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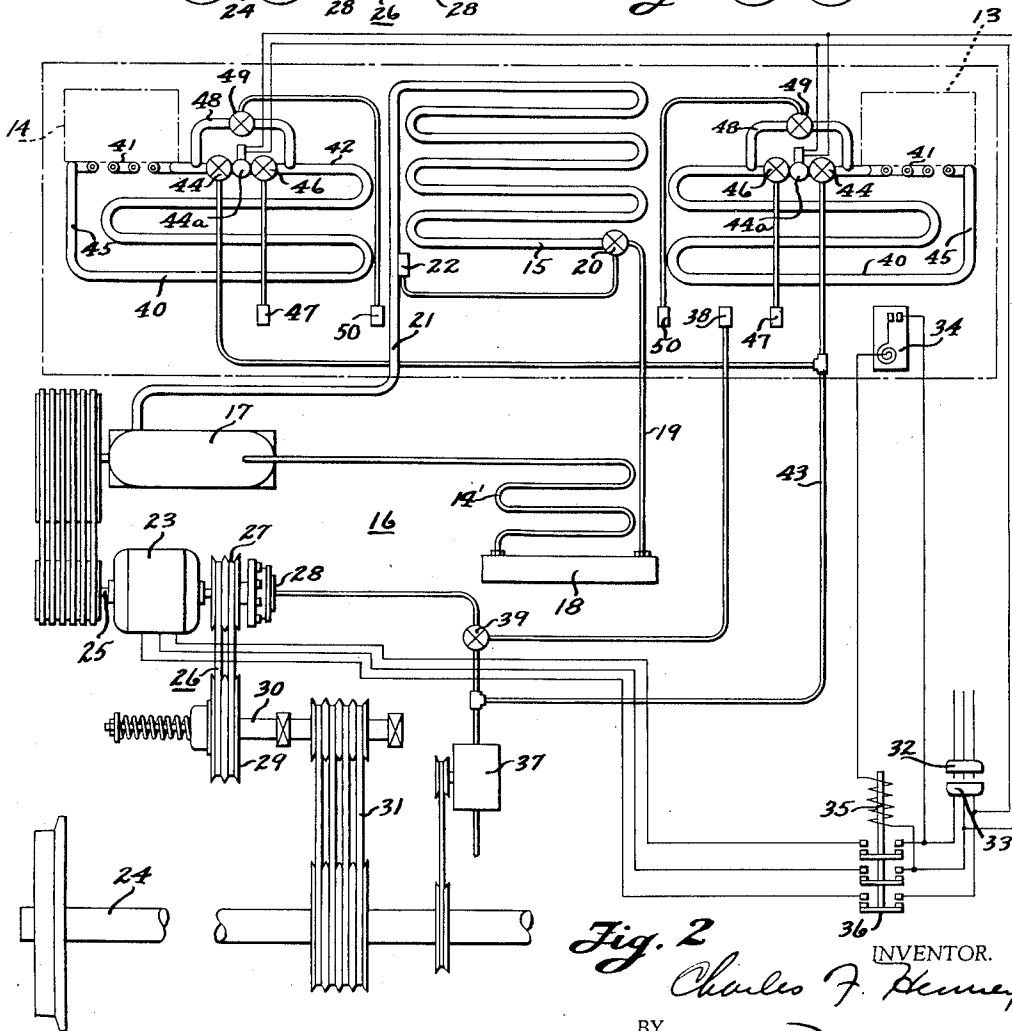
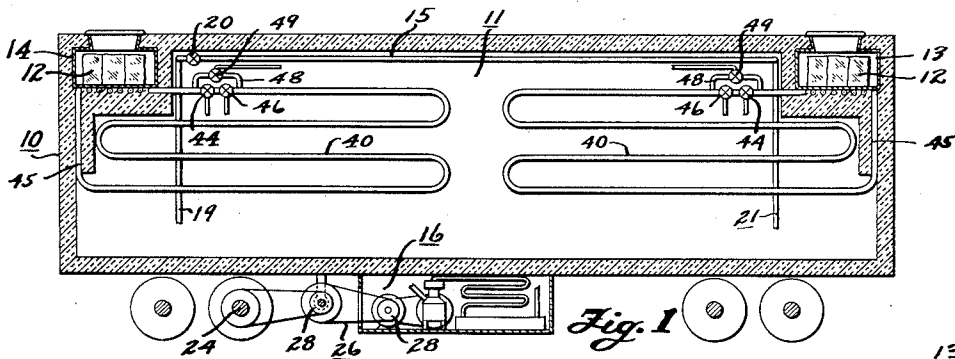
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2,187,569

