Oct. 28, 1941. C. F. HENNEY 2,260,900

AIR CONDITIONING

Filed Dec. 30, 1937 6 Sheets-Sheet 1

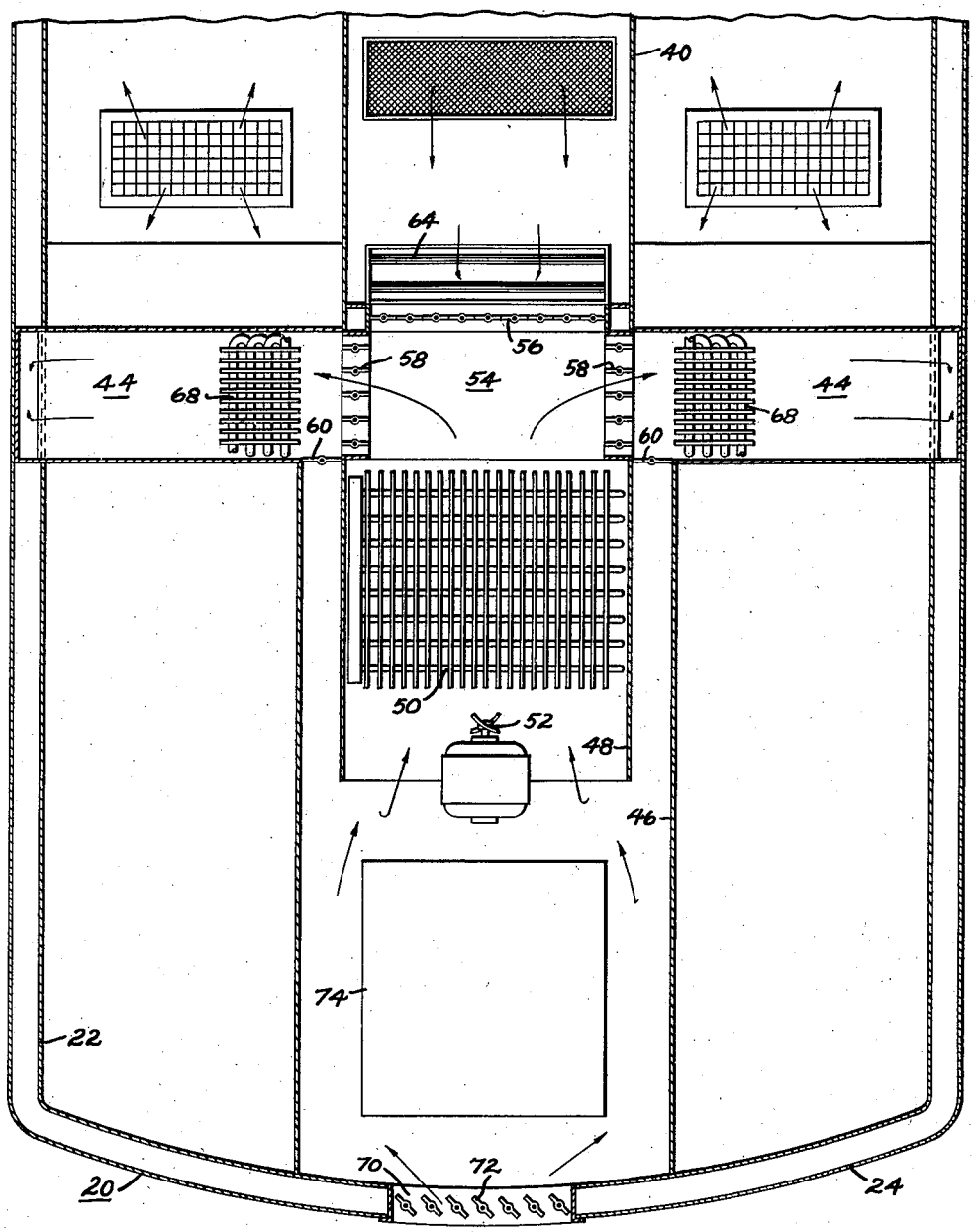


Fig. 1

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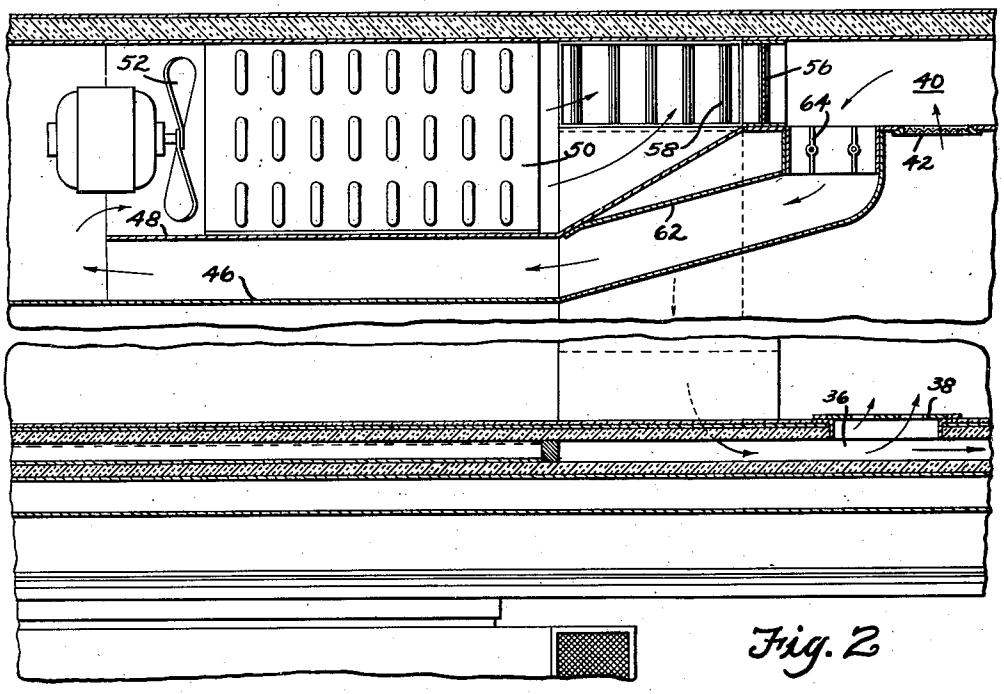


