

Dec. 26, 1939.

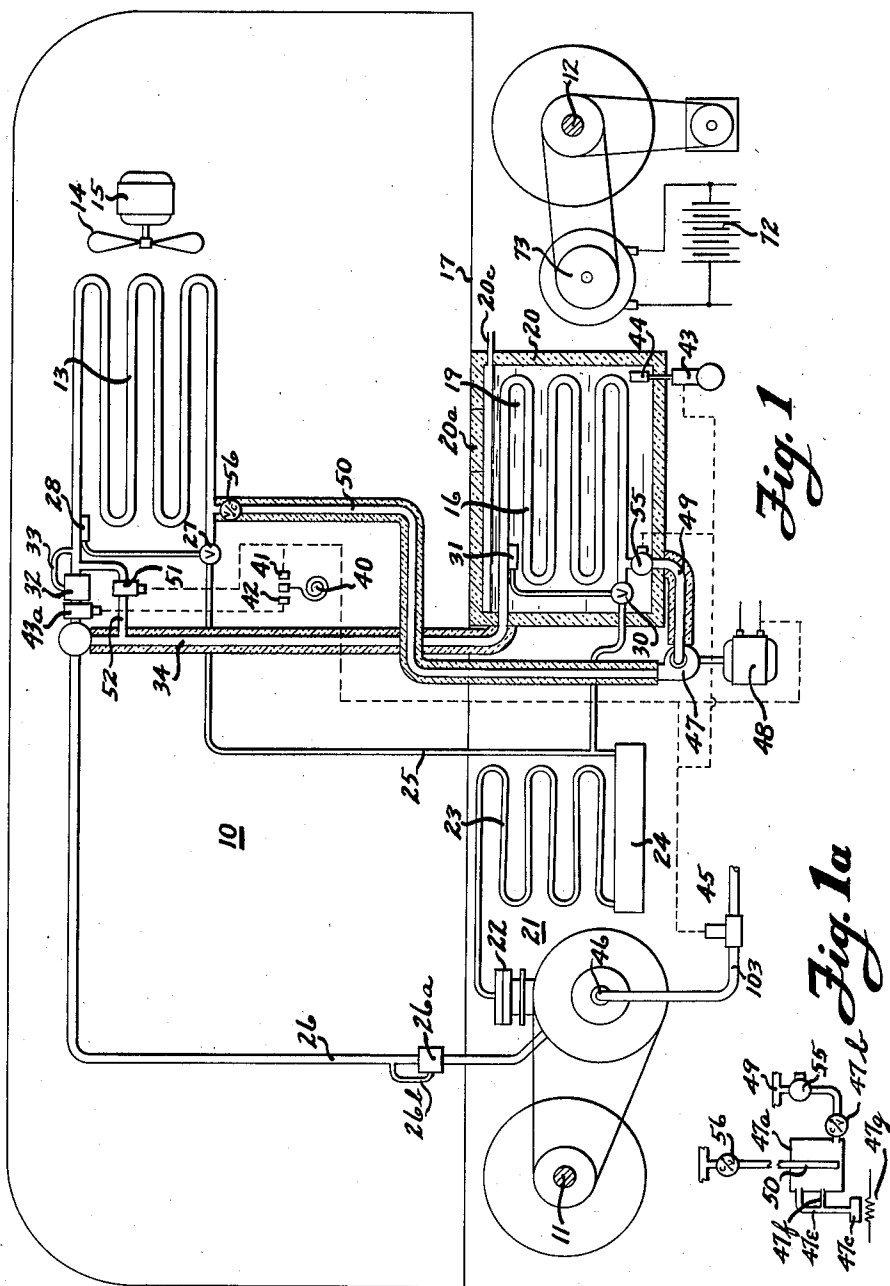
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2,185,022

