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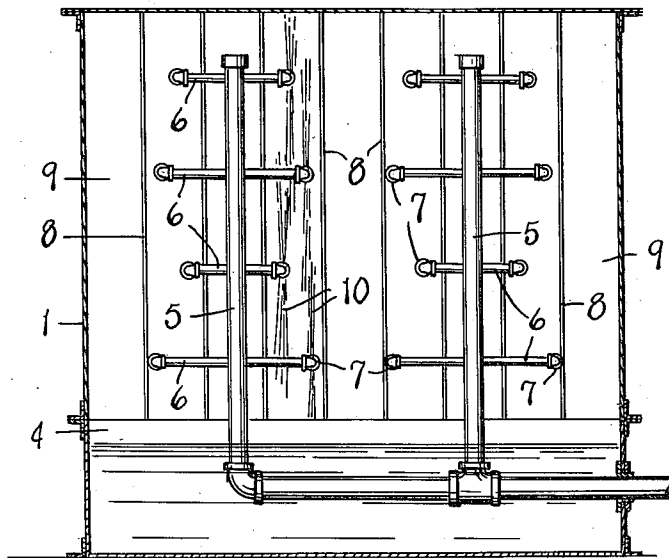
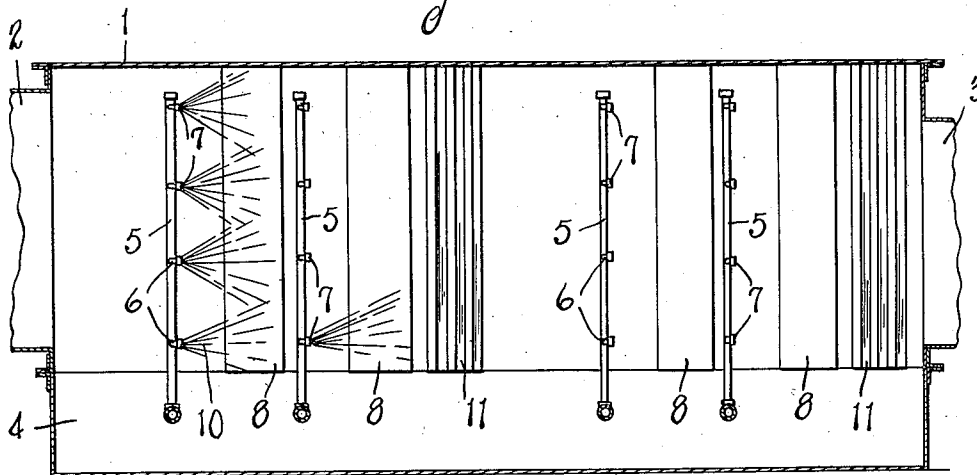
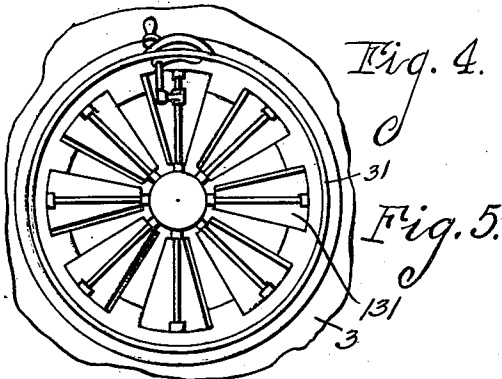
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METHOD AND APPARATUS FOR CONDITIONING AIR

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METHOD AND APPARATUS FOR
CONDITIONING AIR

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16 Claims. (Cl. 261—115)

This invention relates to a method and apparatus for conditioning air, both for comfort of the occupants in the building and for other commercial purposes, and, although equally applicable to winter conditions, has a specific relation to summer time conditioning, at which time it is usually necessary to remove moisture from the air and to cool the air. The air here referred to is a polytropic gas, that is, it is a mixture of water in the gaseous state with other gases. In most instances, the water gas is the only gas that will condense within the ranges of temperature and pressure involved in the conditioning.

Air conditioning is to a great extent the control of latent and sensible heat in the air. When I refer to latent heat I refer to the heat stored in the gaseous water which is the heat that was originally required to change it from the liquid to the gaseous state. In dehumidification of air, this heat must be removed to cause condensation of the water. When I refer to sensible heat I refer to all the other heat in the air which heat was required to raise the air to the heat level of the existing dry bulb temperature.