Fig. 2

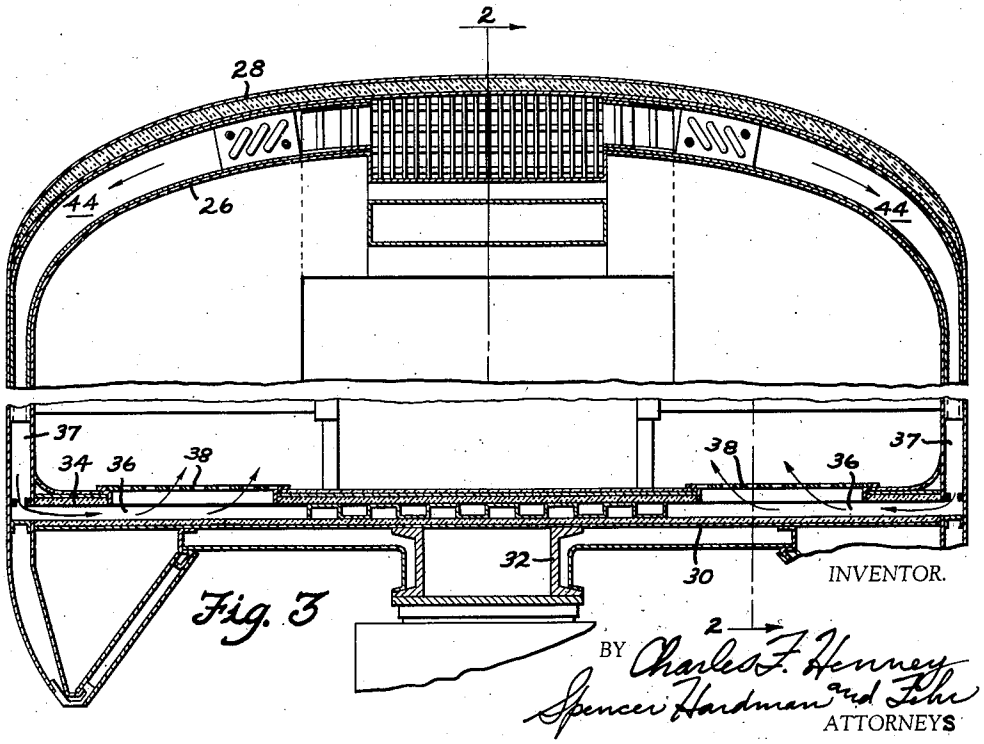


Fig. 3

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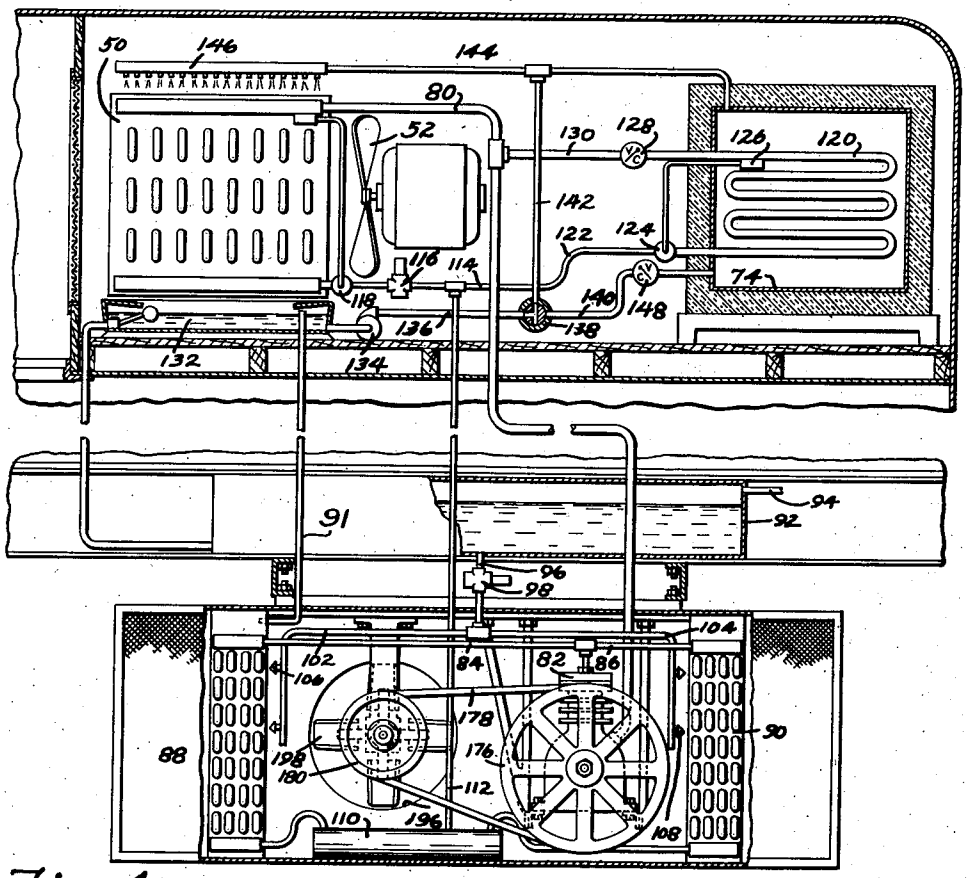


