Nov. 16, 1954 G. E. HICKE ET AL 2,694,553

REFRIGERATION APPARATUS FOR RAILROAD CARS

Filed Jan. 4, 1951 5 Sheets-Sheet 1

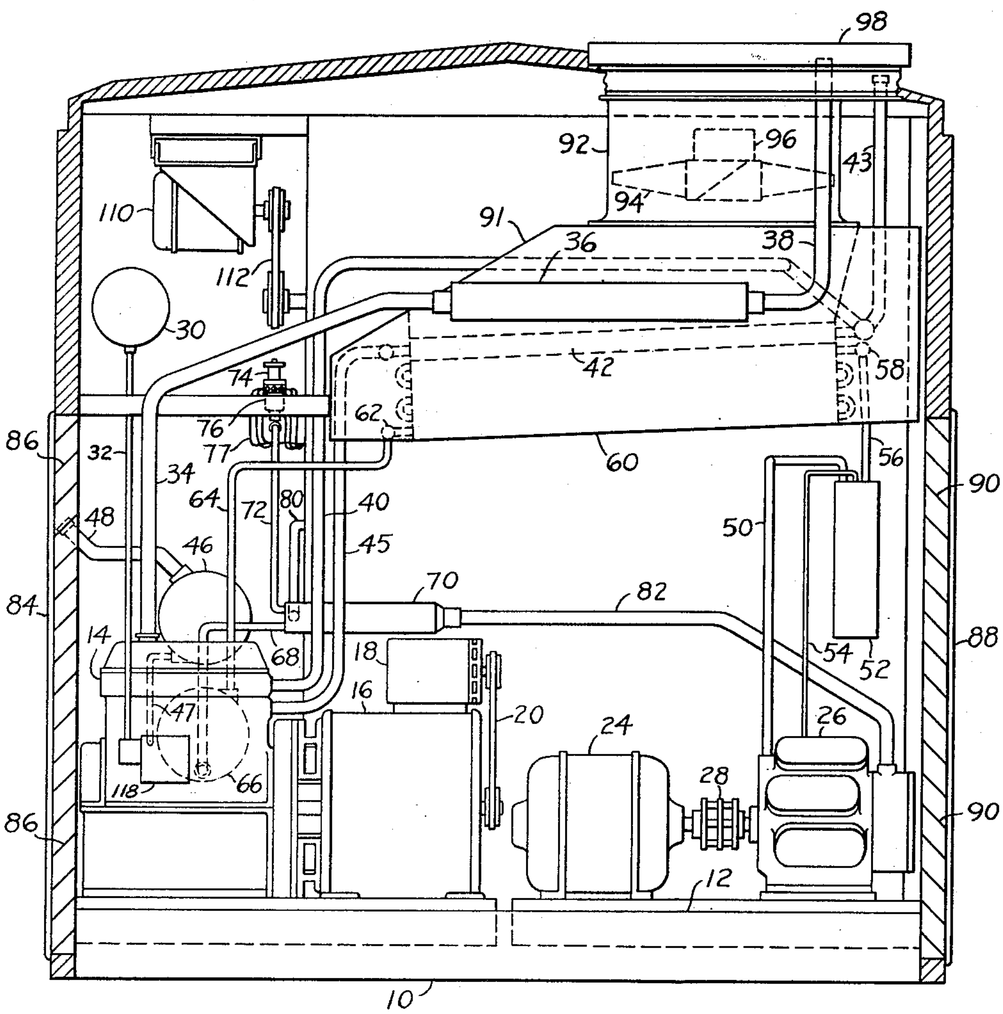

Fig. 1.