The physical law governing the removal of sensible heat is different from the physical law governing the removal of latent heat or the removal of gaseous water. Gaseous water or latent heat is removed from air by contacting said air with a cooling medium. The gaseous water in the air near the cooling medium is cooled because of its proximity to the medium and the vapor pressure of that gaseous water which is near the medium is reduced. The gaseous water in the remainder of the air is at a higher pressure and rushes in to fill the low pressure area, thus supplying additional gaseous water to fill the space near the cooling medium. This gaseous water is in turn condensed and the cycle is repeated. Thus with a cooling medium constantly held at a lower temperature than that corresponding to the vapor pressure of the gaseous water in the air, there is set up a continuous flow of water gas to the cooling medium. This flow can be said to be at a rate determined by the difference in vapor pressure between the gas being treated and the vapor pressure of the gas corresponding to the temperature of the cooling medium.

Sensible heat follows a different law and flows from a warmer to a cooler body in proportion to the dry bulb temperature difference between the bodies without the physical flow above described.

Heretofore in conditioning air, the existence of these different laws has been disregarded. The

air to be conditioned has heretofore been cooled until the excess or undesired water has been condensed and it has been then necessary, because of the low temperature required to remove the moisture, to heat the dried air to give it the desired temperature and relative humidity. This has been done variously by heaters or the addition of warm air to the dried air. In this method heretofore used, considerable waste is involved because it is necessary to remove an excess of sensible heat in order to remove the desired quantity of latent heat and this sensible heat must be restored. This is especially true if the air to be conditioned is not saturated although containing too much water gas.

In carrying out my invention I eliminate this waste by taking advantage of the different physical laws regarding the removal of sensible and latent heat so that the latent heat or the moisture is removed without removing excessive amounts of sensible heat. I accomplish this by arranging vertically-disposed parallel flat sprays of cold water so that the air to be conditioned passes between the flat sprays and by controlling the temperature of the water in the sprays and the volume of water in the sprays, I can control the final condition of the air passing from between the sprays. As the air passes between the sprays sensible heat is transferred from the warm air to the cooler sprays in accordance with the law governing the transfer of that heat. All of the sensible heat is not removed from the air and its temperature level can be controlled as desired. As the gaseous water passes between the cool sprays, it behaves differently from the other gases in the air. The vapor pressure of the water in the cooler sprays is below that of the gaseous water and in the space adjacent the sprays of water condensation takes place, and the latent heat or heat of vaporization of the condensed water is absorbed by the sprays. In this polytropic gas, known as air, the gaseous water and the other gases all follow the well known laws in regard to partial pressure. Each exerts its independent pressure and each arranges itself without regard to other gas present so as to fill the entire space uniformly. As the vapor pressure near the sprays is reduced, the gaseous water becomes rarefied in that vicinity and the re-arrangement of the gaseous water in the space brings more water gas adjacent the cooling sprays. It will be seen that there is a physical flowing of the water gas toward the cooling sprays and a condensation of the water and removal of latent heat. By increasing the volume of water

in the sprays, I do not appreciably increase the surface thereof but merely create a larger body of water that has capacity to absorb more heat without becoming heated to an ineffective point.

5 The greater the volume of water in the spray, the lower its mean temperature and the greater its cooling and drying effect. A lowering of the temperature of the water in the spray affects the condition of the air by causing a more rapid
10 transfer of heat. By controlling either the temperature of or the volume of water passing through the spray I am able to control primarily the removal of latent heat or water at such a rate that I can remove the desired amount of
15 latent heat without removing an excess of sensible heat or I can control primarily the removal of sensible heat without unduly disturbing latent heat conditions. This occurs because of the physical flow of water from the air toward the
20 spaced-apart sprays and the absence of physical flow of sensible heat. In winter I can likewise add latent heat as desired without unduly affecting the sensible heat.

