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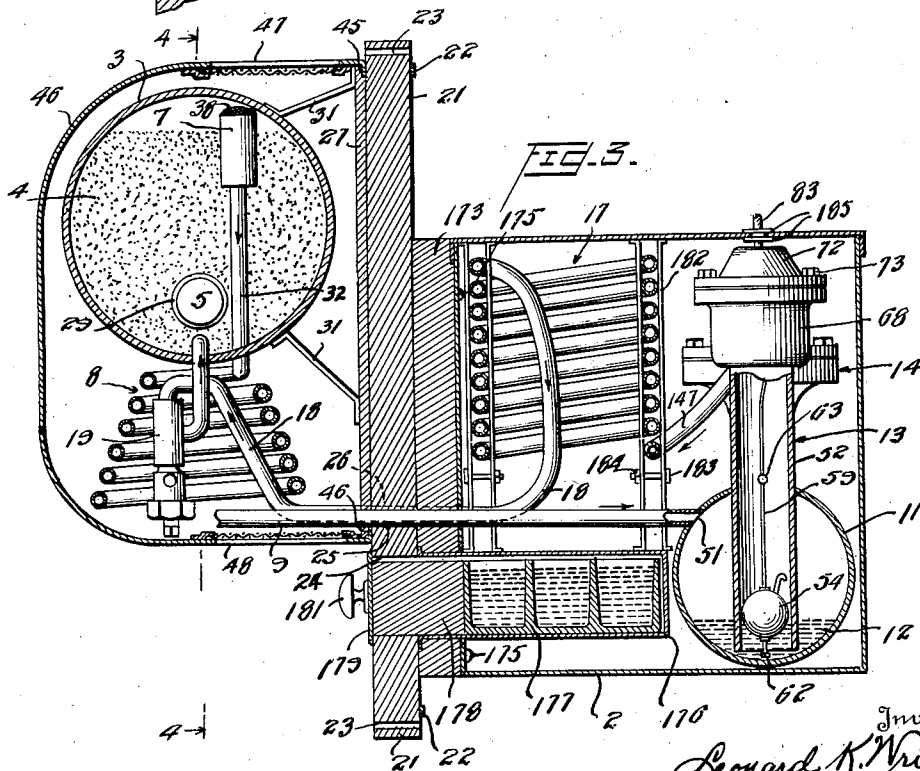
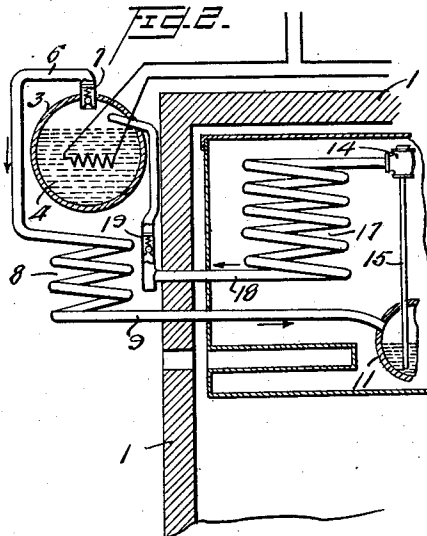
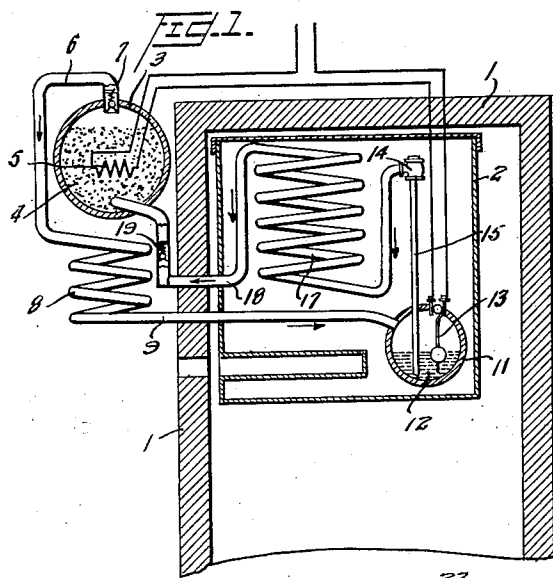
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REFRIGERATION APPARATUS

Filed Nov. 5, 1927

4 Sheets-Sheet 1



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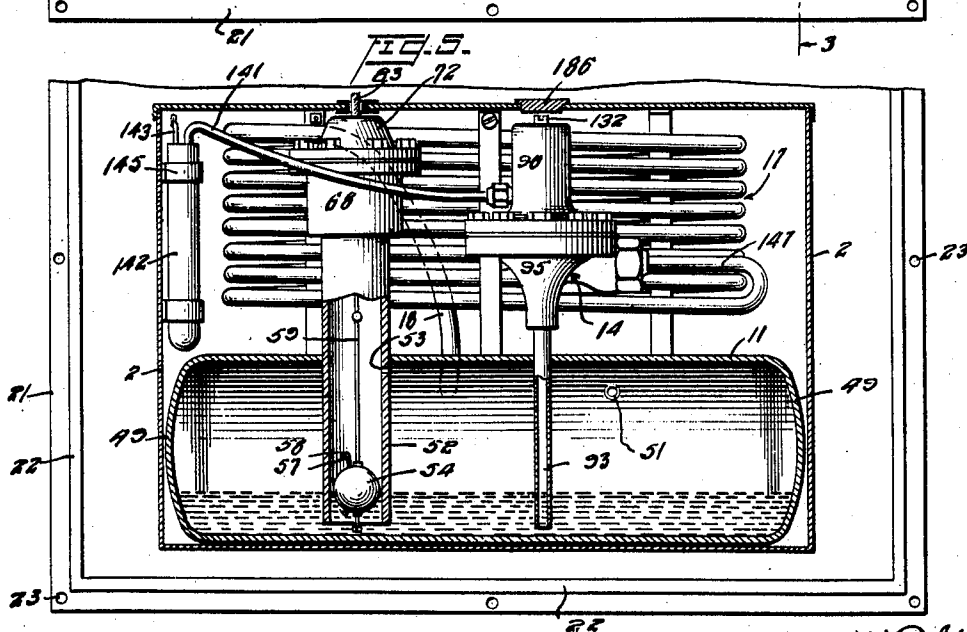
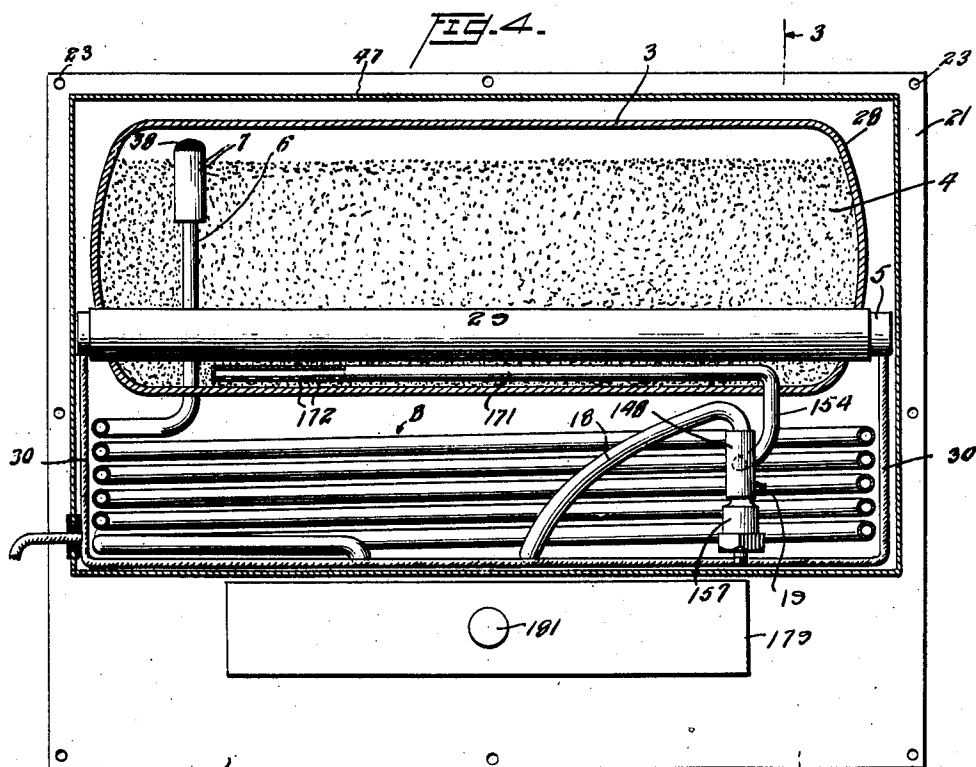
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REFRIGERATION APPARATUS