Fig. 4

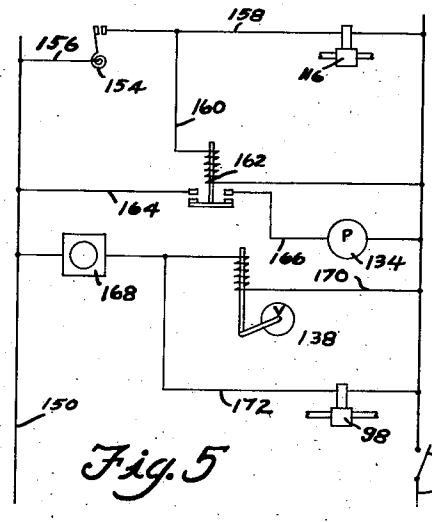


Fig. 5

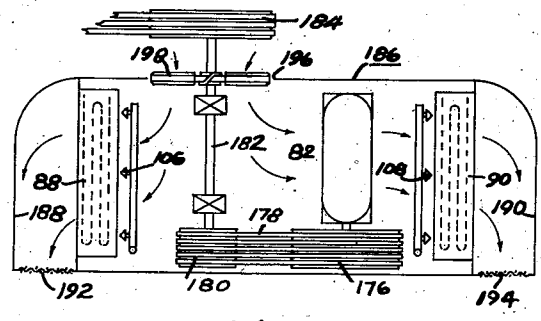


Fig. 6

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AIR CONDITIONING

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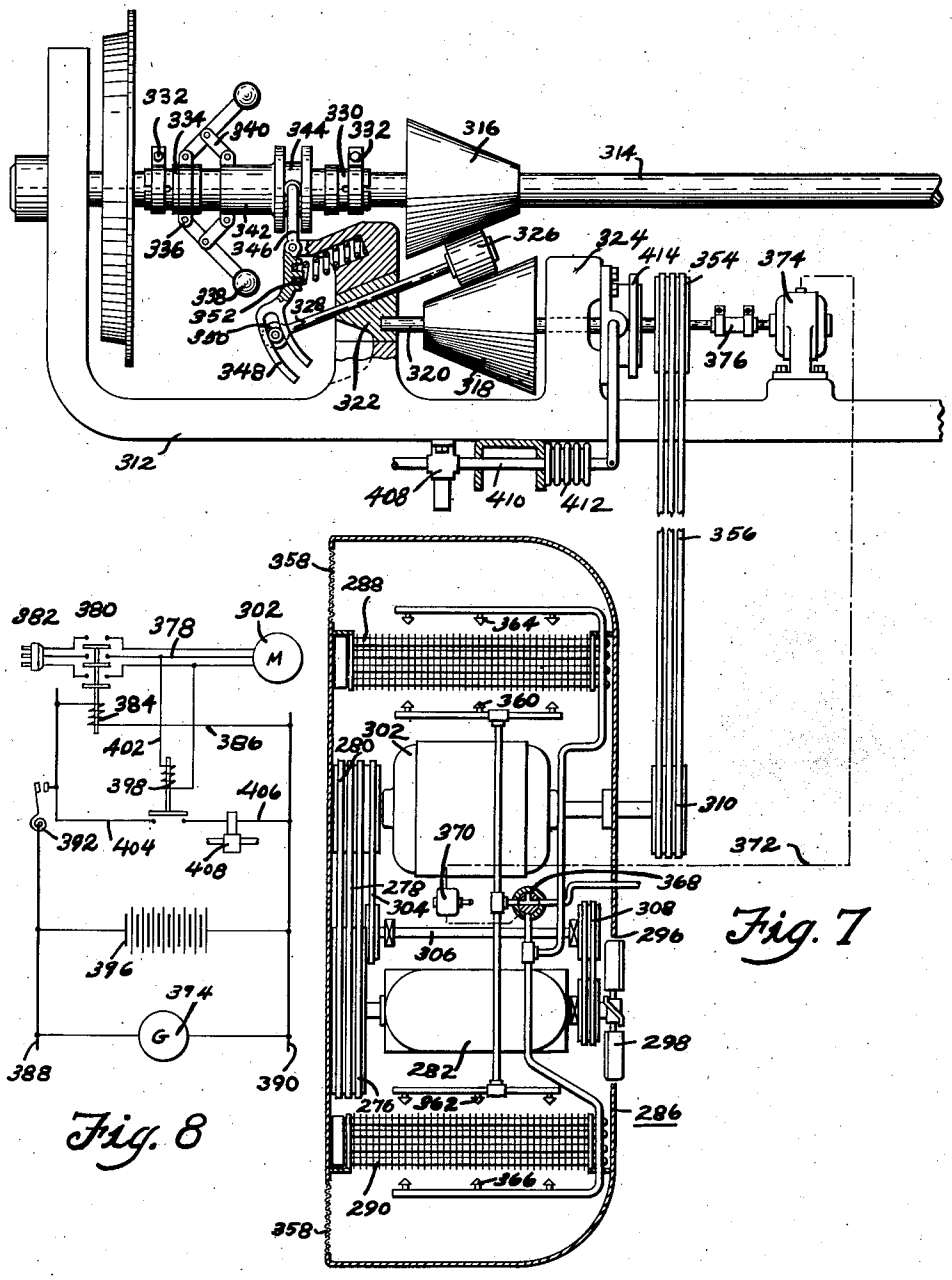


Fig. 7

Fig. 8

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AIR CONDITIONING

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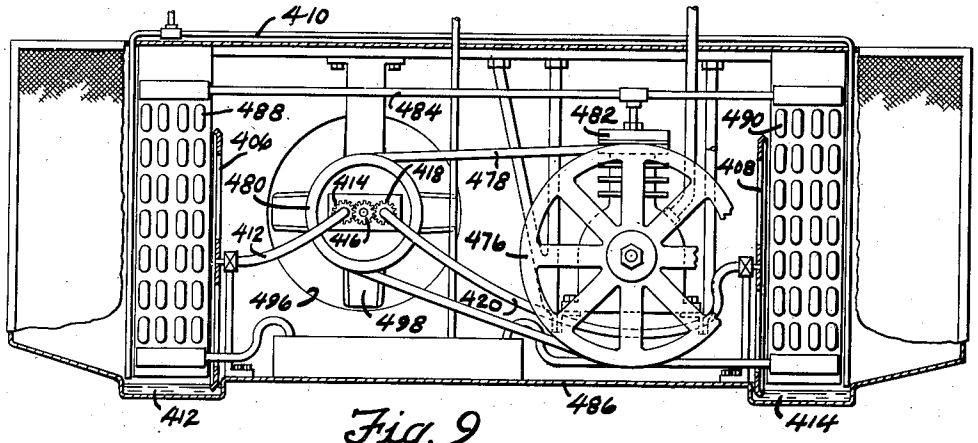


Fig. 9

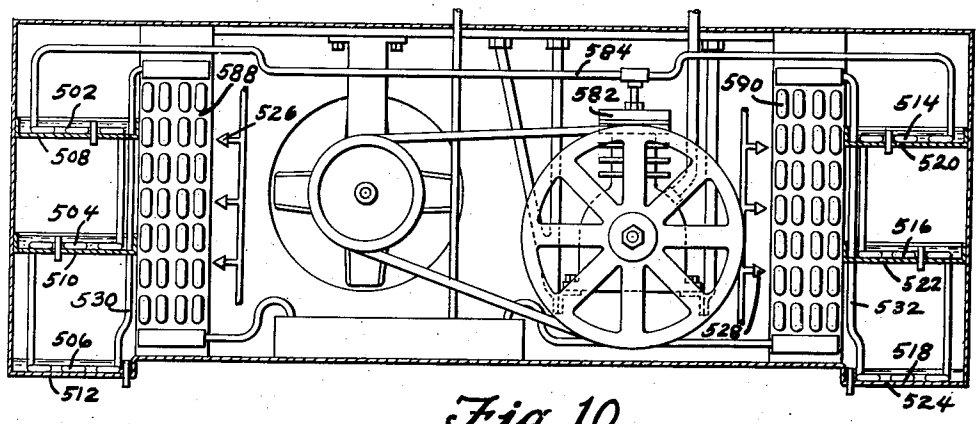


Fig. 10

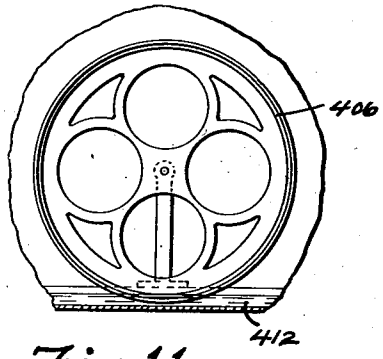


Fig. 11

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AIR CONDITIONING

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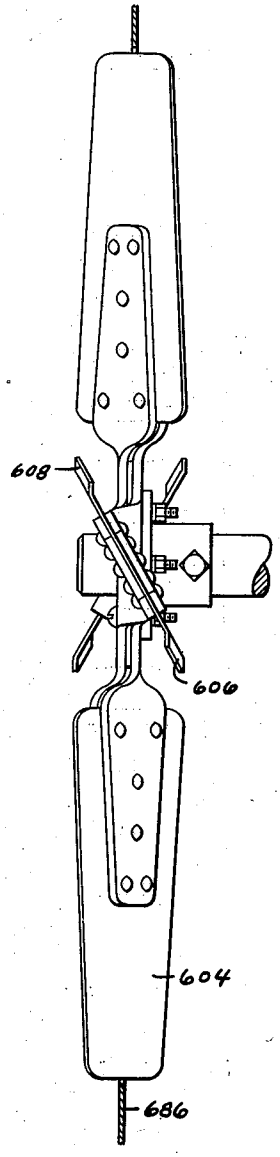


