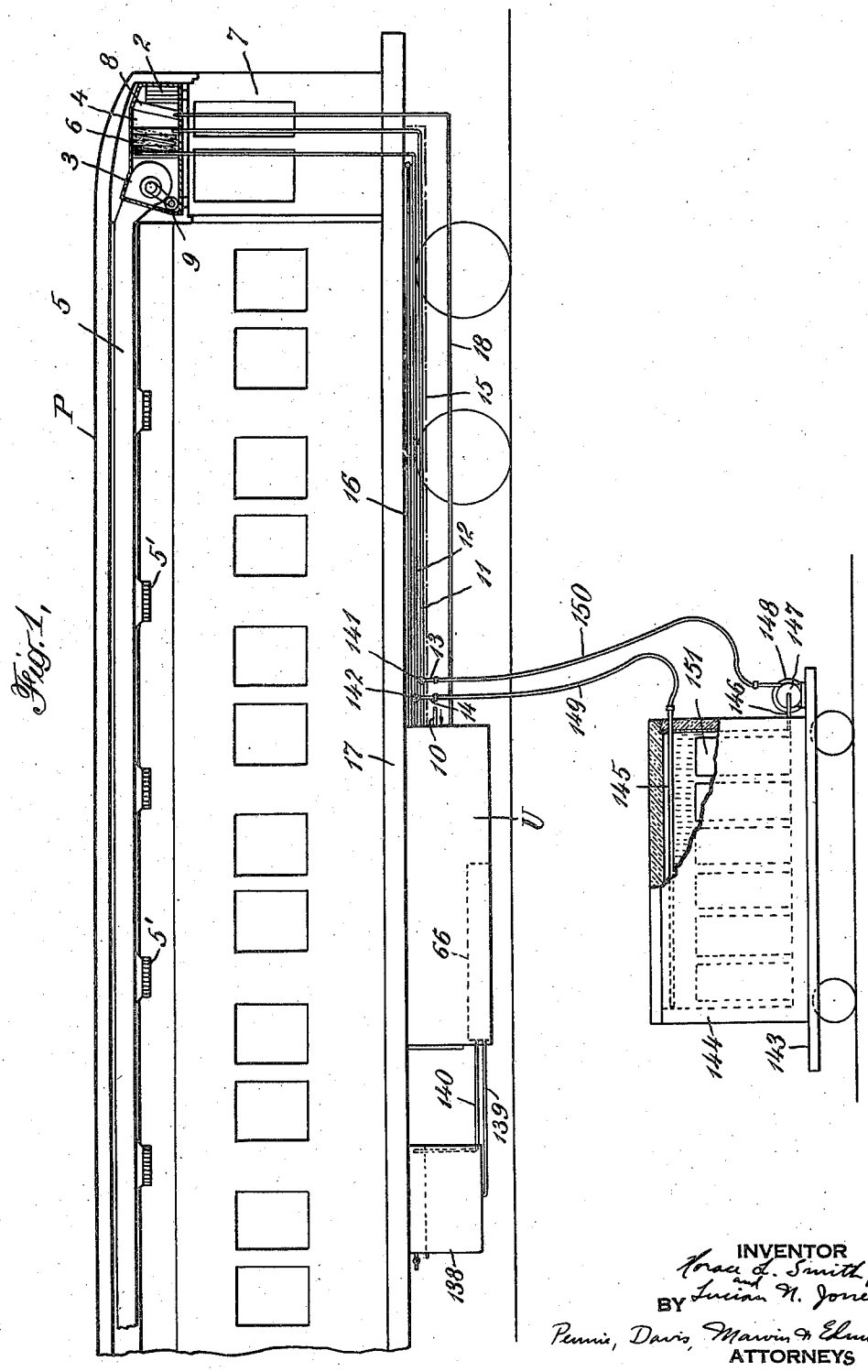
March 22, 1938. H. L. SMITH, JR., ET AL 2,111,905

RAILWAY CAR AIR CONDITIONING SYSTEM

Filed Feb. 8, 1935 5 Sheets-Sheet 1



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RAILWAY CAR AIR CONDITIONING SYSTEM

Filed Feb. 8, 1935 5 Sheets-Sheet 2

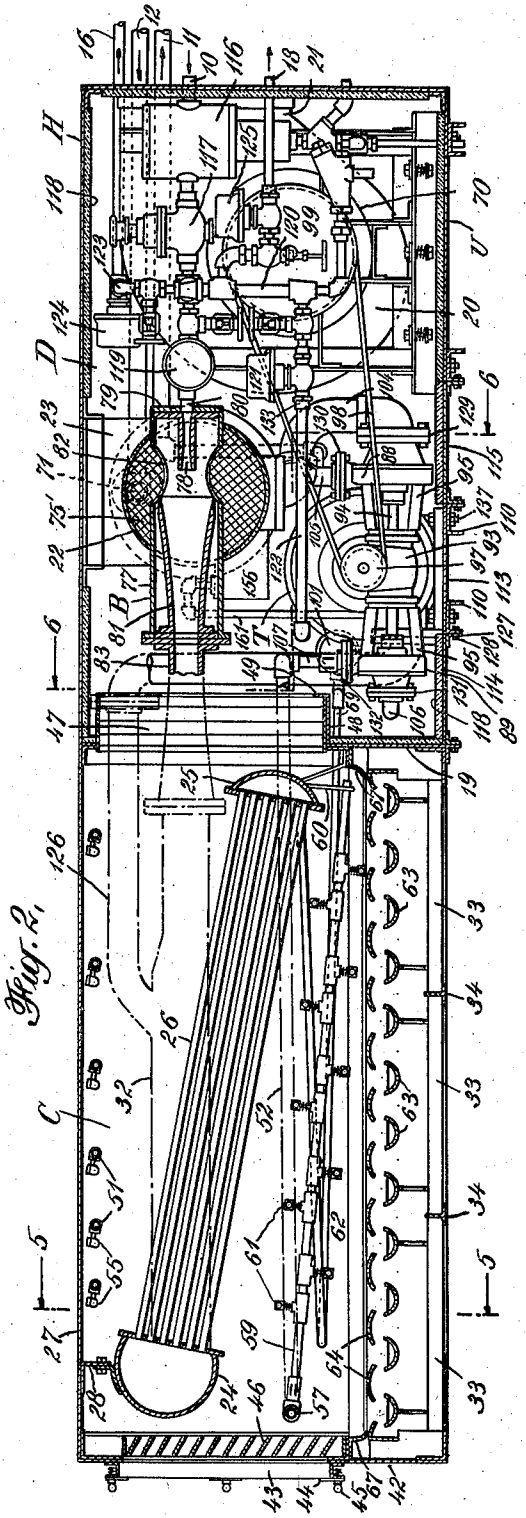


Fig. 2.

