

April 14, 1942.

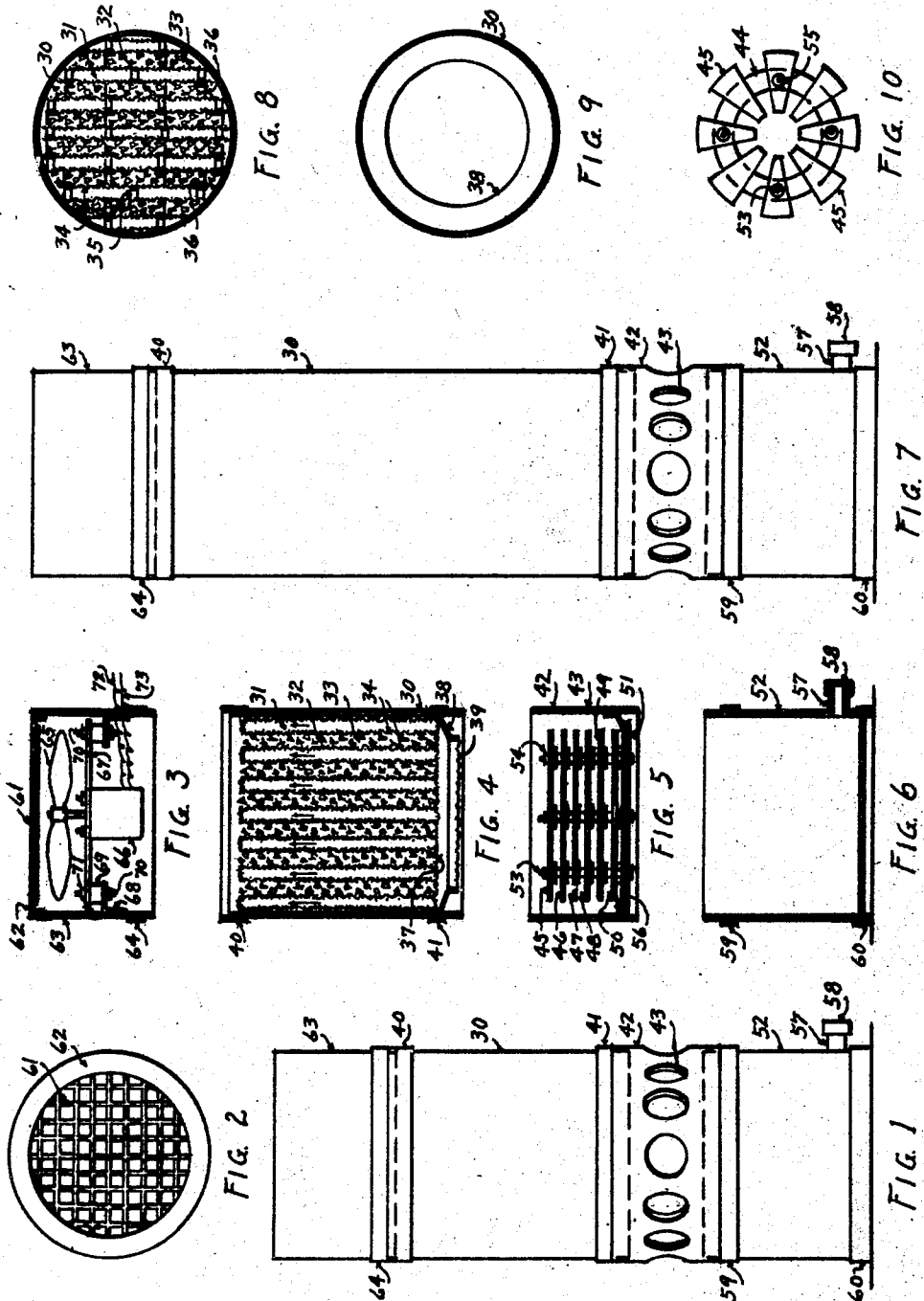
H. J. KAUFMAN

2,279,326

APPARATUS FOR DEHYDRATING AIR

Filed Sept. 13, 1939

2 Sheets-Sheet 1



INVENTOR.