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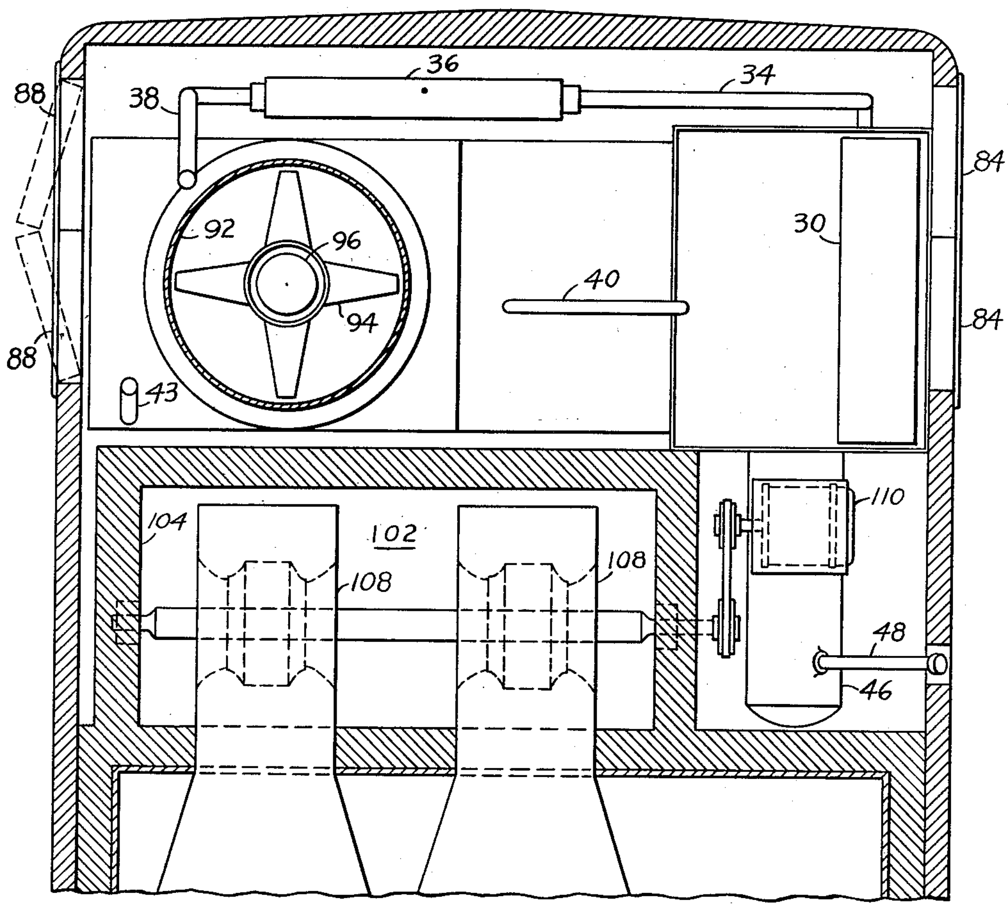

Fig. 2.

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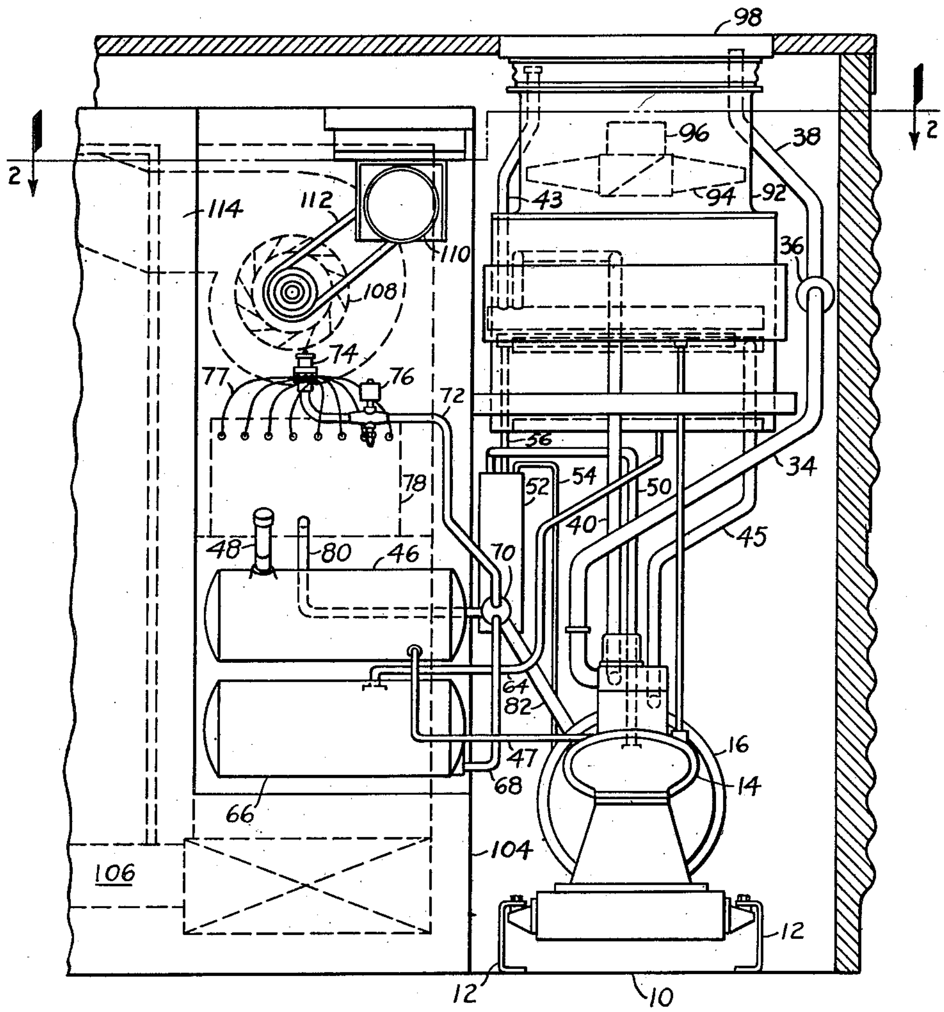