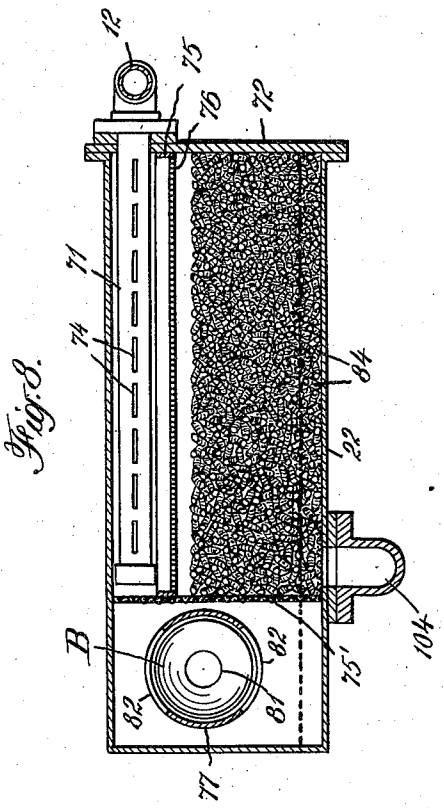


Fig. 8.

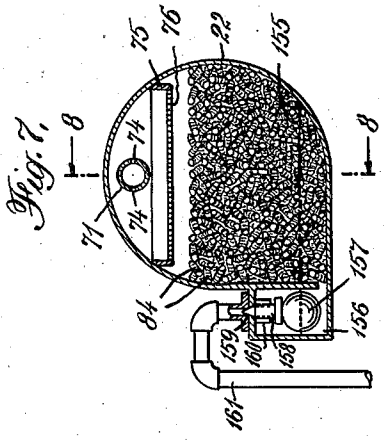


Fig. 7.

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RAILWAY CAR AIR CONDITIONING SYSTEM

Filed Feb. 8, 1935 5 Sheets-Sheet 3

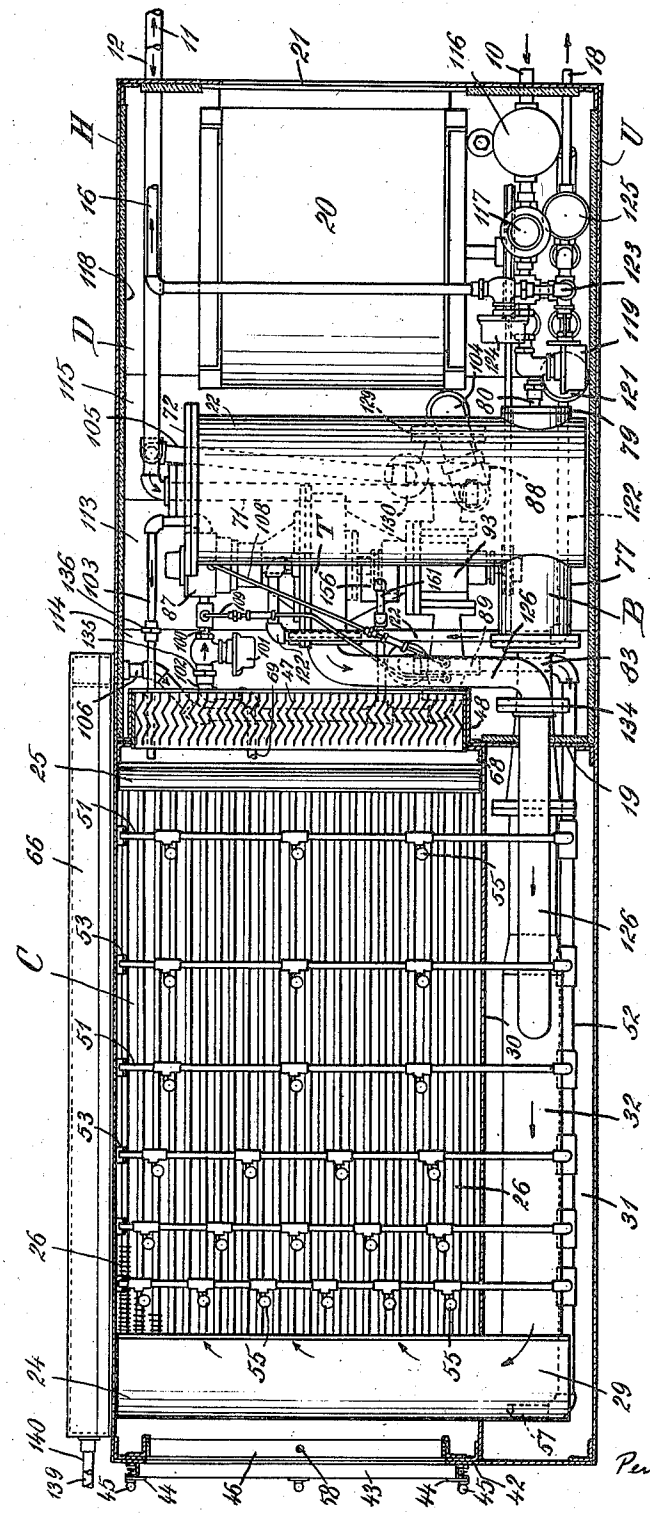


Fig. 3,

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RAILWAY CAR AIR CONDITIONING SYSTEM

