

Nov. 8, 1932.

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1,886,777

AIR CONDITIONING APPARATUS

Filed Feb. 14, 1930

3 Sheets-Sheet 1

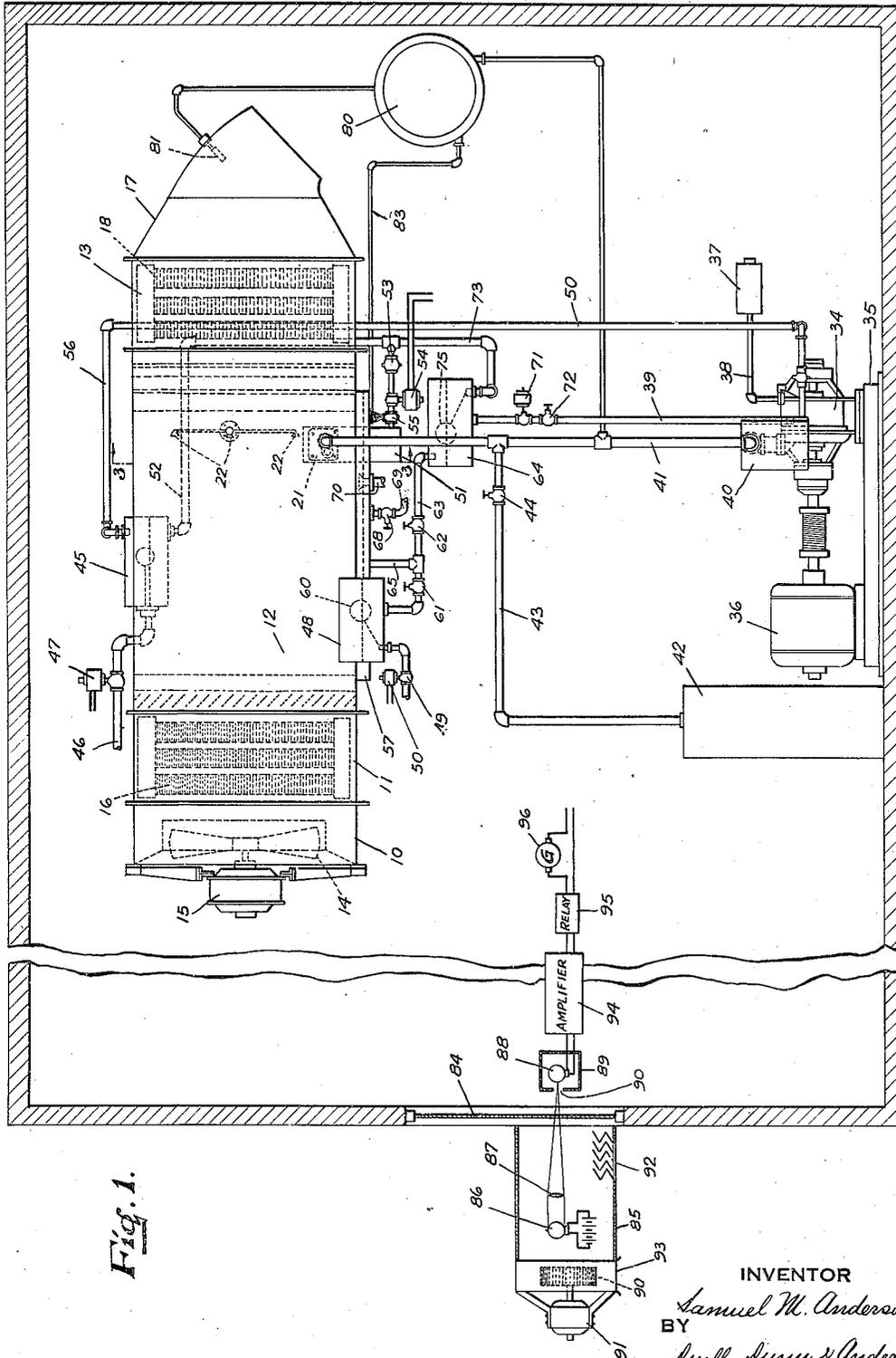


Fig. 1.

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3 Sheets-Sheet 2

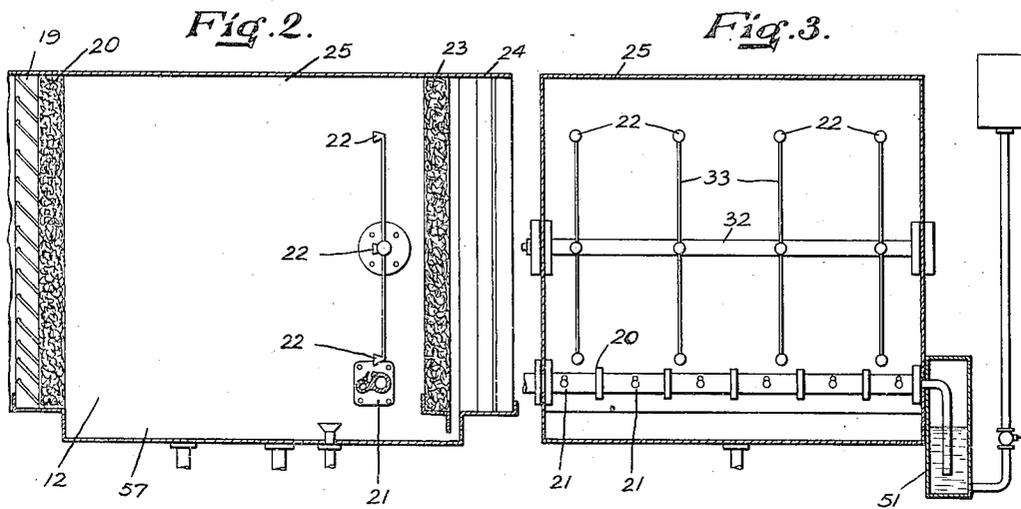


Fig. 4.

