

June 14, 1932.

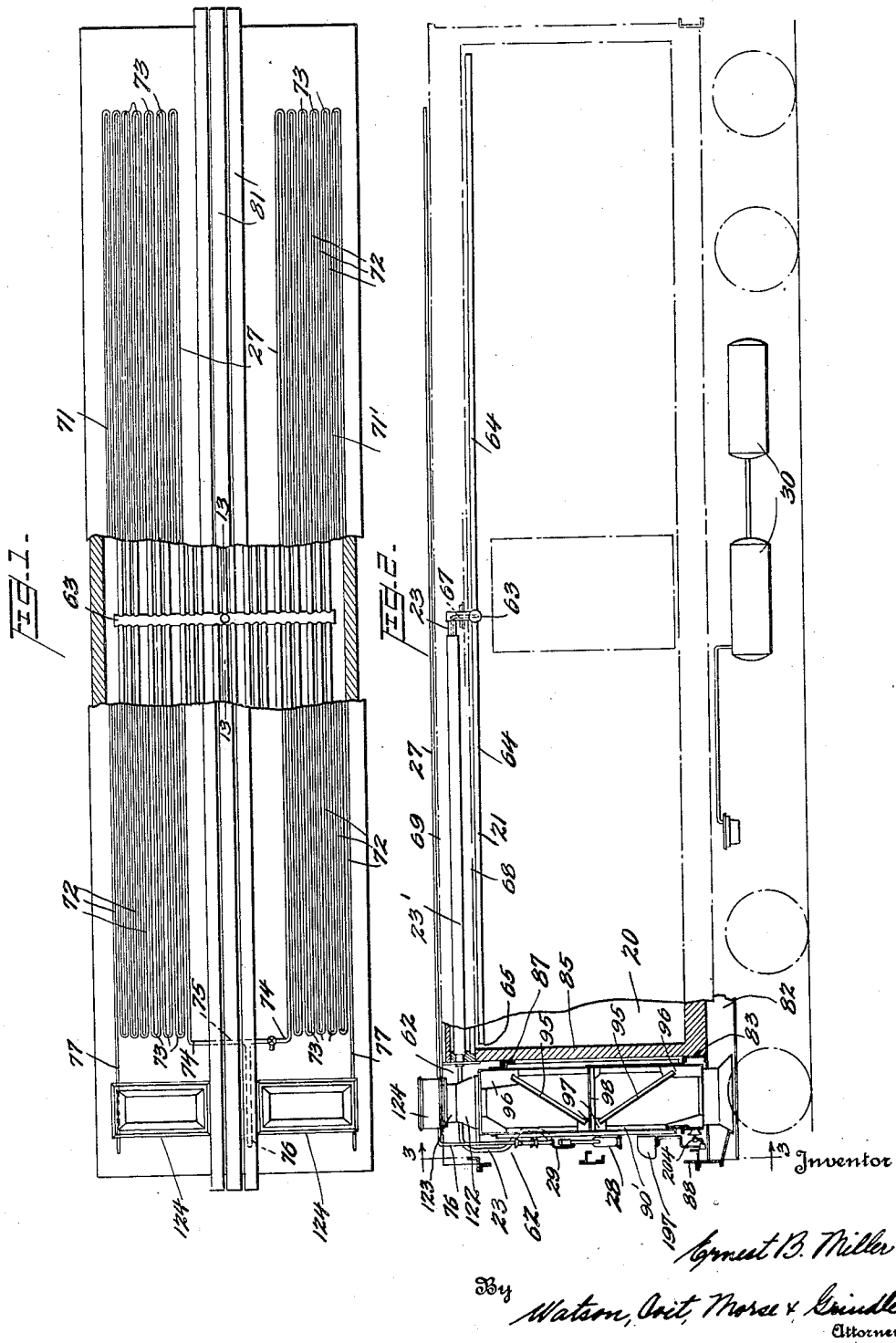
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1,862,604

REFRIGERATION CAR

Filed April 23, 1928

8 Sheets-Sheet 1



June 14, 1932.

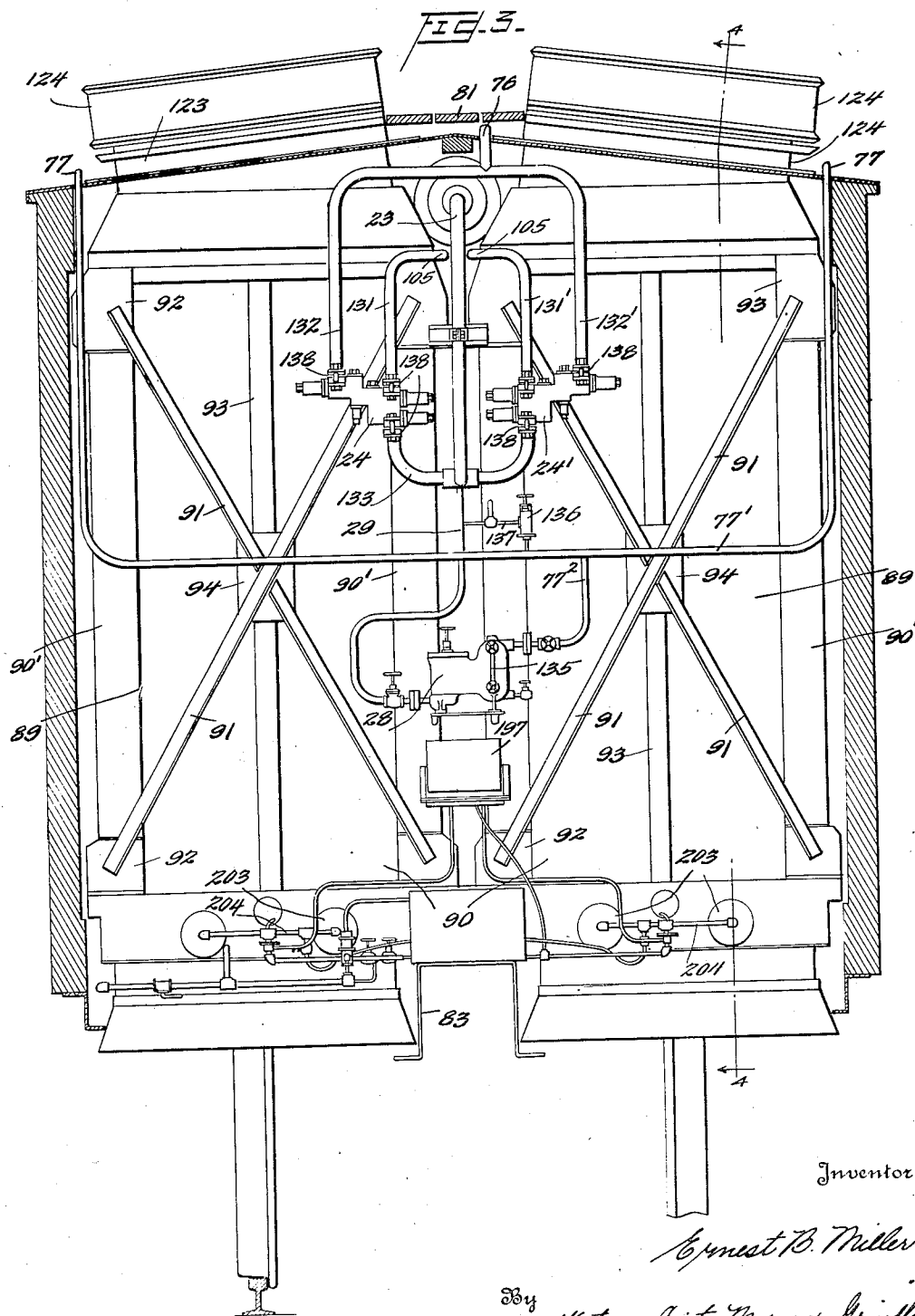
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REFRIGERATION CAR

