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[54] **AIR CONDITIONING METHOD AND SYSTEM**
6 Claims, 2 Drawing Figs.

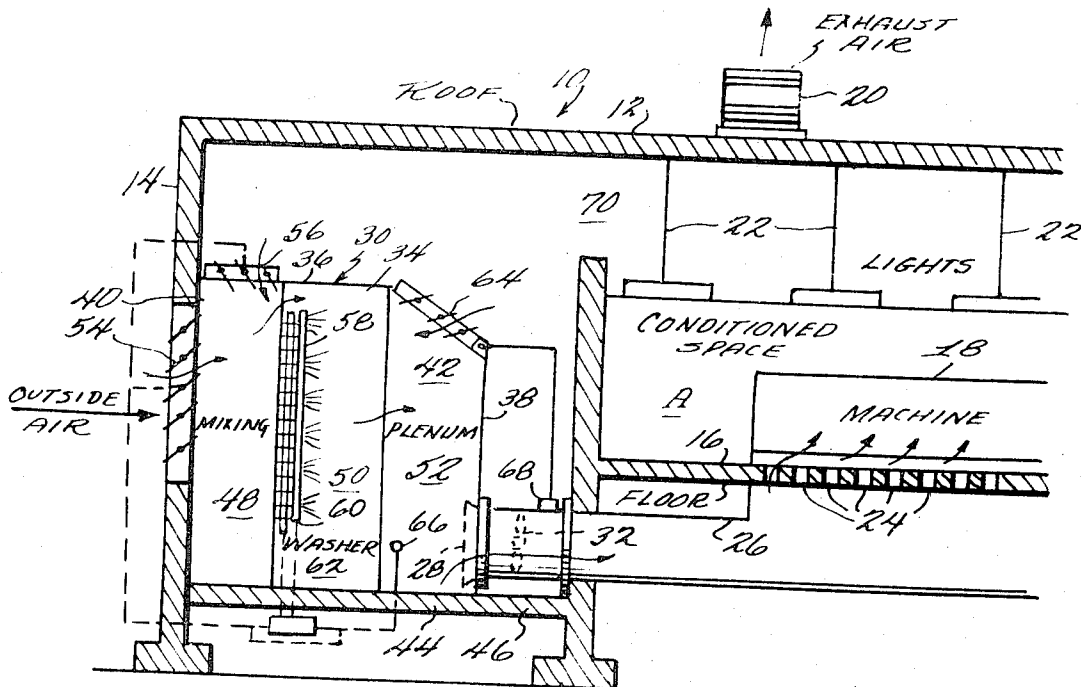
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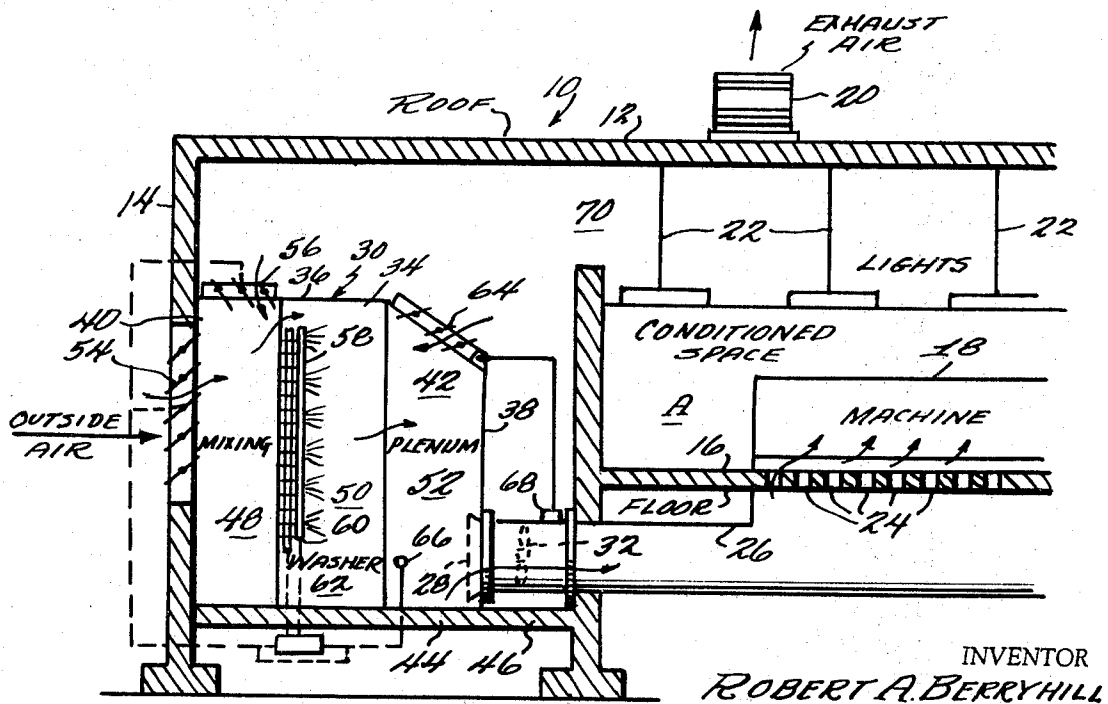
ABSTRACT: A method and apparatus for providing localized or zone air conditioning in enclosures containing heat producing equipment including air heating or cooling means housed in an air conditioning zone, duct means to deliver conditioned air to the lower part of the zone to be air conditioned, return air means above the zone to be air conditioned to deliver heated air to the air conditioning zone, fresh air supply means to deliver fresh air to the air conditioning zone and means to sense the temperature of conditioned air and to control in response to the sensed temperature return air means, the fresh air supply means and the heating and cooling means so as to deliver conditioned air at a temperature to provide a predetermined temperature level in the zone being air conditioned.