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4 Sheets-Sheet 2



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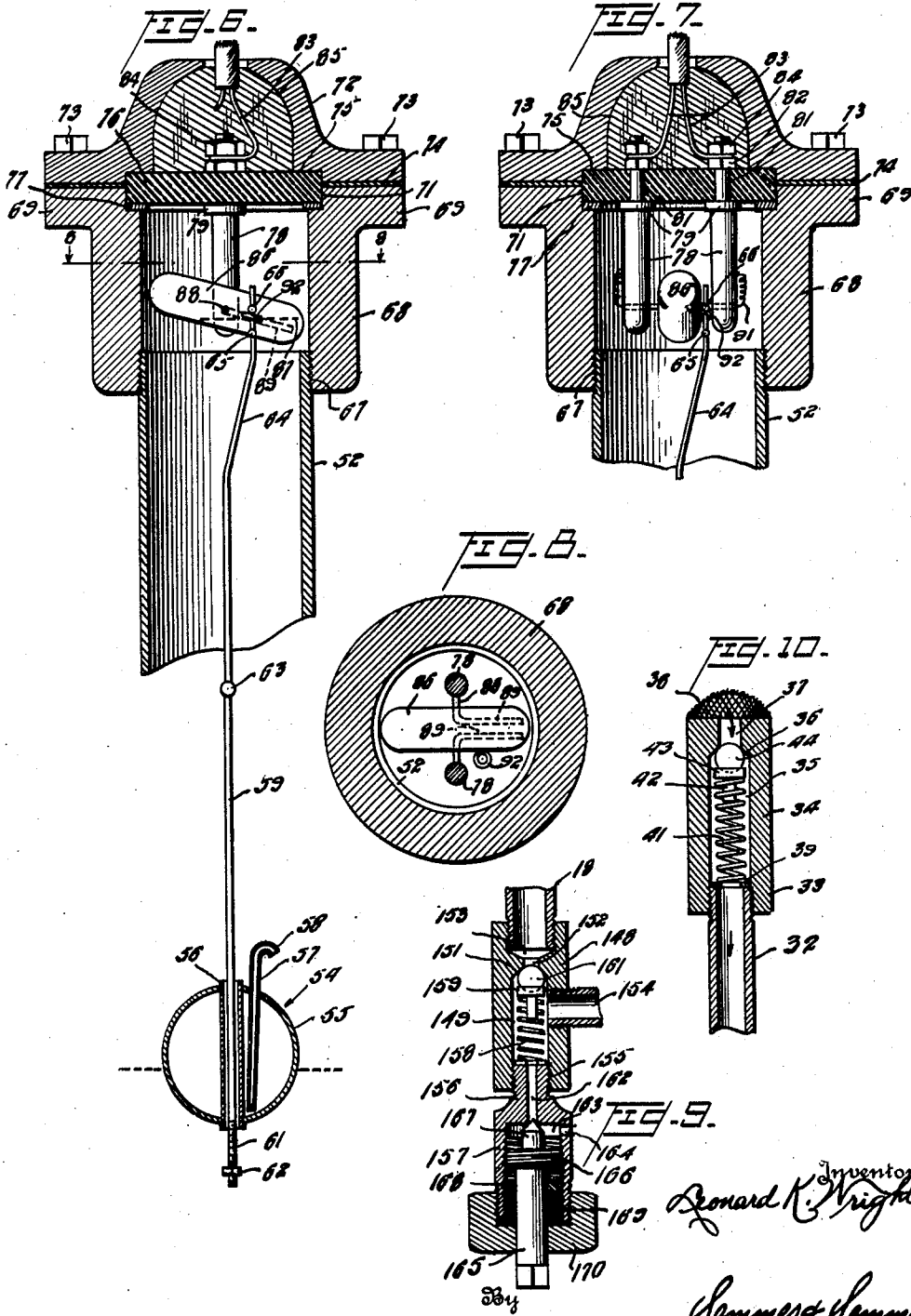
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REFRIGERATION APPARATUS

