

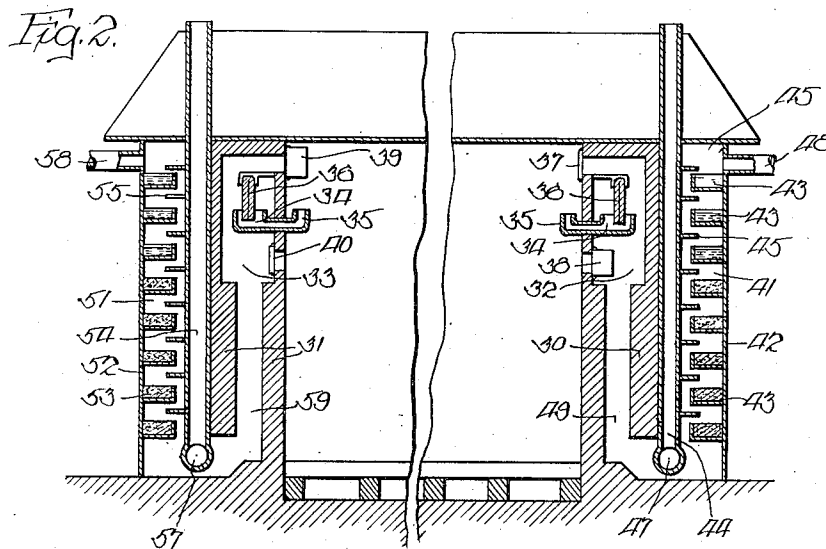
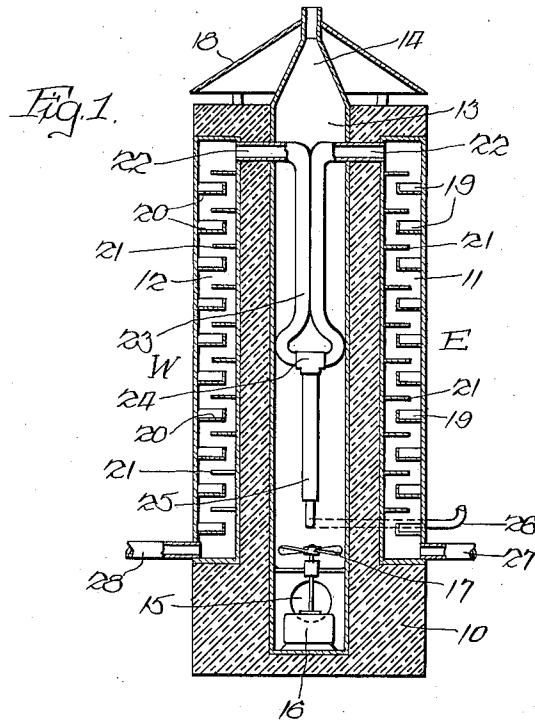
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E. ALTENKIRCH

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DRYING AND COOLING APPARATUS

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Inventor:  
Edmund Altenkirch

By Harry S. Dwarce  
Att'y.

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## DRYING AND COOLING APPARATUS

Edmund Altenkirch, Neuenhagen, near Berlin,  
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This invention relates to air conditioning apparatus and more particularly for means for cooling and drying air.

It is well known that silica gel, charcoal, certain kinds of wood, and other substances have the properties of absorbing water or other refrigerating fluids at one temperature and discharging the water or fluids at a higher temperature. It is also known that certain liquids such as sulphuric acid, lye solution, calcium chloride solution, etc., have the property of absorbing water at a given temperature and discharging it at the higher temperature. Intermittently operating refrigeration devices based upon the aforesaid properties are also well known.

It is an object of the present invention to utilize the above mentioned properties of the substances of this kind for the purpose of cooling or drying air so as to make it more comfortable to live in or for other purposes and to provide novel, inexpensive and practical apparatus for accomplishing this result.

It is another object of the invention to provide means for removing water from air by an inexpensive and simple apparatus.

It is still another object of the invention to provide air conditioning apparatus which may be operated at low temperatures and thus utilize the heat of the sun for operating it.