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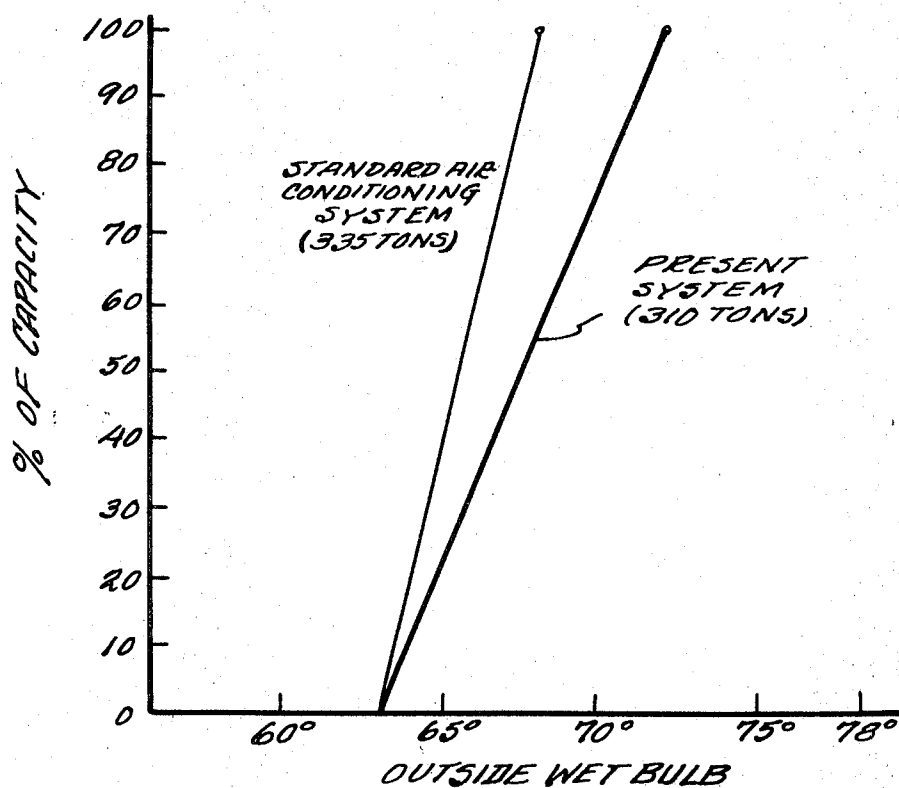


Fig. 2

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AIR CONDITIONING METHOD AND SYSTEM

This application is a continuation-in-part of copending U.S. application Ser. No. 594,862, filed Nov. 16, 1966, now abandoned.

