Sept. 19, 1939. F. A. WHITELEY 2,173,405

METHOD AND APPARATUS FOR CONDITIONING AIR

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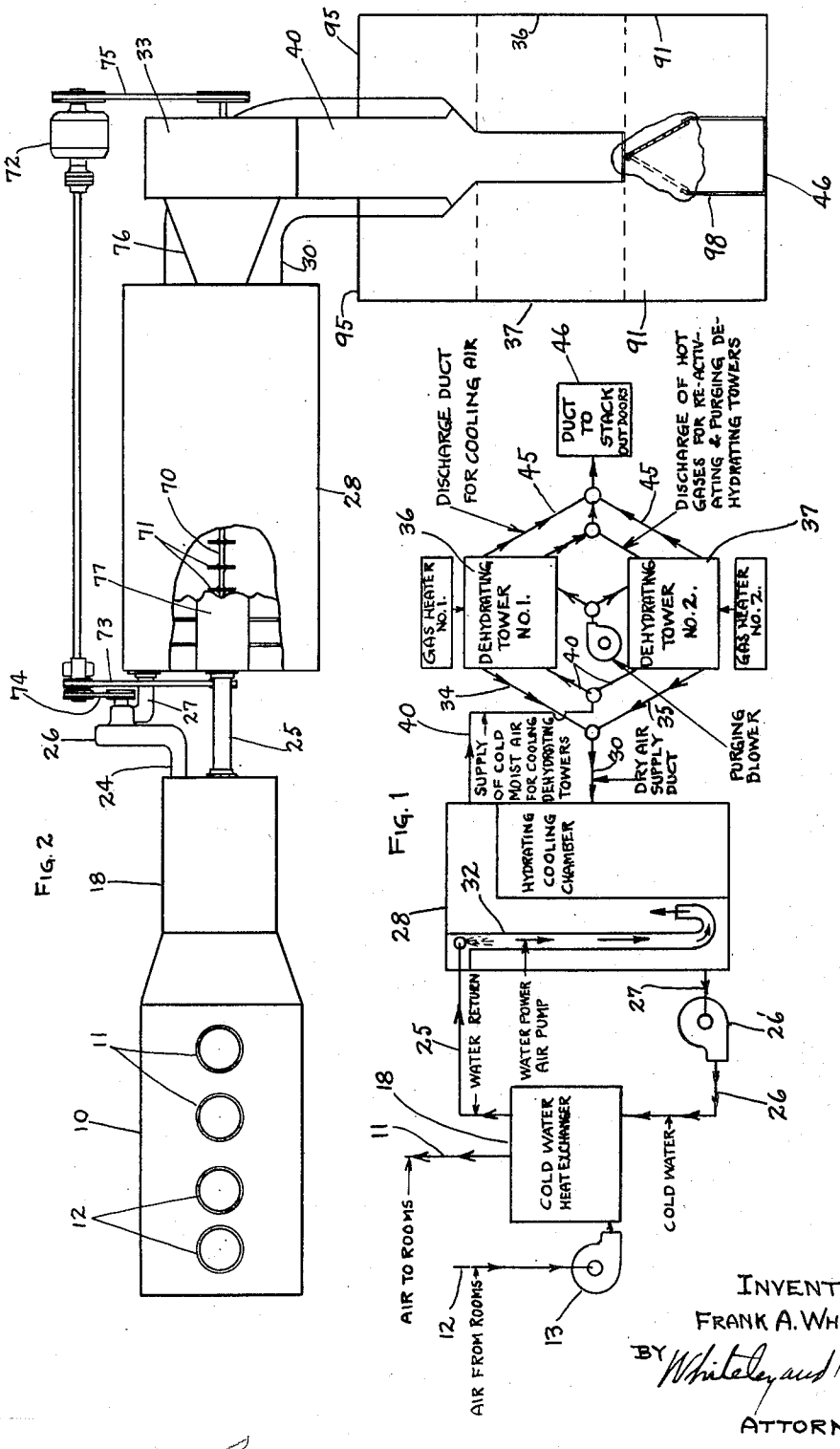


Fig. 1

Fig. 2

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Fig. 4

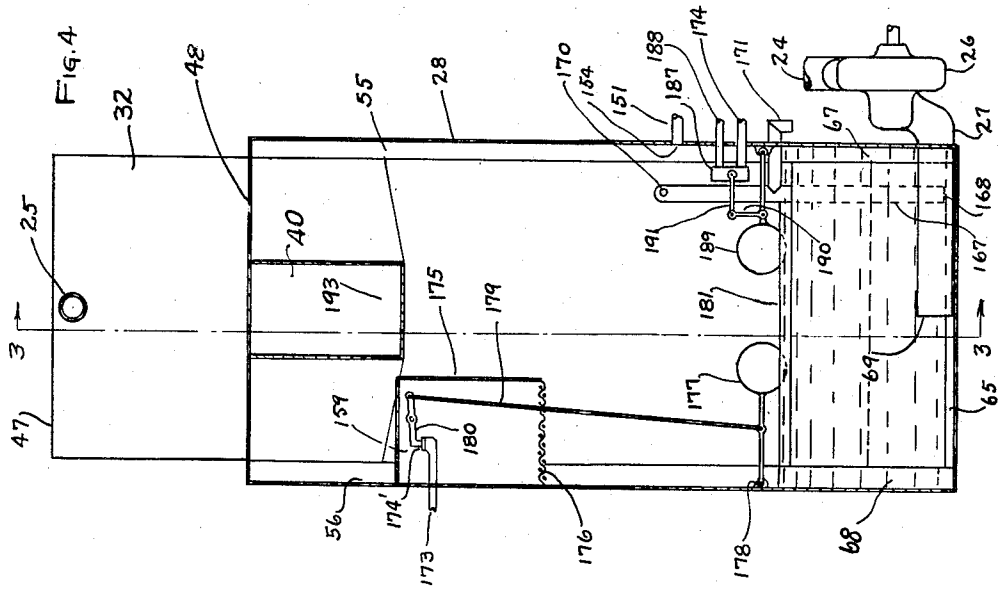
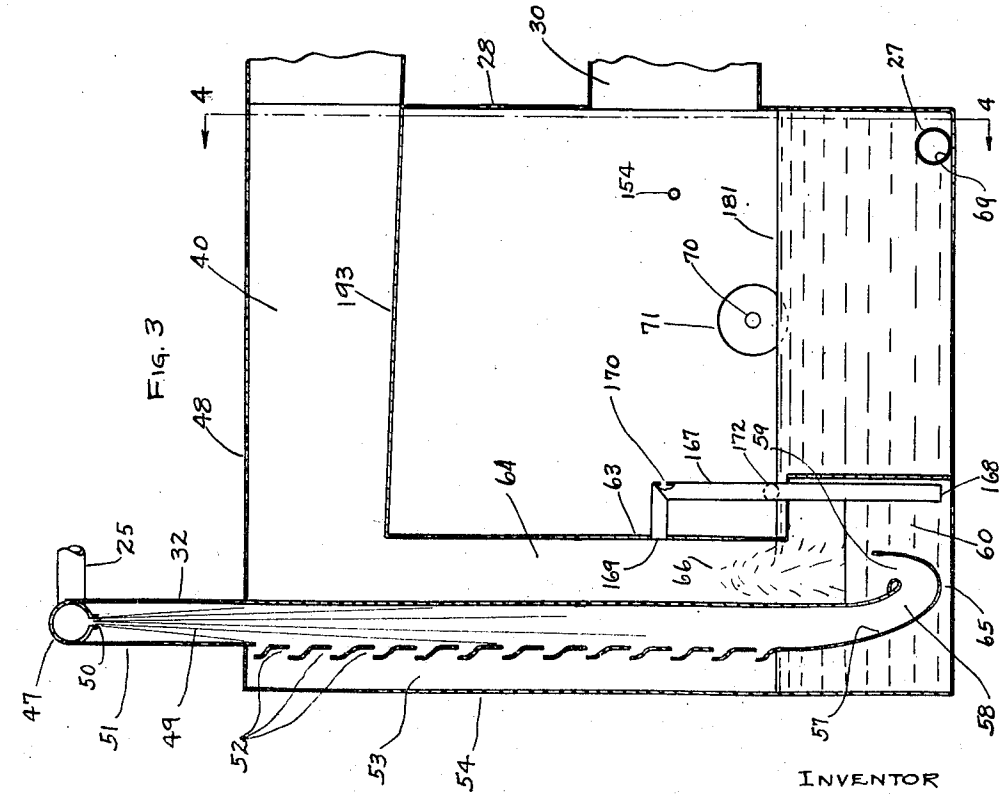