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April 14, 1942.

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2 Sheets-Sheet 2

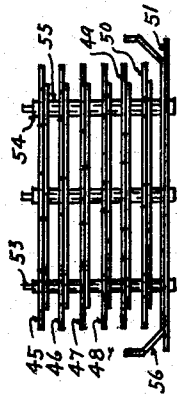


FIG. 17

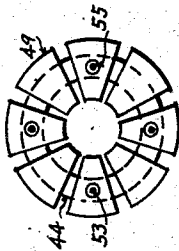


FIG. 14

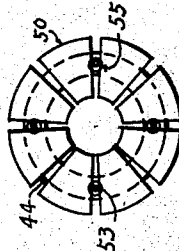


FIG. 15

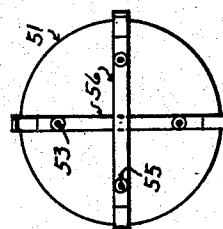


FIG. 16

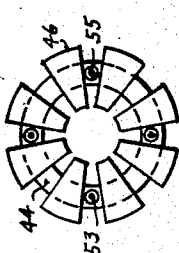


FIG. 11

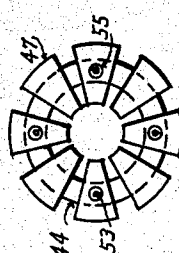


FIG. 12

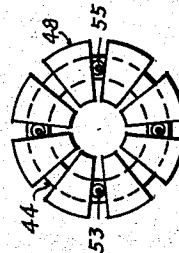


FIG. 13

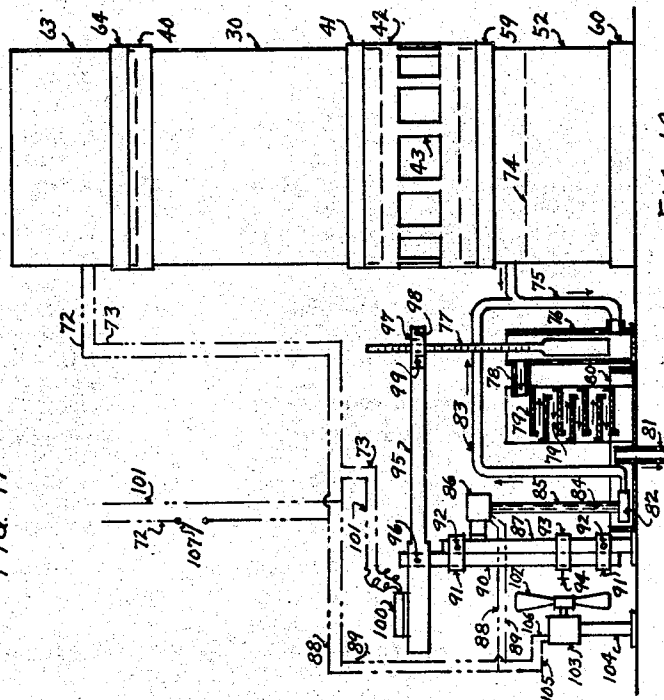


FIG. 18

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2,279,326

APPARATUS FOR DEHYDRATING AIR

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4 Claims. (Cl. 183—4)

This invention relates to apparatus for dehydrating air, and particularly to portable cabinets which use granulated calcium chloride as the absorbing agent.

One of the objects of my invention is to provide apparatus which is composed of demountable and interchangeable sections with variable storage and dehydrating capacities.

Another object of my invention is to provide simple apparatus for drying out spaces which are surrounded by earth or water, and which is not effected by freezing temperatures.

Another object of my invention is to provide cylindrical apparatus in demountable sections for getting through the minimum size of manholes as found between the compartments in the lower holds of marine vessels, and which will operate in marine service with the vertical axis tilted in any direction due to the movement of the vessel.