This invention relates generally to improvements in air conditioning and more specifically to improvements for effecting environmentally controlled enclosures. The present development is ideally suited to provide localized or zone air conditioning in enclosures fabricated to house heat-producing equipment or machinery thereby enabling the operators of such equipment to perform their functions in an environment conducive to maximum efficiency and comfort. The invention can also advantageously be employed in enclosures adapted to accommodate a large number of people such as theaters, exhibition halls, museums, auditoriums, sport arenas and halls.

Heretofore, attempts have been made to condition the atmosphere of large enclosures by heating or cooling air, introducing the conditioned air into the enclosure, generally adjacent the top or roof thereof, removing air from the enclosure adjacent the bottom thereof and venting the removed air via a network of ducts to the atmosphere. Variations of such a system have also been implemented, the modifications often involving the location of means for introducing the air into the enclosure as well as the location of means for venting the air to the atmosphere. Certain alterations of the basic system have also involved means for recirculating, in whole or in part, air removed from the enclosure. These attempts, however, generally all suffer from a common disadvantage in that the capacity of the air introduced into the enclosure to condition the same is based on the total volume of the enclosure. Thus where it has been desired to cool an enclosure of a given dimension the criteria has been the introduction of air of a quality and quantity sufficient to produce a predetermined temperature substantially uniform throughout the enclosure. The same criteria has prevailed when the enclosure was to be heated. In those prior art systems where the conditioning air was admitted to the enclosure adjacent the top or roof thereof the heat produced by the lighting fixtures therein as well as the heat occasioned by the sun shining on the roof had to be included in the cooling load requirements. In consequence, the conditioning air, especially where it was designed to cool the enclosure had to be sufficiently cold to cool the hot rising air so that the air in the space occupied by the machinery and operators was sufficiently conditioned. It has been found that such systems are expensive in that they require excessively large volumes of conditioning air which in turn require excessive expenditures to condition, i.e. heat or cool such air to thereby achieve a proper environmentally conditioned enclosure.

Accordingly, an object of the present invention is to provide a system for conditioning enclosures which is not subject to the foregoing disadvantages.

Another object of the present invention is to provide an air conditioning system for an enclosure in response to the environmental conditions existing in the zone or space occupied by operators of heat-producing machinery housed in said enclosure and positioned in substantially the same zone as that occupied by the operators.

Another object of the instant invention is to provide an air conditioning system which maintains the temperature in a predetermined zone of an enclosure occupied by operators of heat-producing equipment at a comfortable predetermined level at all times and to a control system for conditioning air introduced into the enclosure to maintain said temperature in said zone at said predetermined level.

Yet another object is to provide a novel air conditioning system for large enclosures which reduces significantly the conditioning load requirements heretofore found necessary to maintain the temperature therein at a comfortable level.

These and other objects and attendant advantages of the present invention will become more readily apparent in view of the following description in conjunction with the accompanying drawings, in which:

FIG. 1 is a more or less diagrammatic view in side elevation showing the air conditioning system as applied to an enclosure housing heat-producing equipment; and

FIG. 2 is a graph illustrating the increased efficiency of the instant invention over a standard air conditioning system.

In accordance with the present invention, the foregoing objects generally are accomplished by predetermining the environmental conditions required for the space occupied by the heat-producing machines and the operators therefore, and, in response thereto, introducing conditioning air at the lower part of said zone, withdrawing air from point above said zone, recirculating a predetermined portion of said withdrawn air to a conditioning zone while venting to the atmosphere substantially the remainder, introducing into said conditioning zone predetermined amounts of fresh atmospheric air for mixture with air withdrawn from said enclosure and passing said mixed, conditioned air to said lower part of said zone to be conditioned.

The introduction of predetermined amounts of fresh atmospheric air and recirculation of a predetermined portion of air withdrawn from the enclosure into the conditioning zone is regulated by sensing the dry-bulb temperature of air passed in heat exchange relation with a conditioning medium in the conditioning zone and in response to said sensed dry-bulb temperature selectively controlling the introduction of atmospheric and recirculated air to be passed into heat exchange relation with the conditioning medium in the conditioning zone. Additionally, the sensed dry-bulb temperature of the conditioned air passed in heat exchange relation with a conditioning medium is employed to control the output of heating and cooling apparatus such as a heater unit or an evaporative cooler or humidifier located in the conditioning zone. Also means are provided to introduce into the air, conditioned by having been passed in heat exchange relation with the conditioning medium, a further portion of air withdrawn from the enclosure to further control the temperature and humidity of the conditioned air to be introduced into the zone to be air conditioned. Such means including sensing means for the dry-bulb temperature of the conditioned air leaving the conditioning zone such as a thermostat and means operative in response to said sensed dry-bulb temperature to control the amount of said further portion of air from the enclosure for admixture with said conditioned air.