REFRIGERATING APPARATUS

Original Filed July 31, 1935

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

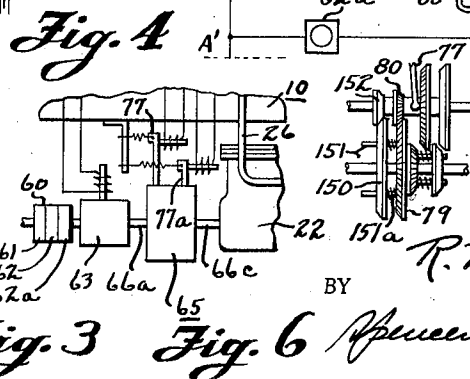
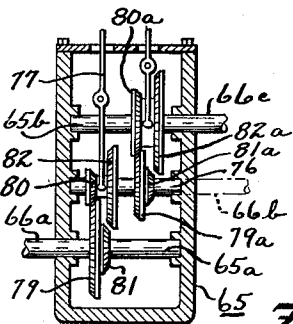
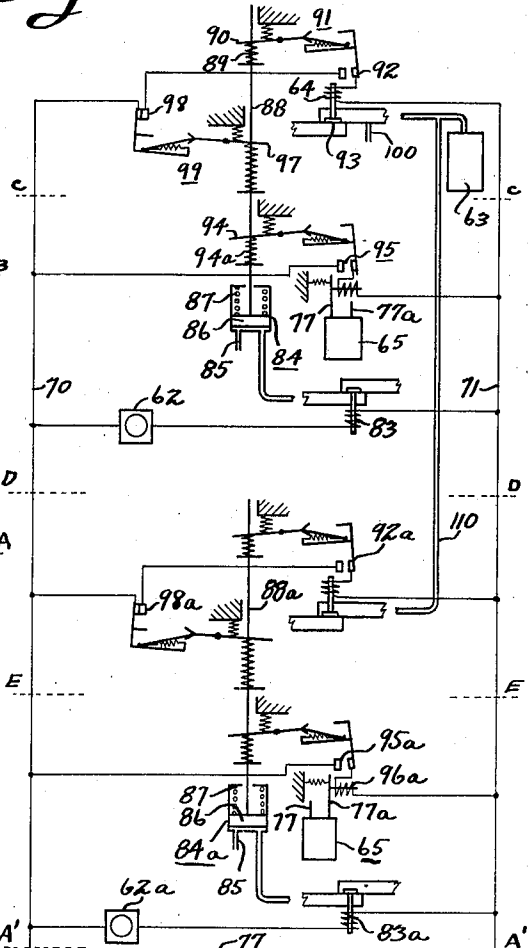
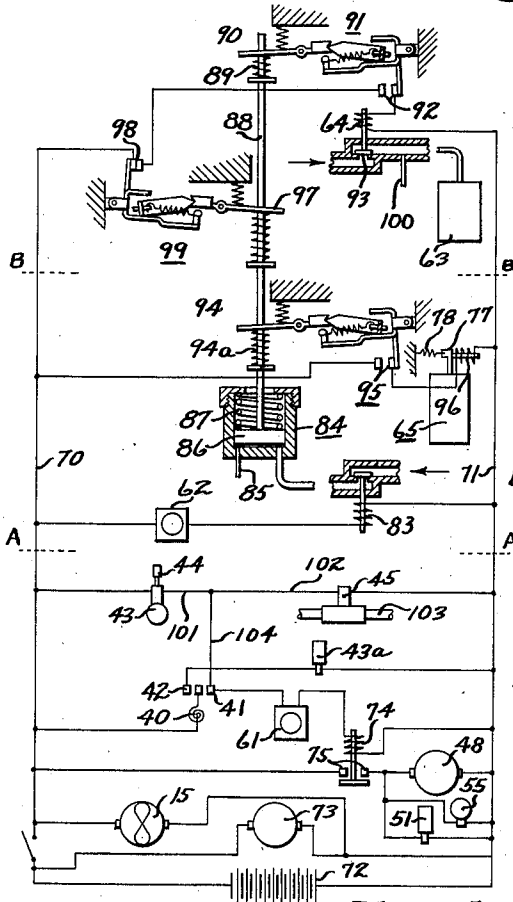
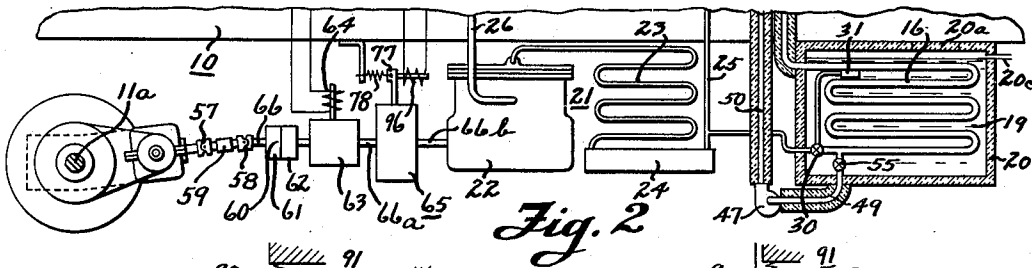