Filed Feb. 8, 1935 5 Sheets-Sheet 4

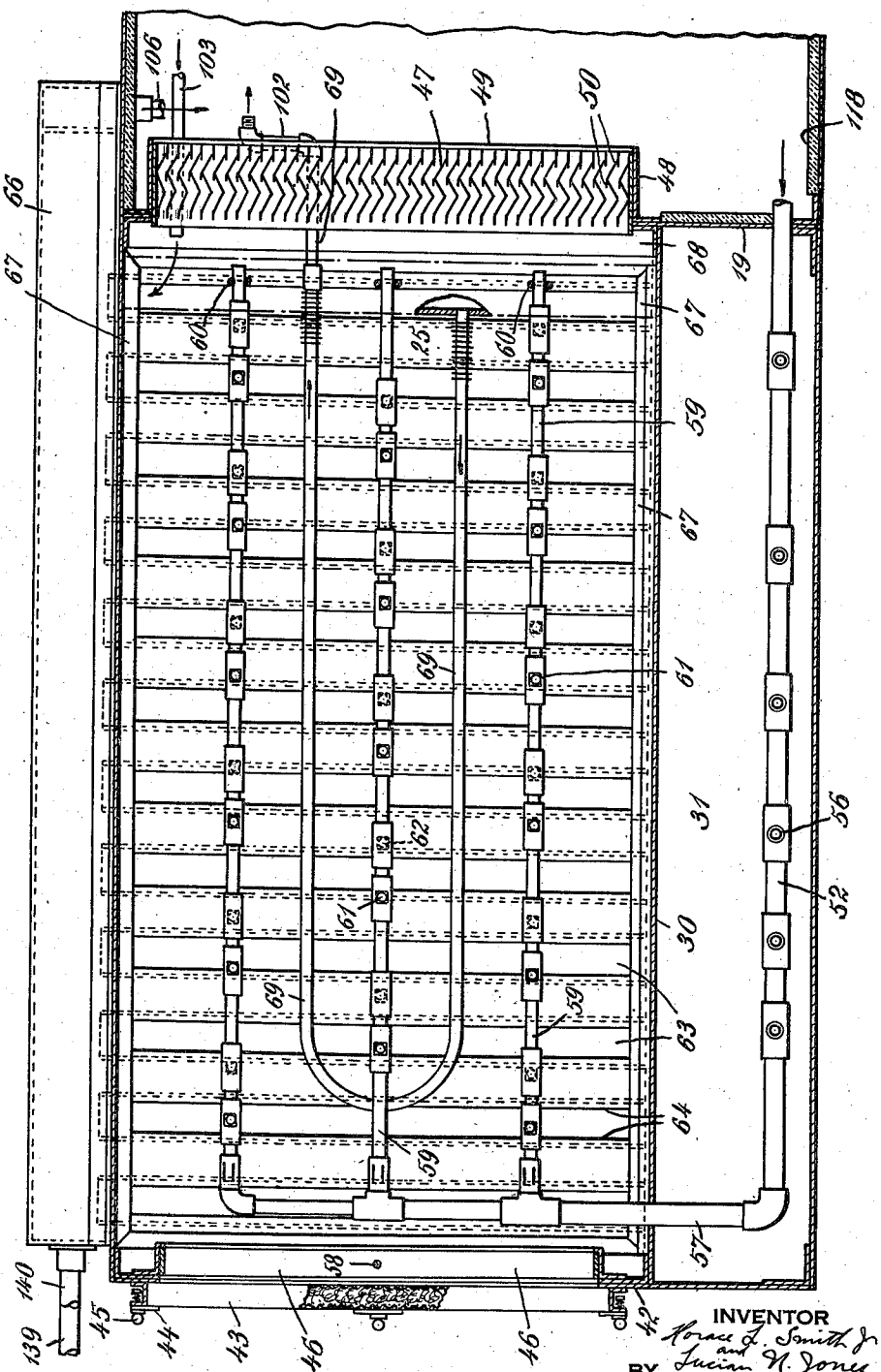


Fig. 4.

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RAILWAY CAR AIR CONDITIONING SYSTEM

Filed Feb. 8, 1935 5 Sheets-Sheet 5

Fig. 5,

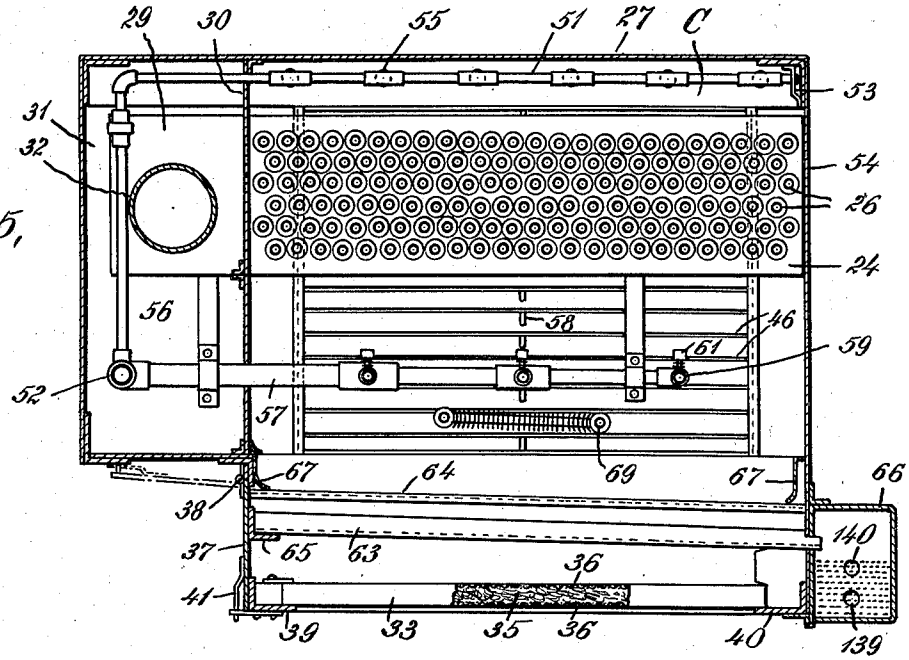
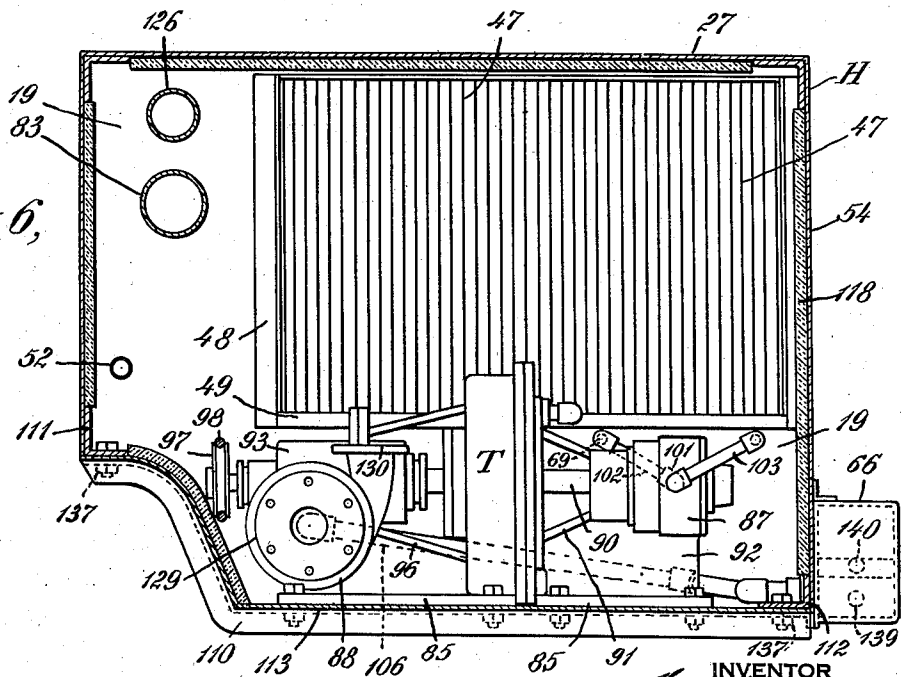


Fig. 6,



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2,111,905

UNITED STATES PATENT OFFICE

2,111,905

RAILWAY CAR AIR CONDITIONING SYSTEM

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Application February 8, 1935, Serial No. 5,532

10 Claims. (Cl. 62—152)

This invention relates to air conditioning and more particularly concerns an improved air conditioning system for use on railway passenger cars.