Referring now by characters of reference to the drawings and initially to FIG. 1 there is shown part of an enclosure 10 having a roof 12, end wall 14 and floor 16. Supported on floor 16 are heat-producing machinery 18 commonly found, for instance, in textile plants or the like. Roof 12 is provided with exhaust means 20 for venting, in part, heated air to the atmosphere. Suspended from roof 12, within the enclosure 10 are one or more lighting fixtures 22. The zone in enclosure 10 to be air conditioned is designated as A, and extends, generally, from adjacent the floor 16 upwardly above the heat-producing machines 18 a vertical distance sufficient so that the operators of such machinery are within said zone. Conveniently, this zone A can extend upwardly to just below the lower extent of lighting fixtures 22.

In communication through suitable apertures 24 in floor 16 is the discharge end of a network of duct means 26 for flow of conditioning air therethrough to condition zone A at a predetermined temperature level. The intake end 28 of duct means 26 is in fluid communication with conditioning air preparation means 30. Forced air circulation means such as a fan 32 can be provided in association with duct means 26 to enhance the flow therethrough to zone A.

Conditioning air preparation means 30 can comprise a housing 34 having a top wall 36, end walls 38 and 40, side walls 42 and bottom 44 which can be supported on flooring 46. Housing 34 can be separated into a plurality of serially connected chambers 48, 50 and 52 which are in fluid communication with each other. Chamber 48, is in fluid communication with the surrounding outside atmosphere via damper means 54 positioned in end wall 14 and with the interior of en-

closure 10 via return air damper means 56 located, preferably at the top wall 36 of housing 34. Chamber 48 is utilized to premix predetermined amounts of fresh outside air with predetermined amounts of return air from the enclosure 10. The premixed air from chamber 48 is in fluid communication with chamber 50 through suitable conduit means, not shown. If necessary, forced circulation means, such as a fan or the like can be employed to convey the premixed air from chamber 48 to chamber 50.

Within chamber 50 there can be provided means 58 for providing a conditioning medium thereto for heat exchange contact with the air delivered to chamber 50 from chamber 48 thereby regulating or adjusting the temperature of the premixed air from chamber 48. Conveniently means 58 can comprise an evaporative cooler or heater, the choice of either depending obviously on the temperature characteristics of outside air. When temperature adjusting means comprises an evaporative cooler it can be in the form of a conventional spray apparatus provided with spray medium conduit means 60, leading to a refrigeration unit 62. When the temperature adjusting means comprises a heater 63, it can be gas fired, electrically heated, or otherwise.

Temperature adjusted air from chamber 50 can be conducted via suitable conduit or duct means to chamber 52 which can be in fluid communication with the interior of enclosure 10 through bypass damper means 64 located, generally, at the top wall 36 of housing 34 and with conditioning air duct means 26, preferably through end wall 38.

Sensing means 66, preferably, a dew point controller, such as a dry-bulb thermostat, is provided within chamber 52, to sense the temperature characteristics of the inflowing air conditioned by having been passed in heat exchange relation with the conditioning medium in chamber 50. The outside air damper 54 and the return air damper 56 are operatively connected to sensing means 66 for controlling the opening and closing of said dampers to provide in chamber 52 a conditioning air having a substantially constant dry-bulb temperature. Sensing means 68, preferably a dry-bulb thermostat, is operatively connected to the intake end 26 of the conditioning air duct means 26 to sense the temperature characteristics of the inflowing conditioned air. The return air damper 64 is operatively connected to sensing means 68 for controlling the opening and closing of damper 64, thereby controlling the amount of a further portion of the air withdrawn from enclosure 10 for admixture with the conditioned air, thereby further controlling its temperature and humidity prior to being introduced into the zone to be air conditioned. The relative amounts and the point of introduction of each type of air into the conditioning air preparation means 30 are thus determined and dependent on the temperature characteristics required of the conditioning air in duct means 26 to produce the predetermined temperature conditions in zone A, on the temperature characteristics of the return air within the enclosure 10 and on the temperature characteristics of the outside air.

