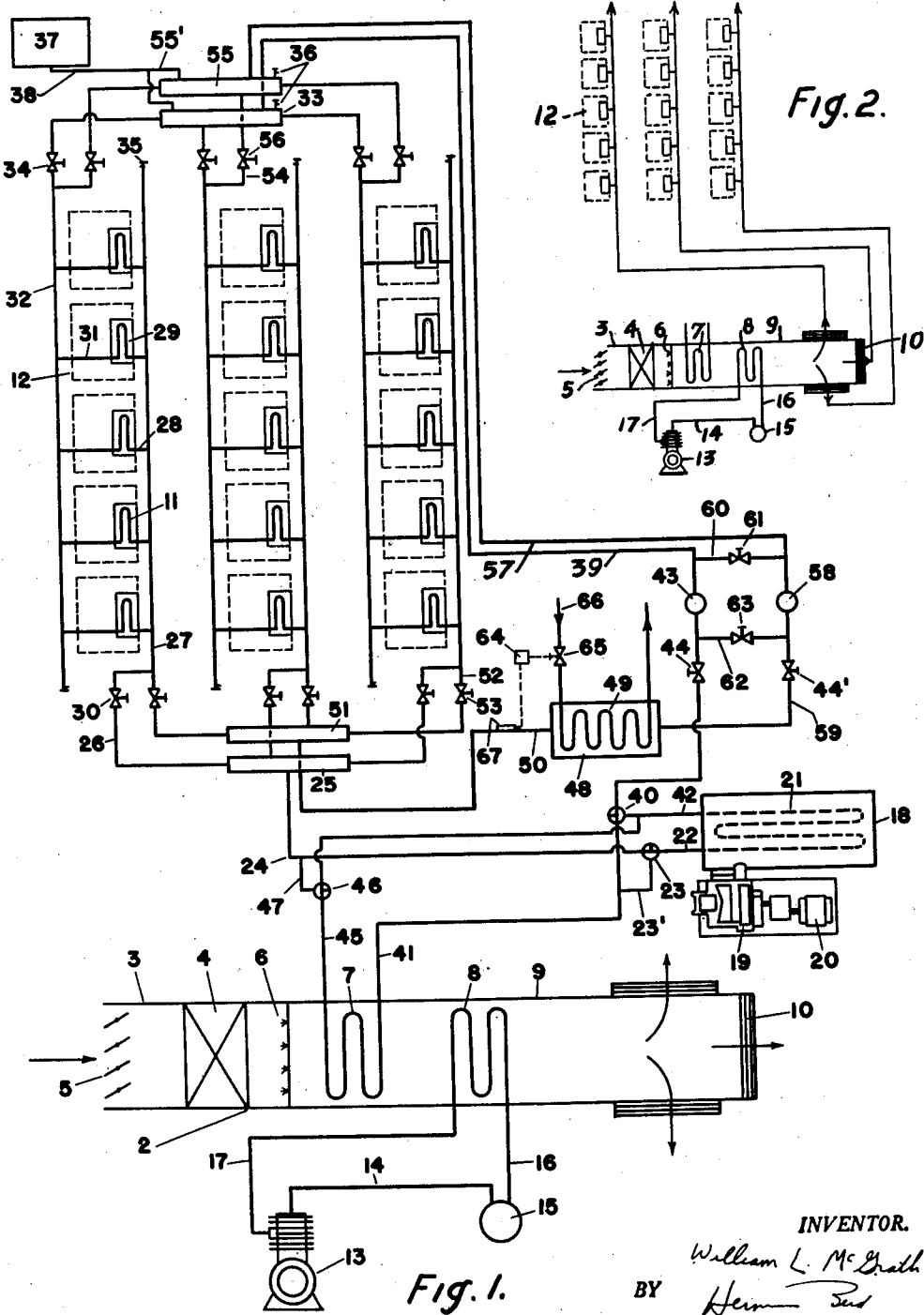


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AIR CONDITIONING SYSTEM
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AIR CONDITIONING SYSTEM

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This invention relates to air conditioning systems and to a method of operating an air conditioning system.