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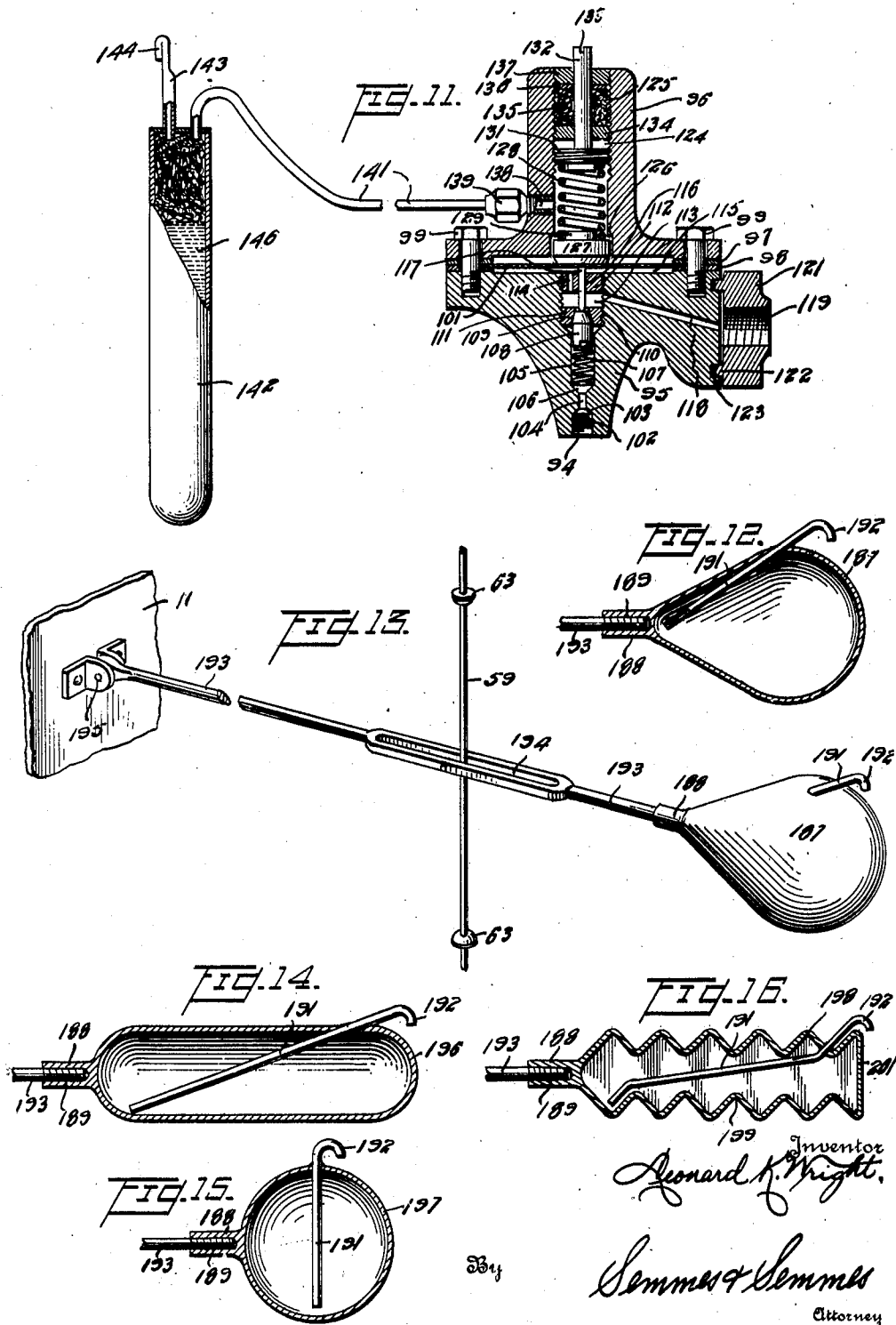
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REFRIGERATION APPARATUS

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4 Sheets-Sheet 4



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## UNITED STATES PATENT OFFICE

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## REFRIGERATION APPARATUS

Application filed November 5, 1927. Serial No. 231,357.

This invention relates to refrigeration, and more particularly has reference to a refrigerating apparatus and process of the adsorption or absorption type.

5 While my invention is particularly adapted for household use, it will be apparent that its application is not limited to such use. Heretofore in the various types of apparatus employed in refrigeration for the ordinary ice-boxes, it has been necessary to make special arrangements to house the unit, usually installing a portion of it on the side, beneath, or on top of the box. It has also been necessary to cut or drill holes through the box, in order to run the necessary pipes to the interior of the box. Difficulty has been experienced in sufficiently closing these holes to prevent the transmission of heat to the interior, and the admission of and retention of moisture to and by the insulation.

Most of the adsorption or absorption refrigerating units heretofore employed have used gas or oil as a source of heat. This is not always desirable, for there is the consequent fire hazard and, not infrequently, danger of explosion.

The condensers heretofore employed have usually necessitated water to obtain condensation of the gaseous refrigerant, and this has necessitated water lines which have seriously interfered with securing a compact and easily installed unit. Most of the refrigerating units have also required a box of special construction.

To overcome the above and other disadvantages inhering in the types of apparatus heretofore employed is one of the objects of this invention.

40 Another object is to provide a refrigerating apparatus, compact, yet durable, in construction, that is adapted to be installed in the ordinary ice-box.

A further object of this invention is to provide a refrigerating apparatus of the adsorption or absorption type that is economical to construct and simple in operation.

A still further object of this invention is to provide a refrigeration apparatus having 50 a minimum of movable parts, and that pre-

sents little opportunity for falling into disrepair.

And yet another object is to devise a refrigerating process that is economical to effect and that requires slight superintendence. 55

To accomplish the above, and other important objects as will be apparent, my invention in general comprises a container for a suitable adsorbing or absorbing material, means for applying heat to such material, 60 to drive off adsorbed refrigerant, apparatus for condensing and subsequently vaporizing the refrigerant, and appropriate control mechanisms.

Referring to the accompanying drawings, 65 in which similar numerals indicate the same parts, but wishing it to be distinctly understood that the showings therein made are merely exemplary, and that various modifications may be made in the structure set forth 70 without departing from the spirit of this invention:

Figure 1 is a diagrammatic sketch of a solid adsorption apparatus.

Fig. 2 is a diagrammatic sketch of a liquid 75 absorption apparatus.

Fig. 3 is a cross sectional view along the lines 3—3 of Fig. 4, looking in the direction of the arrows.

Fig. 4 is a sectional view of the apparatus 80 taken along the line 4—4 of Fig. 3, looking in the direction of the arrows.

Fig. 5 is a view of the rear of the apparatus, partly in elevation, and partly in section. 85

Fig. 6 is a side view in section of the current control device.

Fig. 7 is a detailed front view in section of the upper portion of the current control device. 90

Fig. 8 is a sectional view along the line 8—8 looking in the direction of the arrows.

Fig. 9 is a sectional view of the valve that controls the admission of the refrigerant to 95 the generator.

Fig. 10 is a sectional view of the valve to control the passage of the refrigerant from the generator to the condenser.

Fig. 11 is a detailed view, partly in section 100

tion and partly in elevation, of the expansion valve.

Fig. 12 is a sectional view of a modified form of float.

Fig. 13 is a view in perspective of the associated mechanism for the modified forms of float.

Fig. 14 is a sectional view of an alternative form of float.

Fig. 15 is a sectional view of another modified form of float.

Fig. 16 is a sectional view of still another modified form of float.

Figures 1 and 2 are included in the drawings principally for the purpose of illustrating the operation of my apparatus, and partly to show a desirable modification when a liquid adsorbent is employed in place of a solid adsorbent. An ice-box is denoted by the numeral 1. As will be observed later, this type of ice-box is optional. Within the box is positioned a watertight tank 2 which is usually filled with a brine, or other low freezing point solution. It is not necessary or desirable under all circumstances to provide a tank and a solution.

Within the tank, and immersed in the solution, if any, is the refrigerating portion of my apparatus. On the outside of the tank and box are the elements for heating and condensing the refrigerant. An adsorber-generator 3 is shown in Figure 1 which contains a suitable adsorbent 4, such as, for instance, activated charcoal, silica gel, or silica in the natural state. Interposed in the adsorbent is a suitable heating unit, shown in Figure 1, diagrammatically as a resistance coil 5. The refrigerant admitted to the generator in a gaseous form is adsorbed by the material 4. The capacity of the adsorbent is a function of its temperature, and, therefore, on application of heat the adsorbed refrigerant is driven off in the form of a gas, this quantity depending upon the adsorbing capacity of the adsorbent and whether its maximum has been reached.