Other objects and advantages reside in certain novel features of the arrangement and construction of parts as will be apparent from the following description taken in connection with the accompanying drawing in which:

Figure 1 is a fragmentary cross-sectional view of an apparatus for removing moisture from the atmosphere or from other gases which may be circulated through it, the apparatus illustrating one embodiment of the invention, and

Figure 2 is a fragmentary view of a dwelling house with the walls shown in cross-section and with another embodiment of the invention incorporated therein which is adapted to dry and cool the air in the house.

Referring to the drawing in detail and first to the embodiment of the invention shown in Figure 1, the apparatus is shown as consisting of a vertically extending rectangular structure designated at 10 and consisting chiefly of insulating material, the east and west walls of which have vertically extending rectangular chambers as indicated at 11 and 12.

Centrally located in the structure 10 is a third vertically extending chamber which may be of any shape, either rectangular or circular as shown

at 13. This chamber 13 is connected at the top to chimney 14 and, at the bottom to an opening 15, the opening 15 connecting the chamber 13 to the atmosphere on the north side of the structure. An electric motor 16 and a fan 17 are located in the lower portion of the chamber 13 and provide means for forcing air upwardly through the chamber 13, the air entering through the opening 15 and leaving through the chimney 14.

To prevent the sun from heating the insulating structure 10, a roof 18 may be provided and air may be circulated thereunder if desired.

Each of the east and west chambers 11 and 12 constitutes an absorber-generator and is provided with a number of pans or cup-shaped baffles, those in the east chamber 11 being designated 19, and those in the west chamber 12 being designated 20. These cups or pans are partly filled with a substance such as silica gel, or calcium chloride solution, or other substance adapted to absorb water out of the atmosphere if maintained at reasonably low temperatures. If designed for use with solid absorbents, the pans are preferably perforated. Staggered between the cups 19 and 20 are a number of baffle plates indicated at 21 which serve to direct air over the pans and in contact with the absorbing substance thereon as air circulates through the apparatus.

The upper ends of the chambers 11 and 12 are connected together by means of the gas conduit 22. This gas conduit extends into the chamber 13 in which it passes downwardly to form a U-bend 23, which is connected by means of the T-connection 24 with a pipe 25. The pipe 25 serves as a water reservoir and has its lower end connected to the outlet pipe 26. The pipe 25 may be provided with a faucet, or may drain into a suitable receptacle to collect water supplied to the reservoir 25 by the apparatus.

The lower end of each of the chambers 11 and 12 are connected to the atmosphere by means of the gas conduits 27 and 28. Screens or filters (not shown) may be provided in the conduits 27 and 28, to prevent the entrance of insects into the apparatus. If desired the conduits 27 and 28 may be connected to a suitable air pump or a fan for forcing a draft of air through the apparatus.

Since the outer walls of the east and west chambers 11 and 12 are made of metal, it will be seen that on a sunny day, heat will be transferred from the sun to the air and to the absorbing material in the east chamber 11 in the morning and to the air and the absorbing material in the west

chamber 12 in the afternoon. Other heating devices might also be employed in this apparatus but are not illustrated for the sake of simplicity herein but are shown in the arrangement of Figure 2. It is to be understood, however, that the arrangement of Figure 1 is not limited to the use of the heat from the sun alone to operate it.

Assuming that the plates or trays 19 and 20 of the apparatus of Figure 1 are filled with silica gel the apparatus may be operated to remove moisture from air as follows: In the morning the sun will shine upon the outer wall of the east chamber 11 while the west chamber 12 will be in the shade and at a lower temperature. This will cause the air in the east chamber 11 to have lower density, and, assuming that the pipes 27 and 28 are open to the atmosphere air will rise in the east chamber 11, pass through the conduit 22, which will be maintained at a lower temperature than that of the chamber 11 by the air current set up in the chamber 13. From the conduit 22 the air will flow downwardly through the west chamber 12 and leave the apparatus through the pipe 28. The air will flow in this direction all morning and since the east chamber 11 is quite warm moisture will be given up from the silica gel on the pans 19 to the air. This air having a higher moisture content as it enters the gas conduit 22 than the air entering through the conduit 27, will drop some of its moisture as it is reduced to the temperature of the atmosphere in the inner chamber 13 of the apparatus. During the initial cycle of the apparatus it may be that there will be little or no condensation in the pipe 22 but as the cycle is repeated condensation in this pipe will increase as will be apparent from the description hereinafter. Even during the starting cycle, however, the air entering the conduit 22 will have a higher moisture content than that entering the chamber 11 through the pipe 27.

