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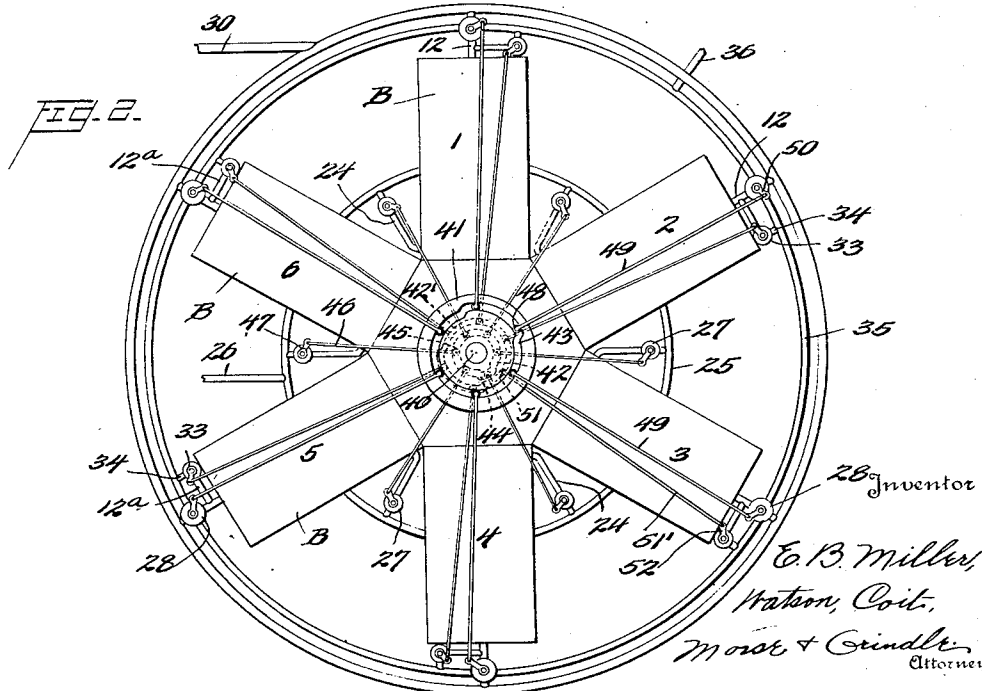
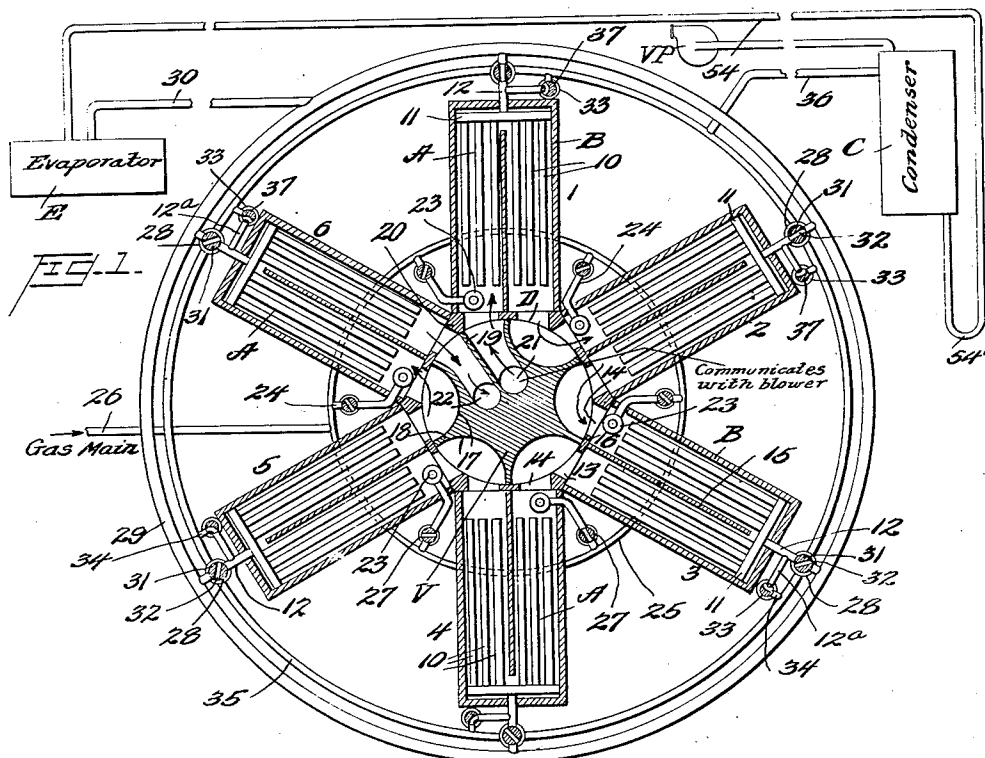
E. B. MILLER

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REGENERATIVE REFRIGERATING APPARATUS

Original Filed June 27, 1927

2 Sheets-Sheet 1



28 Inventor

E. B. Miller,

Watson, Coit.

