

Oct. 21, 1941.

J. R. BALLARD

2,259,541

AIR CONDITIONING APPARATUS

Filed Dec. 15, 1937

3 Sheets-Sheet 1

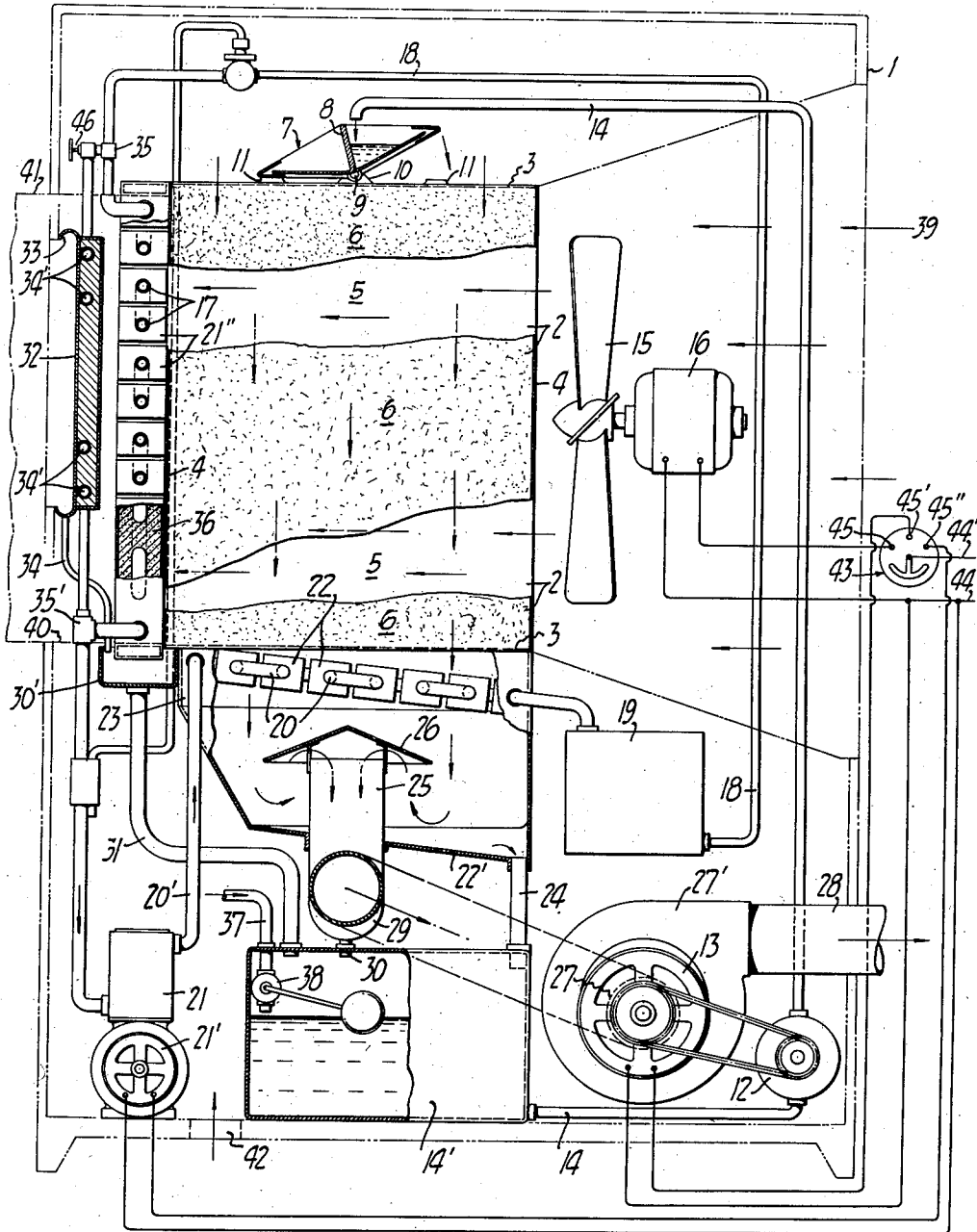


FIG. 1

INVENTOR.