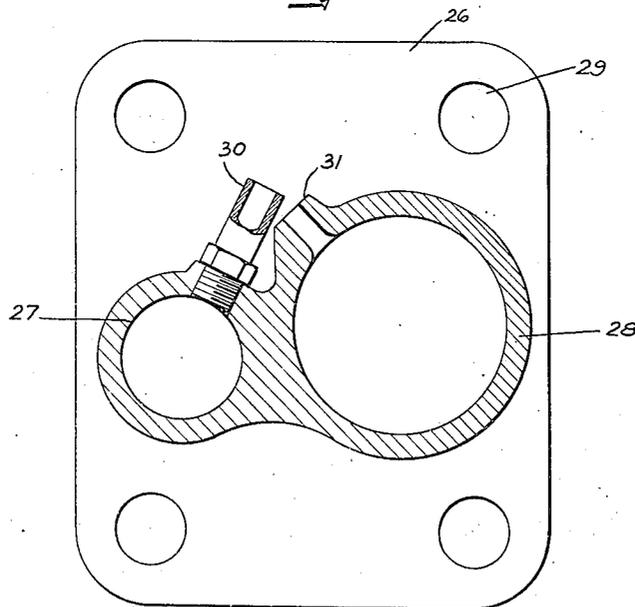
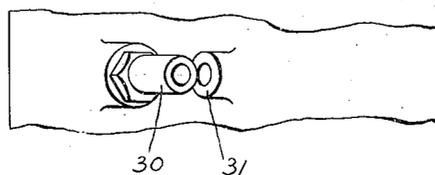


Fig. 5.



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AIR-CONDITIONING APPARATUS

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3 Sheets-Sheet 3

Fig. 6.

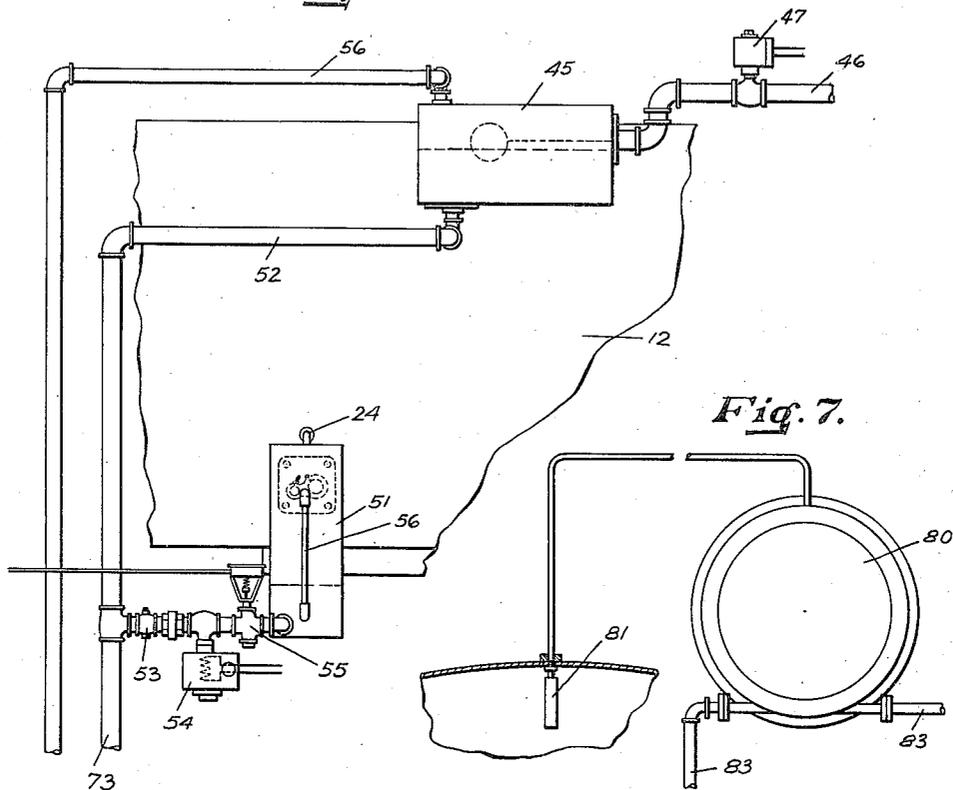


Fig. 7.

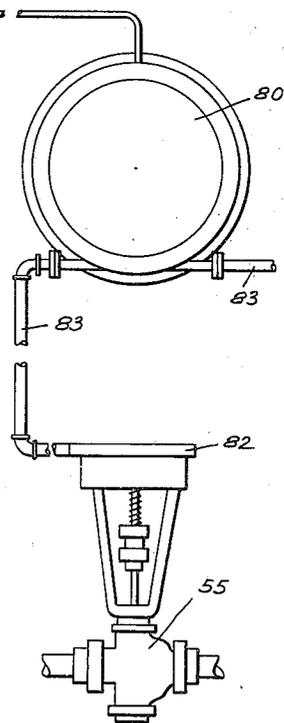
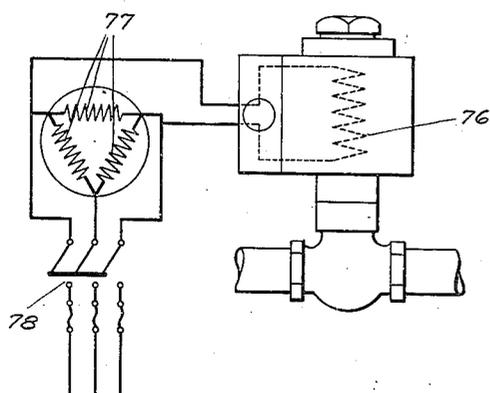


Fig. 8.



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AIR CONDITIONING APPARATUS

Application filed February 14, 1930. Serial No. 428,313.

This invention relates to methods and apparatus for controlling the vapor content of a fluid and relates more particularly to improved apparatus for conditioning air.

It is becoming better and better known that the ventilating systems of buildings should contain apparatus for conditioning the air passing therethrough. Where cleanliness is of importance, it is necessary that some form of air washer or filter be used to remove the dust and other impurities entering or produced within the building. In addition to the necessity for cleaning the air, the necessity for controlling the moisture content of the air is of considerable importance.