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8 Sheets-Sheet 2



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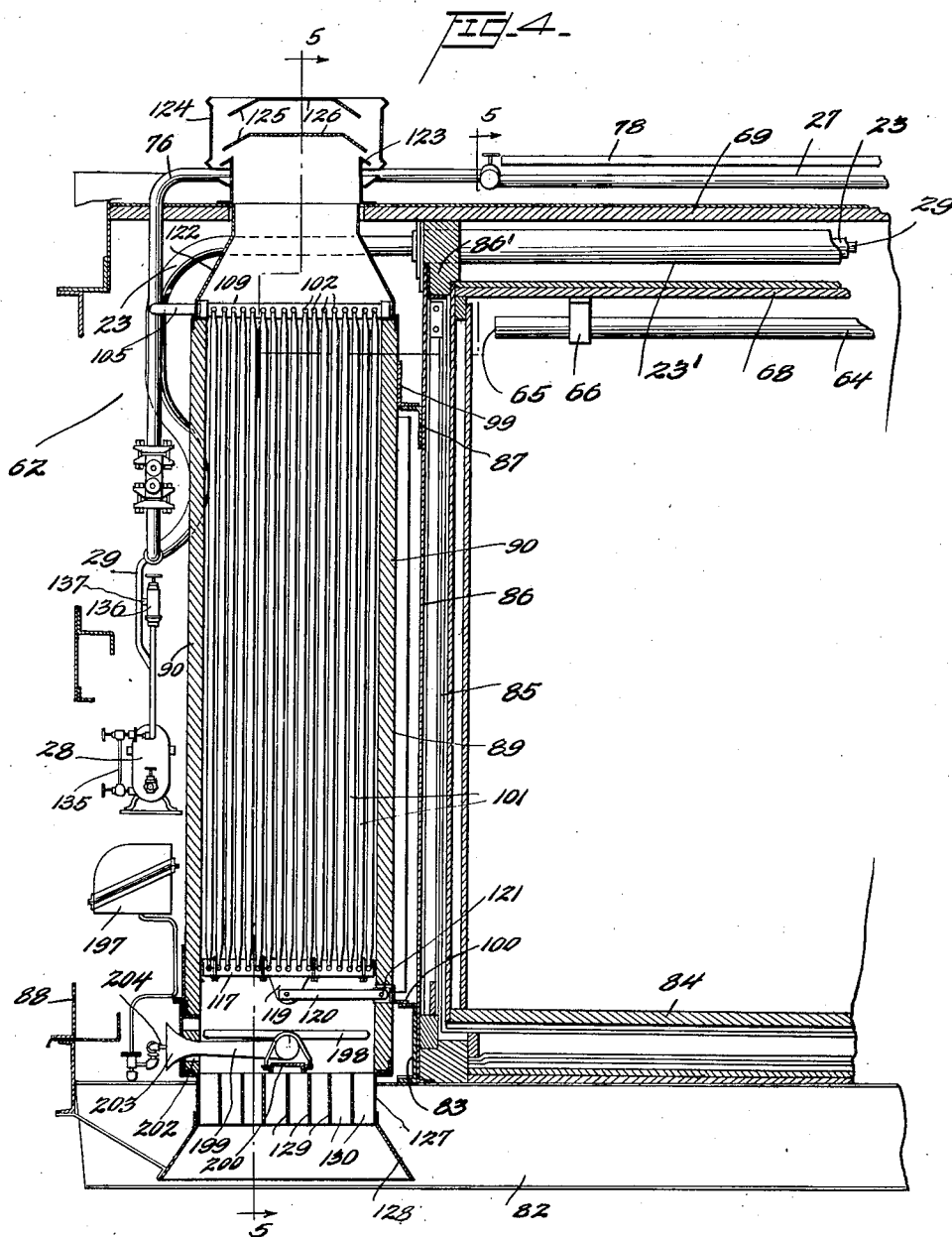
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REFRIGERATION CAR

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8 Sheets-Sheet 3



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REFRIGERATION CAR

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8 Sheets-Sheet 4

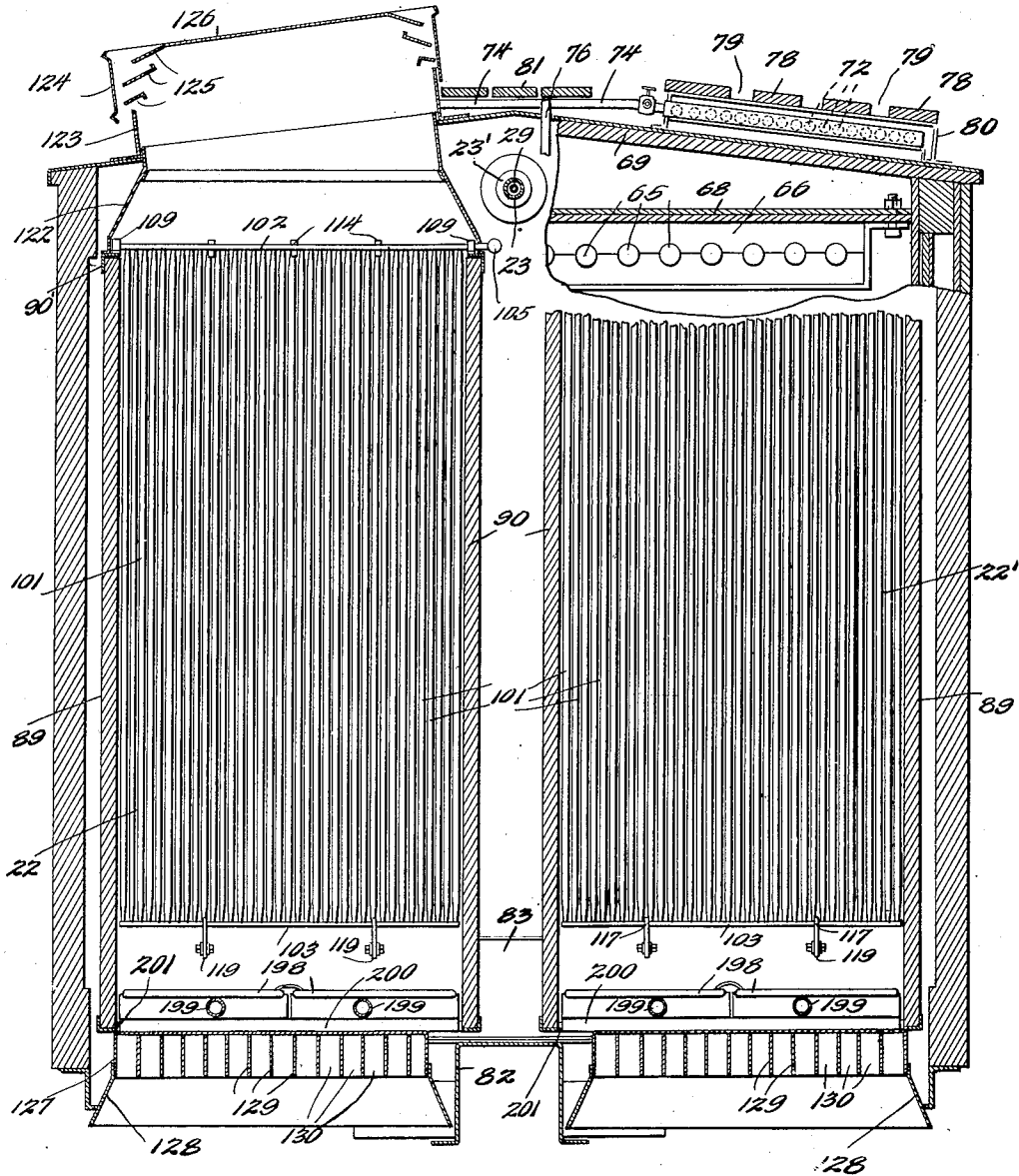


FIG. 5.