John R. Ballard

BY

Boyer & Moller

ATTORNEYS

**Oct. 21, 1941.**

**J. R. BALLARD**

**2,259,541**

## AIR CONDITIONING APPARATUS

Filed Dec. 15, 1937

3 Sheets-Sheet 2

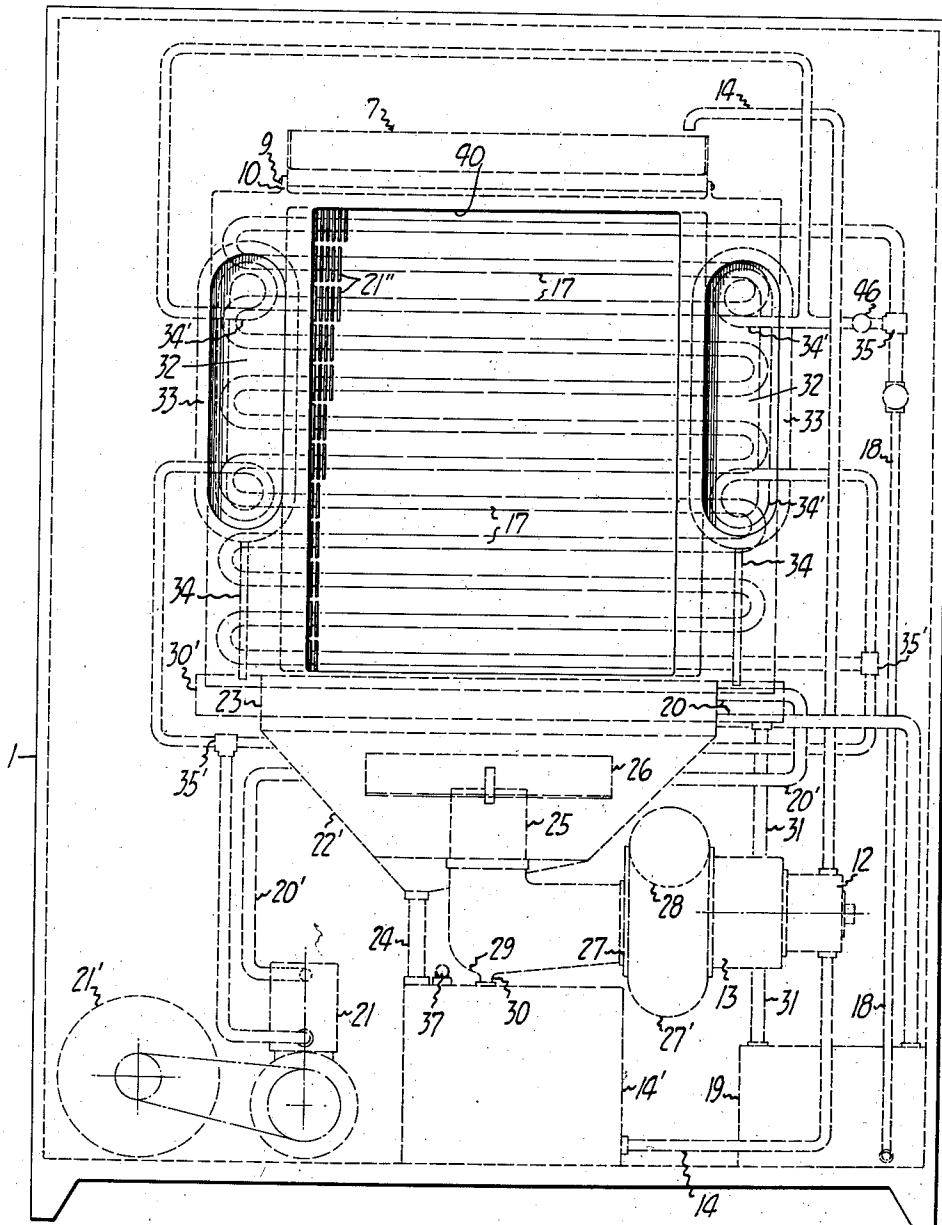


**FIG. 2.**

*BY*

INVENTOR.  
John R. Ballard  
Boyer & Mohler  
ATTORNEYS

Oct. 21, 1941.

