bring the entire air stream to a final temperature well above the desired dewpoint.

Various means may be employed to carry out the method of the invention. Thus, the single air stream supplied to the enclosure may be subjected to heat exchanging contact with a cooling medium in the form of a plurality of relatively spaced bodies whereby some of the air is cooled to or below its dewpoint by intimate contact with the cooling medium while other portions of the air in the stream are cooled to a lesser extent and retain sufficient heat to give a final air temperature well above the saturation point and close to that desired in the enclosure.

In a preferred form of the invention, all of the air to be introduced to the enclosure is collected in a single stream and a cooling medium comprising a liquid in the form of spaced drops, particles or streams is passed across such air stream whereby the temperature of some of the air in the stream is lowered to a value below the dew-point by heat exchanging contact with the liquid while other portions of the air in the stream pass between the liquid bodies and are cooled to a lesser extent.

The conditioning of air by our improved method is preferably variably controlled in accordance with changes in atmospheric conditions within the enclosure to which the treated air is supplied. This may be accomplished by varying the heat exchanging relation between the cooling medium and the air stream so that more or less moisture is condensed from the air in the stream. Thus, in one preferred form of the invention, the cooling medium, in the form of liquid drops, streams, sprays or other bodies, is propelled across the air stream and the amount of heat taken up from the air by such liquid is varied by altering the proportion of the cross section of the air stream with which the air comes into intimate contact. This may be done by varying the liquid pressure on spray nozzles, by varying the openings of elongated liquid discharge orifices extending transversely across the air stream, by changing the angular relation to the direction of flow of the air stream of one or more sheets of sprayed liquid, and in various other ways. It is usually preferred, although not essential to the invention in its broader aspects, that the temperature of the cooling medium as well as its heat exchanging relation to the air, be altered in accordance with atmospheric conditions in the enclosure.

In addition to passing the air in contact with the liquid streams or particles as described above, it is sometimes preferred to subsequently pass all of the air being treated in contact with moistened surfaces whereby any remaining dust or odors are removed prior to the introduction of the air to the enclosure.

In accordance with one embodiment of the invention, it is proposed to cleanse the fresh and recirculated air prior to the humidification or dehumidification thereof by passing such air over surfaces coated with oil or some other suitable viscous substance.

The above and other objects and characteristics of the invention will be best understood by reference to the accompanying drawings, in which an air conditioning system embodying the invention has been diagrammatically illustrated.

In the drawings:

Figure 1 is a diagrammatic representation, partly in section, of an air conditioning system embodying the invention;

Fig. 2 is a sectional plan view showing the liquid regulating valves employed in the system of Fig. 1;

Fig. 3 is a sectional end view of the valves shown in Fig. 2;

Fig. 4 is a sectional view of the valve structure shown in Figs. 2 and 3;

Figs. 5 and 6 are enlarged sectional views of the different types of automatically operable valves employed in the system of Fig. 1;

Fig. 7 is a plan view showing the shape of the eliminator plates used in the system of Fig. 1;

Fig. 8 is a plan view showing the shape of the air filtering plates used in the system of Fig. 1; and

Fig. 9 is a plan view of a modified form of means for variably governing the heat exchanging relation between the cooling medium and the air stream.

Referring to the drawings, and more particularly to Fig. 1, the system shown is employed to condition the air in a room or enclosure represented at 7 and comprises generally a washer W, a fan or equivalent air propelling device 8 and an air heating device H.

The washer W includes a single air chamber 9 having one or more sets of liquid discharge nozzles 10 and eliminator moistening nozzles 11 mounted at the upper end thereof. The bottom wall portion of the chamber 9 forms a liquid collecting pan 12 which is preferably provided with a liquid supply pipe 13 controlled by a float valve 14 and an overflow pipe 15, whereby the water level in the pan 12 may be kept substantially constant regardless of the extraction or discharge of water by the air flowing through the chamber 9. A plurality of eliminator plates or baffles 16 are provided near the discharge end of the chamber 9, each of these plates preferably comprising a plurality of angularly disposed surfaces. The plates 16 are arranged in nesting relationship, as shown in Fig. 7. The surfaces of the plates 16 are kept moist by liquid flowing from the nozzles 11, and the air passing through the circuitous paths defined by the plates is accordingly brought into contact with the liquid and washed or cleansed thereby. A set of similar plates 17 is disposed across the inlet end of the washer chamber 9, the shape of the plates being shown in Fig. 8. The plates 17 are preferably coated with a viscous fluid such as oil which may be supplied to the plates through a valve controlled pipe 18 and nozzle 19. The oil falling from the plates 17 is collected in the oil well 20 and carried off in the oil overflow pipe 21. The suction fan 8 is connected to the discharge end of the washer chamber 9 and delivers conditioned air to the room 7 through the duct 22.