Fig. 3a
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3 Sheets-Sheet 3

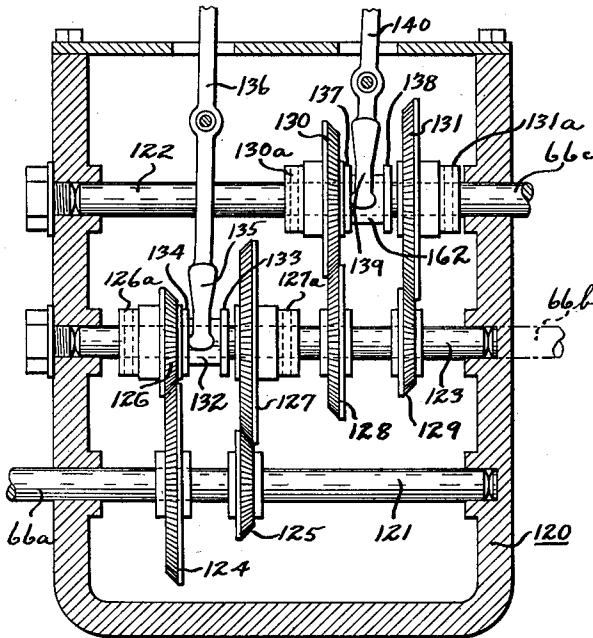


Fig. 7

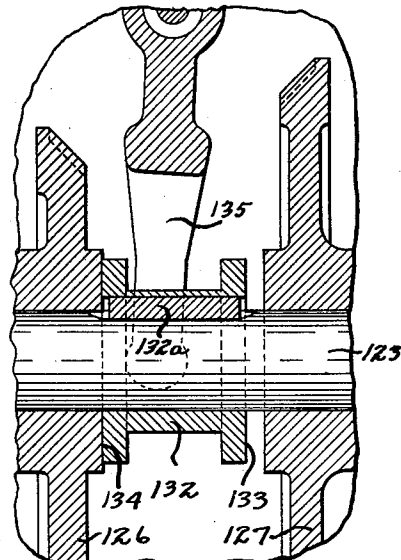


Fig. 8

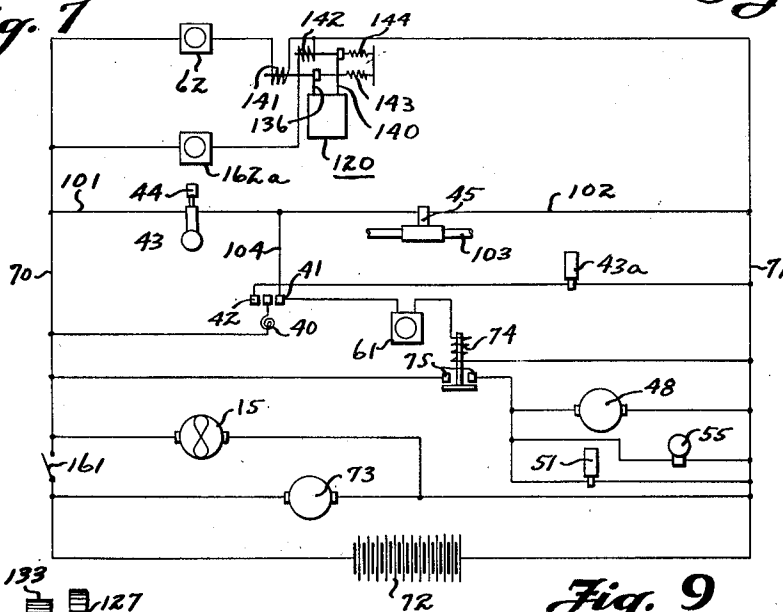


Fig. 9

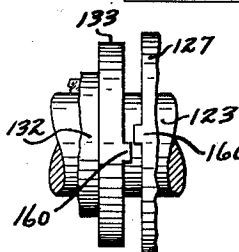


Fig. 8a

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UNITED STATES PATENT OFFICE

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REFRIGERATING APPARATUS

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Application July 31, 1935, Serial No. 34,035
Renewed April 5, 1939

7 Claims. (Cl. 62-117)

This invention relates to refrigeration and more particularly to the refrigeration of a vehicle such as a railway car or the like.

An object of this invention is to provide a refrigerating system for a vehicle in which the compartment to be cooled can be refrigerated by thermal contact with an evaporator while the car travels above a predetermined speed and can be refrigerated through the same evaporator by liquid refrigerant pumped from a second evaporator which is in a lower position.

Another object of this invention is to provide a refrigerated car with a novel variable ratio drive in which a plurality of fixed ratio drives are automatically interposed between the live axle and the refrigerant liquefying unit, compressor or the like.

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 diagrammatic cross-sectional-elevational view of an apparatus embodying features of this invention;

Fig. 1a indicates a different type of liquid refrigerant pump to be used in lieu of the liquid refrigerant pump shown in Fig. 1.

Fig. 2 is a diagrammatic cross-sectional-elevational view showing more details of the liquefying unit drive;

Fig. 3 is a cross-sectional view of a gear box which may be used;

Fig. 3a shows a modification applicable to the mechanism shown in Fig. 3.

Fig. 4 is a wiring diagram showing the electrical control of a system in which a single ratio change is accomplished;

Fig. 5 is a diagram, somewhat similar to Fig. 4, but showing how a plurality of gear ratio changes may be controlled;

Fig. 6 is a diagrammatic showing of a portion of the apparatus shown in Fig. 2 modified to indicate how a plurality of ratio changes is incorporated;

Fig. 7 shows a modified form of gear box;

Fig. 8 is an enlarged detail of Fig. 7;

Fig. 8a shows the drive between clutch faces; and

Fig. 9 is a wiring diagram used in connection with the modification of Figs. 7 and 8.

In accordance with my invention, a vehicle, such as a railway car, may include a compartment to be refrigerated. This vehicle is provided

with one or more live axles 11, 12 on which the wheels of the vehicle are mounted. The functions to be performed by one or more of the live axles are in this figure show to be performed by two live axles, although it is evident that all of the drives may be taken off of one axle as indicated in Fig. 2.

A first evaporator 13 is positioned so that it is in heat exchange relationship with air to be cooled for the compartment 10. Air may be blown over the evaporator 13 by the fan 14 driven by the motor 15. The air blown by the fan 15 may be derived either from the compartment 10, or from the outside, or from both. A second evaporator 16 is positioned below the evaporator 13, and preferably below the floor 17 of the compartment 10. This latter evaporator 16 is in thermal contact with a liquid holdover 19 placed in an insulated compartment 20. This holdover may be water, brine or a holdover which freezes above 32°.

A refrigerant liquefying unit 21 is placed in refrigerant flow relationship with the evaporators 13 and 16 and is driven from the live axle 11. The liquefying unit 21 may include a compressor 22 and a condenser 23 with or without receiver 24. If desired, a fan, not shown, may also be driven from the live axle 11 to blow air over the condenser 23.

The drive between the axle 11 and the compressor 22 may be a direct drive such that the speed of the compressor varies in accordance with the speed of the car throughout the entire speed range of the car. However, I prefer to use a variable ratio drive in which the ratio between the axle and the compressor is varied in accordance with conditions of the vehicle, preferably by steps at different increases of speed of the vehicle as will be hereafter more fully described.

The capacity of the refrigerant liquefying unit is such that at all substantial speeds of the vehicle the capacity of the unit is sufficient to provide the necessary refrigeration demanded of the evaporator 13. On certain occasions, or on all occasions, the capacity is also sufficient to provide refrigeration in the evaporator 16 and to cool or freeze the holdover 19 so that it is in readiness to provide refrigeration when the speed of the car falls below a predetermined limit or stops entirely. It is to be understood that the naming of a speed below a predetermined limit includes complete stopping of the car.

