Sept. 24, 1929. E. B. MILLER ET AL 1,729,082

REFRIGERATING APPARATUS

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FIG. 1.

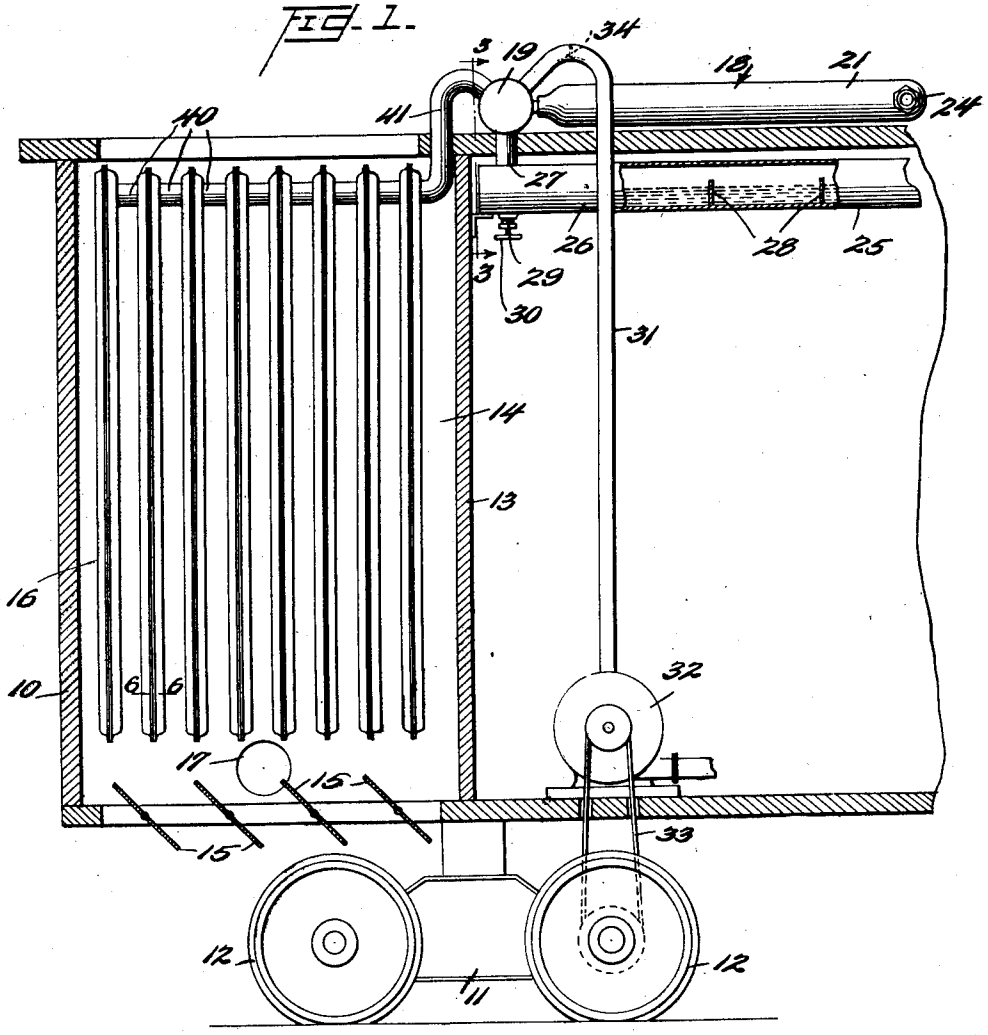


FIG. 6.