J. R. BALLARD

2,259,541

AIR CONDITIONING APPARATUS

Filed Dec. 15, 1937

3 Sheets-Sheet 3

FIG. 3

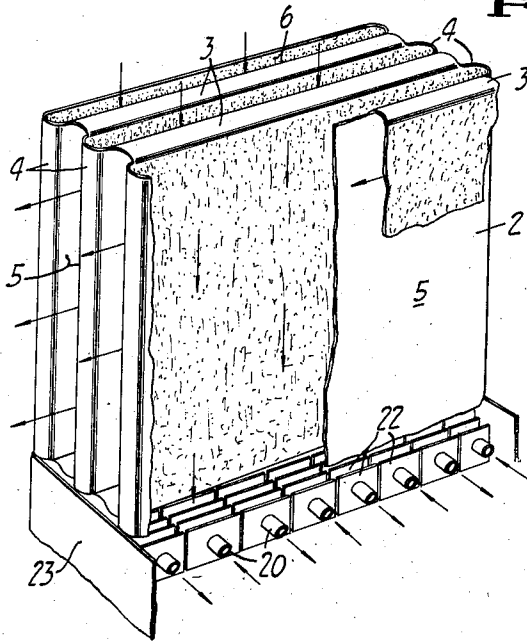


FIG. 4

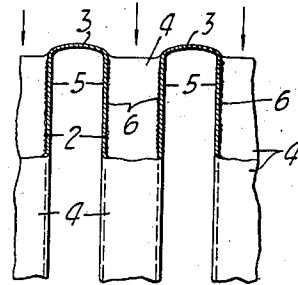


FIG. 5

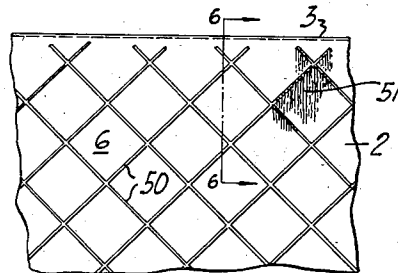


FIG. 7

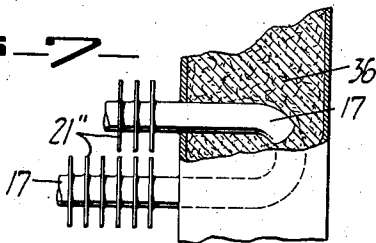


FIG. 8

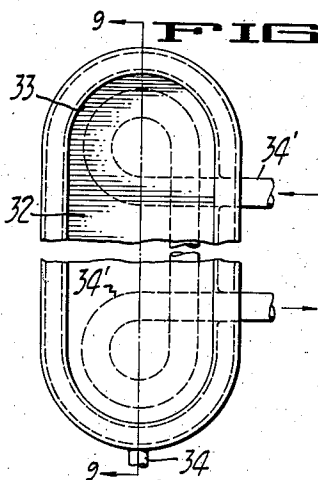


FIG. 6

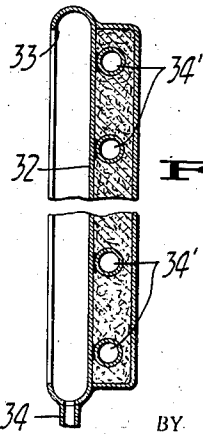
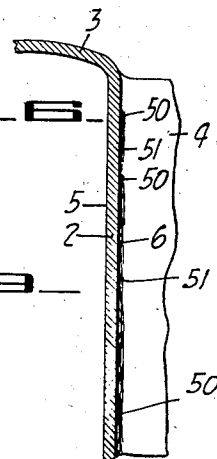


FIG. 9



INVENTOR.  
John R. Ballard  
Boyer & Mohler  
ATTORNEYS

## UNITED STATES PATENT OFFICE

2,259,541

## AIR CONDITIONING APPARATUS

John R. Ballard, San Francisco, Calif.

Application December 15, 1937, Serial No. 179,939

7 Claims. (Cl. 62—129)

This invention relates to apparatus and method for conditioning air and has for its objects the provision of air conditioning apparatus adapted to function more economically than heretofore in cooling the air in a room, in which apparatus the elements thereof are arranged and adapted to effect a pre-cooling of air before ejection of the air into the free atmosphere in the room, and before a final cooling of such air by a refrigerant cooling coil and at the same time to effect a transfer of heat from the condensing unit in the refrigerant line to air for ejection of the heat laden air from the apparatus and away from the room to be cooled thus relieving the compressor in the condensing unit of an excessive load with the resultant increase in the efficiency of the apparatus for cooling air. Another object of the invention is to provide simple, efficient means for reducing the relative humidity in the air where undesirable moisture is present and a still further object is the provision of apparatus of the character described, adapted to be placed within the room wherein the air is to be cooled or which apparatus may be placed at a point remote from such room, if desired, and the conditioned or cooled air conducted to the room. A still further object is the provision of moisture evaporation means for effecting the pre-cooling of the air and for cooling the condenser coil. Other objects and advantages will appear in the specification, drawings and claims annexed hereto.

