June 7, 1932. L. K. WRIGHT 1,861,518

REFRIGERATING APPARATUS FOR FREIGHT CARS

Filed July 19, 1928 4 Sheets-Sheet 1

FIG. 1.

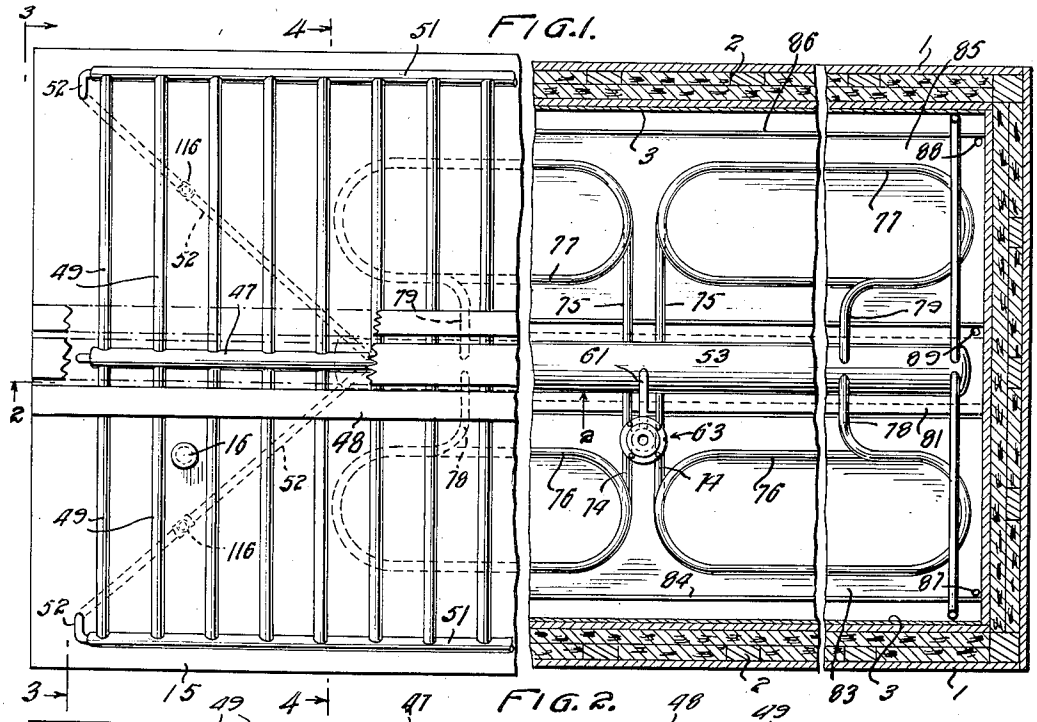
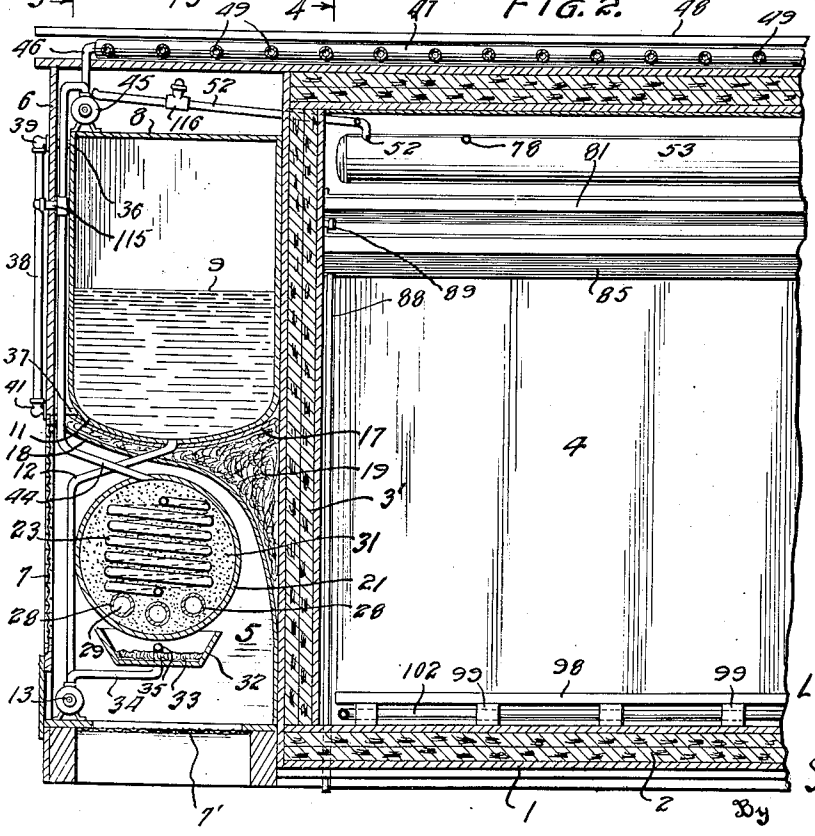


FIG. 2.



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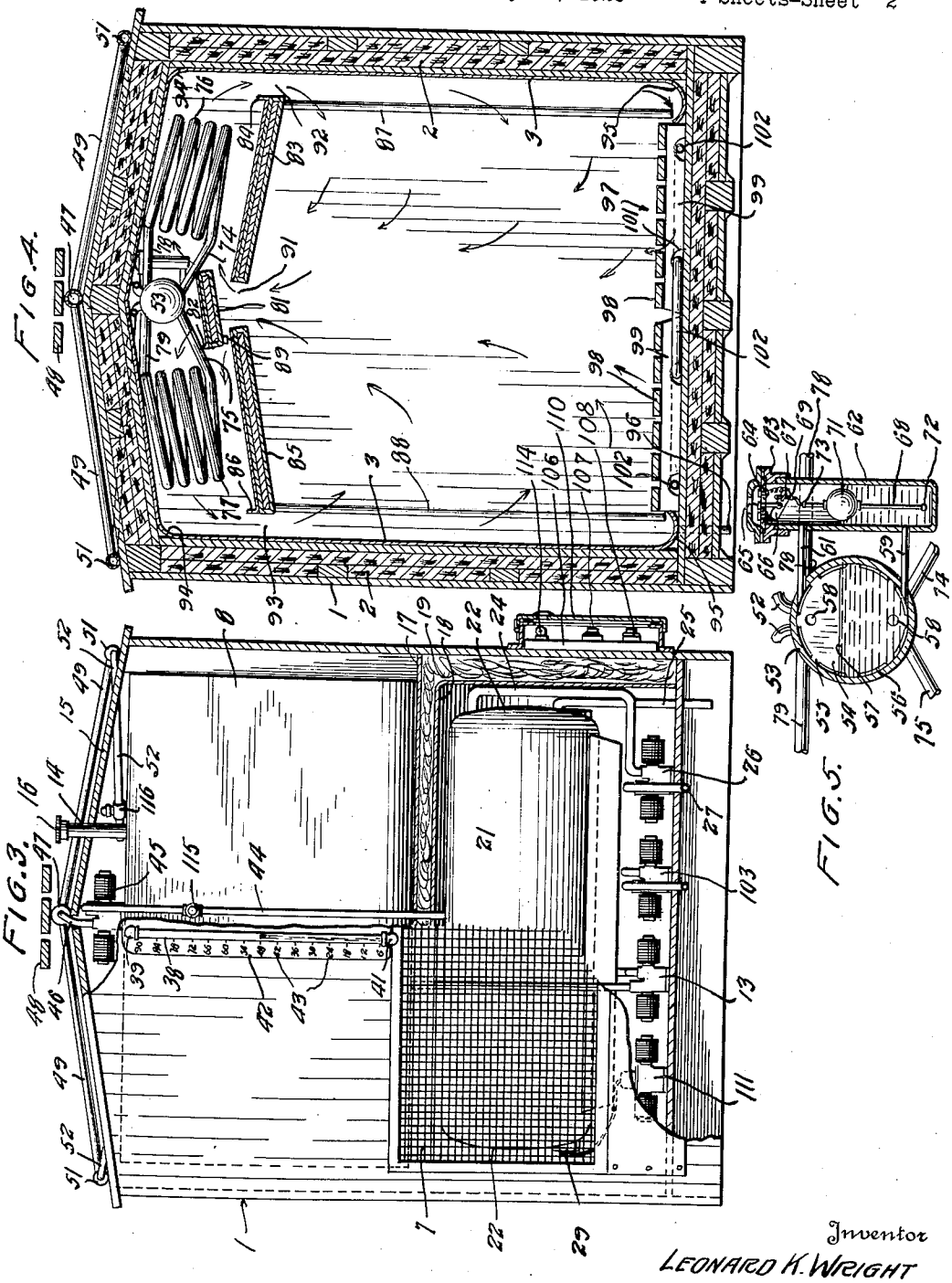