The evaporator 13 is provided with liquid refrigerant through the line 25 and the evaporated refrigerant returns to the compressor through the

line 26. An automatic expansion valve 27 is provided at the inlet of the evaporator and is under the control of a thermostatic bulb 28 placed near the outlet of the evaporator. The construction of the valve 27 is such that it is substantially closed when the pressure in the evaporator is above a predetermined limit and opens when the pressure therein is reduced by the suction of the compressor below a predetermined limit. However, when the refrigerating effect reaches the bulb 28, the valve 27 is automatically throttled or entirely closed. This construction maintains the evaporator 13 in a substantially flooded condition, but prevents flooding of the refrigerant return line 26 beyond the bulb 28. The pressure at which the valve 27 opens preferably corresponds to a temperature slightly above 32° F.

The evaporator 16 is provided with an automatic expansion valve 30 having a thermostatic bulb 31 placed near the outlet of the evaporator 16. The valve 30 and bulb 31 are substantially of the same construction and have the same function as the valve 27 and bulb 28. The setting of the valve 30, however, is such that a lower temperature tends to be maintained in the evaporator 16 than in the evaporator 13. That is, the valve 30 is calibrated to open at a lower refrigerant pressure than valve 27. For example, if holdover 19 is water, the valve 30 opens at a pressure corresponding to a temperature suitably below 32° F.

In addition, an automatic valve 32 is placed in the suction line and this valve is responsive to pressures in the evaporator 13 as diagrammatically indicated at 33. When the compressor tends to reduce the pressure of the evaporator 13 below a predetermined limit (corresponding to a temperature slightly above 32° F. and yet below the setting of valve 27), the valve 32 is throttled. At this time, if the compressor continues to operate, the suction effect of the compressor is then transmitted through the suction line 34 to the evaporator 16 and refrigeration is produced in the evaporator 16 thus cooling or freezing the holdover 19. Because of the action of the valve 32 it is possible for refrigeration to be produced at the same time in both the evaporators 13 and 16, but the temperature in evaporator 13 is preferably maintained higher than that in evaporator 16. It is to be understood, however, that, under certain conditions, many of the advantages of my invention may be derived when both the evaporators are maintained at the same temperature. This is particularly true, where the holdover 19 is chosen to have a freezing point substantially the same as or higher than the temperature desired to be maintained in the evaporator 13.

Automatic controls are provided for controlling the refrigerating effect of the evaporators in accordance with refrigeration demands. To this end a thermostat 40 is provided in compartment 10 which contacts at 41 when the temperature in the compartment 10 rises to a predetermined maximum limit and contacts at 42 when the temperature falls to a predetermined low limit. The arrangement is such that, while the car operates above a predetermined speed, and the temperature falls in the compartment 10 so that the contact 42 is closed, then a solenoid valve 43a is closed completely or throttled as desired thus tending to throttle or stop the refrigerating effect of evaporator 13 and preventing the cooling of the compartment 10 below a desired limit. Under these conditions the com-

pressor can continue to operate until such a time as the temperature of the holdover 19 is reduced to a predetermined limit. At this point, if desired, the thermostatic switch 43, in response to the bulb 44, automatically stops the compressor 22 through the action of the pneumatic valve 45 which actuates the pneumatic clutch 46. If desired, a valve 26a may be placed in line 26, which is automatically throttled, as indicated diagrammatically by 26b when the pressure in line 26 between the valve 26a and the evaporators is reduced below a desired limit. This pressure limit is below the pressure at which the valve 30 opens. This valve 26a may be used in lieu of or in addition to control 43-44. That is, with the valve 26a in operation, the compressor may be allowed to run all the time the car runs and if there is no refrigeration demand at either 13 or 16 the power required to drive the compressor is very little. The valve 26a may be closed completely but preferably always has an oil bleeding action.

Means are provided for causing liquid volatile refrigerant to be pumped from the evaporator 16 to the evaporator 13 when the speed of the car falls below a predetermined slow speed limit or completely stops. This may be accomplished by providing a pump 47, driven by a motor 48, which withdraws liquid refrigerant through the pipe 49 and forces the same through pipe 50 to the lower portion of the evaporator 13. At the same time that the motor 48 is energized a solenoid valve 51 is opened, thus opening the by-pass 52 between the outlet of the evaporator 13 and the pipe 34. Under these conditions, while the pump 47 operates, liquid volatile refrigerant is pumped from the lower portion of the evaporator 16 to the lower portion of the evaporator 13 and gaseous refrigerant, or liquid refrigerant, or both, return from the evaporator 13 to the evaporator 16, through the by-pass 52 and pipe 34. Thus the cooling effect of holdover 19 is transferred by this circulation to evaporator 13.

Under these conditions the pressures in the evaporators 16 and 13 are such that the valves 27 and 30 are closed, and thus receiver 24 is effectively isolated from the evaporators. The compressor 22 is provided with a check valve (its usual discharge check valve) opening in the direction of the condenser 23. Therefore any tendency of refrigerant to force its way backwards from the condenser through the compressor to the evaporators is effectively stopped.

Solenoid valve 55 and check valve 56 are provided, which prevent the flow of refrigerant backwards in the line 49-50 during the time that the pump 47 is not operating. These valves, however, permit the flow of refrigerant from the evaporator 16 to the evaporator 13 while the pump 47 is operating as will be hereinafter apparent.

A different type of pump may be used in lieu of pump 47. Thus, as shown in Fig. 1a, the pipe 49 may discharge into a casing 47a. The pipe 50 extends to a point near the bottom of casing 47a. A check valve is provided at 47b. An overflow compartment 47c, is connected by large pipe 47e and small pipe 47f with the upper part of casing 47a. Compartment 47c is heated, as by electric heater 47g. The heater 47g is placed in the wiring diagrams at the same place as motor 48. As will be apparent, when compressor 22 cannot furnish enough refrigeration, valve 55 is opened and heater 47g is heated. Liquid refrigeration flows from evaporator 16 into casing 76

47a until a small amount overflows at 47f. This small amount flashes into gas and fills the upper part of casing 47a through pipe 47e with gas under pressure. This forces liquid up pipe 50 past check valve 56 into evaporator 13. This intermittent pumping action continues as long as the automatic controls require.