Fig. 3

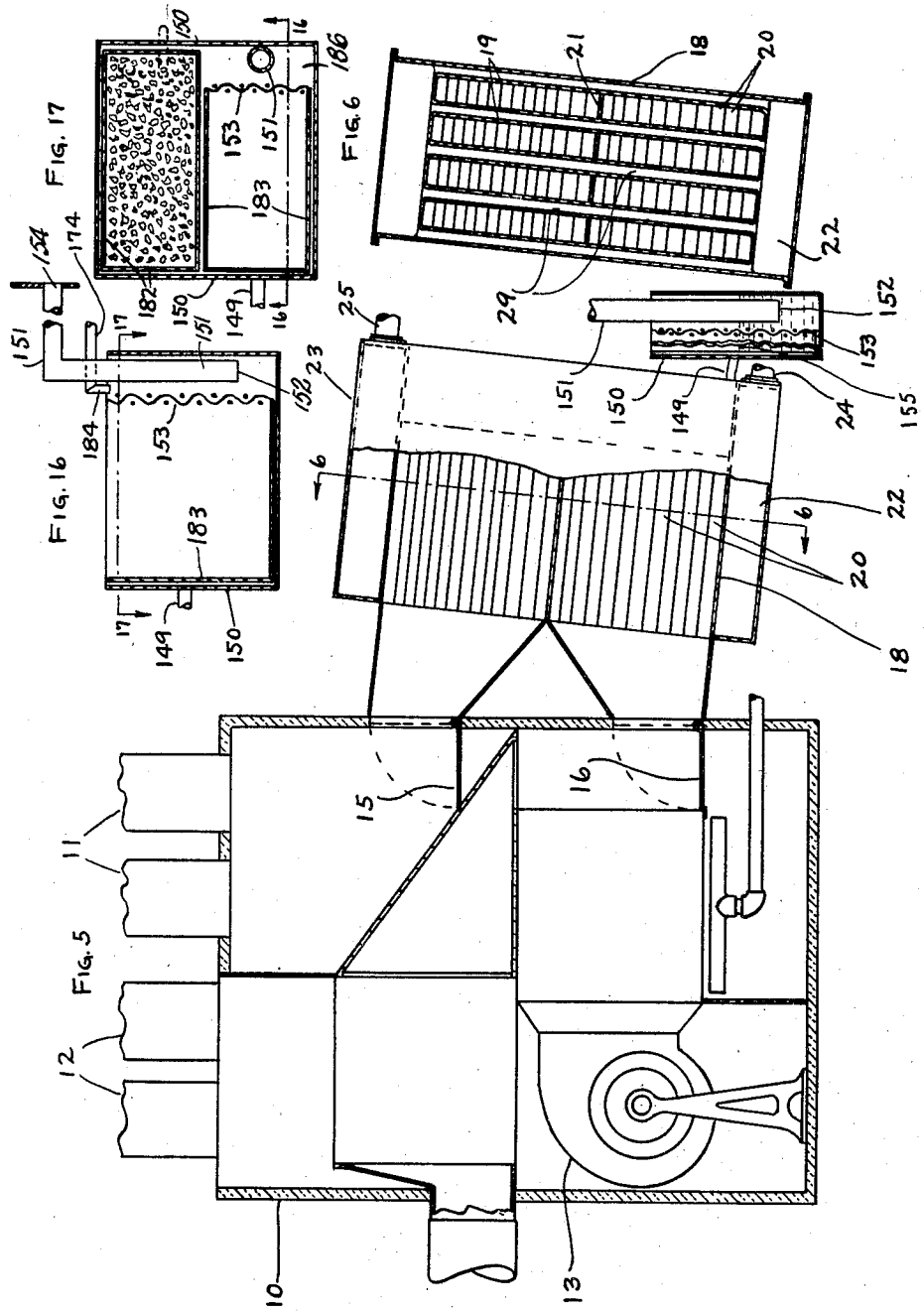


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Fig. 7

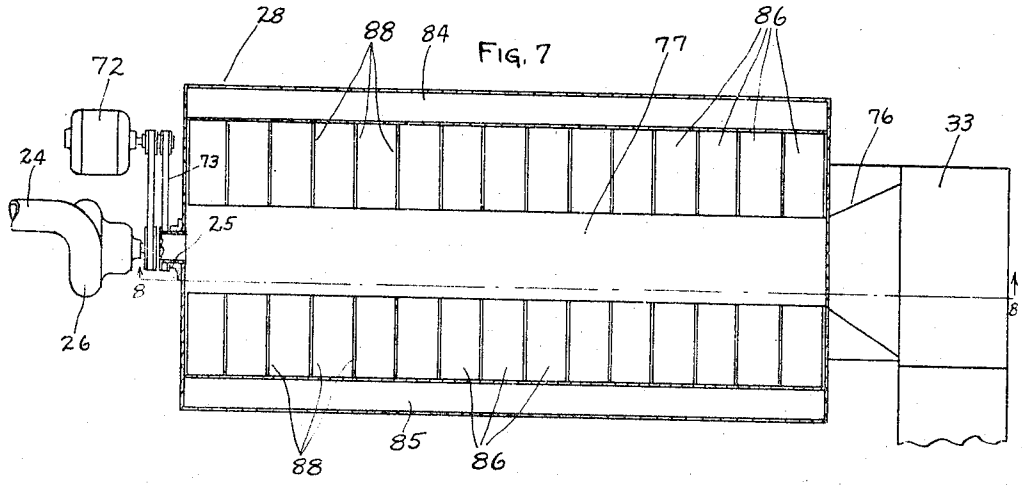
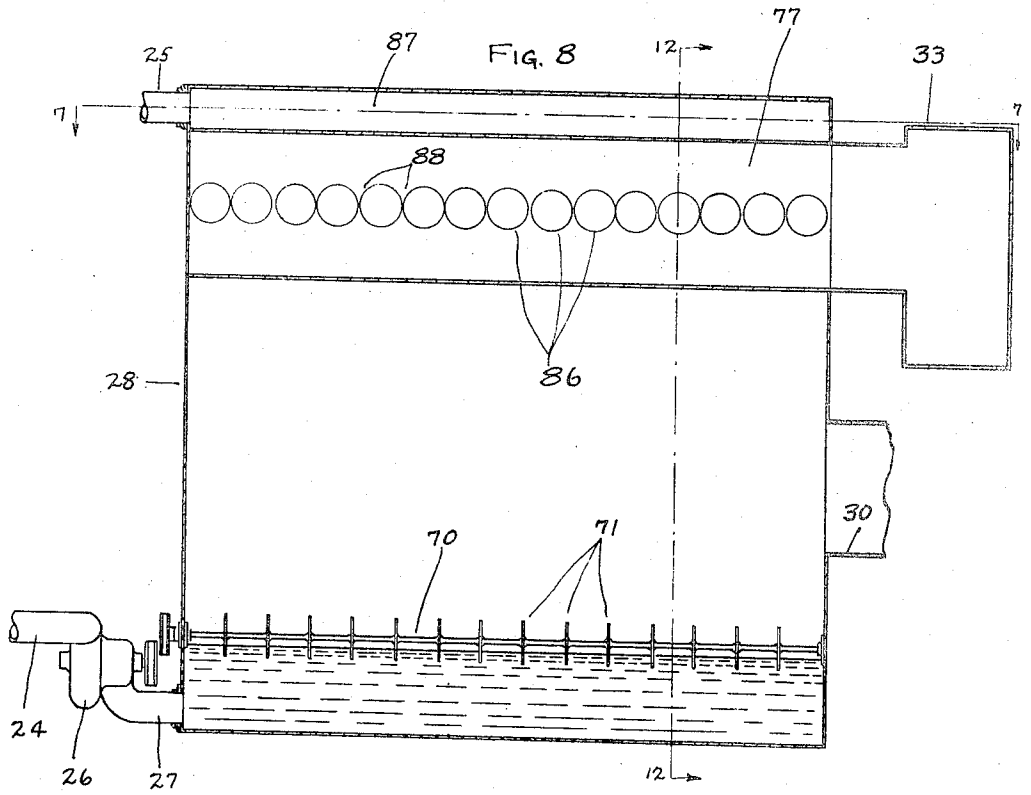