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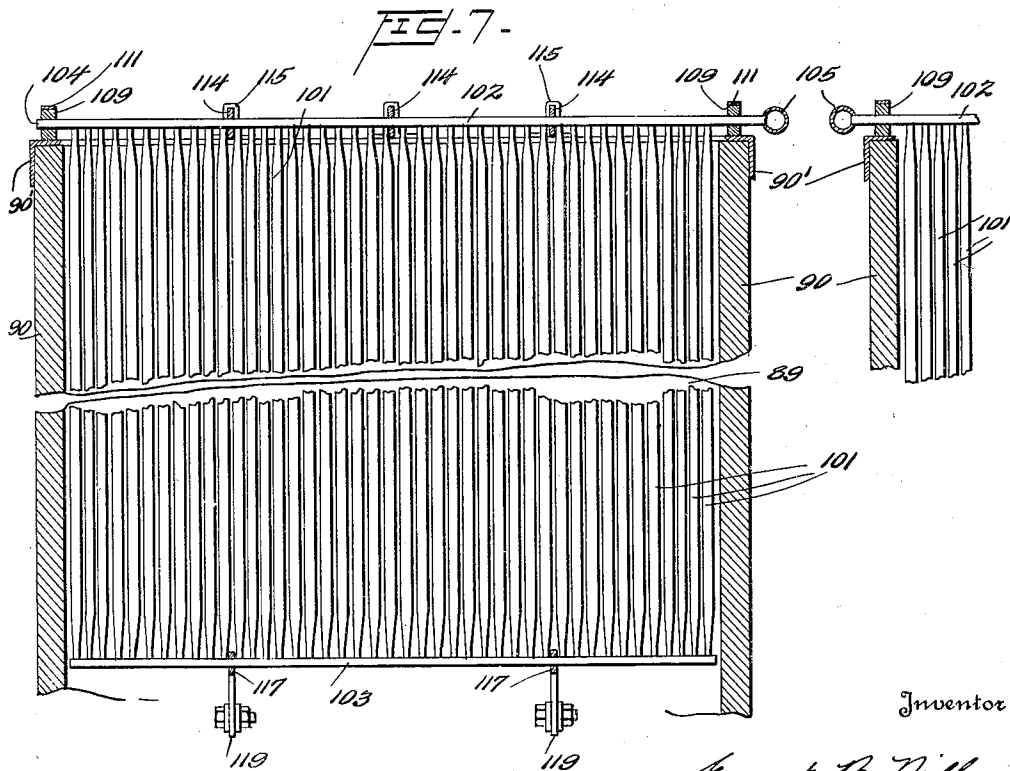
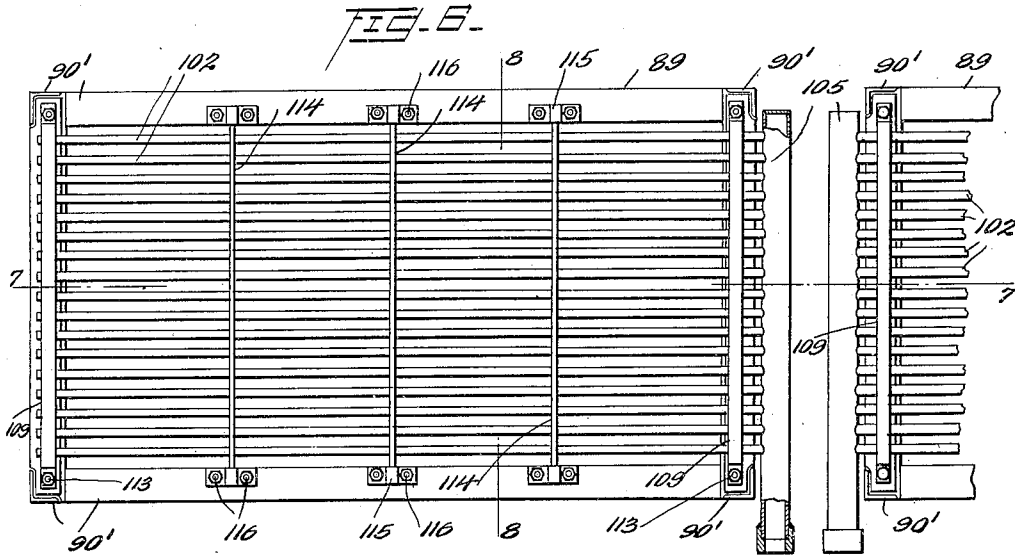
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8 Sheets-Sheet 5



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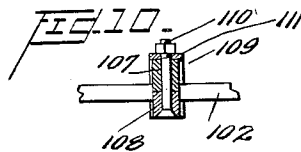
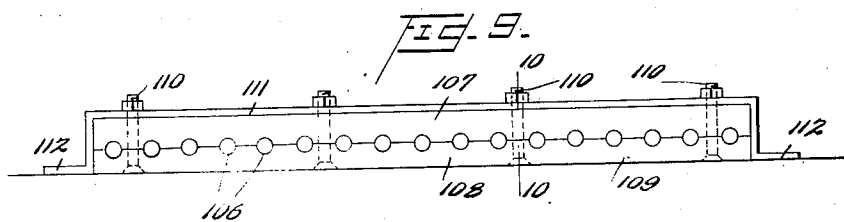
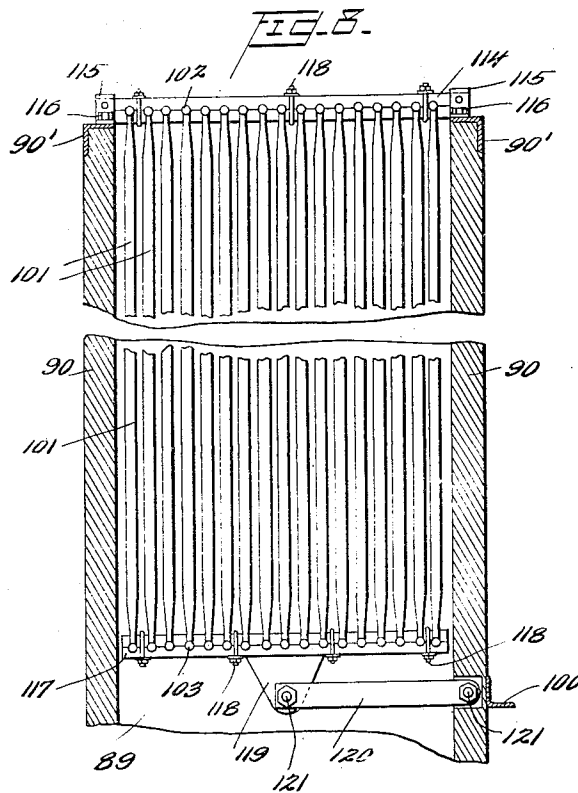
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8 Sheets-Sheet 6



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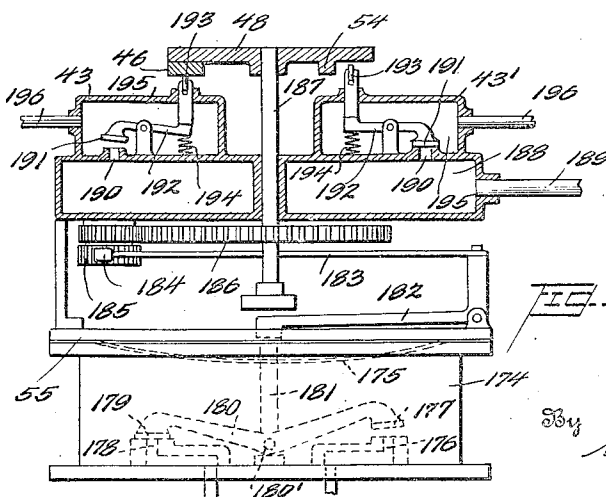
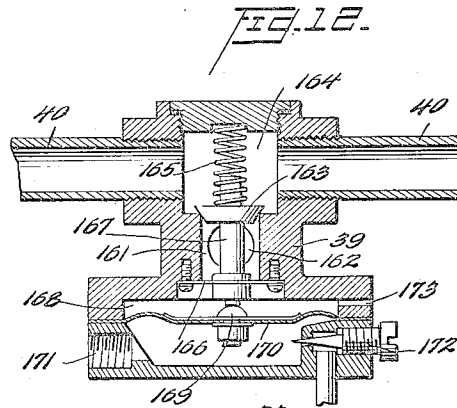
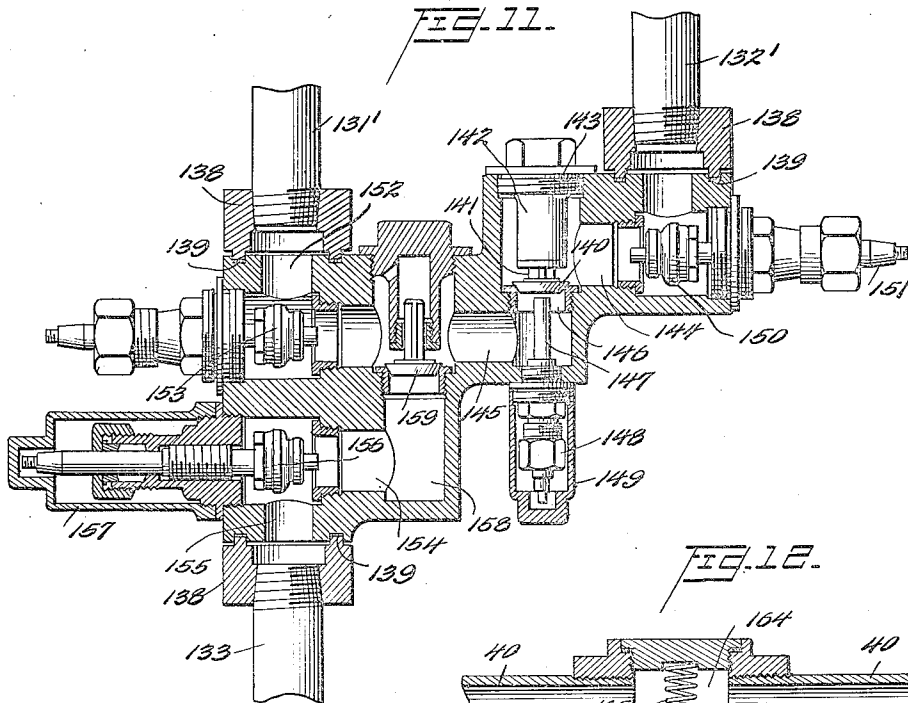
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REFRIGERATION CAR