It is highly desirable that passenger carrying railway cars, such as coaches, sleeping cars, diners and the like, be provided with air cooling, heating and conditioning equipment, in order to maintain comfortable conditions regardless of wide variations in the outdoor temperature and humidity encountered in railway car operation. In a single trip, a railway car may travel from an extremely cold, dry climate to regions where high temperature and high relative humidity prevail and even reasonably comfortable atmospheric conditions cannot be maintained by ventilation alone because of the dust and smoke incident to railway travel. The problem of conditioning the air in a railway car is primarily one of cooling and dehumidifying, since particularly on steam operated trains, the heating of the cars is a relatively simple matter.

It has been proposed to equip railway cars with air cooling and dehumidifying systems embodying apparatus which is operated in whole or in part by electricity. Systems of this type are unsatisfactory because of their high initial cost and the high operating cost resulting from their low efficiency. Thus, when such systems are installed on a railway car, it is necessary to replace the usual car lighting generator and battery with electrical generating and accumulating equipment of greatly increased capacity, and this replacement materially increases the initial cost of the installation. The energy for operating electrically driven systems is delivered from the locomotive through the draw bars, the axle driven generator, the storage battery and the electric motors to the refrigerating apparatus, and consequently, the overall efficiency of the system is low and the operating cost correspondingly high.

Another serious disadvantage of electrically driven air cooling apparatus for railway cars arises from the fact that the servicing personnel and equipment available on steam roads are largely unsuited to handle the repair and maintenance of extensive electrical apparatus of this type. Railway servicing departments are necessarily familiar with repairs to apparatus employing steam and compressed air, but have little or no occasion to handle the servicing of electrical apparatus of large capacity.

The space available for the installation of cooling and air conditioning equipment on a passenger carrying railway car is very limited, and in general, the cooling equipment must be disposed beneath the floor frame of the car. The necessary right-of-way clearances and the presence of brake-operating and car lighting equipment beneath the car leaves very little free space for the cooling equipment. Due to these space limitations, many previously known railway car air conditioning systems employ a plurality of separate under car units to make up the cooling apparatus, and this arrangement adds to the installation cost and complicates the servicing problems.

With the above and other considerations in mind, it is proposed in accordance with the present invention to provide an improved, compact and highly efficient railway car air conditioning system embodying refrigerating or cooling apparatus directly operated by steam alone. The system of the invention includes refrigerating or cooling equipment comprising a single unitary structure embodying structural and operating improvements which reduce its size to such an extent that it may be readily mounted in the limited free space available beneath the floor frame of a standard railway car. The invention further contemplates the provision of railway car cooling or refrigerating apparatus which is so constructed and arranged that the elements or parts thereof which require servicing or repair are readily accessible and may be removed without disturbing the remainder of the apparatus.

A further object of the invention is the provision of improved and effective means for precooling passenger cars when they are stationary and unattached to a locomotive.

Various other specific objects and advantages of the invention will become apparent as the description thereof progresses.

In general, the above and other objects of the invention are carried out by providing a railway car air conditioning system embodying improved cooling or refrigerating apparatus in which a partial vacuum is maintained in a chill tank or evaporator by means of a steam jet operated vacuum booster. The water or other liquid cooled in the chill tank is circulated in heat exchanging relation with the air in the railway car and in this manner, the car air is cooled and dehumidified as required. The improved liquid cooling or refrigerating apparatus is entirely operated directly by steam, and to this end, preferably employs a single condenser, cooled by air circulation and water sprays. The apparatus for circulating the chilled liquid from the tank or evaporator and for circulating the condenser cooling water and air as well

as for extracting condensate from the condenser is preferably operated by a steam turbine and the exhaust steam from this turbine as well as from the steam jet vacuum booster is condensed in the condenser.

The vacuum cooling apparatus of the invention includes an improved chill tank construction in which a steam jet vacuum creating means or booster is disposed directly within the chill tank proper, thereby simplifying the construction and increasing the efficiency of the vacuum booster. The improved chill tank is provided with means for greatly increasing the surface area of the liquid therein whereby the evaporative capacity of the chill tank is greatly increased.

The devices comprising the refrigerating or cooling apparatus of our improved system are preferably disposed in an extremely compact arrangement and are housed and supported to form a single unitary structure of a size and shape suitable for mounting beneath a standard railway car. The apparatus is preferably so constructed and arranged that certain devices, such as the steam turbine and the liquid pumps operated thereby, which require periodic servicing or repair, may be readily removed from the unitary structure without disturbing the remainder of the apparatus.

Our improved means for pre-cooling railway cars equipped with our improved air conditioning systems preferably comprises a unit for supplying chilled water or other liquid from a portable source independently of the car-carried refrigerating apparatus to the air cooling coil or heat exchanging means of the car. By the use of this auxiliary equipment, railway cars may be pre-cooled while standing in passenger stations or railway yards without the necessity of attaching such cars to a locomotive or supplying steam from some other source to operate the car-carrying refrigerating equipment.

The invention will be best understood by reference to the accompanying drawings in which an embodiment thereof is illustrated. In the drawings;

Figure 1 is an elevation, partly in section, of a portion of a railway car equipped with air conditioning apparatus embodying the invention, together with pre-cooling equipment for the car;

Figure 2 is an elevation, partly in section, of the refrigerating unit of a system embodying the invention;

Figure 3 is a plan view of the unit of Figure 2 with the upper wall of the unit housing broken away to show the interior construction;

Figure 4 is an enlarged plan view of the lower portion of the condenser compartment of the unit of Figure 2;

Figures 5 and 6 are respectively sectional views taken along the lines **5—5** and **6—6** of Figure 2 and viewed in the direction of the arrows;

Figure 7 is an enlarged transverse section of the chill tank of the refrigerating equipment; and

Figure 8 is a longitudinal section of the chill tank taken along the line **8—8** of Figure 7.

Referring to the drawings, our improved railway car air conditioning system has been shown as applied to a railway passenger car of conventional construction which has been diagrammatically illustrated at P in Figure 1. The system is of the type in which chilled water or other liquid is circulated in heat exchanging relation with air supplied to the car. The particular form of heat exchange and air propelling means used forms no part of the present invention, and various forms of apparatus may be employed for this purpose. In the embodiment shown in Figure 1, fresh air from outside of the car is drawn by a fan **3** through one or more intake openings **2** into a chamber **4** located above the ceiling of the car vestibule **7** and is propelled by the fan through a duct **5** to suitably placed ceiling outlets **5'** in the car. A cooling coil **6** is located in the chamber **4** in heat exchanging relation with the air drawn therethrough, and this coil is at times supplied with chilled water or other liquid from a refrigerating unit hereinafter described. A heating coil **8**, supplied at times with steam from the train steam line, is also located in the chamber **4**. The fan **3** may be operated by an electric motor **9**, as shown. The fan **3** and motor **9** may be of relatively small capacity and may replace the usual electric fans customarily installed in railway passenger cars. Air may be discharged from the car through the doors, windows or other air pervious openings thereof, or special air outlet ducts may be provided, if desired.