In the drawings,

Fig. 1 diagrammatically illustrates my improved apparatus, with certain elements broken away and in section for clarity.

Fig. 2 is a front view of my apparatus in elevation, showing the general arrangement of some of the elements in dotted line within a cabinet, this view being semi-diagrammatic.

Fig. 3 is a fragmentary perspective view, partly in section, of the pre-cooling plates in the apparatus, with the condenser coils indicated below the plates.

Fig. 4 is an enlarged view of several of the plates, partly in section.

Fig. 5 is a fragmentary elevational view of one side of a portion of one of the plates of Fig. 2, before the fibrous absorbent material is placed on the same, but showing the lines where adhesive is applied.

Fig. 6 is a greatly enlarged sectional view taken along line 6—6 of Fig. 5 with the absorbent material in place on the plate.

Fig. 7 is a view partly in section, of one of the

return bends of the cooling coil, showing the same embedded in insulation.

Fig. 8 is a front elevational view of one of the condensing plates for de-humidizing the air.

Fig. 9 is a sectional view taken along the line 9—9 of Fig. 8.

Briefly described, heretofore the cooling of room air, has been accomplished by passing the air over cooling coils, and into a room, generally as described in my United States Patent No. 2,099,188, dated November 16, 1937, or by passing the air through passages cooled by evaporation of moisture on the outer sides of such passageways, such, for example, as is shown in my co-pending application for Letters Patent Ser. No. 133,742, filed July 5, 1934, now Patent No. 2,107,280. My invention, as hereinafter described, combines the two above methods in a manner whereby the air in the latter instance used for evaporating the moisture on the outer sides of the passageways is utilized to cool the condenser in a refrigerant line while the air passing through the passageways and cooled therein encounters the cooling coil in the refrigerant line with its "top heat" removed, and then passes over the cooling coil and into the room, thereby appreciably increasing the efficiency of the cooling coil throughout its length for uniformly cooling the air and at the same time relieving the compressor of a great deal of its load in compressing the refrigerant. For example, with my arrangement, a  $\frac{1}{4}$  H. P. motor on the compressor readily takes care of the load formerly required by a  $\frac{1}{2}$  H. P. motor where the air is not pre-cooled before passing over the cooling coils and where the refrigerant condenser is merely cooled by blowing room-air directly over the same in the conventional manner.

In detail, my apparatus comprises a casing 1, indicated by dot-dash line in Fig. 1, and in full line in Fig. 2, in the upper portion of which is mounted a plurality of spaced vertically disposed, relatively thin plates 2, such as copper plates or others having high heat transfer efficiency. These plates, as indicated in Figs. 3, 4 are in pairs with the alternate pairs of plates connected at their upper and lower edges by metal strips 3, and at their opposite side edges by strips 4, the strips 4 being disposed alternately relative to strips 3, thus the top and bottom strips 3 form narrow upper and lower sides of open ended horizontally extending passageways 5 and the side strips 4 form narrow side walls for vertically extending open ended passageways 6 (Fig. 4), the

plates 2 forming common partition walls between the horizontal and vertical passageways.

The outer sides of plates 2, relative to the inner surfaces of passageways 5, form the inner sides of passageways 6, and are preferably substantially covered with a very thin coating of absorbent material such, preferably, for example, as cotton fibers or similar absorbent material, secured to the plates by a waterproof adhesive, as later described in detail, or fabric may be used as shown in my co-pending application, above mentioned. The inner surfaces of passageways 5 are uncovered, and consequently water or other liquid discharged over the upper ends of plates 2 and onto strips 3, will readily spread in a thin sheet over the fibrous material on the inner sides of the passageways 6, which constitutes the outer-sides of passageways 5, and any excess moisture will drop from the lower ends of the passageways, while the inner surfaces of passageways 5 will remain dry.