Referring to the drawings wherein the principles of the present invention are shown applied to portable dehydrating cabinets:

Fig. 1 is a side elevational view of the cabinet with its self-contained units assembled,

Fig. 2 is a plan view of the cabinet shown in Fig. 1,

Fig. 3 is a vertical cross-section of the circulating fan unit of the assembly of Fig. 1,

Fig. 4 is a vertical cross-section of the container unit for the hygroscopic solid of the assembly of Fig. 1,

Fig. 5 is a vertical cross-section of the plate unit shown for handling the hygroscopic solution of the assembly of Fig. 1.

Fig. 6 is a vertical cross-section of the waste solution receiver unit of the assembly of Fig. 1,

Fig. 7 is a view similar to Fig. 1 of a cabinet having a unit of Fig. 4 of greater length,

Fig. 8 is a cross-sectional view taken just below the top of the container unit shown in Fig. 4,

Fig. 9 is a cross-sectional view taken slightly above the lower end of the container unit shown in Fig. 4,

Figs. 10 to 15, inclusive, are progressive plan views of the plates making up the unit of Fig. 5,

Fig. 16 is a cross-sectional view of the unit of Fig. 5 taken just above the lower plate,

Fig. 17 is an enlargement of the plate structure shown in elevation in Fig. 5, and

Fig. 18 is a diagrammatic representation of a dehydrating cabinet and hydrometric device for measuring the density of the waste hygroscopic solution to control relative humidity.

Referring specifically to Figures 4, 8 and 9; the air dehydrator containing hygroscopic solid is composed of the cylindrical shell 30, the alternate vertical air passages 31, the alternate verti-

cal spaces 32 for holding granulated calcium chloride 33, the partitions 34 between the said spaces 31 and 32, the tops of the said spaces 31, and the bottoms of the said spaces 32 being formed of wire cloth or perforated metal. The said partitions 34 are attached in pairs, each pair forming an air space and held together by the vertical U-shaped members 35. The said air space assemblies are separated from each other by the vertical L-shaped members 36. This construction may be reversed so that the calcium chloride spaces 32 are assembled with the said partitions 34 in pairs with the U-shaped members 35, and these assemblies separated from each other by the L-shaped members 36 in the air spaces. The said partitions 34 are supported on the perforated rack 37, which is attached to the said shell 30. Underneath the said rack 37 is a conical shaped rim 38 having a water tight connection with the said shell 30 and having a notched drip edge 39 at the bottom to break up the hygroscopic solution, dripping from the said spaces 32 holding granulated calcium chloride 33, into small streams in order to present more surface of solution to the action of the air, which is drawn upwardly through the said air passages 31, and to evenly distribute the said solution over the members below. The bands 40 and 41 are attached to the outside of the said shell 30 in order to maintain the said shell 30 in proper vertical relation to the members shown in Figures 3 and 5.

Referring to Figures 5 and 17; the air dehydrator containing hygroscopic solution is composed of the cylindrical shell 42, having the radial air inlet openings 43 and the horizontal hygroscopic solution members as shown in Figures 10 to 15, inclusive, and which consist of the ring plates 44, which are attached to the radial plates 45 to 50, inclusive, with radial openings between the said plates 45 to 50, inclusive, and which increase in area from bottom to top with the said radial air openings alternately spaced over each other.

Referring to Figure 16; the circulator plate 51 is solid with a diameter slightly smaller than the waste solution tank 52 as shown in Figure 6, to prevent the air from contacting and absorbing moisture from the waste solution. The said plates 45 to 51, inclusive, are held in vertical relation to each other by the bolts 53, the nuts 54 and the ferrules 55, and the whole assembly is supported on the bars 56, which are attached to the said cylindrical shell 42. The air is drawn into the air dehydrator containing hygroscopic solution through the said air inlet openings 43, between the said plates 45 to 51, inclusive, up-

wardly between and over the said plates 45 to 50, inclusive, in counterflow direction to that of the hygroscopic solution flowing downward over and between the said plates 45 to 50, inclusive.

Referring to Figure 6; the waste solution tank 52 has the drain pipe 57 and the cap 58 for draining away the waste solution. The said tank 52 has the band 59 attached to the outside near the top in order to support the said shell 42 and the band 60 attached to the outside at the bottom to stiffen the lower edge and to improve the appearance of the tank.