Fig. 8



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FIG. 9

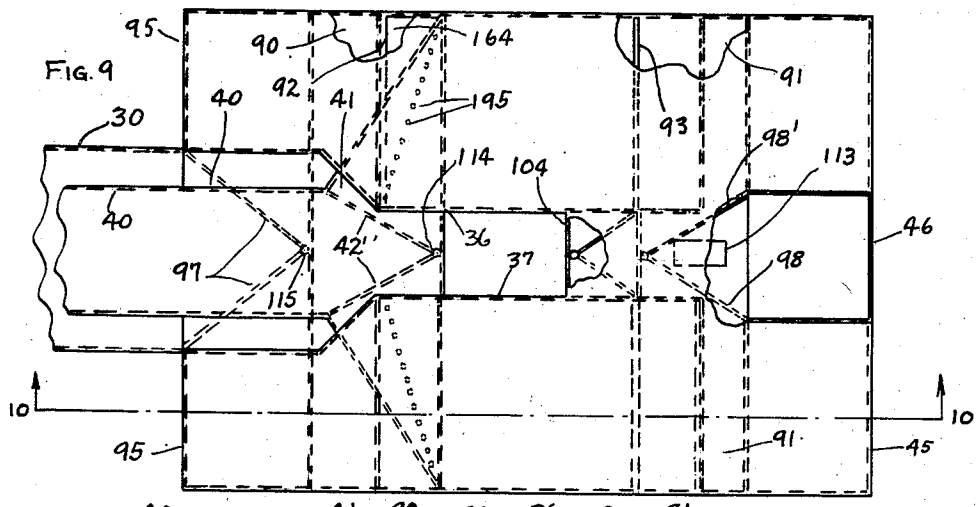


FIG. 10

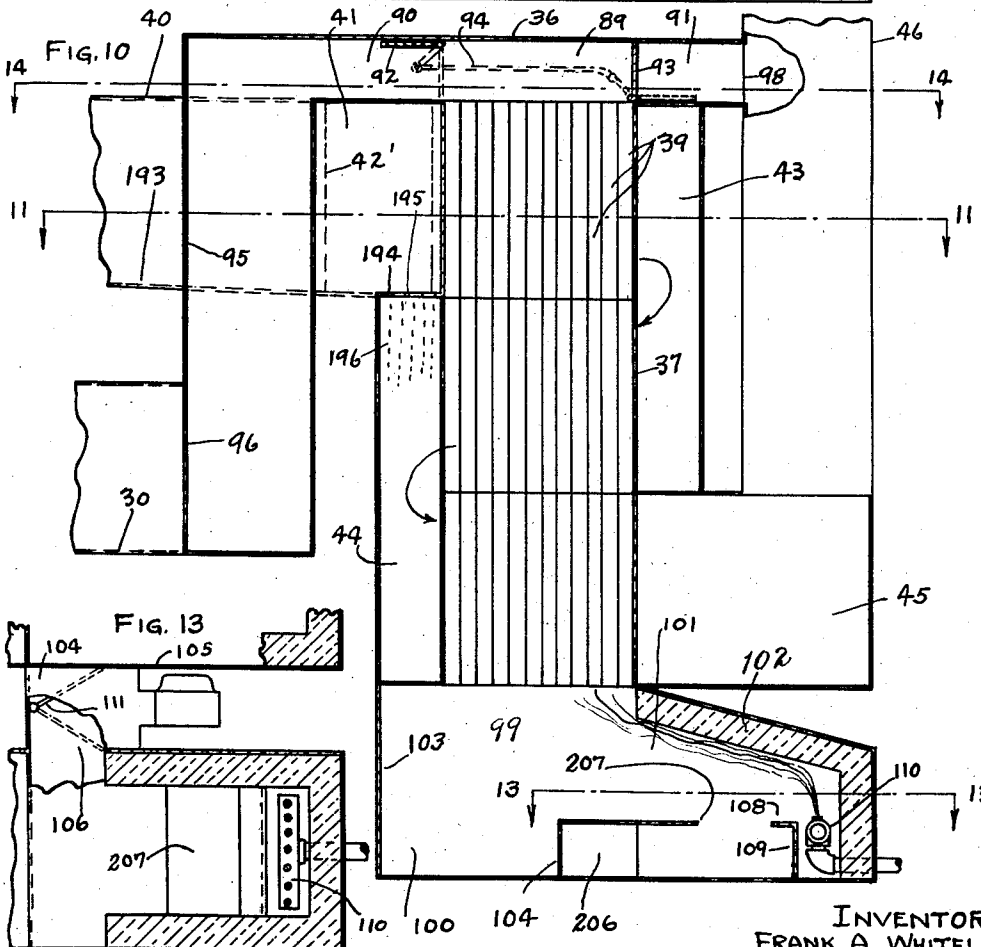


FIG. 13

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FIG. 11

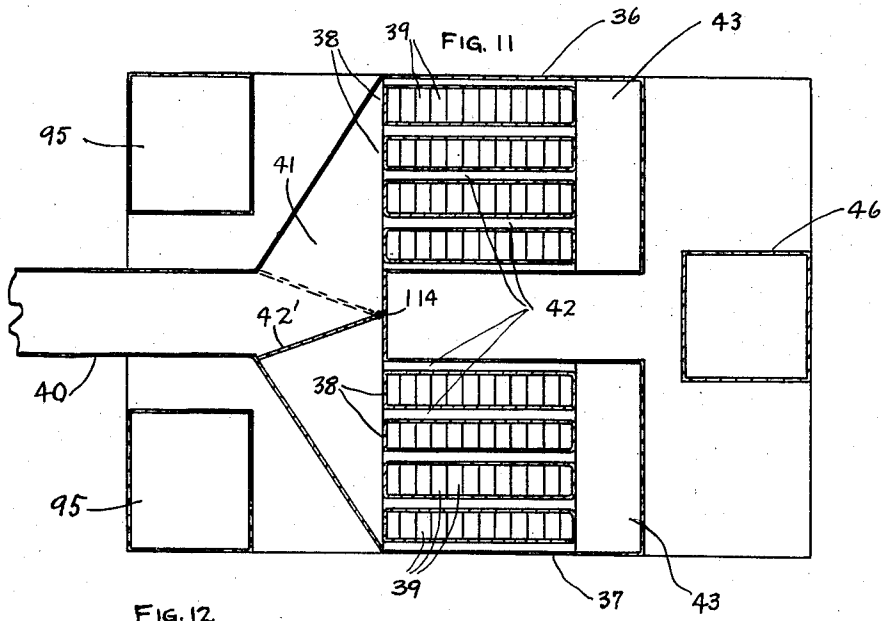


FIG. 12

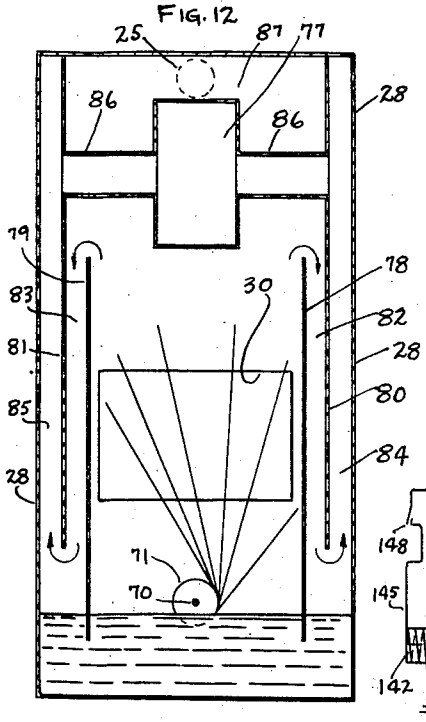


FIG. 14

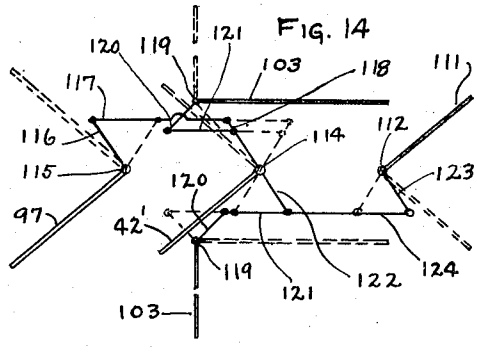
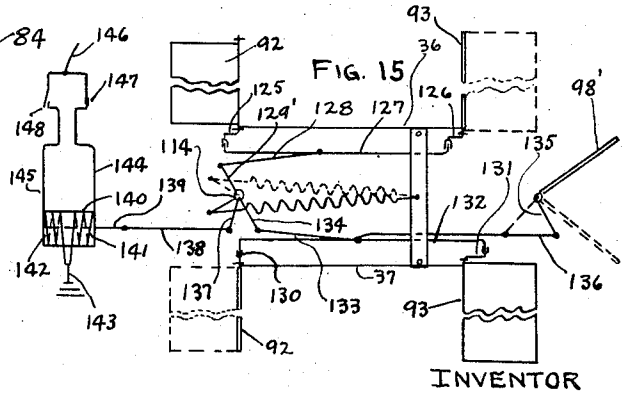


FIG. 15



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Patented Sept. 19, 1939 2,173,405

UNITED STATES PATENT OFFICE

2,173,405

METHOD AND APPARATUS FOR CONDITIONING AIR

Frank A. Whiteley, Minneapolis, Minn.

