March 30, 1937. H. L. HOLLIS 2,075,036

AIR CONDITIONING APPARATUS AND PROCESS

Filed Aug. 26, 1935 2 Sheets-Sheet 1

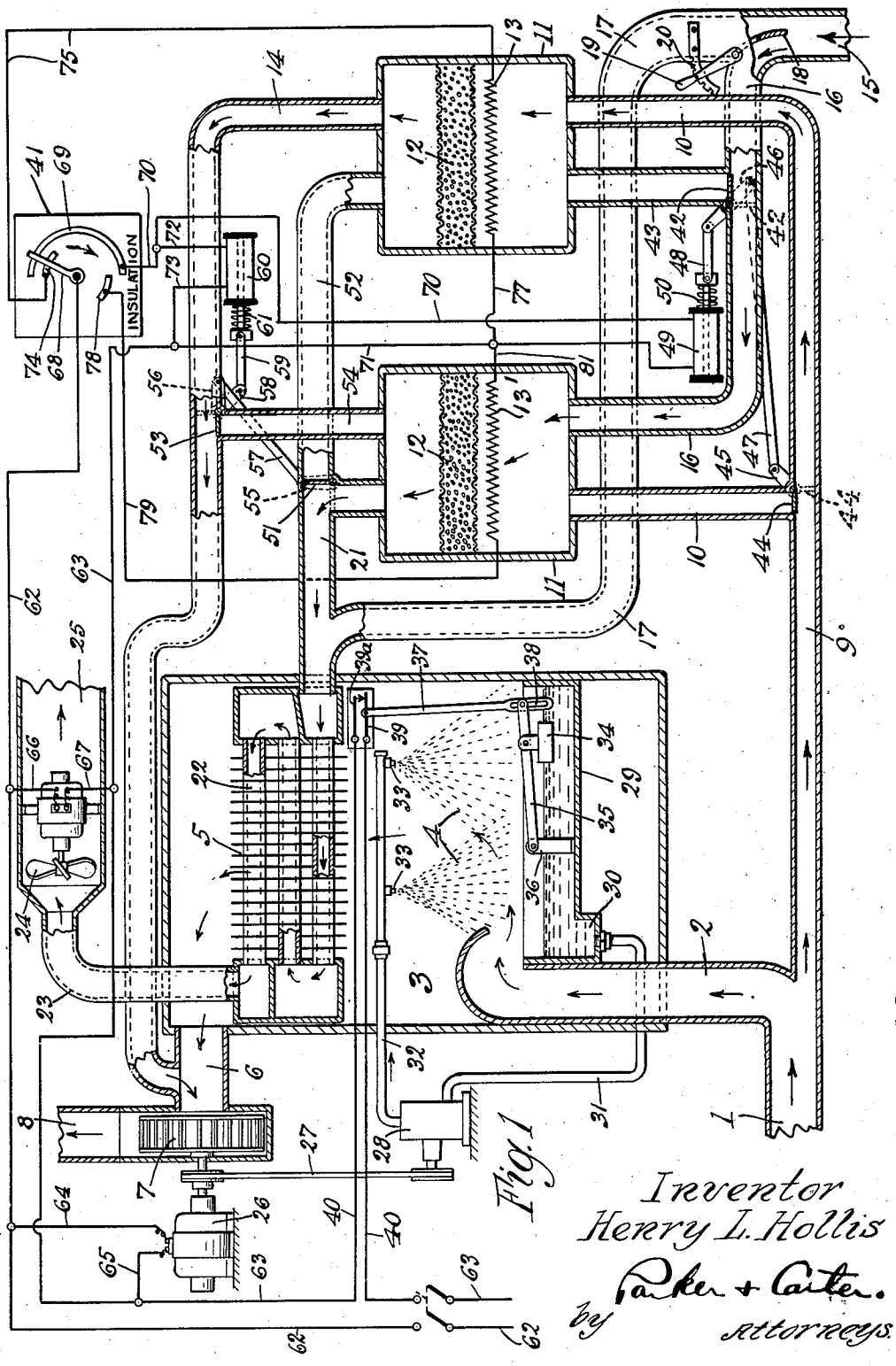


Fig. 1

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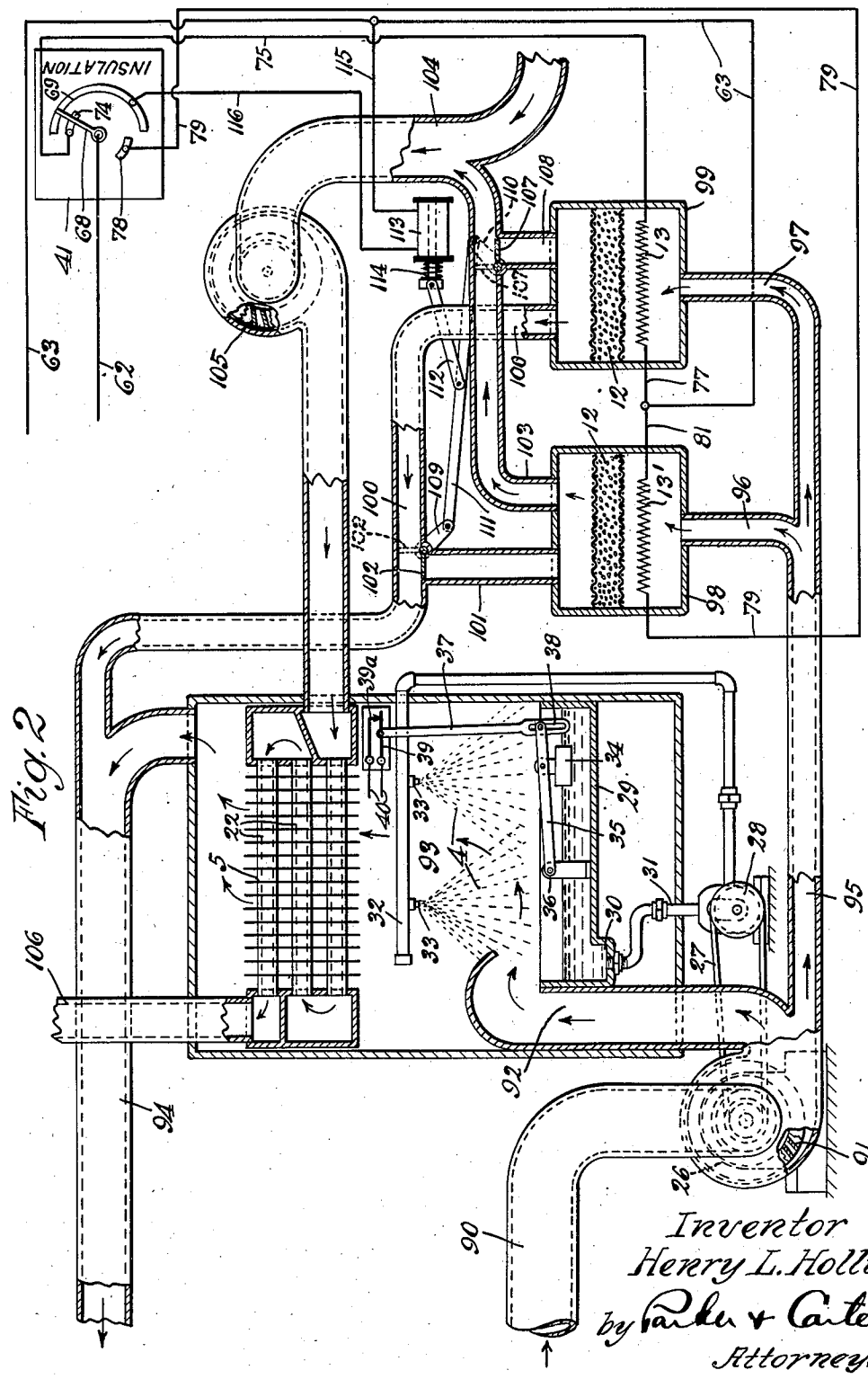


Fig. 2

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AIR CONDITIONING APPARATUS AND PROCESS

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18 Claims. (Cl. 183—4)

This invention relates to an apparatus for conditioning air. It has for one object to provide means for cooling the air in a room or other enclosed space. It has for another object to provide means for dehumidifying such air. It has for another object to provide a compact and readily movable apparatus for cooling and for dehumidifying air. It has for another object to provide an air conditioning means in which no refrigeration mechanism is necessary. It has for another object to provide means for conditioning air without the use of refrigeration and including a cooling unit comprising a closed circuit, water-circulating mechanism. Another object is to provide in an air conditioning unit automatic controls operating to maintain constant and satisfactory operation of the mechanism as a whole.