In Fig. 1, some of the mechanisms are shown as driven from shaft 11 and others from shaft 12, it being obvious that all can be driven from one shaft, as shown in Fig. 2.

To provide precooling for the car after it has remained idle and the holdover 19 has lost its refrigerating power, a trap door 20a is provided to insert frozen cooling medium into the tank 20 around the spaces not filled by the evaporator 16. When water is used as the holdover 19, then ice may be introduced through the trap door 20a. The water displaced by the ice overflows through overflow pipe 20c. When holdovers other than water are used, the corresponding frozen holdover may be inserted, or small tanks containing ice may be inserted. In this case the overflow at 20c may be preserved and reintroduced through the trap door after the small tanks of ice are removed when the car is about to start. The trap door 20a is indicated to be at the top of tank 20; but it is to be understood that it may be located in the side above the level of the holdover, in which case the ice may be introduced from the side of the car without carrying it into the compartment 10. Suitable perforated partitions (not shown) may be provided in tank 20 to prevent the ice from injuring the evaporator 16.

The drive between the axle 11 and compressor 22 is preferably of the variable ratio type more particularly shown in Figs. 2 to 7 inclusive. The drive between the axle 11a and the compressor 22 preferably includes a plurality of fixed ratio drives, and means are provided for automatically changing from one fixed ratio drive to another fixed ratio drive in accordance with conditions of the car, such as at certain predetermined speeds of the car. While this change is going on, the drive is automatically declutched. The fixed ratio drives are shown to be of the gear type, but may be of other types, such as a plurality of belts or pulleys of different diameters.

As shown in Fig. 2, the live axle 11a is connected to a drive shaft 66 by universal joints 57 and 58 and a bayonet coupling 59 so that the axle 11a is free to turn while rounding curves. A centrifugal switch box 60 is provided in which two or more centrifugal switches, diagrammatically indicated as 61 and 62, are provided. In addition, a pneumatic or electrical clutch 63 is provided in which energization of the solenoid 64 automatically declutches the drive either by direct magnetic pull of the solenoid or by causing the solenoid to vary air-flow to a diaphragm actuator in the clutch. Pneumatic clutches, of themselves, are well-known and details thereof are therefore not illustrated. A gear box 65 is also interposed between the shaft 11a and compressor 22. This gear box is provided with one or more pairs of gear drives, so that a change can be made from one fixed ratio drive to another fixed ratio drive. Thereafter the shaft section 66c is connected to the compressor 22, identical with the compressor shown in Fig. 1, from whence refrigerant is delivered to the condenser 23 and receiver 24 which comprises the liquefying unit 21 and which is connected to evaporators 13 and 16 exactly as in Fig. 1.

Fig. 4 shows the electrical controls for chang-

ing the fixed ratio drives and for controlling the operation of the refrigerant pump, and other parts, where only two gear pairs are provided. In this figure, the lines 70 and 71 are placed across the battery 72, which battery is charged by the generator 73 of the character usually provided on railway cars. When the car is standing still, or is traveling at a low speed below a slow predetermined limit, the centrifugal switch 61 is closed. Under such conditions, if the thermostat 40 should contact at 41, indicating that air cooling is required, then current flows through the switch 61 and relay 74. This closes the contacts 75 and current flows through the motor 48 and solenoid valves 51 and 55. This permits liquid refrigerant to be pumped from the evaporator 16 to the evaporator 13 by means of the pump 47, the gaseous or liquid refrigerant returning to the evaporator 16 through the open valve 51 and by-pass 52 and line 34. In this manner cooled refrigerant is transferred from evaporator 16 to 13 and provides cooling power from the holdover 19 for cooling the air. This continues as long as the thermostat 40 contacts at 41. If this contact should be opened, when the temperature in 10 is low enough, then the action of motor 48 and valve 51 is stopped.

When the car starts, or, if desired, after the car has attained a speed above a low limit, the centrifugal switch 61 opens thus stopping the action of pump 47. The axle 11a, at slow speeds, drives the compressor 22 with a relatively high gear ratio through the gears 79 and 80. At some higher predetermined car speed, the centrifugal switch 62 closes and causes the drive to go through gears 81 and 82 at lower ratio as will be hereinafter apparent. Fig. 4 shows the control for gears 79, 80, 81 and 82, while Fig. 5 indicates the control for additional gears 79a, 80a, 81a and 82a.

With the wiring diagram of Fig. 4, gear box 65 contains only gears 79 to 82 inclusive. The portion 66a of the shaft line 66 is connected to shaft 65a upon which gears 79 and 81 are fixed, the shaft 76 is connected to the portion 66b of the drive in a manner indicated by dotted lines in Fig. 3. Gears 80 and 82 are rotationally fixed on the shaft 76; but are axially slidable by lever 77. The top of the lever 77 is moved to the left by the tension spring 78, gears 79 and 80 are meshed together and the drive is effective through the fixed ratio determined by the gears 79 and 80. The compressor then turns relatively fast with respect to the axle 11a, or at a relatively high gear ratio.