Application September 21, 1935, Serial No. 41,621

22 Claims. (Cl. 62—129)

My invention relates to a method and apparatus for conditioning air and has for its object to provide a novel process and means for cold-conditioning the air of rooms without the use of heat exchange by means of a compressor.

Broadly stated it is the object of the invention to circulate air to and from the rooms through a heat exchanger wherein the air is cooled and moisture removed therefrom by cold water circulating through passages in said heat exchanger, to cool said water in a hydrating chamber wherein air dried by passing through a dehydrating tower is circulated in contact with large surfaces of said water provided by spraying, splashing or other suitable means, said air being drawn through the dehydrating material in the tower and through the hydrating cooling chamber under negative pressure, and evaporating water in said cooling chamber under negative pressure, and to pass the air, so cooled by evaporation as the water in the hydrating chamber is correspondingly cooled, through heat exchanger passages in the dehydrating tower, whereby the air passing through the dehydrating material therein is cooled and the heat of dehydration extracted, and to discharge outdoors the air from the cooling chamber after so taking up the heat of dehydration and cooling the dried air. It will be understood that the term "negative pressure" as used herein means a pressure or pressures below atmospheric pressure at any point of use indicated by a gauge adjusted to show actual atmospheric pressure as zero at that point.

Specifically, a further object of my invention is to draw air through the dehydrating tower and the cooling chamber under very considerable negative pressure, both to cause said air to pass through a bed of sufficient extent of suitably small granules of dehydrating material to effectively dry the air, and to produce such negative pressure in the cooling chamber as materially to increase the rate and amount of evaporation therein correspondingly to increase the rate and degree of cooling of both the air and the water therein.

It is a further object of my invention to cause the cooled air from the hydrating chamber, wherein the water therein also is cooled by evaporation to the air, to be moved through heat exchanger passages adjacent passages holding the dehydrating material in the dehydrating tower to cool the dried air going therefrom and withdraw the heat of dehydration generated therein, and then to discharge the so heated air to outside the building.

It is a further object of my invention to provide in combination with the water circulation through the heat exchanger for cooling the air going to the rooms, a water air-pump located in the hydrating chamber and operating to draw air therefrom and through the dehydrating tower so as to produce a substantial negative pressure in the cooling chamber.

It is a further object of my invention to provide a plurality (preferably 2) of dehydrating towers with independent means operative to heat and purge the dehydrating material therein, together with means for controlling the air going to the hydrating chamber and the purging or reactivating of air, or air and combustion gas, going to the stack to be discharged outdoors, so that one of said hydrating towers will be in operation for drying air while the hydrating material in the other is reactivated.

It is a further object of my invention to provide control means for shifting the current of air for drying from one drying tower to the other, and for effecting the operation of reactivation over fixed periods of time of actual operation without regard to the total elapsed time.

Other, and all, of the objects and advantages of my invention will appear in connection with the detailed description thereof, and the features of novelty of my invention are hereinafter particularly pointed out in claims.

In the drawings, illustrating means for carrying out my invention,

Fig. 1 is a diagrammatic showing of the various steps of my process and arrangement of a preferred form of apparatus for carrying it into effect. Fig. 2 is a plan view of one arrangement of apparatus for carrying out my process. Fig. 3 is a longitudinal sectional elevation view taken on line 3—3 of Fig. 4 showing a preferred form of hydrating chamber and water air-pump for producing negative pressure in and moving air from the drying stack through the hydrating chamber. Fig. 4 is a transverse sectional elevation taken on line 4—4 of Fig. 3. Fig. 5 is a longitudinal sectional view of an arrangement of cold-air heat exchanger to be employed in connection with a hot-air furnace so as to use the same air-moving and distributing means to and from the rooms which are used for heating purposes. Fig. 6 is a section taken on line 6—6 of Fig. 5. Fig. 7 is a sectional plan view taken on line 7—7 of Fig. 8, showing a modified form of hydrating chamber. Fig. 8 is a longitudinal sectional elevation taken on line 8—8 of Fig. 7. Fig. 9 is a top plan view of duplicate dehydrating towers and with a section

of stack leading outdoors and connecting passageways. Fig. 10 is a sectional elevation view taken on line 10—10 of Fig. 9. Fig. 11 is a transverse sectional plan view taken on line 11—11 of Fig. 10. Fig. 12 is a transverse sectional elevation view taken on line 12—12 of Fig. 8. Fig. 13 is a fragmentary sectional plan view taken on line 13—13 of Fig. 10. Fig. 14 is a view part diagrammatic of the damper-shifting means viewed downwardly from line 14—14 marking the top boundary of the cooled-air duct 40. Fig. 15 is a similar view part diagrammatic of damper valve operating mechanism taken in plan from the top of the drying stack and ducts leading thereto and showing valve-operating means not shown in Fig. 14. Fig. 16 is a transverse sectional view in full detail of the tank for receiving condensed water from the room air heat-exchanger and for feeding water to the cooling chamber. Fig. 17 is a sectional plan view on line 17—17 of Fig. 16.

Means for circulating the air to, through and from the rooms may be a hot-air furnace as 10, Figs. 2 and 5, wherein pipes 11 convey heated air to the rooms and pipes 12, return said air to heater 10, the air being driven by the blower 13 within casing 10. Dampers 15 and 16 in said casing may direct the air to pass through a cold-conditioning heat exchanger 18, the arrangement being similar to that of my Patent No. 1,969,829, granted August 14, 1934. The heat exchanger 18 comprises a multiplicity of air legs 19 each embodying a large number of elongated air passages 20, the air passing through in one direction and back in the opposite direction on opposite sides of a partition 21, see Fig. 6. Header chambers 22 and 23 receive water from pipes 24 and 25, pipe 24 connecting with a centrifugal pump 26 which draws water through a pipe 27 from a cooling chamber 28 hereinafter to be described. The water circulates through the heat exchanger 18 up passageways 29 therein which flow along the sides of fin plate air legs 19.

This water is cooled in the cooling chamber 28 by the following means, shown diagrammatically in Figs. 1 and 2: Air is drawn into chamber 28 through an air duct 30 by means of an air-exhausting pump such as the water air-pump 32 of Figs. 1 and 3 or the pressure blower 33 of Fig. 2. The air comes through either one or the other of ducts 34 or 35 from one or the other of dehydrating towers 36 and 37, shown in detail in Fig. 11. Each of these towers comprises a heat exchanger arrangement similar to that for the cold-water heat exchanger shown in Fig. 6, embodying vertical air legs 38 with vertical fin plate passages 39 which are filled with granular dehydrating material such as alumina or silica gel. Drawing the air through these dehydrating towers, which may have from four to six feet or more of such dehydrating material, provides a substantial restriction to the flow of air which will, as the air-moving means is shown positioned, require a substantial negative pressure in the cooling chamber 28, varying as the volume of air passed varies, and increasing as that volume increases. This pressure with the water air-pump 32 may be made relatively very low, making possible use of comparatively fine granular dehydrating material in the vertical passages 39 and greatly increasing the evaporating capacity of the dry air contacting a water spray, as hereinafter described, within chamber 28.

