

Aug. 8, 1944.

D. F. ALEXANDER ET AL

2,355,040

REFRIGERATING APPARATUS

Filed July 30, 1941

6 Sheets-Sheet 1

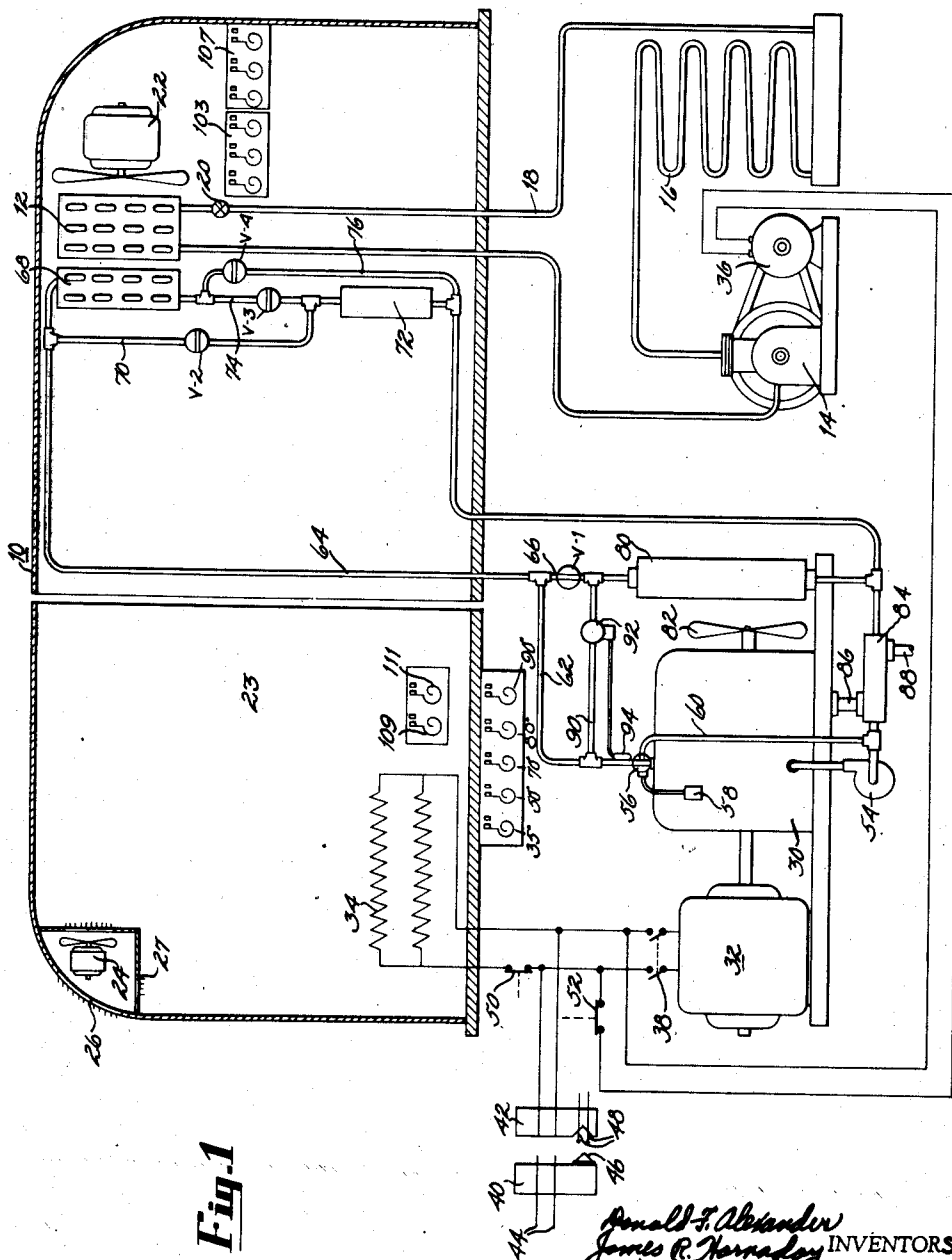


Fig. 1

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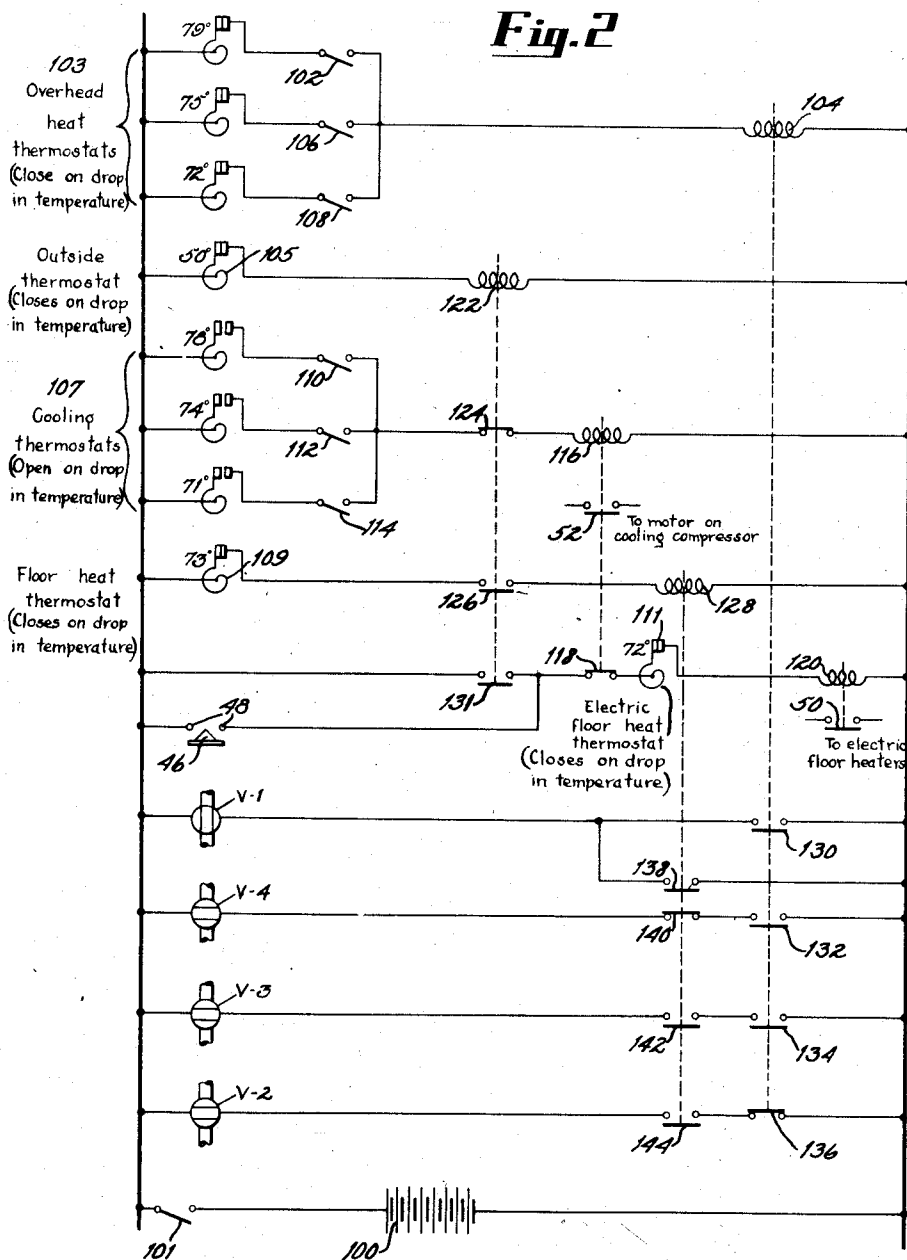
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REFRIGERATING APPARATUS