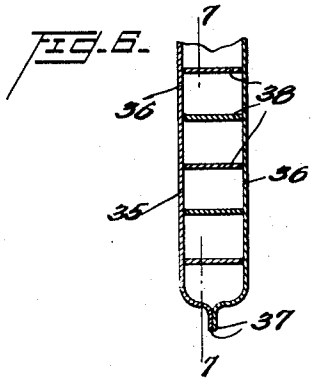
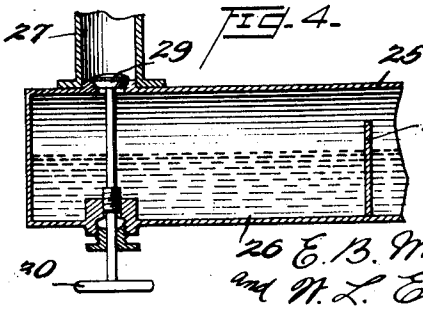


FIG. 4.



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FIG. 2.

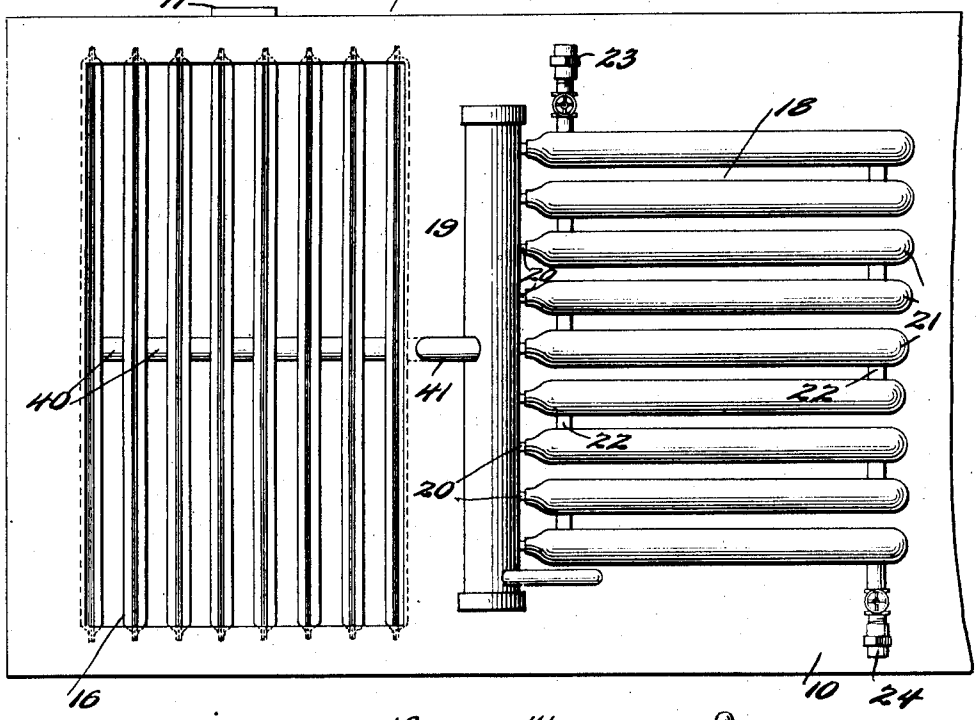


FIG. 3.

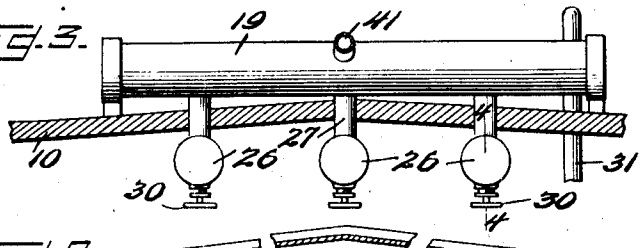
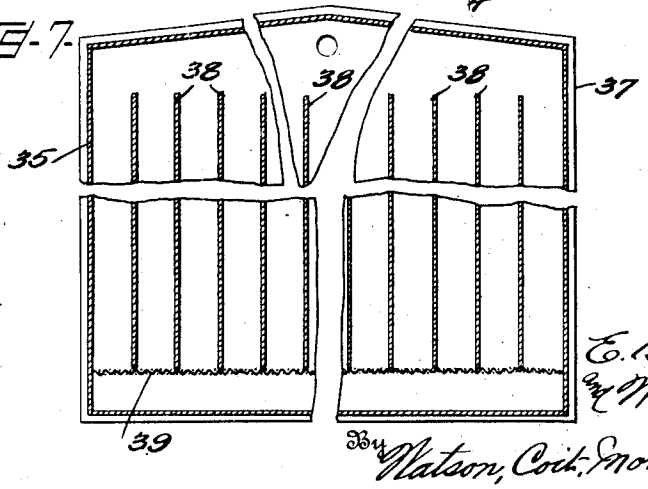


FIG. 7.