Attempts heretofore made to cool water and air in a spray chamber by evaporating water in air dried by passing it through a bed of granular dehydrating material have proved ineffective for home heating, because large volumes of air must be saturated by such evaporation, and means to move such large volumes against the restriction of the granular dehydrating bed have been both very noisy and extremely expensive in great power consumption. As a result, although vast sums have been expended in attempts to develop air-cooling means for homes using beds of dehydrating materials such as silica gel or alumina, no practically successful home-cooling air-conditioner of that type has been produced. The difficulty has been that known applied blower mechanisms move the air by centrifugal action. Because of the comparatively imponderable mass of air particles terrific speeds are required to build up pressures of even two to five inches of water, while to move sufficient volumes of air through the necessary depth of hydrating beds requires pressures of from fifteen to twenty-four inches of water (either negative or suction pressures on one side of the bed, or positive or blowing pressures on the other). For such pressures speeds are so great that consequent ear-splitting noise and enormous power consumption prohibit use in home air-conditioning, or indeed for anything but in industrial processes where noise and cost of operation are not of controlling importance.

I have discovered that a modified application of the water-flow air-exhauster can be adapted in a home air-conditioning system to move the requisite volume of air through the dehydrator bed restriction without prohibitive noise or power consumption; and that this can be done by using the same pump and water line which is required to move the cooled water through the heat exchanger where the room-air is cooled and dehydrated. Moreover this will not only provide an ample volume of dried air moved into and through the cooling chamber, but, which is also important as an element of cooling, a substantial negative pressure in the cooling chamber.

Evaporation of water into this dried air under negative pressure cools both the air and the water. The cold water is used as hereinbefore described by passing it through the heat exchanger 18 by which the air going to the rooms is cooled. The current of air, which is also cooled in passing through chamber 28, is not employed directly for cooling the rooms, that is, said cooled air does not go to the rooms. It is an important feature of my process that I use this cooled air to cool the dry air coming from the dehydrating stack, and to remove the heat of dehydration from said stack. An air trunk 40 leads from water air-pump 32, Fig. 3, or blower 33, Fig. 2, to a valve chamber 41, Figs. 9 and 11, where a damper valve 42' directs said cooled air to go across one or the other of the dehydrating towers 36 or 37 through transverse passages 42 between the heat exchangers containing the dehydrating material in the vertical passageways 39. From chamber 41, as clearly shown in Fig. 10, the cold air passes across the upper third of the dehydrating heat exchangers to a transfer chamber 43. From chamber 43 the air passes back across the middle third of dehydrating heat exchangers to a second transfer chamber 44. From chamber 44 the air passes through the bottom third of the dehydrating heat exchanger to a chamber 45, from which a stack 46 will carry said air out-of-doors. It will be observed that in this triple passage of the cooled air from air-cooling chamber 28 across dehydrating heat exchangers in 36 or 37 said cooled air will become progressively

warmer. In its first passage it will take up the heat of the dried air going to the dehydrating chamber to a point where said air will have a temperature very much lowered over what said temperature would be without said cooling. In its second passage through the passageways across the heat exchangers containing the dehydating material, the air from the cooling chamber will remove more of the heat of dehydration. And in the third position it will remove still more heat of dehydration, by that time becoming quite warm. This warm air will then be passed out-of-doors, and constitutes literally a physical removal of the heat from the room or rooms which are being cold air-conditioned.

The cycle of operations by which this heat transfer is effected is as follows, reference being had to Fig. 1: In the cold water heat exchanger 18 the air from the rooms is cooled and the circulating water is made to absorb heat thus brought from the rooms, which raises the temperature of said water. This water with such raised temperature is then subjected in cooling chamber 28 to currents of dry air therein from one or the other of the dehydrating towers, said air in the cooling chamber preferably being under negative pressure. Large evaporation of water takes place within the cooling chamber, simultaneously saturating and cooling the air passing through it and cooling the water in the cooling chamber, that is, taking from the water heat removed from the rooms. The cooled air then passes through the dehydrating tower and cools the dried air and removes from the tower the heat of dehydration which is passed out-of-doors.

Various forms of cooling chamber, of means for moving air therethrough under negative pressure, and of creating a suitably large evaporating water surface within the cooling chamber, by spraying or other means, may be employed. As shown in Figs. 3 and 4, the water moved by pump 26, after passing through heat exchanger 18, is delivered by pipe 25 to a header 47. This header extends across the width of the casing forming the water air-pump 32, which, as shown in Figs. 3 and 4, is relatively wide and runs through the top 48 of cooling chamber 28 and down through said chamber to near the bottom thereof, forming within said casing a high, wide and shallow passageway 49. From the header pipe or chamber 47 the water passes through a long slot-opening 50 and descends under the force of the pump and of gravity through the passageway 49, which passageway has pressed in its back wall 51 a series of upwardly-turned openings 52 which open only into the interior of cooling chamber 28 and which have connection with the main body of said interior and with the air-inlet duct 30 through chamber 53 adjacent end wall 54 of cooling chamber 28 and through narrow passageways 55 and 56, Fig. 4, extending vertically along the sides of the water air-pump casing 32. The lower end of passageway 49 has its wall 51 curved as indicated at 57 and narrowed at 58 to extend the passageway 49 around the front wall of 32 to an upward discharge as indicated at 59. This upward discharge is within a chamber 60 formed by forward extensions of the side walls of 32 and by front walls 61 and 62 united therewith. A second vertical wall 63 forms a vertical passage 64 which is adapted to continue into passageway 40 as shown in Figs. 3 and 4. The curved portion 57 of back wall 51 at its lower edge is spaced a small distance from the bottom of cooling chamber 28 as indicated at 65.

The above-recited water air-pump construction operates as follows: The wide sheet of water rushing down through passageway 49 past the openings 52 to the interior of cooling chamber 28 drags air through said openings and carries it through the narrowed portion 58 and around to the upward discharge 59, where said air is thrown off at 66 into passageway 64 and is pushed through passageway 40, heat exchanger passageways 42 to dehydrating towers 36 or 37 and thence to the stack or outdoor discharge 46. The water is discharged from opening 59 into chamber 60, whence it passes through opening 65 under the curved bottom 57 of casing 32 into the bottom part of chamber 53, and from there said water passes through the lower portions 67 and 68 of vertical passageways 55 and 56 along the sides of cooling chamber 28 to mix with the main body of water therein, from which an extension of pipe 27, indicated at 69 in Fig. 4, draws water from the bottom central part of the water contained therein. In this way it is assured that the return water from room air heat-exchanger 18 will always be thoroughly mixed with all of the water in the cooling chamber 28 before going back to heat exchanger 18.

In the form of the invention of Figs. 3 and 4 in some cases it will not be necessary to form a separate spray of water in the cooling chamber 28, since the plunging of the air in the sheet of water in passageway 49 and through chamber 60 can provide, in such cases, a sufficient area of water surface for the desired amount of evaporation. In other cases, however, and particularly where it is desired to take advantage of the reduced pressure in cooling chamber 28 to produce increased evaporation, it will be advantageous to form a spray within the cooling chamber. This may be done in various ways. One way is to provide a shaft 70 with a multiplicity of discs 71 extending below the surface of the water toward the bottom of cooling chamber 28, as shown in Fig. 3, and also in Figs. 2 and 12. By suitable connection with a motor, as motor 72 of Figs. 1 and 7, through intermediate shaft connections and belt 73, the shaft 70 is driven at high speed. The discs 71 dragging through the water at the bottom at such high speed will throw a large volume of finely divided spray into the interior of cooling chamber 28. There is some advantage in forming a spray in this way over using pressure pumps and spray nozzles, both because it requires less power to produce a given amount of spray in this way, and, more important, because it involves no difficulties such as arise from the clogging of nozzles.

As shown in Fig. 2, the motor 72 through belt 74 may drive pump 26 and through belt 75 may drive blower 33, the air-inlet for blower 33 being a funnel member 76, Fig. 2, which connects with air trunk 77, Figs. 7, 8 and 12. In this form the air which goes into the cooling chamber 28 through port 30 from dehydrating tower 36 or 37 passes over the top edges of walls 78 and 79 which extend below the water level in chamber 28 and form in conjunction with other walls 80 and 81 passageways 82 and 83 from the lower part of which the air reverses into vertical passageways 84 and 85 extending along the side walls of the cooling chamber 28. The passageways 84 and 85 in turn are united by means of a multiplicity of tubular passageways 86 with the main withdrawal duct 77. The water is returned from pipe 25 upon the top into the space 87 immediately over the top of air duct 77, from which it flows along the

top thereof and spreads out sideways passing down through narrow openings 88 between the tubular passageways 86. This produces two advantageous results, first it passes the returned and warmed water over a relatively large heat-exchanger surface exposed to the cooled air leaving the cooling chamber 28 to go to the passages 42 between heat exchanger air legs containing the dehydrating material, and, second, it results in dripping the water down through the cooling chamber in a heavy spray for providing additional surface to aid in evaporation and cooling of the water.