Filed April 23, 1928

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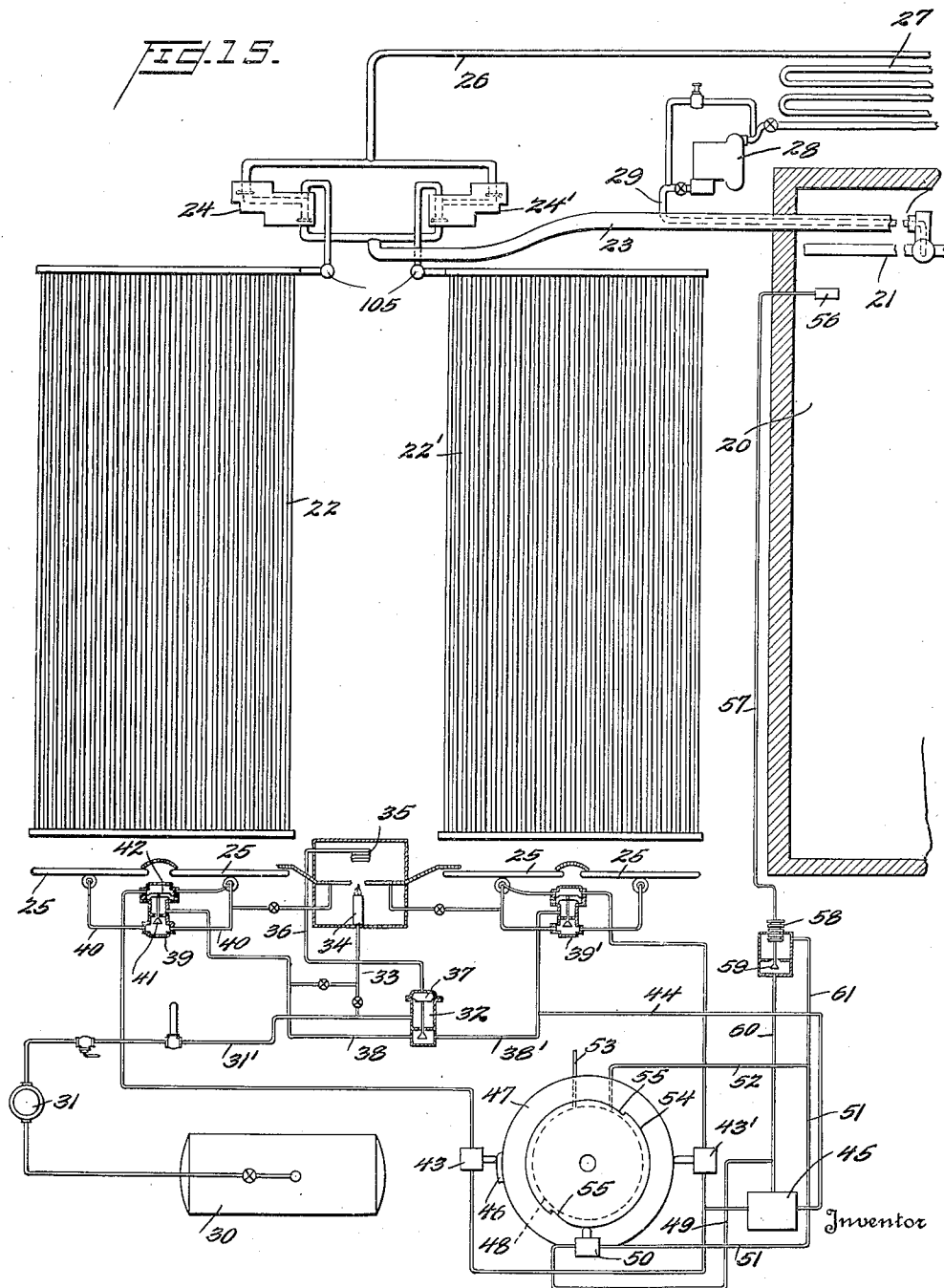
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REFRIGERATION CAR

Filed April 23, 1928

8 Sheets-Sheet 8



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UNITED STATES PATENT OFFICE

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REFRIGERATION CAR

Application filed April 23, 1928. Serial No. 272,293.

This invention relates to refrigeration apparatus and more particularly to refrigeration apparatus as applied to railway cars.

It has been the general practice when conveying perishables, such as fruits, vegetables, meats and the like, to pack them in the storage compartment of a railway car which is provided, usually at each end, with an ice bunker into which ice is loaded and if necessary salt added to maintain a low temperature. Means are usually provided to circulate air from the ice bunker over the articles to be refrigerated in an attempt to keep their temperature below the point which would cause spoilage. Considerable difficulties attend the maintenance of such a system, not the least among which are the requirements for frequent stops for icing and the inability to maintain a constant or even a desired temperature for any extended period of time. It is also difficult to maintain the desired temperature evenly throughout the load in the refrigerated compartment, and the articles at the center of the car are usually at a higher temperature than those at the ends adjacent the ice bunkers.

The present invention contemplates the provision of automatic refrigeration apparatus on board the car and occupying only about the same space as one of the usual ice bunkers. A cooling unit is arranged in the storage compartment of the car just below the roof thereof, where it will not interfere with the load and yet will be in such a position as to adsorb heat evenly from all parts of the load distributed throughout the length of the car. Thus a uniform temperature of the load can be maintained. Automatic means are provided whereby the temperature desired may be maintained within the car irrespective of atmospheric temperatures.

The various features of novelty of the present invention may be enumerated as follows:

A. The use of liquid or liquefied fuel carried by the car and below the level of the burners used in the system.

B. The use of but a small compartment at one end of the car to house the apparatus, which compartment is separated from the

refrigerated compartment by an insulating bulkhead which supports substantially all of the refrigerating apparatus.

C. The construction of the car and associated parts so as to provide the least amount of mechanical stress on the refrigerating apparatus and piping.

D. The arrangement of the adsorbers in units each supported directly from the compartment bulkhead and having an external insulating casing suitably braced and carrying the adsorber tubes.

E. The arrangement of the adsorbers so that their casings are ventilated through the roof of the car and are supplied with air from below the bottom of the car together with means for providing an even draft.

F. The arrangement of heating means in respect to the adsorbers and the draft regulating means to insure even heating.

G. The arrangement of the evaporator both as to its configuration and its position within the car so that irrespective of the incline on which the car may be, a sufficient amount of liquid surface is exposed to enable the functioning of the apparatus and yet to prevent the liquid from spilling over from the evaporator into the other parts of the apparatus due to surges of the car.

H. The arrangement of the vapor and liquid lines connected with the evaporator one within the other.

I. The arrangement of condensers on the roof of the car one on either side of the longitudinal center thereof and each sloping in accordance with the car roof slope, so that it will be self-draining.

K. The arrangement of the condenser pipes in a thin layer and the provision of shade boards above the condensers to keep out the sun without materially limiting the circulation of air.

L. The arrangement of the valves controlling the flow of vapors and liquids in a single unitary casing.

M. The arrangement of a safety valve between the high and low sides of the apparatus and bypassing the normal liquid control between the condensers and the evaporator to permit the flow of vapors into the evap-

orator in case an excess pressure is built up in the condensers.

Other and further features of novelty and objects of the invention will be more apparent to those skilled in the art after a consideration of the accompanying drawings and following specification, wherein is disclosed a single exemplary embodiment of the invention. It is to be understood 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:

15 Figure 1 is a plan view of a railway car provided with refrigeration apparatus according to the present invention, showing certain parts of the roof broken away to illustrate the adsorbers and having the shade boards removed from the condensers.

Figure 2 is a side elevation of the car showing one end of the side wall of the car broken away.

25 Figure 3 is a transverse section through the car on line 3—3 of Fig. 2, showing the refrigerating apparatus in elevation;

Figure 4 is a partial longitudinal vertical section through the car on line 4—4 of Fig. 3;

30 Figure 5 is a transverse vertical section taken on broken line 5—5 of Fig. 4, showing the two sides of the apparatus at the top sectioned in different planes;

Figure 6 is a plan view of the adsorber units with the hoods removed;

35 Figure 7 is a vertical section on line 7—7 of Fig. 6;

Figure 8 is a vertical section transverse to that of Fig. 7, taken on line 8—8 of Fig. 6;

40 Figure 9 is a side elevation of an adsorber tube spacer and support;

Figure 10 is a section on line 10—10 of Fig. 9;

Figure 11 is a section through a valve assembly unit used on one adsorber;

45 Figure 12 is a central section through an automatic burner control valve;

Figure 13 is a section on line 13—13 of Fig. 1, showing the vapor outlet and the liquid return pipes for the evaporator;

50 Figure 14 is a side elevation partly in vertical section through the motor timing unit; and

55 Figure 15 is a schematic and diagrammatic illustration of the apparatus and piping, illustrating the mode of operation.