As the air passes downwardly through the west chamber 12 its moisture content will be reduced due to the absorption of moisture by the silica gel on the trays 20 and the air leaving the apparatus through the conduit 28 will have a lower moisture content than that entering the apparatus through the conduit 27, the difference being that which has condensed in the conduit 22.

As the sun passes the meridian it will not shine on either the east or on the west walls of the apparatus and air circulation therethrough will cease temporarily. In the afternoon the sun will shine on the west chamber 12. Air will then circulate through the apparatus entering in through the gas pipe 28 passing upwardly through the west chamber 12 through the gas conduit 22 and downwardly through the east chamber 11. The silica gel in the west chamber 12 which became highly saturated with water vapor during the morning, now gives up its moisture to the air and as the temperature of the air in pipe 22 is reduced in chamber 13, a large part of the water vapor condenses in the conduit 22 and collects in the reservoir 25.

Likewise the air which flows from pipe 22 into the east chamber 11 now has a higher water vapor pressure than that which enters the west chamber 12 in the morning and the silica gel on the trays 19 become even more saturated than the gel in the trays 20 did in the morning. Nevertheless the air leaving the apparatus through the conduit 27 is in a dryer state than that entering the apparatus through the conduit 28. From then on, if the quantity of gel in the apparatus and the quantity of air flowing therethrough are

properly proportioned, water will be retained in the apparatus at each period of operation.

Since heat is being discharged into the air in the inner chamber 13 of the apparatus a natural draft may be created which will be sufficient to cool the gas conduit 22 and cause condensation therein. In this way the apparatus could be operated without the use of moving parts. The use of a motor driven fan as shown in 17 is preferable, however, in that it maintains the gas conduit 22 at a lower temperature.

It will be seen from the above description that means has been provided for using the heat of the sun for obtaining a supply of water from the air. It is also apparent that the apparatus may be operated to cause the heat of the sun to dry air for bringing comfort to human beings or for other purposes and that the drying process may take place without the use of moving parts. The pipes 27 and 28 may be connected to the room in which it is desired to maintain air at a low relative humidity and the conduits 27 and 28 may be connected through various known valve systems and to blowers or fans in such a way that air may be nearly continuously supplied to a chamber at a relative humidity lower than that of the air entering the apparatus. Conversely, assuming that it is desired to raise the humidity in a room, the conduit 22 might be connected to the room in such a way that it would add moisture to the air. Thus if chamber 13 were sealed from the atmosphere at the top and bottom, and the pipe 22 were cut off at the point of entrance into chamber 13, the humidity of the air in the room 13 could be maintained high by operating the apparatus as described above. Thus the apparatus of Figure 1 may be adapted to condition air in various ways.

Another way of utilizing the principles of the invention to condition air of a dwelling house or the like is illustrated in Figure 2 in which the arrangement is such that not only the humidity but also the temperature of the air may be changed.

Referring to the arrangement of Figure 2 in detail it will be seen that a dwelling house is there indicated as having an east wall 30 and a west wall 31, these walls being shown in cross-section and being constructed of heat insulating material. The walls 30 and 31 are hollow an upper chamber being formed in each one as indicated at 32 and 33 respectively. A humidifying apparatus, or evaporator as for example a water pan 34 and a sheet of wicking or other porous or absorbent material supported above the pan 34 as indicated at 36, is provided in each of the chambers 32 and 33. The pan 34 may be filled through opening 35.