Fig. 3.

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REFRIGERATION APPARATUS FOR RAILROAD CARS

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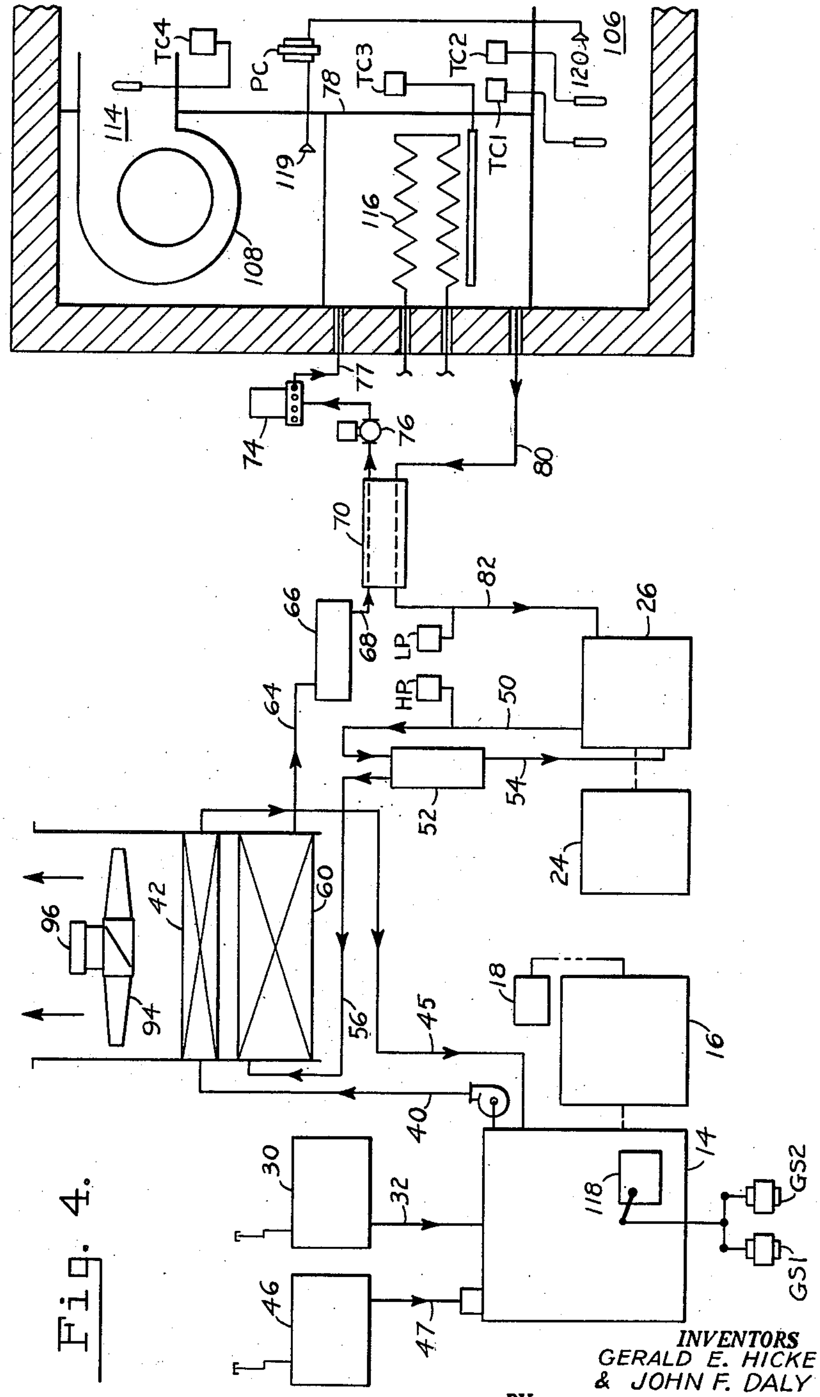

Fig. 4.