In accordance with the present invention, chilled water or other liquid for use in cooling the air delivered to the car is supplied by refrigerating apparatus comprising a unitary structure carried beneath the car and designated U in Figure 1. Steam from the train line is supplied to this unit through a pipe **10** and steam for heating the car heating coil **8** is returned from control devices in the unit U through the pipe **18**. Chilled water is delivered from the unit U to the car cooling coil **6** through the pipe **11** and returned through the pipe **12**. Valve controlled branch connections **13** and **14** are provided on the water pipes **11** and **12** respectively for a purpose hereinafter described. The water pipes **11** and **12** are preferably enclosed in an insulating duct illustrated at **15** and a steam pipe **16** is also enclosed in this duct and at times supplied with steam to prevent freezing of the water in the pipes **11** and **12**.

The refrigerating apparatus of the unit U is enclosed in an elongated housing H suitably secured to the under surface of the car floor frame **17** adjacent one side thereof. One end of the housing H comprises a condenser compartment C which is separated from the remainder of the housing by the transverse substantially centrally located partition **19**. A fan or blower **20** is located adjacent the opposite end of the housing from the condenser compartment C, and the discharge duct **21** of this fan is connected to an opening in the end wall of the housing, as shown in Figures 2 and 3. A chill tank or evaporator **22** carrying a steam jet vacuum booster B therein is supported adjacent the upper wall of the housing between the condenser compartment C and the blower **20** by suitable brackets or supports **23**. A pumping unit including a steam turbine T is provided on the bottom wall of the housing H between the condenser compartment C and the blower **20** and substantially beneath the chill tank **22**.

The condenser of the refrigerating apparatus is cooled by air circulation and a water spray. The condenser proper comprises a pair of spaced headers **24** and **25** connected by the elongated finned tubes **26**. The condenser is so mounted that the tubes **26** lie at an angle to the horizontal, the inlet header **24** being secured near the upper wall **27** of the housing H at the outer end of the condenser compartment C by a bracket **28**, and the outlet header **25** being suitably supported

adjacent the opposite end of the condenser compartment at a considerably lower level than the inlet header 24. As shown in Figures 3 and 5, the inlet header 24 has a lateral extension 29 passing through the side wall of the condenser compartment C and into a compartment 31 extending along one side of the condenser compartment, and an exhaust pipe 32 is connected to this header extension 29, as shown.

Suitable openings are provided for permitting the passage of cooling air through the condenser compartment C in such a direction that this air passes through the tube bundle of the condenser proper over the surfaces of the finned tubes 26. Thus, the bottom wall of the condenser compartment C is substantially open and comprises a series of air permeable filters 33, removably supported on transverse supporting beams 34, as shown in Figure 2. The filters 33 may be of any suitable construction, and as shown in Figure 5, may comprise a mass 35 of interengaging strands compressed between parallel screens or perforated plates 36. The filters 33 are preferably removable for replacement or cleaning through the lower side wall 37 of the condenser compartment C, which wall is hinged at 38 as shown in Figure 5 and may be swung upward to the position shown in dotted lines, whereupon the filters 33 may be disconnected from the longitudinal supporting angles 39 and 40 and removed laterally from the unit. A latch mechanism 41 is provided for securing the hinged wall 37 in its open and closed positions.

An air inlet opening is also provided in the end wall 42 of the condenser compartment C and an air filter 43 is removably secured over this opening by suitable brackets 44 and clamping bolts 45. A set of louvers or air deflectors 46 is secured within the end inlet opening to deflect the entering air downward beneath the condenser tubes 26. A bracing rod 58 passes through the louvers 46 adjacent their centers, as shown in Figure 5. The louvers 46 are preferably removable to give access to the interior of the condenser compartment C.

The air outlet of the condenser compartment C comprises an opening through the vertical transverse partition 19. As shown in Figures 2, 3, 4 and 6, this opening is filled with a set of eliminator plates 47 carried in a frame 48 having a marginal flange 49 along the lower outer edge, as best shown in Figure 4. The eliminator plates 47 are of known construction, comprising angularly disposed parallel plates having inwardly opening pockets 50 thereon for collecting and carrying off any spray water that may be carried by the air passing through the partition opening.

Two sets of spray water pipes are provided in the condenser compartment C, one set lying above and the other below the condenser tubes 26. The upper set comprises a series of transverse pipes 51 connected through the vertical pipes 56 to the manifold pipe 52 in the side compartment 31, and these transverse pipes 51 extend through the side wall 30 and across the condenser compartment C adjacent the top wall 27 thereof, their ends being supported by suitable lugs 53 on the inner housing wall 54. A plurality of spray heads 55 are provided on each of the pipes 51 within the compartment C and are disposed to direct a spray of water from the pipes 51 downwardly onto the condenser tubes 26. An angular extension 57 of the manifold pipe 52 passes through the side wall 30 and extends across the outer end of the condenser compartment C beneath the header 24.

The lower set of spray water pipes 59 extend longitudinally along the condenser compartment C from the pipe 57, and their inner ends are carried by brackets 60 depending from the lower or outlet header 25 of the condenser. Two sets of spray heads 61 and 62 are provided on each of the pipes 59, the set 61 directing spray water upwardly against the condenser tubes 26 and the set 62 directing spray water downwardly into the air entering through the filters 33.

Means are provided for collecting and removing the spray water from the condenser compartment C. This means preferably takes the form of a plurality of spaced parallel concave troughs 63 extending transversely across the lower portion of the compartment and inclined toward the inner wall 54, as shown in Figure 5. The spaces between the concave troughs 63 are bridged by the convex deflectors 64 which are spaced some distance above and disposed in overlapping relation to the troughs 63, as shown in Figure 2. The outer ends of the troughs 63 are carried by a longitudinal angle beam 65 and their inner ends extend through openings in the inner wall 54 of the condenser compartment and into a water sump or collecting tank 66 secured outside of the inner wall 54 adjacent the lower edge thereof. The convex deflectors are suitably secured between the side walls of the compartment C and a marginal gutter 67 is disposed above these deflectors and extends around the four walls of the compartment, as shown in Figure 4. The portions of the gutter 67 extending across the ends of the compartment C protrude outwardly over the edges of the concave water troughs 63, as shown in Figure 2. An angle member 68 is disposed between the inner lower edge of the eliminator frame 48 and the upper edge of the gutter 67, so that water entrained by the eliminator plates 47 drains back over this angle member and the end gutter 67 into the water trough 63. With the arrangement described, a free passage for entering air is provided between the troughs 63 and the deflectors 64 while the falling spray water is deflected into the troughs 63 and drains into the sump 66.

The outlet of the condenser comprises a finned tube or pipe 69 connected to the lower header 25 and extending in a long loop beneath the condenser tubes 26, as shown. This loop insures the condensation of any vapor leaving the condenser. The outlet pipe 69 extends through the central partition 19 just below the air outlet therethrough, as shown in Figure 2.

