

April 8, 1941.

W. E. MOORE

2,237,684

METHOD OF AND APPARATUS FOR TREATING GASES

Filed July 31, 1939

3 Sheets-Sheet 1

Fig. 1.

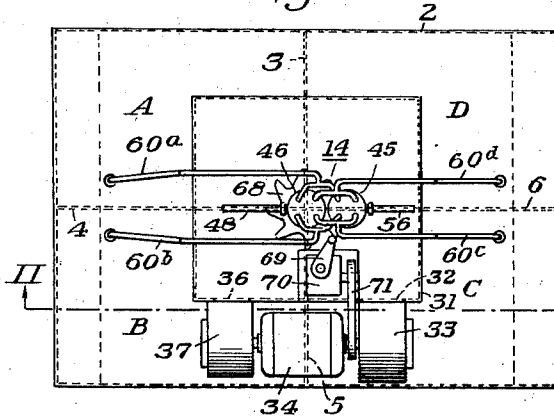


Fig. 12.

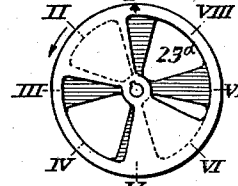


Fig. 15.

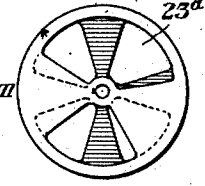


Fig. 13.

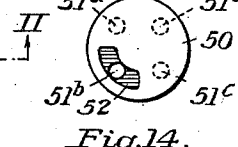


Fig. 16.



Fig. 14.

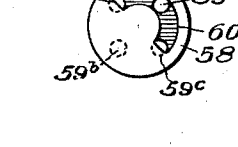


Fig. 17.

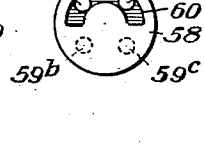


Fig. 2.

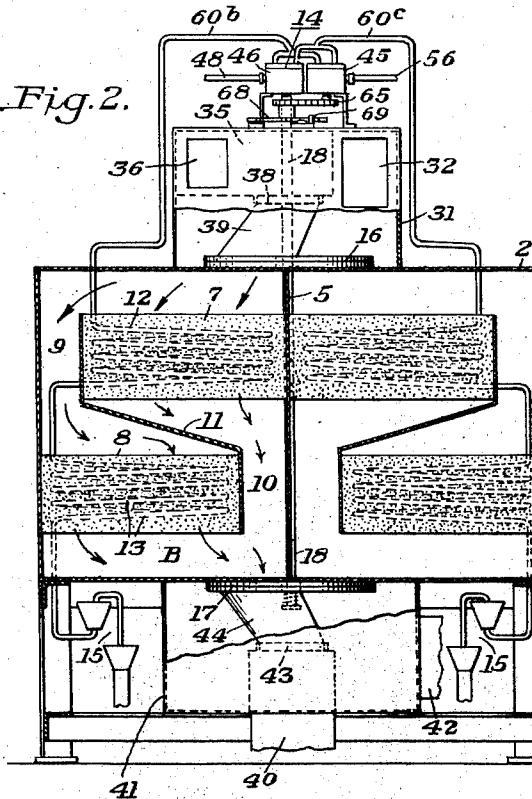
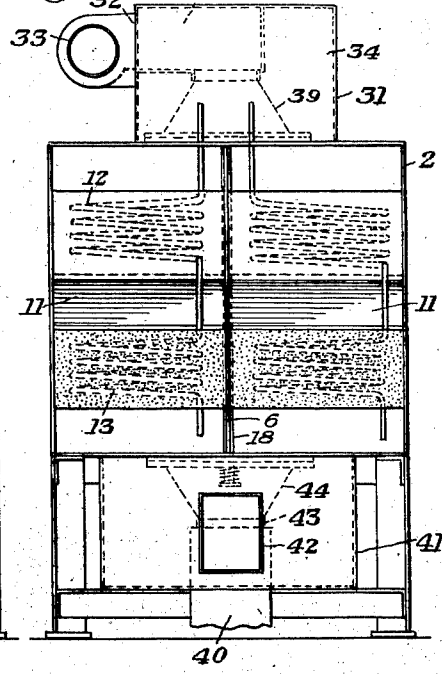


Fig. 3.



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3 Sheets-Sheet 2

Fig. 4.

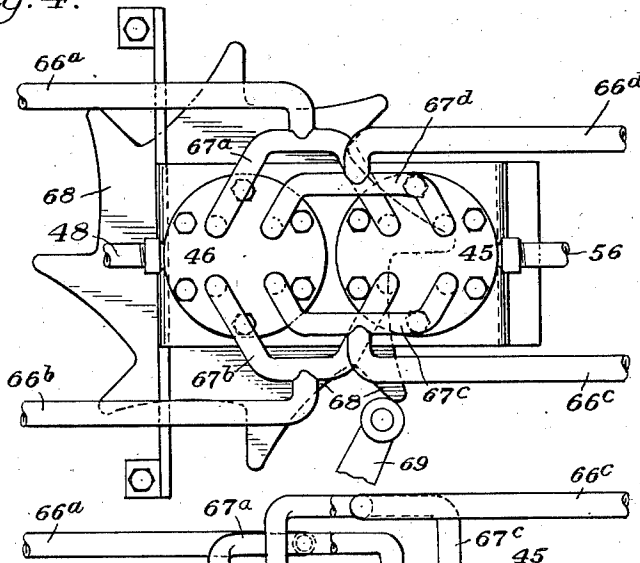


Fig. 5.