To effect moistening of the fibrous material and the inner surfaces of passageways 6, I pivotally mount at its ends an elongated trough 7 over the upper ends of passageways 6, extending transversely of the upper edges of the plates 2 and strips 3, and about midway between the side edges of the plates, which trough is generally of V-shape in cross-section and is centrally divided, longitudinally thereof, by a partition 8 (Fig. 1), extending upwardly from the apex of the V, thus dividing the trough into two parts. The horizontal pivots 9 at the ends of the trough are disposed at the apex of the trough bottom, and are supported in brackets 10 secured to the end plates of the row of plates 2, whereby the trough is free to rock from one side to the other, and soft bumpers 11, such as of rubber, are positioned on 3 at opposite sides of the trough to engage one or the other sides of said trough when the same is rocked to one side or the other. The pivots 9 are disposed relative to the trough and to the upper ends of plates 2 so that the side of the trough engaging the bumper at one side or the other, is inclined downwardly to spill out the water in the side of the trough so engaging the bumper over its outer edge while the portion of the trough between the other side of partition 8 is elevated and in a position to hold water. The outer edges of said trough sides preferably project into the open side of V-shaped strips, the apex of the V being outwardly relative to the free edges of the trough so that part of the water will splash over the strip when the trough is first tilted and the remainder will be deflected by the strip inwardly toward the underside of the trough so as to effect a complete moistening of the plates at one side or the other of the trough.

A water or liquid pump 12 of any suitable character, operated by a motor 13, pumps water through a pipe 14 from a water supply tank 14' for ejection into the portion of trough 7 that is positioned to hold water, and as soon as the weight of the water in said portion overbalances the weight of the opposite, emptying side of the trough, the trough will rock to empty the filled portion and to position the now empty other portion thereof for filling with water. Thus the trough automatically rocks from side to side, and thereby intermittently moistens the fibrous covered sides of plates 2.

Air outside the apparatus is blown horizontally through the passageways 5 from one end and out of the other end by means of a conventional air fan 15 actuated by an electric motor 16 (Fig. 1),

and positioned across the outlet or discharge ends of the passageways is a refrigerant evaporator, or expansion coil, hereinafter termed a "cooling" coil, which coil consists of a plurality of parallel, spaced runs of pipe 17 connected at their ends by return bends, to form a continuous pipe line, the refrigerant inlet to the coil being at one end of the top run of pipe where the pipe connects with a smaller diameter pipe 18 leading from a refrigerant receptacle or supply 19. Receptacle 19 connects with one end of a condenser coil 20 which coil is formed of spaced parallel runs of pipe extending across the lower ends of passageways 6, and the opposite end of the condenser coil connects by a pipe 20' with the "high," side of compressor 21, which compressor is connected with the opposite end of the cooling coil 17 at one end of the lower run of said coil. Thus the circulatory system of the refrigerant, which refrigerant may be methyl chloride, or any other of the well known fluid refrigerants.

The runs of pipe in the cooling coil are provided with the conventional spaced fins 21' for increasing the heat transfer surfaces of the pipes of the coil, the fins being disposed substantially parallel with the directional flow of air through passageways 6. Also similar fins 22 may be provided on the runs of pipe on condenser coil 20.

Below the condenser coil 20 is a receptacle 22' having a bottom and sides, the latter extending upwardly from the edges of the bottom to connect with the sides of a frame 23 that extends around the condenser coil substantially in the plane of the latter, although I prefer that the condenser coil be slightly tilted downwardly in a direction from the end run of pipe connecting with the compressor toward the end run of the pipe that connects with the refrigerant receptacle 19 so that the condensed refrigerant will drain by gravity into the receptacle. The frame 23 connects between the sides of the receptacle 22' and the lower end of the assembly of plates 2 around the outer dimensions of the lower end of the plate assembly so that all the excess moisture from the plates will drop into the receptacle, from which receptacle the water is drained through pipe 24 into water supply tank 14'.