The refrigerating apparatus of the present invention operates on the basic principle disclosed in my Patent No. 1,729,081, granted September 24, 1929, for refrigeration. It operates by the evaporation, within the compartment to be cooled, of a suitable liquid refrigerant, and the adsorption of the vapor in an adsorbent outside of the cooled compartment at such a rate that the evaporation causes a reduction in temperature of the liq-

uid. When the adsorbent is saturated, the adsorber is disconnected from the evaporator and suitably heated to drive off the adsorbed vapor, which is then condensed in a suitable condenser and returned as a liquid to the evaporator by suitable means. This closed cycle works by the mere application at suitable intervals of heat to the adsorbent.

Referring now to Fig. 15, the principle of operation may be readily understood. Within the storage compartment 20 of the car is arranged the evaporator 21 containing a suitable liquid refrigerant. Outside of the cooled compartment 20 are arranged one or more adsorbers 22, 22', each containing a quantity of a suitable adsorbent. The pipe 23 connects the compartment within the evaporator with the adsorbers through suitable check valves arranged in the valve casings 24, 24' so that vapor from the refrigerant may pass into the adsorbers and there be rapidly adsorbed, reducing the pressure in the evaporator and causing continued evaporation of the liquid therein, thus lowering the temperature in compartment 20. When one of the adsorbers becomes saturated, heat is applied as from a burner 25 and the adsorbed vapor driven off and by way of the casing 24 into the pipe 26, and thence to the condenser 27, where the vapor is cooled and condensed and returns by gravity to the trap 28, which may be suitably float controlled to allow the liquid to return, by means of the pipe 29, into the evaporator 21. The float may be arranged in such a manner as always to maintain a small quantity of liquid in the trap 28, thus preventing the possibility of vapors uncondensed in the condenser and thus still in a heated condition, flowing into the evaporator. The valve casings 24, 24' each contain two check valves, one serving to allow connection of the evaporator and the adsorber when the pressure in the evaporator is the greater, and the other at the same time shutting off the condenser pipe 26 from either the adsorber or the evaporator. This second check valve permits the connection of the adsorber and the condenser when the pressure in the adsorber is greater than that in the condenser. At the same time the pressure in the adsorber will be greater than that in the evaporator, and the first mentioned check valve will close.

It is desirable to operate the adsorbers alternately, and for this purpose means are provided for heating each adsorber individually for a sufficient period of time to drive off the adsorbed vapor and then allowing it to cool while the other adsorber is still adsorbing, and so alternating the operation. Conveniently the source of heat may be a liquid or liquefied fuel carried in a tank 30. The fuel is suitably gasified and passes through the pressure reducing valve 31 and through the pipe 31' to the safety valve 32. It may

also pass through the pipe 33 to the pilot burner 34, which has supported above it the coil 35 containing a thermo-responsive liquid. This coil is connected by the tube 36 to the compartment 37 above a diaphragm arranged in the safety valve housing in such a manner that when the liquid in the coil 35 is expanded by heat from the pilot burner, the safety valve is opened, as shown in Fig. 15, but upon accidental or intentional extinguishing of the pilot burner the contraction of the liquid causes the valve to close and shut off the flow of gas beyond the safety valve.

Gas from the lower compartment of the safety valve flows through the pipes 38, 38' to the burner valves 39, 39'. These valves are identical and but one need be described. The pipe 38, it will be seen, leads to the center compartment of the valve housing and from the bottom compartment of the housing pipes 40 lead to the two burners 25 under adsorber 22. The poppet valve 41 is arranged between the center and lower compartments and is under the control of a diaphragm 42 arranged beneath the upper compartment in the casing. Pressure in the upper compartment extends the diaphragm and allows the valve 41 to open so that gas can flow to the burner, and the release of this pressure allows the valve to close under the action of a spring or the natural resilience of the diaphragm, to thus turn off the gas to the burners.

It will be seen that in order to cause the burner to be lighted beneath either adsorber, it is only necessary to apply pressure in the upper compartment of the proper burner valve. This is done by using the gaseous fuel, which is under pressure, and supplying it to the compartment above the diaphragm in the selected burner valve. Such gas is under control of the valves 43, 43' which receive gas from the pipe line 38' by way of the pipe 44 and the strainer 45. The valves 43, 43' are opened by engagement of their plungers with the elevation 46 on the cam disk 47, and it will be seen that if the disk rotates at a constant speed, that the time of burning of any one burner is relatively short as compared with the time between burnings of the burners on the two adsorbers. Furthermore, the single elevation 46 will cause the burners of the two adsorbers to operate successively and alternately due to the 180° positioning of the valves 43, 43'.

The cam disk 47 is driven at a constant speed by means of a motor 48 which is operated by gas from the main supply tank 30. This motor receives its gas from the strainer 45 by way of the pipe 49, valve 50 and pipes 51 and 52, and this gas serves to operate the motor at a constant speed and is exhausted from the pipe 53. The valve 50 is under the control of a cam 54 driven by the motor and having the two depressions 55 in its surface

so as to cause the valve 50 to be closed when these depressions cooperate with its plunger. The arrangement is such that the closing of the valve stops the motor after each half revolution and just before the cam 46 operates to open one of the valves 43, 43'. This is in order that the time between activations may be extended if desired, particularly when low atmospheric temperatures exist, so as not to overcool the compartment 20. The motor is again started, when the temperature in the compartment 20 rises above a desired value or is above that value when the motor stops, by means of a heat responsive element 56 arranged in that compartment and connected by means of a pipe 57 to the syphon bellows 58 which controls the valve 59 which by-passes gas from the strainer 45 around the valve 50 by means of the pipes 60, 61 and 52 so that when the temperature is sufficiently high in the compartment 20, the motor is again started and after being started opens the valve 50 and provides its own supply of gas.

The motor control mechanism and valve arrangements for the fuel supply are more completely described and are claimed in the co-pending application of George E. Hulse, Serial No. 270,488, filed April 16, 1928, for heater control systems.

A practical form of the apparatus is shown in the first fourteen figures of the drawings. In Figs. 1 and 2 is shown a car which may be more or less of the conventional refrigeration type, requiring, however, but a single compartment 62 at one end thereof for the refrigeration apparatus instead of the two usual ice bunkers. This compartment need be no larger than one ice bunker. Within the compartment 20 provided for storage purposes and adjacent the inner insulating roof or ceiling thereof is arranged the evaporator 21, best shown in Figs. 1, 2, 4 and 5. It comprises a central tubular header 63 arranged transversely near the center of the compartment 20 and having extending from the front and rear thereof a plurality of parallel tubes 64 closed at their outer ends as at 65 and suitably supported from the car ceiling by means of hangers such as 66 which also space the tubes properly. If desired, drip troughs, not shown, may be arranged beneath the tubes to collect any condensation and drain it away. The header 63 is arranged at the center of the car in order to insure better distribution of the liquid refrigerant, which is contained in the tubes and is normally of such a quantity as to fill the tubes approximately half full. In this way, if the car is on a steep incline, the liquid will all run down into the tubes at one end of the car and will not overflow from the vapor outlet, which is best shown in Fig. 13 and comprises the vertical pipe 67 leading up from the header 63 and connecting to the horizon-

tal pipe 23 shown in Fig. 15 as leading to the valve assemblies. This pipe 23 is arranged between the ceiling 68 of the car and the roof 69 thereof, and extends substantially parallel to the tubes of the evaporator. The vertical portion 67 is of sufficient height to prevent splashing of the liquid resulting from surges, so that no liquid is carried over into the pipe 23. The pipe 29 which delivers liquid from the condensate trap 28 to the evaporator to maintain the quantity therein substantially constant, is coaxial with the pipe 23, as best shown in Figs. 4 and 5, and preferably has the vertical section 70 within the part 67 which may dip below the liquid level in the header 63. The composite pipe 23, 29 may have the insulating covering 23', as shown.

The condenser 27 is arranged on the roof of the car, where it will be exposed to the air rushing by the car when in transit. It is preferably divided into two sections 71, 71', one on either side of the longitudinal center of the car. As shown in Fig. 5, the roof of the car comprises two substantial planes sloping down on each side of the longitudinal center thereof. Each condenser section comprises a plurality of parallel tubes 72 arranged preferably in a single layer parallel to the plane of that part of the roof over which it is positioned and extending longitudinally of the car. The ends of adjacent tubes are connected together by the U-shaped portions 73 so that each condenser section is arranged with all the tubes thereof in series, although they may be arranged in suitable parallel groups. The inlet to each condenser section is on the high or inner side thereof at the end adjacent the compartment containing the refrigeration apparatus. The two inlets 74 are connected by the pipe 75 to a single pipe 76. Suitable outlet pipes 77 lead from the low or outer side of each condenser at the ends adjacent the compartment 62. It will be seen that by having the inlet at the top or inner side and the outlet at the low side, that the condensers are self-draining and that the uppermost portion is always the hottest, thus giving the most efficient action.