As best shown in Fig. 10, the dried air from the dehydrating towers 36 or 37 goes to a top chamber 89 thereof which is adapted to open to a passageway 90 on one side, and a second passageway 91 on the other side. The passageway 90 is closed by a valve door 92 and the passageway 91 by a valve door 93. As indicated in dotted lines at 94 of Fig. 10, the valves 92 and 93 are linked together outside the casing in such manner that said valves are operated simultaneously one to open and the other to close communication between chamber 89 and the respective passageways 90 and 91. In the full-line position of Fig. 10, chamber 89 is open to passageway 90 and closed to passageway 91. There are of course two sets of passageways 90 and 91 for the two dehydrating stacks 36 and 37, and there will be a double arrangement of the linkage 94 operating the two sets of damper valves 92 and 93 simultaneously and in alternate order so that when valve 92 opens and valve 93 closes in stack 36, as shown in Fig. 10, valve 92 will close and valve 93 will open in stack 37.

Passageways 90 connect with vertical air legs 95, Figs. 10 and 11, and these in turn straddle the air leg 40 and connect laterally as indicated at 96 in Fig. 10 with the inlet air duct 30, there being a damper valve, indicated in its two positions in dotted lines at 97, in Fig. 9, which is operable simultaneously, and in the same direction with damper valve 42', also shown in dotted lines in its two positions in Fig. 9, whereby the air is directed to be drawn from one or the other of the vertical passageways 95 and one or the other of the dehydrating towers 36 or 37, while at the same time the cold return air is correspondingly directed by valve damper 42' to go through the heat exchanger passages 42 for cooling the dried air and withdrawing the released heat from the dehydrating tower.

As shown in Figs. 2, 9 and 10, the passages 91 open through a port 98 into stack 46, said port 98 being controlled by a damper valve 98' similar in operation and working simultaneously with valves 92 and 93, whereby port 98 will be closed to one chamber 91 and open to the other chamber 91 as shown in Fig. 8, with reverse action and effect when the air movement for dehydrating is shifted from dehydrating tower 36 to dehydrating tower 37.

As shown in Fig. 10, at the lower part of each dehydrating tower 36 and 37 is located a chamber 99 which is provided with a main air-inlet portion 100 and a fire chamber portion 101, the latter offset in each case from the dehydrating towers, heavily insulated and with a fire brick roof 102. The front of each inlet chamber is opened and closed by a damper valve 103 indicated in full position in Fig. 10 and in full positions in Fig. 14. The two valves are simultaneously operable in unison with damper valves 42', 92, 93, 97 and 98', valves 103 operating to open the respective inlet passages 100 at the same time that valves 97 and 92 open to permit air to be drawn through a dehydrating tower through passageways 95 and 30 to the cooling chamber, and that valve 42' directs the cooled return air to pass through the other set of heat exchanger passages 42. That is, valves 92, 97 and 103 operate simultaneously to put a circulating current of air through, say dehydrating tower 36, to dry that air. At the same time these valves, together with damper valve 93 and valve 98' into stack 46 operate to close off dehydrating tower 36 from all communication with the stack 46, and valves 42', 98 and 97 close all communication of dehydrating stack 37 with the air-drying circuit, and the valve 103 for stack 37 closes the chamber 99 to the air of the room, and valves 93 and 98' open hydrating tower 37 to discharge heated reactivating gases into stack 46.

Referring to Figs. 10 and 13, an air-box 104 is located adjacent side walls 105 and 106 of chambers 101 below dehydrating stacks 36 and 37 respectively, and said air-box 104 opens through ports 206 into both said chambers 101. At the bottom thereof and within a casing 107 in each chamber 101 and opening thereinto through a top port 207 is a casing 108 which also is provided with apertures 109 below the gas burner tube 110 to provide secondary air of combustion. A damper valve 111 pivoted at 112 operates alternatively to close one and open the other of the respective ports 206. As shown in Figs. 10 and 13 damper valve 111 is held to open air-box 104 through ports 206 and 207 to the chamber 101 where valve 103 has closed the passageway 100 leading to said chamber. A blower 113 at proper times delivers air into air-box 104 to pass through ports 206 and 207 to chamber 101 and mix with gases of combustion from burner 110 to produce the proper gas temperature going through the dehydrating material in dehydrating tower 36 or 37 to reactivate it, and after the burner is extinguished to complete the purging and removal of heat from said reactivated dehydrating material.

As shown diagrammatically in Figs. 14 and 15, all the damper valves are operated from the single vertical shaft 114. Damper 42' is connected directly to shaft 114. Damper 97 is fast on a stub shaft 115 having an arm 116 which is connected by a link 117 pivoted to an arm 118 fast on shaft 114 by which valve 97 is moved in correspondence with valve 42'. The valves 103 are secured to shafts 119 which carry fast thereon arms 120 connected by links 121 with oppositely-extended arms 122 fast on shaft 114 by which valves 103 are moved in opposite directions. The shaft 112 supporting valve 111 has fast thereon an arm 123 connected by link 124 with arm 122 whereby damper 111 is moved to open the port 106 at the same time that valve damper 103 is moved to close inlet passageway 100.

As shown in Fig. 15, fast on a pivotal support for valve 92 is a depending arm 125 and a similar depending arm 126 is fast on the supporting shaft of damper valve 93. These arms are pivotally connected at their ends to a link 127, which, in turn, is connected by a link 128 to an arm 129 fast on vertical shaft 114 for operating valves 92 and 93 of dehydrating stack 36. Correspondingly positioned, but operating in reverse order, the valves 92 and 93 of stack 37 are provided Fig. 15 with arms 130 and 131 fast on the shafts supporting valves 92 and 93 and pivotally connected by an intervening link 132 which is connected by link 133 with an arm 134 fast on shaft 114. An

arm 135 fast on the shaft of damper valve 98' is pivotally connected by link 136 Fig. 15 with the link 132, the valve 98' and its connections being so related to valve 93 and their connections that when chamber 91 is closed to chamber 89 at the top of stack 36 the chamber 91 will also be closed by valve 98' from port 98 leading to stack 46, as shown in Figs. 9 and 10. Conversely, at such times the chamber 91 of dehydrating stack 37 will at that time be open to both chamber 89 and stack 46. And, of course, the operations are reversed when dehydrating stack 37 is opened to the air circulation and closed to the stack 46.

As shown in Fig. 15, shaft 114 has fast thereon an arm 137 which is connected pivotally to a link 138, and that, in turn is pivotally connected to an armature 139 and a push-and-pull solenoid 140. The solenoid 140 is provided with double and reverse windings 141 and 142 going to a ground 143 on one side and connected respectively with feed wires 144 and 145. These are alternatively put in circuit with a main wire 146 by a switch operator which closes a circuit at 147 or 148 at properly-timed intervals. The switch operator, not shown, is of a type similar to that shown and disclosed in my patent, Number 2,011,787, granted August 20, 1935.

With this type of switch operator the shifting of the valves for controlling flows through the dehydrating stacks 36 and 37, the operation of the gas valves, not shown, for the burners 110, and the operation of blowers 13 and 113 and water pump 26 are controlled in synchronism, and for desired periods of time, such periods, however, being periods of operation, and not of elapsed time. The operation of the device is of course controlled by a thermostat. If it be assumed that dehydrating tower 36 or 37 is capable of completely drying air under most severe conditions for a period of two hours, and that one hour is requisite for reactivating the dehydrating material in the other dehydrating tower, the control would operate to continue air flow through the active dehydrating tower for a period of two hours of actual operation, regardless of the elapsed time, and through the inactive dehydrating tower for reactivating the material in it for a period of one hour of actual operation, the last hour, like the two-hour period, being of actual operation in reactivating regardless of elapsed time.