In winter, living conditions in heated buildings are greatly improved when the air within the buildings contains a substantial amount of moisture or water vapor. When air is heated in the absence of free water, as is customary when hot air furnaces or steam radiators are used for heating, it becomes drier, although the actual amount of water vapor present remains the same. In other words, the absolute humidity is the same, but the relative humidity has been lowered. Relative humidity is the ratio of the weight of water vapor in a given space as compared to the weight which the same space is capable of containing when fully saturated at the same temperature. Dry heated air is injurious to the nose, throat and lungs when constantly breathed and is at times responsible for sore throats and ordinary colds. In order that healthful conditions may be restored, it is necessary to add moisture to heated air. Sufficient moisture should be added to the air in public buildings to maintain a relative humidity from 35 to 50%. The humidity to be recommended in good practice is 50% with a room temperature of 77 degrees F.

Humidity also plays a prominent part in many manufacturing processes. The amount

of moisture required varies widely according to the nature of the process, some processes requiring high and others low relative humidities. In textile mills the necessity for humidifying and cooling the air has long been known. Today the field of application of humidity control apparatus includes such industries as candy, paper, tobacco, rubber goods, bakeries and others. The advantages obtained through humidity control are many. The time of manufacture may be reduced, the quality increased, less breakage or waste occurs. In fact, in all cases continuous production may proceed under conditions that are most favorable, regardless of outdoor weather.

In summer in certain locations where the relative humidity of the outdoor air is high a large portion of the time, the air entering the ventilating systems of buildings needs to be dehumidified, that is, a certain amount of moisture should be extracted from the incoming air.

It is highly desirable that the ventilating systems of buildings include apparatus for conditioning the ventilating air so that it may be clean and that its heat and moisture content can be regulated as desired. In winter, the equipment should be capable of cleaning, heating, and humidifying the air. In summer, it should be capable of cleaning, cooling and dehumidifying the air. The present invention accomplishes these results through the use of simple, efficient, and compact air conditioning units.

An object of this invention is to condition air or other fluids with more compact and more efficient equipment than that previously used.

Another object of the invention is to humidify ventilating air through an improved method of mixing air and water.

Another object of the invention is to combine humidifying and dehumidifying func-

tions in compact and efficient air conditioning units.

Another object of the invention is to automatically control the addition of moisture to the air in air conditioning apparatus in order that the desired relative humidity may be automatically maintained.

Another object of the invention is to automatically control the addition of moisture to the air in air conditioning apparatus through observations of condensation of the moisture.

Other objects will be brought out in the following description of the apparatus and process employed in the invention.

According to a feature of the invention, an air conditioning system for buildings may be built up of very small units, the number of units employed being proportional to the size of the system. A typical system comprises ventilating fan units, heating units and air conditioning chamber units.

According to another feature of the invention, an air conditioning chamber unit may be inserted in a ventilating system to serve as a humidifier unit.

According to another feature of the invention, an air conditioning chamber unit may be inserted in a ventilating system to serve as a dehumidifying unit.

According to still another feature of the invention, an air conditioning chamber unit may be inserted in an air ventilating system to perform the functions of a humidifier or a dehumidifier, as desired.

A typical system for humidifying air according to this invention may consist of a ventilating unit, a heater unit and an air conditioning chamber unit, arranged in the order named. The air conditioning chamber unit contains atomizer spray nozzles for humidifying the air.

A typical system for dehumidifying air may consist of the following:—a ventilating unit, an air conditioning chamber unit, and a heater unit arranged in the order named. The air conditioning chamber unit in this case contains water spray nozzles for projecting cooling water into the current of air produced by the ventilating unit.

A typical system which may combine the functions of humidifying air in winter and of dehumidifying air in summer may consist of a ventilating unit, a heater unit, an air conditioning chamber unit and another heater unit arranged in the order named. The air conditioning chamber unit in this case will include atomizer nozzles for humidifying purposes and water spray nozzles for dehumidifying purposes. When the system is used for humidifying air, the first heater unit is employed while the second one is not employed. The atomizer spray nozzles of the air conditioning chamber unit are used, but the water spray nozzles are not. When the system is used for dehumidifying pur-

poses, the first heater unit is not employed, while the second is employed. The water spray nozzles in the chamber unit are employed, while the atomizer spray nozzles are not.

According to another feature of the invention, through the use of a novel air conditioning chamber unit a novel process for dehumidifying purposes is employed.

According to another feature of the invention through the employment of the novel air conditioning chamber unit and the novel atomizer spray nozzles, a new process of humidifying air is employed.

According to another feature of the invention, the control of the air conditioning system may be made automatic, the regulation being responsive to humidity control devices for maintaining the desired humidity.

The novel air conditioning chamber unit for humidifying purposes, according to this invention, contains two fine mesh filters, which serve to close off the two sides of the chamber through which the air to be humidified passes. These filters may be made up of galvanized steel wool or other suitable material. A spray nozzle comprising a water tube to which the conditioning water is continuously supplied and an air tube to which compressed air is supplied, is placed in the conditioning chamber and serves, when the unit is used as a humidifier, to project the conditioning water in a finely atomized spray in a direction opposite to that of the ventilating air, so that a high velocity between the ventilating air and atomized water is obtained. The water and compressed air tubes of the spray nozzle are preferably so arranged that the blast of compressed air in addition to introducing a negative water pressure serving, when the water is not under positive pressure, to pull the conditioning water through the water tube, produces a varying vacuum over the surface of the mouth of the water tube so that the surface of the water at one side of the mouth of the tube is subjected to a vacuum gradient as compared to the surface of the water at the other side of the mouth of the tube. This vacuum gradient causes a turbulence in the water near the mouth of the tube, this resulting in a breaking up of the water particles and expulsion of them into the blast of compressed air, which projects them into the conditioning chamber in such a finely divided condition that they vaporize readily in the current of ventilating air. The conditioning water through the water tube may be under positive pressure or may be drawn from a supply tank by the force of the compressed air across its mouth.