FIG. 4.

FIG. 5.

FIG. 3.

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FIG. 9.

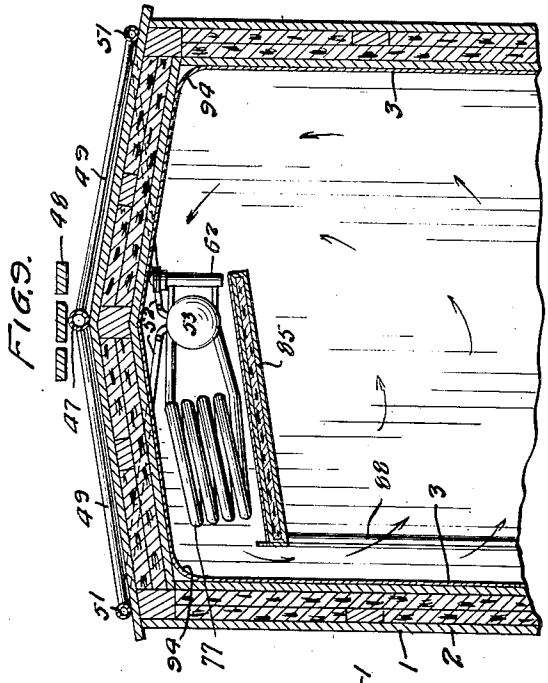


FIG. 8.

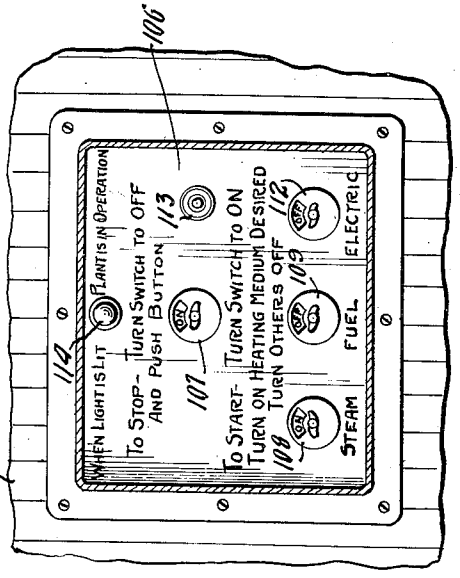


FIG. 6.

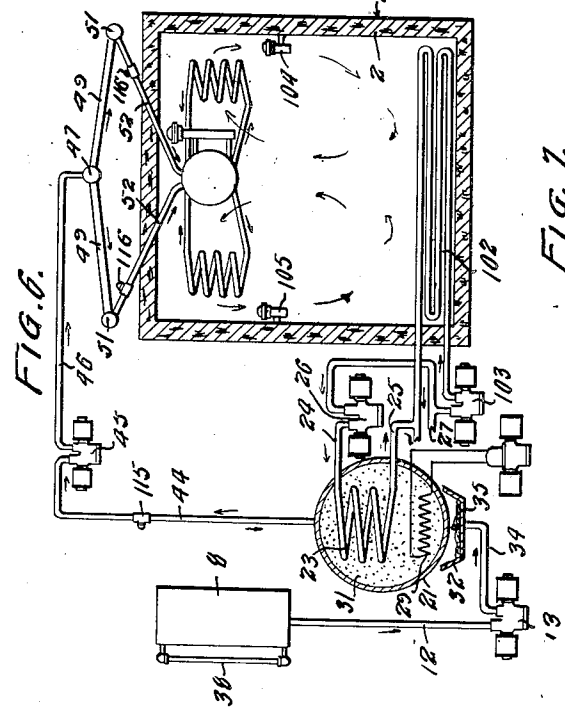
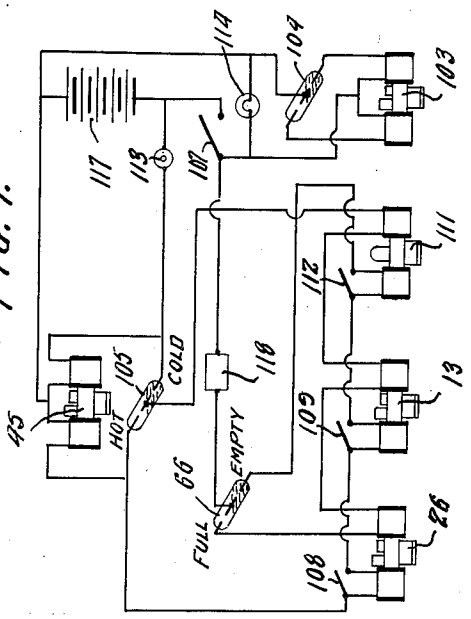


FIG. 7.



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FIG. 10.