REFRIGERATING APPARATUS

Filed June 29, 1935

3 Sheets-Sheet 1



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2,187,569

REFRIGERATING APPARATUS

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3 Sheets-Sheet 2

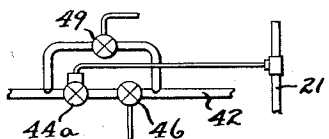
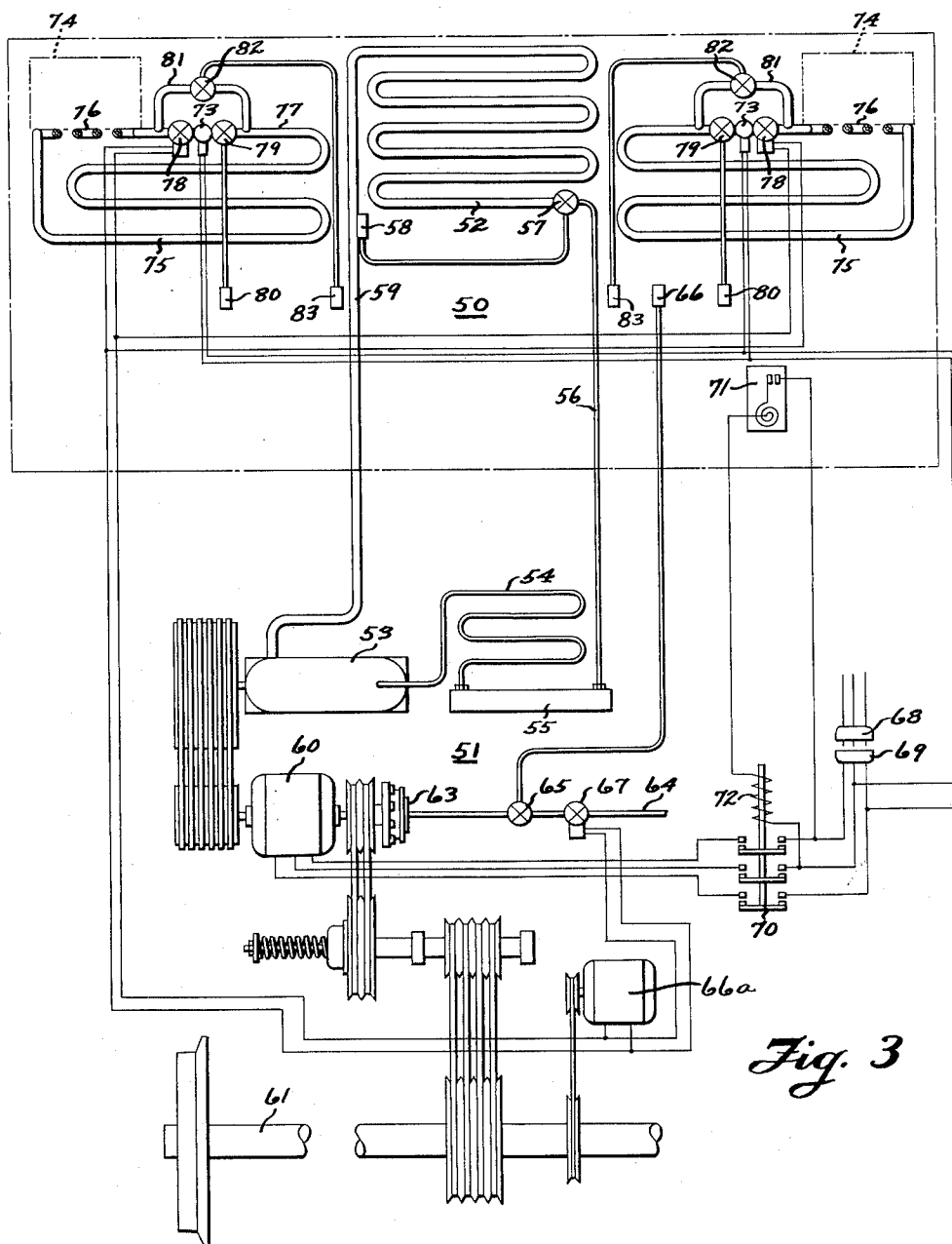