An air conditioning system in extensive use contemplates the division of a building into zones in accordance with the various heat loads present in the rooms of the building. In such system air from the exterior of the building is treated at a central conditioning point remote from the areas to be conditioned to compensate for ventilation and dehumidification requirements of the various zones. It is then distributed at relatively high static pressure and at relatively high velocity to a plurality of units disposed in and serving a plurality of areas to be conditioned in the various zones. The high pressure air supplied to each unit is discharged therein at high velocity inducing a relatively great circulation of air withdrawn from the areas served by the unit. The primary or high pressure air, and the secondary or induced air are then supplied to the conditioned area. Tempering means such as coils or the like are disposed in the various local units to effect heating or cooling of air circulated through the unit as required.

In the operation of the system cold water is furnished to the tempering means under summer conditions and warm water is furnished to the tempering means under winter conditions. Depending upon the heat load in each zone, cold or warm water may be supplied in winter or in summer. Under intermediate operating conditions, some zones of the building are supplied with warm water while other zones of the building may be supplied with cold water.

In an air conditioning system of this character cold water is passed through a coil in the air conditioning equipment to dehumidify air before it is supplied to the various local units in areas to be conditioned. Such cold water serves to reduce the dew point of the air to a desired degree. The refrigerating equipment needed to supply cold water for dehumidifying purposes is also required to supply cold water to the various local units in order to effect individual conditioning of each area in accordance with the variable heat factors present in such area. It will be appreciated refrigerating equipment of great capacity is required for such equipment must possess sufficient capacity to dehumidify the air and to effect local cooling under maximum load conditions. Consequently the cost of refrigerating equipment is a large factor in the initial cost of the air conditioning system and the operating expenses of such system are great since the system does not possess

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sufficient flexibility to permit a reduction in operating costs commensurate with a reduction in the load imposed upon the system.

The chief object of the present invention is to provide a simplified air conditioning system of this general type in which the initial costs of the system and the operational costs of the system are materially reduced.

An object of the invention is to provide a simplified method of operation of an air conditioning system in which the operational costs of the system may be reduced in accordance with the reductions in load imposed upon the system.

A further object is to provide an air conditioning system of enhanced flexibility and low initial cost in which full advantage may be taken of a reduction in load imposed upon the system to effect operating economies. Other objects of my invention will be readily perceived from the following description.

This invention relates to an air conditioning system which comprises in combination means to condition primary air, said means including a first heat exchange member, a second heat exchange member, and means to pass air to be conditioned through said members; means to supply refrigerant to the second heat exchange member in heat exchange relation with air directed therethrough; a plurality of conditioning units disposed in areas to be conditioned, means for supplying conditioned air to said units, heat exchangers in said units for conditioning air therein; a source of supply for conditioning medium including means for varying the temperature of the conditioning medium, means for supplying the conditioning medium to the heat exchangers disposed in said units, return means adapted to receive conditioning medium after its passage through said heat exchangers and to supply the returned conditioning medium to said first heat exchange member, and means for returning the conditioning medium to the source of supply after its passage through the first heat exchange member.

The attached drawing illustrates a preferred embodiment of my invention, in which

Figure 1 is a diagrammatic view of an air conditioning system illustrating the piping diagram for conditioning medium; and

Figure 2 is a fragmentary diagrammatic view of an air conditioning system illustrating the manner in which conditioned air is supplied from a central station to areas being conditioned.

Referring to the attached drawing there is illustrated generally at 2 suitable air conditioning equipment for use in my invention. Such

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equipment may comprise a casing 3 containing a fan 4 adapted to draw air from the exterior of the building through dampers 5 into the interior of casing 3. Fan 4 forwards the air through sprays 6, a precooling coil 7, and a dehumidifying coil 8 into a plenum 9. Air from plenum 9 passes through reheaters 10 and is supplied at high static pressure and high velocity to conditioning units 11 disposed in areas 12 to be conditioned. As previously explained, the conditioned primary air supplied to each unit 11 is discharged therein at high velocity, inducing a relatively great circulation of air withdrawn from the area, served by each unit 11. The primary air and the secondary induced air are then supplied to the conditioned area.