When the car speed increases to another predetermined speed where it would not be safe to drive the compressor at a high speed through the gears 79 and 80, the centrifugal switch 62 closes and this initiates a change from the fixed ratio drive through the gears 79 and 80 to the fixed ratio drive through the gears 81 and 82. When the switch 62 closes, it energizes the solenoid valve 83. This admits air to the slow motion dash-pot 84 which is provided with a bleeder of less flow capacity than the air-flow through the valve 83. This causes the piston 86 to move slowly upwardly against the spring 87 and thereby move the rod 88 slowly to cause a sequence of operations including declutching at 63, changing from gear drive 79—80 to gear drive 81—82 and re clutching at 63.

The slow movement of the rod 88 accomplishes this sequence by operating a series of switches which control the drive. Thus the first switch

is closed by the action of the spring 89 forcing the lever 90 of the snap switch 91 upwardly so that the contacts 92 are closed. Any suitable type of known snap switch, such as diagrammatically indicated may be used. Under such conditions, as switch 99 is closed, current flows through the solenoid 64. This opens an air valve 93 and causes air to flow to the pneumatic actuating member of the clutch 63, it being understood, however, that the solenoid 64 can, if desired, be used to actuate the clutch directly by magnetic pull. A bleeder 100 is provided which is of less flow capacity than air valve 93 so that when valve 93 is open air pressure is produced on the clutch to declutch it, and when valve 93 is closed, slow air bleeding at 100 releases the air pressure and reclutches the clutch. After the clutch 63 is thus declutched by air pressure the continued upward movement of the rod 88 next actuates the lever 94 by the action of spring 94a which in turn closes the snap switch 95. This causes current to flow through the solenoid 96 and moves the top of the lever 77 to the right against the tension of the spring 78. This causes the gears 81 and 82 to mesh and the gears 79 and 80 to unmesh by sliding the pair 80, 82 to the left. Thereafter the continued upward movement of the rod 88 next moves the lever 97 upwardly and opens the contacts 98 of the snap switch 99. The opening of these contacts, which are in series with contacts 92, deenergizes the solenoid 64 and again clutches the clutch 63 by closing the valve 93 and permitting air to bleed slowly through the bleeder 100. Thus when the rod 88 has reached its upper position the clutch 63 is again clutched and the live axle 11a drives the compressor 22 through fixed ratio drive gears 81, 82 with which the compressor does not turn relatively as fast with respect to the shaft 11a. This permits the car to travel at a higher speed without driving the compressor excessively fast.

When the car starts to slow down a reverse sequence takes place. When the car slows down to the point where the compressor would not be driven at a sufficiently high speed with the low ratio drive, then the centrifugal switch 62 opens and this closes the solenoid valve 93. The slow leakage of air through the bleeder 100 causes the spring 87 to move the rod 88 slowly downward. The first action thus produced is the closing of contacts 98 which, with the closed contacts 92, causes a declutching at 63 by admitting air through the valve 93. Next the contacts of switch 95 are opened and this deenergizes the solenoid 96 so that spring 78 moves the top of the lever 77 to the left thus meshing the gears 79 and 80. Thereafter the contacts 92 are opened thus closing the valve 93 and again clutching at 63 so that the compressor is now driven through the gears 79 and 80 through a relatively high gear ratio at a sufficient speed notwithstanding the relatively low speed of the car.

If the car should continue to slow down to the point where the live axle 11a can no longer drive the compressor at a refrigerating speed even through high ratio gears 79, 80, or if the car should stop entirely, then the centrifugal switch 61 closes and causes the pump 47 to operate and the valves 51 and 55 to open to provide refrigeration from the holdover 19 as heretofore described.

If at any time the compartment 10 should be sufficiently cooled, and the holdover 19 should be completely cooled or frozen, the drive between the axle and the compressor can be stopped if

desired, although it is to be understood that the compressor can continue to operate and produce very little refrigeration. If it is desired to stop the compressor automatically, this is accomplished by causing the bulb 44 to open the solenoid switch 43 in response to low temperature of the holdover 19. When the switch 43 is opened the flow of current through the lines 101 and 102 to the solenoid valve 45 is stopped. This controls the flow of air through the air line 103 to the pneumatic clutch 46 and disconnected the drive between the shaft and the compressor. The pneumatic clutch 46 preferably is a different one from the clutch 63 and is interposed anywhere between the compressor and the live axle.

If the car is operating, and the holdover 19 is completely frozen and has disconnected the drive of the compressor at 46 and the compartment 10 should then require refrigeration, the solenoid 40 contacts at 41. Current then flows through the lines 104 and 102 to actuate the pneumatic valve 45 and the clutch 46 causing the compressor to be driven to provide refrigeration for the compartment 10 through the evaporator 13.

Figs. 5 and 6 indicate how more than one pair of fixed ratio drives can be used so that the car can be driven through a greater speed change range than can be taken care of with two fixed ratio drives. Under such conditions, the centrifugal switch box 60 is provided with three centrifugal switches. These are respectively switches 61 and 62 having the same action heretofore described and a third centrifugal switch 62a which is calibrated to close at a still higher speed than the switch 62. These are diagrammatically illustrated in Fig. 6.

Under the conditions shown in Figs. 5 and 6 the gear box 65 contains additional gears 79a, 80a, 81a and 82a. Instead of connecting shaft 76 to 66b (Fig. 2), the additional shaft 65b is connected to the section 66c (Fig. 6). When the car runs at speeds between the closing of switch 62 and the closing of switch 62a, the gear drive is through 81, 82 and through 79a and 80a. When the speed increases to a point where switch 62a closes, then the drive changes to pass through gears 81, 82, 81a and 82a as will be hereinafter apparent.