A pipe 6 is joined to the adsorber-generator to convey the gaseous refrigerant to a suitable condenser 8 where the refrigerant, under pressure, is exposed to a lower temperature which liquefies the refrigerant. Positioned in the pipe 6, adjacent its point of juncture with the adsorber-generator, is a suitable valve 7, which permits the passage of the refrigerant from the generator to the condenser 8, when the pressure in the generator is higher than the pressure existing in the pipe 6.

From the condenser 8, a pipe 9 conveys the liquefied refrigerant to a receiving tank 11. The liquefied refrigerant, indicated in Figure 1 as 12, is held in the tank 11 until the so-called cooling cycle commences.

By means of a control device indicated generally as 13, when the liquefied refrigerant 12

reaches a certain height in the receiver 11, the current flowing into the resistance coils 5 or other heating means is shut off. With a reduction in temperature of the adsorbent, the apparatus commences an adsorption cycle. An extension valve 14, mounted on a pipe 15 from the tank 11, is controlled by the heat of the ice-box. With an increase in temperature of the ice-box, the liquefied refrigerant 12 passes through the valve 14 into an evaporating unit 17, where, under reduced pressure, the refrigerant evaporates and extracts heat from the surrounding medium. From the evaporating unit the refrigerant, now in gaseous form, passes through a pipe 18 and through a check valve 19 back into the adsorber-generator, where it is taken up by the adsorption medium.

This completes the cycle, and the operation is repeated as often as is demanded by an increase in the temperature within the ice-box.

The same principle of operation obtains in the case of a liquid absorption process, and only a slight change is necessary in the apparatus employed. Referring to Fig. 2, the refrigerant is driven out of the absorber-generator by heat, condensed in the condenser, and the liquefied refrigerant, on passing through the expansion valve 14, enters the top of the evaporating coil 17. In the course of evaporation, the refrigerant passes downwardly through the coil and thence through the valve 19 to the adsorber-generator.

This modification is made in order to protect the expansion valve and associated mechanism in case a portion of the absorbent should be vaporized when heat is applied to drive off the refrigerant. If such absorbent should be entrained in the volatilized refrigerant, and an apparatus of the type shown in Figure 1 is employed, the liquefied absorbent would fail to evaporate and would settle in the lower portion of the evaporating coil, seriously interfering with the process and possibly impeding the operation of the expansion valve.

As above stated, Figures 1 and 2 and the foregoing description of the process give a general idea of the apparatus and process of my invention.

My invention is particularly adapted for use when it is desired to convert an ice-box into a heat operated refrigerator. With most types of ice-boxes it is merely necessary to remove the door through which ice is inserted in the box and position my compact unit in the box. The hinges and catches of the door may be removed, and, referring to Fig. 3, a panel 21 fixed over the opening to securely close it. It is thus unnecessary to bore any holes in the box. The panel 21 is provided with gaskets 22, made of felt, rubber or other suitable material, which prevent the

passage of any heat into the ice-box. Bolt holes 23 through the panel 21 receive bolts, screws, or other suitable means for maintaining the panel 21 securely in position. The panel 21 is also provided with an opening 24 through which an ice tray is inserted in the box. Apertures 25 and 26 are drilled in the panel adapted to receive pipes which extend to the interior of the ice-box.

On the exterior of the panel 21 there is provided a supplementary panel 27, preferably made of suitable insulating material, such as asbestos. The panels 27 and 21 are joined securely by appropriate means not shown, such as bolts or screws.

There is shown in Fig. 3 the adsorber generator 3 referred to in Figure 1. As set forth more clearly in Fig. 4, the adsorber generator 3 is a cylinder extending substantially the length of the panel 21, and is provided with bulged ends 28. This is in accordance with pressure vessel design. Other methods may use flat or concave heads. Integral with, and positioned within the generator 3 in a fluid and pressure tight fit, is a heating tube 29 of high heat conductivity which houses the electrical resistance unit 5. The resistance coil 5 may form a tight fit with the jacket 29, as shown in Fig. 4, or if the outside diameter of the resistance coil is less than the inside diameter of the jacket 29, suitable means (not shown) are provided to prevent an escape of heat from the ends of the jacket 29. It will be observed that the jacket 29 extends the length of the generator 3, and is positioned near the bottom of the generator. The heat given off may thus penetrate the entire mass of adsorbent. Wires 30 carry the current from the source of supply to the resistance coil.

Under suitable circumstances the heat may be applied to the adsorbent by means other than electricity, such as a gas, oil, or alcohol flame. The gas or alcohol burners, however, would be placed underneath the generator, or the heating tube 29 may be placed in the generator at an angle or bent in a U or spiral form, so that more tube surface will be available to disperse heat in the adsorbent.

As shown in Fig. 3, there are provided brackets 31, welded, riveted, or fastened or so shaped to support the generator 3, and suitably attached to the panel 27.

Projecting vertically into the generator is a section of pipe 32. This passes through the bottom of the generator in a fluid tight joint. This pipe may have any other location, such as top, or ends as well. Positioned on the end of the pipe 32 is the valve 7, which is shown diagrammatically in Figures 1 and 2.

Referring more particularly to Fig. 10, there is shown the pipe 32 threaded at its end as at 33, and adapted to engage corresponding threads on a casing 34 of the valve

7. The casing 34 is provided with an enlarged channel portion 35 tapering as at 36 to a more restricted channel 37. Over the entrance to the channel 37 and across the top of the casing 34 is fixed a screen 38, which prevents the passage into the valve of any solid material, such as particles of the adsorbent, and permits only the entrance of a gas. The screen may be flat, but is best rounded to present a concave face to the valve. By having the screening surface convex, there is prevented the lodging of any material on the valve, for the material would slide off of the rounded surface.

Positioned within the channel 35 and resting on the top of the pipe 32 is a washer 39. The washer 39 forms a seat for the lower end of a helical or conical spring 41. The top of the spring 41 receives a pin 42 on which is fixed a ball socket 43. Within the socket 43 rests a ball 44, which is normally maintained against the valve seat formed by the slanting sides 36, by the pressure of the spring 41. The valve is therefore normally closed, and only when the pressure within the channel 37, which is the same as the pressure existing in the generator 3, exerts a greater force than the spring 41, does the ball 44 move sufficiently to permit the entrance of a gas into the valve and pipe 32. This spring is quite weak and does not require a very great pressure to open the valve.

The gaseous refrigerant passes through the valve 7, the pipe 32, and into the condenser 8. It will be observed that the coils increase in diameter toward the base of the condenser. Sufficient space is left between each coil to insure the free passage of air on all surfaces of the piping. Under certain circumstances the condensing coils may be equipped with fins, either spiral or disc, to facilitate the dissipation of heat, or the condenser may be of the so-called radiator or block type.

The outlet end of the condenser is joined to the piping 9 which passes through the opening 25 provided in the panel 21. When the refrigerant enters the pipe 9, it has passed into the liquid phase, for the cooling effected in the condenser at the high pressure obtaining there has caused liquefaction of the refrigerant.

At the ends of the supplementary panel 27, and on the side adjacent the panel 21, recesses are provided, which are adapted to receive bent ends 45 of a casing 46 which houses the generator and condenser, or else the casing ends are merely slipped under panel 27. The casing 46 is composed of suitable material such as a metal sheet and is provided at its top and base with screens 47 and 48 to permit the passage of air through the casing. The air enters from the bottom and passes through the condenser, absorbing the heat

of the gaseous refrigerant, and causing a liquefaction of the latter.