Superheated steam may be introduced into the air tube as near to the spray nozzle as convenient. The object of the steam is to obtain high relative humidity (between 95%

and 100%) of the air leaving the conditioning chamber. Steam nozzles have been used for humidifying purposes heretofore, but the past practice has been to eject live steam into the ventilating air. With the past practice, high relative humidities have been obtained, but high temperatures of the ventilating air were also obtained because there would have to be much excess steam in order to get complete saturation, this excess steam being condensed, its latent heat becoming sensible heat which would result in raising the temperature to an unsatisfactory amount. By using steam with compressed air according to the present invention, this excess steam is replaced by compressed air which is inert as far as latent heat is concerned and which distributes the over-all amount of steam necessary to get complete saturation without raising the air temperature unduly. Superheated steam is preferably used because the ventilating air tends to chill the pipe lines within the conditioning chamber and to condense, as a result, steam in the pipe line which is not desired.

The filters which are placed at the inlet and exit portions of the chamber are preferably composed of metal wool which has a large number of small interstices to permit the air to flow without excessive resistance, but serves effectively to catch any entrained water particles. Any particles of water in the spray from the nozzle which may be projected against the inner surface of the inlet filter, are broken up into finer particles by contact therewith, which finer particles are sustained by the ventilating air. Any entrained moisture in the air leaving the conditioning chamber is extracted therefrom by the exit filter, both filters serving to prevent large droplets of water from being carried by the ventilating air.

The invention will now be explained with reference to the drawings, in which:

Figure 1 is a side view of a complete air conditioning system built up of units in which the functions of humidifying and dehumidifying air are combined.

Fig. 2 is a side sectional view of the air conditioning chamber of the system of Fig. 1.

Fig. 3 is a sectional view along the lines 3-3 of Fig. 1 and shows the piping arrangement of the atomizer and water spray nozzles.

Fig. 4 is a sectional view of the atomizer nozzle which is a part of this invention.

Fig. 5 is a top view of the atomizer nozzle shown in section by Fig. 4.

Fig. 6 is a view looking from the rear of the apparatus shown by Fig. 1 and shows a portion of the piping of the apparatus.

Fig. 7 is an enlarged diagrammatic view of the humidity control apparatus of Fig. 1, and

Fig. 8 is a diagrammatic view of the elec-

trical mechanism of the automatic shut-off valves employed with the water piping of the system.

Reference is now made to Fig. 1, which shows a ventilating system built up of the different units which are employed according to this invention, together with associated water, steam and air piping. The ventilating unit 10 contains the fan 14 driven by the motor 15. Attached to the ventilating unit 10 is the heater 11 which contains the heating coils 16. The air conditioning chamber unit 12 is attached at one side to the heater unit 11. The equipment contained within the air conditioning chamber unit will be described in detail later with reference to Figs. 2 and 3 of the drawing. To the other side of the air conditioning chamber unit 12 is attached one side of the heater unit 13 and to the other side of the heater unit 13 is attached the ventilating duct 17. The heater unit 13 contains the heater coils 18, which are similar to the heating coils 16 in the heater unit 11. The current of air produced by the ventilating unit 10 passes first over the heating coil 16 of the heater unit 11, then into the air conditioning chamber unit 12, out of the air conditioning chamber unit 12 over the heating coils 18 of the heater unit 13 and out of the ventilating duct 17 into the room the air of which is to be conditioned. The air conditioning chamber unit 12, as shown in more detail by Figs. 2 and 3, has mounted therein at the side through which the ventilating air enters, the separator baffle plates 19 next to which is placed the filter 20. This filter 20 preferably contains metal wool which contains a large number of small interstices to permit the air to flow into the air conditioning chamber without excessive resistance, but which serves effectively to catch any entrained water particles. Contained also within the conditioning chamber unit 12, are the atomizer nozzles 21, the details of which are shown more clearly by Figs. 4 and 5 and the water spray nozzles 22. The atomizer nozzles 21 serve, as will be explained in detail later, to atomize conditioning water so that it may be vaporized by the ventilating air passing through the air conditioning chamber unit so as to humidify the ventilating air when its humidity is low. The water spray nozzles 22 serve to project a fine spray of water into the air conditioning chamber unit 12 so as to cool and dehumidify the air when the air conditioning chamber unit is used as a dehumidifying unit, as in summer months when the humidity is too high for comfort. The air conditioning chamber unit 12 has at its side, where the ventilating air exits, the fine mesh filter 23 which contains steel wool similar to that of the filter 20, and next to the filter 23 is the separator baffle 24 containing vertically placed baffle plates.

When the apparatus is used as a humidifying system, the fan unit 10, the heater unit 16 and the air conditioning chamber unit 12 are the only units employed and in the air conditioning chamber unit only the atomizing nozzles 21 are used.

When the apparatus is used as a dehumidifying system, the fan unit 10, the air conditioning chamber unit 12 and the heater unit 13 are the only units employed and in the air conditioning chamber unit 12 only the water spray nozzles 20 are used.

The air conditioning chamber unit 12 will now be described with reference to Figs. 2, 3, 4 and 5 of the drawings. This unit comprises the metal casing 25 which forms a part of the air duct through which the ventilating air is caused to flow by the action of the ventilating unit. The casing 25 contains the atomizer nozzles 21 which serve to project a finely atomized spray of water into the ventilating air. The atomizing nozzles 21, as shown by Fig. 3, are built up of a plurality of sections. Each section includes two flanges 26 between which are connected the water pipe 27 and the compressed air pipe 28, the flanges and the two pipes being connected integrally. The sections are bolted together through the holes 29 and as many sections as desired may be used. When bolted together, the pipe sections 27 and 28 form continuous water and air pipes, respectively, extending across the chamber unit. A water tube 30 is threaded into the center of each water pipe section 27. Each compressed air section 28 is formed with an air nozzle 31, the water nozzle 30 and the compressed air nozzle 31 being so arranged that the current of air from the air pipe 28 moving across the mouth of the water nozzle 30 produces a suction therein. By having the axes of the water nozzle 30 and the air nozzle 31 arranged at an angle of slightly less than 90° to each other, the air current from the compressed air tube 28 is not blown exactly parallel to the exit surface of the water nozzle 30 so that a varying vacuum is produced at different points on the surface of the water nozzle 30, this tending, when water is being projected from the water nozzle, to create turbulence in the water flow so as to break the water up into finer particles to assist the atomizing action of the air nozzle 31. The casing 25 also contains the water spray nozzles 22. These nozzles are only used when the unit is to be used for dehumidifying purposes. The spray nozzles 22 are of the ordinary spray type commonly used in the present type of air conditioning apparatus and are supplied with water from a circulating pump through the main pipe 32 and the branch pipes 33. The nozzles 22 are so arranged that the water spray projected from them is in a direction opposing the air current produced by the ventilating unit 10 (Fig. 1) and the spray nozzles 22

and the front filter 20 of the chamber unit cooperate to cool the air passing through the chamber unit 12 inasmuch as the water spray from the nozzles 22 impinge on the surface of the filter 20, this breaking the water up into finer particles so that the ventilating air is cooled both by contact with the surface of the filter 20 and by contact with the water spray filling the chamber unit 12 produced by the nozzles 22.