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6 Sheets-Sheet 2

Fig. 2



All circuits deenergized
Outside temperature below 50°
Inside temperature below 70°

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Aug. 8, 1944.

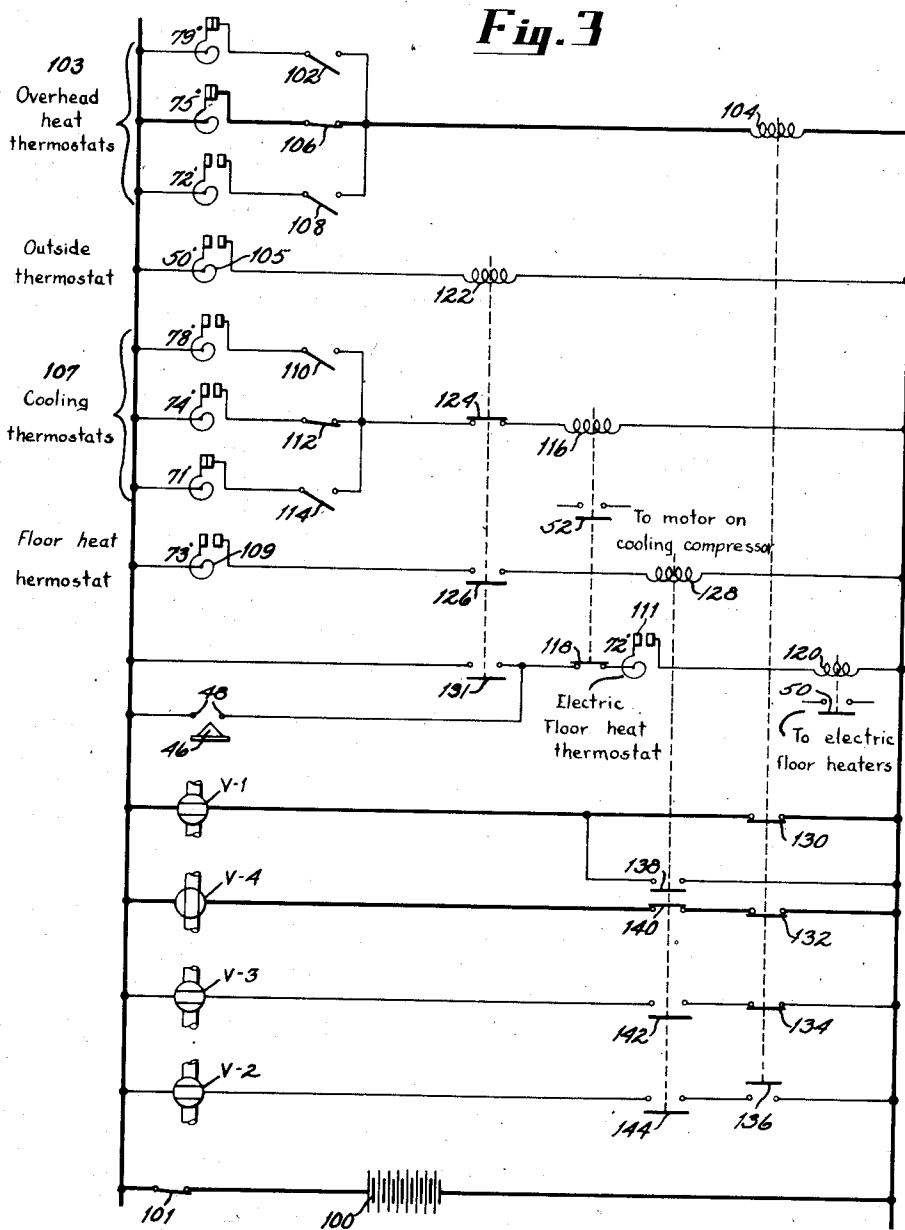
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REFRIGERATING APPARATUS