The heater H may take any suitable form and preferably comprises a coil of pipe 23 disposed within the air duct 22 leading to the enclosure. Steam or any other suitable heating fluid may be introduced to the coil 23 through the pipe 24 under the control of the valve 25 as hereinafter described, and an exhaust pipe 27 having a steam trap 28 therein may be provided for the coil.

The system of the invention is designed primarily to cool and dehumidify the air supplied to the enclosure. Accordingly, means are provided for at times supplying refrigerated water or other liquid to the nozzles 10 and 11. The spray liquid may be supplied to these nozzles by a power driven pump 29 which withdraws liquid from the pan 12 through the pipe 30 and returns this liquid either through a liquid cooler C or directly through the pipe 31 to the nozzles 10 and 11. The proportion of withdrawn liquid which is passed through the cooler C is controlled by means of a mixing valve 39 and the flow of liquid from the nozzles 10 is governed by means of one or more valves 37, as hereinafter explained. It should be understood that the liquid passing through the cooler C is refrigerated by contact with the evaporator coils 32 of a mechanical refrigeration system, or in any other suitable manner. It is generally preferred to operate the pump 29 at a constant speed and to regulate the flow of liquid to the nozzles 10 and 11 by means of the valves 37 and 40. In order to prevent excess liquid pressure in the pipes of the system, the pump employed may be provided with a by-pass adapted to open when the liquid pressure reaches a predetermined high value, or a pump of the impeller type may be used to provide the same pressure limiting operation.

The various control devices and connections employed in the illustrated embodiment of the invention will now be described. The treatment of the air supplied to the enclosure is preferably governed automatically in accordance with atmospheric conditions within the enclosure, and accordingly, the sensitive elements of a dry bulb thermostat 33 and a wet bulb thermostat or hygrostat 34 are disposed within the duct 35 through which air is withdrawn from the enclosure 7. It is obvious that these sensitive elements may be disposed within the enclosure 7 if desired, but it is generally preferred to locate them in the return duct since in this location they will be more readily responsive to changes in atmospheric conditions occasioned by heat and moisture emanating from sources within the enclosure.

The dry bulb thermostat 33 is of known construction and is suitably designed to control the flow of compressed air from a source indicated by the pipe 36 to the operating diaphragms of the valves 25 and 39 in accordance with temperature variations of the air in the duct 35. The thermostat 33 is preferably designed to supply compressed air at full pressure when the temperature of the air in the duct 35 is above a predetermined value, to cut off the supply of such compressed air and vent the valve diaphragm chambers to atmosphere when the air temperature is below such value, and to supply a graduated change of pressure from atmospheric to full pressure as the air temperature varies from a value slightly below to a value slightly above the predetermined value.

The wet bulb thermostat or hygrostat 34 is also of known construction and is designed to control the flow of compressed air from the pipe 36 to the operating diaphragms of the control valves 37 in accordance with changes in the humidity of the return air in the duct 35. The wet bulb thermostat is preferably designed to supply compressed air at full pressure of say 15 lbs. per square inch to the operating diaphragms of the valves 37 when the humidity or temperature of evaporation of the air in the duct 35 is below the predetermined value for which the instrument is set, to cut off the supply of compressed air and vent these valve diaphragms when the humidity of the air is above this predetermined value and to vary the air pressure on the valve diaphragms from atmospheric pressure to full pressure as the humidity of the air in the duct 35 changes from a value slightly above to a value slightly below the predetermined value for which the wet bulb thermostat is set.

