REFRIGERATION APPARATUS FOR RAILROAD CARS

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This invention relates to an air conditioning apparatus particularly for railroad cars or other vehicles employed in transporting perishables.

It is an object of this invention to provide an air conditioning unit which is small and compact so as to occupy a small part of the interior space of the vehicle.

It is another object of this invention to provide apparatus which will provide, in addition to the usual cooling, providing four major assemblies comprising an air handling and conditioning assembly, a condenser and radiator assembly, a power producing including an engine and generator, and a compressor assembly including a compressor and a motor for driving it.

It is another object of this invention to provide an apparatus which is designed to facilitate service and maintenance of the vehicle by allowing accessibility of the various components of the apparatus with a minimum expenditure of time and labor.

It is another object of this invention to provide controls for maintaining, in the vehicle, the proper temperatures for fresh produce or frozen foods using heating or cooling as required.

This is in accordance with the invention, the invention provides for controlling the apparatus against damage in the event of failure of one of the components of the apparatus.

Other objects and advantages of this invention will become apparent as the specification proceeds to describe the invention and the drawings in which:

Fig. 1 is a vertical, partly diagrammatic, plan view of the apparatus installed in the railroad car, but with the end view omitted.

Fig. 2 is a sectional view of the apparatus taken on the line 2—2 of Fig. 3.

Fig. 3 is an end view of the apparatus as seen from the left in Fig. 1.

Fig. 4 is a diagrammatic view of the apparatus showing the location of the controls.

Fig. 5 is a wiring diagram of the controls.

Referring now to Fig. 1 of the drawing, numerical 10 indicates a railroad refrigerator car or other enclosure to be air conditioned. A pair of channels 12 are fixedly secured to the floor of the car 10 in spaced parallel relation to each other. An internal combustion engine 14 and an alternating current generator 16 are bolted to the channels 12. The engine 14 is connected to drive the generator 16. A direct current generator 18 is mounted on the generator 16 and is driven by the generator 16 through a belt 20.

An electric motor 24 and a refrigerant compressor 26 are bolted to the channels 12. The motor 24 drives the compressor through a flexible coupling 28.

Fuel from the fuel tank 30 flows through the fuel line 32. The engine 14 exhausts through pipe 34, muffler 36 and pipe 38. The jacket water of the engine 14 flows through pipe 40 to the radiator 42. Radiator 42 has a filling pipe 43 extending upwardly through the roof of the car. The jacket water returns from the radiator 42 to the engine 14 through pipe 45. Lubricating oil for the engine 14 is contained in a tank 46 which has a filling pipe 48 extending to the outside of the car.

The generator 16 is connected to the engine 14 and furnishes electrical power for the motor 24 and other motors as will be described in detail below. The generator 18 furnishes current for energizing the field winding of the generator 16.

The compressor 26 discharges compressed refrigerant through pipe 50 to an oil separator 52. The separator 52 returns oil to the crankcase of the compressor 26 through a pipe 54. The refrigerant passes from the oil separator 52 through a pipe 56 connected to the inlet header 58 of the condenser 60. The refrigerant condensed in the condenser 60 collects in a return header 62 and is conducted by pipe 64 to a refrigerant receiver 66. Refrigerant liquid leaves the receiver 66 through pipe 68 and enters heat exchanger 70, where it transfers some of its heat to refrigerant gas returning to the compressor as will be described below. Liquid refrigerant passes from the heat exchanger 70 through pipe 72 and enters the expansion valve 74. A solenoid valve 76 interposed in the pipe 72 controls the flow of refrigerant liquid to the expansion valve 74. The refrigerant flows through the expansion valve 74, through a plurality of tubes 77 to the evaporator 78.

A pipe 80 conducts the vaporized refrigerant from the evaporator 78 to the heat exchanger 70. In the heat exchanger 70 any liquid refrigerant carried along with the vapor is vaporized by heat received from the liquid refrigerant also passing through the heat exchanger as described above. A pipe 82 conducts the vapor from heat exchanger 70 to the suction inlet of the compressor 26.

The condenser 60 and the engine radiator 42 are cooled by moving air therethrough. Two doors 84 are pivoted at the engine side of the condenser 60. The doors 84 have louvres 86 to permit air to enter the car to prevent the entrance of rain, snow, etc. Two doors 88 are pivoted at the compressor side of the car to permit access to the compressor and condenser motor. These doors 88 have louvres 90 to permit the entrance of air to prevent the entrance of rain, snow, etc.

A chamber 91 encloses the engine radiator 42 and the condenser 60. A duct 92 is secured to the top of the chamber 91 to air go therefrom. An axial fan 94 is mounted on the duct 92 and is driven by a motor 96. A cover 98 is hinged to the roof of the car in any suitable manner not shown. The cover 98 extends over the duct 92 and is hinged to the exahust pipe 38, and the radiator filling pipe 43. The cover 98 is opened when the refrigeration apparatus is in operation and it is closed when the refrigeration apparatus is not in operation. The cover 98 prevents foreign matter from entering duct 92, the exhaust pipe 38, and the radiator filling pipe 43.