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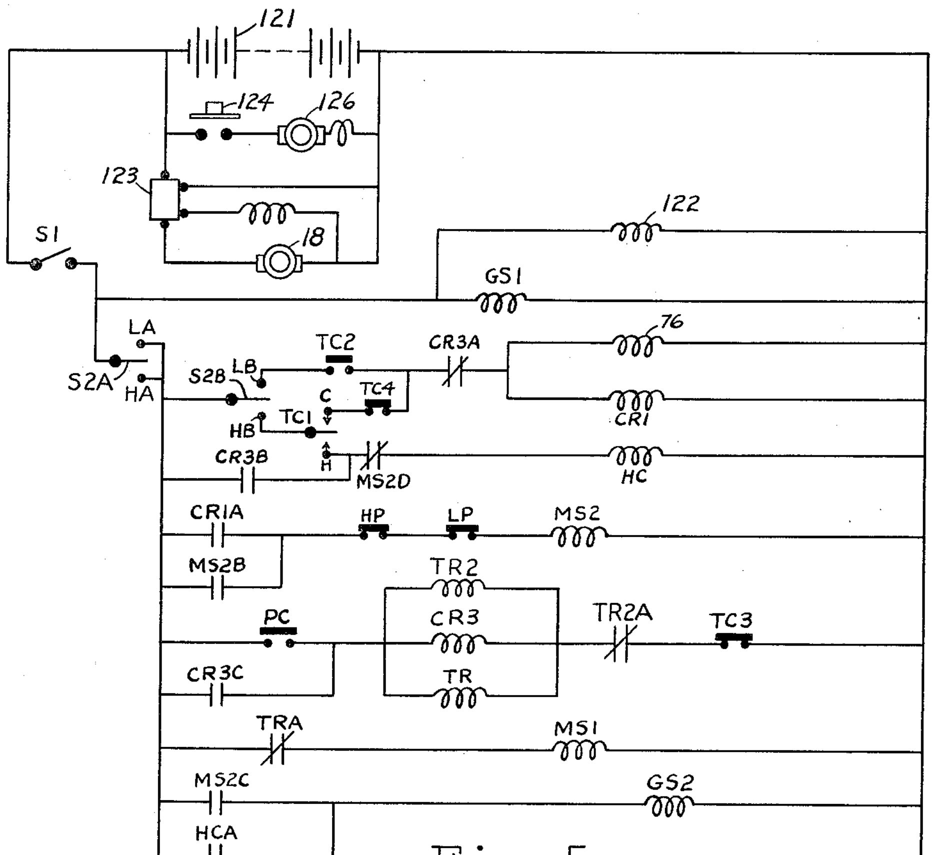

Fig. 5.

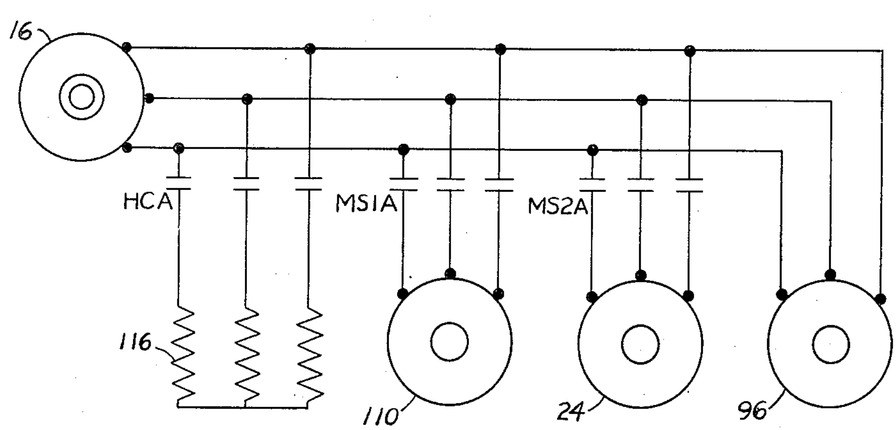

Fig. 6.

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REFRIGERATION APPARATUS FOR RAILROAD CARS

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Application January 4, 1951, Serial No. 204,432

5 Claims. (Cl. 257—3)

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 is easily manufactured and serviced by providing four major assemblies comprising an air handling and conditioning assembly, a condenser and radiator assembly, a power producing assembly 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 apparatus which is designed to facilitate service and maintenance, and to make possible the replacement of 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.