The operation of the valves 25 and 39 will be best understood by reference to Figs. 5 and 6 wherein these valves have been shown in detail. Fig. 5 is an enlarged sectional view of the valve 39 which controls the percentage of spray liquid which passes through the cooler C. The inlet 41 of this valve is connected to the discharge of the liquid pump 29 and the valve gate 42 governs the division of liquid between the pipe 43 leading to the cooler C and the pipe 31 leading to the spray supply pipe 44. When the gate 42 is in the extreme upper position as shown, all of the spray liquid passes through the pipe 43 and the cooler C and accordingly, the lowest available liquid temperature is obtained. With the gate 42 in the lowest position, all of the liquid is by-passed around the cooler C through the pipe 31 and the temperature of the liquid rises to a maximum value due to the heating of the liquid by the air in the chamber 9. At intermediate positions of the valve gate 42, intermediate liquid temperatures are obtained. The valve gate 42 is operated by a flexible diaphragm 45 which is biased upwardly by the spring 46. Thus, an increase in the air pressure supplied to the diaphragm 45 corresponding to an increase in temperature of the air in the duct 35 acts to lower the valve gate 42 and by-pass a greater amount of liquid around the cooler C whereby the liquid temperature is increased whereas a decrease in control air pressure corresponding to a decrease in temperature of the return air permits the gate 42 to rise and supply a greater amount of liquid to the cooler C whereby the liquid temperature is lowered.

The steam valve 25 is operated by a direct acting diaphragm and the construction of a valve of this type is shown in Fig. 6. The valve gate 47 is operated by a flexible diaphragm 48 acting against the pressure of a spring 49, the spring acting to raise the gate and open the valve when the control air pressure on the diaphragm 48 decreases below the predetermined value and the air pressure above a predetermined value acting to lower the gate and close the valve against the resistance of the spring.

The liquid control valve 37 is shown in detail in Figs. 2, 3 and 4. In the disclosed embodiment, a valve of the gate type is employed to control the liquid flow, the valve opening forming the liquid orifice within the chamber 9 of the washer W. As shown, an elongated valve housing 70 extends across the top of the washer chamber and spray liquid is conducted to the interior of this housing through the pipe 71 connected to the pipe 44. The lower surface of the housing 70 is provided with a plurality of laterally spaced diamond or otherwise shaped elongated openings 72 and a valve gate 73 having a plurality of similarly spaced and shaped openings 74 therein is slidably supported within the housing 70 in contact with the lower surface thereof. It will be readily apparent that as the gate 73 is moved to the right, as shown in Figs. 2 and 3, the openings 74 in the gate will register with increasing portions of the openings 72 in the housing 70 and liquid streams of increasing width will be propelled across the air stream in the chamber 9. The gate 73 is operated by a flexible diaphragm 75 acting against the pressure of a spring 76. As clearly shown in Fig. 2, an increase in control air pressure on the diaphragm 75 above that required to compress the spring 76 will move the gate 73 to the left and close the valve openings, while a decrease in the control air pressure below a predetermined value will permit the spring 76 to move the gate 73 to the right and open the valve.

The nozzle 11 which directs spray liquid on to the eliminator plates 16 is continuously supplied with liquid through a pipe 53 regardless of the operation of the liquid valves 37. A pressure regulating valve 40 of any suitable and known construction is provided in the pipe 53 to limit the liquid pressure on the nozzles 11 to a predetermined value.

In a modified form of the invention, as shown in Fig. 9, the flow of liquid across the washer chamber is maintained constant but the liquid is variably directed across larger or smaller proportions of the cross section of the air stream. Thus, as shown in Fig. 9, the liquid supply pipe 71 is connected to a plurality of horizontal nozzle banks 77 which are pivotally mounted to turn about central vertical axes. Each nozzle bank 77 comprises an elongated pipe or chamber having a plurality of liquid discharge orifices in the lower surface thereof. A crank arm 78 is connected to each nozzle bank 77, and an operating rod 79 engages all of the crank arms and is fixed to a flexible pressure operated diaphragm 80 which acts against the resistance of a spring 81. In the position shown in Fig. 9, the nozzle banks 77 are substantially parallel to or aligned with the air stream through the chamber 9, and accordingly, act to propel a plurality of relatively spaced comparatively thin sheets of spray liquid across the stream. As the air pressure on the diaphragm 80 decreases, the spring 81 moves the rod 79 to the right and swings the nozzle banks 77 to positions at an angle to the air stream whereby the sheets of water from the nozzle banks intercept a larger portion of the cross sectional area of the stream. In this manner, the heat exchanging relation between the liquid and the air in the stream may be variably controlled.