I have found that if I vary the volume of water
25 passing to the flat sprays, I control primarily the dry bulb condition of the air passing between the sprays. If the temperature of the water passing to the flat sprays is varied without varying the volume of water, I have found that I control primarily the latent heat. When I refer to controlling primarily the wet bulb or dry bulb conditions of the air, I do not mean that the control
30 of one is entirely independent of the other. I have found that by controlling the volume of water passing to the flat sprays without changing the temperature of the water that air passing through the conditioner has its dry bulb temperature varied primarily, that is, without as
35 great a variation in wet bulb conditions, whereas if I leave the volume of water passing to the sprays constant and vary only the temperature of the water, the wet bulb conditions of the air passing through the conditioner are varied more
40 than the dry bulb conditions. In my apparatus and method I prefer to vary the volume of water under control of desired dry bulb conditions and to vary the temperature of the water under control of desired wet bulb conditions because this combination of controls gives the desired conditions
45 of air leaving the conditioner.

My invention has for its objects:

First, the production of conditioning equipment utilizing parallel spaced apart sprays of water between which the air to be conditioned
55 flows.

Second, to provide such equipment with automatic means for controlling the temperature of the water in the sprays and for controlling the amount of water in the sprays, in order to carry
60 out the principles stated above.

Third, to provide a conditioning system that utilizes this conditioner in a constant volume system without the necessity of supplying bypassing equipment.

65 Fourth, to provide such a system in which the conditioned air may be supplied in varying quantities under control of conditions in the room.

Fifth, to provide a method of removing moisture from air and cooling air based upon the
70 principles above set forth.

Sixth, to provide a method of conditioning air for a given space employing the above stated principles.

75 Other objects and advantages pertaining to details and economies of construction and opera-

tion will appear from the detailed description to follow. Preferred embodiments of my invention are illustrated in the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a constant volume conditioning system employing my conditioner.

Fig. 2 is a diagrammatic view of a conditioning system of the variable volume type embodying my conditioner.

Fig. 3 is an elevational end view of my conditioner.

Fig. 4 is a longitudinal sectional elevation through my conditioner.

Fig. 5 is a view of a volume control means for the fan as employed in the modification of the invention shown in Fig. 2.

The conditioner consists of a longitudinally disposed casing 1 having an inlet 2 and an outlet 3 and a tank 4 for the water sprayed therein. 20 The conditioner shown is a two-stage type having pipes 5 with cross members 6 carrying spray heads 7. I have not illustrated the spray heads in detail but they are of the type which produces a flat spray that is substantially a sheet of water and they are directed to spray the water longitudinally of the casing and vertically disposed therein. The cross members 6 are four in number on each of the pipes 5 and the spray heads 7 are mounted on the ends thereof on both sides of
25 the pipes 5, the cross members 6 varying in length so that the sprays produced thereby are spaced from one another leaving passages therebetween for the air as it is pulled longitudinally through the casing 1. It will be appreciated that flat
30 sprays of water could be produced in other ways, such as by flowing the water.

On the outlet side of each set of sprays are a plurality of vertical partitions 8 forming longitudinal passages 9 in the casing. There are a
35 plurality of such passages and the spray heads 7 are so positioned that certain of the passages 9 are free from sprays and the sprays pass into other of the passages. I have shown the sprays at 10 in Figs. 3 and 4, and they extend through
40 the longitudinal passages 9 and impinge against eliminators 11 which are placed in the casing to remove drops of water and to limit the area of the sprays. It will be understood that satisfactory results could be obtained by eliminating the
45 plurality of passages 9 and that for some work it will be unnecessary to have a two-stage conditioner. It will also be recognized by those skilled in the art that the sprays can be refrigerated or not, and may be well water or city water
50 or water from any other sources furnishing water of desired temperature to meet desired conditions and that if desired, the water can be recirculated or can be used in one set of sprays and then in the other. This particular feature need
55 not be described in detail.

In Fig. 1, I show my system installed for conditioning a room 12. There is provided an outlet duct 13 leading from the room to the inlet 2 of the conditioner and there is a duct 14 for outside fresh air. In the duct 14 I provide a filter
60 15 and could also provide tempering coils if they are desired. There are also shown dampers 16 and 17 which may be used to proportion fresh air and air returned from the room or not as desired. A fan 18 is connected to the outlet 3 of the conditioner and a duct 19 carries the conditioned air back to the room 12. The water is supplied to the sprays 7 through pipe 20 from a
65 70 75

pump 21 which receives the water from any desired refrigerated source or elsewhere.