The apparatus employed for conditioning the enclosure 10 during warm or hot weather is essentially the same as that shown in FIG. 1. During such operation, however, the return air damper 56 generally remains closed at all times and the temperature adjusting means 62 can be a conventional refrigeration unit.

When the novel air conditioning system of this invention is operating to deliver conditioning air to zone A to cool the same to a predetermined temperature, conditioning air is passed from chamber 52 of unit 30 via a network of ducts 26 and apertures or grill means 24 in the floor 16 to said zone A. The attainment of a predetermined temperature level in this zone thus assures comfortable working conditions for the operators of heat-producing machinery 18, such as throwers in a textile plant, housed within the enclosure 10 and supported on floor 16. It can thus be seen that since zone A terminates below conventional lighting fixtures 22 and roof 12, the total heat content to be removed to achieve a comfortable

working area in enclosure 10 for said operators is significantly reduced since the upwardly directed conditioning air is not required to adjust the temperature of the atmosphere above zone A to any predetermined desirable level. Also because heat flows upwardly and is not, generally, disturbed by cross air motion, a heat rise factor can be applied to reduce the machinery heat load in zone A.

A portion of the air above zone A is exhausted to the atmosphere via exhaust means 20 while predetermined amounts are recirculated via return air duct means 70 for use in preparing conditioning air.

Air withdrawn from enclosure 10 can be returned to chamber 52 via bypass damper 64. Fresh air is introduced into chamber 48 via outside air damper 54 and is then conducted to chamber 50 where its temperature is adjusted by evaporative cooler means 58. Generally, the wet-bulb temperature of the outside air is lower than the wet-bulb temperature of the air recycled from enclosure 10 to the conditioning air preparation unit 30 and accordingly the outside air is preferentially introduced into chamber 50 to realize economies in cooling and refrigeration costs. Contact of the fresh air with the spray medium in chamber 50 serves to lower both the wet and dry-bulb temperature of the air. The spray medium employed in chamber 50 can be recycled, if desired, by conventional means to refrigeration unit 62 to remove the heat transferred thereto by reason of contact with the air introduced into chamber 50. Alternatively, the spent spray medium can be discharged to waste and fresh spray medium can be employed.

The cooled air from chamber 50 is conducted to chamber 52 where it is mixed with a predetermined amount of air returned from the zone lying above zone A of enclosure 10 via return air damper 64. The amount of return air introduced into chamber 52 will be dependent on the degree of cooling accomplished in chamber 50, and the humidity of this conditioned air, and this amount in turn is dependent on the temperature conditions established for zone A. The amount of air withdrawn from enclosure 10 and introduced into chamber 52 can, as stated above, be controlled by the opening and closing of damper means 64. This control is responsive to the temperature sensing means 68 located in duct means 26 which senses the temperature of the air therein and can be set to effect the closing and opening of damper 64 on sensing a predetermined temperature. The conditioning air in duct 26 is then introduced into zone A via the apertures 24 in floor 16 and the conditioning cycle is continuously operated to maintain zone A at the predetermined comfortable temperature level.

As the air passes through chamber 50 its dew point is increased thereby causing a rise in pressure output of the dew point controller or temperature sensing means 66, which in turn initially activates the opening of the outside air damper means 54 and the closing of return air damper 56. The sensing means 66 can cause the return air damper 56 to fully close and the outside damper 54 to fully open to maintain, as closely as possible, the temperature characteristics of the air necessary to achieve the predetermined conditions in zone A. Should, however, it be necessary to further cool the air leaving chamber 50 even with the outside damper 54 wide open, the temperature sensing means 66 actuates the refrigeration unit 62 to deliver chilled spray medium to chamber 50 via conduit means 60.

The refrigeration unit 62 will continue to deliver chilled spray medium in response to the temperature sensing means 66 to maintain the air at a constant dry-bulb temperature through output control means 67. The outside air damper 54 can be kept open until the full capacity of the refrigeration unit 62 is reached since the outside air is generally cooler than the return air of enclosure 10. When the dew point of the air chilled by the spray medium reaches a value commensurate with the required conditions the temperature sensing means 66 actuates a relay switch which causes a reversal of the position of the dampers. Thus, outside damper 54 can be closed while return air damper 56 can be opened.