Morse & Grindle
Attorneys

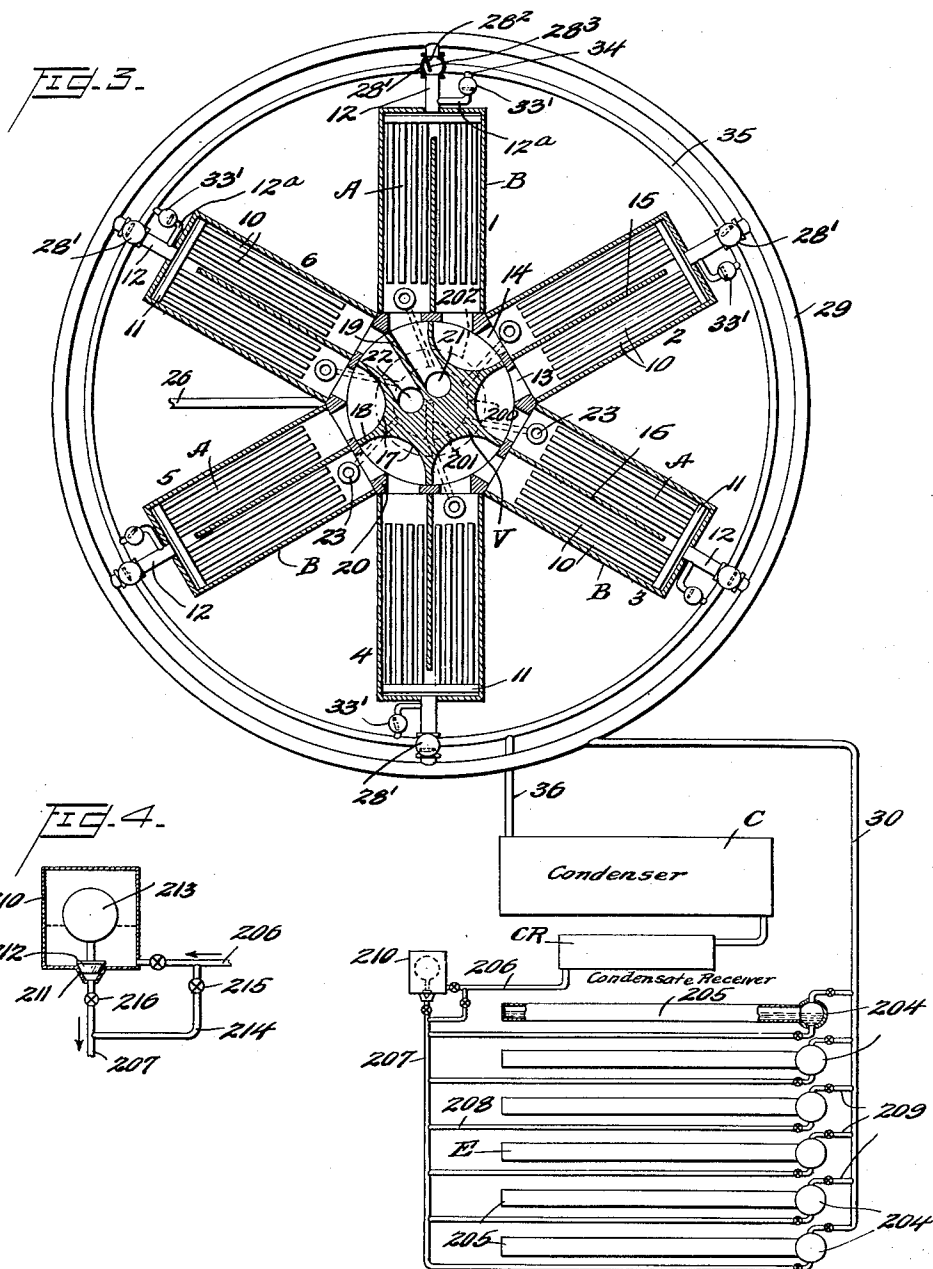
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Inventor

E. B. Miller

Watson, Coit, Moore & Grindle,
Attorney

UNITED STATES PATENT OFFICE

ERNEST B. MILLER, OF BALTIMORE, MARYLAND

REGENERATIVE REFRIGERATING APPARATUS

Application filed June 27, 1927, Serial No. 201,928. Renewed October 8, 1929.

This invention relates to a method of and apparatus for refrigeration and more particularly to that type of refrigeration in which a refrigerant is evaporated for cooling purposes and the vapor therefrom adsorbed by a solid adsorbent which is thereafter heated to drive off the vapor and restore the adsorbent to its initial condition ready for further adsorbing.

It is a general object of the present invention to provide, in connection with refrigeration of the type described, a novel method of, and means for, producing economical refrigeration.