I have provided a three-way mixing valve 22 having one inlet 23 for warm water and an inlet 24 for cold water. The valve is a proportioning valve and can be set to take either warm or cold water or a mixture of both and through this valve I control the temperature of the water fed to the spray heads 7. I have illustrated a humidostat 25 controlling the operation of this valve.

The volume of water fed to the sprays is controlled by a shut-off valve 26 which is connected with a dry bulb thermostat 27 which controls the volume of water fed to the sprays. I have shown the humidostat 25 and the thermostat 27 located adjacent the outlet duct from the room. It will be appreciated that these controlling instruments could be located either in the return duct or elsewhere in the room or in the duct 19 without departing from the spirit of my invention. In place of the humidostat 25, it would be possible to supply a wet bulb thermostat and the operation would be satisfactory. It would also be possible to reverse the controls and have the dry bulb thermostat control the temperature of the water fed to the spray heads 7 and having a humidostat or wet bulb thermostat control the volume of water fed to the sprays. In either event the proper setting of these instruments would give desired conditions in the room, which is the end desired.

In Fig. 2, I show a somewhat different system in that it is a variable volume system. The room 112 has the duct 113 leading to the inlet 2 of the conditioner, a duct 114 for fresh air, a filter 115, dampers 116 and 117 corresponding to dampers 16 and 17 of Fig. 1. A pipe 120 supplies the water from pump 121 which draws water through a three-way mixing valve 122 having a warm water source 123 and a cold water source 124, the operation of which is the same as in the structure of Fig. 1. In this arrangement, in the duct 119 leading from the fan 118 to the room 112, I locate a humidostat 125 to control the operation of the three-way valve 122 and a dry bulb thermostat 127 to control valve 126 to control the volume of water fed to the sprays 7.

In case re-heat is necessary in either the system of Fig. 1 or Fig. 2, I provide a re-heater 28 to heat conditioned air after it passes from the conditioner. This heater can be of the conventional type and can be supplementary to a heater 29 which is shown here as receiving condenser water from the condenser of a refrigerating unit 30. These details are not essential to my invention, but may assist in carrying out my method or arranging my apparatus for most economical operation.

In the system shown in Fig. 2, I vary the volume of conditioned air to the room under control of a dry bulb thermostat 150 which may control any volume control means on the fan. I have shown this thermostat 150 located under the outlet from the room, but it will be appreciated that it could be located in duct 113 or duct 119 or elsewhere in the room to get similar results. I have found that best results could be obtained in controlling the volume both as to economical operation and to creating a responsive flow without critical points by using a constant speed centrifugal type fan having at its inlet a volume control means 31 consisting of a plurality of blades 131 adapted to close the inlet and in open position to impart to air entering the fan wheel a spin in the direction of the rotation of the fan wheel. This device

is fully illustrated in my co-pending application Ser. No. 598,784, filed March 14, 1932, and in my United States Patents Nos. 1,928,331 and 1,928,332, issued September 26, 1933.

In Fig. 1, I show the humidostat 25 and the dry bulb thermostat 27 located in the room and operating directly on the valves 22 and 26 respectively. It will be appreciated that a pilot thermostat 227 can be installed in the duct 19 to prevent the delivery of air in too cool a state to the room. The arrangement of such a pilot thermostat is well known and has been illustrated only diagrammatically.

In carrying out my method of conditioning and in using my apparatus, the sensible heat follows its own law of transfer and the latent heat follows its law. No excess of either is removed and the air passes from the conditioner at desired condition without the waste of removing too much sensible heat and replacing it. Latent and sensible heat removal are separated in that with my method and apparatus it is possible to control either one or the other primarily without affecting the other appreciably and the apparatus is so arranged that latent heat is removed to a greater extent than is the sensible heat.

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

1. In an air conditioner, the combination of a casing, means for causing air to be conditioned to flow longitudinally through said casing, a plurality of vertical partitions forming longitudinal passages in said casing, a plurality of spaced apart spray heads each adapted to create a vertical flat spray of fluid and positioned to create such flat spray in and extending through one of said longitudinal passages, eliminators adapted to intercept the flat sprays as they come from the longitudinal passages, said spray heads being so arranged that flat sprays of fluid are created in part only of said passages, means to supply fluid to said spray heads, temperature control means to control the temperature of the fluid fed to said spray heads, volume control means to control the volume of fluid fed to said spray heads, a dry bulb thermostat to control one of said control means, and a humidostat to control the other of said control means.