The closing of the switch 62a causes a declutching at 63, an unmeshing of the gears 79a and 80a, meshing of the gears 81a and 82a and a re clutching at 63 as will be apparent from a further description of Fig. 5. With respect to Fig. 5, the circuits controlled by the switch 62 are exactly the same as in Fig. 4 and they are therefore numbered similarly and the description heretofore given of the action is not here repeated. After the car has attained a speed such that the switch 62 is closed then the drive from the live axle 11a is through the gears 81 and 82 as heretofore pointed out. Thereafter if the speed increases to the point where the switch 62a closes, then the clutch 63 is again declutched, the gears 79a and 80a are unmeshed, the gears 81a and 82a are meshed and thereafter the clutch 63 is again clutched. This is accomplished by an action substantially identical with that heretofore described with respect to Fig. 4. Thus when the switch 62a closes the valve 93a is opened. This causes a slow movement upward of the rod 88a exactly as heretofore described with respect to rod 88 by the flow of air to dash-pot 84a. The first action of the rod 88a is to close the contacts 92a similarly to the closing of contacts 92. This causes air to flow through the air line 110

and declutch the clutch 63 it being understood that the flow of air through the line 110 is faster than through the bleeder 100. The next action of the rod 88a is to close the contacts of the snap switch 95a. This energizes solenoid 96a and moves the top of the rod 77a to the right. The movement of this rod 77a meshes the gears 81a and 82a while unmeshing the gears 79a and 80a by sliding the pair 80a and 82a to the left. The next action of the upward movement of the rod 88a is to open the contacts 98a, which causes the valve 93a to close and thus stop the flow of air to the pneumatic member of the clutch 63. The slow bleeding at 100 again reclutches clutch 63. Under the foregoing conditions the drive between the axle 11a and the compressor is at a still lower ratio and the car can travel at a high speed without driving the compressor too fast.

As the car slows down from this high speed the action is reversed. Thus the switch 62a opens; this reverses the train of events so that the clutch 63 is declutched, the gears 81a and 82a are unmeshed while 79a and 80a are meshed and the clutch 63 again clutched. If the car continues to slow down, the switch 62 is opened, and this (as was described with respect to Fig. 4) opens the clutch 63, unmeshes gears 81 and 82 and meshes the gears 79 and 80 and again clutches at 63. Thereafter if the car continues to slow down further the switch 61 closes and this causes the opening of solenoid valve 61 and the operation of the pump 47 to provide refrigeration from the holdover 19. It is to be understood that the portion of the diagram below the dotted line A in Fig. 4 is to be attached to the bottom of the diagram shown in Fig. 5 at the line A'.

With the modification shown in Figs. 7, 8 and 9, the gear box 120 replaces clutch 63 and gear box 65 of Figs. 6 and 2. The shaft section 66a of Figs. 6 and 2 are connected to shaft 121 of Fig. 7. The shaft section 66c of Fig. 6 is connected to shaft 122 of Fig. 7. If but a single gear ratio change is sufficient then shaft section 66b of Fig. 2 may be connected to shaft 123 as indicated in dotted lines in Fig. 7.

The gear box 120 has a combined clutching, declutching and gear ratio changing action. Gears 124 and 125 are fixed on shaft 121. Gears 126 and 127 rotate freely on shaft 123 but are axially fixed by fixed abutments 126a and 127a. Gears 128 and 129 are fixed on shaft 123. Gears 130 and 131 rotate freely on shaft 122 but are axially fixed by fixed abutments 130a and 131a. A collar 132 is rotatably fixed on shaft 123 but axially movable by the keyed action shown in Fig. 8 at 132a. The collar 132 is provided with clutch faces 133 and 134, and is moved axially by the yoke 135 on the lever 136. When the yoke 135 moves the collar face 134 against gear 126, this gear is rotatably fixed to shaft 123 by being clutched through face 134 and collar 132. When the yoke 135 moves the collar face 133 against gear 127, this gear is similarly rotatably fixed to shaft 123 and gear 126 is released. A corresponding action takes place with respect to gears 130 and 131 where collar 162 is axially free but rotatably fixed on shaft 122 and is provided with clutch faces 137 and 138 and is axially moved by yoke 139 of lever 140. Thus the drive is effective through whatever gears are contacted by the collars 132 and 136 and an unclutching action takes place while the collars are being shifted.

Automatic controls are provided for progres-

sively moving the collar 132 from left to right and then collar 136 from left to right. This automatically changes gear ratios and automatically unclutches the drive during the change. These automatic controls, including the control of the pump motor 48 and its refrigerant controls, are indicated in Fig. 9.

In Fig. 9 battery leads 70, 71 are placed across the battery 72 and generator 73. The fan motor 15 is under the control of manual switch 161. The centrifugal switch 61 controls relay 74, motor 48 and solenoid valves 51 and 55 as in Fig. 4. The thermostat 40, switches 43 and 43a and valve 45 correspond in function and operation to that described with respect to Fig. 4. Centrifugal switch 62 controls solenoid 141 and centrifugal switch 162a controls solenoid 142. When solenoid 141 is energized the top of lever 136 moves to the left against the tension spring 143. When solenoid 142 is energized the top of lever 140 is moved to the left against tension spring 144.

The sequence of actions of the drive shown in Figs. 7 and 8 as combined with the refrigerating system shown in Figs. 1, 2 and 6 is indicated in Fig. 9. As the car stands and gradually starts and runs to a high speed switch 61 remains closed until the start or until a relatively low first speed limit is reached. During this time pump 47 pumps liquid refrigerant from 16 to 13 as heretofore described. This action stops when the speed reaches the first low limit. As the car starts and before the speed reaches a second limit, higher than the first speed limit, the live axle 11a (Fig. 2) drives the compressor through gears 124, 126, 128 and 130, as the tops of the levers 136 and 140 are pulled to the right by springs 143 and 144. When the car speed reaches the second speed limit switch 62 (Fig. 9) closes and pulls the top of lever 136 to the left and moves the collar 132 to the right. The compressor drive is then through gears 125, 127, 128 and 130. When the car reaches a third and higher speed limit the centrifugal switch 162a closes and this pulls the top of lever 140 to the left and moves collar 162 to the right. The drive is now through gears 125, 127, 129 and 131. Thus the gear ratio is progressively decreased as the speed of the car increases. When the car slows down from its high speed to a stop the actions are reversed.