The associated apparatus for cooperating with the air conditioning chamber unit 12 consists of the combination air and water pump 34 which is mounted on the foundation 35 and adapted to be driven by the motor 36. In this type of pump the air is used as a seal for the end of the air compressor to prevent leakage of the water around the ends of the compressor plates. The air is drawn into the pump through the silencer unit 37 which may be of the "Maxim" type and through the pipe 38. The silencer 37 serves to decrease the noise caused by the air being drawn through the pipe 38 into the pump 34. Water is drawn into the compressor 34 from the water pipe 39. Air and water are forced out of the pump 34 into the separating chamber 40 which separates the water from the compressed air. The compressed air is carried from the separating chamber 40 to the compressed air nozzles 31 of the atomizer nozzles 21 by means of the connecting pipe 41. Superheated steam is supplied to the compressed air pipe 41 from the superheated steam source 42 through the connecting pipes 43 and shut-off valve 44. The point at which the superheated steam is introduced into the compressed air pipe 41 should preferably be as close to the atomizing nozzle 21 as possible in order that as little condensation of the steam as possible will take place in the compressed air pipe. The water for the system is supplied to the reservoir 45 from a suitable water source through the water pipe 46 past the automatic shut-off valve 47 which is adapted to shut off the water when the electrical supply to the motor 36 is shut off. Similarly, the water source supplies water to the reservoir 48 through the pipe 49 and the automatic shut-off valve 50. The nozzle box 51 contains supply water for supplying directly the water to the atomizer nozzles 21, the water being supplied from the reservoir 45 to the nozzle boxes 51 by means of the supply pipe 52. The water from the supply pipe 52 on its way to the nozzle boxes 51 passes through the check valve 53 which serves to prevent return water from flowing from the nozzle boxes 51 and through the electrically operated throttle valve 54 and the compressed air operated throttle valve 55. The valves 54 and 55 control the amount of water to the atomizer nozzles 21 and are operated through humidity control devices, as will be explained in detail later. The gauge glass 56 (Fig. 6)

serves to indicate to the operator the head of water in the nozzle boxes 51 and roughly, through the knowledge of water being vaporized, the degree of humidity being obtained. In operation the amount of water which is atomized by the atomizer nozzles 21 is dependent upon the head of the water in the nozzle boxes 51 and upon the velocity of the compressed air. The velocity of the compressed air is preferably kept constant and the head of water in the nozzle boxes 51 may be varied over a large range to give either a positive or a negative head to control the amount of water passing through the nozzles 21. If the water level in the nozzle boxes 51 is below the mouth of the water nozzle 30 of the atomizer nozzle 21, a negative head of water is present and the compressed air through the atomizer nozzle 21 serves to draw the water from the nozzle box 51. When the water level is above the mouth of the water nozzle 30, there is a positive head of water. The water level in the nozzle box 51 and the resulting amount of water supplied to the atomizing nozzles 21 is regulated by the settings of the throttle valves 54 and 55. After each setting of these throttle valves, the water in the nozzle box 51 will find a level which will represent an equilibrium between the rate at which water is being withdrawn by the action of the blast of compressed air under the head of water determined by the level in the nozzle box and the rate at which the water is brought into the nozzle box by the reservoir 45 through the throttle valves. If, for example, more water is permitted to flow into the nozzle boxes 51 the level will rise increasing the positive head of water (or diminishing the negative head) to the atomizer nozzles 21 and thus greatly increasing the rate at which the water is drawn out by the blast of compressed air. The water pipe 56 connects the reservoir 45 and the pump 34 and serves to return excess water in the separating chamber 40 to the reservoir 45 due to the pressure maintained in the separating chamber 40 by the operation of the pump 34.

The lower portion of the casing 25 of the air conditioning chamber unit 12 has formed therein the drain pan 57 which serves to collect any water deposited within the air conditioning chamber unit 12. The drain pan 57 is connected with the reservoir 48 so that the same level of water is present in both. The reservoir 48 has contained therein the float 60 which serves to maintain the water level in the drain pan 57 and the reservoir 48 at the desired level. The reservoir 48 is connected through the valves 61 and 62 and pipe 63 to the reservoir 64. The water pipe 65 serves to equalize the water level in the tank 48 and the drain pan 57. The valve 68 controls the water from the drain pan 57 which may pass through the pipe 69 to the suction side of the circulating pump which supplies water to

the spray nozzles 22. The overflow pipe 70 is provided for carrying away any excess water from the drain pan 57. The tank 64 collects the water drained from the drain pan 57 and returns any excess water through the automatic shut-off valve 71 and the throttle valve 72 to the water intake pipe 39 which supplies the pump 34.

In order that sufficient water may be present within the compressor 34 to serve as a seal, the tank 64 is connected by means of the pipe 39 to the compressor. The water entering the water pipe 73 is controlled by means of the float 75 so that a constant level is maintained in the reservoir 64 to maintain a constant rate of feed to the compressor 34. Since the amount of water to operate the compressor remains constant under normal operating conditions a throttle valve 72 is supplied which acts in conjunction with the constant head of water to insure an even flow of water into the pump. A final adjustment in the valve 72 is made after starting the apparatus.

