June 15, 1954 W. L. McGRATH 2,681,182

AIR CONDITIONING SYSTEM AND METHOD OF OPERATION

Filed Sept. 10, 1949 2 Sheets-Sheet 1

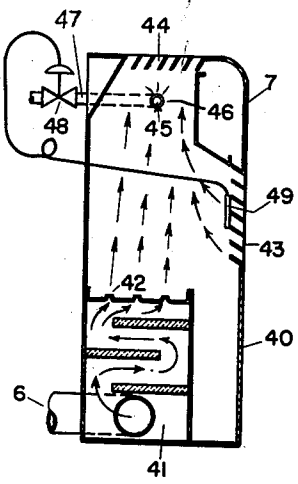


FIG. 2

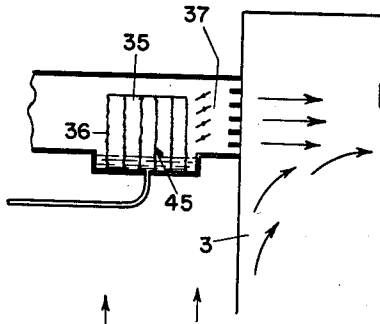


FIG. 3

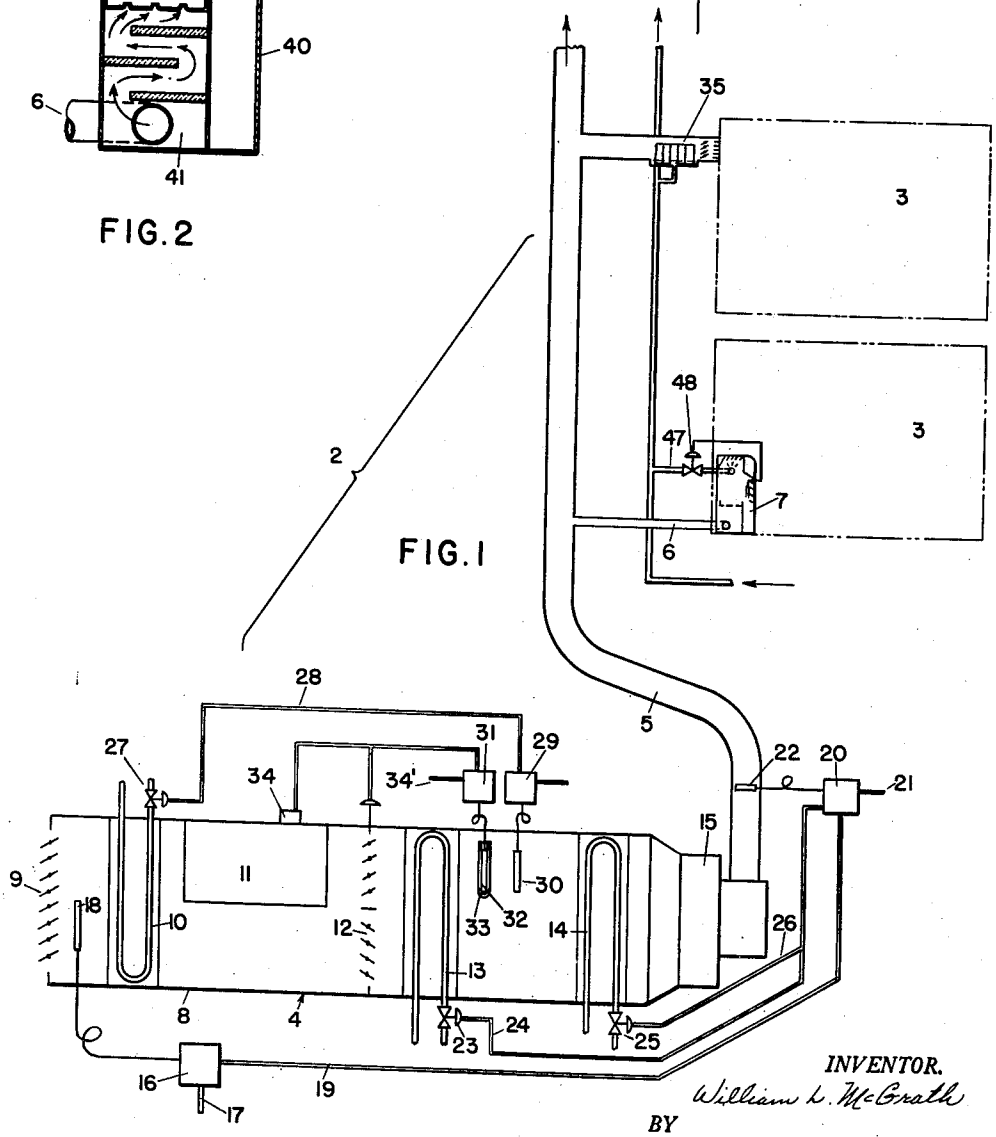


FIG. 1

INVENTOR.
William L. McGrath
BY
Herman Seid
Atty.

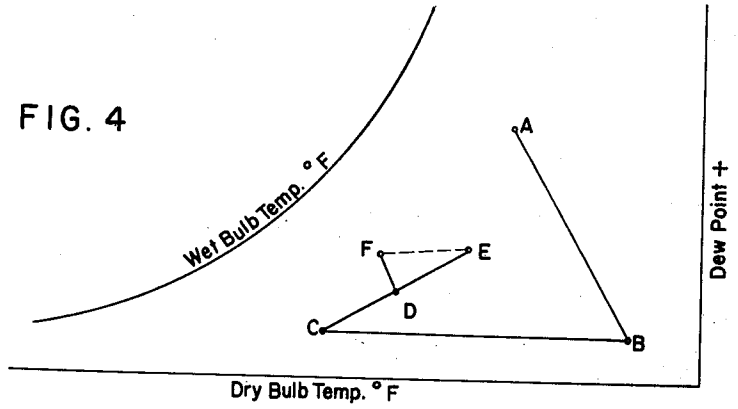
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2 Sheets-Sheet 2

FIG. 4



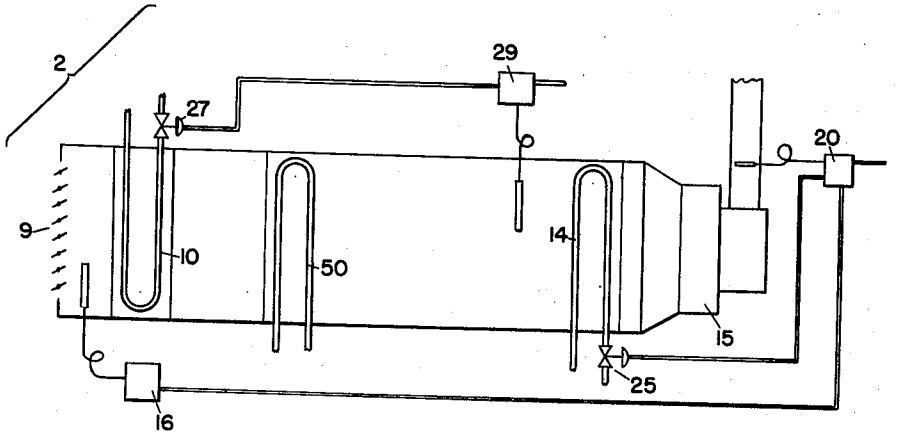


FIG. 5

INVENTOR.
William L. McGrath
BY
Herman Seid
Atty.

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AIR CONDITIONING SYSTEM AND METHOD OF OPERATION

William L. McGrath, Syracuse, N. Y., assignor to Carrier Corporation, Syracuse, N. Y., a corporation of Delaware

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6 Claims. (Cl. 236—44)

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This invention relates to the art of air conditioning and more particularly to an air conditioning system for a building structure including a plurality of areas to be conditioned which affords individual control of each particular area of the structure.