Fig. 4

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3 Sheets-Sheet 3

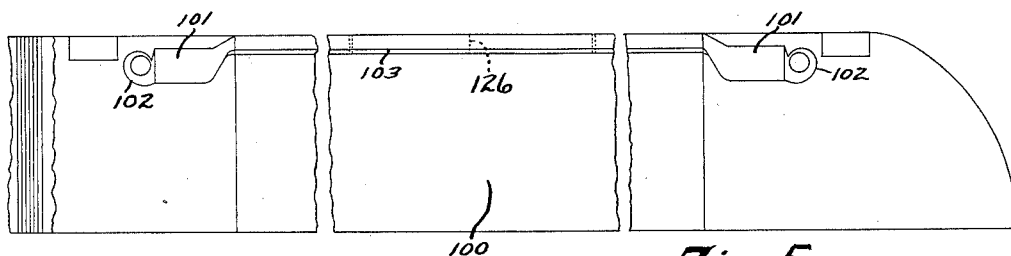


Fig. 5

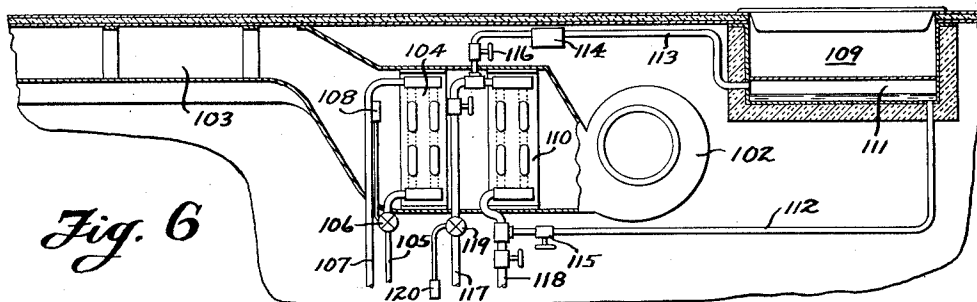


Fig. 6

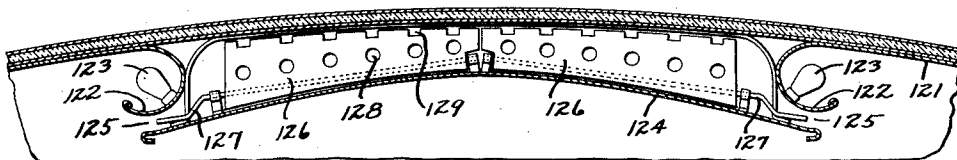


Fig. 7

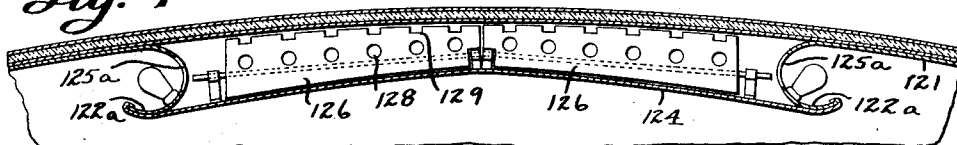


Fig. 8

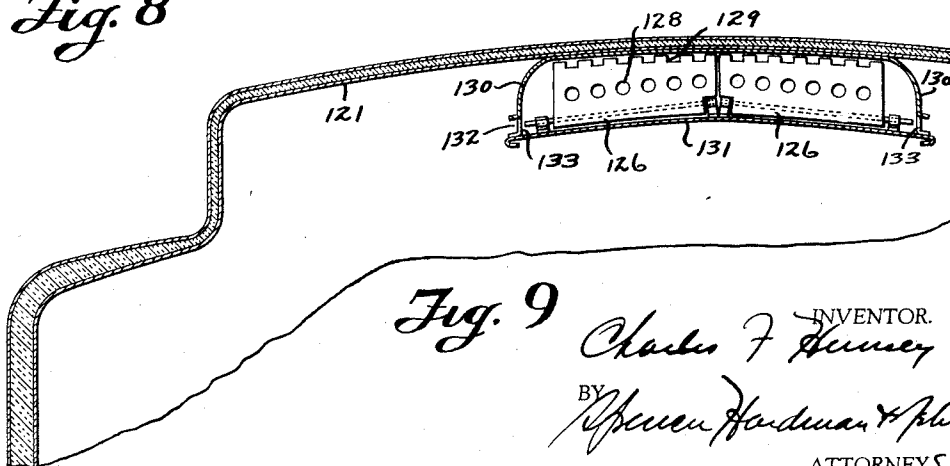


Fig. 9

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REFRIGERATING APPARATUS

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Application June 29, 1935, Serial No. 29,118

18 Claims. (Cl. 62—6)

This invention relates to refrigeration.

An object of this invention is to provide an improved system of cooling a compartment in which the air for the compartment is cooled by a mechanical refrigerating system as long as sufficient energy is available for operating the mechanical refrigerating system and in which a stored refrigeration is utilized for cooling the air for the compartment when the energy is insufficient.