Fig. 12

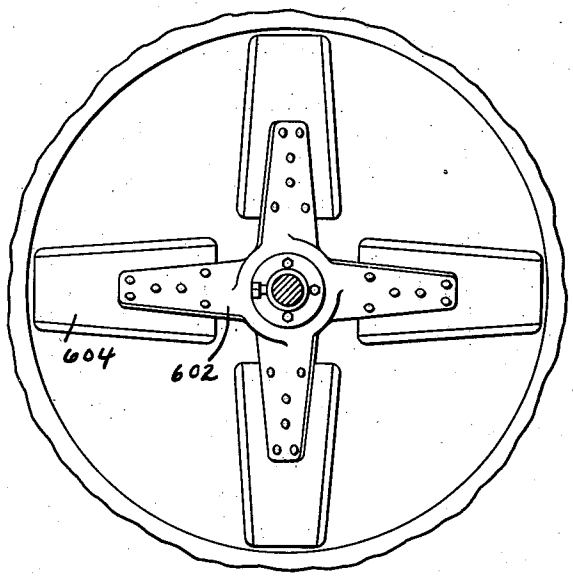


Fig. 13

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Patented Oct. 28, 1941 2,260,900

UNITED STATES PATENT OFFICE

2,260,900

AIR CONDITIONING

Charles F. Henney, Dayton, Ohio, assignor to General Motors Corporation, Dayton, Ohio, a corporation of Delaware

Application December 30, 1937, Serial No. 182,535

6 Claims. (Cl. 62—6)

This invention relates to refrigerating apparatus and more particularly to air conditioning means for railway cars and other vehicles.

The air conditioning of a railway car presents a particularly difficult problem because the car has no dependable source of power. Railway cars when they are pulled by a locomotive, of course can derive power from the pulling of the car by the locomotive and they are provided with a low pressure steam line from the engine for heating purposes. However, when the car is disconnected from the locomotive neither of these sources of power are available.

It has been customary to provide an axle-driven generator and storage batteries for lighting purposes and steam lines are provided at many of the passenger stations for supplying the cars with steam when they are on a siding. In order to provide refrigeration it has been customary to provide a much larger axle-driven generator and a much larger battery for providing electric energy to drive the refrigerator compressor. The electrical equipment for such a system is very costly and the use of the electrical drive for the compressor reduces the overall efficiency of the use of the power provided by the locomotive, and also increases the dead weight of the car which tends to reduce the possible acceleration which might be obtained in normal operation of the train.

It is therefore an object of my invention to provide an improved and more efficient air conditioning system for a railway car and other vehicles which is relatively lighter in weight and lower in cost than the electrically operated air conditioning systems, and which will provide air conditioning under all normal uses of the car.

It is another object of my invention to provide an improved circulating system for a railway car and other air conditioning applications which may be used for both heating and cooling purposes in a very efficient manner.

It is a further object of my invention to provide an improved and more efficient means for liquefying the refrigerant in railway air conditioning systems.

It is another object of my invention to provide an improved railway air conditioning system, operated by a mechanical drive from the car axle, which will have facilities for refrigeration of the air when the car is standing.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a top sectional view of an end portion of a railway car embodying my invention;

Fig. 2 is a vertical sectional view of the end portion of the railway car shown in Fig. 1 taken along the lines 2—2 of Fig. 3;

Fig. 3 is a transverse vertical sectional view of the end portion of the railway car shown in Fig. 1;

Fig. 4 is a view of the refrigerant air conditioning system for the car shown in Fig. 1;

Fig. 5 is a wiring diagram for the air conditioning system shown in Fig. 4;

Fig. 6 is a diagrammatic top view of the refrigerant liquefying apparatus shown in Fig. 4;

Fig. 7 is a view of the constant speed axle drive of the compressor shown in Fig. 4, together with a modified form of liquefying apparatus;

Fig. 8 is a wiring diagram of the apparatus shown in Fig. 7;

Fig. 9 is a modified form of liquefying apparatus;

Fig. 10 is another modified form of liquefying apparatus;

Fig. 11 is a view of one of the water throwers as shown in Fig. 9;

Fig. 12 is a side view of a two-way fan shown in Figs. 4, 6, 7, 9 and 10; and

Fig. 13 is a rear view of the fan shown in Fig. 12.

Briefly I have shown a portion of a railway passenger car having duct means **40** extending along the top of the car and duct means **36** extending beneath the floor of the car which is connected to a duct means in the upper portion of the car. The duct means in the top of the car has openings **42** in its bottom wall while the duct means **36** in the floor of the car have openings **38** underneath the seats of the car. Manually controlled dampers **56**, **58** and **60** are provided so that when the air is being heated a fan forces it out through the openings beneath the seat and the air is withdrawn from the car through the duct means in the top of the car. When the air is being cooled the air is supplied under a slight pressure to the duct means **40** in the top of the car and air is withdrawn from the car through the duct means **36** in the floor of the car.

A multiple refrigerating system is provided for supplying refrigeration to the car. This system has one evaporator **50** located in the air stream of the duct means provided with a fan

52 which circulates the air through the evaporator 50 and the duct means. Water is also sprayed upon this evaporator 50 and any surplus of the water, due to the added condensation of moisture derived from the air is discharged upon the condenser of the liquefying apparatus through a drain pipe such as pipe 91 shown in Fig. 4. During short periods when the car is standing and no electrical energy is available, cold water, which is cooled by a second evaporator 120 of the multiple system, is circulated over the face of the evaporator to supply cooling during such a period. If longer stops are necessary and the electric current is available, the compressor 82 may be driven by an electric motor supplied with such current.

In order to obtain better operation of the compressor, a constant speed variable ratio direct axle drive is provided and in order to make the condensers more efficient, water sprays are provided in order to make possible some evaporative cooling for condensers. Since the car may operate in either direction and the compressor and other apparatus is driven from the axle a two-way compressor and two-way fan together with dual condenser sprays are provided.

Referring now to the drawings and more particularly to the first three figures there is shown an end portion of a railway passenger car 20 having inner walls 22 and outer walls 24 which extend over the top of the car to provide a roof 28, which is insulated, and a ceiling 26. The floor of the car 30 is supported by the car frame 32 and is provided with a false floor 34 which provides two longitudinal ducts 36 at the floor level of the car. Beneath each of the seats this duct is provided with an apertured plate 38.