The liquid employed in the system is preferably water. When the air in the chamber is being dehumidified and cooled, it is sometimes preferred to employ a spray liquid having a lower freezing temperature or a higher vaporizing temperature than water, or one having both of these characteristics. Thus, liquids such as brine solutions or ethylene glycol either in solution with water or in the anhydrous state may be used. The use of low freezing and high boiling point liquids for dehumidification permits the use of very low liquid temperatures and further prevents the reevaporation of the liquid by the heat absorbed from the air being treated.

In operating the illustrated embodiment of our improved air conditioning system, fresh air from outside of the enclosure is drawn in through the duct 60 and is mixed with return air from the enclosure within the duct 61 leading to the chamber 9 of the washer W. All of the mixed fresh and used air then enters the chamber 9 through the angularly disposed passages 62 between the oil coated plates 17, and foreign bodies such as dust, lint, etc., are removed from the air at this point. The passage of the air through the plates 17 also serves to remove eddies from the air currents so that the air flows smoothly and uniformly through the chamber 9. The fresh and recirculated air passes through the chamber 9 preferably at a constant velocity, between the liquid bodies falling from the nozzles 10 and is cooled and dehumidified thereby in accordance with the condition of the control apparatus as hereinafter explained. Because of the spacing of the liquid bodies, only a portion of the air passing through the chamber 9 comes into intimate heat exchanging contact with the liquid while other portions of the air are affected to a lesser degree by the liquid. Thus, for example, when the spray liquid is at a temperature below the dewpoint of the entering air, a portion of this air is cooled below its dewpoint and dehumidified by contact with the liquid while other portions of this air pass between the liquid bodies and accordingly retain considerable heat. The cooled and dehumidified air mixes with and is heated by the warmer air and accordingly, the air discharged from the washer chamber 9, although dehumidified to a certain extent, is nevertheless at a comfortable temperature well above its dewpoint.

In leaving the chamber 9, all of the air passes through the angularly disposed passages 63 between the moistened eliminator plates 16 and is accordingly thoroughly washed to remove any remaining dust or odors therefrom. If desired, the entering fresh air may be initially filtered by a suitable device 64 in the fresh air inlet duct 60.

The conditioned air is delivered to the enclosure 7 through the duct 22 and the used air is returned from the enclosure through the duct 35. In order that the air in the enclosure 7 may be continuously replaced with fresh air, a certain proportion of the return air is withdrawn from the duct 35 and discharged through the duct 65, this amount of wasted air being made up by the fresh air entering the system through the duct 60. It will be readily apparent that rather than discharge the wasted air through a special duct, this air may be permitted to escape through the doors, windows or other openings of the enclosure.

When the heat contained in the fresh and recirculated air entering the chamber 9 is not sufficient to give the desired temperature to the air leaving this chamber, the controls act to supply a heating fluid to the coil 23 of the heater H.

The operation of the automatic control means disclosed will be best understood from an explanation of the operation of the system under changing outside and indoor atmospheric conditions.

Assume first that due to the high temperature and high relative humidity of the outside air or to the supply of considerable heat and moisture to the air in the enclosure from sources therein, or to a combination of these factors, it is necessary to dehumidify and cool the air supplied to the enclosure to the maximum extent. Under these conditions, the thermostat 33 supplies moderate air pressure, of say 8 lbs. per square inch, to the operating diaphragms of the steam valve 25 and the mixing valve 37, maintaining the steam valve 25 closed. The spring 46 of the mixing valve 39 is strong enough to maintain the gate 42 of this valve closed on its upper seat against this air pressure whereby all of the spray liquid is passed through the cooler C and the lowest obtainable spray liquid temperature is produced. The wet bulb thermostat or hygrostat 34 supplies a comparatively low pressure, say 5 lbs. per square inch, to the operating diaphragms 75 of the valves 37 whereby the gates thereof are opened to an intermediate position by the springs 76 and streams of spray liquid are propelled across the air stream. Accordingly, some of the air in the stream passing through the chamber 9 comes into intimate contact with the cooled spray liquid and some of this air is cooled below its dewpoint and dehumidified, while other portions of this air are cooled to a lesser extent and retain sufficient heat to subsequently raise the air stream to a temperature above saturation.