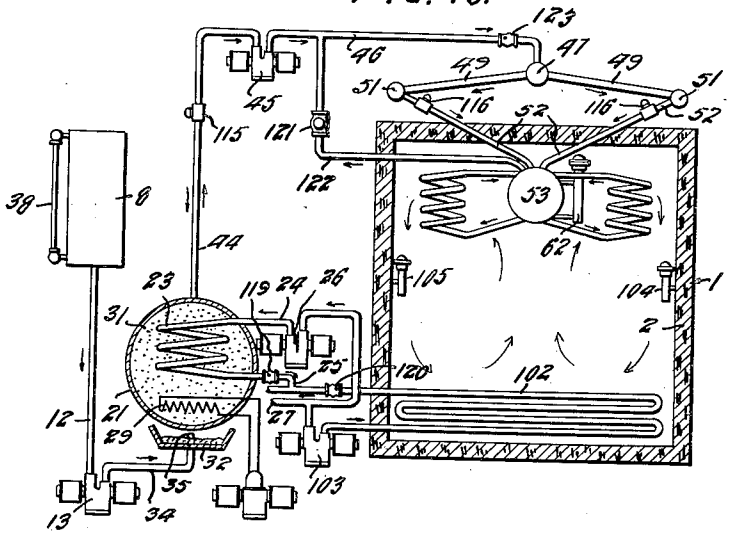
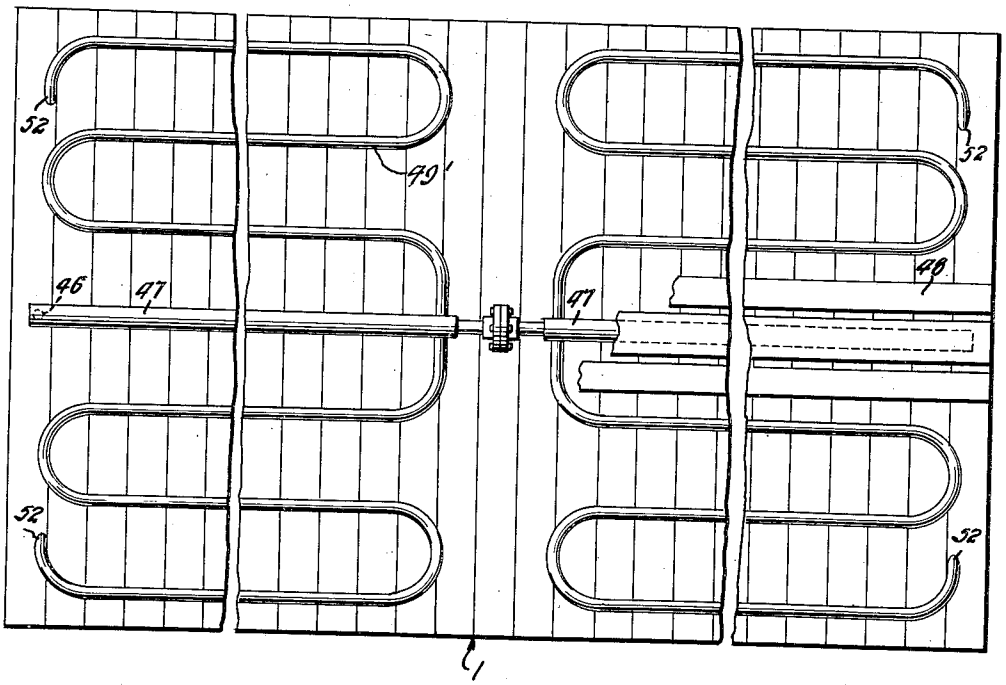


FIG. 11.



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Patented June 7, 1932 1,861,518

UNITED STATES PATENT OFFICE

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REFRIGERATING APPARATUS FOR FREIGHT CARS

Application filed July 19, 1928. Serial No. 293,860.

This invention relates in general to refrigeration and more particularly has reference to a refrigerating apparatus for moving vehicles.

Certain parts of this application may be considered as divided from my copending application, Serial No. 252,304, filed February 6, 1928.

Previous to this time much difficulty has been experienced in maintaining refrigerator cars and similar vehicles at the desired temperature necessary to prevent deterioration of their contents. The apparatus heretofore used have not been adapted to withstand the shocks and vibration incident to transportation, and the complicated character of the apparatus has made frequent adjustments necessary. Particularly is this true in refrigerating apparatus of the so-called mechanical type, which have proved especially unsatisfactory in mobile operation. Refrigerating systems of the absorption type have also had certain inherent difficulties, due principally to the splashing of the absorbent caused by the vibration to which a moving vehicle is subjected. As is self evident, a vehicle, such as a freight car has a wide range of travel, and is subjected to pronounced temperature changes. This necessitates frequent manual regulation of the devices heretofore used.

To overcome the above and other disadvantages inhering in prior refrigerating apparatus is an object of this invention.

A further object is to provide a self-sustaining mobile apparatus that obviates a motor or other mechanical source of power.

Yet another object of this invention is to provide a refrigerating apparatus adapted to withstand severe shocks.

A further object of this invention is to provide a refrigerating apparatus of the adsorption type that may be operated by various types of fuel.

Yet another object of this invention is to provide a refrigerating apparatus with a minimum of movable parts, of simple construction and operation, and occupying a small amount of space.

A still further object of this invention is to provide a process of refrigeration which assures frequent defrosting of the evaporator coils or system.

To accomplish the above and other important objects, as will more fully appear herein, my invention in general comprises means for vaporizing a refrigerant, condensing the vapor, and subsequently evaporating the condensate, combined in a novel arrangement and sturdy in construction.

To insure an adequate comprehension of my invention, but wishing it to be distinctly understood that various modifications may be made in the preferred embodiment herein shown and described without departing from the spirit or scope of my invention, reference is made to the accompanying drawings in which similar numerals indicate corresponding parts.

Figure 1 is a top view of a freight car equipped with my invention, the left-hand section being a top plan view of the car, the center section a sectional view of the middle of the car directly beneath the roof, and the right-hand portion of the figure being a sectional view directly beneath the roof of the end of the car.

Figure 2 is a sectional view along the line 2—2 of Figure 1, looking in the direction of the arrows.

Figure 3 is a sectional view along the line 3—3 of Figure 1, looking in the direction of the arrows.

Figure 4 is a sectional view along the line 4—4 of Figure 1, looking in the direction of the arrows.

Figure 5 is a detailed view in section of the current control device.

Figure 6 is a diagrammatic view of the principal parts of the apparatus.

Figure 7 is a diagrammatical showing of the electrical circuit.

Figure 8 is a view in detail of the switch panel.

Figure 9 is a sectional view of a modified form of apparatus.

Figure 10 is a diagrammatical view of the principal parts of the apparatus, including check valves and control valve.

Figure 11 is a modified view of the condenser.

In Figure 1, I have shown a freight car 1, of the conventional refrigerator type, provided with suitable insulation 2, and preferably lined with metal 3, or other suitable lining material.