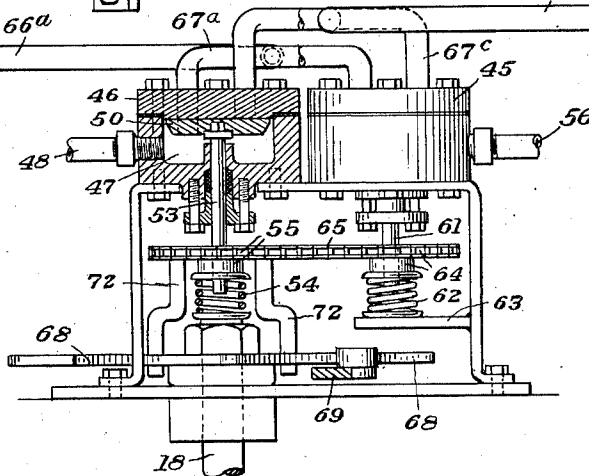


Fig. 6.

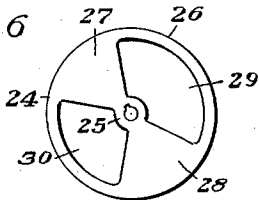


Fig. 7.

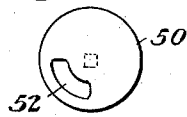


Fig. 8.



Fig. 9.

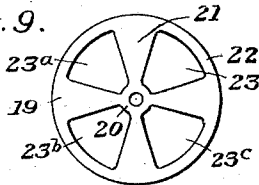


Fig. 10.

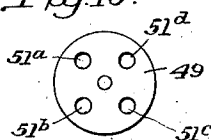
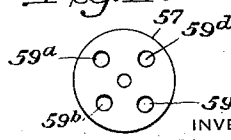


Fig. 11.



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Fig. 19.

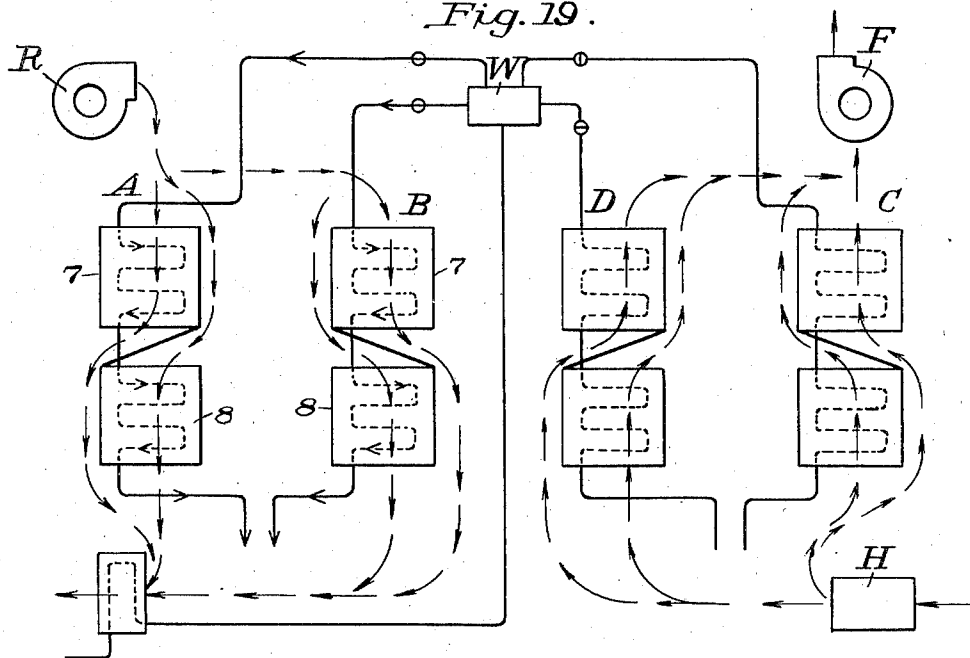
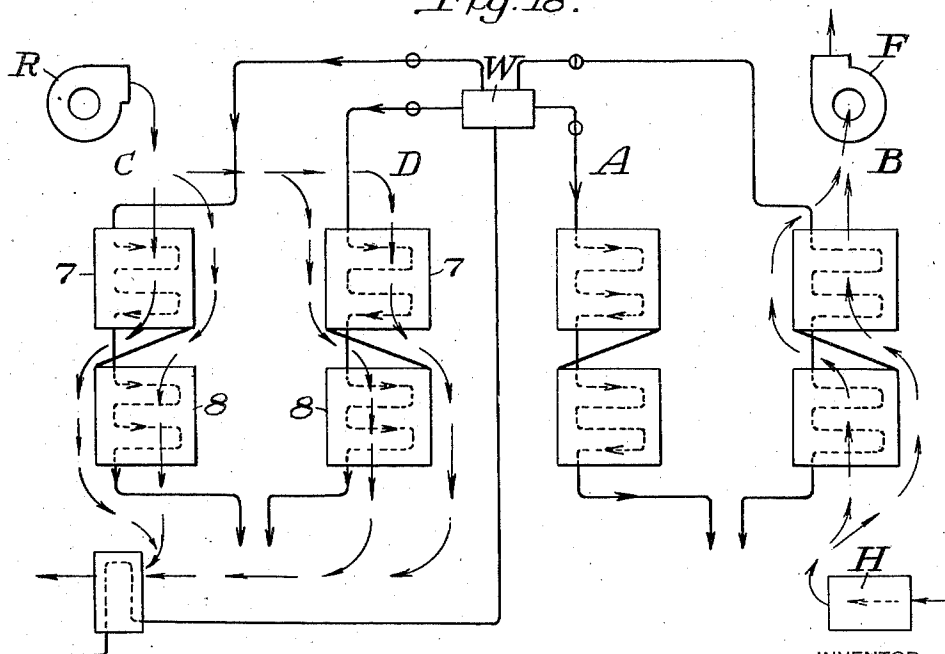


Fig. 18.