Extending substantially centrally through the bottom of the receptacle 22' is a relatively large vertically extending pipe 25, the upper end of which is above the bottom of receptacle 22' and relatively close to the condenser coil. The upper end of pipe 25 projecting within receptacle 22' is open, but a horizontal plate 26 is spaced above the upper open end thereof and extends over said open end to prevent moisture dropping from plates 2 from entering the pipe. The lower end of pipe 25 passes through the bottom of receptacle 22' and connects with the intake 27 (Fig. 1) of a conventional suction blower 27', driven by motor 13, as indicated by the arrows in Fig. 1, and as shown in Fig. 2. Outlet pipe 28 extends from the discharge of said blower to outside casing 1 and to outside the room. The pipe 25 is formed adjacent its connection with the blower to provide a sump 29 (Fig. 2) from which a pipe 30 leads to the water receptacle 14' so that any water that might splash into the pipe 25 will not pass through the blower. This drain pipe 30 is relatively small so as not to interfere with the operation of the blower for performing its necessary functions, which will be later explained.

Below cooling coil 17 I provide an elongated drip pan 30', that is inclined from end to end, and which pan drains into a drain pipe 31 that

leads back to the water receptacle or tank 14' for carrying any condensed moisture dripping from the cooling coil back to the water tank.

Adjacent the return bends of the cooling coil, and exposed to the air in the room, where the apparatus is disposed within the room in which the air is to be conditioned, I may provide condensing plates 32, each formed with a marginal, laterally projecting edge 33 connecting at the lower ends of the plates respectively by drain pipe 34 with the drip pan 30 for draining into the latter.

Said plates 32 are of stainless or non-corrodible material and are respectively secured to a refrigerant pipe 34' connected at its ends respectively with refrigerant line at 35, 35', and the pipes 34' are heat insulated, except where they engage the plates 32. Thus the pipes 34' provide for cooling the plates 32 and for condensing moisture in the still air in the room on said plates for de-humidizing such air where it contains excessive moisture, said plates 32 being positioned out of the flow of air through passageways 5 and exposed to room air.

In order to increase the efficiency of the cooling coil 17 the return bends are insulated, by any suitable insulating material, as indicated at 36 in Fig. 7, which construction functions to increase the efficiency of this coil as explained in my United States Letters Patent No. 2,047,249, dated July 14, 1936.

Water tank 14' may be filled manually, as necessary, or it may be filled from the supply pipe 37 connected with the city water main, and a conventional float valve 38 within the tank may automatically control the filling of said tank to the desired level.

The casing 1 (indicated by dot-dash line in Fig. 1) is provided with an air inlet at 39 for admitting air outside the casing to fan 15 for blowing through the passages 5 and over cooling coil 17 and an air outlet 40 at the opposite side of the casing permits discharge directly into the room from the casing, or into a conduit 41 (indicated in dotted line) for conducting the cooled air to a remote point.

In the bottom of casing 1 is an opening or several openings, 42 (Fig. 1) for admitting air from outside the casing into the same.

The fan motor 16, blower motor 13, and compressor motor 21' are preferably connected in an electric circuit in any conventional manner for successive actuation of the motors respectively, until all motors are being operated simultaneously as by switch 43 indicated in Fig. 1, the main power lines being designated 44, 44'.

In operation, when switch 43 is moved to engage terminal 45 the fan 15 solely is actuated to blow air into a room, and to thereby circulate the room air when conduit 41 is extended to a room at a remote point, or in the absence of conduit 41, with the apparatus in a room, the fan will merely circulate the room air within the room in which the apparatus is positioned. When switch 43 is actuated to engage terminal 45', and the apparatus is positioned within the room in which the air is to be conditioned, (conduit 41 being removed) air from the room will be drawn through openings 42 then around the sides of the assembly of plates 2 and downwardly through passages 6 and finally out of the room. Also pump 12 will be actuated to moisten the walls of passageways 6, with the result of evaporating the moisture in said passageways and cooling plates

2, which in turn results in cooling the air circulated by fan 15 through passageways 5.

The passageways 6 are preferably of less cross-sectional area than passageways 5, and preferably, fan 15 will move an appreciably greater volume of room air per minute through passageways 5 than the blower will move through passageways 6, hence more room air per minute will be circulated in the room through the cooled passageways 5 than is ejected from the room through discharge conduit 28, and the temperature of the room air will be appreciably reduced.