Filed July 30, 1941

6 Sheets-Sheet 3



Outside temperature above 50°

Inside temperature between 73° and 74°

Refrigeration off

All floor heat off

Overhead heat on

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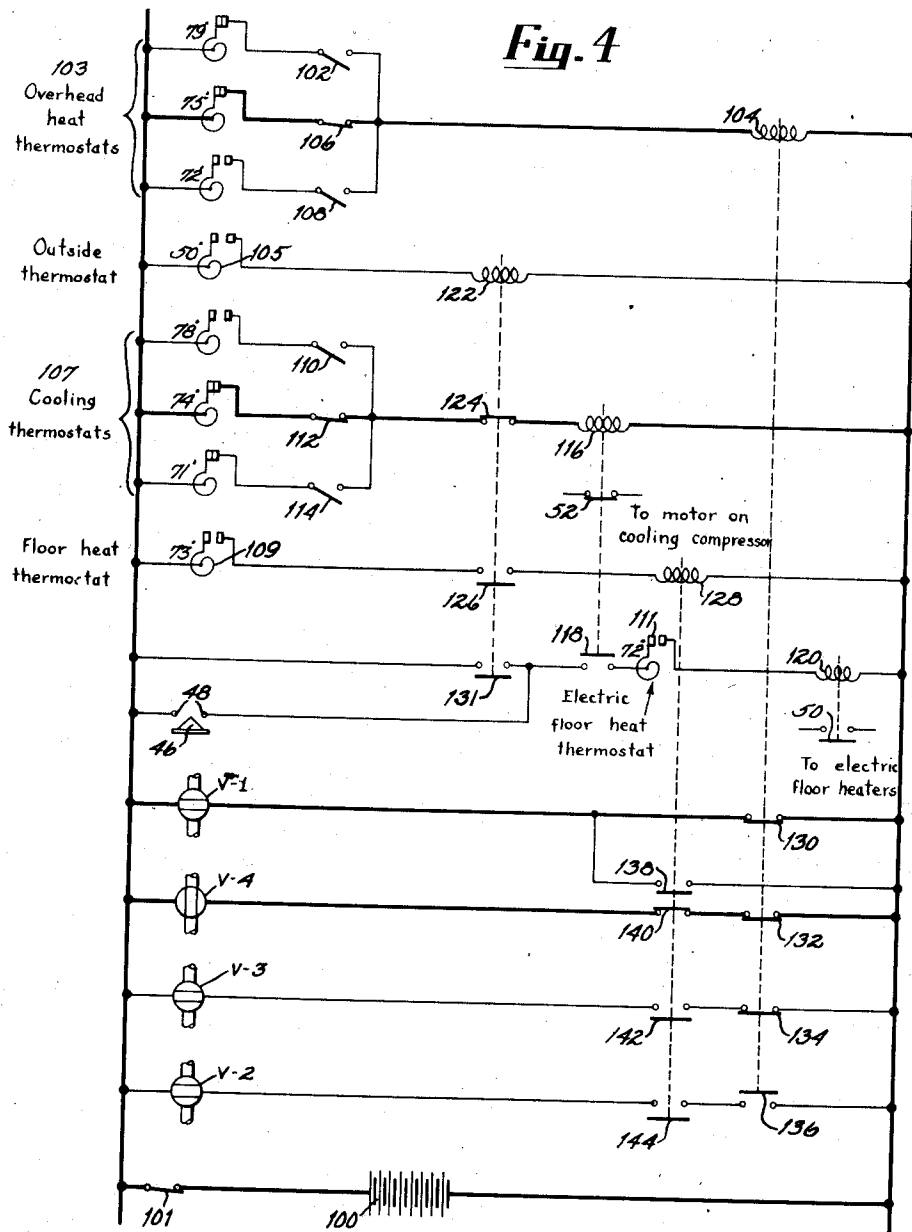
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REFRIGERATING APPARATUS