2. In an air conditioner, the combination of a casing, means for causing air to be conditioned to flow longitudinally through said casing, a plurality of spaced apart spray heads each adapted to create a vertical flat spray of fluid extending longitudinally of said casing, eliminators adapted to intercept the flat sprays, means to supply fluid to said spray heads, temperature control means to control the temperature of the fluid fed to said spray heads, volume control means to control the volume of fluid fed to said spray heads, a dry bulb thermostat to control one of said control means, and a humidostat to control the other of said control means.

3. In an air conditioner, the combination of a casing, means for causing air to be conditioned to flow longitudinally through said casing, a plurality of vertical partitions forming longitudinal passages in said casing, a plurality of spaced apart spray heads each adapted to create a vertical flat spray of fluid and positioned to create such flat spray in and extending through one of said longitudinal passages, said spray heads being so arranged that flat sprays of fluid are created in part only of said passages, means to supply fluid to said spray heads, temperature

control means to control the temperature of the fluid fed to said spray heads, volume control means to control the volume of fluid fed to said spray heads, a dry bulb thermostat to control one of said control means, and a humidostat to control the other of said control means.

4. In an air conditioner, the combination of a casing, means for causing air to be conditioned to flow longitudinally through said casing, a plurality of spaced apart spray heads each adapted to create a vertical flat spray of fluid and extending longitudinally of said casing, means to supply fluid to said spray heads, temperature control means to control the temperature of the fluid fed to said spray heads, volume control means to control the volume of fluid fed to said spray heads, a dry bulb thermostat to control one of said control means, and a humidostat to control the other of said control means.

5. In an air conditioner, the combination of a casing, means for causing air to flow longitudinally through said casing, a plurality of spray heads each adapted to create a vertical flat spray of fluid extending longitudinally of said casing, said spray heads being arranged in spaced groups of spaced spray heads to form air passages between the groups and between the separate flat sprays of fluid formed by the individual sprays, means to supply fluid to said spray heads, temperature control means to control the temperature of the fluid fed to said spray heads, volume control means to control the volume of fluid fed to said spray heads, a dry bulb thermostat to control one of said control means, and a humidostat to control the other of said control means.

6. In an air conditioner, the combination of a casing, means for causing air to flow longitudinally through said casing, means to create a plurality of vertical flat sprays of fluid extending longitudinally in said casing, temperature control means to control the temperature of fluid in said sprays, volume control means to control the volume of fluid in said sprays, a dry bulb thermostat to control said volume control means, and a humidostat to control said control means.

7. In an air conditioner, the combination of a casing, means for causing air to flow longitudinally through said casing, means to create a vertical flat spray of fluid extending longitudinally in said casing, temperature control means to control the temperature of fluid in said spray, volume control means to control the volume of fluid in said spray, a dry bulb thermostat to control one of said control means, and a humidostat to control the other of said control means.

8. The method of conditioning air in the room comprising withdrawing air from the room, passing the air between and parallel to flat sprays of water of substantially constant area, controlling the volume of the water flowing in said flat sprays under control of dry bulb conditions of air after it has passed between the water sprays, controlling the temperature of the water under control of wet bulb conditions of the air after it has passed between the water sprays, and admitting the conditioned mixture to the room in variable quantities under control of conditions in the room.

9. An apparatus for conditioning air in a closed space such as a room comprising a duct leading from said room to a conditioner, a duct for the admission of fresh air to the conditioner, a casing for said conditioner through which the air passes, means in said conditioner for creating a plurality of vertically disposed flat sprays of water extending longitudinally of said casing and

having a substantially constant surface area, means for controlling the temperature of the water in said flat sprays, means for controlling the volume of water in said flat sprays, a dry bulb thermostat in the room for controlling the said volume control means, and a humidostat in said room for controlling said temperature control means, a fan for causing circulation of the air, and means for discharging the conditioned air into the room.