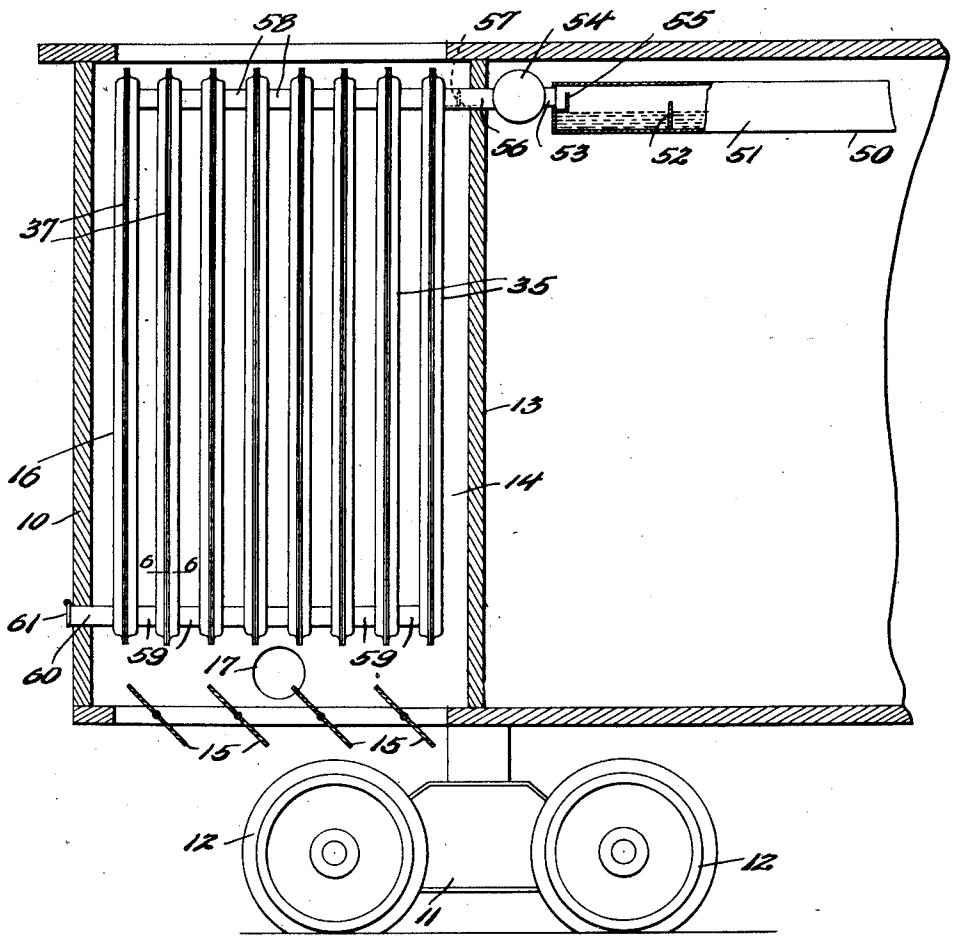
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REFRIGERATING APPARATUS

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FIG. 5.



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1,729,082

UNITED STATES PATENT OFFICE

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REFRIGERATING APPARATUS

Application filed March 11, 1925. Serial No. 14,758.

This invention relates to refrigeration and relates more particularly to a system of refrigeration in which a liquid refrigerant is evaporated and the vapor therefrom is adsorbed in the pores of a porous material in the substantial absence of permanent gases, the porous material being subsequently activated so that it may adsorb again, by liberating the adsorbed vapor.