Referring to Figure 3; the grille 61 is attached to the top rim 62 which is attached to the cylindrical shell 63. The band 64 is attached to the outside of the said shell 63 to support the same in the proper vertical relation to the said shell 30. The fan 65 draws air through the apparatus and is driven by the motor 66 which is bolted to the bar 67, which is attached to the shelf brackets 68, which are supported on and insulated from the said shelf brackets 68 by means of the rubber insulators 69, which are vulcanized to the bolts 70 and are held in place by the nuts 71. Electric current is supplied to the motor by means of the wires 72 and 73.

Referring to Figure 18; the tank 52 has the raised bottom 74, the waste pipe 75 through which the waste hygroscopic solution flows into the lower portion of the tube 76, holding the hydrometer 77 and overflowing through the pipe 78, downward over the level plates 79, in alternate directions as shown by the arrows, and into the tank 80, having the overflow and waste pipe 81. The said plates 79 have one edge turned up and one edge turned down, and the latter notched so as to break up the surface tension of the solution and cause it to drip in a series of small streams so as to be evenly distributed over the surface of each succeeding plate underneath.

A portion or all of the waste solution is recirculated over a portion of this same route by means of the pump 82 and the pipe 83 as shown by the arrows. The said pump 82 is driven by the shaft 84, held in place by the torque tube 85, driven by the motor 86, which is supported by the standard 87. Electric current is supplied to the said motor 86 by the wires 88 and 89. The said standard 87 also supports the compensating thermostatic element 90 by means of the guides 91 which allow vertical movement of the said thermostatic element 90 and which are rigidly attached to the said standard 87 by the bolts 92. The vertical position of the said thermostatic element 90 is determined by the clamp 93 which is held in place against the said standard 87 by means of the set screw 94. The method of positioning this clamp 93 will be explained later. The upper end of the said thermostatic element 90 carries the lever 95, which is balanced on the pivot 96, and which carries the said hydrometer 77 by means of the clamp 97, held in place by the bolt 98, and allowed free motion on the said lever 95 by means of the pivot 99. The opposite end of the said lever 95 carries the mercury tube switch 100, which is supplied with electric current through the wires 73 and 101. Air is blown across the said plates 79 and the said compensating thermostatic element 90 by means of the fan 102, driven by the motor 103, supported by the standard 104 and supplied with electric current through the wires 105 and 106. The electric current for all of the motors is controlled by the switch 107.

The thermostatic element 90 can be made of

hard rubber, metal or other material which is lengthened by an increase and shortened by a decrease in temperature. The active length of the said thermostatic element 90, between the centers of the pivot 96 and the clamp 93, is determined by the relation of the change in length, of any given thermostatic material, due to a definite change in temperature, to the change in vertical position of the hydrometer 77, due to the change in density of the waste hygroscopic solution, necessary to produce the same relative humidity at the same definite change in temperature. This length will vary with the scale of the readings on the particular hydrometer used. The vertical position of the said clamp 93 on the standard 87 should be such that when the hydrometer 77 is placed with the predetermined reading, corresponding to the desired temperature and relative humidity, at the surface of the solution corresponding to the line of the overflow in the tube 76, with the end of the lever 95 attached to the hydrometer 77 by means of the clamp 97, the clamp 93 should be fastened to the standard 87 at a height so that the left end of the mercury tube switch 100 will be tilted downward sufficiently to cause the mercury in the tube 100 to flow to the left end of the tube 100 and away from the ends of the wires 73 and 101, thereby breaking the circuit through the wires 72 and 73 and stopping the motor 66 and the fan 65, which draws air through the apparatus.

As air is drawn through the apparatus, first in contact with a hygroscopic solution and next in contact with a hygroscopic solid, moisture will move from the air to the said hygroscopic solution and hygroscopic solid, due to a difference in vapor pressure until equilibrium conditions are reached, and in a properly designed air dehydrator containing hygroscopic solution and having sufficient solution in contact with the air, the waste solution will have a vapor pressure in equilibrium conditions with that of the entering air, which is equivalent to a definite density and specific gravity for any fixed temperature, and also a definite relative humidity of the air entering the air dehydrator at the same fixed temperature.