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UNITED STATES PATENT OFFICE

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METHOD OF AND APPARATUS FOR TREATING GASES

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Application July 31, 1939, Serial No. 287,461

9 Claims. (Cl. 183—4)

This invention relates in general to the treatment of gases by bringing the gases into contact with reagents or materials which alter in some way the physical characteristics or composition of the gas or gases so treated, as, for example, adsorption processes and apparatus. The present invention is chiefly concerned with improvements in adsorbing apparatus and more particularly to adsorption systems and apparatus for continuous operation in which the adsorbent material employed is of a nature which can be reactivated or revived by heating. Adsorbents are well known which readily adsorb by contact certain constituents from a moving stream of gaseous mixture and when saturated with such constituent can be renewed for re-use by heating. The heating can be conveniently effected by means in contact with the material or by passing hot gases through the adsorbent material, which is conveniently in granular form.

An adsorber of the nature to which this invention is particularly applicable removes moisture from the air or other gas by the physical process of adsorption. Two streams of air flow through the apparatus continuously. The main stream of air to be dried passes through the adsorber beds and gives up its moisture to the granular particles of the adsorbent material. The apparatus has several beds of adsorbing material and the spent beds are reactivated by a second stream of air while the recently reactivated beds are on the drying cycle. This second stream of air is heated to draw off the released moisture from the activated alumina or the alumina may itself be heated so as to cause the moisture to be given up to the second stream of air. A single valve control system directs and controls the air streams and an associated system controls the heating and cooling of the adsorbent beds so that the operation is a continuous one.

My invention is particularly applicable for use in connection with drying and conditioning air and will be described in connection with apparatus for that purpose, but it is to be understood that it is of value for the treatment of other gases as well. I prefer to use activated alumina in granular form as the adsorbent medium, since this material has a very large capacity for adsorbing moisture due to its extensive surface. After adsorption has been carried out, the moisture adsorbed can be driven off by heat and the material used again. This cycle can be repeated indefinitely, which obviates the expense and inconvenience of changing the adsorbent. The

spent alumina may be reactivated by the controlled application of heat, the source of which may be gas, steam, electricity or in some cases, waste heat from other processes, according to circumstances. The moisture evolved during activation is removed by a stream of gas or a vacuum. After all the moisture has been removed, the alumina is cooled and is once more ready for adsorption.

One of the objects of the invention resides in the novel construction and arrangement of the means for controlling the flow of dehumidifying air and the flow of reactivated air through the adsorber unit so that a relatively fixed output of dried air having relatively constant physical properties can be sustained. An important feature resides in the construction and arrangement of the adsorber units and the valves for controlling the flow of air through the unit and the valves for controlling the flow of heating or cooling fluid through various portions of the adsorber unit. The arrangement is such that the operation is continuous and automatic and the apparatus will continue to operate without attention on the part of anyone. The apparatus can be adjusted to cope with varied conditions.

I prefer to make my apparatus of rectangular or square shape, so as to utilize the floor area to the best advantage. The adsorbing beds are placed in layers, one above the other, according to the size of the dryer and are disposed, so that between the edges of the beds and the walls of the apparatus, a space will be left which is utilized as air ducts. The beds are separated physically and baffle plates are interposed so as to direct part of the air flow through one bed and part of the air flow through the bed directly beneath. This arrangement gives a greater area of contact of the air and adsorbent material and diminishes the thickness of material through which the air must flow and consequently lowers the resistance of the material to the flow of the air.

One of the disadvantages heretofore experienced in apparatus of this nature is the difficulty of keeping the degree of dryness of the treated air relatively constant. Heretofore when the air to be dried is first passed through the bed, the bed is at its maximum adsorption capacity, but shortly thereafter the adsorption ability is decreased and the air is not so thoroughly dried, due to the partial saturation of the adsorbent material. To insure that the dryness of the treated air will not greatly vary from time to

time during the operation of the device, I provide apparatus which permits the air to be treated to pass through one full bed and through part of an adjoining bed, while reactivating air is passing through still other beds. The flow to each bed is controlled by a port associated therewith and these ports are successively uncovered or covered so that the open area of the port to an adjoining bed is simultaneously progressively increased, thus decreasing the air flow to a bed which has been partly saturated and increasing the air flow to a bed which is fresh or less saturated than the bed being cut out. The portions of the fresh beds which are thus cut in from time to time equalize the adsorbing ability of the apparatus so that the treated air has relatively constant physical characteristics.

In the drawings I have shown for the purpose of illustration only the present preferred embodiment of apparatus suitable for the practice of my invention.

In the drawings:

Figure 1 is a plan view of the apparatus;

Figure 2 is a side view partly in elevation and partly in section along the line II-II of Figure 1;

Figure 3 is an end view partly in elevation and partly in section of the apparatus, a portion at the top thereof being omitted for the sake of clearness;

Figure 4 is a plan view of the top of the apparatus showing the arrangement of the steam and water valve control system and to an enlarged scale;

Figure 5 is a view partly in section and partly in elevation of the apparatus shown in Figure 4;

Figures 6, 7, and 8 are plan views of the rotating member of the air valve, the steam valve, and the water valve, respectively;

Figures 9, 10, and 11 are plan views of the stationary member of the air valve, the steam valve, and the water valve, respectively;

Figures 12, 13, and 14 are plan views of the air valve, the steam valve, and the water valve, respectively, showing the rotating members of each superimposed on the stationary members in dwell position I;

Figures 15, 16 and 17 are similar views to Figures 12, 13 and 14 but show the valves in dwell position II;

Figure 18 is a flow sheet showing the flow of air to be treated and reactivating air through the various beds when the valves are in the dwell position I; and

Figure 19 is a view similar to Figure 18 but showing the flow in the dwell position II.