Referring to Figure 2, it will be observed that a partition 3′ is positioned adjacent one end of the car, which is suitably insulated in the same manner as the main walls of the car. The partition 3′ separates the car into a refrigerating compartment 4, and what may be designated as a heating compartment 5. The side of the heating compartment opposite the partition 3′ is formed of a plate or panel 6 suitably mounted to the sides and wall of the car, and extending to below the middle of the car. From the lower part of the panel 6 to substantially the floor of the car there extends a screen 7, another screen 7′ is fixed in the bottom of the machine compartment 5 and allows air to enter, cool the generator and make its exit through screen 7. The screens 7 and 7′ permit the free circulation of air to and from the heating chamber.

In the upper portion of the heating chamber there is positioned, supported by means not shown, a tank 8, adapted to hold a liquid 9. This liquid may be kerosene, gasoline, alcohol, or any other suitable fuel. The tank 8 is provided with a curved base 11, to the lower part of which there is affixed a pipe 12, connected to a valve 13, preferably mounted on the floor. The tank 8 is filled with fuel through a filling tube 14, shown in Fig. 3, positioned in the top of the tank 8 and extending through a roof 15 of the car. A cap 16 may be fitted or threaded upon the tube 14 to prevent the escape of any fuel or the entrance of foreign matter into the tank 8.

The tank 8 is supported upon a rest 17 which takes the shape of the base 11, and which is bent back as at 18 to act as a baffle and rests against the partition 3′. The space enclosed by the baffle 17 is filled with a suitable heat insulating material 19.

Positioned immediately below the baffle 18, and supported by suitable means not shown, is a tank 21. This tank 21 is preferably provided with bulged ends 22, although under appropriate conditions it may be closed in any other suitable manner in accordance with ordinary boiler practice. Enclosed within the tank 21 is a coil 23, which is adapted to carry steam through the interior of the tank 21 in a heat exchange relationship with the contents of the tank 21.

Referring to Fig. 3, steam is admitted to the top of the coil 23 from a pipe 24, and the steam, principally condensed, passes out through the base of the coil 23 to a pipe 25. By this arrangement any condensation of the steam within the coil will not injure the system, for the condensate will flow through the coil by gravity out into the pipe 25. There is thus prevented any collection of a liquid within the coil. Steam is admitted to the pipe 24 through a valve 26. This valve is shown as of the solenoid type, and preferably of the construction set forth in my copending application, Serial No. 237,517, filed December 3, 1927, although under suitable circumstances a valve of another type may be employed. Steam is admitted to the valve 26 through a pipe 27 connected to a source of steam.

Referring again to Fig. 2, there are also shown positioned within the tank 21, three tubes 28, adjacent the base of the tank. Under suitable circumstances these tubes may vary in number, and may be differently positioned. The tubes 28 extend longitudinally through tank 21, and are adapted to house electrical resistance heaters 29. The tubes 28 are preferably composed of a strong material that is permeable to heat, so that the heat generated by the resistance coils or heaters may pass readily to the interior of the tank 21, and its contents.

The tank 21 is adapted to contain an adsorbent 31. This adsorbent may be silica gel, activated silicious substances, ammonia nitrate, activated charcoal, or any other suitable material. It will be appreciated, however, that under certain circumstances, an absorbent or an absorbent and adsorbent may be employed. I find that the best results are obtained by practically filling the tank 21 with the adsorbent as shown in Fig. 2. It will be observed that the coils 23 and the tubes 28 are therefore in intimate contact with the adsorbent contained in the tank, and that any heat generated within the coils or tubes is readily transferred to the adsorbent.

To aid in the dispersion of heat to the contents of the tank these tubes, and the steam coil, may be equipped with discs, or spirally wound ribbon or fins. The tank 21 may also be equipped with fins, spirally wound ribbon, or wound with helically formed wire spring, or discs.

This tank 21 may be equipped with a number of tubes, either plain or provided with additional surface, such as fins, inserted longitudinally from head to head, or circumferentially inserted, through which air may flow and cool the vessel. This assures faster cooling of the vessel. In installations operating in relatively high temperature climates or atmospheres, or where it is desired to force the apparatus to greater capacity through repeating cycles with greater rapidity, a fan may be used to force air through these tubes or over the absorber-generator 21 or both. It is also to be observed that the casing of the tank 21 may be provided with discs or fins to increase the dissipation of heat.

Supported beneath the tank 21, by suitable means not shown, is a fire pan 32. The base

of the pan 32 is lined with asbestos or a suitable porous material 33, and there extends through the base of the pan 32 and the lining 33 a pipe 34, which is joined to the outlet port of the valve 13. The pipe 34 is provided with a suitable jet 35 which atomizes the fuel that is supplied from the tank 8. This fuel may be ignited either by providing a tip of spongy platinum on the jet 35, or there may be positioned near the jet 35 a spark plug. I have found it preferable to employ a spongy platinum tip, although I do not wish to be confined to the same.

It will therefore be observed that the tank 21 and its contents may be heated by any one of three means, by the steam coil 23, resistance coils 29, or the fuel 9, or by combinations of these agents. Should occasion require a concentrated or rapid refrigeration of the compartment 4, it may be desirable to employ more than one heating means, so that more heating and cooling cycles may be accomplished in a given time.

Referring particularly to Figs. 2 and 3, I have provided a fluid indicator for the tank 8. At the top of the tank there is joined a pipe 36 which extends through the panel 6, and at the base of the tank 8 a similar tube 37 is provided. Joining the tubes 36 and 37 is a glass or transparent tube 38. It will therefore be observed that the level within the tube 38 will be the same as that existing within the tank 8.

At the top of the tube 38 I provide a safety device (such as a check valve) 39 and a similar device 41 is positioned at the base of the tube. These safety devices prevent the escape of fuel, with the consequent loss and danger attached thereto, should the tube 38 be broken. In back of the tube 38 there is mounted a scale 42, on which appropriate numeraling 43 appears. This scale 42 is properly calibrated so that a reading of the indicator advises the amount of fuel in the tank 8 and the approximate length of time that the supply within the tank 8 will last under normal operating conditions. The operator therefore is able to see at a glance the state of the fuel supply.

A pipe 44 is mounted in the top of the tank 21, and is adapted to convey to or from the tank 21 a refrigerant. This pipe may be provided with an appropriate screen to prevent the passage of solid matter therethrough. The adsorbent material 31 takes up a refrigerant, and holds the same within the tank 21 until the tank is heated. As is well known, an adsorbent's affinity for a material is dependent upon its temperature. As the adsorbent is heated, it gives up the gas which it is holding and the gas passes out from the tank 21 through the pipe 44. The pipe 44 is joined to a valve 45, shown herein as preferably of the solenoid type. On the outlet side of the valve 45 there is connected a pipe 46, which is joined to a header 47.

Referring to Figs. 1 and 3, it will be observed that the header 47 is on top of the roof 15, directly beneath a runner 48 which extends longitudinally of the car. The header 47 with the condenser tubes 49 extends substantially the length of the refrigerating car and, as will be observed, is exposed to the atmosphere. The runner 48 partially protects the header 47 and condenser tubes 49 from the rays of the sun, and when the gaseous refrigerant that is driven off from the adsorbent 31 reaches the condenser, condensation of the gas is desired. Exposed as the condenser is to the atmosphere, and partially protected from the sun's rays, a fairly rapid condensation is effected. The condenser is preferably of galvanized or rust proofed material, which may be coated with a white or aluminum paint to reflect the heat of the sun and also aid in the dispersion of heat.