A hygroscopic solution recirculated in a current of air will absorb or give off moisture so that its vapor pressure will eventually reach equilibrium conditions with that of the air. The vapor pressures, densities or specific gravities, and concentrations of hygroscopic solids dissolved in water are in definite relations to each other at any fixed temperature, and the vapor pressure of air in relation to a fixed temperature is, also, a measure of relative humidity.

The following table shows the specific gravity of calcium chloride solutions in equilibrium conditions of vapor pressure with that of the relative humidity of the air at the same temperature.

Temperature	Relative humidity				
	80%	70%	60%	50%	40%
100	1.212	1.270	1.318	1.358	1.400
90	1.211	1.269	1.317	1.357	1.398
80	1.210	1.268	1.316	1.356	1.396
70	1.208	1.266	1.314	1.354	1.393
60	1.207	1.263	1.312	1.351	1.390
50	1.202	1.260	1.309	1.348	1.387
40	1.199	1.257	1.306	1.344	1.383

The vertical position of a hydrometer rises with an increase of the density and lowers with a

decrease in the density of the solution in which the said hydrometer floats. The density of the said solution and the degree of concentration of dissolved solids in the solution increases slightly with increasing temperature and decreases slightly with decreasing temperature to maintain a vapor pressure in equilibrium with that of air at a constant relative humidity at variable temperatures. By compensating for temperature changes by means of a thermostatic element which acts inversely to a hydrometer with an increase or decrease in temperature, the combination of a hydrometer, actuated by the density of a hygroscopic solution in equilibrium conditions of vapor pressure with that of the surrounding air, and a compensating thermostatic element, actuated by the temperature of the surrounding air, can be used to measure relative humidity and to control apparatus for the regulation of relative humidity of air. The specific gravities of calcium chloride solution concentrations at various temperatures can be found in the technical handbooks.

Greater concentrations of calcium chloride are required at increasing temperatures to produce the same relative humidity of air; also, from reference to handbooks, it is noted that the specific density of calcium chloride solutions decreases with temperature for the same degree of concentration, and that both of these factors can be compensated for by the thermostatic element operating inversely to the hydrometric element.

The operation of the apparatus is as follows: the spaces 32 are filled with granulated or flake calcium chloride, the hydrometric clamp 97 and the thermostatic clamp 93 are set according to the instructions previously given, the switch 107 is closed and which supplies electric current through the wires 72, 73, 101, 88 and 89 to the motor 86, driving the pump 82, to recirculate the hygroscopic solution, and through the wires 105 and 106 to the motor 103, driving the fan 102 to blow air in contact with the compensating thermostatic element 90 and in contact with the recirculated waste hygroscopic solution flowing over the plates 79 and which, on a rising relative humidity, caused by an increase in the vapor pressure of the air and a corresponding decrease in the density of the recirculated waste solution, causes the hydrometer 77 to lower sufficiently to tilt the lever 95 and the mercury tube switch 100 so that the mercury flows to the right in contact with and connecting the wires 73 and 101 and completing a circuit through the wires 72 and 73 thereby starting the motor 66 which drives the fan 65, which draws air into the cabinet through the air inlet openings 43, between and over the plates 44 to 50, inclusive, in contact with the hygroscopic solution in the air dehydrator containing hygroscopic solution, up through the air passages 31, in contact with the hygroscopic solid 33 in the spaces 32 of the air dehydrator containing hygroscopic solid, and discharged through the top outlet grille until the desired relative humidity is reached for the air surrounding and entering the cabinet, at which time the hydrometer 77 rises in the tube 76, due to a lowered vapor pressure of the surrounding air and a corresponding increase in the density of the recirculated hygroscopic solution, which tilts the lever 95 and the mercury tube switch 100 so that the mercury flows to the left and away from the ends of the wires 73 and 101, thereby breaking the electric circuit in the wires 72 and 73 and stopping the motor 66 which drives the fan 65 and which

draws air through the cabinet in contact with the hygroscopic solution and the hygroscopic solid. The apparatus will function without the recirculated solution and the separate air flow except under conditions of low humidity and intermittent operation when the solution may cease to remain a liquid due to crystallization or accumulation of impurities.