More particularly it is an object of the present invention to provide an improved method of and apparatus for refrigeration wherein the cyclic operation of a plurality of units results in a very considerable heat conservation, thus producing a marked economy of operation.

One of the main features of novelty of the present invention consists in a method of refrigeration in which: vapor from a refrigerant is successively adsorbed by one or more of a plurality of units; air is passed over said units, takes up some heat from those units which are adsorbing and gives it up to those units which are to be activated.

Another main feature of the invention comprises the arrangement, in a refrigerating system of the adsorption type, of a plurality of adsorbers arranged to be successively and alternately connected to an evaporator and to a condenser, the said adsorbers being arranged in enclosing compartments connected together by suitable passages whereby air may be caused to pass over those adsorbers which are in the adsorption phase to be thereby heated and then passed over those adsorbers which are to be activated, the heat given off by the adsorbers in the adsorption phase being carried by the air and given up to those adsorbers which are in the activating phase whereby but little heat is lost.

A further feature of the invention consists in the provision, in the arrangement above described, of sets of valves to automatically and periodically connect the proper ad-

sorbers to the condenser and evaporator and to control the flow of air.

An additional feature of the invention consists in the provision of a supplemental heater for each adsorber, in the arrangement above described, together with a mechanism arranged to cause but a single heater to function, i. e., the one arranged in the casing of an adsorber which is activating and particularly in the casing of the leading adsorber on the activation stage.

Still further features of the invention comprise the particular arrangement of the various adsorber casings so that the flow of air therethru takes place in several directions, suitable conduits, passages and valves being arranged to conduct the air in the proper sequence thru the various adsorber chambers and to shift in such a manner that a change over is made when certain of the adsorbers become substantially saturated and others become substantially fully activated.

Other and further objects and features of the invention will be more apparent to those skilled in the art after a consideration of the accompanying drawings and following specifications, wherein are disclosed exemplary embodiments of the invention with the understanding, however, that various changes may be made therein such as fall within the scope of the appended claims without departing from the spirit of the invention.

In said drawings:

Figure 1 is a schematic view partially in horizontal section of a refrigerating apparatus constructed according to the present invention;

Figure 2 is a plan view of the same showing means for controlling the various valves;

Fig. 3 is a view similar to Fig. 1 of a modified form of the invention adapted for use with a refrigerant such as SO_2 , showing in elevation the evaporators, condenser, etc.

Fig. 4 is a detail, in vertical section, of the condensate return valve.

It has previously been proposed to provide refrigerating apparatus which comprises essentially an adsorber, an evaporator and a condenser suitably inter-connected. The adsorber may consist of a chamber filled with

a suitable adsorbent material such as silica gel. The evaporator may contain any suitable refrigerant such as a brine solution, SO₂, etc. The adsorber is arranged so that when the adsorbent material has become saturated with vapor from the refrigerant it may be heated by a suitable heating means and the adsorbed vapor driven off and delivered to the condenser to be reduced to a liquid state and then returned to the evaporator. The evaporator may comprise a tank or other receptacle to be arranged in the compartment which it is desired to cool.

While silica gel is desirable as the adsorbing material, other adsorbent gels or materials may be used if they have sufficient adsorbent capacity. The capacity of the adsorbent should be such that when the adsorber and the evaporator are connected together by suitable piping the vapor formed over the refrigerant in the evaporator will be adsorbed so rapidly that evaporation continues to such a degree that the temperature of the refrigerant is rapidly lowered. As a measure of the adsorptive capacity of an adsorbent suitable for this invention it may be said that it should have enough small pores so that it will adsorb water vapor to such an extent as to contain at least 10% of its own weight of water when in equilibrium with water vapor at a temperature of 30° C. and a partial pressure of 22 mm. of mercury.

Considering as an example a refrigerating device of the type just described, using brine as the refrigerant and say 100 lbs. of silica gel, the metal in the adsorber unit will weigh approximately 250 lbs. In order to properly activate the gel to eliminate the vapor from the brine the temperature is usually raised about 300° F.

To heat the gel there is required:	
100 × 0.20 (specific heat of the silica gel)	× 300 = 6,000
For the metal of the adsorber there is required:	
250 × 0.12 (specific heat of the metal)	× 300 = 9,000
45 Assume that water to the extent of 6% of the weight of the gel is liberated. To vaporize this would amount to about-----	6,000
The total of these various items is-----	21,000

The latent heat amounting to 6,000 B. t. u. is the only useful item and it will be noted that it amounts to less than 30% of the total amount of the heat used during activation.