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 vertical cross-sectional view, somewhat diagrammatic, showing portions of the cooling apparatus as applied to a car;

Fig. 2 is a diagrammatic representation of a way of operating the mechanical refrigerating system together with controls therefor;

Fig. 3 is a view, somewhat similar to Fig. 2, but showing a modified form of the invention;

Fig. 4 is a modified form of a portion of the apparatus shown in Fig. 2;

Fig. 5 is a diagrammatic representation of another embodiment of the invention applied to a passenger car;

Fig. 6 is an enlarged cross-sectional view of a portion of Fig. 5;

Fig. 7 is an enlarged transverse cross-sectional view of the duct shown in Fig. 5;

Fig. 8 is a view somewhat similar to Fig. 7 but showing a slight modification; and

Fig. 9 is a view somewhat similar to Fig. 7 but showing the invention applied to a slightly different type of car.

A car 10 is provided with a compartment 11 to be cooled. The air for this compartment may be cooled by a primary refrigerating system or by refrigeration from a secondary refrigerant, such as solid carbon dioxide, 12 introduced into the receptacles 13 and 14 at each end of the car. The arrangement is such that the mechanical refrigerating system provides refrigeration so long as sufficient power is available therefor and the carbon dioxide provides refrigeration when such power is insufficient.

The mechanical refrigerating system may include a refrigerant evaporator 15 and a refrigerant liquefying unit 16, these being connected in primary refrigerant flow relationship. The liquefying unit may include a compressor 17 discharging into the condenser 14 provided with a liquid

refrigerant receiver 18. From thence liquid refrigerant flows through the line 19 past an automatic expansion valve 20 to the evaporator 15 from whence it returns to the compressor through the line 21. The valve 20 may be of the type which automatically introduces refrigerant into the evaporator when the pressure therein is reduced below a predetermined limit by the compressor. A thermostatic bulb 22, placed near the outlet of the evaporator, automatically throttles the valve 20 when the refrigerating effect in the evaporator reaches the bulb 22. The compressor 17 is driven either by an electric motor 23 or from a live axle 24 of the car. The shaft 25 is drivingly connected to the rotor of the motor 23 and also to an automatically regulated constant speed drive 26. The driven member 27 of the constant speed drive is connected to the shaft 25 through the medium of a clutch 28. The driving member 29 is carried on the jackshaft 30 swingingly carried on the framework of the car and is in turn driven by means of the belts 31 from the live axle 24. The motor 23 may be connected to a source of electricity, such as a central power line by means of a plug 32 25 which may be inserted into the receptacle 33. When this connection is made the thermostatic switch 34 controls the relay 35 and controls the switch 36 between the power house and the motor 23. Thus the motor is controlled in accordance with temperatures in the compartment 11 when it is connected to the source of electricity.

When the compressor 17 is to be driven from the live axis 24, the car is operating at a sufficient speed to cause the air compressor 37 to force air to the pneumatic clutch 28 thus engaging the clutch and causing the live axle 24 to drive the compressor 17. An automatic control, responsive to conditions in the compartment 11, is provided for regulating the refrigerating power 40 of the mechanical system in accordance with refrigeration demands. Thus a thermostatic bulb 38 governs a valve 39 which in turn governs the flow of air to the clutch 28. When the temperature in the compartment 11 has risen to a 45 predetermined limit the bulb 38 causes the shaft 24 to drive the compressor 17 and when the temperature is reduced to another predetermined limit the drive is disengaged at 28 by the closing of the valve 39.

Means are provided for causing the carbon dioxide 12 to cool the air for the compartment 11 when the mechanical refrigerating system is not operating or lacks sufficient refrigerating capacity for the demands upon it. This means may take

the form of a secondary refrigerant system including a secondary evaporator 40 and a secondary condenser 41. The condenser 41 is in thermal contact with the floor upon which the carbon dioxide rests. Volatile secondary refrigerant condensed at 41 flows in liquid form into the evaporator 40 and returns in gaseous form through the line 42 to be reevaporated and returned to the condenser 41. Means are provided for throttling this cooling action both when the mechanical refrigerating system is operating and also in accordance with refrigerating demands when the mechanical refrigerating system is not operating. This may be accomplished by properly throttling the return line 42. When the live axle 24 operates the compressor 37 at proper speed, the air pressure in the line 43 is exerted upon a valve 44 which throttles the line 42. This causes secondary liquid refrigerant to be forced out of the evaporator 40 and up through the riser 45 where it is not available for cooling air. The line 42 also is throttled by the valve 46 in response to impulses from the thermostatic bulb 47 in the compartment 11. When the car slows down or stops and opens the valve 44, the valve 46 takes command under the control of bulb 47 and regulates the operation of the secondary refrigerating system in accordance with temperature conditions in the compartment 11. A by-pass 48 is provided and includes a valve 49 which is controlled by a thermostatic bulb 50. The calibration of the bulb 50 is such that if the temperature in the compartment 11 rises above that set for the bulb 38 or switch 34, then the by-pass 48 is fully opened and thus the cooling power of the carbon dioxide 12 is made available to aid in cooling the compartment 11 when the mechanical refrigerating system lacks sufficient power to refrigerate properly. The opening and closing limits of the valve 49 are so calibrated that they close at a temperature slightly above that at which the thermostats 38 or 34 energize the mechanical refrigerating system.