Assume now that there is a decrease in the relative humidity of the air in the enclosure due to a decrease in outside humidity or in the supply of moisture from sources within the enclosure, or from a combination of these factors. The wet bulb thermostat 34 responds to this change and increases the control air pressure on the diaphragms of the valves 37, thereby partially closing these valves and reducing the size of the cooling liquid streams. The decrease in the amount of spray liquid reduces the dehumidifying effect and also reduces the amount of heat removed from the air stream. As a consequence, the air temperature increases and the dry bulb thermostat 33 responds and increases the air pressure on the operating diaphragm of the valve 39, thereby permitting some of the spray liquid to by-pass around the cooler C, and accordingly, raise the spray liquid temperature. If this increase in spray liquid temperature reduces the dehumidifying effect too greatly, the wet bulb thermostat 34 again responds, and further opens the valves 37 to supply more spray liquid across the air stream and increase the dehumidifying action.

Assume now that there is a decrease in the amount of heat supplied to the system due to a lowering of the outside temperature or to a decrease in the amount of heat emanating from sources within the enclosure. The dry bulb thermostat 33 immediately responds to the lower temperature and reduces the pressure on the operating diaphragms of the valves 25 and 39. This reduction in control air pressure has no effect on the mixing valve 39 which is already closed on its upper seat. The valve 25 is preferably set to remain closed until after the control air pressure has been reduced below the value at which the valve 39 closes its upper seat. Thus, the reduction in control air pressure from the dry bulb thermostat 33 permits the gate 47 of the steam valve 25 to rise to an intermediate point, admitting steam to the coils 23 of the heater H and the desired air temperature is maintained. If the relative humidity of the air withdrawn from the enclosure becomes too low because of the higher air temperature, the wet bulb thermostat 34 further increases the control air pressure on the diaphragms of the valves 37 and decreases the width of the spray streams to limit to the desired degree the dehumidifying action.

As the supply of heat to the system is further reduced the thermostat 33 responds and reduces the control air pressure to a point at which the steam valve 25 is opened more widely and more heat is accordingly supplied to the treated air to maintain the desired temperature within the enclosure.

It will be understood that the wet bulb thermostat or hygrostat 34 automatically regulates the heat exchanging relation between the cooling liquid and the air stream and so automatically maintains the desired degree of dehumidification in the washer. In the form of the invention illustrated in Fig. 9, this is accomplished by moving the several sheets of spray liquid to the positions in which they intercept greater or smaller percentages of the total cross section of the air stream, the size of the liquid sheets remaining constant. It is obvious that the heat exchanging relation between the spray liquid and the air stream could also be varied by altering the pressure on the spray liquid nozzles whereby upon an increase in liquid pressure the spray streams would spread out and come into contact with a larger proportion of the air stream, and upon a decrease in such pressure, the streams would retract and pass in intimate contact with a smaller proportion of the air stream.

Due to the fact that the heat exchanging relation between the cooling medium and the air stream, as well as the temperature of the cooling medium, is variably controlled, the range of the system as well as the rapidity of its response to changing conditions is materially increased.

The term "atmospheric conditions" as employed in the specification and claims herein, means conditions of temperature or of relative humidity or a combination of these conditions. The alteration of the heat exchanging relation between the cooling medium and the air stream, as this term is employed in the claims herein, will be understood to include any change in the size, position or surface area of the medium or in its intimacy of contact with the air stream, which change will result in a change in the amount of heat absorbed by the medium from the air in the stream.