By thus providing adequate radiating surface for the condenser, and by providing for a rapid passage of air over the condenser, the use of a cooling liquid in conjunction with the condenser is obviated. This constitutes a distinct advantage over the apparatus heretofore used, for it has been necessary with such apparatus to provide a cooling medium for the condenser. This of course has necessitated piping and plumbing fixtures, materially increasing the cost of production and operation, and has resulted in a more complex apparatus.

The pipe 9 has a slight pitch, and empties into the receiver 11. The liquefied refrigerant 12 collects in the bottom of the receiver, and is maintained there until the so-called cooling cycle commences—that is, until the liquefied refrigerant commences to evaporate to produce the refrigerating effect. As is more clearly shown in Fig. 5, the receiver 11 is cylindrical in shape with bulged or concave ends 49. The pipe 9 enters the cylinder 11 near the top as shown at 51.

There is soldered, brazed, welded, or cast in the top of the cylinder 11 a well 52, which extends to approximately the base of the receiver 11. As shown in Fig. 5 a small aperture 53 is provided near the top of that portion of the well within the receiver, in order to facilitate the passage of the liquid refrigerant between the well and the tank 11. There is also an adequate clearance between the base of the well and the receiver to allow the free passage of the refrigerant into and from the well. The liquid level of the refrigerant in the receiver 11 is therefore duplicated in the well 52.

Within the well there is provided a float 54. Referring more particularly to Figure 6, the float comprises a sphere 55, through the center of which there extends a tube 56. The tube 56 is affixed in the sphere 55 in such a way as to provide a fluid and pressure proof joint.

The pressures that are built up in the system sometimes vary as much as 100 pounds. There has been considerable difficulty experienced heretofore by reason of these variations in pressure, which have frequently crushed the conventional floats used. To prevent this, I have provided a capillary tube 57 which is provided with a bent end 58. The tube 57 is inserted in the sphere 55 in a fluid and pressure tight fit, and extends to approximately the base of the sphere.

This tube keeps the pressure within the sphere the same as that existing in the receiver 11, and there is therefore no danger of the float being crushed. Should any liquid leak into the float, or if there should occur any condensation of the vapor in the float, the position of the tube 57, extending as it

does to nearly the bottom of the float, will drain off any such liquid. When the pressure in the tank 11 decreases, the higher pressure existing in the float will force any liquid in the float up through the tube 57.

At times the receiver, especially when there is an evaporation of the refrigerant within it, contains a mist of refrigerant droplets. To prevent these droplets falling into the tube, the upper end of the tube is bent. It may be that the inlet 51 is placed so that it discharges the liquid refrigerant near or on top of the float, in which event the bent portion would also prevent the entrance of the refrigerant into the float.

Referring still to Fig. 6, there extends through the channel formed by the tube 56 a rod 59. This rod is threaded at its bottom as at 61, and there is screwed on a nut 62, which may be held in place with a pin or another nut, or a simple bead may be provided. A bead 63 is provided at a certain point on the rod, shown in Fig. 3 as being slightly above the top of the receiver 11. It will be observed that sufficient clearance is permitted between the rod 59 and the tubing 56, to allow a free movement of the float on the rod. The nut 62, and the bead 63, however, are of a greater diameter than the channel of the tube 56, and when the float reaches either the nut or the bead further movement of the float results in a corresponding movement of the rod 59. The rod 59 is bent as at 64, and near its upper end is provided with beads 65 and 66.

The well 52 is provided with threads 67 at its upper end, adapted to engage corresponding threads of a base 68 of the current control device 13. The base 68 is of cylindrical formation, and is provided with outwardly extending flanges 69 and with a seat 71, which will be discussed hereinafter. A head 72 is provided for the current control device, and is secured to the base portion 68 by means of bolts 73. A gasket 74, of suitable material, is positioned between the top 72 and the base 68 of the casing. The top 72 is provided with a recess 75, and within the recesses 71 and 75 there is positioned a bearing 76 for conductors hereinafter to be described. The bearing 76 is composed of molded rubber, porcelain, or any other suitable insulating material. The bearing 76 rests upon a gasket 77 of rubber, asbestos, or composition of both, or any other gasket material. It will be observed that the bearing 76 is held securely in the recesses 71 and 75 by proper adjustment of the bolts 73.

Extending through and supported by the bearing 76 are two conductors 78. Referring to Fig. 7, the conductors 78 are provided with flanges 79 and shouldered portions 81. The free ends of the shouldered portions 81 are threaded, and the shouldered portions 81 are projected into suitable apertures provided in

the bearing 76, until the flanges 79 rest firmly against the bottom of the bearing. Nuts 82 are then screwed on the shoulders, thus holding the conductors securely and gas tight in the bearing. Wires 83 are connected to the shoulders and nuts 84 are threaded on the shoulders to secure the wire. The wires 83 mounted on the shoulders 81 are in a circuit with the resistance coil 5.

The recess 85 in the top of the housing is filled with wax, or a pitch filler in order to properly insulate the wires 83 from a moisture, and also to relieve pressure on the bearing 76. At the lower ends and suspended between the two conductors 78, there is pivoted a glass tube 86. Air is evacuated from this tube, and mercury, indicated by the dotted lines 87 in Fig. 6, is poured into the tube. The tube is best filled with an inert gas preferably under considerable pressure. Referring more particularly to Fig. 8, the tube is supported by means of metallic rods 88, bent and extending longitudinally of the tube as indicated by the dotted lines 89. The portions 88 of the rods rotatably fit in the conductors 78, and to the ends of the rods 88 there are attached wires 91 which are connected to the conductors 78. The bent portions 89 extend to almost the end of the tube, and when the tube is positioned as shown in Fig. 6, the ends of the rods 89 are submerged in the mercury 87.

Fused on the outside of the tube 86 is a ring or eye 92. Through this ring the rod 59 extends. The bead 65 is below the ring and the bead 66 above it, so that movement of the rod 59 effects a change in position of the tube 86.

A closed circuit is established when the tube 86 is in the position shown in Fig. 6. The current flows through one of the wires 83 into the conductor 78, thence through the wire 91 on that conductor into the rods 88 and 89. The mercury in the tube conducts the current from the rod 89 through which it enters the tube to the opposite rod 88, the opposite rod 88, the corresponding wire 91, and thence through the corresponding conductor 78 into the corresponding wire 83. When the tube is tilted toward the horizontal or above the horizontal, the rods 89 are removed from contact with the mercury, the current is broken, and heating of the adsorbent ceases.

There also extends into the receiver 11 a pipe 93, which conveys the refrigerant from the receiver 11. The pipe 93 passes through a fluid tight fit in the top of the receiver and is screwed into a threaded aperture 94, or otherwise fitted to the expansion valve 14. Referring to Fig. 11, the expansion valve comprises a base portion 95 and a head portion 96. Gaskets 97 and 98 are interposed between the top and bottom sections of the valve, and extending through the upper sections 96 and the gaskets 97 and 98 into the base portion 95 are bolts 99 to securely hold the upper

and lower sections of the valve in close contact. A diaphragm 101 is held between the gaskets 97 and 98. A screen 102 is positioned in the inlet 94, in order to prevent the admission of solid foreign particles to the valve.