When connection is made at 32—33, the main passage of secondary refrigerating system is automatically closed. This may be accomplished by a solenoid valve 44a which is energized when the connectors 32—33 are brought together. The valve 44a closes when energized and thus the main passage of secondary system is closed as long as electric energy is available for the motor 23.

Under some conditions one receptacle 14 and one secondary refrigerating system is sufficient; but I have shown a twin construction at each end of the car, it being understood that the operation of both parts are exactly the same.

In the modification shown in Fig. 3 the compartment 50 of a car is provided with refrigerating means somewhat similar to those heretofore described. Thus a mechanical refrigerating system includes a refrigerant liquefying unit 51 and an evaporator 52. The liquefying unit includes a compressor 53, condenser 54 and receiver 55. Valve 57, similar to valve 20, is controlled by a bulb 58 similar to the bulb 22. Evaporated refrigerant returns through the line 59. The compressor 53 is driven either by motor 60 or from a live axle 61. The pneumatic clutch 63 is substantially similar to the clutch 28 but in this case is under the control of the regular air brake system through the air line 64. The valve 65 is operated by a thermostat 66 in the compartment 50 so that when the temperature rises to a predetermined limit air is admitted to the clutch 63 and it is engaged to drive the compressor 53

from the axle 61. This is only possible, however, when the axle 61 is operating at a predetermined speed such that it rotates the generator 66a fast enough to open the solenoid valve 67. When the car stops at the station, the connector plug 68 from the power house may be connected to the receptacle 69 which provides leads to the motor 60 which include the switches 70. When connection is made at 68 and 69 the thermostatic switch 71 controls the relay 72 and thus controls the motor 60 through the switches 70. At the same time this connection at 68 and 69 throttles the secondary refrigerant system through the medium of solenoid valves 73. When the car is standing still the solenoid valve 67 is closed and thus the clutch 63 is disengaged so that the motor 60 can drive the compressor 53.

When the car slows down or is standing still and no connection is made at 68 and 69 the carbon dioxide in the receptacles 74 is caused to cool air for the compartment 50. This is accomplished by causing the secondary refrigerant system to operate under these conditions. The secondary refrigerant system includes an evaporator 75 and a condenser 76 substantially the same as heretofore described. The gas return line 77 is provided with solenoid valves 73 and 78 and a thermostatic valve 79. The valve 78 opens when the car slows down or stops because the generator 66 lacks sufficient speed to close the valve. The valve 79 is operated in accordance with conditions in the compartment 50 through the medium of the thermostatic bulb 80 opening when the temperature reaches a predetermined limit and closing at a lower limit. A by-pass 81 is provided which is similar to the by-pass 48 and is provided with a valve 82 and bulb 83 similar in function and calibration to the valves 49 and bulb 50 of Fig. 2 for causing the carbon dioxide to aid the primary mechanical system if it lacks sufficient refrigerating capacity.

The arrangement of Fig. 3 is such that the mechanical refrigerating system provides refrigeration for the air so long as the temperature in the compartment 50 requires it and so long as the axle 61 has sufficient speed or the connectors 68 and 69 are connected. During that period the secondary system is inoperative because one or the other of the valves 73 or 78 are closed. However, when the car stops and connections are not made at 68 and 69 the secondary refrigerating system causes the carbon dioxide to cool the air for the compartment 50 under the control of the thermostat 80. This tends to maintain desired temperatures in the compartment 50. The thermostat 83 occasionally causes the secondary system to operate even when the mechanical refrigerating system is operating; but this occurs only when the mechanical refrigerating system lacks sufficient capacity to refrigerate properly the compartment 50.