The chief object of the present invention is to provide an air conditioning system which is economical in initial cost and in operating cost and which provides individual control of each area of the building structure without varying the quantity of ventilation air supplied to each area.

An object of the present invention is to provide an air conditioning system adapted for inside zones as well as exterior bays of a building structure and which permits individual control of the temperature and humidity of the air in each area without reference to the other areas of the structure.

A further object is to provide a method of air conditioning in which a small quantity of dehumidified and cooled primary air is supplied to each area of a building structure to be conditioned in such manner that the small quantity of conditioned air supplied serves to induce a greater volume of room air to form a mixture with the conditioned air and in which water is evaporated locally to provide additional sensible cooling, the mixture then being discharged into the area being conditioned without reference to the other areas of the structure being conditioned. Other objects of my invention will be readily perceived from the following description.

This invention relates to an air conditioning system for a building structure containing a plurality of areas to be conditioned comprising in combination a conditioner remote from the areas for dehumidifying and cooling primary air to predetermined conditions of humidity and temperature in accordance with load on the structure, a plurality of individual units disposed in the areas to be conditioned, at least one unit being disposed in each area to be conditioned, conduits for supplying conditioned primary air from the conditioner to each unit and means associated with each of such areas discharging the primary air at relatively high velocity to induce secondary air from the area being conditioned to mix with the primary air stream, and a humidifying device for evaporating water locally to provide additional sensible cooling for each area being conditioned. Preferably, the amount of water evaporated by contact with such air stream is regulated by a control device responsive to the temperature of the area being conditioned.

This invention further relates to a method of

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air conditioning in which the steps consist in dehumidifying and cooling primary air to a predetermined dew point and dry bulb temperature, supplying the dehumidified and cooled air to a unit disposed in an area to be conditioned, discharging the air in such unit in a manner to induce a greater volume of air from the area being conditioned into the unit, mixing the primary and secondary air streams, evaporating water in at least one of said streams to decrease its dry bulb temperature, and discharging the mixture of primary and secondary air into the area being conditioned.

The attached drawings illustrate a preferred embodiment of my invention, in which

Figure 1 is a diagrammatic view of the air conditioning system of the present invention;

Figure 2 is a sectional view through a room unit of the air conditioning system of Figure 1;

Figure 3 is a diagrammatic view of an outlet for use in the air conditioning system shown in Figure 1;

Figure 4 is a graph illustrating the method of air conditioning contemplated by the present invention; and

Figure 5 is a diagrammatic view of a modified central station conditioner.

Referring to the drawings, there is shown an air conditioning system designated generally at 2 for conditioning a building structure containing a plurality of areas 3 to be conditioned. The system includes a central station conditioner 4 connected by headers and risers 5 and run-outs 6 to units 7 disposed in the areas to be conditioned. Preferably, at least one unit 7 is placed in each area to be conditioned.

The conditioner 4 comprises a casing 8 containing dampers 9 through which exterior air is admitted into casing 8, a preheating coil 10, a dehumidifying unit 11, which may be either of the absorption or adsorption type, and a damper 12 which serves to permit some porton of the exterior air drawn within casing 8 to bypass the dehumidifying unit 11. Casing 8 also contains a cooling coil 13 and a heating coil 14 for air passing through casing 8. A fan 15 serves to draw exterior air within the casing to be conditioned and to forward the conditioned primary air through conduits 5 and run-outs 6 to the individual area unit 7. About 40–50% primary air may be supplied to each area. The conduits 5 comprise small tubes or ducts. Fan 15 routes primary air therethrough at a static pressure in excess of ¼" water gauge and at a velocity of the order of 2000 to 3000 feet per minute.