During the adsorption period heat is generated, liberated and usually lost, and during the activation period heat must be supplied to drive off the vapor from the adsorbent and to heat up the metal of the container. Preferably, then the present invention contemplates circulating air around or thru one or more adsorbers during the adsorption cycle whereby the air becomes heated and then circulating this heated air around one or more adsorbers which it is desired to activate, whereby the heat taken up by the air during adsorption is transferred to the adsorber unit

or units to be activated. This air takes up heat from the metal of certain units and returns it to the metal of other units. Theoretically the only heat lost would be the difference between the B. t. u. in the entering cool air and the B. t. u. in the warm air exhausted after activation, for the heat in the activated material and in the metal is recovered. Practically it is necessary to boost the amount of heat in the air just before it enters the adsorber or adsorbers on the activating cycle. Then the total amount of heat required to be added will be the amount required to make up the loss due to the difference in temperature between the intake air on the one hand and the exhaust air on the other plus the amount lost by radiation. Obviously the greater the number of adsorbers employed the less will be the heat required because the more nearly can the temperature of the exhaust air be brought to that of the entering air.

In Figures 1 and 2 a schematic arrangement of six adsorbers, numbered 1 to 6 inclusive, has been disclosed for simplicity in describing the cycle of operations. The evaporator E is a tank or other suitable container adapted to be partially filled with a suitable brine solution. It is arranged in the space desired to be cooled. The condenser C is any suitable form of condenser to condense the heated vapors liberated during the activation cycle of the various adsorbers. Six adsorber units A are arranged in suitable compartments B so that they extend radially from a central compartment D in which is arranged the rotatable valve member V.

Each adsorber unit comprises a plurality of tubular members 10 connected to one or more communicating headers 11 which are suitably connected to a pipe 12. Each of the tubes 10 contains a quantity of adsorbent material such as silica gel. Each of the compartments or housings B for the adsorber units is formed as a completely enclosed compartment of suitable heat insulating material. The inner end of each compartment is provided with two openings 13 and 14 and a central radial partition 15 extends from the wall 16 between the openings almost to the outer end of the compartment so that air may enter, for instance, the opening 14, pass radially outwardly thru one side of the compartment and then radially inwardly thru the other side of the compartment, and finally out thru the opening 13. In this manner air, which may be caused to circulate thru the compartments, is brought into intimate contact with the surfaces of the various adsorber tubes 10 for the purpose previously described.

The openings 13 and 14 of the various adsorber compartments open into the circular chamber D in which is rotatably mounted

the multiple valve member V. This valve member is more or less hexagonal in section with five concave sides such as 17, the partition walls 18 between the concave sides being spaced apart 60° in the case of a six adsorber unit outfit, so that when properly positioned they contact with the walls 16 between the inlet and outlet ports of the various adsorber compartments. In this manner a passage is formed between the outlet of each one of five compartments and the respective inlets of the adjacent compartments. A partition wall 19 divides the sixth side of the valve member into two compartments and this partition is adapted to abut tightly the junction wall 20 between two adsorber compartments. Extending axially of the valve are the inlet passage 21 and the outlet passage 22, one on either side of the partition 19 and in communication with the respective compartments formed thereby. By the use of a blower air may be forced into the inlet passage 21 or by the use of an exhaust fan may be exhausted from the outlet passage 22.

With either type of air-moving means, the circulation of the air is as follows: Air enters in a suitable manner thru the inlet 21 in the central valve which is positioned as shown in Figure 1. It passes outwardly thru the left hand side of the adsorber compartment 1 and then inwardly thru the right hand side entering the valve compartment, thence is directed by one of the sides 17 into the next adsorber compartment where it passes outwardly and then inwardly in the same manner and so on thru the various adsorbers until from adsorber 6 it enters the left hand side of the partition 19 in the hexagonal valve and leaves by way of the outlet 22 to atmosphere.

Arranged in each adsorber compartment on the inlet side is a gas burner 23, all of the burners being connected by pipes 24 to the manifold or conduit 25 supplied by the main 26 with suitable gas. Each burner supply pipe 24 has provided therein a valve 27 in order that the proper burner may be supplied with gas at the required time. Suitable pilot burners (not shown) serve to ignite the gas issuing from any particular burner when its valve 27 is turned on.

The pipes 12 leading out from the adsorbers enter the valve housings 28 which are connected to the vapor manifold 29 which leads by the pipe 30 to the evaporator E. Valve cocks 31 each provided with a passage 32 are rotatably arranged in the housings 28 so that the various adsorbers may be connected to or shut off from the vapor manifold by suitable manipulation of these cocks.

Leading from each pipe 12 is a short pipe 32 to a condenser valve 33 which is connected by means of the pipe 34 to the condenser manifold 35 which is connected by means of a pipe 36 to the condenser C. Valve cocks

37 are arranged in the valve casings 33 and are rotatable to connect the adsorbers to the condenser manifold or disconnect the same therefrom.