The automatic shut-off valves 47, 50 and 71 are provided to shut off the water supply, when the apparatus is shut down, to prevent flooding of the pump with consequent inconvenience and delay when it is desired to start the apparatus again. The arrangement of these automatic shut-off valves is illustrated by Fig. 8. Each valve contains the solenoid 76 which is magnetized to hold the valve open when the motor 36 is running by connection across two of the terminals 77 of the motor so that when the switch 78, which controls the motor 36, is opened the solenoid 76 connected with each valve is demagnetized, permitting the valve to close shutting off water action. A similar action takes place in case of power failure, thus serving as an additional safety factor.

The water for supplying the water spray nozzles 22 enters the reservoir 48 and the drain pan 57 and passes through the return pipe 69 to a circulating pump (not shown). This circulating pump forces the water through the supply pipes 32 and 33 to the nozzles 22. The water from the nozzles 22, after being projected through the air and against the filter 20 to cool the air to be humidified, collects in the drain pan 57 and is used over and over again. This water will ordinarily be used with a refrigeration apparatus with the cooling water being used over and over again with refrigeration with each cycle, any loss of water due to evaporation or leakage being automatically made up from the reservoir by the float valve 60 and any excess of water as from condensation being disposed of through the overflow 70.

When the system is used for humidifying air as in the winter months, the ventilating air is forced by the fan 14 past the heating coils 16 of the heater unit 11, thus heating the

air to the desired temperature. This heated air passes into the air conditioning chamber unit 12 through the separator baffle plates 19 and filter 20 and passes from the air conditioning chamber unit 12 through the filter 23 and the separator baffle 24. The atomizer nozzle 21 is so arranged that the compressed air from the compressed air pipe 28 blowing across the water nozzle 30 produces a very fine atomized spray of water. The superheated steam introduced into the compressed air pipe 41 from the superheated steam source 42 enables higher relative humidities to be obtained from the use of the apparatus inasmuch as insufficient steam is supplied to raise the temperature unduly but sufficient steam is supplied to get complete saturation, the steam being so mixed with a large amount of compressed air that no excess steam is required to get complete saturation. The spray which leaves the atomizer nozzle 21 consists of finely atomized particles of water mixed with air and steam. This atomized spray is so fine that it is readily vaporized by the heated air passing through the air conditioning chamber unit. The atomized spray from the atomizer nozzle 21 is projected in a direction opposing the air current through the air conditioning chamber unit. In this way a high relative velocity between the air current and the projected atomized spray is obtained. The atomized spray is projected against the current of air to the front filter 20 and is then carried by the current of air back through the air conditioning chamber unit to the exit filter 23 where any entrained moisture is separated from the air. Since the atomized spray is projected initially to flow opposed to the air to be conditioned, the water particles not only have a high relative velocity relative to the air particles, but this high relative velocity is maintained for a considerable period of time so that much of the humidifying effect is obtained before the water particles begin to flow rearwardly with the air current. Due to this it is possible to utilize a conditioning chamber of relatively short length and yet obtain an efficiency of conditioning favorably comparable with the very large chambers heretofore employed.

The water spray nozzles which have been heretofore used for humidifying purposes have been of the type which employed water nozzles having small orifices through which the conditioning water is forced under pressure to produce a finely divided spray with which contact with the air is promoted. Due to the very small orifices required it has been difficult to keep the nozzles clean and from being choked up especially where, in certain manufacturing plants, considerable lint or solid refuse is deposited from the air. This type of nozzle also has the disadvantage that the spray is insufficiently atomized to permit the necessary intimate contact with the par-

ticles of the air current unless an extremely large quantity of water is used. The amount of water vaporized employing such nozzles is only a fraction of that sprayed through the nozzles. Another disadvantage with systems employing the common spray nozzles for projecting moisture into the air is that no regulation of the spray or of the amount of water vaporized by the air can be made, since the nozzles operate under water pressure alone. The volume of the spray and the degree of vaporization are both determined by the water pressure and this water pressure must be maintained within fairly close limits to obtain any effective spray for vaporization. If the water pressure is decreased below its full value, the volume of water passing through the nozzle is not only decreased, but the spray value may be entirely lost, the water being forced out only as a stream and not as a spray. The water must be either full on or full off, no intermediate spraying conditions being permissible. According to the present invention, accurate control of the amount of water to be vaporized and a high efficiency of vaporization are obtained. The volume admitted to the water tubes and atomized in the form of spray is exactly governed by the head of water either positive or negative and the velocity of the air blast. The amount of water actually vaporized depends, however, upon the degree of moisture which it is desired to impart to the air. For example, if it is desired to approach 100% of humidity practically all of the spray is vaporized, only a very small amount of water being returned to the drain. For theoretical maximum humidification an increased amount of water is required and since the air becomes less capable of sustaining the water particles at high humidities, a large portion of the water will be returned to the drain. In any case, however, the humidifying system, according to this invention, employs only a small amount of water for the usual nozzle for the same amount of humidification. Also, since a water tube with a single large orifice is employed (in the preferred form is about $\frac{3}{8}$ of an inch) there is little or no possibility of this becoming stopped up. The spray will therefore operate continuously over a long period of time without the necessity of a shut-down for repairs or cleaning.

When the apparatus in the system is used for dehumidifying purposes, the air to be dehumidified is forced by the fan 14 of the ventilating unit 10 through the air conditioning chamber unit 12 and over the heating coils 18 of the heater unit 13. The air, of course, passes over the heater coil 16 of the heater unit 11, but in this case the heater coil 16 of the heater unit 11 is not heated, so that the heater unit 11 is not in operation. In operation, the heater coils 13 of the heater unit 18 are heated by steam, gas, or other