The blower 20 is provided with inlet openings 70 at its sides, and when this blower is in operation, air is drawn into the condenser compartment C through the filters 33 and 43, passes upwardly through the bundle of condenser tubes 26 and out of the condenser compartment through the eliminator plates 47, finally entering the blower inlets 70 and out of the housing through the blower outlet 21. The entering air is cooled by the evaporation therein of water from the downwardly directed spray heads 62 and spray water from the heads 55 and 61 facilitates the rapid transfer of heat from the condenser tubes 26 to the air passing over these tubes.

The refrigerating equipment is located in the compartment D to the right of the partition 19, as viewed in Figures 2 and 3. This compartment D is preferably thermally insulated by suitable means, such as the sheets 118 of insulating material carried by the walls thereof, as shown. The chill tank or evaporator 22 and steam jet

booster B are of improved design. The chill tank 22 is preferably cylindrical and disposed transversely of the housing H. A water inlet pipe 71 is connected through the end head 72 of the chill tank and this inlet pipe is connected to the return pipe 12 from the car cooling coil 6. As shown in Figures 7 and 8, the inlet pipe 71 extends substantially across the interior of the tank 22 at the top thereof, and is provided with a plurality of oppositely disposed substantially horizontal outlet openings 74. A distributing tray 75 having perforations 76 therethrough is suitably supported below the pipe 71 and serves to distribute the incoming water in fine streams or drops about the interior of the tank.

In accordance with the invention, the steam jet vacuum booster B is located directly within the chill tank 22. As shown in Figures 2, 3 and 8, this booster comprises a cylindrical casing 77 passing horizontally directly through the chill tank 22 and sealed in aligned opposite openings in the cylindrical wall thereof. A steam nozzle 78 of proper design is carried by the head 79 of the casing 77 and is supplied with steam from a pipe 80. A tapered throat 81 is secured within the casing 77 in axial alignment with and spaced from the nozzle 78 and a plurality of openings 82 are formed in the casing 77 adjacent the nozzle outlet and the throat inlet to admit vapor from the chill tank 22 to the throat 81. The location of the steam jet booster B directly within the chill tank 22 not only provides an extremely compact construction, but also improves the efficiency of the apparatus. Thus, with this arrangement, vapor from the evaporating water in the tank 22 flows directly to the entraining steam jet and into the throat 81 from opposite sides of the jet, and frictional losses due to unsymmetrical vapor flow to and through the jet are largely eliminated.

The Venturi throat 81 is connected to a complementary throat section 83 passing through the partition 19 and connected at its end with the exhaust pipe 32 in the compartment 31. It will be noted that the throat comprising the sections 81 and 83, as well as the exhaust pipe connected thereto, presents a straight unobstructed passage of considerable length aligned with the steam jet of the booster B. This arrangement permits the efficient operation of the booster since undue frictional retardation of the exhaust fluid prior to complete expansion is avoided and a high fluid velocity through the booster throat is obtained. The straight throat and exhaust passage are employed without increasing the overall length of the refrigerating unit since the outer end of the exhaust pipe 32 is connected to the outer and upper condenser header 24 and the condenser tubes 26 extend back substantially longitudinally of the unit housing H and occupy the same longitudinal space as the booster throat and the exhaust pipe.

We prefer to employ novel means for increasing the evaporating capacity of the chill tank. This means takes the form of a plurality of small helical coils of wire 84 loosely disposed in the chill tank beneath the water distributing tray 75. A coarse transverse screen 75' extends across the chill tank adjacent the steam jet booster B to prevent the coils 84 from entering the booster throat. Water from the tray 75 spreads in a thin film on the surfaces of the coils 84 and thus presents a very large surface area from which evaporation takes place at a very rapid rate. Various forms of coils may be used, and in general, any type of coil in which the successive turns are spaced apart may be employed. Since the surface area of the liquid distributed on the coils 84 is considerably greater than the largest level surface area obtainable in the tank 22, it is preferred to keep the liquid level at a low point within the tank as indicated at 155.

Any suitable means may be employed for maintaining the liquid level in the chill tank 22 constant. As shown in Figure 7, a float operated valve may be provided in a compartment 156 connected to the tank 22 adjacent the bottom thereof, this valve being arranged to control the admission of liquid to the tank. The simple form of float valve disclosed includes a float 157 bearing directly on a valve plug 158, the valve plug cooperating with a seat 159. Suitable guide means 160 guide the valve plug 158 to the seat 159. The valve seat 159 is connected to the water tank or sump 66 by a pipe 161. When the water level within the chill tank 22 and the connected compartment 156 drops below the point desired, the float 157 falls and permits the plug 158 to disengage the seat 159, whereby water flows from the sump 66 into the chill tank 22 because of the sub-atmospheric pressure maintained in the chill tank by the steam jet booster B. When the water level has risen to the required point, the admission of further water is cut off by the rising of the float 157 and the closing of the valve 158.

The pumping equipment of the refrigerating apparatus comprises a unitary structure carried by a base plate 85 mounted on the bottom wall of the compartment D. As shown in Figures 2, 3 and 6, this equipement comprises a vacuum suction pump 87, a chilled water circulating pump 88 and a spray water pump 89, all driven by a centrally located steam turbine T. The suction pump 87 operates at a high speed and is directly connected to the turbine shaft 90, as shown, and the casing of the pump 87 is preferably connected to the turbine casing and the base 85 by suitable brackets or webs 91 and 92. The pumps 88 and 89 operate at a lower speed than the suction pump 87 and are driven by the turbine T at a suitably reduced speed through a spiral or worm gearing connection located in the housing 93, this housing carrying the common drive shaft 94 of the pumps 88 and 89 at right angles to the turbine shaft 90. The casings of the pumps 88 and 89 are connected to the gear housing 93 by the webs 95, and similar webs 96 connect the gear housing 93 to the casing of the turbine T whereby a rigid unitary structure is provided. A pulley 97 is fixed to the end of the turbine shaft 90 beyond the gear housing 93 and a belt 98 effects a driving connection between this pulley and a driving pulley 99 on the shaft of the blower 20.

The vacuum suction pump 87 has an intake pipe 100 connected through the control valve 101 and the pipe 102 to the outlet pipe 69 of the condenser, while the outlet pipe 103 of the pump 87 extends through the partition 19 and discharges over the angle member 68 and gutter 67 through the transverse trough 63 and into the water sump 66, as best shown in Figures 2 and 3. The pump 88 is connected to withdraw water from the bottom of the chill tank 22 through the pipe 104 and to discharge this water through the pipes 105 and 11 to the car cooling coil 6. The spray water pump 89 is connected to draw water from the sump 66 through the pipe 106 and to deliver water through the pipe 107 to the spray manifold pipe 52.