Since the car may stand for long periods exposed to the sun or may be so exposed during runs in latitudes where the sun's heat is quite large, provision is made to insure adequate condensation even under these conditions. This comprises the shade boards arranged above each section of the condenser. They are best shown in Fig. 5 and comprise the longitudinally arranged slats 78 spaced apart as shown at 79 and supported on suitable transverse bridge members 80 carried by the roof of the car. These slats or shade boards are spaced above the condenser tubes to allow an adequate circulation of air, and are spaced apart as at 79 for the same purpose. Each board preferably covers a plu-

rality of tubes, which are quite close together, so that no matter what the angle of the sun, most of the tubes will be protected without unduly cutting off the supply of cooling air. The condensers being on either side of the car will allow adequate room for the runway 81 along the top of the car for the use of the brakemen. The shade boards prevent any accidental damage to the condenser tubes in case the brakemen should step off the runway.

The car is constructed, in the particular instance shown, with a large center girder 82 upon which is supported the transverse channel beam 83. The girder carries the insulating bottom and flooring 84 of the compartment 20, and the beam 83 comprises means for attaching the insulating bulkhead 85 forming the end of the storage compartment 20 and preferably including the metal sheet 86 running from the girder along the face of the beam 83 and reaching to the roof purlin 86'. The bulkhead is quite rigid by virtue of the multiple layers of insulating material and general laminated structure. Near the top it is provided with the transverse angle bar 87 securely attached thereto. The compartment 62 at the end of the car for the refrigerating apparatus need not be insulated and preferably is entirely open at the bottom on the two sides of the center girder. The top is closed, however, by the usual car roof, but there is no ceiling in the compartment as in the storage compartment. The outer end wall of the compartment is preferably formed of metal, as shown in Fig. 4 where the metal sheets 88 form a large portion of it, the remainder being formed by doors, not shown, which close the apertures between the plates and allow access to be had to the interior.

This end compartment is largely occupied by the two adsorbers, as seen in Figs. 4 and 5. Each adsorber unit is arranged within a rectangular tubular casing 89. These casings are identical, and description of one will suffice for both. The tubular casings are open at top and bottom and are each composed of four heavy sheets 90 of heat insulating and heat resisting material, such as asbestos board or the like. Each sheet is bound by suitable metal angle bars such as 90' on both the vertical and horizontal edges. As seen in Fig. 3, the sheets forming the outermost walls of the adsorber casings are each reinforced by diagonal angle bars 91 secured at the corners to suitable gusset plates 92 connected to the corner binding angles 90'. Vertical reinforcements 93 are provided connected to the diagonals by means of the plates 94 and to the top and bottom angles. The side members of each casing are best shown in Fig. 2, and are reinforced by the two diagonals 95 connected to the gusset plates 96 at top and bottom and to the tie plate 97 and the horizontal reinforcer 98 at the center.

The careful bracing of the walls of the casing is provided, since each casing carries all of the load of its adsorber from the bulkhead. The rear walls of the casings are adequately reinforced and provided with the transverse angle bar members 99 at the top which rest on the angle bar member 87 secured to the bulkhead. Suitable bolts through the meeting flanges of these angles serve to resist the tendency of the casings to fall away from the bulkhead. The main load of the casings is carried by the transverse angle bar 100 secured near the bottoms thereof and resting on the upper flange of the beam 83. By having the casings supported only from the bulkhead, motions of the car body are not transmitted to the casings and the adsorbers are free from weaving or other tendencies to open joints.

Within each adsorber casing is arranged a group of substantially vertical adsorber tubes 101, best shown in Figs. 4 to 8. The tubes are of suitable drawn metal and are seamless, and each is filled with some adsorbent, such as silica gel. The tubes are arranged in parallel rows, each tube of a row being secured to and in communication with a top sub-header 102 and a bottom connecting tube 103. The bottom tubes 103 are slightly less in length than the longest dimension of the inside of the casing, as shown in Fig. 7, and are closed at the ends. The sub-headers 102, of which there is one for each row of tubes, as shown in Fig. 6, are longer than the longest interior dimension of the casing, so that they may be supported from the upper edges of the end walls thereof. The outer ends 104 of these tubes are closed, and the inner ends communicate with the main headers 105, as seen in Figs. 6 and 7.

Referring to Figs. 9 and 10, the manner of supporting and spacing the sub-headers 102 will be seen. Each sub-header fits in a hole 106 formed as the result of combining two semi-circular channels in the block parts 107 and 108 of the combined spacing and supporting units 109. The parts 107 and 108 are preferably of some heat resisting material, and are clamped together by means of the vertical bolts 110, and thus secured to the strap 111 which has the feet 112 suitably secured to the reinforcing members of the upper edge of the casing by bolts, as seen at 113 in Fig. 6. The supporting units 109 at either end of the sub-headers support these ends, but the considerable weight intermediate the ends of the sub-headers requires intermediate supporting means, such as clearly shown at 114 in Figs. 6, 7 and 8. These intermediate spacers and supports may comprise straps of metal split longitudinally and provided with semi-circular grooves to combine and form circular openings for the reception of the sub-header tubes when the two parts of the strap are clamped around

the sub-headers. The ends of these intermediate supports rest on the top edges of the casing walls and may be fastened down to the casing by means of the U-shaped clips 115 straddling the supports and bolted as at 116 to the reinforcing members on the upper edges of the casing walls.

The bottom connecting tubes 103 are suitably secured together and properly spaced by means of several bottom spacer members 117 similar to the intermediate supporting members 114. The two parts of the spacers 117 are clamped together by U-bolts 118, as are intermediate portions of the upper members 114. The lower portion of each bottom spacer 117 is provided with the depending lug 119, and this lug is connected by means of the link 120 to one of the side walls of the casing. The connections at the ends of the link or sway bar 120 are pivot bolts 121. The sway bars effectually prevent any swinging of the bottoms of the adsorber tubes under the motion of the train, but at the same time, due to their pivoted connections, allow longitudinal expansion of these tubes resulting from changes in temperature, and form an important feature of the invention.

Referring to Figs. 4 and 5, it will be seen that the top of each casing is provided with a frusto-pyramidal hood 122 suitably secured to the upper edges thereof and having a tubular portion 123 extending upwardly therefrom and through the roof of the car to the ventilating cap 124 provided with suitable louvres 125 for the outward passage of air so arranged, however, that fore or aft movement of the car will not force air down into the casings. It will be seen from Figs. 4 and 5 that the louvres are only in the sides of the cap and that suitable baffles 126 serve to keep out rain and down drafts. These composite ventilators provide means for the escape of the heat used for activating the adsorbers and to assist in the natural draft which cools the adsorbers after the activation.

Air is admitted to the bottom of each adsorber casing through a suitable tube 127 secured thereto and having the flaring bottom funnel 128 reaching substantially down to the level of the bottom of the center girder 82. Within the tube 127 is arranged a series of vertical plates 129 at right angles to each other, forming cells 130 open top and bottom like the well-known egg crate fillers, which serve to control the air entering the casing from the bottom to prevent swirling and irregular movement of the same resulting from movement of the car. They tend to cause the air to flow in substantially straight lines vertically through the casing, in order that it may come in contact equally with all of the adsorber tubes.

Referring now to Figs. 3 and 4, the piping arrangement of the refrigerating apparatus

may be seen. The main headers 105 from the adsorbers are each connected to a pipe 131, 131' which leads to a composite valve casing shown in Fig. 15 as 24, 24'. The condensate inlet pipe 76 branches, as shown in Fig. 3, into the parts 132, 132', each of which leads to one of the casings 24, 24'. A pipe 133 serves to connect the two valve casings together and from the center of this the pipe 23 leads upwardly by a sinuous path to the evaporator header. The condensate delivery pipe 29 enters the vapor pipe 23 at its junction with the pipe 133. The condensate return pipes 77 combine in the horizontal pipe 77', as previously mentioned, which joins with the pipe 77² leading into the condensate trap 28. This trap may be a conventional steam trap having a float controlled valve which opens to allow the draining of liquid from the bottom of the trap when a suitable quantity is collected therein, but prevents any vapor passing through by the dropping of the float and consequent closure of the valve when the quantity of liquid in the trap is sufficiently reduced. The pipe 29 which leads the condensate back to the evaporator emerges from the bottom of this trap 28, which may be provided with the gauge glass 135.

It may sometimes be found that the condensers are unable to completely liquefy the vapors as rapidly as they are supplied from the activating adsorber, and an unusual pressure may be built up therein. If this condition exists, the pressure will be transmitted to the pipe 77' and to the safety valve 136, which will blow off for protection. It does not exhaust to atmosphere, however, in order to save the refrigerant. Its outlet is through the pipe 137 which leads into the pipe 29, normally conducting liquid back to the evaporator. This will allow vapors to pass into the evaporator 64 which is at a reduced pressure, and will absorb large quantities of the vapor with sufficient rapidity to prevent the pressure building up dangerously in the condensers. The safety valve is, of course, spring controlled and may be adjusted to the desired blow-off pressure.