When operating the device it is preferred to have two adsorber units adsorbing simultaneously, one unit cooling, two units activating and one heating up preparatory to activating. In Figure 1 units 1 and 2 are considered to be adsorbing and their vapor valves are shown to be open to the vapor manifold and their condenser valves closed; unit 3 is cooling and its vapor and condenser valves are closed; 4 and 5 are considered to be activating and their vapor valves are shown as closed and their condenser valves as open. Unit 6 is heating up preparatory to activating and both valves are closed. The gas valve supplying the burner in unit 4 is shown as open so that booster heat is supplied to units 4 and 5. Unit 3 is considered to be cooling after activation in order to prepare for an adsorption period. It may be either connected or disconnected from the vapor manifold for it is in a more or less inactive condition as is also unit 6.

From Figure 1 it will be seen that cool air entering the large central valve thru the passage 21 first passes thru adsorber compartment 1. The adsorber unit therein is adsorbing and the air removes and makes up a portion of the heat of adsorption therefrom. The air passes on to unit 2 which is also adsorbing and takes up some of its heat of adsorption. Passing on to unit 3 the air cools this unit to some extent, for the unit has just previously been activating and has a temperature higher than that already imparted to the air. Unit 4 is being activated and the air heated by units 1, 2 and 3 passes over the same. Since the temperature of this air is not high enough for satisfactory activation additional heat is supplied by the burner 23 in compartment 4. The air next passes to compartment 5 and still has sufficient temperature to activate the adsorbent material therein. Passing on to compartment 6 the remaining heat in the air serves to heat up this compartment and its adsorber to place them in readiness for activation. The air with most of its heat removed then escapes to atmosphere thru the outlet 22.

The central valve V moves in a clockwise direction in steps of 60° suitably timed to allow proper functioning of the various units. The next position of the valve succeeding that shown in Figure 1 arranges unit 1 to be heating preparatory to activating; unit 4 to be cooling preparatory to adsorbing; unit 6 to activating, and cooled unit 3 to be adsorbing. Units 2 and 5 merely advance one step in the same process in which they were previously engaged. In this manner the heat losses are a minimum.

The opening and closing of the various

valves may be effected in accordance with the schematic arrangement shown in Figure 2. The shaft 40 forms a mounting for and extends from the valve V and may be suitably driven in 60° steps by any well known mechanism (not shown) timed in suitable relation to the speed of activation or otherwise in accordance with certain requirements of the refrigerator being cooled. The shaft 40 carries a disk 41 for rotation therewith and this disk is preferably provided with the three cam grooves 42, 42' and 43. The inner cam groove 42 is circular except for one small projection 44 and in this groove run the rollers 45, on the ends of the push rods 46 connected to the arms 47 on the cocks 37 of the gas valves for operating these valves. The projection 44 of the cam groove is positioned to open the proper gas valve in accordance with the above description of the operation of the device.

In the outer cam groove 43 run the rollers 48 on the ends of the push rods 49 connected to the arms 50 on the valve plugs 31 of the vapor valves. The cam groove 43 is so shaped that two successive vapor valves are always open in the proper relation and four are retained closed.

The intermediate cam groove 42' receives the rollers 51 on the push rods 51' which lead to the arms 52 on the condenser valve cocks 37. This cam groove is so shaped as to cause the condenser valves to open diametrically opposite to the open vapor valves.

The operation of this form of the invention will be clear from the above description. It will be noted that there are always two adsorbers connected to the evaporator so that refrigeration is continuous. Two adsorbers are always being activated and since the period of activation is usually less than the time necessary for adsorption to near the saturation point, adequate activating is obtained. The vapors liberated during activation are collected and condensed by the condenser and may be returned by any suitable means such as the trapped pipe 54 to the evaporator. The pressure in the evaporator is always lower than that in the condenser and the trap 54' is of such depth as to require a difference in pressure equivalent to one inch of mercury to cause a flow. Extreme economy of operation is effected by reason of the fact that the heat of adsorption is largely used to effect activation and the heat used to raise the temperature of structural materials is not lost. The speed of adsorption is increased by rapidly carrying off the heat of adsorption. By using a large number of adsorbers a plurality is always adsorbing and a plurality may be activating and cooling so that the air is finally discharged at a temperature not much above that of the entering air. The only power necessary in the operation of the device is that necessary to

cause the circulation of the proper quantity of air and a small amount necessary to operate the valves. The quantity of heat supplied by the booster burners is not large.

It is highly desirable that the adsorbers operate in the substantial absence of permanent gases. This condition may be attained for instance by connecting a small vacuum pump such as V. P. to the condenser and operating the same occasionally to remove any accumulated air or other permanent gas. Other methods of maintaining the system free of permanent gases may be resorted to.

In the form of the invention more particularly disclosed in Figures 3 and 4, the apparatus of Figs. 1 and 2 has been modified to function with a refrigerant of different characteristics than the brine previously alluded to. The refrigerant selected as most satisfactory for use with silica gel as the adsorbent is sulphur dioxide (SO_2) which has a boiling point at atmospheric pressure of -10°C . This low boiling point insures evaporation of the liquid in the evaporator without a reduction of pressure therein. In fact, the device can be worked with positive pressure where very low refrigerating temperatures are not required. The latent heat of SO_2 is only about one seventh that of water which requires that about seven times the quantity be evaporated to produce the same effective refrigeration. However, under the pressures which can be used in the adsorbers, silica gel will adsorb about seven times the quantity of SO_2 vapor as water vapor and therefore a substantial balance is obtained such that only the same quantity of silica gel is necessary as the adsorbent in connection with SO_2 as in connection with brine.