It is to be understood that minor changes can be made in the general arrangement and detail of the invention in order to adapt it to modern industrial and commercial practice, and that other hygroscopic materials, such as magnesium chloride and soda lime, can also be used as the dehydrating agents.

What I claim is:

1. A portable sectional cabinet for dehydration of air comprising a plurality of self-contained changeable operating units superimposed one above the other to collectively define a vertical conduit for the passage of air, said units including a base unit in the form of a receptacle to receive by gravity flow waste hygroscopic solution, a plate unit above said base unit and having an interior structure over which the hygroscopic solution flows, air inlet openings defined in the wall of said plate unit to admit air to flow over said interior structure, a container unit above said plate unit for the solid hygroscopic material, said container unit being opened at the top and bottom and having as its interior structure, a cellular container of openwork side walls defining a plurality of adjacent vertical air passages and storage compartments for said solid material, and an upper unit having means for drawing air upwardly through said cabinet.

2. A portable sectional cabinet for dehydration of air comprising a plurality of self-contained changeable operating units superimposed one above the other to collectively define a vertical conduit for the upward passage of air and the downward flow of hygroscopic solution, said operating unit being cylindrical with their adjacent ends in sealed relation and including a base unit to receive waste hygroscopic solution, a plate unit above said base unit having an interior structure for spreading said solution in the air flow as the solution flows toward said base unit, horizontal air inlets in said plate unit for admitting air to pass over said interior structure, a container unit above said plate unit, said container unit having a cellular openwork interior structure to receive solid hygroscopic material and defining vertical air passages, and a top unit located above said container unit and having means for drawing air upward through said cabinet and discharging it therefrom.

3. Air conditioning apparatus comprising a first section open at the top and having a rack at the bottom, a group of baskets with open tops and perforated sides and bottoms for holding hygroscopic solid material supported upon said rack, said baskets being spaced to define air passages, a second section below said first section having horizontal air inlets in the sides and a vertical series of horizontal plates with openings in the said plates staggered over each other, to allow hygroscopic solution, dripping from the said hygroscopic solid material, to flow downward, through, and between the said plates, in a counter flow direction of air and solution when the vertical axis of the apparatus is tilted in any direction, a third section positioned below the said second section for collecting the waste hygroscopic solution, and a fourth section, super-

imposed above the said first section, containing means for drawing air into and upward, through the apparatus in contact with the hygroscopic solution and between the said baskets containing hygroscopic solid material.

4. Air conditioning apparatus, comprising a first cylindrical section open at the top, with a rack at the bottom, a group of baskets supported on said rack with open tops, and perforated sides and bottoms for holding hygroscopic solid material, said baskets being spaced to define air passages therebetween, a ring at the bottom of and attached to the sides of the said first cylindrical section, sloping away from the sides of the said first cylindrical container with a circular drip edge at the bottom having a diameter smaller than that of the said first cylindrical section for directing the hygroscopic solution, dripping from the said hygroscopic solid material, toward the center of the apparatus when the vertical axis is tilted in any direction,

the said circular drip edge notched so as to cause the solution to drip in a series of small streams, and superimposed above a second cylindrical section having horizontal radial air inlets in the sides and a vertical series of horizontal plates with openings in the said plates staggered over each other, to allow the hygroscopic solution, dripping from the said hygroscopic solid material, to flow downward, through, and over the said plates and to allow the air to flow over, upward, through and between the said plates, a third cylindrical section, positioned below the said second cylindrical section for collecting the waste hygroscopic solution, and a fourth cylindrical section, superimposed above the said first cylindrical section, containing means for drawing air into, upward and through the apparatus in contact with the hygroscopic solution and between the said baskets containing hygroscopic solid material.

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