Other objects will appear from time to time in the specification and claims.

The invention is illustrated more or less diagrammatically in the accompanying drawings, wherein:—

Figure 1 is a diagrammatic showing or "flow sheet" of the apparatus of the present invention in which only sufficient mechanism is shown to illustrate the operation of the device. It is to be understood that the mechanism illustrated herewith is shown diagrammatically.

Figure 2 is a diagrammatic showing illustrating a modified form.

Like parts are designated by like characters throughout the specification and drawings.

In each of the figures, for purposes of simplicity of understanding, the mechanism has been separated and arranged in the form of a "flow sheet".

As shown in Figure 1, 1 designates the air intake from a source outside of the room, for example, outside or street air. The air passes through the conduit or intake 1, to a second conduit 2 and is discharged into a spray chamber 3. It passes through sprays 4 and thence upward between the coils of a heat exchanger 5 into a discharge conduit 6, passing a fan 7 and through a final discharge conduit 8 to the outer air.

All of the air entering from the outside through the conduit 1 does not pass into the conduit 2. Some of it is by-passed through a conduit 9 into one or the other of a pair of passages 10 which lead to dehumidifying units 11, 11. Each unit comprises a dehumidifying portion 12 which may be of any suitable nature. Each dehumidifying unit also includes a coil 13, 13' for a purpose to be described below. As shown in Fig. 1, the air from the conduit 9 is passing from the right hand conduit 10 into the right hand dehumidifying unit 11 and is passing thence through a conduit 14 into the conduit 6 and outward through the final discharge 8 to the open air.

It will be seen thus that the charge of air entering is divided and a portion of it passes through the spray chamber, the heat exchanger and thence out, while a portion of it passes through one of the dehumidifiers. The purpose of this second portion of outside air is to carry off moisture from the dehumidifier. It will be understood that a dehumidifier of the general type indicated contains some chemical or other substance capable of absorbing moisture from the air. It may contain what is known as "activated aluminum oxide." After a certain amount of air has passed through the unit this dehumidifying agent will have absorbed all the moisture possible. The automatic control which will be described below then switches the current of air entering from the room so that it flows through the other dehumidifying unit and the first dehumidifying unit is then heated by the coil 13 and the outside air passing through it carries off moisture and discharges it into the outer air. Thus the two dehumidifying units are alternately, by the automatic mechanism shown, switched into and out of use and the unit which is out of use is reactivated so that it is ready for use when the other unit requires reactivation. That portion of the outside air which passes through the dehumidifying unit first carries off the moisture during the time that the coil is energized and thereafter, when the coil is no longer energized, continues to pass through the unit to effect its cooling so that when it is thereafter again brought into use for dehumidifying it has been cooled sufficiently.

Air within the room enters the system through the conduit 15 which communicates with a conduit 16 and a second conduit 17. An adjustable control member 18 is positioned at the junction of the conduits 16 and 17 with the conduit 15. A handle 19 and a quadrant 20 permit adjustment of the member 18 so that any desired proportion of the entering air may be directed to the conduits 16 and 17.

That portion of the room air which passes through the conduit 16 enters the left hand humidifying unit, which is in condition for dehumidifying and is cooled, and after leaving it passes through a conduit 21 and through the coils 22 of the heat exchanger 5, thence through a conduit 23, past a fan 24 and is discharged into the room through the final conduit 25.

That portion of the room air which enters the

conduit 17, however, does not pass through the dehumidifier but passes directly into the coils 22, joining at that point with the air which has been dehumidified and which is flowing through the conduit 21, and the undehumidified air follows the same course as, and is mixed with, the dehumidified air.