However, there are certain advantages to be gained by the use of SO_2 , first among which is the elimination of positive mechanical means for actuating the vapor and condenser valves. Owing to the low boiling point of SO_2 , higher pressures can be used, as previously pointed out, which will be effective to operate check valves. Furthermore, the higher pressures cause increased velocity of flow of the vapor and smaller pipes and valves can thus be used. During adsorption, the pressure in the adsorber is lower than the pressure in the evaporator which will cause the check valve, previously referred to as a vapor valve, to open and permit the flow of vapor from the evaporator into the adsorber. During activation the pressure in the adsorber is raised, due to heating, which closes the check valve leading to the evaporator and opens the check valve into the condenser. The adsorber pressure during activation may reach approximately 80 lbs. gauge under ordinary operating conditions, while the condenser pressure is somewhat lower, dependent on its rapidity of cooling. During adsorption the pressure

over the adsorbent is approximately zero gauge, and the evaporator pressure may be adjusted to say 2 lbs. gauge, which is the equivalent to substantially -70° C. This temperature may be adjusted as desired to maintain the refrigerator, in which the evaporator is arranged, at a suitable temperature.

The construction of the various units of the apparatus, when adapted for use with SO_2 , is substantially identical with that shown in Figure 1, and all parts which are the same have received the same reference characters. The valves, however, differ in this respect. Both the vapor valves and the condenser valves are of the check type. For instance, in Figure 3 the vapor valve 28' may be seen to comprise a casing having a seat 28² and a flap 28³ hinged to cooperate with this seat and adapted to open when the pressure in the pipe 12 is less than that in the vapor manifold 29, and to close when the pressure unbalance is reversed. The condenser valves 33' are of the same construction as the vapor valves, but are turned in the opposite direction so that they close when the pressure in the pipe section 12 is less than that in the condenser manifold 35.

A simpler form of gas distribution to the burners 23 is shown in Figure 3. Here the gas line 26 leads to the center of the end of a disk 200 on one end of the central valve member V. From the center of this disc a passage 201 leads radially to the edge of the disk. The disk fits within a housing 202 from which radiate the pipes 24 leading to the gas burners. Passages thru the housing bring the pipes into communication with the edge of the disk so that when the disk is rotated in steps with the valve V, its radial passage 201 successively communicates with the burner pipe sections 24 to supply gas to each burner in turn, as required.

By the construction just disclosed, it will be seen that all mechanical valve mechanisms have been eliminated, and the device materially simplified, while yet retaining the same efficiency of operation.

The evaporator in Figure 1 has been shown merely schematically as a simple tank, whereas in Figure 3 it has been shown, in more detail, to comprise a series of evaporators each consisting of a header 204 and a plurality of horizontal pipe sections 205. For the sake of simplification, these headers have been shown one above the other in the figure, but they should preferably be arranged in the same horizontal plane and, if desired, in different compartments of a refrigerator.

The vapor driven off from the adsorbers during their activation passes to the condenser C, which as previously described, may be of any desired type. The liquid condensed in the condenser C is collected in the condensate receiver CR from whence it is delivered to the respective evaporators thru the

pipes 206, 207 and the respective branch pipes 208 leading into the lower portion of the headers.

From the upper portion of the headers the branch pipes 209 lead to the pipe 30 connecting with the vapor manifold 29.

In operation, as the liquid SO_2 in the various evaporators adsorbs heat from the materials in the refrigerator, it is vaporized and the vapor passes thru the pipes 209, 30, 29 and thru the check valve 28' of the adsorber or adsorbers which is in condition for adsorption. The rapid adsorption of the vapor by the adsorbent maintains a lowered pressure on the surface of the SO_2 in the evaporators so that it continues to evaporate and reduce its temperature.

Owing to the comparatively high pressures obtained during activation due to the rapid liberation of vapor, some vapor would be driven through the condenser and into the evaporators before it had time to condense or liquid would be all forced out of the condenser and receiver and the vapor follow it into the evaporators and would prevent the proper functioning of the apparatus if means were not provided to prevent this. For this purpose, a condensate trap 210 is inserted between the pipes 206 and 207. This trap is best shown in Figure 4 and will be seen to comprise a casing or tank provided with a valve seat 211 thru its bottom leading to the pipe 207. A valve plug 212 is carried by the float 213. Liquid condensate is admitted thru the pipe 206, but cannot escape thru the pipe 207 due to the valve plug closing on the valve seat until the liquid level has reached such a point that the float 213 lifts the valve plug from its seat. Any pressure within the housing of the condensate trap will be ineffective in forcing the condensate into the pipe 207 until the float has unseated the valve and then but a limited quantity can flow before the valve again closes.