Compressor 13 is connected by line 14 to a condenser 15; condenser 15 is connected to dehumidifying coil 8 by line 16. Dehumidifying coil 8 is connected to compressor 13 by line 17. Compressor 13 serves to compress gaseous refrigerant and to supply such gaseous refrigerant through line 14 to condenser 15, where it is condensed to liquid form. The liquid refrigerant is supplied through line 16 to dehumidifying coil 8 which serves in effect as the evaporator of the refrigerating system. The evaporated refrigerant is then returned through suction line 17 to compressor 13. Conditioning medium such as cold water is supplied to precooling coil 7 as hereinafter explained.

At 18 there is designated generally a suitable source of supply for conditioning medium which may be, for example, cold water. The source of supply of conditioning medium includes means for cooling the conditioning medium. Any suitable means may be supplied; for example, a centrifugal compressor 19 operated by a suitable motor or turbine 20 may supply cooled brine to a cooler 21 where it is placed in heat exchange relation with water adapted to be cooled and used as the conditioning medium.

In the normal operation of the system under maximum load, water passes from cooler 21 through line 22, three way valve 23, and line 24 to a supply header 25 adapted to supply a plurality of supply mains or risers. From header 25 it passes through lines 26 to supply mains 27 which supply the conditioning medium through lines 28 to heat exchange coils 29 disposed in units 11. Valves 30 are disposed in lines 26 for a purpose hereinafter explained. Conditioning medium from coils 29 passes through lines 31 to lines 32 which conduct the conditioning medium to a common return header 33. Valves 34 are disposed in lines 32 for a purpose hereinafter explained.

Suitable vents 35 are disposed at the stub ends of supply mains 27 to permit air entrapped in the system to escape therefrom. Likewise, a suitable vent 36 is disposed at one end of header 33. An expansion tank 37 is connected to header 33 by means of a line 38.

A return line 39 extends from header 33 to a three-way valve 40. A line 41 connects valve 40 with precooling coil 7. A pump 43 is disposed in line 39. A line 42 connects valve 40 with cooler 21. A valve 44 is disposed in line 39 between pump 43 and three-way valve 40 for a purpose hereinafter described.

A line 45 in which is disposed a three-way valve 46 connects precooling coil 7 with line 42. A line 47 serves to connect valve 46 with line 24.

The above description contemplates the supply of cooled conditioning medium such as cold

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water to the various units 11 disposed in areas 12 to be conditioned. It will be appreciated, if desired, provision may be made for the supply of warmed conditioning medium to the coils 29 of units 11 under winter operating conditions, for example. Under intermediate conditions, of course, it may be desired to supply cooled conditioning medium to certain zones, while it is desired to supply warmed conditioning medium to other zones. A suitable system for supplying warm water to the coils 29 of units 11 may include a heater 48 which comprises a coil 49 adapted to place steam in heat exchange relation with conditioning medium to be supplied to the coils 29 of units 11.

Conditioning medium passes from heater 48 through line 50 to a warm water header 51 common to supply mains 27. Lines 52 in which are disposed valves 53 connect header 51 with supply mains 27. The warm water then passes through lines 28, coils 29, lines 31 to lines 32. Lines 54 extend from lines 32 to a warm water return header 55. Header 55 may be attached to expansion tank 37 by line 55'. Valves 56 are disposed in lines 54. Return line 57 leads from header 55 to a pump 58. Line 59 connects pump 58 with heater 48, valve 44' being disposed in line 59. A line 60 connects return lines 39 and 57, a valve 61 being disposed in line 60; a line 62 also connects lines 39 and 59, a valve 63 being disposed in said line.

Preferably, a thermostat 64 is provided adapted to control a valve 65 disposed in steam line 66 to govern the amount of steam passing through coil 49 in heater 48. Thermostat 64 may be controlled by means of a bulb 67 disposed in thermal contact with line 50 connecting heater 48 and header 51.