The fans 7 and 24 are shown as driven by separate motors. This is a possible arrangement but ordinarily in a commercial installation the parts would be so arranged that the two fans would be driven by the same motor. As a matter of economy and compactness this is desirable, although not essential. The water circulation may also be accomplished by driving from the same motor. As here shown a motor 26 which drives the fan 7 is connected by a belt 27 to a pump 28 which is preferably a centrifugal or rotary pump of some type. 29 is a pan or basin suitable to contain water. It is preferably provided at one end with a sump or depression 30 from which a pipe 31 leads to the pump 28. A pipe 32 leads from the pump and liquid is discharged through it and sprayed through the spray chamber 3 by means of one or more spray nozzles 33. A float 34 is mounted within the pan 29 and arranged to float upon the liquid within the pan. This float is adjustably positioned upon an arm 35 pivoted at 36 and carrying at its outer end a switch control link 37 which is slotted as at 38. The switch control link is arranged to move the part 39 of a switch. This switch by means of wires 40, 40, is in communication with the wiring system of the installation. When the level of liquid within the pan 29 falls below a predetermined limit, due to evaporation, leakage or other cause, the float 34 moves downwardly sufficiently to move the link 38 downwardly and to break the switch connection by moving the member 39 out of contact with the member 39a of the switch and so the circuit through the wires 40 is interrupted and the operation of the entire system is cut off.

The automatic switching whereby the flow of air is caused to move alternately through the dehumidifying units and whereby the coils within those units are energized and de-energized will now be described. While almost any suitable form of control may be used, it is convenient for most purposes to use a time clock indicated diagrammatically at 41. The time clock is arranged to operate the controls in relation to the dehumidifying units so that when one unit has been in use long enough to be exhausted it will be automatically cut out and the un-exhausted or reactivated unit will be automatically cut in. At the time that this occurs the exhausted unit will be re-activated by the energizing of the heating coil within it, which drives off the moisture, which moisture is discharged from the system by that portion of the outside air which passes through the dehumidifying unit during its re-activation.

A valve 42 is positioned in a conduit 43 which communicates between the conduit 16 and the right hand dehumidifying unit. A corresponding valve 44 is positioned to control passage through the conduit 10 which communicates between the conduit 9 and the left hand dehumidifying unit. A lever 45 moves the valve 44 and a lever 46 moves the valve 42. These levers are connected by a link 47. One arm of the lever 46 is connected to a second link 48 which is actuated to be moved back and forth by a solenoid 49. A spring 50 moves the solenoid out when free to do so and is compressed when the solenoid is energized.

A valve 51 is positioned at the junction of the conduit 21 and a conduit 52 which latter conduit, when open, conducts air from the right hand dehumidifying unit to the conduit 21. A valve 53 is positioned at the junction of a conduit 54 within the conduit 14. When this valve is open, air may flow from the left hand dehumidifying unit, through the conduit 54, to the conduit 14 and discharge from the system. A lever 55 moves the valve 51 and a lever 56 moves the valve 53. These levers are connected by a link 57. A third lever 58, connected also to the valve 53, is connected to a link 59 which is moved in one direction by the solenoid 60 and in the other direction by the spring 61.

Current for operating the entire system may be furnished by wires 62, 63. The wires 40 to the float control switch 39 may conveniently be cut in to the wire 63. The motor 26 is operated from the wire 62, 63, by wires 64, 65 and the motor for the fan 27 is similarly connected by wires 66, 67. One of the wires 62 is connected with the base of a wiper arm 68 of the time clock 41.

The wiper arm is moved by the time clock mechanism or otherwise and contacts a curved contact 69. From this contact 69 a wire 70 leads to one pole of the solenoid 49. A wire 71 leads from the other pole of the solenoid 49 to the wire 63 and thus when the wiper arm 68 is in contact with the member 69 the solenoid 49 is energized, the link 48 is moved to the left within the solenoid, the spring 50 is compressed and valves 42 and 44 are moved to the position shown in Figure 1. The solenoid 60 is connected by a wire 72 to the wire 70 and by a wire 73 to the wire 71 and thus it is energized at the same time as the solenoid 49. Energizing of the solenoids thus moves the valves 42, 44, 51, and 53 to the position they occupy in Fig. 1. When the time clock carries the wiper arm 68 so far that it clears the member 69, the solenoids are de-energized, the springs 50 and 61 are free to expand and the valves are then moved from the positions shown in full lines to the dotted line positions and flow of air is reversed with respect to the dehumidifying units.