The chamber 32 is connected to the room of the dwelling house by two dampers or doors, the damper 37 being above the humidifying apparatus and opening into the room, and the damper 38 being below the humidifying apparatus and opening into the chamber 32. Likewise the chamber 33 is provided with similarly arranged dampers 39 and 40.

Outside of the east wall 30 of the dwelling house an absorbing chamber is formed as shown at 41 by means of the vertically extending metallic structure 42. This chamber contains a number of pans or trays as indicated at 43 adapted to contain calcium chloride or silica gel or other absorbing material, the arrangement shown having a solution of calcium chloride on the upper three of the baffle trays 43, with silica gel on the lower five of these trays. The use of

two absorbents in each chamber, which is one feature of the invention, permits absorption to a high degree, because the absorbents will absorb the water vapor at different partial pressures.

For heating the chamber 41 in addition to heat which may be conveyed through the wall 42 of the chamber from the sun, a chimney or heater 44 is provided. This chimney also provides means for supporting the baffle plates 45 which serve to direct air passing through the chamber 41 over the absorbing substances on the trays 43. Below the chimney 44 a horizontally extending passage 47 may be provided and this passage may contain a gas heater, air for combustion being supplied to the heater from the outside by any suitable means. This artificial heating means need not be used all the time, but may be used as desired.

The upper end of the chamber 41 may be connected to the atmosphere or to any air circulator such as a fan by means of the air conduit 48. The lower end of the chamber 41 is connected to the chamber 32 in the wall 30 by means of an air passage 49 in the wall 30.

The arrangement on the outside of the west wall 31 of the house is exactly the same as that on the east side, a chamber 51 being formed by an outer metallic wall 52, the chamber 51 having a number of trays 53 for supporting absorbing material. A chimney 54 is provided and supports baffle plates 55. The chimney 54 is heated by a heater in a horizontally extending conduit 57. The upper end of chamber 51 is connected to the atmosphere or a fan (not shown) by pipe 58. The lower end of the chamber 51 is connected to the chamber 33 in the wall 31 by means of the air passage 59 in the wall 31.

The conditioning of the room in the dwelling is effected preferably automatically by the sun. It can, however, be effected artificially and periodically by alternately heating the chambers 41 and 51. Assuming that it is desired that the apparatus be used to lower the humidity or cool the air in the room and that the apparatus is operated by the sun only, the operation is as follows: In the morning the sun shines against the wall 42 on the east side of the house and the contents of the chamber 41 are heated. Circulation of air is thus produced by convection. The air enters through the conduit 58 on the west side of the house goes downwardly through the chamber 51, rises in the conduit 59, enters the room after going through the chamber 33 and across the humidifier therein, passes through the opening at the top of the chamber 33, the damper 40 being closed at this time. After flowing through the room the air flows downwardly through the conduit 49 in the wall 30, the damper 38 then being open and enters the chamber 41 on the east side of the house, passes upwardly therethrough and leaves this chamber through the conduit 48. The west side of the house being cool and the east side warm during this portion of the cycle, the humidity of the air in the chamber 51 is decreased and that in the chamber 41 increased, as long as the air flows in the direction indicated. The air entering the room to be conditioned may be actually lowered in temperature by means of the humidifier 34. As for example, assuming that the dew point of the air passing downwardly through the chamber 51 is lowered to such an extent that as it passes into the chamber 33 it has a temperature of 35 degrees C. and a dew point of 0° C. This air may be cooled to a temperature of 20° C. by contact with the wick-

ing 36 in the chamber 33 while the dew point of the air is raised to 14° C. By changing the position of the shutters 39 and 40, the temperature of the air entering the room can be raised and the dew point lowered. For example, if the lower shutter 40 is opened only a small amount the air in the room may assume a temperature of 25° C. while the dew point becomes about 10° C. In operating the apparatus of Figure 2, the direction of air circulation is reversed periodically in synchronism with the heating periods. Where convection alone is used to cause circulation of the air, the synchronism of air and heating periods is automatic, the heating of chamber 41 causing circulation of air in the direction just described and the heating of chamber 51 causing circulation in a reverse direction.