Conditioner 4 is regulated in response to the

dry bulb temperature of exterior air. A pneumatic control system is shown in which the various thermostats are connected to a source of supply of compressed air at predetermined pressure. Thermostat 16 is connected to the main air supply by line 17 and is actuated by means of bulb 18 disposed in the path of exterior air to regulate the pressure of the air passing through line 19 to discharge thermostat 20 which is also connected by line 21 to the main air supply. It will be understood bulb 18 may be placed in a position where it is also responsive to sun effect and the like. Thermostat 16 serves to reset the control point of discharge thermostat 20. Thermostat 20 may be actuated by means of a bulb 22 disposed in the path of conditioned primary air leaving conditioner 4. Thermostat 20 actuates a valve 23 disposed in the line supplying cooling fluid to the cooling coil 13 by regulating the pressure of the air imposed on the diaphragm of such valve through line 24. It also actuates valve 25 disposed in the steam line of heater 14 by varying the air pressure imposed on its diaphragm through line 26.

Preheater 10 is regulated by means of a valve 27 disposed in its steam line connected by line 28 to thermostat 29, connected to the main air supply. Thermostat 29 is regulated by means of a bulb 30 disposed in casing 8.

Dehumidifying unit 11, in casing 8, as pointed out above may be of the adsorption or absorption type and may be regulated by means of thermostat 31 which reflects the wet bulb temperature of air passing through casing 8 by means of a bulb 32 disposed in a sock 33 in casing 8. Thermostat 31 is connected to the main air supply by line 34'. Thermostat 31 also serves to regulate damper 12 to determine the amount of exterior air passing through the dehumidifying unit 11 or by-passing the same. The various thermostats described above are standard equipment and do not require extended description.

The area units 7 are shown in exaggerated scale in Figure 2. Each unit 7 includes a casing 40 containing a plenum 41 connected to a run-out 6. Air enters the unit through run-out 6 and passes into the plenum. From the plenum 41 the primary air is discharged into the units 7 through nozzles 42. Air is discharged through nozzles 42 at relatively high velocity and serves to induce a greater volume of secondary air from the area being conditioned into units 7 through inlet 43. The primary and secondary streams of air intermix in the unit and pass upwardly to outlet 44 from which they are discharged into the area being conditioned. In the path of the mixture of primary and secondary air within the unit there is disposed a humidifying device 45 which may be a suitable atomizing spray nozzle 46 connected by pipe 47 to a suitable source of supply of water. The water discharged into the mixture of primary and secondary air is evaporated and serves to cool such mixture by increasing its wet bulb temperature. Preferably a valve 48 disposed in pipe 47 controls the quantity of water supplied to nozzle 46. Valve 48 may be regulated by means of a bulb 49 disposed in the path of secondary air drawn within the unit and hence serves to regulate the humidifying device in response to the dry bulb temperature of the area being conditioned.

While I have shown the humidifying device 45 disposed in the path of a mixture of primary and secondary air, it will be understood similar results may be achieved if desired by humidifying either the primary or the secondary air streams instead of the mixture of primary and secondary air.

If desired, the conditioned primary air may be supplied to an individual unit 35 of the outlet type as shown in Figure 3. In this case only primary air is treated by the humidifying device 45. Such device in the structure shown in Figure 3 may comprise a plurality of wick-like members 36 having their ends suspended in a water pan (not shown) disposed in the path of primary air. Suitable dampers 37 may be provided in the outlet to regulate the proportion of primary air passing through or bypassing the humidifying device. A float valve (not shown) may be placed in the pan to maintain a desired water level therein. Discharge of primary air from the outlet induces secondary air from the area being conditioned to mix therewith after its discharge.

In Figure 5 I have illustrated a modification of my invention. In this case separate dehumidifying and cooling members are not provided in the central station 2, instead a direct expansion coil 50 serving as the evaporator of a suitable refrigeration system (not shown) may be employed to cool and dehumidify the exterior air passing through the casing. In other respects, the central station conditioner of Figure 5 is similar to the central station conditioner of Figure 1. If a wick arrangement of the type shown in Figure 3 be employed in a unit 7 it may be desirable to provide a damper and by-pass for room air in place of control valve 48 in order to expedite response to a change in area temperature.