It is another object of the invention to provide a single air propelling means for causing air to move over the engine, the generator, the motor, the compressor, the condenser and the engine radiator.

It is another object of this invention to provide apparatus which will withstand the shock and vibration encountered in a vehicle such as a railroad freight car.

It is another object of the invention to provide controls for protecting 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 with reference to 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 wall of the car removed.

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.

Fig. 6 is a wiring diagram of the electrical power circuit.

Referring now to Fig. 1 of the drawing, numeral **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**.

The engine **14** receives fuel from the fuel tank **30** from which the fuel flows to the engine by gravity through fuel line **32**. The engine **14** exhausts through pipe **34**, muffler **36** and pipe **38**. The jacket water of the engine **14** flows from the engine 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**

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is contained in a tank **46** which has a filling pipe **48** extending to the outside of the car.

The generator **16** is direct-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 separated oil returns 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 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** to an 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 from 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 car to permit access to the engine and generators. The doors **84** have louvres **86** to permit air to enter the car and 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 compressor motor. These doors **88** have louvres **90** to permit the entrance of air and 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 conduct air therefrom. An axial flow fan **94** is mounted in 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**, the exhaust 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 the air 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 the 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. Hicke, 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 passing through holes in the 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 heat 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 symbols used indicate the inter-connection of the elements. For instance winding CR1 operates contacts CR1A, time delay relay winding TR operates contacts TRA and motor starter winding MS2 operates motor starter contacts MS2A.

Referring now to Fig. 4 which shows schematically the control elements, the engine **14** has a governor **118** which is adjusted to idling speed by energization 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 **50** 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 temperature controller TC1 is located in the opening **106** in the path of air from the refrigerated space to the evaporator **78**. Temperature controller TC1 controls the temperature in the fresh produce temperature range by connecting the apparatus for cooling operation or for heating operation. A temperature controller TC2 is also located in the opening **106** in the path of air moving from the refrigerated space to the evaporator **78**. Temperature controller TC2 controls the temperature in the frozen food temperature range. A temperature controller TC3 is located within the evaporator **78** and breaks contact when the temperature of the coil exceeds about 36°. A pressure controller PC has a pressure tap **119** in the path of air leaving the evaporator **78** and a pressure tap **120** in the path of air entering the evaporator **78**. Pressure controller PC makes contact when the difference in pressure between points **119** and **120** has increased to the extent that defrosting of the evaporator **78** is desirable. A temperature controller TC4 is located in the outlet **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 Figs. 4, 5, and 6, 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 battery through a current and voltage regulator 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 GS1 and the field winding **122** 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 temperature such as 34° F. which is suitable for fresh produce storage. For the purpose of this explanation let us assume that the switches S2A and S2B are moved to contacts LA and LB respectively for frozen food storage. TC2 will close because the car 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 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. Winding 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 thus 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 PC closes to energize winding 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 TRA to deenergize winding MS1 which opens contacts MS1A to deenergize the evaporator fan motor **110**.

CR3B closes but heater control winding HC is not energized, because normally closed contact MS2D is open. However when the compressor has pumped the refrigerant from the coil, the low pressure switch LP opens to deenergize winding MS2 and shut off the compressor motor **24**. When MS2 is deenergized normally closed contacts MS2D close 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 insure that all the frost has been removed from the coil, the contacts of temperature controller TC3 open 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 contact 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 first 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 MS1A, winding MS1 and normally closed time delay relay contacts TRA. Assume now that the evaporator **78** has become frosted to the extent that refrigeration is impaired. The pressure control PC closes energizing winding CR3, which in turn opens normally closed contact CR3A, deenergizing 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 control TC3 opens deenergizing winding CR3 opening contact CR3B deenergizing winding HC and opening contact HCA to shut off the heaters **116**.

Opening of contact TC3 deenergizes winding CR3 which permits contact CR3A to close and energize winding 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 TR which allows contact TRA to close after a time delay and energize winding MS1 which closes contact MS1A to start the evaporator fan motor **110**.

Although temperature 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 PC closes to initiate a defrosting operation. After time delay relay winding TR2 has been energized for a period of time sufficient for defrosting the evaporator 78, winding TR2 opens normally closed contacts TR2A to terminate the defrosting operation and reestablish refrigerating operation in the same manner as if switch TC3 were opened.