When operated by the sun, circulation of air effected by convection ceases as the sun passes the meridian. In the afternoon when the sun shines upon the west side of the house so that the direction of circulation of air is reversed, the air enters the apparatus through the conduit 48, passes downwardly through the chamber 41 and into the room through the chamber 32 in the wall 30. In general, it should be said that during this portion of the cycle the damper 37 should be open and damper 38 closed, while the damper 39 is closed and damper 40 open. Air then leaves the room through the damper 40, passes downwardly through the passage 59 and upwardly through the chamber 51, leaving the apparatus through the conduit 58.

Inasmuch as the absorbent material in chamber 41 became very dry during the morning, due to the fact that it was heated, the air now entering the chamber 32 will be even dryer than that which enters the chamber 33 in the morning.

In the afternoon the air entering the room may be cooled by means of the humidifier 34 and its associated apparatus in the chamber 32 just as it was cooled by the humidifier in the chamber 33 in the morning.

It will be seen that when operated in this way the apparatus provides means for drying and cooling air supplied to a room, and on warm summer days when the sun is shining the air may be conditioned by means of the sun alone. It will also be seen that it is possible to air condition a room without the use of moving parts, the air being circulated through the room merely by convection currents. It is to be understood, however, that it is within the purview of the invention to cause the air to circulate in the directions indicated above by using fans or blowers. It is also contemplated to promote circulation in the desired direction under the pressures created by wind blowing around the house, as for example, across the roof. The conduits 43 and 58 may be connected to funnels or vents on the roof so positioned as to create the desired draft through the house depending upon the direction and magnitude of the wind. Due to the provision of the heaters 47 and 57 the apparatus can be operated without utilizing the heat of the sun and the period of heating or cooling of the chambers 41 and 51 can be varied as desired.

It is also possible to use the apparatus of Figure 2 to raise the humidity of air entering the room by causing the air to circulate in the opposite directions to those given above. Thus if the air is circulated, by means of a fan or the like associated with pipe 58, downwardly in chamber 51, upwardly through passages 59 and 33, across

the room, downwardly through passages 32 and 49 and upwardly through chamber 41, while chamber 51 is heated and chamber 41 cooled, the humidity in the room will be raised.

However operated, it is within the purview of the invention to so construct the chambers 41 and 51 as to permit them to be slowly turned so as to face the sun and thus operate at maximum efficiency.

It is also contemplated to place the conduits conveying air into and out of the room in heat exchange relation so as to increase the effectiveness of the apparatus.

While the apparatus has been explained in connection with the conditioning of air, it is obvious that other inert gases could be conditioned thereby and absorbable constituents other than water removed therefrom.

Various other changes in the arrangement and construction of parts may be made without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. Apparatus for conditioning the air in a room comprising two chambers, absorbent material in said chambers, means for conveying air through one of said chambers, the room, and the other of said chambers, means for periodically reversing the direction of flow of the air comprising means for alternately heating said chambers to cause the absorbent in the chamber heated to give up moisture to the air therein.

2. Apparatus for conditioning the air in a room comprising two chambers, absorbent material in said chambers, means for conveying air through one of said chambers, the room, and the other of said chambers, means for periodically reversing the direction of flow of the air comprising means for alternately heating said chambers to cause the absorbent in the chamber heated to give up moisture to the air therein and means for cooling the air entering the room by causing water to evaporate into the air.

3. Intermittent absorption refrigerating apparatus comprising a first absorber-generator, a second absorber-generator, an evaporator, means for periodically causing an inert gas to flow first through the first mentioned absorber-generator, the evaporator and the second mentioned absorber-generator and then through the second mentioned absorber-generator, the evaporator and the first mentioned absorber-generator comprising means for heating each of said absorber-generators only when the inert gas is flowing through it after having passed through the other absorber-generator and the evaporator.