In the modification shown in Fig. 4, the control of the secondary system shown in Fig. 2 is slightly modified. The valves 46 and 49 operate as previously described. However, the valve 44 is operated in response to suction pressures in the return line 21 rather than in response to air pressures in the line 43. Thus the return line 42 of the secondary system is throttled so long as the mechanical refrigerating system can maintain a sufficiently low back pressure in the line 21. However, when the mechanical system stops, the pressure in 92 rises and this rise in pressure opens the valve 44 to place the secondary system under the control of the thermostatic valve 46.

The solenoid valve 44 may be omitted, if desired, in this modification. All other parts of the system to be used with the apparatus shown in Fig. 4 are substantially the same as that shown in Fig. 2.

This invention may also be applied to railway passenger cars and the like. In the embodiment shown in Figs. 5 to 9 inclusive, air for the compartment 100 is conditioned in the conditioning compartment 101. Air is forced through this compartment by means of a fan 102 and is delivered to a distributing duct 103 running along the roof of the car. A single treating zone or conditioning compartment may be used or two such compartments, one at each end of the car, may be used as indicated in Fig. 5. The mechanical refrigerating system may include a mechanical refrigerant liquefying unit operated from a live axle and from a stand-by motor substantially as indicated in Figs. 2 and 3. Such a liquefying unit may be connected in primary refrigerant flow relationship with a primary evaporator 104. Liquid refrigerant enters the evaporator 104 through the line 105 past an expansion valve 106 and returns in gaseous form through the line 107 to the liquefying unit. The valve 106 may be substantially the same in construction and action as the valve 20 and may be provided with a bulb 108 controlling the valve similarly to the bulb 22. Air for the compartment 100 is forced past the vertical fins in the transverse pipes of the evaporator 104 and is cooled thereby and is thereafter distributed by the duct 103.

The air may also be refrigerated from a secondary refrigerant, such as solid carbon dioxide, placed in the receptacle 109. Means for causing the carbon dioxide to refrigerate the air may be provided. This may take the form of a closed secondary refrigerant system including a secondary evaporator 110 and a secondary condenser 111. Liquid from the condenser 111 flows through the line 112 and gaseous refrigerant returns through the line 113. The square 114 represents diagrammatically valves and by-pass similar to 44, 44a, 46, 48 and 49 of Fig. 2 so as to control the action of the secondary refrigerating system in a similar manner to that described with respect to Fig. 2.

In the winter time the secondary evaporator 110 may be used to heat the air. This may be accomplished by closing the valve 115 then placing solid carbon dioxide in 109 and causing the entire charge of secondary refrigerant to be trapped in the condenser 111. Thereafter the valve 116 may be closed and steam from the train line may be introduced into the evaporator 110 through the line 117. The condensed steam may flow by gravity through the line 118 to the usual automatic steam trap for discharging condensed water. The flow of steam into the evaporator 110 may be controlled by a valve 119 actuated from the thermostatic bulb 120 placed in the compartment 110.

The distributing duct 103 may be of any suitable construction. Thus the ceiling member 121 of the car may have a portion 122 curled around to provide an indirect lighting shield for the lights 123. A duct floor 124 is supported underneath so as to form a continuous discharge opening 125 along the length of the duct between the floor 124 and the shield 122. The cooled air is thus discharged through the opening 125 all along the length of the car. In order to insure a more even distribution of the air, baffles 126

are mounted on the rods 127 so that the baffle may be adjusted to build more or less pressure as desired along the opening 125. The baffle 126 may be provided with openings 128 along the main body thereof and also with openings 129 along the top.

In the modification shown in Fig. 8 the construction is substantially the same as in Fig. 7 except that instead of having opening 125 along the bottom, the shield 122a may be provided with an opening 125a along the length of the car, so that the cooled air is discharged at this point instead of at the bottom of the duct.

In the modification shown in Fig. 9 the duct may be formed of an inverted U-shaped channel 130 cooperating with the floor 131 and forming the discharge opening 132 along the length of the car and along the bottom of the distributing duct. The floor 131 may be supported by brackets 133 placed at intervals along the length of the car. The baffle arrangement is substantially the same as described with respect to Fig. 7.

The primary refrigerant evaporators may be placed in the car substantially in the same position as those shown in my copending application for Refrigerating apparatus, Serial No. 29,119, filed concurrently herewith. The evaporators of the secondary system may be placed in positions corresponding to the secondary evaporator in that application.

While the form of embodiment of the 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. In a car, a live axle, a refrigerant liquefying unit drivably connected to said axle, a compartment to be cooled, an evaporator disposed to cool air for said compartment, refrigerant flow connections between said evaporator and unit, an independent secondary refrigerant receptacle, means for cooling air for said compartment from secondary refrigerant in said receptacle, means for controlling the cooling of air by said secondary refrigerant in accordance with the operation of said live axle, and means for controlling the cooling of air by said evaporator in accordance with conditions in said compartment.