For the sake of maintenance, the by-pass pipe line 214 may be provided around the trap and have the hand valve 215 therein which can be opened and the valves 216 closed when it is desired to clean or adjust the trap.

It will be understood by those skilled in the art that practical forms of the device may vary considerably from the schematic and diagrammatic forms illustrated herein for convenience in disclosing the invention. However, it is intended to cover various forms of the apparatus such as fall within the scope of the appended claims without departing from the spirit of the invention.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. The method of refrigeration consisting in adsorbing vapor from a refrigerant into a solid porous adsorbent, removing a portion

of the heat of adsorption from said adsorbent and using said heat to activate adsorbent material previously used.

2. The method of refrigeration comprising adsorbing vapor from a liquid refrigerant into a solid porous adsorbent material, removing a portion of the heat of adsorption from said adsorbent and causing said heat to assist in activating adsorbent material previously used.

3. The method of refrigeration comprising adsorbing vapor from a liquid refrigerant into a solid porous adsorbent material, transferring a portion of the heat of adsorption of said material to a fluid medium and further transferring said heat from said medium to adsorbent material previously used for adsorbing to assist in driving off the vapors from the same.

4. The method of refrigeration comprising adsorbing vapor from a liquid refrigerant into a solid porous adsorbent material, transferring a portion of the heat of adsorption of said material to a fluid medium, supplying additional heat to said medium and transferring heat from said medium to adsorbent material previously used, to drive off the condensed vapors from the same.

5. The method of refrigeration consisting in adsorbing vapor from a refrigerant into a solid porous adsorbent, removing a portion of the heat of adsorption from said adsorbent, using said heat to activate adsorbent material previously used and using said activated material to adsorb vapor from said refrigerant.

6. The method of refrigeration comprising adsorbing vapor from a liquid refrigerant into a solid porous adsorbent material, removing a portion of the heat of adsorption from said adsorbent, causing said heat to assist in activating adsorbent material previously used and adsorbing vapors from said refrigerant into said activated material.

7. The method of refrigeration comprising adsorbing vapor from a liquid refrigerant into a solid porous adsorbent material, transferring a portion of the heat of adsorption of said material to a fluid medium, further transferring said heat from said medium to adsorbent material previously used for adsorbing to assist in driving off the vapors from the same and adsorbing vapors from said refrigerant into the adsorbent material from which the vapors have been driven by said heat.

8. The method of refrigeration comprising adsorbing vapor from a liquid refrigerant into a solid porous adsorbent material, transferring a portion of the heat of adsorption of said material to a fluid medium, supplying additional heat to said medium, transferring heat from said medium to adsorbent material previously used to drive off the condensed vapors from the same, and adsorbing

vapors from said refrigerant into the adsorbent material from which the vapors have been driven by said heat.

9. In a refrigerating apparatus, in combination, a plurality of adsorber units, means to connect said units individually and successively to an evaporator containing a liquid refrigerant, means to connect said units individually and successively to a condenser and means to pass air over said units progressively and successively starting with a unit connected to said evaporator.

10. In a refrigerating apparatus, in combination, a plurality of adsorber units, means to connect said units individually and successively to an evaporator containing a liquid refrigerant, means to connect said units individually and successively to a condenser and means to pass air over said units progressively starting with a unit connected to said evaporator, there being a gap of at least one unit between the one connected to the evaporator and the one connected to the condenser.

11. In a refrigerating device, in combination, a plurality of grouped adsorber units, a compartment enclosing each unit, an evaporator containing a liquid refrigerant, means to selectively connect said adsorber units in timed progression to said evaporator, a condenser, means to connect each adsorber to said condenser at an interval of said progression after it has been connected to said evaporator, means to pass a fluid medium thru said compartments in succession, said medium always passing over an adsorber connected to said evaporator before passing over an adsorber connected to said condenser.

12. In a refrigerating device, in combination, a plurality of adsorber units, an evaporator containing a liquid refrigerant, means to successively connect each adsorber unit to said evaporator, a condenser, means to successively connect each adsorber unit to said condenser after it has been connected to said evaporator and means to transfer the heat of adsorption of the unit connected to said evaporator to at least one other unit.

13. In a refrigerating device, in combination, a plurality of adsorber units, an evaporator containing a liquid refrigerant, means to successively connect each adsorber unit to said evaporator, a condenser, means to successively connect each adsorber unit to said condenser after it has been connected to said evaporator and means to transfer the heat of adsorption of the unit connected to said evaporator to the unit connected to said condenser.