As will be observed in Fig. 3, the roof 15 of the car is of the usual hipped type, and there extend laterally from the header 47, down the slanting sides of the roof, a series of pipe or tube sections 49. These sections 49 slant away from the header 47 and are joined at their lower ends to auxiliary headers 51. These auxiliary headers have a slight pitch to each end of the car and act as liquid collectors. Condensation of any gaseous refrigerant is effected in the header 47, the sections 49 and to some extent the headers 51.

At the ends of the headers 51 there are provided pipes 52 which extend to receiving tanks 53. The size and number of the tanks 53 is optional, depending upon the particular conditions of operation, the size of the generator and the absorbent qualities of the absorbent used, but I find it preferable to employ two receiving tanks 53. This arrangement, when provided with the proper joints in the associated mechanism, makes for ease of assembly. It will be observed that the sections 49 and the pipes 52 are inclined at an angle so that the refrigerant condensed or liquefied in the condenser unit (header 47 and the condenser tubes 49) may readily flow from the header 47 and tubes 49 to the liquid headers 51 and thence to the receiving tanks 53, via the liquid tubes 52.

The tubes 49, headers 47 and 51, may be equipped with fins, strips, or spirally wound ribbon to increase the effective radiating surface and make the condenser unit more efficient. By the use of additional surface, the condenser proper may be reduced in size and may only occupy a portion of the car top or roof.

The receiving tanks are adapted to contain the condensed refrigerant until the evaporating cycle is commenced. Referring particularly to Figure 5, the receiving tanks 53 are

provided with surge plates 54, which are joined to the tanks 53 by means of brackets or fins 55 welded to the tank or firmly pressed into position. It will be observed that spaces 56 are left between the surge plate and the tank 53 to permit the passage of a condensate 57 from one section of the tank to another. Apertures 58 are also provided in the surge plates to permit the passage of liquid refrigerant. It will be observed, however, that only a limited amount of refrigerant may pass through the plates 54, and therefore jars and shocks to the refrigerating car will not have any appreciable effect upon the liquid in any one part of the receiving tanks. This is especially desirable in a refrigerating apparatus for use on a moving vehicle, for the shocks to which such apparatus are subjected, would, in the absence of such means as here shown, cause the liquid to splash or surge about within the tank and slop over into other parts of the apparatus.

In Figure 5 there is shown the associated mechanism for controlling the operation of the apparatus. Joined to the base of the tank 53 is a section of pipe 59, and a similar section 61 is provided near the top of the tank 53. Suitably supported, by means not shown, near the tank 53 is a well 62 to which the pipes 59 and 61 are joined. The well 62 is provided with a cap 63 within which is mounted a plate 64. The plate 64 is of insulating material and supports a plurality of binding posts 65. One of the binding posts 65 serves as a pivot for a mercury tube 66. The mercury tube is adapted to establish or break a circuit and to establish another circuit depending upon its position. An eye 67 is provided on the mercury tube 66 through which extends a rod 68. Various beads 69 are provided on the rod 68, immediately above and below the eye 67, so that movement of the rod 68 throws the mercury tube 66 about its pivot. Slidably mounted on the rod 68 is a float 71, capable of free movement up and down the rod. Beads 72 and 73 are provided on the rod 68, and the float 71 on contacting with these beads and throws the mercury tube 66 about its pivot. This mechanism is set forth in more detail in my copending application, Serial No. 231,357, filed November 5, 1927.

It will be observed that the level of the condensate 57 in the well 62 is the same height as exists in the receiving tank 53. Liquid refrigerant passes from the receiving tank to the well 62 by way of the pipe 59. Any gaseous refrigerant evaporated from the condensate 57 in the well 62 may pass back into the tank 53 by way of the pipe 61. Other appropriate means may be provided within the well as associated mechanism shown herein for controlling the current under suitable circumstances, but I find it preferable to employ the mechanism herein shown, or the snap action mechanism as set forth in my copending application Serial No. 258,359, filed March 1, 1928.

Referring more particularly to Fig. 4, there are shown pipes 74 and 75 connected to the base of the receiver 53. These pipes slope downwardly as shown, and empty into evaporating coils 76 and 77 respectively. I have shown one evaporating coil positioned on each side of the receiving tank 53. Although the preferred method is as shown in Fig. 1, there may be actually only one coil on each side, or as will be subsequently pointed out the evaporating device may be limited to one side of the receiving tank. I have found it preferable to have two coils on each side, as in Fig. 1, in that it facilitates assembly or removal of the apparatus from the car. Under suitable circumstances of course any plurality of evaporating coils may be provided in a refrigerating car or refrigerating space. To increase the effective refrigerating surface the coils 76 and 77 may be equipped with strips, corrugations, discs, fins or spirally wound ribbon, which gives greater heat transfer.

The liquid refrigerant contained in the tank 53 flows through the pipes 74 and 75 to the coils 76 and 77, and rises to the same height in the evaporating coils as exists in the receiving tank. A pipe 78 passes from the top of the coil 76 to the top of the receiving tank 53, and a similar pipe 79 is provided for the coil 77. The liquid refrigerant therefore enters the coils at their base and the vaporized refrigerant passes back into the receiving tank 53 from the top of the evaporating coils.

Positioned immediately below the receiving tank 53 is a drain plate or insulated deck 81 slightly slanted as shown in Fig. 4, and provided at its lower end with a gutter 82. During an evaporating cycle the receiving tanks 53 and coils 76 and 77 become frosted on the exterior, and, on termination of the refrigerating cycle warm air coming in contact with these members defrosts them. The drippings from the tank 53, therefore fall upon the drip pan of deck 81 and are carried by the gutter 82 to a proper drain pipe 89.

Positioned below the evaporating coil 76 is an insulated deck 83 supported at a slight angle and provided with a drip pan and gutter 84. This drip pan on the deck catches the drippings from the evaporating coil 76. A similar deck 85 and drip pan and gutter 86 is positioned beneath the evaporating coil 77 and serves the same function.

The decks 81, 83 and 85 are composed of suitable material, preferably having an insulating layer interposed between the top and bottom wooden sheathing and a sheet or pan of galvanized or rust proof metal is affixed to the top of each deck to catch the drippage. All of these decks have a slight longitudinal slant so that the water within the gutters on

the respective decks flows to one end or to each end. The deck 83 is joined at one end to a pipe 87 which conveys the water from the gutter 84 to the base of the car. A similar drain pipe 88 is provided for the gutter 86, and a pipe 89 is also joined to the gutter 82. The drain pipe 89 discharges the water from the gutter 82 onto the drip pan on deck 85.