It may thus be seen that the air enters both sides of the car through the doors 84 and 88. The air passes over and removes heat from the engine 14, the generators 16 and 18, the motor 24, and the compressor 26. The air passes first through the condenser 60 then through the engine radiator 42, and is finally discharged by the fan 94 to the outside through the duct 92.

The air handling and conditioning assembly provides a space 102 enclosed by an insulated wall 104. Air from the refrigerated space enters the space 102 through opening 106 adjacent the floor of the refrigerated space. The air is drawn upwardly through the evaporator 78 by fans 108 of the centrifugal type. The fans 108 are driven by a suitable source of power as by electric motor 110 through belt 112. The fans 108 discharge the air into the refrigerated space through openings 114.

The evaporator 78 is constructed similar to that shown in U. S. patent application of Gerald E. Hecke, Serial No. 785,091, filed November 10, 1947 and now Patent No. 2,529,215. The evaporator 78 has heat conducting plate type fins and tubes 116 through which fins. The tubes are in heat conducting contact with the fins. Some of said tubes conduct refrigerant, and others of said tubes contain electric heating elements indicated schematically at 116 in Fig. 4. When frost accumulates
on the surfaces of the evaporator 78 to the extent that its function is impaired, the electric heating elements 116 are connected to a source of electricity to cause the coil until the frost is melted or shed from the evaporator surfaces to restore proper operation of the coil.

The controls are shown in Figs. 4, 5, and 6. The switch 14 is a governor isolating switch 155. It is a point at which damage to the produce might occur.

Referring now to Fig. 4 which shows schematically the control elements, the engine 14 has a governor 116 which is adjusted to idling speed by energizing of governor solenoid GS1. When a load is applied to generator 16, governor solenoid GS2 is energized to adjust the governor to a higher speed to accommodate the load. A high pressure switch HP is connected in the discharge pipe so from the compressor, and switch HP opens when the pressure exceeds a predetermined amount. A low pressure switch LP is connected in the suction pipe 82 between the compressor 26 and the heat exchanger 70. This low pressure switch LP opens when the pressure in pipe 82 drops below a predetermined amount. A governor 116 is connected in the opening in the path of air from the refrigerated space to the evaporator 78. Temperature controller TC1 controls the temperature in the fresh produce temperature cycle by connecting or disconnecting the compressor or for heating operation. A temperature controller TC2 is also located in the opening in the path of air moving from the refrigerated space to the evaporator 78. Temperature controller TC3 is located in the outlet in 114 and breaks contact when the temperature of the air being discharged into the refrigerated space decreases to a point at which damage to the produce might occur. Referring now to Fig. 5, the control cycle of the apparatus will be described. A battery 121 supplies energy for the control system. The battery 121 is charged by the direct current generator 18 which is connected to the current and voltage regulating and reverse current relay 123. When it is desired to put the apparatus into operation switch S1 is closed manually to energize idling speed governor solenoid GS2 and of the alternating current generator 16. The push button switch 124 is then closed to energize the starting motor 126 which starts the engine 14. The switches S2A and S2B are then moved to the contacts LA and LB respectively for temperatures such as -10° F, which are suitable for frozen foods, or to the contacts HA and HB respectively for some temperatures such as 34° F, which are suitable for fresh produce storage. For the purpose of this explanation, let us assume that the switches S2A and S2B are moved to the contacts LA and LB respectively for frozen food storage. TC2 will close because the air temperature will be above the control point. Since CR3A is normally closed contact, solenoid valve 76 is energized and in open position to admit refrigerant to the expansion valve 74. Winding CR1 is also energized and it closes contact CR1A to energize winding MS2 which closes contacts MS2A to energize the compressor motor 24. Winding MS2 also closes contact MS2B to maintain its energization independent of contact CR1A. Winding MS2 also closes contact MS2C to energize governor solenoid GS2 to permit engine 14 to operate at high speed. MS1 is energized because normally closed contact TRA is closed due to the fact that winding TR is deenergized because of open contact PC. Winding MS1 closes contacts MS1A to energize the evaporator fan motor 110.

It is evident that the apparatus is operating to maintain the desired temperature of -10° F. However, during such operation frost accumulates on the surfaces of the evaporator 78 until the pressure drop across the evaporator increases to the point at which pressure controller CR3 and winding TR energization of winding CR3 opens normally closed contact CR3A to deenergize and close solenoid valve 76. Energization of winding TR opens normally closed contact MS2D and shut off the compressor motor 24. When MS2 is deenergized normally closed contacts MS2D and winding HC is energized and contacts HCA are closed to put the electric heaters 116 into operation.

When the heaters 116 have raised the temperature of the evaporator 78 to about 36° to assure that all the temperature controller TC3 opens deenergizing winding CR3 and allowing normally closed contact CR3A to close and energize solenoid valve 76 to open said valve. Closing of contact CR3A starts the compressor motor through winding CR1, contact CR1A, winding MS2, and contact MS2A.