A duct 37 also extends longitudinally within the side walls upon each side of the car between the window-sill and the floor of the car. Each of these ducts 37 connects with the adjacent longitudinal duct 36 at various points along the car arranged in such a manner as to provide even distribution of air discharged from the apertured plates 38. One side of each of the ducts 37 is exposed to the interior of the car so as to readily emit or absorb heat, as the temperature conditions may require, from the interior of the car for providing greater comfort. Thus, in cold weather the side walls are kept comfortably warm by the ducts 37 which also, by natural convection of air, provide a stream of warm air flowing upwardly past the windows. In warm weather, the inner face of the side walls may be kept cool by the cool air flowing through the ducts 37.

Extending longitudinally along the top of the car is a second duct 40 provided with grilled or screened openings 42 at various points in its bottom wall. The ducts 36, located in the floor of the car upon opposite sides beneath the seats, through their connection with the longitudinal ducts 37 in the sides of the car are connected by a pair of upwardly extending ducts 44 extending between the inner and outer walls of the car to the duct means 40 at the top of the car. The duct means 44, and the duct means 40 are connected to a second duct means 46 also located in the top of the car substantially in alignment with the duct means 40.

Within this duct means 46 is provided an inner means 48 containing refrigerant evaporating means 50 and a continuously operable propeller type fan 52 for constantly blowing air through the inner duct means 48 and the evaporating means 50 into a common chamber 54 located at the intersection of the duct means 44 and 48. The chamber 54 is provided with manually controlled multiple dampers 56 at the entrance of the duct means 40 and is provided with manually controlled multiple dampers 58 at the entrance of each of the duct means 44. The duct means 44 are also directly connected to the duct means 46 through separated openings which may be closed by the manually operated dampers 60. The duct means 40 are also connected to the duct means 46 by a duct means 62 under the control of the manually operable and multiple dampers 64. Each of the duct means 44 are provided with heating coils 68. Fresh air to the system is provided by an opening 70 in the vertical end of the car connecting directly to the duct means 46 under the control of suitable multiple dampers 72. Also located within the duct means 46 is an insulated chamber 74 containing a holdover solution forming a portion of the system as shown in Fig. 4.

During the heating season, the dampers 56, 58 and 60 are in the position in which they are shown in Figs. 1, 2 and 3 of the drawings. The air flow during the heating season has been shown by means of arrows in Figs. 1, 2 and 3. Thus as shown in Fig. 2, the air to be heated enters the duct system through the openings 42 which are provided in the main ceiling duct 40. Inasmuch as the damper 56 is closed during the heating season, the air flowing through the duct 40 flows through the open damper 64 into the duct 62 (Fig. 2) which conveys the air into the fan chamber. As shown in Fig. 1, the air picked up by the fan 52 is discharged through the open dampers 58 into the ceiling air ducts 44 in which the heating coils 68 are located. The air ducts 44 communicate with the side ducts 37 whiich distribute the heated air to the outlet grills 38. During the cooling season the dampers 58 and 64 are closed and the dampers 56 and 60 are open. With this latter arrangement of the dampers, air is withdrawn from the passenger compartment of the car through the grills 38 and passes through the ducts 37 and 44 which convey the air to the fan chamber via the dampers 60. Inasmuch as the dampers 58 are closed, and the damper 56 is open during the cooling season, the air leaving the fan 52 discharges into the overhead duct 40 from whence the air is distributed into the passenger compartment through the grills 42.

In Fig. 4 the evaporating means 50 is connected by a return conduit 80 which extends downwardly to a refrigerant compressor 82 which compresses the evaporated refrigerant and forwards the compressed refrigerant through laterally extending conduits 84 and 86 to the dual condensers 88 and 90. The condensers are supplied with water from a water tank 92, located beneath the car and provided with air under pressure from the air-brake system through the air pipe 94. The tank 92 is connected by a downwardly extending water pipe 96 provided with a solenoid valve 98 and laterally extending conduits 102 and 104 which extend to the spray nozzles 106 for spraying water upon the condenser 88 and to the spray nozzles 108 which spray water upon the condenser 90 for evaporative cooling.

The compressed refrigerant is liquefied in the condensers 88 and 90 and is collected in the common receiver 110. From the common receiver liquid refrigerant is forwarded through the vertical supply conduit 112 to the branch supply con-

duit 114 provided with a solenoid valve 116 for controlling the supply of liquid refrigerant to the inlet of the evaporator. A thermostatic expansion valve 118 is also provided for controlling the flow of liquid refrigerant into the evaporator according to the temperature existing at the outlet of the evaporator.

Connected in parallel in refrigerant circuit relationship with the evaporator 50 is a second evaporator 120 which is located within the tank 74 which contains a suitable holdover solution. This second evaporating means is connected by the laterally extending refrigerant supply conduit 122 to the vertical refrigerant supply conduit 112 and has a thermostatic expansion valve 124 connected at the inlet of the evaporating means 120. This expansion valve 124 has its thermostat bulb 126 located within the tank 74 in contact with an outlet portion of the evaporator 120 so that it is responsive both to the outlet temperature of the evaporating means and to the temperature of the solution in the tank 74. The outlet of the second evaporator means 120 is provided with a check valve 128 connected by a laterally extending conduit 130 with the return conduit 80 which extends to the inlet of the compressor 82.

In order to provide better control of the humidity of the air in the car and also to provide means for cooling the car when the compressor is not in operation I have provided a liquid circuit which includes a collecting sump 132 located beneath the first evaporator 50 for collecting all moisture and liquid discharged from the exposed surfaces of the evaporator 50. This sump 132 is connected by a pump 134 which pumps the liquid through a circuit which includes a pipe 136, a two-way valve 138 and thence either through the pipe 140 to the interior of the tank 74, or through the vertical pipe 142 to a horizontal pipe 144 which extends from the top of the tank 74 to a discharge spray 146 located directly over the evaporators 50. A check valve 148 is provided for preventing the liquid tank 74 from being drained through the conduit 140. The liquid used in this liquid circuit may be ordinary water, or in some cases a brine or other type of solution may be employed if proper precautions are taken. However, for general use water is more practical, since it has a greater latent heat of fusion. A small amount of ethylene glycol may be provided in the water to prevent the water from freezing completely solid.

In operation water or other liquid in the tank 74 is supplied with refrigeration wherever available until the water or liquid congeals about the evaporating means 120 and the thermostat bulb 126. The expansion valve 124 is preferably set so that it will close when the water or other liquid used congeals about the bulb 126. This provides a reserve supply for refrigeration.