Due to the tendency of air within a closed compartment to stratify, the decks 83 and 85 serve a dual function in that they keep the air within the car in a state of circulation. As is well known, warm air, being of less density tends to rise, forcing the cooler air to the bottom. The warmer air within the car therefore tends to rise, and pass through the opening 91 between the decks 83 and 85.

The decks, 83 and 85, may be pitched toward each other, if desired, or where the shape of the roof or where the refrigerator car height permits.

In loading the refrigerator car with cubical cargo that tends to present a solid mass, spacer laths or beams must be interspersed, especially at the sides of the car and throughout the center, so that the air may chill the lading and remove heat, in circulating through the load.

The deck 81 is placed sufficiently far above the decks 83 and 85 to permit the free passage of this warm air into the region of the evaporating coils. On contacting with the evaporating coils the air is chilled and tends to fall, passing through an opening 92, between the deck 83 and the proximate wall of the car, and the opening 93 between the deck 85 and its adjacent wall. I have also curved the lining 3 of the car at the top as at 94 to eliminate all sharp angles within the car, and thus prevent the formation of air pockets. The lining 3 is curved at the bottom as at 95, which not only prevents the formation of air pockets, but also provides a gutter for the drain pipes 87 and 88. These gutters have a slight inclination so that the water will flow to one end or both ends of the refrigerated space. At the lowest point of the gutter there is provided a pipe 96 which discharges the water beneath the car.

On the floor of the car there rest a series of racks 97 having longitudinal slats 98 and transverse support members 99. The member 99 may be hinged to the floor, so that the racks may be raised when it is desired to clean the car. By providing racks as shown, circulation of the air is facilitated, for it is possible to expose even the lowest layer of the car's contents to the chilled air. The air may pass beneath the racks and rise between the slats 98 and travel upwardly in contact with the contents or lading.

The device shown in Fig. 4 is preferable where it is desired to obtain very low temperatures and where it is essential that a uniform temperature be maintained. For work not so exacting, I have devised an apparatus as shown in Fig. 9, in which I employ only one coil 77, positioned on one side of the receiving tank 53. The deck 85 is used here, but it will be observed that it extends beneath the receiving tank 53 and well 62 also. The device shown in Fig. 9 is admirably adapted for lighter work, such as in fruit, vegetable, or egg cars. Its mode of operation is the same as the device set forth in the other figures of the drawings.

Referring again to Fig. 4, it will be observed that the supports 99 are cut away as at 101, and through these cut away portions there extends a pipe 102, which may be convoluted. The purpose of this pipe 102 is to provide a channel for steam. Frequently during the journey of a freight car, or other vehicle, a very sudden drop in atmospheric temperature is encountered as for instance, on arrival in a cooler climate or a passage over a mountain. In such instances, perishable fruits or other delicate commodities might become frozen and valueless.

I therefore provide the pipe 102 which is controlled by a valve 103 tapped on to the pipe that supplies valve 26 with steam. Automatic means are provided whereby on a sudden drop in temperature the valve 103 is opened and steam is introduced to the pipe 102, which comprises a thermostat control 104 (shown in Figure 7) to regulate the valve 103. This thermostat may be of the conventional type, but I find it preferable to employ one of the positive snap acting mercury bulb type. A similar thermostat 105 is provided to regulate the refrigeration apparatus. These thermostats are positioned at central points within the car, although under suitable conditions their location may be changed.

Referring to Figs. 3 and 8 there is shown a panel 106, on which are mounted various switches. A main switch 107 is provided. This switch may be of the conventional rotary type with suitable indicia as to whether it is on or off. A similar switch 108 is provided which governs the steam valve 26. A switch 109 governs the fuel valve 13. An automatic switch 111 shown in Fig. 3, is positioned, in the circuit of which the resistance coils or electric heaters form a part, and this switch 111 is controlled by switch 112 on the panel 106. There is also provided on the panel a button 113 which is pushed when it is desired to teminate the operation of the apparatus. I have also provided a pilot light 114, which when the plant is in operation is lighted. An operator therefore may see at a glance whether the apparatus of a car or other vehicle is in operation. A hinged cover 110 encloses the panel 106 and the switches.

Referring to Figs. 2 and 3, it will be ob-

served that in the line 44 there is positioned a safety valve 115, which is preferably of the rupture disc type. In the event of any excess pressure in the heating side of the apparatus this valve 115 will open or burst its diaphragm and relieve the pressure existing within the system. A similar valve 116 is provided in the pipes 52, and serves a similar function on the evaporating side of the apparatus. These valves may either discharge the refrigerant into the atmosphere or they may be connected to a section or sections of pipe to convey the escaping refrigerant to a tank or container holding a suitable absorbent such as water, or chemical mixtures.

In Fig. 7 there is shown diagrammatically a storage battery 117, which may be positioned at any suitable place in the car or it may be slung beneath the car. It should be preferably placed, however, in the compartment 5. This battery is for operating only the various valves and switches, the resistance coils 29 being supplied with electricity from another source. A circuit breaker 118 is provided which permits the passage of electricity for a short period after the establishment of a circuit, and then breaks the circuit. This circuit breaker effects a material economy in electricity and also insures longevity of the various valves, for the current remains on only a sufficient time to operate the valves, and then is terminated. The circuit breaker may be located at any appropriate place on the car. This circuit breaker is disclosed in my copending application, Serial No. 250,774, filed January 31, 1928.

From the foregoing the operation of my invention is obvious. The particular amounts of adsorbent or absorbent, refrigerant and fuel are placed in the apparatus, and the switch 107 is turned on. Upon deciding the agent for heating the adsorbent, the appropriate switch controlling that agent is opened or turned to "on", which will allow the valve it controls to function. Assuming that fuel is used as the heating medium, switch 109 is turned to the "on" position. Fuel passes from the tank 8 through the pipe 12 and valve 13 to the jet 35. The spongy platinum tip or ignition means will ignite the atomized fuel. Referring to Fig. 7, and assuming that all of the refrigerant within the system has been adsorbed by the adsorbent 31, the receiving tank 53 and well 62 will be empty. The mercury bulb 66 will therefore be in the "empty" position.

A circuit is now established which is as follows: from the battery 117 to the switch 107; to the circuit breaker 118; to the center of the tube 66; from the center of the tube 66 to the "empty" end of the tube and thence to the valve 111. In Fig. 7, the tube 66 is shown in the "empty" position. By having the switch 112 in the "off" position the current is shunted across the "open" solenoid of the switch 111, and this device is inoperative, and the current passes on to the "open" solenoid of valve 13, switch 109 being "on" or open. Valve 13 is thus opened, and fuel passes from the tank 8 to the jet 35 where it is dispersed. From the "open" solenoid of valve 13 the current is shunted across the "open" solenoid of valve 26 (the switch 108 being in the "off" position), and this valve remains inoperative. The current then passes to and through the "open" solenoid of valve 45, for it will be observed that the thermostat 105 is in the "cold" position, and therefore prevents the passage of current through it. From the "open" solenoid of valve 45 the current returns to the battery 117.