It will be understood unit 7 may be controlled manually or automatically as desired. As illustrated, automatic control is provided since the system is particularly adapted to simplified control for only a small volume of water is required for each unit in the order of 2 pounds of water per hour and no change-over of the water supply is required to permit operation under summer or winter operating conditions.

In Figure 4 I have shown a graph which serves diagrammatically to illustrate the operation of the system. This graph is drawn on the usual psychrometric chart. Point A represents a condition of outside air or a mixture of outside air and return air being drawn into the central station conditioner 4. Let us assume that air at such condition is 70° F. wet bulb temperature and 85° F. dry bulb temperature. Passing through dehumidifying unit 11 its moisture content is reduced along a line of constant wet bulb temperature (line A—B) to a desired point B. The air at point B under these conditions may be considered as of 70° wet bulb temperature and 115° dry bulb temperature containing approximately 38 grains of moisture per pound of dry air. By means of cooling coil 13 such air is then cooled to approximately 50° dry bulb temperature and 40° dew point.

It will be assumed conditions in an area being treated are about 50% relative humidity with a dry bulb temperature of 76°. This is shown at point E on the diagram. The conditioned air being discharged through the nozzles 42 into the units 7 is mixed with a relatively large quantity of secondary air which is being maintained at point E. The mixture may therefore be represented by point D on the diagram, the assumed conditions being 69° dry bulb temperature and 54° wet bulb temperature. In passing through the unit humidifying device 45 the mixture will have its dry bulb temperature lowered along the line

of constant wet bulb temperature (D—F). The amount of decrease in temperature will be regulated by the amount of water which is admitted to the humidifying device and evaporated in the air stream leaving unit 7. The air leaving the humidifying device may be represented by point F on the diagram for a particular load condition and a particular position of valve 46, it being assumed here that such air is at a dry bulb temperature of 63° and a wet bulb temperature of 54°. The air in entering the area being conditioned will absorb latent and sensible heat from the area in a proportion indicated by the relation between point F and point E on the diagram. It will be understood air at condition A may be exterior air or some proportion thereof may comprise return air.

Individual control of the conditions in each area being treated is obtained by the action of valve 48 determining the amount of water evaporated from humidifying device 45. The position of point C on the diagram is shifted as a function of load conditions on the building or zone as a whole. As the outside temperature drops, the amount of after-cooling is reduced so as to provide a higher temperature at point C thereby likewise providing a higher temperature at point D.

Thermostat 16 resets the control point of thermostat 26. Thermostat 26 regulates valve 23 and valve 25. When there is a requirement for cooling air, valve 23 is regulated; when there is a requirement for heating the air, valve 25 is regulated. Dehumidifier 11 is regulated by wet bulb thermostat 31 and operating switch 34 which places the device in operation. Thermostat 31 also serves to regulate damper 12 to determine the relative quantities of air passed through or bypassed around the dehumidifying device 11. As exterior temperature decreases, at some point dehumidifying device 11 will become inoperative by reason of the low exterior wet bulb temperature. Thermostat 29 will then regulate valve 27 of preheater 10 to limit the temperature of exterior air entering the conditioner 4 under such conditions.

Preferably where unit sprays are used, distilled water is supplied to such sprays for evaporation in the mixture of primary and secondary air. If it is not desired to use distilled water for this purpose the wick and pan arrangement described above may be employed. It will be appreciated if a spray device is employed an atomizing nozzle preferably is used in order to assure that all water sprayed within the stream of air is carried therewith; if atomizing nozzles be employed a drain pan is not necessary.

It will be appreciated all air drawn within conditioner 4 need not be exterior air. If desired, some portion of the air passing into conditioner 4 may be returned or recirculated air from the various areas being conditioned.