This invention has particular reference to the construction of an air-cooled adsorber unit suitable for use in such a system of refrigeration, and has reference also to a railway car refrigerating plant in which this air-cooled adsorber is employed.

It is an object of this invention to provide a form of adsorber which has a maximum cooling and heating surface per pound of porous material, and which has also a minimum distance of heat travel through the porous material.

A further object of this invention is to provide an adsorber unit of this character which is simple in construction and economical to manufacture.

A still further object is to provide a refrigerating plant for a railway car which is adapted to be used in conjunction with the air-cooled adsorber referred to above.

Other objects and advantages of our invention will be apparent from the following description, taken in conjunction with the accompanying drawings, which form a part of this specification, and in which:

Figure 1 is a side elevation of a railway car refrigerating installation embodying our invention, the side of the car and a part of the apparatus being broken away to more clearly show the invention;

Figure 2 is a top plan view of the same;

Figure 3 is a fragmentary transverse vertical section taken on the line 3—3 of Figure 1;

Figure 4 is an enlarged fragmentary longitudinal vertical section taken on the line 4—4 of Figure 3;

Figure 5 is a view similar to Figure 1, showing our air-cooled adsorber utilized in a railway car refrigerating installation of a different type;

Figure 6 is an enlarged fragmentary horizontal section of one of the adsorber units, taken on the line 6—6 of Figures 1 and 5; and

Figure 7 is a cross section of one of the adsorber units, taken on the line 7—7 of Figure 6.

Referring more particularly to the drawings, in which like reference characters denote like parts throughout the several views thereof, Figures 1 to 4, inclusive, show a railway car refrigerating plant according to one embodiment of our invention.

A railway refrigerating car 10 is mounted on trucks 11 having wheels 12. A partition or bulkhead 13 separates one end of the car from the remainder and forms a chamber or compartment 14, which is suitably heat-insulated from the rest of the car. The top of the compartment 14 is open, and the bottom is likewise open but may be closed by means of shutters 15. An air-cooled adsorber 16, the details of which will be later described, is mounted in the compartment 14. The compartment 14 is also provided near the bottom thereof with a pipe connection 17, thru which hot gases may be introduced into the chamber 14.

A condenser 18 is mounted on the top of the car adjacent the compartment 14. This condenser may be of any suitable type, and as shown consists of a header 19, tubes 20 connected thereto, water jackets 21 surrounding the tubes 20 and connected in series by means of pipes 22, and valved connections 23 and 24 communicating with the end water jackets, said connections being adapted to be connected to suitable cooling water supply and discharge pipes when the condenser is in operation.

An evaporator 25 is mounted inside the main portion of the car adjacent the partition 13 and the top of the car. The evaporator may comprise a plurality of cylindrical tanks 26 communicating with the header 19 of the condenser by means of pipes 27. The evaporator tanks 26 are provided with transverse baffles 28, the object of which is to prevent the liquid refrigerant from rushing from one end to the other of the tank during the motion of the car. Each pipe 27 is adapted

to be closed by a valve 29, thereby shutting off communication between the evaporator tanks 26 and the condenser header 19. The valves 29 are manually operable by means of handles 30, and the construction of the valve and its operating parts is shown in detail in Figure 4. The evaporator tanks may also be provided with suitable drip pans, not shown, to catch water condensing on the outside of the tanks and prevent it from damaging goods in the car.

The header 19 is also connected by means of a pipe 31 with a vacuum pump 32, adapted to be driven by means of a belt 33 from a pulley on the axle of the wheel 12. The pipe 31 is provided with a check valve 34, which is adapted to open when the pressure on the pump side of the valve is less than that on the side connected to the header 19.