In the drawings there is shown an apparatus constructed according to my invention for dehumidifying air or other gases, or for extracting one gas from a mixture. The apparatus is particularly suitable for dehumidifying air and will be described in connection therewith.

The adsorber is in the form of a metal box or casing 2 rectangular in plan, the top, bottom and sides of which are made from metal sheets. The box is divided by vertical partitions 3, 4, 5 and 6 which extend from the top to the bottom of the box and intersect to form four separate compartments A, B, C, and D. In each compartment or bed section there are two horizontally extending beds 7 and 8 of a suitable material such as activated alumina. The alumina of each bed is enclosed in a box having the side, top and bottom of foraminous metal. The beds 7 and 8 are spaced apart vertically so that there

are spaces between the beds and between the beds and the top and bottom of the adsorber 2. Each bed is of the same width as its compartment so as to fit closely between the partitions and the adjoining side of the adsorber, but the bed is shorter in length than the compartment so that when the upper bed 7 is in place with the inner end against the partition 5, there is a space 9 between the outer end of the bed and the end wall of the adsorber and when the lower bed 8 is in position with one end resting against the end wall of the adsorber 2, there is a space 10 between the inner end of the bed and the partition 5. The spaces 9 and 10 provide passages for the flow of air around the upper bed 7 and lower bed 8, respectively. An inclined zigzag partition of sheet metal 11 extends along the edges of beds 7 and 8 and diagonally from the outer bottom edge of the upper bed 7 to the inner top edge of the lower bed 8 and from the partition 4 to the outer side wall of the adsorber.

By this arrangement air passing through the compartment B will be guided and part of the air will flow through the upper bed 7 and part through the lower bed 8 as indicated by the arrows. While only two beds have been illustrated and described in each compartment, it is evident that one or more beds can be provided and where more than one bed is provided the beds and partitions should be arranged so that the air to be treated will flow equally through each bed. By arranging the beds in this manner, a large surface area is presented to the air to be treated and the thickness of the beds may be kept to such a point that there is not too much resistance to the flow of the air there-through while insuring that there will be ample contact area for the air with the particles of adsorbent material.

Adsorbent material, on taking up vapors or gases, rises in temperature due to the heat of adsorption. Most adsorbent materials function more effectively if the temperature is maintained at a fairly low point and for this purpose I provide cooling coils of pipe 12 and 13 in each of the beds 7 and 8 for removing the heat of adsorption from the adsorber beds and/or cooling the air on passage therethrough. The coil 12 is connected at the top to a water and steam control system 14, later to be described, and at the bottom to the coil 13. The bottom of the coil 13 runs to a drainage system 15. If desired, a cooling fluid can be passed through these coils by way of the valve system 14 or steam or hot water can also be passed through this system by way of the valve 14 so that the beds may be cooled or heated as desired.

The passage of air through the adsorber unit is controlled by a top valve 16 at the top of the unit and a bottom valve 17 at the bottom of the unit. Both valves are actuated by a shaft 18 which is centrally located in the box between the partitions and extends from the bottom to the top of the box and beyond to the water and steam control valve system 14, which will later be described. As the valves 16 and 17 are similar to one another, it will suffice to describe the top valve 16. The top valve 16 is made up of a stationary member 19 (Figure 9) and a rotating member 20 (Figure 6) which overlies and is concentric with the member 19 and is spring urged against it. The stationary member 19 has a central hub portion 20 through which the shaft 18 projects. Four radial spokes 21 equally spaced apart extend from the hub 20 to the periphery

22. The spokes have a radial width of about 30° and between the adjoining spokes there are open spaces or ports 23a, 23b, 23c, and 23d, extending from the hub to the periphery, the sides of each of which are about 60° apart. The member 19 is secured to the adsorber box 2 at the top thereof so that the center lines of the spokes 21 lie along the center lines of the partitions 3, 4, 5 and 6. There are openings in the top of the adsorber unit corresponding to the ports 23a, 23b, 23c and 23d in the stationary member 19, and leading to bed sections A, B, C, and D, respectively.

The rotating member 24 has a hub portion 25 through which the shaft 18 projects and to which the member is secured so as to turn with the shaft. Projecting from the hub 25 to the periphery 26 is a spoke 27 which has an angular width of about 66° and a spoke 28 which has an angular width of about 63°. Between the spokes there is an adsorption port 29 the sides of which are radial and spaced about 143° apart and a reactivation port 30, the sides of which are radial and spaced about 88° apart. In Figures 12 and 15 I have shown the top valve 16 in an assembled position, the stationary member 19 underlying the rotating member 24. It will be apparent from an inspection of these figures that either of the spokes 27 and 28 will completely cover either of the ports 23a, 23b, 23c and 23d of the stationary member 19 and that the adsorption port 29 is large enough to extend over one complete port, e. g. 23a, and a part of an adjoining port, e. g. 23d, while the reactivation port 30 is large enough to completely extend over one port 23c or over parts of two adjoining ports, e. g. 23c and 23d.