The valve assemblies 24 and 24' are identical and are used in reverse position, as best shown in Fig. 3. Fig. 11 indicates in cross section one of these assemblies from which it will be noted that the casing comprises a unitary casting provided with means for attaching the various pipes 131', 132' and 133. Any suitable type of joint may be used, but here unions such as 138 are shown secured to the pipe ends and suitably pressed, by any desirable means, against packing in grooves such as 139 in the outer surface of the casing surrounding the passages entering the same. The interior of the casing comprises a series of communicating compartments each

formed by intersecting drilled or cored passages.

The check valve, generally indicated by the reference character 140, allows the passage of vapors from within the compartments of the casing out through the pipe 132', but prevents reverse flow. It will be seen that this valve is of the conventional poppet type, the stem 141 being on the upper side of the valve proper and being guided in the boss 142 on the plug 143 which closes the opening through which the valve itself is inserted into the casing. This valve is effective between the horizontal passage 144 and the horizontal passage 145 which overlap and communicate by means of the vertical passage 146 in which the valve seat is arranged. It may be necessary or desirable at times to maintain this check valve off of its seat or to lift it from its seat against pressure or against sticking, without opening the compartment, and for this purpose a stem 147 is arranged beneath the valve and passing through a bushing in the wall of the casing. It may be provided with suitable packing compressed by the packing nut 148. The end of the stem is arranged to cooperate with a suitable tool for rotating the same whereby under the action of its threads, not shown, it may be pressed against the under surface of the valve. A suitable cap 149 may be provided to normally fit over the stem and the packing nut to protect the same and to further insure gas tightness.

It may at times be desired to isolate the condenser and for this purpose a cutoff valve 150 may be provided between the check valve 140 and the outlet to which the pipe 132' is connected. This valve may be of any conventional construction and be housed in the horizontal passage 144 with its operating stem 151 projecting outwardly through the end of the casing as shown. It may be provided with the conventional packing and packing nut.

The horizontal passage 145 intersects the vertical passage 152 which communicates with the pipe 131' and at the junction of these two passages is the cutoff valve 153 of the same type as that disclosed at 150 and intended to be used for a similar purpose.

At the intersection of the horizontal passage 154 and the vertical passage 155 leading to the pipe 133, is the third cutoff valve 156 of a construction similar to 150 and 153 and intended to be used when it is desired to isolate the evaporator. At 157 is shown a cap which may fit over the external portion of the valve 156 to enclose the same and protect it against injury and to further insure against leakage which may happen around the packing. Such a cap is intended also to be used over the valves 150 and 153.

Intersecting the horizontal passages 145 and 154 is the communicating vertical pas-

sage 158 and at the junction of this passage with the passage 145 is the check valve 159 identical in construction with that previously described except that it does not have the lifting stem. While this valve and its guide project down into the horizontal passage 145 they do not shut off communication between the passage 152 and the passage 144. The valve 159 only controls flow from the passage 152 to the passage 155, preventing flow in that direction and permitting it in the opposite. It will be seen that the whole valve assembly is extremely simple and is all housed in a single casing provided with the necessary passages and outlets. Furthermore, each valve and its seat is separately replaceable if necessary.

In Fig. 12 is shown in detail one of the valves 39, 39' which is gas operated to control the flow to the burners. Its position is inverted from that shown in Fig. 15. The incoming gas enters the center compartment 161 from the port 162 and when the poppet valve 163 is lifted from its seat flows into the upper compartment 164 and thence to the pipes 40 leading to the burners. The valve is retained against its seat by means of the spring 165 in the compartment 164. At the lower end of the compartment 161 is the diaphragm 166 closing that end of the compartment and yet allowing the valve stem 167 to pass into the compartment 168 and there engage with the center button 169 on the flexible diaphragm 170, which is larger in diameter than the diaphragm 166. The compartment beneath this diaphragm 170 is adapted to be supplied with gas through the port 171 from one of the valves 43, 43' and when gas under pressure is in this compartment the diaphragm 170 is flexed and through its action the valve 163 is lifted from its seat. The needle valve 172 controls the bleed from the compartment below the diaphragm 170. The compartment 168 is in communication with the atmosphere through the port 173 so as not to interfere with the action of the diaphragm 170.

The gas operated motor 55 which regulates the flow of gas to the burners is more completely shown, described and claimed in the co-pending application of George E. Hulse, for heater control systems, Serial No. 270,488, filed April 16, 1928, but in Fig. 14 is shown a simple form of the same. It comprises a gas chamber 174 closed at the upper end by the flexible diaphragm 175. Gas is adapted to be admitted to the compartment through the port 176 controlled by the valve 177 and exhaust is effected through the port 178 controlled by the valve 179. The valves 177 and 179 are on the rigid rocker 180 pivoted at 180' and provided with a suitable snap action mechanism. This rocker is adapted to be shifted to open one valve and close the other by the movement of the diaphragm post 181

as the diaphragm raises and lowers under the action of the incoming and exhausting gas. Motion from the diaphragm post is transmitted to the bell crank lever 182 and thence by means of the link 183 and pawl 184 to the ratchet wheel 185 and attached pinion which drives the main gear 186 mounted on the central shaft 187, which carries the cam plate 48 previously referred to having on its under surface the cams 46 and 54.

Supported from the compartment casing 174 is a valve assembly. Only those valves controlled by the cam 46 are shown, but that controlled by the cam 54 is similar in construction. The valves 43 and 43' are identical in construction so but one will be described. A compartment 188 is adapted to receive gas by means of the pipe 189 from the reservoir 30. This compartment has an outlet port 190 controlled by a valve pad 191 carried on the pivoted lever 192 supporting at its opposite end the holder for the cam follower 193 adapted to cooperate with the cam 46 to lift the pad 191 from the port 190 against the action of the spring 194. The valve pad and its rocker are in the chamber 195 and the cam follower holder may pass through a suitable stuffing box, as shown, or a diaphragm may be used to make a gas tight fit with the upper wall of the compartment, as in the case of the valve 39. From the compartment 195 the pipe 196 leads off to the port 171 in the valve shown in Fig. 12. It will be understood that the valve corresponding to 50 in Fig. 15 will be interposed in the gas line leading to the inlet port 176 of the motor and upon the release of this valve by the cam 54 the motor will be stopped.

The gas motor just described and its associated parts are preferably housed in the metal chest 197, best shown in Figs. 3 and 4, and mounted just inside of the doors of the adsorber compartment and beneath the condensate trap 28.

The burners for heating the adsorbers to cause activation are best seen in Figs. 3, 4 and 5, and may be of more or less conventional type comprising the burner heads 198 of which conveniently two are arranged in each casing and the supply and mixing tubes 199 attached thereto in any suitable manner. The two burners in each casing may best be supported by a transverse channel bar 200 hung at its ends as seen in Fig. 5 from suitable lugs 201 attached to the reinforcing angles at the lower edges of the casing sheets. The burners are prevented from tipping about the axis of this bar by having their mixing tubes 199 pass through suitable apertures 202 in the front wall of the casing. The flared ends 203 of these mixing tubes provide for the air control and the gas jets 204 enter into the center of these funneled ends as is customary.

The various parts shown and described in this specification are to be understood as il-

illustrative only and not to be construed in a limiting sense except in accordance with the scope of the appended claims.

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

1. In a railway refrigeration car, in combination, a storage compartment, an apparatus compartment adjacent thereto, a bulkhead transverse to the car and separating said compartments apparatus for cooling said storage compartment including an adsorber unit, said unit being self-contained and wholly supported from the said bulkhead.

2. In a railway refrigerator car, the combination with a storage compartment having a roof and an end wall, of refrigeration apparatus including an evaporator supported from said roof and an adsorber unit supported from and outside of said end wall.

3. In a railway refrigerator car, in combination, a storage compartment having a roof and an end wall, refrigeration apparatus including an evaporator supported beneath said roof, an adsorber unit supported from and outside of said end wall, and a condenser supported by said roof and outside thereof.

4. In a refrigeration device of the adsorption type, in combination, an adsorber unit comprising an open ended tube of heat insulating material, bracing means for the walls thereof, hangers on one wall to support said casing from a vertical support and adsorbent receptacles carried by said tube.

5. In a refrigeration device of the adsorption type, in combination, an adsorber unit casing comprising a tube formed of flat sheets of heat insulating material, means joining and reinforcing the corners of said tube, means reinforcing the upper edges of said sheets and supports for adsorber tubes secured to said edge reinforcing means.

6. An adsorber assembly for refrigeration devices including in combination, a tubular outer casing, means to support said casing, adsorbent containing tubes extending longitudinally of said casing, sub-header tubes secured to the tops of said adsorbent containing tubes and extending transversely of said casing, said sub-header tubes being supported from opposite edges of said casing.