Although the invention has been disclosed in connection with a single air conditioning system embodying the principles thereof, it should be understood that various changes or omissions may be made in the system disclosed without departing from the scope of the invention as defined in the appended claims. Thus, in certain cases where a smaller capacity or range of control variation is required the temperature control of the air treating medium may be dispensed with and the operation of the system may be governed by altering only the heat exchanging relation between the medium and the air in accordance with the atmospheric conditions in the enclosure. In certain cases the alteration of the heat exchanging relation between the cooling liquid and the air may be effected solely by varying the amount or surface area of the liquid supplied to the eliminator plates, the other liquid stream being dispensed with, and the invention includes this method of controlled dehumidification. It is not essential to the invention in its broader aspects that a liquid be employed as the medium of variable surface area and such media as cooled metallic surfaces of variable area or variable heat exchanging relation to the air stream may be used.

We claim:

1. The method of cooling and dehumidifying a quantity of air which comprises moving the air through an unobstructed passageway, subjecting the entire volume of air in such stream to the action of a cooling medium in the form of segregated liquid particles in such manner that some of the air in the stream is cooled to a temperature below its dew point and moisture is condensed therefrom while other portions of said air are cooled to a lesser extent, the total cooling effect being insufficient to bring the average air stream temperature down to the saturation value, and varying the degree of dehumidification obtained by varying the surface area of said segregated liquid particles while in heat-exchanging relation with said air stream.

2. The method of cooling and dehumidifying a quantity of air which comprises propelling the air in a single stream through an unobstructed passageway, projecting a liquid at a temperature below the dew point of the air stream across said air stream in the form of a curtain of segregated liquid particles in such manner as to cool a portion of the air in such stream to a temperature below its dew point while cooling other portions of said air to a temperature above its dew point whereby heat is extracted from portions of said air as latent heat of condensation and from other portions of said air as sensible heat and varying the quantity of heat extracted as latent heat of condensation by adjusting said sprays to alter the surface area of the liquid particles in heat-exchanging relation with said air stream.

3. The method of cooling and dehumidifying a quantity of air which comprises moving the air through an unobstructed passageway, subjecting the entire volume of air in such stream to the [illegible] f a cooling medium in the form of segregated liquid particles in such manner that some of the air in the stream is cooled to a temperature below its dew point and moisture is condensed therefrom while other portions of said air are cooled to a lesser extent, the total cooling effect being insufficient to bring the average air stream temperature down to the saturation value, and automatically altering the surface area of the liquid particles in heat-exchanging relation with the air stream in accordance with variations in the relative humidity of the entering air stream to thereby maintain the discharged air at a substantially constant humidity.

4. The method of cooling and dehumidifying a quantity of air which comprises moving the air through an unobstructed passageway, subjecting the entire volume of air in such stream to the action of a cooling medium in the form of segregated liquid particles in such manner that some of the air in the stream is cooled to a temperature below its dew point and moisture is condensed therefrom while other portions of said air are cooled to a lesser extent, the total cooling effect being insufficient to bring the average air stream temperature down to the saturation value, automatically altering the surface area of the liquid particles in heat-exchanging relation with the air stream in accordance with variations in the relative humidity of the entering air stream to thereby maintain the discharged air at a substantially constant humidity, and simultaneously altering the temperature of the liquid in accordance with changes in the temperature of the entering air stream so that the temperature and relative humidity of the discharged air are mainained at desired values.

5. The method of cooling and dehumidifying a quantity of air which comprises propelling the air in a single stream through an unobstructed passageway, projecting a liquid at a temperature below the dew point of the air stream across said air stream in the form of a curtain of segregated liquid particles in such manner as to cool a portion of the air in such stream to a temperature below its dew point while cooling other portions of said air to a temperature above its dew point whereby heat is extracted from portions of said air as latent heat of condensation and from other portions of said air as sensible heat and automatically varying the quantity of heat extracted as latent heat of condensation in response to changes in the relative humidity of the entering air stream by adjusting said sprays to alter the surface area of the liquid particles in heat-exchanging relation with said air stream.