Supply of water to the cooling chamber 28 may be provided from two sources, first, as indicated somewhat diagrammatically in Fig. 5, water of condensation taken from the cooling air in heat exchanger 18 will gravitate through drain pipe 149 into a tank or receptacle 150 which is open to atmosphere at its top. A pipe 151 has its inlet end 152 located near the bottom of tank 150 back of a screen 153. The pipe 151 will enter chamber 28 at a point 154, see Figs. 3 and 4, which is sufficiently high so that the negative pressure created in the cooling chamber 28 will be sufficient to draw the condensation water from tank 150 when the water level therein, under pressure of atmosphere, rises to near the discharge of pipe 149, but not at a level much below that point. Thus, if it be assumed that a negative pressure of eighteen inches of water is created in cooling chamber 28, the distance from inlet 154 of pipe 151 to that water level slightly below discharge pipe 149, indicated at 155, would be eighteen inches. In this manner the condensation water from heat exchanger 18, which is practically mineral-free, filtered of materials washed from the air going to the rooms, will be transferred to the evaporating cooling chamber 28. In the event that more water of condensation should be thus introduced into cooling chamber 28 than is evaporated therefrom, which might occur on very humid days, means is provided for removing such excess water. To accomplish this a pipe 167 has its open lower end 168 near the bottom of chamber 60 and its upper end opening at 169 into passageway 64, where the air will be at substantially atmosphere pressure, and is provided with an opening 170 into the interior of the cooling chamber 28. From pipe 167 a branch pipe 171 leads to the sewer or any suitable receptacle, not shown. Since the space in pipe 167 above the water level is open to both atmosphere pressure and the negative pressure within cooling chamber 28, the reduced negative pressure will have no effect upon the level of water in pipe 167, which will always represent the true water level in cooling chamber 28. Hence, whenever that level rises to the discharge opening 172 of pipe 171 water will flow under normal gravity action through said opening into discharge pipe 171 and out of the system.

As there might be more water evaporated from cooling chamber 28 than would thus be supplied by condensation in heat-exchanger 18, additional water from any source may be supplied from a water pipe 173 or in alternation water pipe 174, Figs. 4 and 16. In one form this water is admitted by a valve 174' in a zeolite chamber 175 within chamber 28 preferably formed with a reticulate bottom 176. The valve 174' is controlled by a float 177 pivoted at 178 and operating through a link 179 and rocking lever 180 to open and close valve 174' in response to changes in the level 181 of the water in cooling chamber 28. For convenience in taking care of the zeolite for regeneration, and also for cleaning accumulations of matter carried from the room-air heat-exchanger by water condensed therein, I provide the tank construction shown in Figs. 16 and 17, which may be understood is the same which is shown diagrammatically in Fig. 5.

In this arrangement a basket or receptacle 182 Figs. 16 and 17 is removably held within the tank casing 150, alongside of the removable dirt-collecting receptacle 183, which receives condensed water from the room-air heat exchanger from pipe 149. Tap water may be delivered to the zeolite receptacle 182 by pipe 174 from a nozzle 184 connected therewith, and the water after passing through the zeolite in receptacle 182 will pass through apertures at the bottom thereof from which the water may flow along the bottom to the space 186, from which the pipe 151 is caused by negative pressure to deliver the water within cooling chamber 28. The flow of this water through pipe 174 is controlled by valve 187 connected with a supply pipe 188 Fig. 4, and the valve is controlled by a pivoted float 189 connected by a link 190 with valve arm 191. In this manner, when water level 181 in the cooling chamber 28 falls, tap water from the city system will be supplied, being caused first to pass through the zeolite in receptacle 182. It will be obvious that the receptacles 182 and 183 can readily be withdrawn, the former to be given a bath of salt brine for regenerating of the zeolite and the latter to have the collected dirt washed therefrom.

As clearly shown in Figs. 3 and 4, it will be noted that the bottom wall 193 of cold-air duct 40 has a downward slope. This is provided be-

cause evaporation in cooling chamber 128 takes place at reduced pressure and the air passing through the water air-pump channel 49 will be saturated with moisture at that reduced pressure, consequently when said air reaches the conduit 40 at atmospheric pressure it may release some of its contained moisture, rising in temperature at the same time, until it produces a balance of temperature and dew-point at atmospheric pressure. This release of moisture will be in the form of a mist, which will be carried into conduit 40 and there may sufficiently condense to accumulate on the sloping floor 193 of the conduit. This moisture will flow along the slope of the floor above the passageway 44, Fig. 10, of whichever hydrating tower 36 or 37 may then have the return air current passing through it. The upper wall 194, Fig. 10, and Fig. 9, shown in dotted lines, is provided for each dehydrating tower with a diagonally-disposed line of perforations 195 through which said water of condensation is caused to spray down into chamber 44, as indicated in Fig. 10 at 196. As the air passing into and through chamber 44 has been very considerably warmed through contact with the air-leg walls of heat-exchanger passages 42, this heat will reevaporate the water so sprayed, effecting further cooling of the air by latent heat of evaporation, and, in turn, producing increased heat removal in the final passage through the bottom set of heat-exchanger passageways 42, so that all the moisture of condensation will be evaporated and pass outdoors and will be effective in doing the work and accomplishing the result of my process.

The advantages of my invention will be apparent from the foregoing description. The effect of the entire process will be literally to withdraw heat from the rooms and pump it out-of-doors, in the air which has been first cooled in the cooling chamber and then heated in the dehydrating stack by withdrawing therefrom the heat of dehydration. The transfer of heat from the rooms is, of course, effected through the circulation of the water cooled in the cooling chamber through the room-air heat exchanger. A sufficient volume of air is caused to move through the granular material in the dehydrating stack by reason of the fact that the water air-pump pulls the air through the stack and through the dehydrating chamber and pushes it out by means of a positive action, the effectiveness of which is well-known but which never has been applied to the uses of my process. An enormous advantage from home heating comes from the fact that the water air-pump is an adjunct of the circulating of the cold water through the room-air heat-exchanger and the power necessary for a domestic installation is relatively very small, only a small fraction of the power required for cooling with a compressor. The cost of the apparatus for carrying out the process is reasonable, since it is composed largely of sheet metal, and the very low cost of operation will bring the process and apparatus within the means of ordinary householders for cold air-conditioning, so that there may be all-year-round air-conditioning in homes of moderate cost.

I claim:

1. A method of conditioning air for rooms which consists in cooling, and dehydrating by circulating water, a current of air going to the rooms out of contact with said water, cooling the water by evaporation in dry air circulated in contact with said water, drying said last-named air by circulating it through dehydrating material before it contacts the water, removing the heat of dehydration from the dried air and dehydrating material by the same air after it has gone through the evaporating water-cooling step, and then discharging said last-named air outdoors.

2. A method of conditioning air for rooms which consists in cooling, and dehydrating by circulating water, a current of air going to the rooms out of contact with said water, cooling the water by evaporation in dry air circulated in contact with said water, drying said last-named air by circulating it through dehydrating material before it contacts the water, removing the heat of dehydration from the dried air and dehydrating material by the same air after it has gone through the evaporating water-cooling step, then discharging said last-named air outdoors, and adding the water condensed from the room air to the original supply of water to replace water taken therefrom by evaporation.

3. A method of conditioning air for rooms which consists in cooling, and dehydrating by circulating water, a current of air going to the rooms out of contact with said water, cooling the water by evaporation in dry air circulated in contact with said water, producing in the circulating air while it contacts said water a substantial negative pressure, drying said last-named air by circulating it through dehydrating material before it contacts the water, removing the heat of dehydration from the dried air and dehydrating material by the same air after it has gone through the evaporating water-cooling step, and then discharging said last-named air outdoors.

4. A method of conditioning air for rooms which consists in cooling, and dehydrating by water, a current of air going to the rooms out of contact with said water, circulating the water under pressure for effecting said air-cooling and dehydration, cooling said water by evaporation in a voluminous current of air passed in intimate contact with the water and at a substantial negative pressure and using said water as so circulated for causing said current of air and creating said negative pressure.

5. A method of conditioning air for rooms which consists in cooling, and dehydrating by water, a current of air going to the rooms out of contact with said water, circulating the water under pressure for effecting said air-cooling and dehydration, cooling said water by evaporation in a voluminous current of air passed in intimate contact with the water and at a substantial negative pressure using said water as so circulated for causing said current of air and creating said negative pressure, drying said last-named air by circulating it through dehydrating material before it contacts the water, removing the heat of dehydration from the dried air and dehydrating material by the same air after it has gone through the evaporating water cooling step, and then discharging said last-named air outdoors.

6. A method of conditioning air for rooms which consists in cooling, and dehydrating by water, a current of air going to the rooms out of contact with said water, cooling the water by evaporation of air circulated in contact with said water, producing in the circulated air while it contacts said water a substantial negative pressure, and through said negative pressure causing the water condensed from the room air to be added to the original supply of water to replace water taken therefrom by evaporation.