suitable means. The heater unit 18 may be connected directly to the ordinary household heating system. With the ventilating unit 10 in operation so that a current of the air to be dehumidified is passed through the air conditioning chamber 12, the water supply through the pipe 49 to the reservoir 48 is turned off and the circulating water pump (not shown) is set into operation. Cold water, or a solution (capable of being cooled below the freezing point of water), if preferred, is sprayed from the nozzles 22 into the air current, cooling the air by direct contact. The larger particles of cooling liquid are discharged with sufficient velocity to reach the inlet screen 20, which they strike with such force that they are immediately broken into still finer spray, some of which remains upon the screen, while the rest is carried back through the spray chamber by the air current, absorbing more heat therefrom by direct contact. A portion of the spray falls downwardly through the chamber and is collected in the drain pan 57. Still another portion of the spray is carried back with the air current and onto the outlet stream 23, heat being absorbed from the air by direct contact through this movement. The cold water which impinges upon the inlet screen 20, and which is carried by the air current onto the outlet screen 23, absorbs heat from the metal wool, or other material, which is contained within the screens, reducing the temperature thereof. Although the cooling liquid does not penetrate the inlet screen to any substantial extent, nevertheless, due to the heat conductivity of the material composing this screen, the entire mesh of the screen will be reduced in temperature and will, in turn, become effective to cool the air flowing through it. With such material as metal wool forming the screen, the air will be broken up into a multiplicity of minute air currents, which will be of relatively high velocity, thereby securing a rapid heat transfer from the air to the screen and to the water entrained in the screen. Such water as is caught by the screen, which in the case of the outlet screen 23 will be considerable, will not only absorb heat from the screen, but being exposed to the air, will absorb heat directly therefrom. As the water collects on the inlet and outlet screens, it will work downwardly, finally being discharged into the drain pan 57, as will be any water which may be collected upon the separator baffles 19 and 24. In addition to cooling the air, the water entrained in the screen will act to collect particles of dust and dirt carried with the air current, the screens thus having the additional function of washing the air, and since fresh spray water is continuously supplied, the screens are kept clean.

Due to the fact that heat is absorbed from

the air not only by the cooling water but by the filters, a very efficient and rapid absorption of heat is secured, permitting the use of an apparatus of small dimension and requiring the use in handling of but a relatively small amount of water. For example, I have found by actual experience that by the use of the process and apparatus above described, the same cooling and dehumidifying effect can be secured upon a given volume of air by apparatus less than one-quarter of the size of that heretofore required, and with the use of less than one-quarter the amount of water heretofore required.

According to another feature of this invention, I propose to spray through the cooling nozzles of the humidifier unit a liquid or solution having low vapor pressure which does not have the tendency to cause rust, as a brine solution does. Such a liquid may be, for example, glycerine or any similar liquid. The glycerine may be mixed with water or other liquid to form a solution.

The advantages of using a liquid such as glycerine as a cooling spray are:—(1) The glycerine does not add vapor to the air, as water does. This results in an economy in the amount of liquid used and in a saving in refrigeration capacity. (2) The glycerine or glycerine solution does not have the tendency to rust the spray nozzles and other metal used in the unit, as the brine solution now used. (3) The glycerine or glycerine solution can be cooled by the refrigeration equipment to a temperature much lower than that of water.

The dehumidifying system herein disclosed is not necessarily limited to cooling or dehumidifying air. For example, it may be used for cooling a liquid, the latter being sprayed through the nozzles while air of lower temperatures is passed through the apparatus. The present apparatus and process may be used for the cooling or heating of air, or the cooling or heating of liquids, as desired, depending upon the relative temperatures of the air and the liquid. Nor is the invention limited to the use with air alone for, obviously, it may be used with various other gaseous fluids, as with different gases.

In winter months, when it is desired to heat and humidify the ventilating air with the system shown by Fig. 1 of the drawings the air, after passing through the heater unit 11, may have a dry bulb temperature of 117° and a wet bulb temperature of 64.5°. After passing through the air conditioning chamber unit 12, and being subjected to the action of the atomizer nozzles 21, the air will pass from the air conditioning chamber unit at the dry bulb temperature of 77° and a wet bulb temperature of 64.5°, this being equivalent to a relative humidity of 50%, which is that desirable in offices or homes.

In summer months, the air entering the

air conditioning chamber 12 may have a dry bulb temperature of 90° and a wet bulb temperature of 85°, this being equivalent to a relative humidity of 82%. The water spray nozzles 22 may project a water spray having an average temperature of approximately 53° into the air, this resulting in the air leaving the air conditioning chamber unit 12 having a dry bulb temperature of 57° and a wet bulb temperature of 57°, this being equivalent to a relative humidity of 100%. After passing through the heater unit 13, the air is heated and raised to a dry bulb temperature of 77° and a wet bulb temperature of 64.5°, this resulting again in a relative humidity of 50% which is that desirable for comfort.

The system herein disclosed may perform the functions of humidifier or dehumidifier, as desired. Obviously, of course, the system may be made to perform only one of the functions, and may be cheapened and simplified by omitting the apparatus which is essential only for the other function. For example, if the equipment is to be used for humidifying purposes only, it is not necessary that the heater unit 13, nor the water spray nozzles 22, with their associated equipment, be employed. Also, if the equipment is to be used for dehumidifying purposes only, it is obvious that the heater unit 11 and the atomizer nozzles 21 and their associated equipment, may be omitted.

In order that the adjustment of the apparatus may be automatic when performing humidifying functions, there have been provided two methods of automatic control, both of which may be used alone. One of the methods utilizes a humidity recorder-controller to control the flow of water to the atomizer nozzles, and the other utilizes an apparatus for shutting off the water supply to the atomizer nozzles when the humidity within the room becomes so high that moisture condenses on the window panes or upon other transparent mediums within the room, the air of which is being humidified.

Referring now to Figs. 1 and 7 of the drawings, the humidity recorder-controller 80, which may be of any well known construction, is provided with a member 81 which is placed within and near the discharge duct 17, through which the humidified air is discharged into the room, which is sensitive to the amount of moisture in the conditioned air. In order to adjust the throttle valve 55 as desired, the compressed air valve 82 is connected to the throttle valve 55 and is controlled from the humidity controller 80 through the compressed air line 83, which may be supplied with compressed air from the compressor pump 34. As the humidity increases above the desired level, the recorder-controller operates the compressed air valve 82 to adjust the amount

of water flowing to the atomizer nozzle 21. As the humidity decreases below the desired level, the humidity controller 80 operates through the compressed air valve 82 to permit more water to flow through the water supply pipe to the atomizer nozzle 21.