With continued actuation of switch 43 to engage terminal 45'' the compressor motor 21' goes into operation, and the refrigerant expanding in the cooling coil 17 will further cool the air circulated within the room, or the air may be conducted by conduit 41 to a remote room, when a conduit is supplied for that purpose. Since the air passing over the cooling coil is pre-cooled by passing through passageways 5 in contact with the cool surfaces thereof, it is readily apparent that the efficiency of the cooling coil for cooling the air that is ejected into the room is greatly increased, the "top heat" of the air in the room already having been removed from the air by heat transfer plates 2. Since there is also an absorption of heat from the air passing through passageways 6, due to evaporation of the moisture, and since this latter moist air passes over the condenser coil 20, it is manifest that the efficiency of the condenser is greatly increased, with a further lessening of the load on the compressor motor, and the heat from the blower and its motor is carried away by the air entering openings 42 to passageways 6, and from thence outwardly of the room, thereby increasing the evaporative efficiency of this air when it passes over the moistened walls of passageways 6. Of course, any moisture that may drop from passageways 6 into tank 22' will also drop onto the condenser coil and its fins 22 to further dissipate the heat of the condenser coil, by evaporation thereon, and resultant ejection of such heat in the air discharged out of the room. It is preferable that the switch making the circuits to the various motors be of a character to cause actuation of the motors successively, merely by continued movement of a single switch, such switches being conventional.

Where the moisture in the room air is excessive, the condenser plates 32 may be cooled as by opening valves 46 in the refrigerant lines leading thereto, thus de-humidifying the air in the room. Where the moisture in the air is thus reduced, there is, of course, an increased efficiency in the rate of evaporation of the moisture on the walls of passageways 6 and an increase in the efficiency of the pre-cooling effect of passageways 5 and 6 on the air ejected into the room and in the air passing over the condenser.

Referring again to plates 2, particularly to the inner surfaces of passageways 6, before the plates are assembled, I preferably apply a waterproof adhesive, such as shellac, to the plate surface along lines 50, indicated in Fig. 5, thus defining square or diamond areas between the intersecting lines, with the lines extending perpendicularly to each other but at angles of 45° relative to vertical. After the shellac is deposited along said lines, a cotton or other fibrous material 51, such as fibrous lint, is blown against the side of the plate to adhere to the shellac, or the fibrous, moisture absorbent material may be stuck to the shellac in any other suitable manner. After the

shellac has dried the fibers of cotton or the like will fall over and against the bare metal as indicated in Fig. 6, and when water from the trough 7 is spilled over the strips 3 this water will flush over the cotton fibers and will be held against the plates 2 in a thin film, and also the water will be distributed over the side of each plate along the lines where the adhesive or shellac is applied to insure a thorough distribution of the moisture.

This structure is important, in that there is no fabric to be pulled away from the plates, nor is there any appreciable loss in heat transfer due to the plates having any material portion of their surfaces covered by adhesive, and the successive flushing of the sides with moisture will cleanse the sides of sediment that may be in the water.

It will be seen from the foregoing, that under any of normal conditions that may arise, insofar as air temperatures, relative humidity of the air, and the like, my apparatus will function to appreciably lower the temperature of the air to be ejected into the room, and will at the same time effect an appreciable lowering of the costs of reducing the air temperature by reason of the pre-cooling of the room air before it passes over the cooling coil, and in dissipating the heat in the condenser coil.

As described in my co-pending application, the intermittent moistening of the surfaces of passageways 6, greatly promotes the cooling effect of evaporation of the moisture, since the evaporation is substantially at the very surface of the plates during the final stages of evaporation and before a new supply of water flushes over said surfaces. Hence the heat transfer effected by virtue of the plates is not impeded by the necessity for conducting the heat through any appreciable layer of water to the evaporating surface. This feature, of course, results in obtaining a higher cooling efficiency with less air flowing through passageways 6, than by any system where heat transfer surfaces are moistened continuously.

The air for passing through passageways 6, which are completely blocked off from room air except at their upper open ends, is obtained by normal infiltration of air into the room or by any other suitable means.