10. An apparatus for conditioning air in a closed space such as a room comprising a duct leading from said room to a conditioner, a casing for said conditioner through which the air passes, means in said conditioner for creating a plurality of vertically disposed flat sprays of water extending longitudinally of said casing and having a substantially constant surface area, means for controlling the temperature of the water in said flat sprays, means for controlling the volume of water in said flat sprays, a dry bulb thermostat in the room for controlling the said volume control means, and a humidostat in said room for controlling said temperature control means, a fan for causing circulation of the air, and means for discharging the conditioned air into the room.

11. An apparatus for conditioning air in a closed space such as a room comprising a duct leading from said room to a conditioner, a casing for said conditioner through which the air passes, means in said conditioner for creating a plurality of vertically disposed flat sprays of water extending longitudinally of said casing, means for controlling the temperature of the water in said flat sprays, means for controlling the volume of water in said flat sprays, a dry bulb thermostat in the room for controlling the said volume control means, and a humidostat in said room for controlling said temperature control means, a fan for causing circulation of the air, and means for discharging the conditioned air into the room.

12. In an apparatus for conditioning a room, the combination of a duct for withdrawing air from the room to a conditioner, means for introducing fresh air to the conditioner, a conditioner comprising a casing having means therein for creating vertical flat sprays of water extending longitudinally of said casing, a duct leading from said conditioner to the room, means for controlling the volume of the water in said flat sprays, means for controlling the temperature of the water in said flat sprays, a dry bulb thermostat between said conditioner and said room for controlling said volume control means, a humidostat between said conditioner and said room for controlling said temperature control means, a constant speed centrifugal fan between said conditioner and said room, volume control means for said fan comprising a plurality of blades adapted to impart to air entering the fan a swirl in the direction of rotation of the fan wheel, and a dry bulb thermostat in said room for controlling said volume control means for said fan.

13. In an apparatus for conditioning a room, the combination of a duct for withdrawing air from the room to a conditioner, a conditioner comprising a casing having means therein for creating vertical flat sprays of water extending longitudinally of said casing, a duct leading from said conditioner to the room, means for controlling the volume of the water in said flat sprays, means for controlling the temperature of the water in said flat sprays, a dry bulb thermostat between said conditioner and said room for controlling said volume control means, a humidostat

between said conditioner and said room for controlling said temperature control means, a constant speed centrifugal fan between said conditioner and said room, volume control means for said fan comprising a plurality of blades adapted to impart to air entering the fan a swirl in the direction of rotation of the fan wheel, and a dry bulb thermostat in said room for controlling said volume control means for said fan.

14. In an apparatus for conditioning a room, the combination of a duct for withdrawing air from the room to a conditioner, a conditioner comprising a casing having means therein for creating vertical flat sprays of water extending longitudinally of said casing, a duct leading from said conditioner to the room, means for controlling the volume of the water in said flat sprays, means for controlling the temperature of the water in said flat sprays, a dry bulb thermostat between said conditioner and said room for controlling said volume control means, a humidostat between said conditioner and said room for controlling said temperature control means, a fan between said conditioner and said room, volume control means for said fan, and a dry bulb thermostat in said room for controlling said volume control means for said fan.

15. The method of conditioning air to provide desired conditions of humidity and dry bulb temperature therein by controlling the dry bulb temperature and humidity thereof, comprising creating a plurality of spaced-apart, substantially sheet-like, flat, vertical sprays of fluid, causing

the air to be conditioned to flow between and parallel to the planes of said sprays whereby the bounding surfaces of the sprays and the adjacent air stream passing between the sprays contact and the air passes along and not transversely through said sprays, controlling the temperature of the fluid in said sprays under control of the desired conditions of humidity and controlling the rate of flow of fluid in said sprays under control of the desired dry bulb condition without substantially varying the area of the air contacting surfaces of said sprays.

16. The method of conditioning air to provide desired conditions of humidity and dry bulb temperature therein by controlling the dry bulb temperature and humidity thereof, comprising creating a plurality of spaced-apart, substantially sheet-like, flat, vertical sprays of fluid, causing the air to be conditioned to flow between and parallel to the planes of said sprays whereby the bounding surfaces of the sprays and the adjacent air stream passing between the sprays contact and the air passes along and not transversely through said sprays, controlling the temperature of the fluid in said sprays under control of the desired conditions of humidity and controlling the rate of flow of fluid in said sprays under control of the desired dry bulb condition without substantially varying the cross sectional area of the space between the sprays and through which the air to be conditioned is caused to flow.

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