It will be observed that the inlet 94 has sloping shoulders 103 which discharge into a reduced channel 104. The channel 104 opens into an enlarged area 105 with a sloping inlet 106. The small diameter of the channel 104 prevents the sudden admission of large quantities of refrigerant. Vaporization of the refrigerant within the valve is therefore prevented, and the possibility of refrigeration within the valve is thus eliminated. Difficulty has been experienced heretofore in that there has been a premature refrigeration in the valve, impeding its efficient operation. This is especially so when valves or constricted areas are placed in the line before the valve.

Positioned within the area 105 is a spring 107, the base of which rests against the top of the funnel shaped inlet 106. Resting on the spring 107 is a valve stem 108, having sloping sides 109 at its top. The channel 105 is enlarged and threaded as at 110.

There is screwed into the portion 110 preferably tightly or with litharge and glycerine a member 111 having an aperture adapted to receive the tapered end 109 of the valve pin and serving as a valve seat. When the spring 107 forces the stem 108 against the seat 111, the opening in the seat is closed, preventing any passage of the refrigerant therethrough. If the spring 107 is compressed, however, and the stem 108 withdrawn from the opening, the refrigerant may pass through the member 111.

There is also screwed into the recess 110 a member 112, in such a way that there is left a space 113, between the members 111 and 112 as shown in Fig. 11. The member 112 is provided with a small channel 114, which permits the passage of the refrigerant into a pressure area 115 between the diaphragm and the base portion 95 of the valve. Another aperture 116 is also provided in the member 112 and is adapted to receive a pin 117 which may be integral with the pressure pin 108 or may be separate. It will be observed that a clearance is afforded the pin 117 in the aperture 116, in order that there may be a free passage of refrigerant between the areas 113 and 115. The top of the pin 117 rests against the diaphragm 101 and therefore any depression of the diaphragm results in a depression of the stem 108.

A channel 118 is provided in the base member 95 which conveys the refrigerant from the area 113 to the outlet channel 119 of the valve. The channel 119 is formed by the member 121, which is secured to the valve by flanges 122 which fit within recesses on the

base of the valve and which, together with gaskets 123, furnish a fluid tight contact.

It will therefore be observed that a refrigerant may now be admitted from the inlet 94, pass through the channel 104 into the enlarged channel 105. If the spring 107 is released, the refrigerant will be unable to proceed further, but if the spring 107 is compressed, as for instance by a downward movement of the diaphragm 101, the refrigerant may pass through the seat in the member 111 into the area 113.

When the refrigerant reaches the area 113 a portion of it may pass through the channel 114 into the space 115, but the major portion of the refrigerant will flow through the channel 118 to the outlet 119. As will be observed later, the channel 119 is a zone of reduced pressure, and when the refrigerant arrives there it is vaporized, producing the refrigerating effect. It will be noted that the small size of the channel 118 does not allow expansion of liquid to take place until it reaches the channel 119. This protects the valve and parts from sudden cooling.

The upper part 96 of the valve is provided with a recess 124 which extends from the top to the bottom of the member 96. This channel is threaded as at 125, and is provided with a recessed portion 126. Within the recessed portion 126 there is vertically slidable a head member 127, which is held in contact with the diaphragm 101 by means of a spring 128. A knob 129 is provided on the head member 127 to maintain the spring in proper position with respect to the head member 127. It will be observed that the head member 127 is capable of restricted vertical movement in the recess 126.

The tension of the spring 128 may be adjusted by means of the threaded member 131 which is integral with a shaft 132 extending above the top of the casing 96. The end of the shaft 132 is provided with a groove 133 in which a screw driver or other suitable instrument may be inserted to rotate the shaft and member 131, or the end may be shaped so that a wrench can be used. A threaded disc 134 provided with an aperture for the shaft 132 is threaded in the channel 124 and is adapted to limit the upward movement of the shaft 132. Packing 135 of suitable material is inserted and upon the packing there is placed a washer 136. To maintain the packing and washer 136 in proper position there is provided another threaded disc 137. The discs 134 and 137, and the packing 135 and washer 136 are adapted to provide a gas tight gland for the shaft 133. The washer 136 prevents a lumping of the packing when the shaft 133 is rotated. The discs 134 and 137 are provided with holes to accommodate a spanner for adjusting.

Entering the channel 124, below the threaded member 131, is a channel 138, provided

with suitable threads on its interior. There is screwed into the channel 138 a connector 139 which is welded, or joined by other suitable means, to a piece of tubing 141 which is connected to a pressure tube 142. The tube 142 is provided with a suitable pressure fluid 146, which will be hereinafter described. The pressure fluid is inserted in the tube 142 by means of a charging tube 143, which, after the filling of the tube 142, may be bent as shown at 144 and squeezed shut. As an additional precaution against leakage of the pressure fluid, the end of the charging tube may be soldered.

Referring to Fig. 5, the pressure tube 142 may be suitably affixed to the interior of the refrigerator by means of brackets 145. The fluid 146 used in the tube 142 should be of a higher pressure-temperature relation than the refrigerant that is used in the apparatus, or the refrigerant may be used as the pressure fluid provided the pressure space 115 on the bottom of the diaphragm be reduced.

As the temperature of the fluid 146 is raised, there is an increase in pressure exerted by the fluid which is transmitted through the tubing 141 to the area 124 in the casing 96. This pressure, added to the tension of the spring 128, tends to depress the diaphragm 101. As has been stated, a downward movement of the diaphragm, acting through the pin 117 tends to push the valve stem 108 out of the valve seat in the member 112, thus admitting the refrigerant from the channel 94.

It will be observed that the spring 107 is fixed as to the tension it exerts, but the spring 128 may be adjusted by means of the shaft 132, although for a given operating condition the spring 128 may be considered as fixed. Having determined the temperature desired in the refrigerator, the spring 128 is adjusted accordingly, depending upon the temperature difference desired. When the temperature rises above the point determined upon, the pressure exerted by the fluid 146 as a result of the increased temperature will tend to depress the diaphragm 101, thus permitting a passage of the refrigerant through the valve.

One of the principal advantages of this valve is, as stated above, that it prevents a vaporization of the refrigerant within the valve. This is accomplished by reducing the areas within the valve that are occupied by the refrigerant, thus admitting only a relatively small amount of refrigerant, and keeping this in a small area under pressure. An additional precaution against premature vaporization results from the particular arrangement and operation of the valve parts. Should the temperature of the box increase suddenly, causing the pressure fluid to expand rapidly, and thus depress the dia-

phragm, there would be a sudden rush of refrigerant from the inlet 94 to the areas 113 and 115, thus building up a back pressure on the under side of the diaphragm, which would tend to close the valve. It is also to be noted that a temperature differential is always maintained between the inlet and outlet ports of the valve, for the refrigerant on the outlet side of the valve creates a back pressure that tends to maintain the valve closed.