Filed July 30, 1941

6 Sheets-Sheet 4

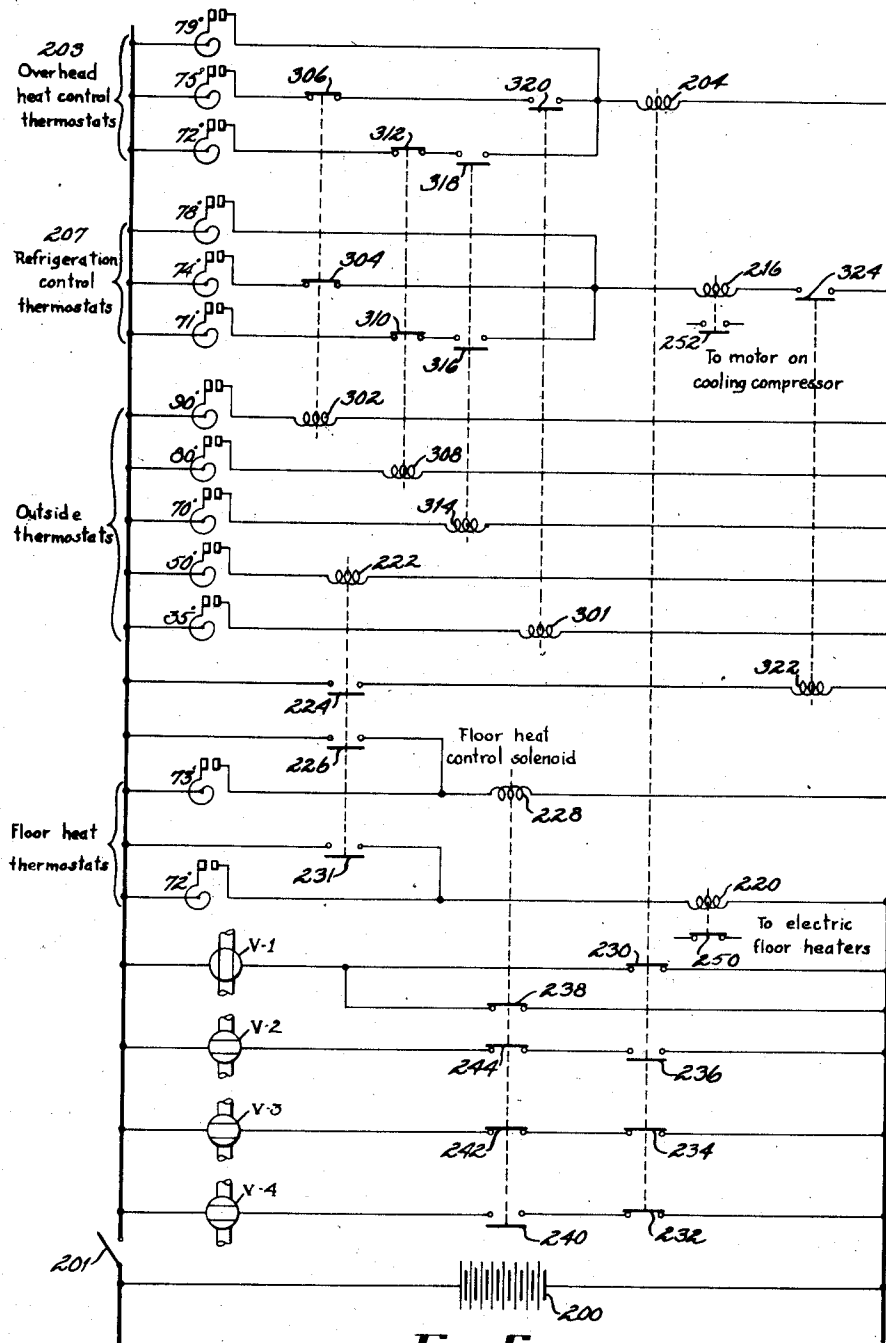


Outside temperature above 50°
 Inside temperature between 74° and 75°
 Overhead heat on
 Refrigeration on
 All floor heat off

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2,355,040

6 Sheets-Sheet 5



All circuits deenergized
Outside temperature below 35°
Inside temperature below 77°

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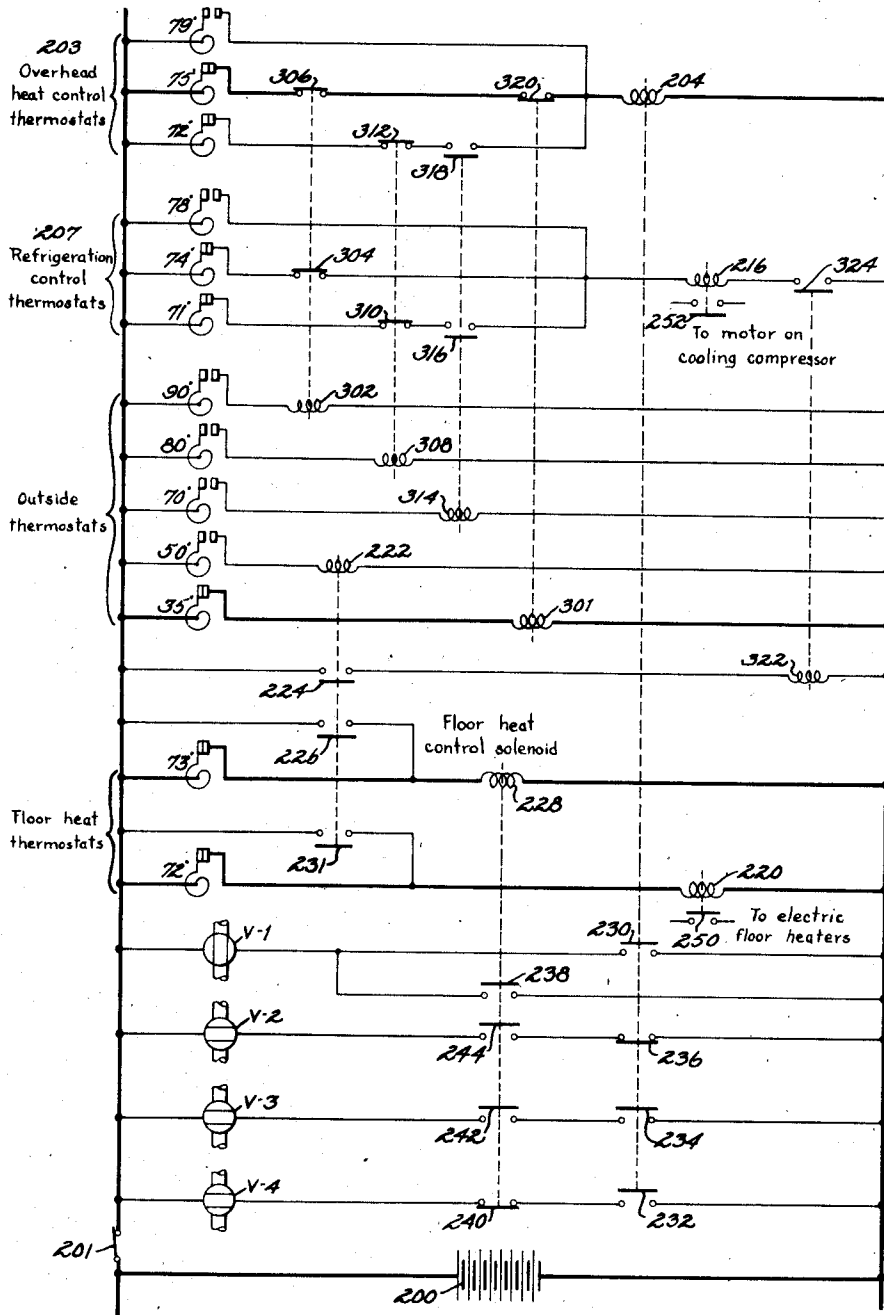
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REFRIGERATING APPARATUS