In operation during cool or cold weather a heating unit can be employed to heat the air in chamber 50, the actuation of the heating unit also being responsive to the temperature sensing means 66 through output control means 67. The operation of the control means is essentially the same as that described above in connection with the process for conditioning the air during warm or hot weather. Generally, however, return air damper 56 can be selectively opened or closed to permit introduction of return air in chamber 48 for premixture with fresh outside air therein, prior to treatment of the air in chamber 50. This arrangement significantly reduces the heating load requirements necessary to bring the air to a level sufficient to maintain, ultimately, the predetermined temperature level in zone A.

The following examples illustrate the efficiency and economy of the instant invention during summer and winter operations:

	Summer	Winter
Outside dry-bulb temperature, ° F	95	10
Outside wet-bulb temperature, ° F	70	
	Summer	Winter
Internal heat:		
Roof B.t.u./hr.	380,000	
Lights B.t.u./hr.	590,000	590,000
Machinery, B.t.u./hr.	3,050,000	3,050,000
Total	4,020,000	3,640,000
Dry-bulb temperature design for Zone A, ° F	80	80
Wet-bulb temperature design for Zone A, ° F	68	68
Dry-bulb temperature design above Zone A, ° F	93	87.5
Wet-bulb temperature design above Zone A, ° F	72	70.5
Room space, cu. ft.	930,000	930,000
Zone A space, cu. ft.	580,000	580,000
Space above Zone A, cu. ft.	350,000	350,000
Room air supply, cu. ft./min.	150,000	150,000
Outside air supply, cu. ft./min.	120,000	20,000
Return air supply, cu. ft./min.	30,000	130,000
Dry-bulb temperature of air leaving washer, ° F	64	64
Wet-bulb temperature of air leaving washer, ° F	63	63
Dry-bulb temperature of air entering Zone A, ° F	70	70
Wet-bulb temperature of air entering Zone A, ° F	65	65
Refrigeration load, tons	310	
Room load, tons	335	

	Summer	Winter
Return air for mixture with air leaving washer, percent.	20	20
Return air for mixture with fresh air to washer, percent.	0	67
Fresh air for mixture with return air to washer, percent.	80	13
Heating Load, B.t.u./hr.		800,000
Air mixture:		
O.A. at 120,000 c.f.m. = 8,940 lbs./min. $\times 64^{\circ} = 51.7$		
13.47 c.f./lb.		
R.A. at 30,000 c.f.m. = 2,120 lbs./min. $\times 93^{\circ} = 17.8$		
14.2 c.f./lb. 11,060		69.5 Mixed Air
Heat to be removed from outside air:		
120,000 c.f.m. = 8,830 lb./min. $\times 60$ min./hr. $\times 5.77$ B.t.u./lb. = 3,050,000		
13.6 c.f./lb. B.t.u./hr., mach. load only		
Enthalpy of air at washer, 28.5 B.t.u./lb.		
Enthalpy of O.A., 34.25 B.t.u./lb.		
Enthalpy of room design, 32.5 B.t.u./lb.		
120,000 c.f.m. = 8,830 lb./min. $\times 60$ min./hr. $\times 7$ B.t.u./lb. = 3,720,000		
13.6 B.t.u./hr. max design load.		

FIG. 2 graphically illustrates the economic advantages attainable with the instant invention over commercially available conventional air conditioning systems under substantially

the same conditions to produce a conditioned environment at substantially the same temperature level. Thus, for instance, when a standard system is at 50 percent capacity, the system of this invention is at about 25 percent capacity and when the standard system is at 100 percent capacity the system of this invention is operating only at about 50 percent capacity. It can thus be seen that the present invention provides highly significant operational savings over conventional systems.

Although the invention has been described by making detailed reference to certain preferred embodiments, such detail is to be understood in an instructive rather than in any restrictive sense, many variants being possible within the scope of the following claims.