2. In a car, a live axle, a refrigerant liquefying unit drivably connected to said axle, a compartment to be cooled, an evaporator disposed to cool air for said compartment, refrigerant flow connections between said evaporator and unit, an independent secondary refrigerant receptacle, means for cooling air for said compartment from secondary refrigerant in said receptacle, means for controlling the cooling of air by said secondary refrigerant in accordance with conditions in said compartment, and means for controlling the cooling of air by said secondary refrigerant in accordance with the operation of said live axle.

3. In a car, a live axle, a refrigerant liquefying unit drivably connected to said axle, a compartment to be cooled, an evaporator disposed to cool air for said compartment, refrigerant flow connections between said evaporator and unit, an independent secondary refrigerant receptacle, means for cooling air for said compartment from secondary refrigerant in said receptacle, means causing the cooling of air for said compartment by said secondary refrigerant when said evaporator lacks sufficient refrigerating capacity to cool said compartment, said last named means

including means under the control of the movement of said car.

4. In a car, a live axle, a refrigerant liquefying unit drivably connected to said axle, a compartment to be cooled, an evaporator disposed to cool air for said compartment, refrigerant flow connections between said evaporator and unit, an independent secondary refrigerant receptacle, means for cooling air for said compartment from secondary refrigerant in said receptacle, means controlling the operation of said compressor from said live axle in accordance with refrigeration demand, and means causing the cooling of air by said secondary refrigerant when said evaporator lacks sufficient refrigerating capacity to cool said compartment and tending to prevent such cooling when said evaporator has sufficient capacity.

5. In a car, a live axle, a refrigerant liquefying unit drivably connected to said axle, a compartment to be cooled, an evaporator disposed to cool air for said compartment, refrigerant flow connections between said evaporator and unit, an independent secondary refrigerant receptacle, means for cooling air for said compartment from secondary refrigerant in said receptacle, means controlling the operation of said compressor from said live axle in accordance with refrigeration demand, and means whereby the air may be cooled by said secondary refrigerant when the speed of said live axle drops below a predetermined value.

6. In a car, a compartment on said car, a live axle, a refrigerant liquefying unit, a drive having a clutch between said axle and said unit, an evaporator connected in refrigerant flow relationship with said unit and disposed to cool air for said compartment, means for controlling said clutch in accordance with refrigeration demand, means for receiving a secondary refrigerant medium and for the cooling of air for said compartment by said medium, means tending to reduce the cooling of air by said medium when said live axle is operating at a sufficient speed, and means controlling the cooling of air by said medium when said live axle lacks sufficient speed.

7. In a car, a compartment on said car, a refrigerant liquefying unit, a motor drivably connected to said unit, an evaporator in refrigerant flow relationship with said unit and disposed to cool air for said car, means for receiving a secondary refrigerant medium and for cooling air for said compartment by said medium, means for controlling the operation of said liquefying unit in accordance with refrigeration demand, means tending to reduce the cooling of air by said medium when said unit is operating, and means controlling the cooling of air by said medium when said unit is not operating.

8. In a car, a compartment on said car, a refrigerant liquefying unit, a motor drivably connected to said unit, an evaporator in refrigerant flow relationship with said unit and disposed to cool air for said car, means for receiving a secondary refrigerant medium and for cooling air for said compartment by said medium, a switch responsive to refrigeration demand controlling the operation of said motor, means tending to reduce the cooling of air by said medium when said unit is being operated by said motor under the control of said switch and for controlling the cooling of air by said medium when said motor is disconnected from its source of power by other means than said switch.

9. In combination, a compartment to be cooled,

an insulated receptacle for the reception of solid carbon dioxide, a closed secondary refrigerating system in thermal exchange relationship with said carbon dioxide and with air to be cooled for said compartment, means controlling said secondary refrigerating system in accordance with conditions in said compartment, a primary refrigerating system including a primary refrigerant liquefying unit, and a primary refrigerant evaporator connected to said unit and disposed to cool said compartment, energizing means for said primary refrigerating system, and means tending to reduce the operation of said secondary refrigerating system when said energizing means is effective upon said primary system.

10. In combination, a compartment to be cooled, an insulated receptacle for the reception of solid carbon dioxide, a closed secondary refrigerating system in thermal exchange relationship with said carbon dioxide and with air to be cooled for said compartment, means controlling said secondary refrigerating system in accordance with conditions in said compartment, a primary refrigerating system including a primary refrigerant liquefying unit and a primary refrigerant evaporator connected to said unit and disposed to cool said compartment, a live axle, a clutch drive between said axle and liquefying unit, and means reducing the operation of said secondary refrigerating system when said axle is operating above a predetermined speed.