When TC3 opens, winding TR is deenergized and normally closed contacts TRA closes after a time delay to energize winding MS1 and start the evaporator fan motor. In this manner the starting of evaporator motor 110 is delayed until after the compressor motor 24 has been started. The operation of the apparatus when set for the fresh produce storage condition of 34° will now be described.

Switches S2A and S2B are moved to contacts HA and HB respectively. Temperature controller TC1 then contacts post C when cooling is required and post H when heating is required. Let us assume that cooling is required and TC1 is contacting post C. Temperature Controller TC4 will be closed as long as the discharge temperature is not so low as to damage the produce. Solenoid valve 76 will be energized to open position to admit refrigerant to the expansion valve 74. Winding CR1 will be energized and will close contacts CR1A to energize winding MS2 which in turn energizes the compressor motor 24 through contacts MS2A. The evaporator fan motor 110 is also energized through contacts MS1, winding MS1 and normally closed time delay relay contacts TRA. Assume now that the evaporator fan motor 110 has ceased to operate to the extent that refrigeration is impaired. The pressure control PC closes energizing winding CR3, which in turn opens normally closed contact CR3A, deenergizing winding MS2 and allowing solenoid valve 76 to close. When PC closes, winding TR is energized to open normally closed contacts TRA and deenergize winding MS1 which in turn deenergizes the evaporator fan motor through contacts MS1A. The compressor motor 24 continues to operate to remove refrigerant from the evaporator 78 until the pressure is reduced to the point where low pressure contact LP opens deenergizing winding MS2 which opens contacts MS2A of compressor motor 24. The electric heaters are now energized through contacts HCA which are closed by the energization of winding HC through normally closed contact MS2D and contact CR3B which is closed by winding CR3 which is energized. When the temperature of the evaporator rises to 36° indicating that defrosting is complete, temperature controller TC3 opens deenergizing winding MS2 and contact CR3B deenergizing winding HC and opening contact HCA to shut off the heaters 116.

Opening of contact TC3 deenergizes winding CR3 which prevents winding MS2 from closing contact MS2C which operates CR1 which in turn closes contact CR1A to energize winding MS2 which in turn closes contact MS2A of compressor motor 24 to start said motor. Opening of contact TC3 deenergizes winding MS2 and closes contact TRA which closes contact MS1A to start the evaporator fan motor 110.

Although temperature controller TC3 will terminate defrosting operation and reestablish refrigerating operation, additional means has been provided to accomplish this change in operation in the event that temperature controller TC3
fails. A time delay relay winding TR2 is energized when pressure switch FC closes to initiate a defrosting operation. After time delay relay winding TR2 is energized for a period of time sufficient for defrosting the evaporator 78, winding TR2 opens normally closed contact TRA to terminate the defrosting operation and reestablish refrigeration operation in the same manner as if switch TC3 were opened.

Let us now assume that the outside temperature drops to a point that the temperature of the air in the car is below this temperature at which the thermostat TCI is set. TCI will contact post H to energize heater winding HC through normally closed contact MS2D. Heater winding HC will close contact HCA to energize the heater 116. The evaporator fan motor 110 will be energized because winding MS1 will be energized through normally closed contact TRA and winding MS1 will close contacts MS1A to energize the evaporator fan motor 110. The winding HC being energized, contacts HCA will be closed and governor solenoid GS2 will be energized to govern the engine at high speed to accommodate the heating load. Air is then drawn into the evaporator 116, is cooled to dew point, is directed toward the roof of refrigerator car. 2. A refrigerator compartment extending transversely of said vehicle from one side of said vehicle to the other side of said vehicle, an engine in said compartment, a generator in said compartment, and being connected to said engine, an electric motor energized by said electric generator, and said refrigerant compressor connected to said electric motor and being driven by said electric motor, a refrigeration condenser, means for conducting refrigerant from said condenser, a heat exchanger having refrigerant conduits and electric heating elements, means for conducting refrigerant from said condenser to said refrigeration conduits, means for conducting electrical energy from said generator to said electric heating elements, control means for said internal combustion engine to operate said engine at a low speed or at a high speed, thermostatic means in the enclosure for connecting or disconnecting said electric motor or said electric heating elements to said electric generator, control means being responsive to said thermostatic means to operate said internal combustion engine at high speed when said thermostatic means connects said electric motor or said electric heaters to said electric generator.

3. Refrigeration apparatus for an enclosure comprising an internal combustion engine, an electric generator connected to said engine and being driven by said engine, an electric motor energized by said electric generator, a refrigeration compressor connected to said electric motor and being driven by said electric motor, a refrigeration condenser, means for conducting refrigerant from said condenser and heat exchanger to said condenser, a heat exchanger having refrigerant conduits and electric heating elements, means for conducting refrigerant from said condenser to said refrigeration conduits, conduit means for conducting refrigerant from said condenser to said heat exchanger, a valve in said conduit means for controlling the flow of refrigerant through said conduit means, means for operating said internal combustion engine at a low speed or at a high speed, control means being responsive to said thermostatic means to operate said internal combustion engine at high speed when said thermostatic means connects said electric motor or said electric heaters to said electric generator.

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