I claim:

1. A method for conditioning air in a zone of an enclosure, said zone having included therein heat-producing equipment so that said zone is maintained at a predetermined temperature level, the steps of which comprise:

- predetermining the temperature level to be maintained in the zone to be air conditioned;
- introducing fresh atmospheric air from the outside atmosphere into a first chamber in an air conditioning zone through first closable opening means in communication with said first chamber in said air conditioning zone and said outside atmosphere;
- adjusting the temperature of said fresh atmospheric air in said air conditioning zone thereby adjusting the dew point temperature thereof to correspond to a constant dew point which is determined by the temperature level to be maintained in the zone to be air conditioned;
- introducing said temperature-adjusted air into a second chamber in said air conditioning zone;
- sensing the adjustment in the dew point temperature of the temperature-adjusted atmospheric air in said second chamber of said air conditioning zone;
- regulating the position of said first closable opening means to an open position in response to a rise in the dew point temperature of the temperature-adjusted air sensed in step 5 above said constant dew point;
- withdrawing a portion of air from a second zone in said enclosure above said zone to be air conditioned, said withdrawn air being at a temperature higher than the temperature of the air in said zone to be air conditioned;
- introducing a portion of said heated withdrawn air into said second chamber in said air conditioning zone through second closable opening means in communication with said second chamber in said air conditioning zone and said second zone in said enclosure;
- admixing said heated withdrawn air with the temperature-adjusted atmospheric air therein to provide a conditioned air;
- withdrawing the conditioned air from said second chamber of said air conditioning zone;
- introducing the conditioned admixed air into said zone to be air conditioned adjacent the lower part thereof;
- sensing the temperature of the conditioned air introduced into said zone to be air conditioned; and
- opening said second closable opening means in response to the sensed temperature of the conditioned air to provide a conditioned air capable of maintaining essentially constant said predetermined temperature level in said zone to be air conditioned.

2. The method of claim 1 including controlling the output of means for adjusting the temperature of said fresh atmospheric air in said air conditioning zone in response to the adjustment in dew point sensed in step 5 above.

3. The method of claim 1 including withdrawing another portion of air from said second zone in said enclosure above said zone to be air conditioned and introducing said another portion of air into said first chamber through third closable opening means in communication with said first chamber in said air conditioning zone and said second zone in said enclosure and opening said third closable opening means in

response to the adjustment in the dew point temperature sensed in step 5 above.

4. The method of claim 1 wherein the temperature of said fresh atmospheric air is adjusted by contacting the same with an aqueous cooling spray medium.

5. The method of claim 1 wherein the temperature of said fresh atmospheric air is adjusted by heating said fresh atmospheric air.

6. A method for conditioning air in a zone of an enclosure, said zone having included therein heat-producing equipment so that said zone is maintained at a predetermined temperature level, the steps of which comprise:

1. predetermining the temperature level to be maintained in the zone to be air conditioned;
2. introducing fresh atmospheric air from the outside atmosphere into a first chamber in an air conditioning zone through first closable opening means in communication with said first chamber in said air conditioning zone and said outside atmosphere;
3. transferring the atmospheric air from said first chamber to a second chamber in said air conditioning zone, said second chamber being in communication with said first chamber and adjusting the temperature of said fresh atmospheric air in said second chamber thereby adjusting the dew point temperature thereof to correspond to a constant dew point which is determined by the temperature level to be maintained in the zone to be air conditioned;
4. introducing said temperature-adjusted air into a third chamber in said air conditioning zone;
5. sensing the adjustment in the dew point temperature of

the temperature-adjusted atmospheric air in said third chamber of said air conditioning zone;

6. regulating the position of said first closable opening means to an open position in response to a rise in the dew point temperature of the temperature-adjusted air sensed in step 5 above said constant dew point;
7. withdrawing a portion of air from a second zone in said enclosure above said zone to be air conditioned, said withdrawn air being at a temperature higher than the temperature of the air in said zone to be air conditioned;
8. introducing a portion of said heated withdrawn air into said third chamber in said air conditioning zone through second closable opening means in communication with said third chamber in said air conditioning zone and said second zone in said enclosure;
9. admixing said heated withdrawn air with the temperature-adjusted atmospheric air therein to provide a conditioned air;
10. withdrawing the conditioned air from said third chamber of said air conditioning zone;
11. introducing the conditioned admixed air into said zone to be air conditioned adjacent the lower part thereof;
12. sensing the temperature of the conditioned air introduced into said zone to be air conditioned; and
13. opening said second closable opening means in response to the sensed temperature of the conditioned air to provide a conditioned air capable of maintaining essentially constant said predetermined level in said zone to be air conditioned.

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