Referring particularly to Figures 6 and 7, the adsorber 16 comprises a series of spaced units, each of which consists of a relatively thin hollow metallic shell 35, of substantially rectangular contour. The shells 35 may be made in two pieces, each symmetrical half being preferably manufactured by stamping cupped and flanged edges on a plate of sheet metal, thereby forming a shallow tray 36 having a peripheral flange 37. Each tray 36 is provided with a plurality of metal spacers or fins 38, which may be welded along one edge to the inside of the tray, these fins being so spaced that when two cooperating trays 36 are joined, preferably by welding together their flanges 37, a fin projecting from one tray will be spaced midway between two fins secured to the other tray, as shown in Figure 6, and will be almost in contact with the opposite tray. These spacers are used as stiffeners to prevent collapsing of the walls when the adsorber is subjected to a greater external than internal pressure, and also serve to conduct heat away from the porous material. The spacers 38 do not extend the entire length of the shell 35, but terminate a distance above the bottom and below the top of the shell. A screen 39 is secured adjacent the lower ends of the spacers 38, and serves to support the charge of adsorbent material which is loaded into the shell only as far as the top of the spacers. A pipe 40 connects each unit with its neighbor and the unit nearest the partition 13 is connected to the header 19 by means of a vapor pipe 41. These pipes 40 and 41 communicate with the interior of the shells 35 thru apertures disposed above the upper ends of the spacers 38.

Adsorbing materials suitable for the present invention should have pores of such size that the material will adsorb water vapor to such an extent as to contain not less than about 10% of its own weight of water when in equilibrium with water vapor at 30° C. and a partial pressure of substantially 22 mm. of mercury. Preferably silica gel is employed as the porous material. This material has pores of such size that it will adsorb water vapor to such an extent as to contain approximately 21% of its own weight of water when in equilibrium with water vapor under the above conditions. But other adsorbents might be used provided they have a sufficient percentage of their internal volume made up of small pores. Thus, activated cocoanut charcoal, gels of oxide of tin, aluminum, tungsten, or iron, gels of combinations of two or more of these oxides, or gels of combinations of one or more of these oxides with silica, might be advantageously employed.

The operation of this system is very simple. To start the apparatus in operation the evaporator 25 is first filled with a suitable liquid refrigerant, such as brine. The valves 29 may then be opened and when the car starts on its run the apparatus will be evacuated by means of the pump 32. The liquid in the evaporator 25 will be evaporated by heat from the objects to be cooled, and the resulting vapor will pass through the pipe 27 into the header 19 and thence through the pipe 41 into the adsorber 16. Here it will be adsorbed in the silica gel or other adsorbent. Of course it is understood that a certain amount of vapor will be constantly drawn off by the vacuum pump 32 and lost by exhaustion to the atmosphere, but the loss of refrigerating liquid thus sustained is slight and does not interfere with the operation of the apparatus. Occasionally, of course, liquid must be added to the evaporator 25 to compensate for that lost. When the car reaches the end of its run the apparatus may be activated, as it is called, or put in condition for another adsorbing cycle by liberating the adsorbed vapor from the porous material as by heating in a suitable manner. This is accomplished by closing the valves 29 and the shutters 15, connecting the connection 17 to a source of hot gases from an activating station alongside of the track, and connecting the condenser 18 to cooling water supply and discharge pipes by means of the connections 23 and 24. The hot gases entering through the connection 17 will heat the adsorbent and cause the refrigerant adsorbed therein to be driven off as vapor into the condenser 18, where it is cooled and condensed to liquid. As the car is stationary during this operation, of course the vacuum pump 32 is not running and the check valve 34 is closed. When the adsorbing material has been substantially freed from vapor, the source of hot gases may be disconnected from the connection 17, the shutters 15 opened and the adsorber 16 permitted to cool off. If it is desired to hasten this cooling operation, cold air may be forced to circulate thru the chamber 14 by connecting a suitable blower to the connection 17. The valves 29 may now be reopened, whereupon the liquid in the condenser 18 will drain back into the evapo-

rator 25. Upon disconnection of the cooling water supply and discharge pipes from the condenser 18, the car is ready to start upon another trip and the apparatus is in condition for a repetition of the refrigerating cycle.