4. The process of conditioning air which consists in periodically passing the air over two separate bodies of absorbent material, first in one direction and then in the other, maintaining the body over which the air first passes at a lower temperature than the other body thereby causing the body over which the air first passes to remove moisture from the air and thereby causing the body over which the air passes last to give up moisture to the air, and exposing the air passing from one absorbent body to the other to water thereby causing water to evaporate into the air and cool the air.

5. Apparatus for conditioning air of the type employing two absorber-generators containing absorbent medium connected by a fluid conveying means and so arranged that when one of said absorber-generators is subjected to the heat of the sun the other is shielded therefrom, and

having an opening in each of said absorber-generators near the end remote from said conveying means, said apparatus being characterized by the fact that during part of the day air flows in one of said openings, through one of said absorber-generators, through said conveying means and then through the other absorber-generator, and during another part of the day the air flows in the reverse direction, said reverse flow being caused by the reversal of said absorber-generators with respect to the sun, whereby air is dried as it passes through said shielded absorber-generator, and said heated absorber-generator is re-activated for subsequent use as a drier.

6. Apparatus for conditioning air of the type employing two absorber-generators containing absorbent medium and one of which is periodically subjected to the heat of the sun to re-activate the absorbent while the other is shielded from the heat of the sun to permit water vapor to be absorbed from atmospheric air, and in which means is provided for delivering air discharged from one absorber-generator to the other, said absorber-generators being characterized by the fact that each has an air inlet so positioned that the heating of either one thereof will cause the air therein to rise and thereby cause air to flow first through one absorber-generator, then through said air delivery means, and finally through the other absorber-generator.

7. Apparatus for conditioning air comprising a housing, independent absorber-generators containing absorbent medium positioned at opposite sides of said housing such that the sun may heat first one and then the other thereof to drive off water vapor contained in said absorbent while one remains shielded from the heat of the sun to dry air passing therethrough, air inlet means to each of said absorber-generators, means within said housing for conducting air between said absorber-generators, and means operable to modify the condition of the air as it passes between said absorber-generators as the result of thermo-syphonic action caused by the heating of one of said absorber-generators by the sun.

8. The process of conditioning air which comprises passing a rising stream of air over absorbent medium heated by the sun to reduce the moisture content of the absorbent, conducting said flowing air stream into an area shielded from the heat of the sun, modifying the absolute humidity of the air for a utilitarian purpose, then passing the air stream downwardly over absorbent medium shielded from the heat of the sun to dry the air, and periodically reversing the direction of air flow by subjecting said shielded absorber-generator to the heat of the sun.

9. The method of conditioning an enclosure which comprises passing air over a first body of absorbent to dry the air, cooling the air by evaporative cooling, conducting the cooled air to an enclosure, venting the air displaced by said cool air to the atmosphere after first conducting the same over partially saturated absorbent heated by the sun to reactivate said absorbent, and then reversing the direction of air flow by heating the moistened absorbent by solar energy while shielding the first body of absorbent therefrom.

10. Apparatus for conditioning air consisting of two chambers and an air conducting means connecting the chambers, each chamber containing a body of absorbent material, each chamber having an opening permitting communication between such chamber and a point outside the apparatus, and each chamber having a heating

means; the arrangement being such that when either chamber alone is heated air will pass in series through the other chamber, the air conducting means connecting the chambers, and finally through said chamber being heated.

11. A structure comprising a building having a room to be conditioned, a pair of chambers communicating with said room and absorbent bodies in each of said chambers; each chamber having a conduit for affording communication between the same and the atmosphere outside said structure and each chamber being positioned on the building to be shaded thereby from the heat of the sun when the other chamber is exposed to the heat of the sun; the arrangement being such that when one of the chambers is heated by the sun a circulation of air will be promoted, in series, from the exterior of the building through the other chamber, said room and said chamber heated by the sun.