The showing in the gear boxes 65 and 120 is intended to be diagrammatic. It is to be understood that details may be varied in accordance with transmission practice. Thus, as shown in Fig. 3a the gears in box 65 may be provided with synchronizing discs to prevent clashing. Thus gear 79 may be provided with a disc 150 fixed thereto rotationally but slidable axially on pins 151 against the springs 151a. The disc 152 is secured axially and rotationally to gear 80. The discs 150 and 152 contact on relatively smooth frictional faces before contact of the gears 79 and 80, thus synchronizing them. The other gears 81, 82, 79a, 80a, 81a and 82a may likewise be provided with corresponding synchronizing discs. In gear box 120, for example, the clutch faces may be conical to increase the frictional surface, or widely separated lugs 160 may be placed on gears 126, 127, 130, 131 and on faces 133, 134, 137 and 138 to insure a positive drive, as indicated in Fig. 8a.

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. A vehicle having a compartment to be refrigerated, a refrigerant liquefying unit, an evaporator positioned in heat exchange relationship with air for said compartment and in refrigerant flow relationship with said unit, a fan circulating air in heat exchange relationship with said evaporator, a second evaporator below said first evaporator and in refrigerant flow relationship with said unit, pumping means, separate from said liquefying unit, for elevating liquid volatile refrigerant from said second evaporator to said first evaporator, a live axle, a variable ratio drive between said live axle and said liquefying unit, means changing the drive ratio of said drive in accordance with changing conditions of said vehicle and means for controlling said pumping means in accordance with vehicle speed conditions.

2. A vehicle having a compartment to be refrigerated, a refrigerant liquefying unit, an evaporator positioned in heat exchange relationship with air for said compartment and in refrigerant flow relationship with said unit, a second evaporator below said first evaporator and in refrigerant flow relationship with said unit, pumping means, separate from said liquefying unit, for elevating liquid volatile refrigerant from said second evaporator to said first evaporator, a live axle, a variable ratio drive between said live axle and said liquefying unit and including a plurality of positively meshable gears, means for changing the drive through said gears to change said ratio in response to changing conditions of said vehicle, means automatically declutching the drive between said axle and unit while said ratio is being changed and when the vehicle speed falls below a predetermined limit, and means controlling said pumping means in accordance with vehicle speed.

3. A vehicle having a compartment to be refrigerated, a refrigerant liquefying unit, an evaporator positioned in heat exchange relationship with air for said compartment and in refrigerant flow relationship with said unit, a second evaporator below said first evaporator and in refrigerant flow relationship with said unit, pumping means, separate from said liquefying unit for elevating liquid volatile refrigerant from said second evaporator to said first evaporator, said refrigerant liquefying unit including a compressor and condenser, a live axle, a variable ratio drive between said live axle and said compressor and including a clutch, a plurality of fixed ratio drives, means for changing the effective drive between said axle and compressor from one to another of said fixed ratio drives and means automatically declutching said axle from said compressor during said change and when said compartment is sufficiently cooled.

4. A vehicle having a compartment to be re-

frigerated, a refrigerant liquefying unit, an evaporator positioned in heat exchange relationship with air for said compartment and in refrigerant flow relationship with said unit, a second evaporator below said first evaporator and in refrigerant flow relationship with said unit, pumping means for elevating liquid volatile refrigerant from said second evaporator to said first evaporator, means automatically causing operation of said pumping means when the speed of the vehicle is below a predetermined speed, said refrigerant liquefying unit including a compressor and condenser, a live axle, a variable ratio drive between said live axle and said compressor and including a clutch, a plurality of fixed ratio drives, means for changing the effective drive between said axle and compressor from one to another of said fixed ratio drives and means automatically declutching said axle from said compressor during said change and when said compartment is sufficiently cooled.

5. A vehicle having a compartment to be refrigerated, a refrigerant liquefying unit, an evaporator positioned in heat exchange relationship with air for said compartment and in refrigerant flow relationship with said unit, a fan forcing air in heat exchange relationship with said evaporator, a live axle, a variable ratio drive between said live axle and said liquefying unit and including a plurality of positively meshable gears, means for changing the drive through said gears to change said ratio in response to changing conditions of said vehicle, means declutching the drive between said axle and unit while said ratio is being changed, and means responsive to a psychrometric function of air controlling said last mentioned means.

6. A vehicle having a compartment to be conditioned, a live axle, a unit connectable with said live axle, an air modifier positioned in air modifying relationship with air for said compartment and in fluid flow relationship with said unit, a variable ratio drive between said live axle and said unit and including a clutch, a plurality of fixed ratio drives, means for changing the effective drive between said axle and said unit from one to another of said fixed ratio drives, and means automatically declutching said axle from said unit during said change and in response to air conditions in said compartment.

7. A vehicle having a compartment to be conditioned, a live axle, a unit connectable with said live axle, an air modifier positioned in air modifying relationship with air for said compartment and in fluid flow relationship with said unit, a variable ratio drive between said live axle and said unit and including a clutch, a plurality of fixed ratio drives, means for changing the effective drive between said axle and said unit from one to another of said fixed ratio drives, and means automatically declutching said axle from said unit during said change.

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