There is suitable threaded, or otherwise joined in the channel 119, piping 147 which conveys the fluid from the valve to the evaporating coil 17. Referring to Figures 3 and 5, it will be observed that the coils there shown are adapted for use with a solid adsorbent, for the refrigerant enters the lowest part of the evaporating coil and is discharged at the top. After the refrigerant has passed through the expansion valve and has entered the zone of reduced pressure of the evaporating unit, there is a vaporization of the refrigerant which produces the refrigerating effect. If the evaporator is in contact with a brine solution, the solution is thereby lowered in temperature. After passing through the evaporating coils 17 the refrigerant is carried by the pipe 18 to the valve 19.

Referring particularly to Fig. 9, valve 19 comprises a body portion 148, into the side of which is threaded a pipe 154 which leads into the generator 3. Within the body portion 148 there is a chamber 149 tapering as at 151 into a reduced passage 152. The chamber 152 empties into a channel 153, in which is threaded the pipe 18. The lower end of the chamber 149 is threaded as at 155, and there is screwed into this chamber the head 156 of a member 157. Resting on the head 156 is a spring 158 which supports a socket 159 carrying a ball 161. The ball 161 is pressed by the spring 158 against the tapered portion of the chamber 149, and when the ball is in the position shown in Fig. 9, there is prevented any passage of the refrigerant through the valve. When, however, there is a sufficient pressure in the pipe 18, the ball 161 is pushed away from its seat 151, and the refrigerant is admitted into the chamber 149, from whence it passes into the pipe 154.

The member 156 is provided with a channel 162 which empties into a threaded chamber 163 in the body portion 157. Adjacent the top of this chamber 163 is an aperture 164. A spindle 165, with an enlarged portion 166 screwing into the threaded chamber 163, is integrally fitted with a tapered portion 167, which fits the aperture 162. A screw 168 is threaded in the channel 163, and there is also provided a suitable packing 169. A cap 170 maintains the packing 169 about the valve spindles and sides in a gas tight condition.

It will be observed that if the spindle or valve shaft 166 is rotated so that the tapered portion 167 is withdrawn from the channel 162 the refrigerant may be inserted through the aperture 164 and chamber 163 into the main chamber of the valve 149. This device is provided so that in the initial charging of the apparatus, and in case of replacement of the refrigerant, the necessary refrigerant may be introduced to the system in the simplest way. Having introduced the refrigerant, it is merely necessary to turn the bolt 166 so that the tapered portion 167 will close the channel 162 and prevent a leakage of the refrigerant from the system.

Referring particularly to Fig. 4, there is shown the pipe 154 entering the generator 3 and extending approximately the length of the generator as shown at 171. Throughout the length of the piping 155 are apertures 172 in the bottom. This arrangement insures a distribution of the volatilized refrigerant over a comparatively large area of the adsorbent, and makes for a uniformity of distribution and effectiveness in the adsorbing operation.

Referring to Fig. 3, there is shown a panel 173 suitably affixed to the panel 21. The panel 173 supports the tank 2, which houses the receiver, evaporating coil, and associated mechanism. The tank 2 is suitably secured to the panel 173 by means of bolts 175. The tank is of water tight construction, and is preferably filled with a brine or other low freezing solution. A pocket 176 is provided in the tank which serves as a compartment for the freezing of ice cubes or desserts. Into the pocket 176 may be inserted an ice tray 177 having compartments for the ice, and the front portion 178 of which is composed of appropriate insulating material. The face 179 of the ice tray is formed to provide an air tight fit, so that the ice pocket may be free from the warm air outside of the refrigerator. A knob 181 of any suitable material is provided on the ice tray.

A series of parallel bars 182 extend from the top of the tank to the top of the pocket 176, and are held in proper alignment by means of the bolts 183 and nuts 184. These bars 182 are clamped on either side of the evaporating coil 17 and serve to support and maintain the evaporating coils in proper spaced relationship.

The wires 83 of the automatic control extend through the top of the tank 174, and a water-tight fit is provided by means of washers or molded rubber 185. These means also prevent chafing of the electric wires by the metal. Referring to Fig. 5, it will also be observed that a stopper 186, composed of cork or other suitable material, is inserted in an aperture cut in the top of the tank 2. The stopper 186 is directly over the expansion valve 14 and may be removed when it

is desired to adjust the valve by means of the shaft 132.

In Fig. 12 there is shown a modified form of float for use in the current control device.

5 This float 187, it will be observed, is pear shaped, and provided with a butt 188 having a recess 189 which is internally threaded. A tube 191 projects through the top of the float 187 which is also provided with a bent portion 192.

10 A modified form of associated mechanism which this type of float and those shown in Figs. 14, 15 and 16 require is set forth in Fig. 13. Into the butt 188 there is enthreaded a shaft 193. This shaft 193 is provided with a longitudinal slot 194, through which slot the rod 59 projects. It will be observed that the rod 59 is provided with the beads 63. The shaft 193 is pivoted to a wall of the receiver 11 by means of the bracket 195 which is suitably secured to the receiver. The float 187 will rise and fall with changes in the liquid level within the receiver, and, as it is mounted on the pivoted shaft 193, the rod 25 59 will rise and fall likewise. Movement of the shaft 193 with respect to the rod 59 is free and unrestricted until the shaft 193 contacts with either one of the beads 63. At the time of such contact, further movement 30 of the shaft 193 will impart to the rod 59 a vertical movement, which, in turn, will swivel the tube 86.

In Fig. 14 I have shown another modified form of float 196. It will be observed 35 that this float is tubular in shape with closed end portions, and that the tube 191 slantingly projects through the top of the float.

In Fig. 15 there is shown still another modification in the float. In this case the 40 float is of spherical formation, and the tube 191 is placed vertically in the float.

A still further modification may be made in the float as shown in Fig. 16. The peripheral corrugations 199 shown in this style of 45 float are adapted to withstand great pressure differentials between the inside and outside of the float. It will be observed that slight modifications may be necessary in the tube 191 in order to conform with the shape 50 of this type of float.

From the foregoing, the operation of my invention is obvious. Assuming that the apparatus is filled with the necessary materials for the operation, and that the refrigerant 55 has been adsorbed, the current for the machine is turned on. On the application of heat the adsorptive capacity of the material is diminished and consequently the refrigerant in gaseous form is driven off. In being 60 driven off, it builds up a pressure within the generator 3 and, when this pressure is sufficient to overcome the tension of the spring 41 in the valve 7, the gaseous refrigerant passes through the valve 7 into the pipe 6.

65 The screen 38 prevents the entrance of any

of the adsorbent into the valve should any of the adsorbent become entrained in the refrigerant.

The refrigerant passes through the pipe 6 to the condenser 8. In view of the arrangement 70 of the valve 7, during application of heat to the adsorbent, the pressure in the pipe 6 will be the same as that existing in the generator. As the refrigerant passes through the condenser 8, under pressure, the 75 air entering the casing 46 from the bottom will cool the refrigerant to such an extent that it liquifies. The refrigerant in the form of a liquid will then pass through the pipe 9 to the receiving tank 11.

80 As the heating continues there will be an increased amount of gaseous refrigerant driven off and subsequently liquefied. With the increase in liquid in the receiver 11 the float 54 will rise on the rod 59 and finally will 85 contact with the bead 63. A further rise in the liquid level will cause the float 54 to raise the rod 59. In doing this the tube 86 will be moved toward a horizontal position, and the mercury 87 in the tube will flow to the oppo- 90 site end and cause the tube to tilt, removing the rods 89 from the mercury 87.