14. In a refrigeration device, in combination, a plurality of adsorber units arranged in a series, an evaporator containing a liquid refrigerant, means to connect each adsorber of said series in rotation to said evaporator,

a condenser, means to connect each adsorber in rotation to said condenser after said adsorber has been connected to said evaporator, means to pass a fluid medium successively over each of said units in said series, and means to cause said medium to pass over the adsorber connected to said evaporator before passing over the adsorber connected to said condenser.

15. In a refrigeration device, in combination, a plurality of adsorber units arranged in a series, an evaporator containing a liquid refrigerant, means to connect each adsorber of said series in rotation to said evaporator, a condenser, means to connect each adsorber in rotation to said condenser after said adsorber has been connected to said evaporator, means to pass a fluid medium over each of said units in said series, means to cause said medium to pass over the adsorber connected to said evaporator before passing over the adsorber connected to said condenser and means to add heat to said medium between its passage over the first and second mentioned adsorbers.

16. The method of refrigeration consisting in adsorbing vapor from a liquid refrigerant into one of a group of adsorber units, passing a fluid over said absorbing unit, whereby said fluid is heated by the heat of adsorption of said unit, then passing said fluid over a unit having completed adsorbing thereby transferring heat from said fluid to said second mentioned unit to activate the same, and reversing the operations of said mentioned units, whereby the retained heat of adsorption of the first mentioned unit assists in its activation.

17. The method of refrigeration consisting in adsorbing vapor from a liquid refrigerant into one of a group of adsorber units, passing a fluid over said absorbing unit thereby heating said fluid by the heat of adsorption of said unit, passing said fluid over a unit having completed adsorbing thereby transferring heat from said fluid to said second mentioned unit to activate the same, reversing the operations of said mentioned units, whereby the retained heat of adsorption of the first mentioned unit assists in its activation, and passing said fluid from the activating unit to an idle unit to heat up the same.

18. The method of refrigeration consisting in adsorbing vapor from a liquid refrigerant successively into each of a plurality of adsorber units, passing a fluid successively through said units beginning always with the adsorbing unit whereby said fluid is heated by the heat of adsorption, and transferring the sensible heat imparted to said units from one to another in a closed cycle.

19. The method of refrigeration consisting in adsorbing vapor from a liquid refrigerant successively into adjacent units of a plurality

of adsorbers, transferring the heat of adsorption to a fluid, passing said fluid successively through the remaining units to heat certain of them for activating, said fluid causing a cyclic transfer of the sensible heat of said units.

20. The method of refrigerating consisting in adsorbing vapor from a liquid refrigerant into a portion of a group of adsorption units, passing a fluid through the adsorbing units to take up the heat of adsorption, passing said fluid through another portion of said group of units which has completed an adsorption period to thereby activate the same, and successively advancing activated units to the adsorbing phase in a direction counter to the flow of said fluid.

21. The method of refrigerating consisting in adsorbing vapor from a liquid refrigerant into certain of a plurality of adsorption units, passing a fluid through the adsorbing unit to take up the heat of adsorption, passing said fluid through a unit previously saturated with vapor thereby transferring heat from said fluid to said unit to drive off the vapor, transferring said adsorbing unit while hot to the activating phase to conserve the sensible heat thereof, and transferring the sensible heat of the activated unit, by said fluid, to a unit about to be activated to heat up the same.

22. The method of refrigerating wherein a system is employed comprising an evaporator and a plurality of adsorber units; such method consisting in having each adsorber unit repeatedly complete a cycle including adsorbing vapor from said evaporator and then being activated to drive off adsorbed vapor so that the unit may again adsorb and passing a fluid over each unit while it is adsorbing to thereby heat the fluid and then passing the heated fluid over an adsorber which is in the activating phase to thereby heat the same and liberate the adsorbed vapor.

23. The method of refrigerating wherein a system is employed comprising an evaporator and a plurality of adsorber units; such method consisting in having each adsorber unit repeatedly complete a cycle including, first adsorbing vapor from said evaporator, second being idle, third being activated to drive off adsorbed vapor so that the unit may again adsorb and fourth being idle; and passing a fluid over each unit while it is activating to thereby heat the fluid, then passing said heated fluid over other units one in each of the above stages and in the order named to thus cool the second unit which has just been heated to activate the same, heat the third unit to activate the same and warm up the fourth unit which has just completed adsorbing to prepare the same for activation.

24. The method of refrigeration comprising adsorbing vapor from a refrigerant into a solid adsorbent material and thereafter applying heat from the refrigeration process to

said adsorbent material to drive off said vapor.

25. The method of refrigerating comprising absorbing heat into a refrigerant to evaporate the same, adsorbing the vapor of said refrigerant into a solid porous adsorbent, collecting the heat of adsorption and applying it to vapor saturated adsorbent to drive off the vapor.

26. The method of conserving heat in an adsorption refrigeration system comprising extracting the sensible heat from the adsorbent and its container and using it to activate other adsorbent and heat its container.

In testimony whereof I hereunto affix my signature.

ERNEST B. MILLER.

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