Referring now more particularly to Fig. 5 there is shown a portion of the electrical control circuit for the air conditioning apparatus which is connected by the conductors 150 and 152 to a source of electrical power such as the ordinary electric lighting circuits usually supplied with power from an axle-driven generator. A thermostat 154 is provided at some suitable place within the interior of the car and controls the flow of current from the conductor 150 through the conductor 156 and the conductor 158 to the solenoid refrigerant valve 116 while another conductor 160 at this same time energizes an electromagnetic switch 162 which controls the flow of current from the conductor 150 through the conductors 164 and 166 to the water pump 134 and the other conductor 152.

Thus when refrigeration is required the thermostat switch 154 closes, the solenoid valve 116 is opened while the electromagnetic switch 162 is closed to cause the operation of a water pump for pumping the liquid over the evaporator 50. The opening of the solenoid valve 116 will permit the normal supply of refrigerant to flow into the evaporator 50, which by the evaporation of refrigerant within the evaporator will keep the evaporator 50 at the proper temperature and will also keep the water cool, which circulates over the evaporator 50. The water circulating over the evaporator 50 acts as an air washer and removes dust, smoke and pollen from the air. A centrifugal switch 168 is provided which is either directly or indirectly responsive to the speed of either the compressor or axle. When the axle or compressor operates at a sufficient speed to supply proper refrigeration, the centrifugal switch 168 will close and permit electric energy to flow from the conductor 150 through the conductor 170 to the conductor 172 for energizing the solenoid of two-way valve 138. This will cause the valve 138 to be turned as shown in Fig. 4 to cause the water or liquid to be pumped directly from the sump 132 through pipes 136, 142 and 144 to the liquid spray 146 located above the evaporator, so long as the thermostat 154 is closed, to provide refrigeration in the evaporator 50 and to cause operation of pump 134. When the axle or compressor operates at insufficient speed to supply proper refrigeration, the centrifugal switch 168 will open thereby deenergizing the solenoid of the two-way valve 138. This will cause the valve 138 to be turned from its position shown in Fig. 4 so that the water or liquid will be pumped from the sump 132 through the pipes 136 and 140 into liquid tank 74 where it will mix with the holdover liquid previously cooled by the evaporator 120 and from which it will be discharged through the pipe 144 and the liquid spray 146 onto the evaporator 50. The liquid tank 74 has a comparatively large volume so that any surplus of refrigeration may be used to cool this water so that it will be cooled sufficiently to provide refrigeration for the car from the water spray which flows over the evaporator 50 during times when refrigeration is not available.

Inasmuch as the temperature of the coil 50 is frequently below the normal dew-point temperature of the air to be conditioned when the refrigerating system is in operation, a certain amount of moisture from the air will be removed by the coil 50 and this moisture will be added to the water in the sump 132. A drain pipe 91 causes any surplus water resulting from such condensation to be drained onto the condenser 88, thereby increasing the condensing capacity of the condenser.

The centrifugal switch also controls the flow of electric energy from the conductor 150 through the conductor 172 to the conductor 150 for energizing the solenoid 98 which permits the water to flow from the tank 92 to the condenser spray nozzles 106 and 108 for evaporative cooling of the dual condensers 88 and 90. The entire system may be controlled by a manual switch 174 provided in series with the conductor 152. Should no refrigeration be required in the passenger compartment, the thermostat 154 will permit the refrigerant valve 116 to close and the switch 162

to open to stop the water pump 134 so that no circulation of liquid will take place and all the refrigerant will be supplied to the evaporator 120 in the tank 74.

Fig. 6 shows the general lay-out of the liquefying apparatus shown in Fig. 4 and particularly shows the compressor drive and the air circulation therein. The compressor is provided with a five groove pulley 176 which is connected by five V-belts 178 to a drive pulley 180 located upon one end of a countershaft 182 which is provided at its opposite end with a three belt pulley 184 for connection with some suitable constant speed drive having a variable ratio driving connection with one of the axles of a railway car or other vehicle so as to drive the pulley 184 at a substantially constant speed regardless of the speed of rotation of the axle.

The liquefying apparatus is provided with an air-tight casing 186 which contains the compressor 82 and its drive mechanism as well as the dual condensers 88 and 90 which are located at the outlets of the sealed chamber 186 connected by ducts 188 and 190 to the screened outlets 192 and 194. The casing 186 is also provided with an opening 196 for a two-way fan 198 which is mounted upon the countershaft 182 half way inside the casing 186 and half way out. This two-way fan 198 is peculiar in that it is symmetrically shaped to provide substantially equal delivery of air in each direction of rotation. With this type of fan, when the car operates in one direction, the air will be forced through the condensers by the fan forcing the air into the casing 186; while the air will be drawn through the condensers in the opposite direction when the car operates in the opposite direction by the fan pulling the air out of the casing 186 and thereby creating a lesser than atmospheric pressure within the casing 186.

Efficient evaporative condenser cooling is very important for railway air conditioning since by the efficient use of a small amount of water, the compressor load and therefore the load upon the heavily loaded locomotive can thereby be reduced. I have found that the water sprays for evaporative cooling of the dual condensers do not operate efficiently in both directions when designed as shown in Fig. 6. I have therefore provided an improved arrangement in Fig. 7. In Fig. 7 the casing is designated by the reference character 286 and contains dual condensers 290 and 288 between which is located the compressor 282 driven from the shaft of an alternating current electric motor 302 which serves in place of the countershaft 182 and provides a pulley 280 for driving the compressor through three V-belts 278 and a pulley 276. Another V-belt 304 drives a countershaft 306 which is provided at its other end with a two-belt pulley 308 for driving a two-way fan 298 located within an aperture 296 in the wall of the casing directly adjacent one end of the compressor 282. The other end of the alternating current motor shaft of the alternating current motor 302 is provided with a three belt pulley 310 located outside the casing 286 for connection to the constant speed axle-driven drive means.

In Fig. 7 there is shown a frame member 312 which is connected to the frame of one of the trucks of a railway passenger car or possibly a refrigerator car. Such a truck is provided with an axle 314 upon which is mounted the variable ratio constant speed device for changing the variable speed of the car axle into a constant speed drive. This is desirable because of the fact that refrigeration requirements are substantially the same regardless of the speed of the car and also because it is desirable to operate the compressor at a speed which will provide the greatest capacity obtainable after giving due consideration to efficiency and long life. I have provided a novel form of constant speed drive which includes a cone-shaped driving member 316 provided upon the car axle and a driven cone member 318 mounted upon a countershaft 320 which is supported upon bearing bosses 322 and 324 formed as a part of the frame member 312. Between the driving and driven cone members 316 and 318 is an intermediate idler pulley 326 freely rotatable upon the end of a non-rotatable but slidable shaft 328 which is slidably mounted in the bearing boss 322.

Since the cone-shaped members 316 and 318 have their small ends facing in opposite directions it will be understood that when the pulley 326 is between the small portion of the cone 316 and the large portion of the cone 318, several revolutions of the axle 314 will be required to drive the countershaft 320 through one revolution. Also it will be noted that when the idler pulley 326 is located between the large portion of the cone members 316 and the small portion of the cone member 318, one revolution of the axle 314 will provide several revolutions of the countershaft 320. I take advantage of a varying driving ratio which can be obtained by such mechanism to maintain the countershaft 320 rotating at a constant speed so long as the axle 314 rotates at a sufficient speed to bring it within the possibilities of this mechanism.