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6 Sheets-Sheet 6



Outside temperature 40°
Inside temperature 75°
Floor heat off

Fig. 6

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UNITED STATES PATENT OFFICE

2,355,040

REFRIGERATING APPARATUS

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Application July 30, 1941, Serial No. 404,686

6 Claims. (Cl. 257—3)

This invention relates to refrigerating apparatus and more particularly to an improved arrangement for conditioning the air in a railway car or the like.

It is common practice in air conditioning systems to utilize waste heat of a prime mover for supplying heat to an enclosure for heating purposes. It has been found, however, that numerous problems are involved in controlling the discharge of this waste heat into the conditioned space. It is an object of this invention to provide an improved control system for determining when and where this waste heat is to be discharged into the conditioned space.

Another object of this invention is to provide an improved control arrangement which prevents cold drafts adjacent the floor.

Still another object of this invention is to provide an improved arrangement for changing from overhead heating to floor heating.

A further object of this invention is to provide a simplified arrangement for selecting the temperature to be maintained within a conditioned space.

Another object is to provide an improved control for controlling the heating of the car while standing in the yard.

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 diagrammatically shows a preferred arrangement of the heating and cooling elements as applied to a railway car;

Fig. 2 shows an electrical circuit which may be used in controlling the heating and cooling apparatus shown in Fig. 1;

Figs. 3 and 4 correspond to Fig. 2 and show which portions of the main circuit are energized under certain designated temperatures; and

Figs. 5 and 6 show a modified form of control circuit.

Reference numeral 10 designates a conventional railway car of the passenger type equipped with air conditioning apparatus embodying our invention. Reference numeral 12 designates a conventional refrigerant evaporator which is used for cooling the air for the passenger compartment during the summer season. The compressor 14 withdraws vaporized refrigerant from the evaporator 12 and discharges compressed refrigerant into the condenser 16 in accordance with well-known practice. The condensed re-

frigerant is supplied to the evaporator through the line 18 in which is located a conventional refrigerant flow control device 20. The control 20 may be either of the thermostatic expansion valve type or the fixed restrictor type. The air to be conditioned is circulated over the evaporator 12 by means of the fan unit 22.

A separate fan unit 24 has been provided for ventilating purposes so as to provide circulation of either fresh air, return air or a mixture of both. The fan unit 24 draws fresh air into the car through the damper controlled inlet 26 and recirculates car air through the opening 27. This fan unit may operate simultaneously with the fan unit 22 or it may be used to operate at such times when fan unit 22 is not in operation.

Reference numeral 30 designates an internal combustion engine preferably of the Diesel type which is used for supplying power for driving the generator 32. The generator 32 may be either a direct current generator or an alternating current generator and is used for supplying electrical energy to the electric floor heaters 34 mounted in the passenger compartment 23 of the vehicle 10. The generator 32 also supplies electric energy to the compressor operating motor 36. A double pole switch 38 is provided for disconnecting the compressor motor 36 and the floor heaters 34 from the generator 32.

Since there may be times when either refrigeration or heating may be required when the Diesel engine 30 is not in operation, such as when the vehicle is standing at a station, means have been provided for supplying outside electrical energy to the floor heaters 34 or the compressor motor 36. This means comprises a plug 40 which may be plugged into the socket 42 carried by the car. The plug 40 is provided with leads 44 connected to an external source of electrical energy at the station. A jumper 46 is provided on the plug 40 for bridging the contacts 48 for a purpose to be explained more fully hereinafter. In order to simplify the disclosure we have shown the switch 38 as a manually controlled switch, whereas in actual practice this switch would be controlled automatically, so as to open upon the electrical circuit being connected to the outside source of current. The flow of current to the electric floor heaters 34 is controlled by the solenoid operated switch 50, as explained more fully hereinafter. Likewise the flow of current to the compressor motor 36 is controlled by the solenoid operated switch 52, as explained more fully hereinafter.