In order to aid in a better understanding of my invention I will describe the operation thereof, it being assumed that the system is operating under maximum load conditions. Cooler 21 supplies cold water to the system. Water from cooler 21 passes through line 22, valve 23, line 24, to cold water header 25. From header 25 the cold water passes through lines 26, valves 30 being opened and valves 53 being closed, to supply mains 27. The cooled conditioning medium then passes through lines 28, heat exchangers 29 of units 11 disposed in areas 12, lines 31 to lines 32. The conditioning medium passes from lines 32 to common return header 33, valves 34 being open and valves 56 being closed. From header 33 the conditioning medium passes to return line 39, valve 40, line 41 to precooling coil 7 where the conditioning medium serves to precool air drawn into the air conditioning equipment by fan 4. The conditioning medium is conducted from coil 7 through line 45, valve 46 and line 42 to cooler 21.

The air supplied to the conditioning units 11 disposed in the areas 12 to be conditioned is drawn into equipment 2 by fan 4 through dampers 5 and is passed through sprays 6, precooling coil 7 and dehumidifying coil 8. The conditioned air is then passed through reheaters 10 if desired and is supplied to units 11 through suitable ducts (not shown). Discharge of conditioned primary air into each unit induces a flow of secondary air into the unit from the area in which it is disposed and the mixture of primary and secondary air is then discharged into the area to be conditioned.

Under the conditions described above, it is assumed that the air conditioning system is operating under maximum load conditions. It will be obvious that a considerable reduction in oper-

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ating expenses is obtained by using the returned conditioning medium to precool the air being conditioned. Under these conditions reduced power consumption is obtained; for example, the returned conditioning medium may be used to compensate for perhaps 75% of the necessary cooling load of air being conditioned, while the dehumidifying coil 8 need be operated to compensate only for the remaining portion of the cooling load, approximately 25%. Such operation permits a smaller compressor to be used in the operation of coil 8 and also enables smaller refrigeration equipment to be used for supplying the local units 11 and precooling coil 7. The power consumption is thus reduced and additional flexibility for primary air dehumidifying may be provided under very light load conditions.

Assume for example that the load has decreased a reasonable amount below maximum load conditions. Under such circumstances coil 8 may be rendered inoperative by stopping compressor 13. Three-way valves 40, 23 and 46 are rotated. Rotation of valve 40 returns conditioning medium from header 33 through lines 39 and 42 to supply 21. Cooled conditioning medium is furnished from supply 21 through line 22. Rotation of valve 23 directs the conditioning medium from line 22 through line 23' and line 41 to coil 7 which then serves to dehumidify the air being conditioned. Conditioning medium is then passed from coil 7 through line 45 to valve 46; rotation of valve 46 directs the conditioning medium through line 47 and line 24 to header 25 which permits its supply to mains 27, coils 29 of units 11, and its subsequent return from header 33 through line 39, valve 40 and line 42, to the source of supply 21.

Assume the reduction in load conditions is so great that it is desired to furnish warm water to the coils 29 of units 11. In such case valves 30 and 34 are closed and valve 53 and 56 are opened. Warm water is supplied by heater 58 through line 50 to header 51. The warm water passes through line 52 to mains 27 and is supplied through lines 28 to coils 29 of units 11. The warm water then passes through lines 31 to lines 32, lines 54, valves 56 to header 55. The warm water is returned from header 55 through 57 to pump 58 which passes the conditioning medium through line 59 to heater 48. Under these circumstances valves 23, 40 and 46 are rotated to permit cold water to be supplied to header 25 without passing through precooling coil 7, precooling coil 7 being thus rendered inoperative. Actuation of compressor 13 permits coil 8 to carry the complete dehumidifying load.

It will be appreciated that certain zones may require warm water, while other zones may require cold water. Zones requiring warm water may be supplied from header 51 while the zones requiring cold water may be supplied from header 25. Such headers are filled with warm and cold water respectively at all times, and the zones may draw their requirements from such headers as required in accordance with the load conditions encountered in such zones.