Assuming that the refrigerated compartment is at a sufficiently low temperature, and that all of the refrigerant is driven out of the adsorbent 31, the following circuit will be established: from the battery 117 through switch 107 to the circuit breaker 118; from the circuit breaker 118 to the center of tube 66. When all of the refrigerant is driven from the adsorbent, and the receiving tanks consequently filled with condensed refrigerant, the mercury tube 66 will have flipped to the "full" position, and the current will pass from the center of the tube to the "full" end. From the "full" end of the tube 66 the current will pass through the "closed" solenoid of valve 26. It will be observed that this valve is already closed, for the switch 108 has been in the "off" position, and the circuit first described had consequently been shunted across its "open" solenoid. From the "closed" solenoid 26 the current will pass to the "closed" solenoid of valve 13. This will close the fuel valve and terminate the supply of fuel to the jet 35, extinguishing the flame beneath the adsorber-generator 21. From the "closed" solenoid of valve 13 the current passes to the "closed" solenoid of valve 111 (which valve was already closed by turning the switch 112 to "off" at the beginning of the operation). From the "closed" solenoid of valve 111 the current will pass to the center of the thermostat 105. As has been above stated, this tube is in the "cold" position, for the refrigerating compartment was at a sufficiently low temperature at the commencement of the operation. From the center of the tube the current will pass through the mercury to the "cold" end, and thence to the "closed" solenoid of valve 45 and close this valve. From the "closed" solenoid of valve 45 the current will return to the battery 117.

From this it will be seen that all of the refrigerant has been driven off from the adsorbent, condensed in the condensing apparatus, and stored in the receiving tanks 53 and coils 76 and 77. The valve 45 being closed, the communication between the evaporating system and the adsorber-generator is cut off.

During the heating cycle the application of heat to the adsorber-generator 21 and its contents increases the pressure within the adsorber-generator. This pressure of course extends to all of the refrigerating system in open communication with the adsorber-generator, and, inasmuch as the valve 45 was open during the heating cycle, the pressure within the receiving tank 53 and the coils 76 and 77 is the same as that existing in the adsorber-generator 21.

The pressure thus built up is sufficient to maintain the refrigerant liquefied in the condenser and conveyed to the receiver 53, and coils 76 and 77, in substantially the liquid phase, and when the valve 45 is closed by the last described circuit, the pressure within the evaporating system is maintained at a pressure corresponding to the temperature of the evaporator system which will be approximately the same pressure existing during the heating cycle. When the application of heat to the adsorber-generator is withdrawn, there is a consequent reduction in pressure within the adsorber-generator and all that part of the system in open communication therewith. This reduced pressure, however, does not extend to the evaporating system when the valve 45 is closed. Inasmuch as the refrigerating compartment is at a low temperature, there is no need of refrigeration within the compartment, and therefore evaporation of the condensed refrigerant in the tank 53 and coils 76 and 77 is prevented until the temperatures within the refrigerating compartment increases enough to require additional cooling.

When the temperature rises in the refrigerating compartment the bulb in the thermostat 105 will flip to the "hot" position, opposite to that shown in Figure 7. The circuit will then be from the battery 117 through the switch 107 to the circuit breaker 118. From the circuit breaker 118 the current will pass to the center of the mercury tube 66 to the "full" end of the tube (as the tank 53 is filled, or partially so, with the condensed refrigerant). From the "full" end of the tube 66 the current will pass through the closed solenoid of valve 26, the closed solenoid of valve 13, the closed solenoid of valve 111, to the center of the mercury tube within the thermostat 105. With the increased temperature in the refrigerating compartment this tube, flipped to the "hot" position, will direct the current to the open solenoid of valve 45, and from the valve 45 the current will return to the battery 117.

This circuit has opened the valve 45, and the evaporating system is now in communication with the adsorber-generator. As above pointed out, the adsorber-generator has undergone a reduction in pressure, and on opening the valve this reduction in pressure extends to the evaporating system. With a decrease in pressure in the evaporating portion of the system, the liquid refrigerant will evaporate. The vaporized refrigerant will pass from the evaporating coils through the pipes 78 and 79 to the receiver or tank 53, and, with the refrigerant that is vaporized within the receiving tanks 53, will pass through the pipes 52, headers 51, sections 49 to the header 47. It will be recalled that the header 47 is connected to the pipe 46, and the refrigerant will pass through the valve 45 and pipe 44, back to the adsorber-generator. The adsorbent within the tank 21, with a reduction in temperature, has a pronounced affinity for the refrigerant, creating a suction therefor that extends throughout the entire system when the valve 45 is opened.

When the liquid level of the refrigerant within the receiving tanks 53 falls through dissipation due to its refrigerating duty of evaporation, the mercury bulb 66 flips to the "empty" position. The apparatus is now ready for the cycle first described.

It will be observed from the foregoing that the operation of this device is entirely automatic and that vaporization of the refrigerant occurs only when the temperature within the refrigerating compartment requires. The refrigerant may be stored in the receiving tanks 53 for any period, and vaporization commences only with a rise in temperature and a fall in pressure.

Referring to Figs. 6 and 7, it will be observed that a valve 103 is connected to the line from the source of steam which is used for the car. This valve is of the solenoid type, and may be operated as are the other valves herein described. In Figs. 7 there is shown the electrical arrangement of this valve in the circuit, the control of which circuit is governed by the thermostat 104, similar to the thermostat 105. When the switch 107 is closed there is established for the steam valve the following circuit: from the battery 117 through the switch 107 to the "closed" solenoid of valve 103; from the "closed" solenoid of the valve to the "hot" end of the thermostat 104, and thence back to the battery.

The thermostat 104 will be regulated so that it will normally be in the "hot" position. When, however, the car is subjected to an extremely cold atmospheric temperature, the thermostat will switch to the "cold" position and the circuit will then be from the battery 117 through the switch 107 to the valve 103. The current will now pass through the "open" solenoid of valve 103 to the cold end of the bulb in the thermostat 104. From the cold end of the bulb the circuit will pass to the center of the bulb, and thence back to the battery 117.

The valve 103 will now be open, steam will be introduced into the pipes 102 positioned in the bottom of the car, giving the required

heat to preserve the contents. When the temperature has sufficiently risen the thermostat will switch to the hot position, and the circuit will then be from the battery 117 through the switch 107, through the closed solenoid 103, through the thermostat 104 to the battery 117. The switch 103 is now closed and heating of the car terminated.

As above pointed out, when the system is in operation, the pilot light 114 will be lit and the operator able to see at a glance that the apparatus is in operation. This light is positioned as shown in Fig. 7, and when the switch 107 is closed, will always be lit.

While I have shown what I consider to be the preferable form of my invention, it is of course obvious that various modifications may be made in its structure. The condenser heretofore described furnishes an abundance of effective cooling surface, and is therefore preferable for high pressure refrigerants such as ammonia, methylamine and ammonia or methyl chloride.