7. An air-conditioning apparatus comprising a cooling chamber containing a supply of water, means for admitting air to said chamber including dehydrating means which produces a predetermined flow restriction, a passageway for removing air from said chamber, and a water air-pump in said passageway for causing the air to be removed from said chamber in contact with the water of said air-pump at such a rate of flow in relation to said inlet restriction as to create substantial negative pressure in the cooling chamber.

8. An air-conditioning apparatus comprising a cooling chamber containing a supply of water, a dehydrating tower containing granular dehydrating material which will effect a restriction of flow of air therethrough, means for passing air from said dehydrating tower after it has gone through the dehydrating material into the cooling chamber, a passageway for removing air from said chamber, and a water air-pump in said passageway for causing the air to be removed from said chamber in contact with the water of said air-pump at such a rate of flow in relation to the inlet restriction of the dehydrating material as to create substantial negative pressure in the cooling chamber, and to evaporate enough water to sufficiently cool said supply of water.

9. An air-conditioning apparatus comprising a cooling chamber containing a supply of water, a dehydrating tower containing granular dehydrating material which will effect a restriction of flow of air therethrough, means for passing air from said dehydrating tower after it has gone through the dehydrating material into the cooling chamber, a passageway for removing air from said chamber, a water air-pump in said passageway for causing the air to be removed from said chamber in contact with the water of said air-pump at such a rate of flow in relation to the inlet restriction of the dehydrating material as to create substantial negative pressure in the cooling chamber, air-conveying heat-exchanger passageways across the dehydrating tower, and means for causing the air moved from the cooling chamber to go through said last-named passages and discharge outdoors to remove the heat of dehydration from the dried air and dehydrating material.

10. In air-conditioning apparatus, an evaporating cooling chamber for containing a quantity of water, a heat-exchanger for conditioning the air of the rooms, a pump and pipe connections for circulating said water under pressure through the heat-exchanger and back to the cooling chamber, a wide, shallow passageway receiving said water at its top and having openings into the air-cooling chamber, means for causing said water to be thrown through said passageway in a wide, high sheet, then to be reversed in direction whereby it will draw large volumes of air through said cooling chamber and openings and into said passageway, and means associated with the said passageway for conveying said air from the cooling chamber.

11. The step in the method of conditioning air for rooms by circulating water under pressure out of contact with said air but in heat exchange therewith and which water is cooled by evaporating a portion thereof in a current of air dried by means which restrict the flow of said air, which consists in causing the return portion of the circuit of said water to descend in a wide and high sheet within an enclosure which admits said restricted air-flow to contact said sheet, whereby is created substantial negative pressure in the enclosure thereby causing said current of air to move through said restricting means to and through the enclosure in large enough volumes so evaporation therein will sufficiently cool the circulating water.

12. An air-conditioning apparatus comprising a cooling chamber containing a supply of water, means including a multiplicity of disks rotating in contact with said water for filling the chamber with water spray, a stack leading outdoors, a dehydrating tower containing granular dehydrating material with passages through it opening to the stack, a room-air heat-exchanger, means to circulate water from said supply through said heat exchanger and back to the cooling chamber, and means associated with the return flow of said water circulation, whereby it will cause large volumes of air to move through said granular material, to and through the cooling chamber and through said passages to the stack.

13. An air-conditioning apparatus comprising a cooling chamber containing a supply of water, means including a multiplicity of disks rotating in contact with said water for filling the chamber with water spray, a stack leading outdoors, a dehydrating tower containing granular dehydrating material with passages through it opening to the stack, means to circulate water from the supply at the bottom of said cooling chamber and return it at the top thereof, and means controlling said return flow whereby it will be made to cause large volumes of air to move through said granular material, to and through the cooling chamber and through said passages to the stack.

14. An air-conditioning apparatus comprising a cooling chamber with means therein for filling it with water spray, a stack leading outdoors, a dehydrating tower containing granular dehydrating material with passages through it opening to the stack, means to circulate water from the supply at the bottom of the cooling chamber and return it at the top thereof, and means controlling said return flow whereby it will be made to cause large volumes of air to move through said granular material, to and through the cooling chamber and through said passages to the stack.

15. In air-conditioning apparatus means for drying air including a container holding a body of granular material such as silica gel which forms a restriction to flow of air therethrough, a closed chamber having air-duct connection with said container and adapted to contain a body of water, a pump for withdrawing water at the bottom of said chamber and returning it into the chamber at the top so as to form a descending stream, and means controlling the flow of air going through said chamber to cause it to be subjected to the action of said descending stream of water so that said descending stream will act upon said air to cause it to move in large volume through said granular material in the container to be dried thereby.

16. A method of conditioning air for rooms which consists in cooling, and dehydrating by circulating cold water, a current of air going to the rooms out of contact with said water but in heat exchange therewith, cooling the water by evaporation in dry air circulated in contact with the water, and preliminarily cooling said last-named air before it enters into contact with the water by subjecting it to heat exchange with the

same air after it has gone through the evaporating water-cooling step, and then discharging all of said last-named air outdoors.

17. In an air-conditioning apparatus, an evaporating cooling chamber adapted to contain a quantity of water, means for producing a current of air through the cooling chamber so as to cause it to contact the water therein whereby both water and air are cooled, a heat exchanger through which said current of air passes in going to the cooling chamber, means for causing all the air of said current after it leaves the cooling chamber to go through said heat exchanger and preliminarily cool said current of air and thereafter discharge outdoors, a heat exchanger for cold conditioning the air of rooms, and means for contacting said heat exchanger with the cooled water to effect said cold conditioning.

18. In an air-conditioning apparatus, an evaporating cooling chamber adapted to contain a quantity of water, means for producing a curent of air through the cooling chamber so as to cause it to contact the water therein whereby both water and air are cooled, a heat exchanger through which said current of air passes in going to the cooling chamber, means for causing all the air of said current after it leaves the cooling chamber to go through said heat exchanger and preliminarily cool said current of air and thereafter discharge outdoors, and means contacted by said cooled water for cold conditioning the air of rooms.

19. In an air-conditioning apparatus, an evaporating cooling chamber adapted to contain a quantity of water, means for forming a spray of said water in said cooling chamber, means for producing a current of air through the cooling chamber and through said spray so as to cause it to contact the water therein whereby both water and air are cooled, a heat exchanger through which said current of air passes in going to the cooling chamber, means for causing all of the air of said current after it leaves the cooling chamber to go through said heat exchanger and preliminarily cool said curent of air and thereafter discharge outdoors, and means contacted by said cooled water for cold conditioning the air of rooms.

20. The step in the method of conditioning air for rooms by circulating water under pressure out of contact with said air but in heat exchange therewith and by cooling said water by evaporating a portion thereof in a current of air which has been dried by passing it through dehydrating material, which consists in removing the heat of dehydration from the dried air and dehydrating material by heat exchange with said current of air after it has cooled the water and has itself been cooled by evaporation.

21. In combination, a chamber for containing a quantity of water, a passageway formed to extend through the top to substantially below the level of said water in the bottom of the chamber and formed with openings into the chamber, a pump and pipe connections circulating water under pressure by withdrawing it from the bottom of said chamber and introducing it into the top of said passageway, an air discharge duct extending from below the surface of said water to outside the chamber, and means at the bottom of said passageway opening into said duct for reversing the direction of flow of the water, whereby the movement of water through the passageway will draw large volumes of air through said openings into said passageway against negative pressure within the chamber and will discharge said air through said duct against positive pressure outside the chamber.

22. In combination, a chamber for containing a quantity of water, a passageway formed to extend from the top to substantially below the level of said water in the bottom of the chamber and formed with openings into the chamber, said passageway extending substantially across the width of the chamber and being shallow relative to its width and having openings along its greater dimension into the chamber, a pump and pipe connections circulating said water under pressure by withdrawing it from the bottom of said chamber and introducing it into the top of said passageway, means for causing said water to be thrown through said passageway in a high, wide sheet, an air discharge duct extending from below the surface of said water to outside the chamber, and means at the bottom of said passageway opening into said duct for causing the sheet of water to reverse in direction, whereby the movement of water through the passageway will draw large volumes of air through said openings against negative pressure within the chamber and will discharge said air through said duct against positive pressure outside the chamber.

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