A restricted pipe 108 delivers water at a limited rate from the casing of the spray water pump 89 to the casing of the vacuum suction pump 87, thus maintaining the required amount of sealing water in the suction pump casing. A similar restricted pipe 109 connects the inlet ports of the spray water pump 89 and the vacuum suction pump 87 whereby water is drawn from the sump 66 by the suction of the pump 87 to prime the pump 89.

Steam is supplied to the refrigerating unit through a pipe 10 and passes through a water trap 116, a pressure regulator 117 and a control valve 119 to the vacuum booster nozzle inlet pipe 80. A branch pipe 120 conducts steam through the control valve 121 and pipe 122 to the turbine T and another branch pipe 123 conducts steam through a control valve 124 to the pipe 16 which heats the water pipe housing 15. A further steam branch passes through the control valve 125 and the pipe 18 to the car heating coil 8. Exhaust steam from the turbine T passes through the pipe 126 extending through the partition 19 and flows to the exhaust pipe 32 and thence to the upper header 24 of the condenser.

In accordance with the invention, the pumping equipment including the turbine T is conveniently removable from the housing H as a unit. To this end, the base 85 of the pumping equipment is supported on a removable wall section which comprises a pair of transverse channel beams 110, removably bolted at their ends to the longitudinal housing beams 111 and 112 and carrying the housing wall plate 113, as shown in Figures 2 and 6. A pair of removable access plates 114 and 115 are respectively disposed on either side of the plate 113 being secured to the adjacent sections of the bottom wall of the housing by suitable transverse angle bars 127 and bolts 128, as clearly shown in Figure 2. When it is desired to remove the pumping equipment for inspection, replacement or repair, the plates 114 and 115 are removed and the openings thus provided give access to the connections between the pumping equipment and the other apparatus. The belt 98 is removed from the pulley 99, the flanged couplings 129 and 130 in the intake and outlet pipes 104 and 105 of the chilled water circulating pump 88 are disconnected and the flanged couplings 131 and 132 in the intake and outlet pipes 106 and 107 of the spray water pump 89 are disconnected. The steam supply pipe 122 of the turbine T is disconnected at the union 133 and the turbine exhaust pipe 126 is opened at the flanged coupling 134. The condenser outlet pipe 69 is disconnected from the suction pump 87 at the union 135 and the outlet pipe 103 of this pump is opened at the union 136. The pumping equipment including the turbine T and the pumps 87, 88 and 89 is thus entirely disconnected from the other apparatus in the housing, and may be removed as a unit by removing the bolts 137 at the ends of the channel beams 110 and lowering these beams, thereby withdrawing the pumping equipment from the housing H.

The operation of the refrigerating apparatus in cooling the railway car will be readily apparent to those skilled in the art. When conditions require that the car air be cooled and dehumidified, suitable control apparatus closes the steam supply valves 124 and 125 and opens first the turbine steam supply valve 121, and then the vacuum booster steam supply valve 119. As the turbine T starts up, the suction pump 87 creates a vacuum in the intake of the spray water pump 89 and so draws water from the sump 66 through the pipe 106 to prime the pump 89. The pump 89 then forces water drawn from the sump 66 through the pipes 52, 56, 57, 51 and 59 to the spray heads 55, 61 and 62 in the condenser compartment, a large portion of this spray water being returned to the sump 66 by the troughs 63. The blower 20 draws cooling air through the condenser compartment C from the filters 33 and 43. The steam jet booster B evacuates the chill tank 22 and causes the evaporation and consequent cooling of the water therein, and this chilled water is circulated through the car cooling coil 6 by the pump 88. The water lost from the circulatory system including the car cooling coil 6 and chill tank 22 by evaporation in the chill tank is made up by water drawn up from the sump 66 through the pipe 61 under the control of the float 157 and the valve plug 158 operated thereby. The exhaust steam from the booster B and the turbine T is condensed in the condenser tubes 26 and the vacuum suction pump 87 purges the condenser of condensate and air and delivers the condensate to the sump 66.

The return of condensate from the condenser to the water sump 66 assists in making up for water lost from the system by evaporation in the condenser compartment. However, some additional make up water is required and a water make up tank 138 is accordingly provided, connected as shown in Figure 1 beneath the car floor frame 18 adjacent one end of the refrigerating apparatus unit U. The make up water tank 138 may be of any suitable construction and is preferably arranged to maintain a constant water level in the sump 66. To this end, the tank 138 is connected to the sump 66 by a pipe 139 entering the sump below the water level therein as shown in Figures 1 and 5, and a vent pipe 140 extends from a point adjacent the upper end of the tank 138 to a point just below the water level in the sump 66 and above the water feed pipe 139. With this arrangement, when the water level in the sump 66 falls below the end of the vent pipe 140, air enters this pipe and relieves the vacuum in the tank 138, thus permitting water to flow from this tank to the sump 66 until the water in the sump again covers the end of the vent pipe 140.

It is frequently necessary to pre-cool railway cars while standing in yards or stations before they are occupied by passengers. In accordance with our invention, this may be conveniently accomplished without the necessity for connecting a locomotive or other source of steam to the cars. To this end, we provide means for circulating chilled water through the cooling coil 6 independently of the refrigerating unit U. As shown in Figure 1, the chilled water supply and return pipes 11 and 12 are respectively provided with branch ducts 13 and 14 and three-way valves 141 and 142 of conventional construction are provided at the junctures of these branch ducts with the chilled water circulating pipes. The three-way valves 141 and 142 act in a known manner to either cut off the branch ducts 13 and 14 and open the pipes 11 and 12, or to connect the pipes to the branch ducts and cut off the pipes from the car-carried refrigerating unit U.

Chilled water for circulation through the pipes 11 and 12 may be supplied from a truck 143 carrying a closed heat insulated ice bunker 144 with a spray pipe 145 at the top thereof and an

outlet pipe 146 at the bottom thereof as shown. A water circulating pump 147 driven by an electric motor 148 is connected to the outlet pipe 146, and energy for operating this pump may be supplied from an electrical outlet in the car yards or station where the railway car is standing. The inlet spray pipe 145 is connected by a flexible hose 149 to the branch duct 14 and thence to the chilled water return pipe 12, and the outlet of the pump 147 is connected by a flexible hose 150 to the branch duct 13 and thence to the chilled water feed pipe 11. When the pump 147 is operated, chilled water is drawn from the ice bunker 144 and delivered through the hose 150, the branch duct 13 and the pipe 11 to the car cooling coil 6, returning through the pipe 12, the branch duct 14, the hose 149 and the spray pipe 145 and running over the ice cakes 151 in the bunker 144. The air blower 3 in the car is operated to draw air over the cooling coil 6 and into the car. This operation is continued until the car temperature is reduced to the required point and the car is ready to be connected to a locomotive.