It has long been common practice to utilize

the waste heat of an internal combustion engine for heating the air for an enclosure during the winter. The waste heat of an engine has also been used for reheating the air during the summer season. In the prior art systems, however, considerable difficulty has been experienced in properly controlling the disposal of the waste heat of the engine.

In the arrangement shown in Fig. 1 the engine cooling fluid is circulated by means of a conventional pump 54 driven by the engine 30 in accordance with conventional practice. For convenience in description only, the engine cooling fluid will be referred to hereinafter as water, whereas in actual practice an anti-freeze solution is used the year around so as to prevent the fluid from freezing.

A thermostatically controlled three-way valve 56 is provided for regulating the engine water temperature. The engine temperature responsive thermostat 58 controls the valve 56. Upon starting the engine the three-way valve 56 causes all of the water discharged from the engine cooling jacket to flow directly through the line 60 to the intake of the pump 54, whereby no water is circulated to any of the heat dissipating radiators until the engine temperature comes up to that temperature at which the engine is designed to operate most efficiently. After the engine temperature comes up to normal the heated water leaving the engine normally flows through the line 62 which leads to the lines 64 and 66. The line 64 conveys the heater water to the overhead air heating coil 68 located at the air outlet side of the evaporator coil 12 and the floor heating coil 72.

During cold weather heating is often required adjacent the floor of the passenger compartment even though the temperature prevailing in the upper portion of the car is satisfactory. This is especially true when a car door is open since at that time cold air sweeps along the floor of the car. In order to simplify this disclosure, only one floor heating coil 72 has been shown whereas in actual practice several such coils are placed along the length of the passenger compartment.

A group of valves controls the flow and the path of the heater water delivered through line 64, passing this water through either one, or both, of coils 68 and 72, or shutting off the flow entirely. When overhead heat is not desired, but floor heat is desired, a by-pass 70 controlled by the valve V-2 has been provided for supplying the heated water directly to floor heat coil 72. When overhead heat and floor heat are both required, water leaving the overhead heat coil 68 may be supplied to the coil 72 through the line 74 in which is provided control valve V-3. When no floor heat is required but overhead heat in coil 68 is required for reheating during the summer season, the water leaving coil 68 may be by-passed around the floor heat coil 72 through the by-pass line 76 controlled by the valve V-4. The controls for operating valves V-1, V-2, V-3, V-4 to accomplish the above functions are described hereinafter.

Since there are times when no heating of any form is desired in the passenger compartment, provision has been made for causing all of the heated water leaving the engine 30 to flow from the pipe 62 into the pipe 66 in which is provided a valve V-1. When the valve V-1 is open, all of the water flows directly to the main engine radiator 80 which serves to cool the water in accordance with well-known practice. The fan 82 75

which is driven by the main engine 30 circulates cooling air in thermal exchange with the radiator 80. The water leaving the radiator 80 as well as the water returning from the heating coils 68 and 72 flows through the heat interchanger 84 through which the exhaust gas from the engine flows. The exhaust gas enters the heat interchanger 84 through the pipe 86 and is discharged through the pipe 88. A by-pass 90 has been provided in order to prevent overheating of the engine. The by-pass 90 is controlled by the thermostatic valve 92 which in turn is controlled by a thermostatic bulb 94 placed in thermal exchange with the water leaving the engine. The valve 92 opens when the temperature of the water leaving the engine becomes excessive so as to cause water to flow directly into the main radiator 80 even though the valve V-1 is closed.

By providing the reheat coil 68 adjacent the cooling coil 12 the apparatus may be used for dehumidifying the air when little or no refrigeration is required. During average operating conditions in the summer time the refrigerating system will operate continuously and the temperature within the passenger compartment will be controlled by the turning off and on of the reheat. Under extreme conditions the cooling capacity of the refrigerating system may be so great in comparison to the capacity of the reheat coil that the reheat coil will operate continuously and the temperature will be controlled by turning on and off the refrigerating system as will be explained more fully hereinafter. As the outside temperature falls below the 50° value it is desirable to completely discontinue the operation of the cooling apparatus and control the temperature in the passenger compartment by turning on and off the overhead heat and the floor heat.

Referring now to Figs. 2, 3 and 4, which show one form of electrical circuit which may be used in controlling the heating and cooling apparatus shown in Fig. 1, reference numeral 100 designates a conventional storage battery which supplies electrical energy to the control system. Reference numeral 101 designates a master control switch which is provided for deenergizing the entire circuit.

Since the temperature best suited for the passenger compartment will obviously vary from time to time depending largely upon the outside air temperature, some means must be provided for adjusting the inside temperature from time to time. The temperature to be maintained may be selected manually or automatically. Figs. 2, 3 and 4 show a circuit suitable for use when the inside temperature range is manually selected whereas Figs. 5 and 6 show a circuit which includes automatic selection based on the outside temperature. The controls which have been provided in each instance comprise the three overhead heat thermostats designated by the reference numeral 103 in Figs. 2, 3 and 4, only one of which is intended to be placed in control at any one time, one 50° outside thermostat 105 responsive to the outside air temperature, three cooling thermostats 107, only one of which is intended to be in control at any one time, and two thermostats 109 and 111 located in the passenger compartment adjacent the floor thereof. Thus, three separate thermostats have been provided for controlling the supply of overhead heat. Likewise, three separate thermostats have been provided for controlling the cooling apparatus.