But where other refrigerants are used in the system such as ethyl chloride, sulphur dioxide, methylamine with very little or no ammonia contained, less surface is required. Some of the tubes 49 may be eliminated, even where the apparatus is used in warm climates. Another and a cheaper method is to build the condenser of the so-called hairpin type as shown at 49′ in Figure 11. Such a modification eliminates to a large extent the welding of joints that is required in the apparatus shown in Figure 1. It is also to be noted that in this modified form the liquid headers 51 may be eliminated, the condenser 49′ being directly connected or integral with pipe 52.

The hairpin condensers have a slight pitch so that condensed refrigerant flows by gravity to the pipes 52. These pipes should be so installed that they are located one at each end of the car. In this way at least one-half of the condenser surface would be effected even if the car were at a standstill on a grade.

The refrigerating plant described could also be made in smaller sizes so that dual generators could be used, one generator absorbing while the other is heating. This would tend to maintain a constant temperature for any holdover period.

A modified form of generator-adsorber might also be substituted for the one heretofore described, in which the generator would be provided with a number of tubes or forms, the space between them being filled with an adsorbent. This would hasten the heating and cooling of the adsorbent material. Or again, the generator might be constructed of tubes joined into a lower and upper head, the tubes being filled with adsorbent material.

In Figure 10 there is shown a modified arrangement of the unit, in which check valves 119 and 120 might be installed in the condensate end of the steam coils for the generator, and heating coils 102, respectively. This would allow the steam and condensate to be active in the desired coil, and would prevent a back flow of the condensate into the coil that was not in operation.

Also a check valve 123 may be installed in line 46, which would allow the gas to flow only in the direction of the arrows. Such a valve would prevent the gas from tanks 53 returning to the adsorber by way of the condenser. A separate line 122 may also be run from the top of the receiver 53 to the line 46, and thus eliminate any return of the evaporated refrigerant to the generator by way of the condenser. An appropriate valve 121 may be installed in the line 122 to allow the passage of refrigerant in only the direction of the arrow.

After the generator has been heated, and the refrigerant driven off and condensed, lodged in receiver 53, and the control 62 actuated, if the storage space is cold, valve 45 would be closed by the thermostat 105. The generator would be cooled, and the pressure therein being reduced, any actuation of the thermostat 105 by virtue of an increase of temperature in the refrigerating chamber, would open the valve 45. Check valve 123 would prevent the gasified refrigerant from passing back through the condenser. The efficiency of the apparatus is thus improved by the use of the direct line 122. It prevents the cold gas from absorbing further heat, which might occur in passing through the condensing unit.

The valve 121 opens only when the generator is cool and of proper pressure, and when so opened the refrigerator coils become active. When sufficient refrigeration has lowered the temperature to the point where the thermostat 105 is actuated, the check valve 45 is closed, discontinuing the refrigeration. The action of the automatic check valve 45 and the valve 121 is such that no gas can pass to the generator unless the generator is in a condition to adsorb. The pressure actuated valve 121 should be of such construction that it is operated solely by the pressure existing on the generator side and irregardless of pressure on the evaporator sides. Conventional valves of this type are now easily obtainable.

When the generator is driving off gas the automatic valve 121 is closed due to high pressure on the generator side and the gas travels to the receiving tanks 53 by way of only the line 46.

From the foregoing it will be observed that by my invention I provide a compact refrigerating apparatus for moving vehicles. Its compactness is of especial importance in such an application, in that it makes available for transportation purposes space that with most refrigerating systems would normally be occupied by the apparatus.

It is to be noted that the apparatus which is the subject of this application is simple and economical to construct, and is provided with a minimum of parts. The various elements of the device are sturdy and capable of withstanding the shocks incident to transportation. The baffles 53 provided in the various tanks employed in my apparatus, prevent a surge of the liquefied refrigerant and a slopping over into other parts of the apparatus not adapted for the liquid phase. Because there are few moving parts, there is consequently little opportunity for wear in the apparatus.

It will be observed that my invention is automatic, and once having been set in operation requires no attention. This automatic feature is not at the expense of efficiency, for I have devised means for maintaining the temperature at a uniform and constant level and any variations from this temperature are immediately compensated for by the amount of refrigeration produced by my apparatus.

I have shown my invention with reference to a freight car, and while I have referred specifically to its application in such a field, it is of course appreciated that its use is not confined thereto, for it may readily be installed in vans, barges, boats and other carriers.

While I have referred herein to an adsorption apparatus, the words adsorption and adsorbed are not to be taken as limiting the scope of this invention, for under suitable conditions an adsorbent, absorbent, or combination adsorbent and absorbent may be employed in this device.

It will be appreciated, as above pointed out, that various modifications may be made in the apparatus herein depicted and described, without exceeding the scope of my invention as defined in the appended claims, it being distinctly understood that the prior art and claims alone are to be definitive of my invention.

I claim:

1. In combination with a railroad car, means for heating in the lower part of said car and means for cooling said car including coils in the upper part of said car, said cooling means comprising a refrigerating cycle operated by heat, a single source of heating fluid and means intermediate said heating means and said coils responsive to temperature changes within said car for selectively admitting a heating fluid from said source to said heating means or to a part of said refrigerating cycle.

2. In a car, a flooring perforated at least beneath the cargo-carrying portion of the car, heating means beneath said flooring whereby air may be heated and thence circulated by convection directly upwardly through the floor to the cargo-carrying portion of the car, inclined baffling means within and adjacent the upper portion of said car, and cooling means above said baffling means.

3. In a car, a flooring perforated at least beneath the cargo-carrying portion of the car, heating means beneath said flooring whereby air may be heated and thence circulated by convection directly upwardly through the floor to the cargo-carrying portion of the car, inclined baffling means within and adjacent the upper portion of said car, cooling means above said baffling means, and means for operating said heating means when the temperature in said car falls below a predetermined point.

4. In a car, a flooring perforated at least beneath the cargo-carrying portion of the car, heating means beneath said flooring whereby air may be heated and thence circulated by convection directly upwardly through the floor to the cargo-carrying portion of the car, inclined baffling means within and adjacent the upper portion of said car, cooling means above said baffling means, means for shutting off said heating means and means for starting said cooling means when the temperature in the car rises above a predetermined point.

5. In a car, a flooring perforated at least beneath the cargo carrying portion of the car, heating means beneath said flooring whereby air may be heated and thence circulated by convection directly upwardly through the floor to the cargo-carrying portion of the car, inclined baffling means within and adjacent the upper portion of said car, cooling means above said baffling means within the car between said heating and cooling means, means for operating said heating means when the temperature in said car falls below a predetermined point and means also within the car and between said heating and cooling means for operating said cooling means when the temperature in the vehicle rises above a predetermined point.

In testimony whereof I affix my signature.

LEONARD KAY WRIGHT.