We claim:

1. Refrigerating apparatus for a railway car air conditioning system comprising a horizontally extending elongated housing, a chill tank extending transversely of said housing and spaced from one end thereof, a steam jet vacuum booster connected to evacuate said chill tank and extending longitudinally of said housing adjacent the top wall thereof, a throat member and an exhaust duct connected to and aligned with said booster, said exhaust duct terminating near one end of said housing adjacent the top wall thereof, a condenser comprising a plurality of elongated tubes extending longitudinally of said housing downwardly at an angle to the horizontal from a point adjacent the end of said exhaust duct toward said chill tank, means connecting the end of said exhaust duct to the upper ends of said condenser tubes, said housing having air inlet openings beneath said condenser tubes and means for expelling air from said housing adjacent the end thereof remote from said condenser whereby air is drawn through said inlet openings and upwardly over said condenser tubes.

2. Refrigerating apparatus for a railway car air conditioning system comprising a horizontally extending elongated housing, a chill tank extending transversely of said housing and spaced from one end thereof, a steam jet vacuum booster connected to evacuate said chill tank, and extending horizontally adjacent the top of said housing near one side thereof, an exhaust duct connected to and aligned with said vacuum booster and extending therefrom along one side of said housing and terminating at a point adjacent one end thereof, a header disposed transversely of said housing and connected to the end of said exhaust duct, a plurality of elongated condenser tubes connected to said header and extending diagonally downward toward the other end of said housing, said housing having air inlet openings therein beneath said condenser tubes, means for expelling air from said housing adjacent the end thereof remote from said condenser tubes whereby air is drawn upwardly from said inlet openings and over said condenser tubes, means for circulating spray water over said condenser tubes and a steam turbine exhausting into said condenser and connected to drive said air exhausting and water circulating means.

3. In a railway car air conditioning system of the type in which a chilled liquid is circulated in heat exchanging relation with air delivered to the car, car-carried refrigerating apparatus for chilling the liquid so circulated comprising a horizontally extending elongated housing, a condenser in said housing adjacent one end thereof, said housing having an air inlet opening therein adjacent said condenser, means in said housing for spraying water on said condenser, an air blower in said housing adjacent the other end thereof connected to discharge air from said housing whereby air is drawn over said condenser from said inlet opening, a chill tank in said housing between said condenser and said blower, steam jet means connected to evacuate said chill tank, pumping means for circulating liquid through said chill tank, supplying water to said condenser spraying means and withdrawing fluid from said condenser, a steam turbine connected to operate said pumping means and said air blower, said turbine and said pumping means being disposed substantially beneath said chill tank and between said condenser and said blower, and means for conducting exhaust steam from said jet evacuating means and from said turbine to said condenser.

4. In a railway car air conditioning system of the type in which a chilled liquid is circulated in heat exchanging relation with air delivered to the car, car-carried refrigerating apparatus for chilling the liquid so circulated comprising a horizontally extending elongated housing, a condenser in said housing adjacent one end thereof, said housing having an air inlet opening therein adjacent said condenser, means in said housing for spraying water on said condenser, means disposed adjacent the other end of said housing for circulating air from said inlet opening over said condenser, a chill tank and a steam jet evacuator therefor disposed adjacent the top of said housing between said condenser and said air circulating means, pumping means for supplying water to said condenser spraying means, means for circulating liquid through said chill tank, a steam turbine connected to operate said pumping and circulating means, said turbine and said pumping and circulating means being mounted below said chill tank adjacent the bottom of said housing between said condenser and said air circulating means and means for conducting exhaust steam from said turbine and said steam jet evacuator to said condenser.

5. Refrigerating apparatus for a railway car air conditioning system comprising an elongated housing, a chill tank in said housing spaced from one end thereof, a steam jet vacuum booster connected to evacuate said chill tank and disposed longitudinally of said housing, a substantially straight expansion throat and exhaust duct extending longitudinally of said housing and aligned with said booster, an elongated condenser connected to said exhaust duct and disposed substantially longitudinally of said housing beside said exhaust duct and expansion throat, a steam turbine arranged to discharge to said exhaust duct and means driven by said turbine for circulating water through said chill tank, circulating air and water in heat exchanging relation with said condenser and withdrawing fluid from said condenser.

6. Refrigerating apparatus for a railway car air conditioning system comprising a chill tank, a steam jet vacuum booster connected to evacuate said chill tank, a condenser connected to receive exhaust steam from said booster, means for cir-

culating water in heat exchanging relation with said condenser, means for circulating cooling air over said condenser, a vacuum pump for withdrawing fluid from said condenser, means for circulating water through said chill tank and a steam turbine exhausting into said condenser and connected to drive said condenser water circulating means, said cooling air circulating means, said vacuum pump and said chill tank water circulating means.

7. In a railway car air conditioning system, a unitary housing and refrigerating apparatus in said housing comprising a chill tank, steam jet evacuating means connected to evacuate said chill tank, a condenser connected to receive the exhaust from said steam jet evacuating means, means for spraying water over said condenser, a suction pump connected to said condenser, a pump connected to circulate water through said chill tank, a pump connected to deliver water to said condenser spraying means, and a steam turbine connected to drive all of said pumps and having an exhaust duct connected to said condenser.

8. In a railway car air conditioning system, a car-carried housing and refrigerating apparatus in said housing comprising a chill tank and steam jet evacuating means therefor, a condenser connected to receive exhaust vapor from said evacuating means, means for spraying water on said condenser, a chilled water circulating pump connected to said chill tank, a suction pump connected to said condenser, a spray water pump connected to said condenser spraying means, a removable wall section on said housing, means connected to drive all of said pumps, means for mounting all of said pumps and said driving means on said removable wall section, and at least one removable access plate in said housing adjacent said removable wall section disposed to give access to the connections to said pumps from the exterior of said housing.

9. In a railway car air conditioning system, in combination with a railway car, a housing mounted beneath said car and having a removable wall section in the bottom wall thereof, refrigerating apparatus in said housing comprising a chill tank and steam jet evacuating means therefor, a condenser connected to receive exhaust vapor from said evacuating means, means for spraying water on said condenser, a chilled water circulating pump connected to said chill tank, a suction pump connected to said condenser, a spray water pump connected to said condenser water spraying means, a steam turbine arranged to discharge to said condenser, driving connections between all of said pumps and said turbine, means for mounting all of said pumps, said turbine and said driving connections on said removable wall section, and at least one removable access plate forming a part of the bottom wall of said housing adjacent said removable wall section for giving access to the connections to said pumps and said turbine.

10. In refrigerating apparatus for railway car air conditioning systems, in combination, a chill tank and means for evacuating said chill tank comprising an elongated cylindrical duct sealed in opposite openings in said chill tank, a steam nozzle adjacent one end of said duct terminating at a point within said chill tank, and a tapered throat in said duct aligned with said nozzle and spaced from the end thereof, said duct having a plurality of oppositely disposed openings in the cylindrical wall thereof within said chill tank and adjacent the space between said nozzle and said throat.

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