In the arrangement shown in Figs. 2, 3 and 4 manual switches 102, 106, 108, 110, 112 and 114 have been provided for selecting the particular thermostats to be used at any one time. Reference numeral 102 designates the manual switch which is used for placing the 79° overhead heat thermostat in control of the solenoid 104. Reference numerals 106 and 108 designate manual switches arranged in series with the 75° and 72° thermostats, respectively. Only one of the manual switches 102, 106 and 108 is intended to be closed at any one time and the particular switch which is closed depends upon what temperature is to be maintained in the car. Manual switches 110, 112, 114 are arranged in series with the 78°, 74° and 71° cooling thermostats respectively. When it is desired to maintain the temperature within the car between 74° and 75°, the manual switches 112 and 106 would be closed so as to place the 74° cooling thermostat and the 75° overhead heat thermostat in control of the cooling apparatus and the overhead heat coil respectively. The cooling thermostats control the solenoid 116 which when energized closes the switch 52 so as to cause the compressor motor 36 to operate. The solenoid 116 also controls the switch 118 arranged in series circuit relationship with the 72° electric floor heat thermostat and the solenoid 120. The solenoid 120 controls the supply of electrical energy to the floor heater as pointed out hereinafter. It has been found that at outside temperatures below 50°, no refrigeration should be used. It has also been found that at temperatures below 50° it is necessary to provide heat adjacent the floor of the passenger compartment as well as to discharge heated air into the space above the passenger compartment. Accordingly the 50° outside thermostat has been provided in series with the solenoid 122. The 50° outside thermostat is adapted to close whenever the outside air temperature drops below 50° so as to energize the solenoid 122. Energization of the solenoid 122 opens the switch 124 which renders the refrigerating apparatus inoperative by deenergizing the compressor control solenoid 16. Energization of the solenoid 122 also serves to close the switch 126 which is arranged in series with the 73° floor heat thermostat 109 and the solenoid 128. Energization of the solenoid 128 lifts the switches 138, 140, 142, and 144 so as to turn on floor heat as will be described more fully hereinafter. Energization of the solenoid 122 also closes the switch 131 arranged in series with the switch 118 and the 72° floor heat thermostat which controls the electric floor heaters through the solenoid 120 and the switch 50. By virtue of the above described arrangement, whenever the outside air temperature drops below 50°, the refrigerating apparatus is rendered ineffective, the 73° floor heat thermostat is placed in control of the solenoid 128 and the 72° floor heat thermostat is placed in control of the solenoid 120. The 72° and 73° floor heat thermostats are adapted to close on a drop in temperature. Consequently, when the temperature adjacent the floor is between 72° and 73° the circuit through the solenoid 128 will be closed but the circuit through the solenoid 120 will be opened whereby no electric energy will be used in heating the air. As the temperature adjacent the floor drops below 72° the electric floor heat is turned on. This serves the dual purpose of increasing the load on the engine so as to increase the waste engine

heat available for heating and also serves to supplement the engine waste heat by electrical heat. Energization of the solenoid 128 makes it possible to utilize waste heat of the engine for heating the air adjacent the floor.

In Fig. 2 of the drawings, the thermostats are shown in the position which they will occupy when the outside temperature is below 50° and the inside temperature is below 70°. In Fig. 3 shown the arrangement of the thermostats and the switches when the outside temperature is above 50° and the inside temperature is between 73° and 74°. The heavy line circuits indicate those circuits which are energized, whereas the light line circuits indicate those circuits which are deenergized. For purposes of illustration the manual switches 106 and 112 have been shown closed in Figs. 3 and 4 whereby the 75° overhead heat thermostat controls the circuit through the solenoid 104 and the 74° cooling thermostat controls the circuit through the relay 116. When the inside temperature is between 73° and 74° and the outside temperature is above 50° the solenoid 104 is energized through the 75° overhead heat thermostat. Under these conditions the circuit is completed through the solenoid valve V—1 whereby the valve V—1 is closed. The circuit through the valve V—4 is likewise closed with the result that the valve V—4 is opened. The valves V—2 and V—3 which are normally closed when deenergized are closed under these conditions since the circuits leading thereto are deenergized. The solenoid 104 controls the switches 130, 132, 134 and 136 arranged as shown in Figs. 2, 3 and 4. The solenoid 128 controls the switches 138, 140, 142 and 144, arranged as shown in Figs. 2 through 4. Whenever the solenoid 104 is energized and the switches 130, 132, 134 and 136 are in their elevated positions, the overhead heat is on. Whenever the solenoid 128 is energized and the switches 138, 140, 142 and 144 are in their elevated position the floor heat, supplied by the floor coil 72, is on.

Fig. 4 shows in heavy lines those circuits which are energized when the outside temperature is above 50° and the inside temperature is between 74° and 75°. Fig. 4 shows the 75° overhead heat thermostat in control of the overhead heat solenoid 104 and shows the 74° cooling thermostat in control of the compressor motor and therefore the cooling coil 12.

As best shown in Fig. 2 in which all of the circuits are deenergized by virtue of the manual switch 101 being open, the solenoid valves V—2, V—3 and V—4 are closed when deenergized whereas the solenoid valve V—1 is open when deenergized. When it is desired to discontinue operation of the Diesel engine and to energize the compressor motor and the electric floor heat coils from an external source of electric energy, the jumper 46 carried by the plug 40 closes the circuit between the contacts 48 whereby the 72° floor heat thermostat controls the floor heat solenoid 120.

The circuit diagram shown in Figs. 2, 3 and 4, merely illustrate representative conditions. Obviously, other portions of the circuits would be energized under other conditions. It is not considered necessary to show those portions of the circuits which would be energized under every conceivable combination of inside, outside and floor temperatures.