A short contact member 74 is positioned to be contacted by the wiper arm 68. It is connected by a wire 75 with one pole of the coil 13 and the circuit is completed by a wire 77 which connects with the other pole of the coil 13 with the wire 71. When the wiper arm 68 is in contact with the member 74 the coil 13 in the right hand dehumidifying unit is energized and that unit is heated to vaporize the moisture which it has previously taken from the air. It will be noticed that the length of the contact member 74 is much less than that of the member 69. This is desirable because it requires only a relatively short time to drive off the moisture from either of the dehumidifying units, but after that has been accomplished the valves remain in the position shown a sufficient time to permit air to pass through the re-activated unit so that it is cooled adequately.

78 is a second short contact member positioned diametrically opposite the member 74. It is connected by a wire 79 to one pole of the coil 13' at the left hand dehumidifying unit. The opposite pole of this unit is connected by a wire 81 to the wire 71. The operation of energizing this coil is the same as that above described for the coil 13.

The form of the device shown in Figure 2 is in many respects similar to that shown in Figure 1 and it differs from that just described principally in the control of the movement of the room

air. In the form of Figure 1 the room air is dehumidified and cooled, while in the form of Figure 2 the room air is merely cooled. A further difference between the two forms lies in the fact that in the form of Figure 1 the outside air is not discharged into the room but is used only in the heat exchanger to cool the room air which passes through the coils of the heat exchanger and is used in carrying off the vaporized moisture from the dehumidifying units, while in the form of Figure 2 some of the outside air, after having been dehumidified, passes into the room air and moves with it through the cooling coils of the heat exchanger and is discharged with it into the room.

90 is the intake from the outside air. The air is drawn through this intake conduit by a fan or blower 91. A portion of it passes through the conduit 92 into the spray chamber 93 which is generally the same in detail and operation as the spray chamber 3 above described. This then passes upwardly through the heat exchanger 5, through the conduit 94 for discharge to the outside.

Another portion of the outside air passes through a conduit 95 and through conduits 96 and 97 leading respectively to dehumidifying units 98 and 99. These units are generally the same in construction and operation as the units shown and described in connection with Figure 1. Since there are no valves to control the conduits 95, 96 or 97, it is obvious that air flows through these conduits constantly irrespective of the condition of the dehumidifying units, in a manner which will be described below. In the position of adjustment shown in Figure 2, air is flowing from the left hand dehumidifying unit 99 through the conduit 100, into the conduit 94 and it is being discharged to the outer air. Thus the conduit 99 is being re-activated and the air passing through it is carrying off the moisture and will serve to cool the conduit. With the wiper arm 68 in the position shown in Figure 2, the coil 13 of the unit 99 is energized and this unit is being re-activated. The left hand unit 98 is not heated and it is serving to dehumidify air which enters it through the conduit 96. The air from the unit 98 cannot pass into the conduit 100 for discharge into the outer air because the conduit 101 which leads from it to the conduit 100 is closed by the valve 102 and the air, therefore, must pass outward through the conduit 103 into the main conduit 104 through which the room air enters and the air from the conduit 103 thus joins and mingles with the air from the conduit 104. A fan or blower 105 draws air through the conduit 104, passes it through the coils 22 of the heat exchanger and discharges it again into the room through a discharge conduit 106.

The air from the heated dehumidifying unit 99 is prevented from passing into the room air by the position of the valve 107.

The valve 102 being positioned at the junction of the conduits 100 and 101 controls the passage of air through those conduits and the valve 107, being positioned at the junction of the conduits 103 and 108 controls the passage of air through those conduits. The valves 102 and 107 have attached to them levers, respectively, 109 and 110 which are joined by a link 111. A second link 112 is attached to the solenoid 113. When the solenoid moves in one direction to the position occupied in Figure 2, the valves are moved to the full line position. When the solenoid is de-energized the spring 114 is free to move it in the reverse direction and through the linkage shown the valves are then moved to the dotted line position to reverse the flow of air. As in the case of the form of the device shown in Figure 1, the time clock 41 controls the movement of the valves and the energizing of the solenoid and of the coils. The contact units 74 and 78, which control the coils, are much shorter than the unit 69 which controls the solenoid and thus the coils are energized for only a relatively short portion of the time that the valves occupy any one setting.