Having described my invention, I claim:

1. Apparatus for conditioning the air of a room comprising a source of water at a temperature below that of the air to be conditioned, a plurality of open ended passageways, means for moistening the outer surface of said passageways with water from said source, means for causing air from the room to flow in one general direction through said passageways and in one general direction over the moistened outer surfaces thereof for evaporating the moisture and thereby cooling the walls of the passageways, a refrigerant cooled coil disposed to be in contact with the air passing out of one end of said passageways and a refrigerant condenser coil disposed to be in contact with the air passing from over the moistened outer surfaces of the passageways, a refrigerant and a compressor for compressing the refrigerant, said compressor being connected with the condenser coil for passing the refrigerant under compression to the condenser coil and the condenser coil being connected with the cooling coil for passing the liquefied refrigerant from the condenser coil to the cooling coil and a line connecting between the cooling coil and compressor for passing the expanded refrigerant from the cooling coil to the compressor.

2. Air conditioning apparatus of the character described comprising a plurality of substantially parallel open ended passageways for air and a refrigerant system for a fluid refrigerant, said refrigerant system comprising a compressor, condenser and an evaporator, means mounting the evaporator in a position across one of the open ends of the passageways for passage of air from the passageways over the evaporator, means for causing air to move through said passageways from the opposite open ends thereof and over the evaporator, means for moving air over the outer sides of the walls of said passageways, means for moistening said outer sides of the walls, means mounting the condenser in a position to be engaged by the air moved over said moistened outer sides after the air has passed over said outer sides, and means for conducting the air engaged by the condenser away from the condenser.

3. In a construction as defined in claim 2, said second mentioned means comprising a power driven fan disposed adjacent said opposite open ends of the passageways and the means for moving air over the moistened outer sides of said passageways comprising a suction blower positioned adjacent said condenser and the condenser being disposed between the intake end of the suction blower and the passageways.

4. Air conditioning apparatus of the character described comprising a plurality of substantially parallel, open ended passageways, means for intermittently moistening the outer sides of said passageways with a relatively thin sheet of moisture, a refrigerant system including a compressor, a condenser and an evaporator for the refrigerant, a power driven fan positioned at one of the open ends of the passageways for blowing air through the passageways and out of the opposite open ends, a suction blower positioned adjacent the passageways for drawing air across the moistened outer sides thereof, said evaporator being disposed in the path of travel of the air ejected from the passageways and the condenser being disposed between the intake part of the blower and the passageways and in the path of travel of the air drawn over the moistened outer sides of the passageways and means for receiving condensed moisture that may drop from the evaporator and for receiving moisture that may drop from the outer sides of the passageways.

5. In a construction as defined in claim 4, a casing enclosing said passageways, compressor, condenser, evaporator, fan and suction blower, said casing having an air inlet and an outlet respectively positioned adjacent said fan and evaporator for admitting air to the fan and for ejecting such air from the casing after it has passed over the evaporator, and the casing having another inlet for admitting air to within the casing and means for directing substantially all of the air admitted through the last mentioned inlet over the moistened outer sides of said passageways for passage thereover to the inlet part of the blower for ejection of the air from the blower, and means for conducting the air from the blower to outside the casing.

6. Air conditioning apparatus including a fluid refrigerant, an expansion cooling coil, a condenser coil, and a compressor connected for cyclic movement of the refrigerant through the coils and compressor upon actuation of the compressor, means for passing air over said condenser coil for cooling the same, means for passing air over the cooling coil for cooling the air passing thereover, cooling means independently of the cooling

coil and cooling function thereof for cooling the air passing over the condenser and over the cooling coil substantially immediately prior to the passage of the air over the condenser and cooling coil, means for ejecting the air passing over the cooling coil into a room, and means associated with said cooling coil for condensing moisture in the air adapted to be passed over said condenser and cooling coil.

7. Air conditioning apparatus, including a fluid refrigerant, an expansion cooling coil, a condenser coil, and a compressor connected for cyclic movement upon actuation of the compressor, means for passing air over said condenser coil for cooling the same, means for passing air over the cooling coil for cooling the air so passing thereover, means for cooling the air passing over

the condenser and over the cooling coil substantially immediately prior to the passage of the air over the condenser and cooling coil, the means for cooling the air passing over the condenser coil and over the cooling coil comprising a plurality of first passageways adapted to conduct air to the cooling coil and a plurality of second passageways adapted to conduct air to said condenser coil, the outer surfaces of said first passageways being the inner surfaces of said second passageways and said outer surfaces being moistened and disposed for engagement by the air adapted to be conducted by said second passageways for passage over the condenser coil, and means for moistening said outer surfaces.

JOHN R. BALLARD.