Resting on top of the adsorber unit 2 and surrounding the valve 16 is a sheet metal air chest 31 having sheet metal sides and top. In one of the sheet metal sides is a port 32 through which the air to be dried is forced by means of the blower 33. The blower is driven by the motor 34. Inside the chest 31 and adjacent the top is a chamber 35 which is smaller in all dimensions than the chest 31. The chamber 35 has a port 36 into which reactivating air is introduced from the blower 37 driven by the motor 34. Around the shaft 18 which projects through the chest 31 and concentric with the shaft is an opening 38 in the bottom of the chamber 35. A sloping metal duct 39 connects the opening 38 with the reactivation port 30 in the rotating member 24 of the valve 16. The duct 39 is secured to the rotating member 24 and rotates therewith. Through the duct 39 the reactivating air is led to the various ports 23a, 23b, 23c, or 23d, as the case may be, and at the proper interval in the cycle of operation the reactivating air passes through certain of the ports 23a, 23b, 23c, or 23d in the stationary member 19 and through the beds 7 and 8 and through the bottom valve 17 from whence it is discharged through the duct 40. Attached to the bottom of the adsorber unit 2 and surrounding the bottom valve 17 is a chest 41 which has a port 42 through which the treated air may be discharged. The duct 40 projects into the chest 41 and has a circular opening 43 which is concentric with the center line of the shaft 18. A duct member 44, similar to the member 39, is connected to the rotating member of the valve 17 and covers the reactivation port therein and leads the air from the reactivating port to the opening 43. The arrangement is very similar to the arrangement described in connection with the top valve 16. The valves are disposed with respect

to and operated by the shaft 18, so that the various ports of the stationary member of both valves are in line and the rotating members have their corresponding ports in line.

Mounted on the top of the chest 35 is the control system 14 for the cooling water and the steam which is used to cool or heat, as the case may be, the beds 7 and 8 by means of the coils 12 and 13, embedded therein. The admission of water to the coils 12 and 13 is controlled by a water control valve 45 and the admission of steam to the coils is controlled by a steam control valve 46.

The steam control valve 46 consists of a steam chamber 47 to which steam is led, at a suitable pressure from a suitable source, by a pipe 48 and a stationary member 49 and a rotating member 50. The stationary member 49 (see Figure 10) has four ports 51a, 51b, 51c, and 51d equiangularly and equi-radially disposed about the center of the member, which ports are connected to the heat exchange coils of the compartments A, B, C and D, respectively. The rotating member or disk 50, see Figure 7, has a steam port 52 which is annular in shape, the ends of which are about 90° apart and the port 52 is concentric with the ports 51a, 51b, 51c, and 51d of the stationary member 49 and the radial distances of the centers of the port 52 and the ports 51a, 51b, 51c, and 51d are equal. The members 49 and 50 are concentrically disposed, relative to each other, so that upon rotation of the member 50, relative to the member 49, the ports 51a, 51b, 51c, and 51d are covered or uncovered depending on the relative position of the ports, see Figures 13 and 14. The rotating member 50 is concentrically mounted on and rotated by the shaft 53. The abutting faces of the valve cover 48 and the rotating disk 50 are ground so as to have a fluid tight fit and the disk 50 is urged against the bottom of the disk 49 by the shaft 53. The shaft 53, in turn, is urged upwardly by the spring 54, which is interposed between the top of the shaft 18 and a sprocket wheel 55 which is secured to the shaft 53.

The water valve 45 is constructed similarly to the steam valve 46 which has just been described. Water from a suitable source and at a suitable pressure and temperature is led to the valve by the pipe 56. The supply of water to the coils 12 and 13 is controlled by a stationary member 57 similar to disk 49 and a rotating member 58 which is somewhat similar to the rotating member 50. The stationary member 57 has four ports 59a, 59b, 59c, and 59d which are equi-angularly and equi-radially disposed with respect to the center of the disk 57. Pipes lead the water at the desired temperature from the ports 59a, 59b, 59c, and 59d to the coils 12 and 13 of the compartments A, B, C, and D. The rotating disk 58 has a port 60 which is somewhat similar to port 52 of member 50, but the port 60 extends through an angle of 180° so that the port 60 may extend over two full ports, e. g. 59c, 59d (Figure 17) or over one full port 59d and two ports 59a, 59c, one on each of the full port 59d (Figure 14). The disk 58 is rotatably secured to and rotatably supported by the shaft 61 which is resiliently urged upward by the spring 62 supported on the bracket 63. A sprocket wheel 64 is secured to the shaft 61, and is connected to the sprocket wheel 55 by a chain 65 so that the two sprocket wheels are driven synchronously and in the same direction.

The water or steam, as the case may be, is led from the ports 51a, 51b, 51c, and 51d and 59a, 59b, 59c, and 59d of the valve device 14 to

each of the compartments A, B, C and D by the pipes 56a, 56b, 56c, and 56d, respectively, one to each compartment. Each of the pipes is connected by the manifold 57a, 57b, 57c, and 57d to the ports 51a, 51b, 51c, and 51d, respectively of the steam and to the ports 59a, 59b, 59c, and 59d of the water valve (see Figure 4).

A Geneva wheel 68 is secured to the upper end of shaft 18 and serves to drive it. The wheel 68 is driven anti-clockwise by means of the driving arm 69 on the speed reducer 70, which is in turn driven by the motor 34 by means of a belt 71. The Geneva wheel 68 also rotates the sprocket wheel 55 by means of the pegs 72 which make a sliding fit with the Geneva wheel 68.