In order to drive the countershaft 320 at a constant speed I provide a centrifugal means operated by the axle for moving the idler pulley 326 toward the large end of the cone member 316 when the axle 314 rotates at a slow speed, and for moving the idler pulley 326 toward the small end of the cone member 316 when the axle 314 rotates at a high speed. To this end I provide a sleeve 330 which is clamped upon the axle shaft 314 by binding the clamps 332. This sleeve 330 has a collar 334 fixed thereto which is provided with pivot bosses 336 to which are pivoted the arms of the fly-ball members 338. The arms of the fly-ball member 338 are connected by links 340 to a collar 342 slidably mounted upon the sleeve 330. This collar 342 is provided with a groove 344 which receives a roller mounted upon one end of the lever 346 which is pivoted to an extending portion of the projection 322. The opposite end of the lever 346 is provided with a slotted end 348 which receives a roller 350 provided at the end of the slidable shaft 328 upon which is mounted the idler pulley 326.

A compression type coil spring 352 is provided for opposing the centrifugal action of the fly-ball members 338 and particularly for pulling the idler pulley 326 toward the large end of the cone member 316 when the speed of rotation of the axle 314 and the centrifugal force of the fly-ball 338 is relatively small. When the speed of the axle increases, the fly-ball members 338 will develop a greater centrifugal force thus overcoming the spring 352 and pushing the idler pulley 326 toward the small end of the cone member 316 in accordance with the increasing speed of the axle 314. By such a device within the possibilities of the ratio provided by the cone members 316 and 318 the countershaft 320 is driven at a substantially constant speed. This countershaft

320 is provided with a grooved pulley 354 which through the medium of three V-belts 356 connected to the pulley 310 drives the compressor 282.

It will be seen by this arrangement that the compressor 282 will be driven in one direction when the car is pulled in one direction and the compressor will be driven in the opposite direction when the car is being pulled in the opposite direction. Reciprocating compressors can readily be made which can operate in both directions with substantially equal facility. The fan 298, however, reverses the direction of air flow when this reversal of drive takes place. In order to provide efficient evaporative cooling of the dual condensers 288 and 290 it is necessary to take in account this reversal of direction of cooling air through the dual condenser. When the car moves in one direction the fan 208 will force air into the casing 286 into the portion of the casing containing the motor 302 and the compressor 282 from which a portion of air will flow in opposite directions through the dual condensers 288 and 290 and out the grilled or screened openings 358 located at the opposite ends of the casing.

When the car is pulled in the opposite direction the fan 298 will create a lower pressure within the casing containing the compressor 282 and the motor 302. This will cause air to flow into the casing through the grilled or screened openings 358 and thence through the dual condensers 288 and 290 into the portion of the casing occupied by the motor and compressor.

In order to properly apply water to these condensers in both directions I have provided two sets of spray systems, one of which includes the nozzles 360 and 362 located in the central portion of the casing 286 and a second set of nozzles 364 and 366 which are located in the end portions of the casing 286 upon the opposite sides of the dual condensers. I then provide a two-way rotary valve 368 which supplies water to the spray nozzles 364 and 366 when the fan 298 draws air into the casing 286 through openings 358 and discharges the air out through the fan opening 296. When the car is pulled in the opposite direction the fan 298 rotates in the opposite direction and pulls air into the casing 286 through the fan opening 296 and discharges the air from the casing through the openings 358. When the air is discharged from the openings 358, the valve 368 will cause the water to be supplied to the nozzles 360 and 362. The valve 368 is controlled by an electrical operating mechanism 370 which is supplied with direct current through conductor means 372 which connects to a small generator 374 which is directly connected to the countershaft 320 through coupling 376 for the purpose of controlling the valve 368 in accordance with the direction of rotation of the countershaft 320. The generator 374 is preferably of a simple direct current type which is adapted to reverse the flow of current upon a change in the direction of its rotation. The electrical operating mechanism 370 is preferably like an ordinary direct current motor excepting that it is provided with a battery operated field so that it will turn in opposite directions according to the direction of the flow of current provided by the generator 374. The valve 368 is preferably provided with stops, so as to stop its rotation by the operating means 370 when it reaches the positions at which it connects with the sprays 360 and 362 at one position and 364 and 366 at the other position. The operating mechanism 370 is preferably made so as to receive whatever current is generated by the generator 374 even when the operating mechanism 370 is stalled.

The alternating current motor 302 is provided for the purpose of driving the compressor 282 when the car stands, usually at a station, for a suitable period of time, much longer than the holdover tank 74 can supply adequate refrigeration under normal circumstances. This motor 302 does not necessarily have to be an alternating current motor, but should be a motor which can operate upon a source of electric energy available at the stations where it is to be used. However, since it is customary to have available three phase alternating current at railway stations, such a motor is shown herein.

Referring now to Fig. 8 which shows a wiring diagram of a portion of the control system, the electric motor 302 is shown provided with a three phase system of conductors 378 which connects to a relay 380 which in turn connects to a three-phase connecting plug 382 for convenient connection with the three-phase source of power. The closing of the relay 380 is controlled by the energization of its operating solenoid 384 which is connected by its conductors 386 with supply conductors 388 and 390 when the thermostat 392 is closed. The thermostat 392 is preferably responsive to the car temperature. The direct current generator 394 which is usually provided for lighting purposes serves to supply the energy to the supply conductor 388 and 390 and also supplies energy to the battery 396 connected in parallel with the generator 394 so that it may receive energy from the generator when the generator is in operation and so that it may supply energy when the generator is not in operation.

When the relay switch 380 is closed a second relay switch 398 is opened. This second relay switch 398 is connected through the electric circuit 402 to two wires of the three-phase conductors 378. The relay 398 controls the flow of energy through the conductors 404 and 406 to an electromagnetic valve 408 which controls the supply of air through an air pipe 410 to a bellows 412 which operates a clutch 414 provided on the countershaft 320 between the projection 324 and the pulley 354. When the magnetic valve 408 is energized by the closing of the thermostat 392 and the relay 398, the valve opens to permit air to be supplied through the pipe 410 to the bellows 412 to cause the clutch 414 to be closed. Thus, when either of the switches 392 or 398 is open, the valve 408 closes, vents the air from the bellows 412 and the clutch 414 opens. Thus when the car is standing and the motor 302 is energized the switch 398 opens to cause the clutch 414 to be opened thus releasing the drive mechanism for the compressor from a constant speed drive mechanism connected to the axle. Under such conditions the thermostat 392 controls the operation of the motor 302 through the relay switch 380.