Only a small quantity of water need be supplied to each humidifying device permitting the use of a simplified control valve for no change-over from summer to winter operating conditions is necessary.

The present invention permits individual area control in a building structure without varying the air quantity supplied to each area. It permits high velocity distribution without danger of the system being upset or unbalanced due to operation of dampers in the supply air system. The present invention provides an air conditioning system which is more economical in initial cost and in operating cost than systems heretofore employed. It may be employed to condition inside zones of building structures as well as exterior bays. Air supplied to the area has a specific capacity, the evaporation of water therein increasing that capacity; hence less air is required for supply to the area being conditioned than need be supplied by the usual central stationing conditioning system.

While I have described a preferred embodiment of my invention, it will be understood my invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

I claim:

1. In an air conditioning system for a building structure containing a plurality of areas to be conditioned, the combination of a conditioner remote from the areas for dehumidifying and cooling primary air to predetermined conditions of humidity and temperature in accordance with exterior temperature, a plurality of individual units disposed in the areas to be conditioned, at least one unit being disposed in each area to be conditioned, conduits for supplying conditioned primary air from the conditioner to each unit, means for delivering primary air from the conditioner through said conduits at a static pressure in excess of ¼" water gauge and at a velocity of the order of 2000 to 3000 feet per minute, means including a wall having a plurality of nozzles positioned in the path of the primary air in each unit for discharging the primary air in the unit at a relatively high velocity to induce a substantial volume of secondary air from the area being conditioned into the unit to mix with the primary air, and a humidifying device in the unit for cooling the mixture of primary and secondary air.

2. An air conditioning system according to claim 1 in which the humidifying device comprises a spray member to discharge water into at least one of the air streams in the unit and means are provided responsive to room dry bulb temperature of the room to regulate the quantity of water supplied to the spray.

3. An air conditioning system according to claim 1 in which the humidifying device includes a water sump and a plurality of wicks extending from the sump having their ends disposed therein, said wicks being disposed in the path of the air stream to be cooled.

4. In an air conditioning system for a building structure containing a plurality of areas to be conditioned, the combination of a conditioner remote from the areas, said conditioner including a dehumidifying element to dehumidify exterior air and a separate cooling element to cool dehumidified air to predetermined conditions of humidity and temperature, a plurality of individual units disposed in the areas being conditioned, at least one unit being disposed in each area to be conditioned, conduits for supplying conditioned primary air from the conditioner to each unit, means for routing primary air through the conduits at a static pressure in excess of ¼" water gauge and at a velocity of the order of 2000 to 3000 feet per minute, means including a wall having at least one nozzle positioned in the path of the primary air in each unit for discharging the primary air in the unit at relatively high velocity to induce a substantial volume of air from the area being conditioned into the unit,

to mix with the primary air, means in each unit to evaporate water in at least one of the air streams in the unit and a control device for said means responsive to the temperature of the area being conditioned.

5. In an air conditioning system for a building structure containing a plurality of areas to be conditioned, the combination of a conditioner remote from the area, said conditioner including a dehumidifying element to dehumidify exterior air and a separate cooling element to cool dehumidified air to predetermined conditions of humidity and temperature, a plurality of individual units disposed in the areas being conditioned, at least one unit being disposed in each area to be conditioned, conduits for supplying conditioned primary air from the conditioner to each unit, means for routing primary air through the conduits at a static pressure in excess of ¼" water gauge and at a velocity of the order of 2000 to 3000 feet per minute, means including a plenum chamber having a wall provided with at least one nozzle positioned in the path of the primary air in each unit for discharging the primary air in the unit at relatively high velocity to induce a substantial volume of air from the area being conditioned into the unit, to mix with

the primary air, means in each unit to evaporate water in at least one of the air streams in the unit and a control device for said means responsive to the temperature of the area being conditioned.

6. An air conditioning system according to claim 5 wherein said plenum chamber includes baffles disposed therein.

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