Let us now assume that the outside temperature drops to such a point that the temperature of the air in the car is below the temperature at which the thermostat TC1 is set. TC1 will contact post H to energize heater winding HC through normally closed contact MS2D. Heater winding HC closes contact HCA to energize the heaters 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. It is thus seen that the governor solenoid GS2 is energized to govern the motor at high speed whenever the compressor motor 24 or the electric heaters 116 are in operation.

The operation of the temperature controller TC4 will now be described. During periods when the apparatus is cooling a load of fresh produce down to the temperature desired, frost accumulates on the evaporator and reduces the volume of air flowing through the coil and results in a reduction in temperature of the air discharged by the fan to some point such as 24° below which the produce will be damaged. But when this temperature is encountered the temperature controller TC4 opens to deenergize and close solenoid valve 76 so that no refrigerant flows to evaporator 78. The temperature of the discharge air will then rise slowly until a predetermined temperature such as 28° is reached and at which point temperature controller TC4 closes and reestablishes flow of refrigerant to evaporator 78 by opening solenoid valve 76.

Although we have described specifically the preferred embodiments of our invention, we contemplate that many changes may be made without departing from the scope or spirit of our invention, and we desire to be limited only by the claims.

We claim:

1. A refrigerated vehicle comprising an elongated enclosure, louvered doors pivoted to each of the sides of said enclosure at one end, an electricity generating unit mounted in said enclosure with its axis of rotation extending transversely of said enclosure, a refrigerant compressing unit mounted in said enclosure with its axis of rotation extending transversely of said enclosure, said refrigerant compressing unit being energized by said electricity generating unit, a refrigerant condenser mounted in said enclosure above said refrigerant compressing unit, means for conducting refrigerant from said refrigerant compressing unit to said refrigerant condenser, an opening in the roof of said enclosure, a duct extending from said refrigerant condenser to said opening and means for moving air into said enclosure through said louvered doors, through said refrigerant condenser and discharging said air from said enclosure through said duct, an evaporator, means for conducting refrigerant from said condenser to said evaporator and from said evaporator to said refrigerant compressing unit, means for moving the air of said enclosure through said evaporator to remove heat from the air.

2. A refrigerator car comprising an internal combustion engine, an electric generator connected to said engine and being driven by said engine, said internal combustion engine and said electric generator having substantially aligned axes extending transversely of the refrigerator car, an electric motor, a refrigerant compressor connected to said electric motor and being driven by said electric motor, said electric motor and said refrigerant compressor having substantially aligned axes extending transversely of the refrigerator car, a refrigerant condenser mounted above said electric motor and said refrigerant compressor, an engine radiator mounted above said refrigerant condenser and means for moving air inwardly through the sides of said car and over said engine, said electric generator, said electric motor, and said refrigerant compressor, then through said refrigerant condenser, then through said engine radiator, and then outwardly through the roof of refrigerator car.

3. A refrigerator vehicle comprising a 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 to be driven by said engine, said engine and said generator having substantially aligned axes of rotation extending transversely of said vehicle, a motor in said compartment, a compressor in said compartment and being connected to said motor to be driven by said motor, said motor and said compressor having substantially aligned axes of rotation extending transversely of said vehicle, an inlet opening in each side of said vehicle to admit air to each end of said compartment, a refrigerant condenser mounted above said motor and said compressor, means for conducting refrigerant from said compressor to said condenser, a radiator above said condenser, means for conducting cooling fluid from said engine to said radiator, means for conducting cooling fluid from said radiator to said engine, a discharge opening in the roof of said vehicle, a duct above said radiator communicating with said discharge opening, and means for moving air into said compartment through said inlet openings and upwardly successively through said condenser, said radiator, said duct and said discharge opening.

4. 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 refrigerant compressor connected to said electric motor and being driven by said electric motor, a refrigerant condenser, means for conducting refrigerant from said compressor to said condenser, a heat exchanger having refrigerant conduits and electric heating elements, means for conducting refrigerant from said condenser to said refrigerant 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 a high speed, thermostatic means in the enclosure for connecting or disconnecting said electric motor or said electric heating elements to said electric generator, said 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.

5. 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 refrigerant compressor connected to said electric motor and being driven by said electric motor, a refrigerant condenser, means for conducting refrigerant from said compressor to said condenser, a heat exchanger having refrigerant 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 moving air from said enclosure through said exchanger, means for returning said air to said enclosure, first temperature responsive means in the path of air entering said heat exchanger for closing said valve when the air entering said heat exchanger drops below a first predetermined temperature and second temperature responsive means in the path of the air returning to said enclosure for closing said valve when said air returning to said enclosure drops below a second predetermined temperature.

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