In the modification shown in Figure 5, the structure of the railway car, the adsorber compartment, and the adsorber units may be the same as that shown in Figures 1 to 3, and the same reference characters are therefore applied to these parts. The condenser and the vacuum pump of the previous modification are, however, entirely eliminated, and the structure of the evaporator somewhat changed.

The evaporator 50, shown in Figure 5, may consist of a plurality of cylindrical tanks 51 having baffles 52 therein, and connected by pipes 53 to a header 54. Baffles 55 prevent liquid from the evaporator tanks from spilling into the pipes 53 during movement of the car, and thus getting into the adsorber 16.

The header 54 is connected to the adsorber by means of a pipe 56, in which is mounted a check valve 57, which is adapted to open when the pressure in the adsorber is less than that in the evaporator. The tops of the adsorber units 35 are connected together by pipes 58, and the bottoms of the units are also connected in series by means of pipes 59. A vent pipe 60 is connected to the last unit of the series and extends thru the end wall of the car. This vent pipe 60 is provided with a check valve 61 adapted to open when the pressure in the adsorber exceeds that of the atmosphere.

The operation of this system is completely disclosed in our co-pending application Serial No. 14,759 filed concurrently herewith, and need not be repeated in detail. It is sufficient to state here that the adsorbed vapor is liberated from the porous material in the adsorber and discharged to the atmosphere, carrying with it all permanent gases from the apparatus. The system is then ready for a repetition of the adsorbing cycle.

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

1. A railway car refrigerating plant, comprising in combination, a railway car having a compartment closed from the rest of the car but open to the atmosphere, an air-cooled adsorber in said chamber having a charge of porous adsorbing material therein, and an evaporator always containing a quantity of liquid in the main portion of said car connected to said adsorber.

2. A railway car refrigerating plant, comprising in combination, a railway car having a compartment closed from the rest of the car but open to the atmosphere, an air-cooled adsorber in said compartment having a charge of porous adsorbing material therein, an evaporator in the main portion of said car connected to said adsorber, a condenser connected to said adsorber and said evaporator, and means for shutting off communication between the evaporator and the condenser and the adsorber.

3. A railway car refrigerating plant, comprising in combination, a railway car having a separate compartment at one end thereof, openings in the top and bottom of said compartment, a connection for introducing hot gases into said compartment, an air-cooled adsorber in said compartment having a charge of porous adsorbing material therein, a vapor pipe connected to said adsorber, a condenser connected to said vapor pipe, an evaporator mounted within the main portion of said car and also connected to said vapor pipe, means for shutting off communication between said evaporator and said vapor pipe, and a vacuum pump connected to said vapor pipe.

4. The combination as claimed in claim 3, in which said vacuum pump is driven from an axle of the railway car, and is connected to said vapor pipe thru a check valve adapted to open when the pressure is less on the pump side than on the vapor pipe side.

5. A railway refrigerating plant, comprising in combination, a railway car having a compartment closed from the rest of the car but open to the atmosphere, an adsorber in said compartment, means to cause the motion of the car to force air through said compartment to cool said adsorber, an evaporator in the main portion of said car connected to said adsorber, and a condenser connected to said adsorber and evaporator.

6. A railway refrigerating plant, comprising in combination, a railway car having a compartment closed from the rest of the car, an adsorber in said compartment, means to cause air to pass through said compartment when the car is in motion to cool said adsorber, an evaporator in the main portion of said car containing a body of liquid and an unrestricted connection between said adsorber and said evaporator.

7. A railway car refrigerating plant, comprising in combination, a railway car having a compartment closed from the rest of the car, a multipart adsorber in said compartment, means to cause air to pass through said compartment to cool said adsorber, an evaporator in the main portion of said car, a condenser outside of said car and connections between said adsorber, said evaporator and said condenser.

In testimony whereof we hereunto affix our signatures.

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