7. An adsorber assembly for refrigeration devices including in combination, a tubular outer casing, means to support said casing, groups of adsorbent containing tubes extending longitudinally of said casing, a sub-header secured to the tops of each group of said tubes and extending transversely of said casing, said sub-headers extending over and beyond the edges of said casing and being secured thereto.

8. An adsorber assembly for refrigeration devices including in combination, a tubular outer casing, a plurality of adsorbent containing tubes extending longitudinally of

said casing and arranged in transverse rows, top and bottom sub-headers connecting the tubes of each row, said top sub-headers extending over the edges of said casing and being secured thereto.

9. An adsorber assembly for refrigeration devices including in combination, a tubular outer casing, a plurality of adsorbent containing tubes extending longitudinally of said casing and arranged in transverse rows, top and bottom sub-headers connecting the tubes of each row, said top sub-headers extending over the edges of said casing and being secured thereto, said bottom headers being above the tube bottom, and means to prevent swaying of the bottom headers.

10. An adsorber assembly for refrigeration devices including in combination, an outer casing open top and bottom, a plurality of adsorbent containing tubes extending vertically in said casing and arranged in transverse rows, a plurality of top sub-headers one connected to the upper ends of the tubes of each row, said sub-headers extending over the edges of said casing at their ends, combined spacing and supporting means on said edges for the ends of said sub-headers, a plurality of bottom sub-headers above the lower end of said casing, one for each row of tubes, a spacing member secured to said bottom sub-headers and a sway bar secured to said spacing member and to a wall of said casing.

11. An adsorber assembly for refrigeration devices including in combination, an outer casing open top and bottom, a plurality of adsorbent containing tubes extending vertically in said casing and arranged in transverse rows, a plurality of top sub-headers one connected to the upper ends of the tubes of each row, said sub-headers extending over the edges of said casing at their ends, combined spacing and supporting means on said edges for the ends of said sub-headers, a plurality of bottom sub-headers above the lower end of said casing, one for each row of tubes, a spacing member secured to said bottom sub-headers, and means pivoted to said spacing member and to said casing to prevent swaying of said tubes but permitting expansion and contraction thereof.

12. In a railway car for refrigeration purposes, in combination, a vertical casing supported between the roof and floor of said car, adsorbent containing tubes in said casing, a ventilator attached to the upper end of said casing and passing through said roof, an air intake secured to the lower end of said casing and passing below the level of said floor and air directing means in said intake.

13. In a railway car for refrigeration purposes, in combination, a vertical casing supported between the roof and floor of said car, adsorbent containing tubes in said casing, a ventilator attached to the upper end of said casing and passing through said roof, an air

intake secured to the lower end of said casing and passing below the level of said floor and means in said air intake to evenly distribute the air throughout the cross-section of said casing and to cause the same to move in substantially straight lines through the casing.

14. In a railway car for refrigeration purposes, in combination, a vertical casing supported between the roof and floor of said car, adsorbent containing tubes in said casing, a ventilator attached to the upper end of said casing and passing through said roof, an air intake secured to the lower end of said casing and passing below the level of said floor, air directing means in said intake and heat supplying means between the bottoms of said tubes and said air directing means.

15. In a railway car for refrigeration purposes, in combination, a vertical casing supported between the roof and floor of said car, adsorbent containing tubes in said casing, a ventilator attached to the upper end of said casing and passing through said roof, an air intake secured to the lower end of said casing and passing below the level of said floor, air directing means in said intake, and a fluid fuel burner arranged above said air directing means and supported by said casing.

16. In an evaporator for adsorption refrigeration systems for railway cars, in combination, a central horizontal header extending transversely of the car in the storage compartment thereof and a plurality of horizontal tubes extending from said header toward the ends of said storage compartment.

17. In an evaporator for adsorption refrigeration systems for railway cars, in combination, a central horizontal header extending transversely of the car in the storage compartment thereof, a plurality of horizontal tubes extending from said header toward each end of said car and a pipe communicating with said header and extending through the upper wall of said storage compartment.

18. In an evaporator for adsorption refrigeration systems for railway cars, in combination, a horizontal header arranged transversely of the storage compartment of said car, a plurality of horizontal tubes extending from said header toward each end of said car, a pipe in communication with said header and directed upwardly therefrom, a continuation of said pipe extending substantially parallel to said horizontal tubes, a liquid in said header and tubes, said upwardly directed pipe being of such height as to prevent the flow of liquid into said continuation on the steepest grade encountered by the car.

19. In a railway car, in combination, a cooled storage compartment, an evaporator therein, an adsorber outside of said compartment and a condenser on the roof of said car, piping connecting said evaporator, said adsorber and said condenser into a system, a re-

frigerant in said system normally under pressure, and a purge valve in said condenser.

20. In a railway refrigeration car, in combination, a condenser unit supported above the roof of said car and comprising a plurality of spaced longitudinally arranged cooling tubes spread out in a thin layer over a large area of said roof and a plurality of spaced, longitudinally arranged shade boards each above a plurality of said tubes.

21. In an adsorption refrigeration system, in combination, an adsorber, a condenser and an evaporator connected by piping into an operative system, a liquefiable refrigerant in said system, said condenser being adapted to liquefy said refrigerant, said evaporator having a lower pressure than said condenser, means controlled by the quantity of condensed refrigerant to regulate its delivery to said evaporator, a bypass around said means and a pressure controlled valve in said bypass.

22. In an adsorption refrigeration system, in combination, an adsorber, a condenser, means to conduct refrigerant vapor from said adsorber to said condenser, an evaporator, means to conduct refrigerant from said condenser to said evaporator, means to normally permit only liquid refrigerant to pass from said condenser to said evaporator and means to permit refrigerant vapor to pass from said condenser to said evaporator when the pressure in said condenser exceeds a predetermined limit.

23. In an adsorption refrigeration system, in combination, an adsorber, a condenser, means to conduct refrigerant vapor from said adsorber to said condenser, an evaporator, means to conduct refrigerant from said condenser to said evaporator, a trap in said last mentioned means to permit only the flow of liquid and a bypass around said trap to permit the flow of vapor when the pressure thereof exceeds a predetermined value.

24. In an adsorption refrigeration system for a railway car, in combination, an evaporator in the top of the storage compartment of said car, an adsorber outside of said storage compartment, a condenser on the roof of said car, a pipe from said adsorber leading to said condenser, a condensate receiving trap, a pipe from said condenser to said trap, a pipe from said trap to said evaporator and a pipe surrounding said last mentioned pipe and extending from the evaporator to the adsorber.

25. In a multiple valve assembly for adsorption, refrigeration apparatus having an adsorber, an evaporator and a condenser, the combination of a unitary hollow casing, a connection from each of the mentioned refrigeration units to said casing, and a manually operable valve in said casing for each of said connections each adapted to isolate

the unit with which it is associated from the other connections.

26. In a valve structure for an adsorption refrigeration system, in combination, a casing having a central compartment and three passages leading from said compartment to outlets, a manually controlled valve in each passage and a check valve in one of said passages in series with the manually controlled valve therein.

27. In a valve structure for an adsorption refrigeration system, in combination, a casing having a central compartment and three passages leading from said compartment to outlets, a manually controlled valve in each passage, a check valve in one of said passages in series with the manually controlled valve therein to prevent flow from said compartment and a check valve in another passage in series with the manually controlled valve therein to prevent flow into said compartment.

28. A railway refrigeration car having a storage compartment provided with a roof and an end wall, an evaporator supported from said roof and in said compartment, a condenser supported above and by said roof, and cold producing apparatus entirely supported from said end wall outside of said compartment.

29. In a refrigeration car, in combination, a cooled storage compartment occupying substantially the full length of the car, a small compartment at one end of said car separated from said storage compartment by an insulating bulkhead, cold producing apparatus in said compartment and means to gain access to said apparatus from the end of said car.

30. In a refrigeration car, in combination, refrigeration apparatus requiring heat for operation, a burner adapted to supply heat at controlled intervals to said apparatus, means to control the intervals and a source of fluid fuel for said burner.

31. In a refrigeration car, in combination, a storage compartment, a cooling unit therein, means to cool said unit including a plurality of adsorber units, fuel burner for each adsorber unit, a source of fluid fuel carried by said car and means to supply said fuel successively to the said burners.

32. An adsorber assembly for refrigeration devices including, in combination, a tubular outer casing, a plurality of adsorbent containing tubes extending longitudinally of said casing and arranged in transverse rows, a top sub-header connecting the tubes of each row, said sub-headers being supported by the casing, means joining the lower ends of the tubes of each row and means to prevent swaying thereof.

33. In a railway refrigeration car, in combination, a storage compartment having a roof, a floor, and a substantially vertical en-

closing wall, refrigeration apparatus including an evaporator in said compartment, and an adsorber unit supported from and outside of said wall.

In testimony whereof I hereunto affix my signature.

ERNEST B. MILLER.

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