In the form of the device shown in Figure 2, only one solenoid is used. Its operation is generally the same as that described for the operation of a solenoid in connection with Figure 1. Thus solenoid 113 is connected by a wire 115 to the wire 63 and at its other pole it is connected by a wire 116 to the contact member 69.

The use and operation of my invention are as follows:

In both of the forms of the device, no direct refrigeration such as a refrigerating coil and the necessary mechanism is used. Outside air is drawn into the system and is passed through a spray of liquid, preferably water. Some cooling of the air takes place due to the evaporation at this point. The cooled air passes from the spray about the coils of a heat exchanger and is discharged into the outer air. Air from the room or other enclosed space is drawn into the system, passes through the coils of the heat exchanger and is thus cooled and redischarged into the room.

In one form of the invention, there is no mixing of the air from the outside with the room air and the room air is dehumidified before being cooled, that is to say—the room air passes through a dehumidifying coil before passing to the heat exchanger for cooling. In the other form of the invention, the room air is not directly dehumidified but is merely cooled. It is, however, mixed with a certain variable quantity of dehumidified outer air, the mixture of the dehumidified outer air with the room air passing through the cooling coil.

In both forms of the invention dehumidifying units are provided and automatic means is arranged for reactivating them at necessary intervals and for carrying off moisture discharged from the dehumidifying air as a result of the reactivation and also for cooling the reactivated unit after reactivation is complete.

I claim:

1. The method of treating air in an enclosed space which comprises setting up two relatively independent currents of air, one of outside air, the other of inside air, cooling said outside air, dehumidifying said inside air and cooling said dehumidified inside air by said cooled outside air.

2. The method of treating air in an enclosed space which comprises setting up two relatively independent currents of air, one of outside air, the other of inside air, cooling said outside air, dehumidifying said inside air and cooling said dehumidified inside air by said cooled outside air, by-passing a portion of said outside air for use in reactivating a dehumidifying unit.

3. The process of treating air in an enclosed space which comprises the following steps, setting up a circulation of air from outside said space, cooling said air, setting up a circulation

of air within said space, dehumidifying said air, cooling said inside dehumidified air by said first mentioned cooled outside air, redischarging said dehumidified and cooled air into said space and redischarging said outside air.

4. The process of treating air in an enclosed space which comprises the following steps, setting up a circulation of air from outside said space, cooling said air, setting up a circulation of air within said space, dehumidifying said air, cooling said inside dehumidified air by said first mentioned cooled outside air, redischarging said dehumidified and cooled air into said space and redischarging said outside air, and by-passing a portion of said outside air for use in reactivating a dehumidifying unit.

5. The process of treating air in a room which includes the following steps, setting up a confined current of outside air, cooling said air, setting up a circulation of room air, dehumidifying said room air, cooling said room air by said cooled outside air and redischarging said dehumidified and cooled air into said room, and utilizing a portion of said outside air to assist in reactivating a dehumidifying unit of said system.

6. The process of treating the air in a room which comprises the following steps,—setting up a confined circuit of outside air, cooling said confined circuit, by-passing a portion of said outside air selectively to one of a plurality of dehumidifying units, setting up a circuit of inside air, cooling said air by means of said cooled outside air and redischarging said cooled air into said room.

7. The process of treating the air in a room which comprises the following steps,—setting up a confined circuit of outside air, cooling said confined circuit, by-passing a portion of said outside air selectively to one of a plurality of dehumidifying units, setting up a circuit of inside air, dehumidifying said air, cooling said air by means of said cooled outside air and redischarging said dehumidified cooled air into said room.

8. The process of treating air in a room which comprises the following steps,—setting up a controlled enclosed current of outside air, cooling said air and redischarging a portion of said air to the outside, by-passing a portion of said outside air, dehumidifying said by-passed outside air, setting up a current of inside air, mixing it with said by-passed outside air, cooling the two together and redischarging them into said room.