12. Apparatus for drying air comprising two inter-connected chambers, each of which contains absorbent material, an opening near the top of each of said chambers to the atmosphere, means for alternately heating said chambers to facilitate the passage of air through said chambers in series for the purpose of reactivating absorbent material in the heated chamber and drying air in the unheated chamber for a useful purpose, means conducting said dried air through a chamber to be conditioned, said air passing through said chambers in first one direction and then in the opposite direction, the arrangement being such that the chamber through which the air last passes in either direction is maintained at a higher temperature than the other chamber by said heating means.

13. Apparatus for removing moisture from air comprising a first chamber containing absorbent material, a second chamber containing absorbent material, means connecting said chambers to the atmosphere and a conduit connecting said chambers whereby air may flow through said chambers and conduit in either direction, means for exposing the first mentioned chamber to a source of heat whereby the air is caused to flow from the first mentioned chamber to the second mentioned chamber, means for exposing said second mentioned chamber to a source of heat after discontinuing the heating of the first chamber whereby the air is caused to flow from the second mentioned chamber to the first mentioned chamber, the arrangement being such that the absorbent material gives up moisture to the air when the chamber in which it is located is heated, and removes moisture from the air when the chamber in which it is located is not heated whereby the moisture content of the air in said conduit is greater than that of the air entering or leaving the apparatus.

14. In a structure having a room to be air conditioned, an east wall, a west wall, a chamber associated with the east wall adapted to be exposed to the heat of the sun in the morning, the chamber associated with the west wall being adapted to be exposed to the heat of the sun in the afternoon, said chambers containing independent charges of absorbent material, and means for conveying air periodically in opposite directions through first one of said chambers, said room, and then through the other of said chambers.

15. The process of conditioning air which comprises passing the air over two separate bodies of absorbent material periodically, first in one

direction, and then in the opposite direction by alternately heating one of said bodies above the temperature of the other, the process being such that the absorbent bodies are automatically caused to alternately give up moisture to the air synchronously with the periodic flow of the air, the moisture so given up being moisture which has been absorbed from the air by one of the bodies when that body was not being heated.

16. The method of conditioning air which comprises drying one portion of a stream of air for a useful purpose by passing it over absorbent material shielded from the heat of the sun during the forenoon, which absorbent material has been reactivated by the heat of the sun during a previous afternoon, and simultaneously reactivating another body of absorbent material containing a high percentage of moisture acquired on a previous afternoon by passing another portion of said stream of air thereover while said material is being heated by solar energy.

17. The method of conditioning air substantially throughout the daytime, which includes passing a stream of atmospheric air over first one body of absorbent material, and then another body thereof, one of said bodies being subject to the heat of the sun and the other being shielded therefrom during part of the day, and the position of said bodies with respect to the sun being reversed during another part of the day, whereby the air passing over said shielded body of absorbent is dried for a useful purpose, and the other body of absorbent material being heated by the sun is being simultaneously reactivated for use later in drying other air.

18. Apparatus for conditioning air of the type employing two absorber-generators containing absorbent mediums and connected by fluid conveying means including a chamber to be conditioned for conducting air in series therethrough, said apparatus requiring only a source of heat to energize and operate the same and being constructed and arranged to condition atmospheric air at atmospheric pressure, and to automatically cause flow of the air being conditioned there-through by thermo-syphonic action, said apparatus being characterized by the fact that when one absorber-generator is being heated by a source of heat the other is shielded therefrom, whereby heat may be applied periodically to first one absorber-generator to dry the absorbent medium while the other absorber-generator is used to dry air passing therethrough, and then to the other absorber-generator to reverse the flow of air through the apparatus.

19. Apparatus for conditioning air of the type employing two absorber-generators containing independent absorbent charges and one of which is alternately subjected to the heat of the sun for a period of time to reactivate the absorbent while the other is shielded from the heat of the sun for a period of time to permit water vapor to be absorbed from atmospheric air, and thereafter said absorber-generators are reversed with respect to the heat of the sun, said apparatus being characterized by the fact that the dried air delivered by one of said absorber-generators is conducted to a point of use which is heat insulated from both of said absorber-generators, the air being subsequently returned to the other absorber-generator for use in reactivating said last named absorber-generator.

EDMUND ALTENKIRCH.