11. In combination, a compartment to be cooled, an insulated receptacle for the reception of solid carbon dioxide, a closed secondary refrigerating system in thermal exchange relationship with said carbon dioxide and with air to be cooled for said compartment, means controlling said secondary refrigerating system in accordance with conditions in said compartment, a primary refrigerating system including a primary refrigerant liquefying unit, and a primary refrigerant evaporator connected to said unit and disposed to cool said compartment, an electric motor connected to said compressor, and means tending to reduce the operation of said secondary refrigerating system when said motor is connected to a source of electricity.

12. In combination, a compartment to be cooled, an insulated receptacle for the reception of solid carbon dioxide, a closed secondary refrigerating system in thermal exchange relationship with said carbon dioxide and with air to be cooled for said compartment, means controlling said secondary refrigerating system in accordance with conditions in said compartment, a primary refrigerating system including a primary refrigerant liquefying unit and a primary refrigerant evaporator connected to said unit and disposed to cool said compartment, an electric motor connected to said compressor, a switch responsive to conditions in said compartment and controlling the flow of current from said source to said motor, and means tending to reduce the operation of said secondary refrigerating system when said motor is connected to a source of electricity.

13. In a car having a live axle, a compartment to be cooled, an insulated receptacle for the reception of a secondary refrigerant medium, a closed secondary refrigerating system in thermal exchange relationship with said medium and with air to be cooled for said compartment, means controlling said secondary refrigerating system in response to a change in

the psychrometric condition of the air in said compartment, a primary refrigerating system including a primary refrigerant liquefying unit and a primary refrigerant evaporator connected to said unit and disposed to cool said compartment, a driving connection including a clutch between said live axle and said liquefying unit, and valve means in said secondary refrigerating system closing in response to said live axle attaining sufficient speed to drive said liquefying unit at sufficient speed to cool said compartment.

14. In a car having a live axle, a compartment to be cooled, an insulated receptacle for the reception of a secondary refrigerant medium, a closed secondary refrigerating system in thermal exchange relationship with said medium and with air to be cooled for said compartment, means controlling said secondary refrigerating system in response to a change in the psychrometric condition of the air in said compartment, a primary refrigerating system including a primary refrigerant liquefying unit and a primary refrigerant evaporator connected to said unit and disposed to cool said compartment, a driving connection including a clutch between said live axle and said liquefying unit, valve means in said secondary refrigerating system closing in response to said live axle attaining sufficient speed to drive said liquefying unit at sufficient speed to cool said compartment, a motor connected to said liquefying unit, means for disengaging said clutch and for throttling said secondary refrigerating system when said motor is connected to a source of electricity.

15. In a car, a live axle, a refrigerant liquefying unit drivingly connected to said axle, a compartment to be cooled, an evaporator disposed to cool air for said compartment, refrigerant flow connections between said evaporator and unit, an independent secondary refrigerant receptacle, means for cooling air for said compartment from secondary refrigerant in said receptacle, means for controlling the cooling of air

by said secondary refrigerant in accordance with the speed of said live axle, and separate means responsive to temperature conditions within said compartment for controlling the cooling of air by said secondary refrigerant.

16. In a car, a live axle, a refrigerant liquefying unit drivingly connected to said axle, a compartment to be cooled, an evaporator disposed to cool air for said compartment, refrigerant flow connections between said evaporator and unit, an independent secondary refrigerant receptacle, means for cooling air for said compartment from secondary refrigerant in said receptacle, electrically operated valve means for controlling the cooling of air by said secondary refrigerant in accordance with the operation of said unit, and means for controlling the cooling of air by said evaporator in accordance with conditions in said compartment.

17. In a car, a live axle, a refrigerant liquefying unit drivingly connected to said axle, a compartment to be cooled, an evaporator disposed to cool air for said compartment, refrigerant flow connections between said evaporator and unit, an independent secondary refrigerant receptacle, means for cooling air for said compartment from secondary refrigerant in said receptacle, air operated valve means for controlling the cooling of air by said secondary refrigerant in accordance with the operation of said live axle, and means for controlling the cooling of air by said evaporator in accordance with conditions in said compartment.

18. In a car, a compartment to be cooled, a receptacle for the reception of a cooling medium, means for cooling air for said compartment by said medium, a separate mechanical refrigerating system driven by an electric motor, and means throttling the cooling action of said medium in response to connection of said motor to a source of electricity.

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