9. The process of treating air in a room which comprises the following steps,—setting up a controlled enclosed current of outside air, cooling said air and redischarging a portion of said air to the outside, by-passing a portion of said outside air, dehumidifying said by-passed outside air, setting up a current of inside air, mixing it with said by-passed outside air, cooling the two together and redischarging them into said room, selectively by-passing a portion of said outside air to cooperate in reactivating a dehumidifying unit.

10. In combination, in an air treating system, for treating air in a room, a spray chamber, means for creating a liquid spray within it, a heat exchanger, means for drawing outside air to the spray chamber, for passing it through the heat exchanger and for discharging it to the outside, a dehumidifying unit, means for drawing air into it for dehumidifying it therein, for moving it to the heat exchanger and for discharging it into the room.

11. In combination, in an air treating system, for treating air in a room, a spray chamber, means for creating a liquid spray within it, a heat exchanger, means for drawing outside air to the spray chamber, for passing it through the heat exchanger and for discharging it to the outside, a dehumidifying unit, means for drawing air into it for dehumidifying it therein, for moving it to the heat exchanger and for discharging it into the room, and means for reactivating the dehumidifying unit.

12. In combination, in an air treating system for treating air in a room, a spray chamber, means for creating a liquid spray within it, a heat exchanger, means for drawing outside air to the spray chamber, for passing it through the heat exchanger and for discharging it to the outside, a plurality of dehumidifying units, automatic means for controlling the movement of air to move air to one of said units to dehumidify it therein, and for moving it thence to said heat exchanger and for discharging it into the room, and automatic means for selectively reactivating said dehumidifying units.

13. In combination, in an air treating unit, cooling means, a plurality of dehumidifying means, means for drawing outside air into the cooling means to cool the latter, means for drawing inside air into the dehumidifying unit for cooling it and for discharging it from the system and automatic means for selectively controlling the passage of air to one of said dehumidifying units and for reactivating a unit when not in use.

14. The method of treating air in an enclosed space which comprises setting up two relatively independent currents of air, one of outside air, the other of inside air, cooling said outside air, passing said inside air through a dehumidifying unit and dehumidifying said inside air and cooling said dehumidified inside air by said cooled outside air, reactivating said dehumidifying unit by heating, and by-passing a portion of said outside air through said unit for use in reactivating said dehumidifying unit.

15. The process of treating air in an enclosed space which comprises the following steps, setting up a circulation of air from outside said space, cooling said air, setting up a circulation of air within said space, passing said inside air through a dehumidifying unit and dehumidifying said air, cooling said inside dehumidified air by said first mentioned cooled outside air, redischarging said dehumidified and cooled air into said space and redischarging said outside air, reactivating said dehumidifying unit by heating, and by-passing a portion of said outside air through said unit for use in reactivating said dehumidifying unit.

16. The process of treating air in a room which includes the following steps: Setting up a confined current of outside air, cooling said air, setting up a circulation of room air, passing said room air through a dehumidifying unit and dehumidifying said room air, cooling said room air by said cooled outside air and redischarging said dehumidified and cooled air into said room, reactivating said dehumidifying unit by heating, and utilizing a portion of said outside air to assist in reactivating said dehumidifying unit.

17. The method of treating air in an enclosed space which comprises setting up two relatively independent currents of air, one of outside air, the other of inside air, cooling said outside air, passing said inside air through a dehumidifying unit and dehumidifying said inside air and cooling said dehumidified inside air by said cooled outside air, reactivating said dehumidifying unit by

heating it to drive off moisture, bypassing a portion of said outside air through said unit to carry off said moisture, and cooling said unit after the moisture has been driven off by further bypassing a further portion of said outside air.

18. The process of treating air in an enclosed space which comprises the following steps, setting up a circulation of air from outside said space, cooling said air, setting up a circulation of air within said space, passing said inside air through a dehumidifying unit and dehumidifying said air, cooling said inside dehumidified air by said first mentioned cooled outside air, redischarging said dehumidified and cooled air into said space and redischarging said outside air, heating said dehumidifying unit to drive off moisture to reactivate it, bypassing a portion of said outside air through said unit to carry off said moisture, discontinuing said heating and cooling said unit by further bypassing of outside air therethrough.

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