Under maximum load conditions it may be desired to use both return lines 39 and 57 as return lines for cold conditioning medium or for warm conditioning medium. The use of both lines 39 and 57 as return lines under a maximum cooling or maximum heating load obviates forming line 39 of such size as to handle the maximum water flow under peak load conditions. Under conditions of maximum cooling load,

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heating will not be required in the zones. By opening valves 34 and 56 as well as valves 30, headers 33 and 55 will both be supplied with conditioning medium returning from the coils 29 of units 11 and both return lines 39 and 57 will be used to return the cold conditioning medium. Valve 61 in line 60 is opened permitting conditioning medium in return line 57 to flow into return line 39. If it be desired to supplement the head produced by pump 43, pump 58 may be actuated; in such case valve 61 in line 60 and valve 44' in line 59 are closed and valve 63 in line 62 is opened permitting pump 58 to supplement the head produced by pump 43. Likewise, under conditions of maximum heating load, valve 61 is opened, valve 44 being closed, permitting conditioning medium in line 39 to flow into lines 57 and 59. Pump 43 may also be used as an auxiliary by closing valve 61 and opening valve 63 permitting returned medium to pass into line 59 from line 39. Both pumps 43 and 58 may be used for cooling or heating, or one may be used for cooling and the other for heating.

The present invention provides an air conditioning system in which the capacity of the required refrigerating equipment is so designed as to effect maximum economies in initial costs and operating costs. My invention permits reduced power consumption and a more favorable balance between water temperature and water quantities supplied to the local units than is possible in systems heretofore used. My invention provides more satisfactory flexibility of the primary air dehumidifying operation under very light load conditions. In the system so provided the capacity of the cooler is selected to correspond with the temperature requirements only of the water supplied to the local units. In my invention returned conditioning medium may be used for perhaps 75% of the required cooling load, while only 25% of the load need be carried by the dehumidifying equipment; this permits an enormous reduction in power consumption.

Assume conditioning medium at 60° F. is supplied to all the zones of the system and that it is desired to cool the primary air to a required dew point of 48° F. Under average conditions the load on the dehumidifying coil will amount to approximately 25% of the total air conditioning load. For the remainder of the load, returned conditioning medium at perhaps 60° F. may be used at peak load, and at even higher temperatures at reduced load. It will be appreciated that a system so designed permits a great reduction in operating costs.

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, the combination of means to condition primary air, said means including a first coil, a second coil, and a fan to pass air to be conditioned through said members; a refrigeration system including a reciprocating compressor to supply refrigerant to the second coil in heat exchange relation with air directed thereto; a plurality of conditioning units disposed in the areas to be conditioned, means for supplying conditioned air to said units, coils in said units for conditioning air therein; a source of supply for conditioning medium including a centrifugal refrigerating system for cooling the conditioning medium, a supply line for sup-

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plying conditioning medium to a common supply header, a plurality of supply mains connected to said header adapted to supply conditioning medium to the unit coils, a common return header adapted to receive conditioning medium from the unit coils, a return line connected to said return header to supply the returned conditioning medium to the first coil, and a line for returning the conditioning medium to the source of supply after its passage through the first coil.

2. In apparatus of the character described, the combination of a source of supply for conditioning medium including a centrifugal refrigeration system for cooling the conditioning medium, a supply line for supplying the conditioning medium to a plurality of units disposed in areas to be conditioned, a return line for returning conditioning medium from the units, a first coil adapted to precool air for supply to the areas to be conditioned, a second coil adapted to dehumidify precooled air, a line connecting the first coil to the return line to permit passage of the returned conditioning medium through the first coil, a second line connecting the first coil to the source of supply to permit conditioning medium after its passage through the first coil to return to the source of supply, a refrigeration system including a reciprocating compressor for supplying refrigerant to the second coil, a line connecting the source of supply with said return line, and a valve disposed at the juncture of said line and the return line, rotation of said valve passing returned conditioning medium to the source of supply or to the first coil as desired.