The apparatus is so designed that the various rotating valve members are moved step by step in unison by the operation of the Geneva wheel 68 to eight separate dwell positions I through VIII spaced 45° apart. The length of the dwell period is determined by the conditions to be met. Successive portions of fresh compartments are at each interval subjected to the flow of the air to be treated, and the flow to the partially saturated compartments is being cut off at the same time, while the compartments which have the adsorbent saturated with moisture are being reactivated. The air which has flowed through the fresh compartment and the air which has

cycle, since port 23b is fully opened. Steam is being admitted to the coils 12 and 13 in beds 7 and 8, compartment B, since the steam port 23b, which leads to compartment B is uncovered. Cooling water at full flow is being supplied to the coils in the compartment D, the water port 59d being fully opened and water at reduced flow is being supplied to the coils 12 and 13 in compartments A and C, since the water ports 59a and 59c are partly opened (Figure 14).

In the dwell position II the port 23d leading to the bed section D is fully opened to the flow of air for adsorption and the port 23a leading to the compartment A is partly open, allowing partial flow of air through that compartment. The flow of reactivating gas through the compartment B has been cut down by the partial closing of the port 59b to that compartment and a small flow of reactivating air has been established through compartment C by the partial opening of the port 59c. Steam will pass in reduced volume through the coils 12 and 13 in the compartments B and C as both steam ports 51b and 51c are partially opened. Cooling water will pass at full force through the coils 12 and 13 in the compartments D and A since the ports 59d and 59a are fully open. The following list shows the flow cycle of the air to be treated, the reactivating air, the cooling water and the heat medium (steam) for the various dwell positions.

Dwell position	Compartment A	Compartment B	Compartment C	Compartment D
I.....	No air flow. Reduced water flow. Partial adsorption.	Full reactivation. Full steam flow. Partial reactivation.	Partial adsorption. Reduced water flow. Partial reactivation.	Full adsorption. Full water flow. Full adsorption.
II.....	Full water flow. Full adsorption. Full water flow.	Reduced steam flow. No air flow. Reduced water flow.	Reduced steam flow. Full reactivation. Full steam flow.	Full water flow. Partial adsorption. Reduced water flow.
III.....	Full adsorption. Full water flow. Full adsorption.	Partial adsorption. Full water flow. Full adsorption.	Partial reactivation. Reduced steam flow. No air flow.	Partial reactivation. Reduced steam flow. Full reactivation.
IV.....	Partial adsorption. Reduced water flow. Partial reactivation.	Full water flow. Full adsorption. Full water flow.	Reduced water flow. Partial adsorption. Full water flow.	Full steam flow. Partial reactivation. Reduced steam flow.
V.....	Full reactivation. Reduced steam flow. Full reactivation.	Partial adsorption. Full water flow. Partial adsorption.	Full adsorption. Full water flow. Full adsorption.	Full reactivation. Reduced steam flow. No air flow.
VI.....	Full steam flow. Partial reactivation. Reduced steam flow.	Reduced water flow. Full reactivation. Reduced steam flow.	Full water flow. Full adsorption. Full water flow.	Reduced water flow. Partial adsorption. Full water flow.
VII.....	Full steam flow. Partial reactivation. Reduced steam flow.	Reduced water flow. Full reactivation. Reduced steam flow.	Full water flow. Full adsorption. Full water flow.	Reduced water flow. Partial adsorption. Full water flow.
VIII.....	Full steam flow. Partial reactivation. Reduced steam flow.	Reduced water flow. Full reactivation. Reduced steam flow.	Full water flow. Full adsorption. Full water flow.	Reduced water flow. Partial adsorption. Full water flow.

flowed through the partially saturated compartments mingle and are discharged through the duct 42, with a relatively constant moisture content.

The dwell positions for air in description are indicated on the Figure 12 by the Roman numerals I through VIII. It will be observed that these numerals run anti-clockwise. A small arrowhead has been shown on the periphery of the rotating member 24 (Figure 12) to indicate the position of the rotating members in the operating cycle. Thus Figures 8, 9, and 12 show the relative positions of the ports in the rotating member 24 and the stationary member 19 of the valve 16 in the dwell position I; Figure 13 shows the relative positions of the ports of the stationary member 49 and the rotating member 59 of the steam valve 46; Figure 14 shows the relative position of the ports of the stationary member 57 and the rotating member 59 of the water valve 45, all in dwell position I. In the dwell position I the beds in compartment D are fully opened to the flow of air for adsorption, since port 23d is fully opened; the compartment C is also partly open to air for adsorption, since port 23c is partly opened; compartment A is on the cooling cycle, just preparatory to being cut in for adsorption, since port 23a is closed; and the compartment B is on the full reactivation

From a consideration of the cycle of operation set forth in the above table, it will be seen that adsorption is taking place in and there are parallel streams of air to be treated flowing through the beds of two adjoining compartments at all times. It is well known that the adsorber beds become saturated after a period of adsorption and the rate of adsorption drops so that the amount of moisture in the air output rises, but before this rise can assume any significant value, a new adsorber component is partially cut in, which keeps the variation in the moisture content of the treated air output at a minimum. At the time of adsorption the beds in adsorption are cooled by the water flowing through the coils in those beds, since most adsorbent material functions more effectively if the temperature thereof is kept fairly low. It will be observed that the flow of water to the beds is proportional to the flow of air to be treated. When a bed is on full adsorption, the water through the coils of that bed is in full flow and when the bed is on partial adsorption, the flow of water through that bed is also partial. The circulation of the water may also serve to lower the temperature of the bed and consequently of the treated air. As soon as the passage of adsorption air to a compartment is cut off, the steam flow is established through the coils in that compartment in reduced volume and re-

activating air in reduced volume is passed through the beds. This will be readily appreciated by comparing Figures 12, 13, and 14 with Figures 15, 16, and 17, respectively. In Figure 15 which shows the valves in the dwell position II, the reactivating air has just begun to flow at reduced volume to compartment C through the partly opened port 23c and steam is beginning to flow through the coils 12 and 13 in the compartment C through the partly opened steam port 51b and continues to flow to the compartment B through the partly closed steam port 51c. The heating of the beds by the steam passing through the coils aids the reactivating process. The rate of flow of the steam is varied with the flow of reactivating air.