Referring now to Fig. 1 of the drawings, the room or enclosure, the air of which it is desired to humidify may have associated with the window pane 84 the light-responsive apparatus for shutting off the supply of water to the atomizer nozzles 21 when moisture condenses on the inner surface of the window pane. The light-proof enclosure 85 is mounted on the outside of the building and against the lower portion of the window pane 84, which is exposed to the atmosphere. The enclosure 85 has contained therein the light source 86, the light of which is focused by the lens 87 through the window pane 84 upon the light-sensitive cathode of the photo-electric cell 88 contained within its light-proof enclosure 89 within the room, the air of which is to be humidified. In order that the surface of the window pane 84 which is covered by the enclosure 85 may be exposed to the same atmospheric conditions as though the enclosure 85 were not there, the fan 90 is mounted within the enclosure 85 at the opposite end of the enclosure from the window pane 84 and is adapted to be driven by the motor 91 so as to draw air through the light-proof shutters 92. The air drawn through the light-proof shutters 92 circulates along the surface of the window pane 84, which is covered by the enclosure 85 and is discharged from the enclosure 85 through the fan outlet 93. With such an arrangement, the only light focused by the lines 87 on the photo-electric cell 88 is that from the light source 86 and atmospheric temperature conditions at the surface of the window pane covered by the light-proof enclosure 85 are maintained the same as if the enclosure were not present.

The photo-electric cell 88 and the light source 86 and lens 87 are so placed with respect to the window pane 84 that the first moisture which condenses on the inner surface of the window pane cuts off a portion of the light focused by the lens 87 on the light-sensitive cathode of the photo-electric cell 88. The enclosure 89 is so placed with reference to the enclosure 85 and the aperture 90 of the enclosure 89 is so arranged, that no direct light through the window pane, except in the concentrated beam from the lens 87, is permitted to reach the photo-electric cell 88. As moisture collects on the inner surface of the window pane 84, a portion of the light is cut off from the photo-electric cell 88. This change in illumination of the cathode of the photo-electric cell causes a decrease in current through the amplifier 94 and the relay 95, this causing the relay contacts to open

the circuit including the current source 96 and the solenoid winding of the throttle valve 54. This throttle valve 54 may be of the type shown by Fig. 8 of the drawings. The arrangement is such that the appearance of moisture on the inner surface of the window pane 84 causes a decrease in current through the relay 95, this permitting the relay to open the circuit in which the solenoid winding of the throttle valve 54 is connected, this permitting the valve to close and in doing so shut off the supply of water to the atomizer nozzle 21. When the moisture disappears from the inner surface of the window pane 84, the increase in illumination of the cathode of the photo-electric cell causes an increased current to flow through the amplifier 94 and relay 95, this causing the relay 95, this causing the relay 95 to close the circuit including the current source 96 and the solenoid of the throttle valve 54, this energizing the solenoid of the throttle valve 54 and causing the valve to open to supply water again to the atomizer nozzle 21.

The air conditioning system which has been described herein is seen to be built up of a number of small, compact, interchangeable and easily detachable units. The air conditioning units, such as the fan units, the heater units and the air conditioning chamber units, are adapted to be placed one above the other in line with each other, or alongside of each other, in their proper relations, in order to build up an air conditioning system of any desired size. As previously stated, the units are very compact and are so small that they may be used in small enclosures. For example, a successful conditioning chamber unit, such as has been described, may be only 16 inches long in the direction of the air blast and 26 inches high. The different units may be built up in a system employing a single unit of each type for conditioning the air within an ordinary room, or may be built up with a number of units of each type for conditioning the air of an entire building. Heretofore, air conditioning systems have been very large and bulky, and in installing the present type of systems the buildings have had to be remodelled, or considerable changes have had to have been made in the buildings. With the system according to the present invention, due both to the compactness of the units and to their high efficiency and low water consumption, they may be placed as air conditioning systems in almost any enclosure without material changes.

Whereas one embodiment of the invention has been described for the purpose of illustration, it should be understood that many apparently widely different embodiments of the invention can be made without departing from the scope thereof and that it is intended that all matter contained in the above de-

scription or shown in the drawings shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. Air conditioning apparatus comprising, in combination, a conditioning chamber having a water tube and an air nozzle cooperable to cause water from said tube to be projected in said chamber in an atomized state by air delivered from said nozzle, and a water supply apparatus for said tube having a head of water adjustable for making the discharge from said tube, either dependent or independent of air delivered from said nozzle.

2. An apparatus for humidifying the air within an enclosure comprising a chamber through which the air to be humidified flows, an atomizing nozzle within said chamber for moistening said air, and means controlled by the formation of a film of moisture upon an observation surface within said enclosure for controlling the moisture from said nozzle.

3. An apparatus for humidifying the air within an enclosure comprising a chamber through which the air to be conditioned flows, an atomizing nozzle within said chamber for moistening said air, a transparent medium within said enclosure, and means controlled by the condensation of moisture upon said medium for controlling the moisture from said nozzle.

4. Apparatus for humidifying the air within an enclosure comprising a chamber through which the air to be conditioned flows, an atomizing nozzle within said chamber for moistening said air, a transparent medium separating said enclosure from an atmosphere having a different temperature, and means responsive to light variations through said medium due to condensation of moisture thereon, for controlling the moisture from said nozzle.

5. Air conditioning apparatus comprising in combination, a conditioning chamber having a fixed water tube and an air nozzle cooperable to cause water from said tube to be projected in said chamber in an atomized state by air delivered from said nozzle, a water supply apparatus for said tube, and means for varying the water level in said water supply apparatus.

6. Air conditioning apparatus comprising in combination, a conditioning chamber having a water tube and an air nozzle cooperable to cause water from said tube to be projected in said chamber in an atomized state by air delivered from said nozzle, a water supply apparatus for said tube, and means responsive to the relative humidity of the air delivered from said air conditioning apparatus for controlling the head of water in said water supply apparatus and the result-

ing amount of water discharged from said tube.

7. Apparatus for humidifying the air within an enclosure, comprising a chamber through which the air to be humidified flows, means within said chamber for moistening said air, and means controlled by the formation of a film of condensed moisture within said enclosure for controlling the moistening means within said chamber.

In testimony whereof I affix my signature.

SAMUEL M. ANDERSON.

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