3. In an air conditioning system, the combination of means to condition primary air, said means including a first coil, a second coil and a fan to pass air to be conditioned through said members; means to supply refrigerant to the second coil in heat exchange relation with air directed therethrough; a plurality of conditioning units disposed in the areas to be conditioned, means for supplying conditioned air to said units, coils in said units for conditioning air therein in accordance with the variable heat factors present in each area; a source of supply for conditioning medium including a refrigerating system for cooling the conditioning medium, a supply line for supplying conditioning medium to a common supply header, a plurality of supply mains connected to said header adapted to supply conditioning medium to the unit coils, a common return header adapted to receive conditioning medium from the unit coils, a return line connected to said return header to supply the returned conditioning medium to the first coil, a line for returning the conditioning medium to the source of supply after its passage through the first coil, a valve disposed in the return line, a second valve disposed in the supply line, a third valve disposed in the line connecting the first coil and the source of supply, and a second line connecting the third valve and the supply line, location of said valve permitting the return of conditioning medium directly to the source of supply and its supply to the unit coils without passage through the first coil.

4. In apparatus of the character described, the combination of a source of supply for conditioning medium including means for varying the temperature of the conditioning medium, a supply line for supplying the conditioning medium to a plurality of units disposed in areas to be conditioned, a return line for conditioning medium passing from the units, a first heat ex-

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change member adapted to treat air for supply to the areas to be conditioned, a second heat exchange member adapted to further treat air for supply to the areas to be conditioned, a line connecting the first exchanger to the return line to permit passage of returned conditioning medium through the first heat exchange member, a second line connecting the first heat exchange member to the source of supply to permit the conditioning medium after its passage through the first heat exchange member to return to the source of supply, means for supplying refrigerant to the second heat exchange member, a valve disposed in the return line, a second valve disposed in the supply line, a third valve disposed in the line connecting the heat exchanger with the source of supply, rotation of said valves permitting conditioning medium to pass through the first heat exchange member and then to the supply line, and returned conditioning medium to pass directly to the source of supply without passing through the first heat exchange member.

5. In apparatus of the character described, the combination of a source of supply for conditioning medium including a refrigeration system for cooling the conditioning medium, a supply line for supplying the conditioning medium to a plurality of units disposed in areas to be conditioned, a return line for returning conditioning medium from the units, a first coil adapted to precool air for supply to the areas to be conditioned, a second coil adapted to dehumidify pre-cooled air, a line connecting the first coil to the return line to permit passage of the returned conditioning medium through the first coil, a second line connecting the first coil to the source of supply to permit conditioning medium after its passage through the first coil to return to the source of supply, means for supplying refrigerant to the second coil, a line connecting the source of supply with said return line, a valve disposed at the juncture of said line and the return line, rotation of said valve passing the returned conditioning medium to the source of supply or to the first coil as desired, a second valve disposed in the supply line, a third valve disposed at the juncture of the line connecting the first coil with the source of supply and a second line connecting the first coil with the supply line, rotation of said valve serving to pass returned conditioning medium to the source of supply, then through the first coil and to the supply line.

6. In an air conditioning system the combination of means to condition primary air, said means including a first heat exchange member, a second heat exchange member and means to pass air to be conditioned through said members, means to supply refrigerant to the second heat exchange member in heat exchange relation with air directed therethrough to cool the same; a plurality of conditioning units disposed in areas to be conditioned; means for supplying conditioned air to said units; heat exchangers in said units for conditioning air therein; a source of supply for conditioning medium including means for varying the temperature of the conditioning medium; means for supplying the conditioning medium to the heat exchangers disposed in said units; return means adapted to receive conditioning medium after its passage through said heat exchangers and to supply the returned conditioning medium to said first heat exchange member; means for returning the conditioning medium to the source of supply after its passage through the first heat exchange member; controls to direct returned

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conditioning medium to the source of supply and means to pass conditioning medium from the source of supply through the first heat exchange member and then to the heat exchanger in the units, the second heat exchange member being rendered inoperative by discontinuing the supply of refrigerant thereto and the first heat exchange member serving to dehumidify the air passing therethrough.

WILLIAM L. McGRATH. 10

REFERENCES CITED

The following references are of record in the file of this patent:

10

UNITED STATES PATENTS

Number	Name	Date
2,072,166	Goodman -----	Mar. 2, 1937
2,073,677	Broderick -----	Mar. 16, 1937
2,112,520	Crawford -----	Mar. 29, 1938
2,159,276	Lawless -----	May 23, 1939
2,304,243	Crawford -----	Dec. 8, 1942