The apparatus which I have described operates automatically and continuously, once it is adjusted to meet the desired conditions. The apparatus can be adjusted at any time to meet varied conditions.

It is, of course, apparent that the reactivating air could itself be heated, the heating thereof being controlled by the operation of the valve system 14, in which case it might be unnecessary to allow steam to pass through the embedded coils. If desired, the reactivating air and coils could both be heated and this valve system 14 can be adapted to control such an operation. It is also apparent that the reactivating air could flow counter to the flow of the air to be treated.

In Figure 18 I have shown diagrammatically the flow of air to be treated, the flow of reactivating air and the flow of the cooling water through the apparatus, when the valves are in the dwell position I (Figures 12, 13 and 14). The air to be dried, urged by the fan R, is forced at full flow through the compartment D since the port 23d is wide open, and at partial flow through the compartment C, since the port 23c is almost closed. The reactivating air is shown as being heated by being passed through the heater H before it is drawn through the compartment B, at full flow by the exhaust fan F, since the port 23b is wide open. The beds in compartments A, C and D are being cooled by water from the water header W. The flow of water through the compartment D is full, while the flow through the compartments A and C is partial, since the port 59d is wide open, the port 59a has just been partly opened, and the port 59d has just been partly closed. The beds in the compartment A are being finally cooled by flowing water preparatory to being cut in for treatment of the air flow.

The Figure 19, which diagrammatically shows the various flows, when the valves are in the dwell position II. The air to be treated, driven by the fan R, is flowing at full rate through the compartment D and flow at a partial rate has just been established through the compartment A. The beds B and C are being reactivated by the flow therethrough of reactivating air heated by passage through the heater H and drawn through the beds by the exhaust fan F. The flow through both the compartments B and C is partial, since the port 23b has been reduced and the port 23c has just been partly opened. The beds in the compartments A and D are being cooled by water from the water header W which is flowing at full force through the wide open ports 59a and 59d.

The invention has been described as being particularly useful for the purpose of dehydrating atmospheric air, such as for conditioning the air in an enclosed space and for use in operations which require substantial dehydration of air, such as metallurgical operations, but it is

to be understood that the invention is not to be limited to such application, since it can be used for treating other gases from which one or more constituents are to be removed.

Where the word "air" is used in the claims, it is intended to include mixtures of gases and/or gases and vapors such as humidified air.

While I have described a preferred embodiment of my invention, it is to be understood that my invention is not limited to this embodiment but may be practiced within the scope of the following claims.

I claim:

1. The method of treating gas with a reagent contained in a series of compartments which comprises dividing the flow of gases in such a manner that a portion of the total gas flow is passed through one compartment and the remainder through an adjoining compartment in predetermined relative portions, intermittently advancing the flow through the series of compartments while maintaining said division of flow while reversing the proportions of said rate of flow relative to each other, and maintaining a flow of conditioning fluid through ducts in said compartments which flow of conditioning fluid is substantially proportional to the rate of flow of gas through said compartments.

2. The method of treating gas with a reagent contained in a series of compartments which comprises dividing the flow of gases in such a manner that a predetermined portion of the total gas flow is passed through one compartment and the remainder through an adjoining compartment in predetermined relative proportions, intermittently advancing the flow through the series of compartments while maintaining said division of flow and reversing the said rate of flow relative to each other, and maintaining a flow of fluid through ducts provided in the said compartments at a temperature which is different from the temperature of the gases and at a rate which is substantially proportional to the rate of flow of gas through said compartments.

3. In apparatus for treating gases, a plurality of separate treating compartments disposed closely adjacent around a central point, each compartment containing a gas treating material, an opening in each end of each compartment concentric with said central point through which gas may be introduced to and withdrawn from the compartments, means for circulating gas through the compartments and valve means for controlling the flow of gases to the compartments, said valve means comprising a stationary disk concentric with said central point and having spaced openings, one for each compartment, the openings of the disk and the compartment openings being in register, and a rotating disk concentric with the stationary disk and in face to face contact therewith, means for rotating the rotatable disk step by step from one position where the full area of one opening in the stationary disk and a predetermined portion of an adjoining opening of the stationary disk is uncovered, to a position where a predetermined part of said disk opening and another adjoining opening of the stationary disk is uncovered, the rotatable disk having a main port and a secondary port, the main port being large enough to cover one full opening, and a part only of one adjoining opening of the stationary disk when the valve is in dwell position, the secondary port being large enough to slightly more than cover one of the disk openings and being oppositely

radially disposed with reference to the main port.

4. In apparatus for treating gases, a plurality of separate treating compartments disposed about a central point, each compartment containing a gas treating material, an opening in each end of each compartment through which gas may be introduced to and withdrawn from the compartment, means for circulating gas through the compartments, valve means for controlling the flow of gases to the compartments, said valve means comprising a stationary disk having spaced openings, one for each compartment, the openings of the disk and the compartment openings being in register, and a rotating disk concentric with the stationary disk and in face to face contact therewith, means for intermittently rotating the rotatable disk step by step from one dwell position to another, the rotating disk having a main port and a secondary port, the main port being large enough to cover one full opening and a part of an adjoining opening of the stationary disk, fluid circulating ducts in each compartment and valve means for controlling the flow of conditioning fluid through the ducts of a compartment in proportion to the rate of flow of gases through the gas treating material.