In Fig. 9 a different sort of evaporative condenser system is shown provided for the liquefying unit shown in Fig. 4. In this system the overflow from the sump 132 connects with piping 410 which extends downwardly at its opposite ends to sumps 412 and 414 which are provided beneath the condensers 488 and 490. The refrigerated water spray collects a considerable portion of the moisture from the air to provide the sump 132 with a supply of water for condenser cooling purposes. The casing 486 is provided with a fan opening 496 for the two-way

fan 498 which has the drive pulley 480 connected by belting 478 to the compressor pulley 476 for driving the compressor 482. The compressor supplies the dual condensers 488 and 490 with compressed refrigerant through the piping 484. In order to supply water to the dual condensers 488 and 490 for condensing purposes, a water slinger 406 is provided in the form of a wheel which has its rim dipping into the water which collects in the sump 412. The slinger 406 is driven through the flexible shaft extending through a casing 412 to a gear 414 which meshes with the gear 416 upon the shaft of the pulley 480. Another gear 418 meshes with the gear 416 upon its opposite side and drives a flexible shaft within the casing 420 which is connected at its opposite end to the slinger 408 also in the form of wheel having its rim dipping into the water in the sump 414. Each slinger throws films of water up in front of the condensers which are carried by the movement of air created by the fan 498 through the condensers. The slinger 406 is better shown in Fig. 11. Pans may be provided upon the opposite sides of the condensers to collect the excess water and return it to the sump.

In Fig. 10 I show a more elaborate and more efficient form of an evaporative condenser for the liquefying apparatus shown in Fig. 4. In this form the outlet of the compressor 582 is connected by piping 584 with coils 502, 504 and 506 arranged in water collecting basins 508, 510 and 512 located upon one set of the dual condensers 588 while coils 514, 516 and 518 are located in water collecting basins 520, 522 and 524 upon the extreme opposite side of the dual condenser 590. These coils are also connected to the compressor by piping 584. On each side the collecting basins are provided with serially arranged overflow pipes arranged in cascade fashion in order to maintain a sufficient supply of water to cover the coils and to carry away any surplus to any coils requiring such a surplus. These collecting basins collect any water which passes through the dual condensers from the spray nozzles 526 and 528 located upon the opposite sides of the dual condensers. Thus a very efficient use of the water or evaporative cooler is made. The serpentine coils 502, 504 and 506 remove the superheat from the compressed refrigerant and then the compressed and cooled refrigerant is conducted upwardly through the conduit 530 to the top of the dual condenser 588 while the refrigerant cooled by the serpentine coils upon the opposite side of the unit is carried up through the conduit 532 to the top of the companion dual condenser 590.

In Figs. 12 and 13 is shown the two-way fan which has also been shown upon a smaller scale in Figs. 4, 6, 7, 9 and 10. In this fan 4, 6 or 8 blades are usually provided upon a 4, 6 or 8 arm spider 602 which is provided with a hub and mounted upon the fan shaft. The arms of the spider are set at an angle of about 30° and the blades 604 are riveted to the arms of the spider. In order to make the structure more rigid, the arms of the spider extend upon both sides of the plate and the rivets go completely through both portions of the spider and the blade for firmly holding the blades. The blades taper from the center to the outside and are provided with bent edges 606 and 608 upon their forward and trailing edges. These bent edges are bent substantially in the plane of rotation of the fan and serve to make the fan efficient in operating in both directions of rotation and also serve to stiffen the fan blades. In order to get equal delivery from the fan in opposite directions the fan is placed exactly central with respect to the casing 686 and the plane intersecting the middle of the blades also intersects the adjacent portions of the casing wall.

Thus it will be seen that I have provided an improved highly efficient railway air conditioning system with common duct means and air circulating means for both winter and summer operation requiring heating and cooling, and I have provided a mechanical drive from the axle to the compressor through the medium of a constant speed device for providing a simple relatively inexpensive drive for the compressor, and I have also provided means for supplying refrigeration during both short and long periods when the car is not in operation.

While the form of embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. An air conditioning system including a first and a second cooling means, means for circulating air in heat exchange relation with said first cooling means, a liquid container in heat exchange relation with said second cooling means, means for circulating liquid from said liquid container into heat exchange relation with said circulating air when said first cooling means is not effective, and means for by-passing said liquid container and circulating the liquid into heat exchange relation with the first cooling means and the circulating air when the first cooling means is effective.

2. An air conditioning system including a first and a second cooling means, means for circulating air in heat exchange relation with said first cooling means, a liquid container in heat exchange relation with said second cooling means, a circuit for conducting liquid from said liquid container into heat exchange relation with said first cooling means and the circulating air and returning the liquid to the liquid container, said circuit being provided with a by-pass around said liquid container, means for circulating liquid through said circuit, and means for controlling the by-passing of said liquid container by the liquid.

3. An air conditioning system including a first and a second cooling means, means for circulating air in heat exchange relation with said first cooling means whereby said air is cooled and moisture is condensed onto said first cooling means, a liquid container in heat exchange relation with said second cooling means, a circuit for conducting liquid from said liquid container into heat exchange relation with said first cooling means and the circulating air and returning the liquid and condensate to the liquid container, said circuit being provided with a by-pass around said liquid container, means for circulating liquid through said circuit, and means for controlling the by-passing of said liquid container by the liquid, a liquefying means for supplying refrigerant to and for withdrawing refrigerant from said cooling means, and means for conducting a portion of liquid from said circuit into heat exchange relation with said liquefying means.

4. An air conditioning system including a first and a second cooling means, means for circulating air in heat exchange relation with said first cooling means whereby said air is cooled and

moisture is condensed onto said first cooling means, a liquid container in heat exchange relation with said second cooling means, a circuit for conducting liquid from said liquid container into heat exchange relation with said first cooling means and the circulating air and returning the liquid and at least a portion of the condensate to the liquid container, said circuit being provided with a by-pass around said liquid container, means for circulating liquid through said circuit, and means for controlling the by-passing of said liquid around said liquid container, a liquefying means for supplying refrigerant to and for withdrawing refrigerant from said cooling means, means for conducting a portion of the liquid from said circuit into heat exchange relation with said liquefying means, a variable speed source of power, a constant speed driving mechanism connecting said source of power to said liquefying means, said means for controlling the by-passing of the liquid being responsive to the speed of said variable source of power.

5. In combination with a vehicle, means for circulating a stream of air for said vehicle, means for cooling said air, first and second liquid sumps, means for cooling the liquid in the first of said sumps, means for spraying liquid from said first sump into said air stream when said air cooling means is inoperative to cool said air, and means for spraying liquid from said second sump only into said air stream when said air cooling means is operative to cool said air.

6. In combination, air cooling means, means for flowing air to be conditioned in thermal exchange relationship with said cooling means, a first liquid sump, a second liquid sump, means for changing the temperature of the liquid in said first sump, means for circulating liquid from said first sump into thermal exchange with said air stream when said air cooling means is inoperative to cool said air, and means for spraying liquid from said second sump only into said air stream when said air cooling means is operative to cool said air.

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