A current will not now pass through the tube, and the heating of the adsorbent by the resistance coil or other means will cease. 95

As the temperature of the adsorbent decreases, there will be an increase in its adsorptive capacity, and a decrease of pressure in the generator, which in effect creates a suction. When the pressure in the generator 3 100 drops below the pressure existing in the pipe 18, the valve 19 is forced open and the pressures in the evaporator 17 and the generator 3 are equalized.

Assuming that the refrigerator is above 105 that temperature at which it is desired to keep it, the pressure liquid 146 in the tube 142 will be expanded and a pressure will be built up in the tube 142, pipe 141 and chamber 126. This pressure together with the 110 tension of the spring 128 will be sufficient to depress the diaphragm, which in turn will force the valve stem 108 from its seat in the member 112. The refrigerant will then be free to pass through the expansion valve 14 115 into the evaporating coil 17.

As above stated, this passage of the refrigerant is closely regulated. When it reaches the zone of reduced pressure, there is a consequent vaporization of the refrigerant, and 120 absorption of the heat from the brine solution or other medium, thus lowering the temperature in the ice-box. The refrigerant then flows through the pipe 18 and the valve 19 by reason of the suction created by the 125 adsorbent when the application of heat to it is ceased. The gaseous refrigerant may then pass into the pipe 171, where it is distributed and adsorbed by the adsorbent. When this has gone on for a sufficient period, the tem- 130

perature of the ice-box will be lowered, resulting in a decreased pressure of the liquid 146 in the bulb 142. This will cause the valve to close and will prevent any further vaporization of the refrigerant until the temperature again rises.

When the level of the liquid in the tank 11 has been lowered and when the float 54 contacts with the nut 62 on the rod 59, the tube 86 will be tilted so that the mercury will cover the two rods 89, thus completing the circuit and commencing the heating of the adsorbent. The heating cycle will then be commenced and repeated as described.

It will be observed that I have provided a refrigerating apparatus that may be manufactured economically. The device is simple in construction, and as there are few moving parts, there is little chance for wear. An ordinary ice-box may be readily converted to an automatic refrigerator by merely removing the ice door and securing my device in the ice compartment. After installation of the apparatus, there is no need for further attention. When the apparatus, is once adjusted, it maintains a substantially uniform temperature in the box. The expense of operation is negligible, for the only item is that for the heat that is applied to the adsorbent. It is of course obvious that my invention is adapted to use either solid adsorbent or a liquid adsorbent, and that any type of refrigerant may be employed.

While I have shown and described herein a preferred embodiment of my invention, it is to be understood that this is exemplary, rather than restrictive, and that various modifications may be made in this form without departing from the scope of the appended claims, by which claims alone I wish my invention to be limited.

I claim as my invention:

1. A refrigerating apparatus for installation in an ice-box comprising a panel adapted to be substituted for a door of the ice compartment, on the exterior of the panel an adsorber-generator, a condenser connected to the adsorber-generator, on the interior of the panel a refrigerant storage tank connected with the condenser, an evaporator, means to convey a fluid from the storage tank to the evaporator, and means to convey a fluid from the evaporator to the adsorber-generator.

2. A refrigerating apparatus comprising a panel adapted to be mounted upon an ice-box, a casing upon the exterior of the panel, within the casing an adsorber-generator and condenser, means to supply a current of air to the condenser, a refrigerant storage tank upon the opposite side of the panel adapted to be positioned within the box, an evaporator connected with the tank, and means for conveying a fluid from the evaporator to the adsorber-generator.

3. A refrigerating apparatus comprising a panel, an adsorber-generator supported upon the panel, heating means within the adsorber-generator, a condenser connected with the adsorber-generator, said parts being so arranged that a current of air will be induced to flow over the condenser.

4. A refrigerating apparatus comprising a fluid tight tank, positioned within the tank a receiving tank, evaporating coil, a fluid line from the receiving tank to the coil, means to regulate the passage of a fluid from the receiving tank to the coil, current control means associated with the receiving tank and adapted to regulate an electric circuit in a determined relationship to the level of a body of liquid within the receiving tank.

5. A refrigerating apparatus comprising a panel adapted to be positioned in the doorway of an ice compartment, a fluid tight tank mounted upon the panel and extending within the compartment, within the tank a compartment adapted to contain material for freezing, a refrigerant storage tank, an evaporator, a channel from the receiving tank to the evaporator, positioned in said channel a valve actuated by the temperature existing within the first mentioned tank, and current control means operable upon variations in the level of a liquid in the storage tank.

6. A refrigerating apparatus adapted to be installed in an ice-box, comprising a panel adapted to be substituted for a door of the ice compartment of said ice box, an adsorber-generator mounted upon the panel, heating means for the adsorber-generator, an air cooled condenser mounted adjacent the generator and connected therewith, a casing surrounding the adsorber-generator and the condenser, said parts being so arranged that a current of air will be induced to flow over the condenser, a tank mounted upon the opposite surface of the panel containing a refrigerant receiving tank, means associated with the tank for regulating the heating means, an evaporator connected with the tank, and thermostatic means to control the passage of a fluid from the receiving tank to the evaporator.

7. In a refrigerating apparatus operating on the adsorption principle, a casing in which are mounted a generator and a condenser and an opening at the base of the casing and another opening at the top for circulation of air therethrough.

8. An apparatus for installation in an ice box comprising a tank adapted to be inserted in the ice compartment, a member on which the tank is mounted replacing the door of the ice compartment, a generator and condenser supported by the member, and within the tank evaporating means joined to the generator.

9. An integral refrigerating apparatus for installation in an ice box comprising a sup-

port member, mounted on the support member a generator and a condenser, both enclosed in a casing, a tank mounted on the support member, and, within the tank, evaporating means operatively associated with the generator.

10. A refrigerating apparatus for installation in an ice box comprising an angular support member, one portion of the support member adapted to be mounted on the front of the ice box and the other portion extending over the top of the box, a refrigerating tank supported by the first portion, and a generator and condenser supported by the second portion.

11. In a refrigerating apparatus operating upon the adsorption principle, a generator and a heating means therefor, an air cooled condenser positioned below said generator, a casing about the generator and the condenser and having an opening at its top and another at its bottom, whereby the heat effective upon the generator tends to create a substantially vertical draft of air in the casing to cool the condenser.

12. In a refrigerating apparatus operating upon the adsorption principle, a generator and a heating means therefor, an air cooled condenser, a casing about the generator and the condenser, and having an opening at its top and another at its bottom, said condenser being adjacent and above said bottom opening, whereby the heat effective upon the generator tends to create a substantially vertical draft of air in the casing to cool the condenser.

13. In a refrigerating apparatus operating upon the adsorption principle, a generator and a heating means therefor, an air cooled condenser positioned below said generator, a casing about the generator and the condenser and having an opening at its top and another at its bottom, said condenser being adjacent and above said bottom opening, whereby the heat effective upon the generator tends to create a substantially vertical draft of air in the casing to cool the condenser.

In testimony whereof, I affix my signature.

50 LEONARD KAY WRIGHT.