5. In an adsorber for treating gases, a quadrilateral casing divided into substantially equal compartments by intersecting partitions, adsorbent material in each compartment, each compartment having an opening thereinto, a stationary disk having apertures equally spaced about the center of the disk, each of which apertures are connected to a compartment opening, a rotatable member in contact with the stationary disk and concentric therewith, means for rotating the rotatable member step by step from one dwell position to another, the rotatable member having an adsorption port and a diametrically opposed reactivation port arranged concentrically with the stationary disk apertures and registrable therewith, the adsorption port being large enough to extend over one aperture and a substantial part of an adjoining aperture, the reactivation port being of a size substantially large enough to extend from the center line of one stationary disk aperture to the center line of the next aperture, means for controlling the passage of temperature conditioning fluids to said compartments, said means comprising a fixed disk having a connection to each compartment and a rotatable disk having means to cover and uncover at least a portion of the adjoining terminals of two of said connections to control the flow of conditioning fluid to ducts in the various compartments, and means for synchronously driving said means and rotatable member.

6. In apparatus for treating gases, a plurality of substantially equal separate treating compartments disposed closely adjacent a central spindle, each compartment containing a bed of gas treating material, each compartment having a radially centrally disposed opening thereinto, valve means controlling the openings, said valve means comprising a stationary disk and a rotatable disk, the stationary disk having equal radial apertures uniformly spaced about the center of the disk, a spoke between each aperture, each of said apertures being connected to a compartment opening, a rotatable disk being in face to face contact with the stationary disk, said rotatable disk having an adsorption port and a diametrically opposed reactivation port, the ports

being arranged concentrically with the stationary disk apertures, the adsorption port having a radial width large enough to extend substantially over two apertures and the intervening spoke, the reactivation port being large enough to extend substantially over one aperture and an adjoining spoke, means for rotating the rotatable member from one dwell position to another dwell position step by step, the dwell positions being equally spaced apart.

7. In apparatus for treating gases, a plurality of substantially equal separate treating compartments disposed closely adjacent a central spindle, each compartment containing a bed of gas treating material, each compartment having a radially centrally disposed opening thereinto, valve means controlling the openings, said valve means comprising a stationary disk and a rotatable disk, the stationary disk having equal radial apertures uniformly spaced about the center of the disk, a spoke between each aperture, each of said apertures being connected to a compartment opening, a rotatable disk being in face to face contact with the stationary disk, said rotatable disk having an adsorption port and a diametrically opposed reactivation port, the ports being arranged concentrically with the stationary disk apertures, the adsorption port having a radial width large enough to extend substantially over two apertures and the intervening spoke, the reactivation port being large enough to extend substantially over one aperture and an adjoining spoke, means for rotating the rotatable member from one dwell position to another dwell position step by step, the dwell positions being equally spaced apart, one of the dwell positions being such that the adsorption port extends over a full aperture, a substantial part of an adjoining aperture, the spoke between said apertures, and a substantial part of a second spoke adjoining the full aperture.

8. In apparatus for treating gases, a plurality of substantially equal separate treating compartments disposed closely adjacent a central spindle, each compartment containing a bed of gas treating material, heat exchange coils in said compartments, each compartment having a radially centrally disposed opening thereinto, valve means controlling the openings, said valve means comprising a stationary disk and a rotatable disk, the stationary disk having equal radial apertures uniformly spaced about the center of the disk, a spoke between each aperture, each of said apertures being connected to a compartment opening, a rotatable disk being in face to face contact with the stationary disk, said rotatable disk having an adsorption port and a diametrically opposed reactivation port, the ports being arranged concentrically with the stationary disk apertures, the adsorption port having a radial width large enough to extend substantially over two apertures, and the intervening spoke, the reactivation port being large enough to extend substantially over one aperture and an adjoining spoke, means for rotating the rotatable member from one dwell position to another dwell position step by step, the dwell positions being equally spaced apart, and means operated synchronously with the rotatable disk for controlling the flow of heat exchanging fluids through the coils so that when a bed is in the partial adsorption phase, or there is no air flow therethrough a reduced flow of cooling fluid is maintained, and while a bed is in partial reactivation a reduced flow of heated fluid is maintained, and while in the full reac-

tivation phase a full flow of heated fluid is maintained.

9. In apparatus for treating gases, a plurality of substantially equal separate treating compartments disposed closely adjacent a central spindle, each compartment containing a bed of gas treating material, each compartment having a radially centrally disposed opening thereinto, valve means controlling the openings, said valve means comprising a stationary disk and a rotatable disk, the stationary disk having equal radial apertures uniformly spaced about the center of the disk, a spoke between each aperture, each of said apertures being connected to a compartment opening, a rotatable disk being in face to face contact with the stationary disk, said rotatable disk having an adsorption port and a diametri-

cally opposed reactivation port, the ports being arranged concentrically with the stationary disk apertures, the adsorption port having a radial width large enough to extend substantially over two apertures and the intervening spoke, the reactivation port being large enough to extend substantially over one aperture and an adjoining spoke, means for rotating the rotatable member from one dwell position to another dwell position step by step, the dwell positions being equally spaced apart, an air chest surrounding the valve and divided into two chambers, one of which is connected by a revoluble duct to one of the ports in the rotating disk, the other being in communication with the other port.

WILLIAM E. MOORE.