6. The method of cooling and dehumidifying a quantity of air which comprises propelling the air in a single stream through an unobstructed passageway, projecting a liquid.

at a temperature below the dew point of the air stream across said air stream in the form of a curtain of segregated liquid particles in such manner as to cool a portion of the air in such stream to a temperature below its dew point while cooling other portions of said air to a temperature above its dew point whereby heat is extracted from portions of said air as latent heat of condensation and from other portions of said air as sensible heat and automatically varying the quantity of heat extracted as latent heat of condensation in response to changes in the relative humidity of the entering air stream by adjusting said sprays to alter the surface area of the liquid particles in heat-exchanging relation with said air stream, and simultaneously modifying the temperature of the liquid in response to changes in the temperature of the entering air stream to thereby maintain the temperature and humidity of the air at desired values.

7. In an air conditioning system, the combination with the enclosure in which conditioned air is used, of a conduit of undivided cross section, means for propelling a single stream of air co-extensive with said conduit through said conduit into said enclosure, a series of liquid sprays extending across the top of said conduit, means for supplying said sprays with liquid at a temperature below the dew point of the air in said stream, said sprays being designed to discharge the liquid therefrom in streams of liquid particles, and means for adjusting said sprays to vary the surface area of the liquid particles in heat-exchanging relation with the air in said stream to thereby vary the proportion of the air whose temperature is reduced below its dew point.

8. In an air conditioning system, the combination with the enclosure in which conditioned air is used, of a conduit of undivided cross section, means for circulating a single stream of air co-extensive with said conduit through said conduit into said enclosure, and thence repeatedly back through said conduit, a series of liquid sprays extending across the top of said conduit, means for supplying said sprays with liquid at a temperature below the dew point of the air in said stream, said sprays being designed to discharge the liquid therefrom in streams of liquid particles, means for adjusting said sprays to vary the surface area of the liquid particles in heat-exchanging relation with the air in said stream to thereby vary the proportion of the air whose temperature is reduced below its dew point, an hygrometer in the conduit in the path of the air entering the conduit and means controlled by said hygrometer for regulating said adjusting means to maintain the air entering the enclosure at the desired humidity.

9. In an air conditioning system, the combination with the enclosure in which conditioned air is used, of a conduit of undivided cross section, means for propelling a single stream of air co-extensive with said conduit through said conduit into said enclosure, a series of liquid sprays extending across the top of said conduit, means for supplying said sprays with liquid at a temperature below the dew point of the air in said stream, said sprays being designed to discharge the liquid therefrom in streams of liquid particles, means for adjusting said sprays to vary the surface area of the liquid particles in heat-exchanging relation with the air in said stream to thereby vary the proportion of the air whose temperature is reduced below its dew point, a thermometer in the conduit, and means controlled by said thermometer for regulating the temperature of said liquid to maintain the air entering the enclosure at the desired temperature.

10. In an air conditioning system, the combination with the enclosure in which conditioned air is used, of a conduit of undivided cross section, means for circulating a single stream of air co-extensive with said conduit through said conduit into said enclosure, and thence repeatedly back through said conduit, a series of liquid sprays extending across the top of said conduit, means for supplying said sprays with liquid at a temperature below the dew point of the air in said stream, said sprays being designed to discharge the liquid therefrom in streams of liquid particles, means for adjusting said sprays to vary the surface area of the liquid particles in heat-exchanging relation with the air in said stream to thereby vary the proportion of the air whose temperature is reduced below its dew point, a thermometer and an hygrometer in said conduit in the path of the air entering the conduit and means controlled by said hygrometer and thermometer for regulating said spray adjusting means and the temperature of said spray liquid to maintain the air entering the enclosure at the desired temperature and humidity.

In testimony whereof we affix our signatures.

ALFRED D. KARR.
KARL D. PERKINS.

# DISCLAIMER

1,846,875.—*Alfred D. Karr*, Newark, N. J., and *Karl D. Perkins*, New York, N. Y. AIR CONDITIONING. Patent dated February 23, 1932. Disclaimer filed January 13, 1938, by the assignee, *Auditorium Conditioning Corporation.*

Hereby makes this disclaimer of claims 1, 2, and 7 of said Letters Patent.

[*Official Gazette February 8, 1938.*]