Each of the solenoid operated switches shown herein is of the type which drops by gravity and

is lifted when the switch operating solenoid is energized. In the circuits shown in Figs. 5 and 6 all of the thermostats are of the type which are adapted to be closed upon an increase in temperature. The overhead heat control thermostats and the refrigeration control thermostats in each case are adapted to be placed within the passenger compartment so as to respond to the temperature prevailing in the passenger compartment. A preferred location for these thermostats is in the return air stream.

Figs. 5 and 6 show a modified circuit arrangement which includes four additional outside thermostats which are used for automatically selecting the temperature to be maintained within the conditioned space. The four additional outside thermostats are set to operate at 35°, 70°, 80° and 90°. The 90° outside thermostat controls the solenoid 302 which in turn controls the switch 304 in series with the 74° refrigeration control thermostat and also controls the switch 306 arranged in series with the 75° overhead heat control thermostat. The 80° outside thermostat controls the solenoid 308 which when energized lifts the switches 310 and 312 which are arranged in series with the 71° and 72° thermostats respectively. The 70° outside thermostat controls the solenoid 314 which when energized lifts the switches 316 and 318. The switch 316 is in series with the 71° refrigeration control thermostat and the switch 318 is in series with the 72° overhead heat control thermostat. The outside thermostats are adapted to place the proper inside thermostats in control of the overhead heat and the compressor motor. When the outside temperature is above 90°, all of the outside thermostats will be closed and the 78° and 79° indoor thermostats will be the only thermostats capable of controlling the overhead heat and the refrigeration. The inside temperature accordingly will be maintained between 78° and 79°. If the outside temperature drops below 90° but remains above 80°, the solenoid 302 will allow the switches 304 and 306 to close whereby the 74° and 75° indoor thermostats will control the heating and cooling so as to maintain the inside temperature between 74° and 75°. If the outside temperature drops to a value below 80° but above 70°, the solenoid 308 will be deenergized whereby the switches 310 and 312 will close, since the outside temperature is above 70° the solenoid 314 will be energized and the contacts 316 and 318 will be closed whereby the inside temperature will be maintained between 71° and 72°. As the outside temperature drops below 70°, the 70° thermostat will open so as to deenergize the solenoid 314. Deenergization of the solenoid 314, opens the switches 316 and 318 whereby the 71° and 72° inside thermostats are rendered inoperative and the 74° and 75° thermostats control the air conditioning apparatus. By virtue of this arrangement when the outside temperature is between 50° and 70° a slightly higher indoor temperature will be maintained so as to compensate for the cold windows, etc. When the inside temperature drops below 50° the solenoid 222 becomes deenergized with the result that switches 224, 226 and 231 are opened whereby the refrigeration is turned off and the floor heat is placed under control of the 72° and 73° thermostats, as shown. When the outside temperature falls below 35°, it becomes necessary to maintain considerably higher temperatures in the car. Accordingly, the 55° outside thermostat opens at temperatures below 35° so as to deenergize the re-

lay 301. Deenergization of the relay 301 opens the switch 320 so as to render the 75° thermostat incapable of turning off the overhead heat. As a consequence thereof, the 79° thermostat controls the solenoid 204 whereby overhead heat will be supplied at all temperatures below 79°. Referring to Figs. 5 and 6, it will be observed that the solenoid 204 controls the switches 230, 232, 234 and 236 respectively. In this modification, as in the modification shown in Figs. 2, 3 and 4, the 73° floor heat thermostat controls the solenoid 228 which in turn controls the application of floor heat through the switches 238, 240, 242 and 244. In the modification shown in Figs. 5 and 6 the 72° floor heat thermostat controls the electric floor heaters through the solenoid 220. The 50° outside thermostat controls the solenoid 222 which in turn controls the switches 224, 226 and 231. It will be observed that the switch 224 is in series with a solenoid 322 which in turn controls a switch 324 so as to prevent operation of the compressor motor at temperatures below 50°.

In order to simplify this disclosure specific temperatures have been referred to throughout, whereas it is apparent that other temperature values may be used without departing from the spirit of this invention. Thus, the 50° outside thermostat could, for example, be set to operate at 60° or any other temperature which may be found more suitable.

In each instance where several thermostats have been shown in the same location, it is apparent that a single thermostat having several sets of contacts adapted to close at different temperatures could be substituted therefor.

While the arrangement disclosed herein is especially suitable for use on railway cars, it is apparent that the system is also applicable to stationary installations.

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 combination with an enclosure, an internal combustion engine, a generator driven by said engine, electric heaters within said enclosure adapted to be supplied with electrical energy from said generator, means for supplying waste heat from said engine to said enclosure including means for supplying a portion of said waste heat into the upper portion of said enclosure and another portion of said heat to the lower portion of said enclosure, means responsive to the temperature within said enclosure controlling the heat supplied to the upper portion of said enclosure, thermostatic means controlling the supply of waste heat to the lower portion of said enclosure, and temperature responsive means preventing energization of said electrical heaters when the temperatures in the enclosure are such that one or the other of said waste heat supplying means is inoperative to supply waste heat to said enclosure.

2. Means for heating an enclosure comprising in combination, an internal combustion engine, means for supplying waste heat from said engine to said enclosure, a generator driven by said engine, electric heating means, means for energizing said electric heating means from said generator so as to heat air for said enclosure, means responsive to the temperature in said enclosure controlling said electric heating means, control means responsive to the temperature

outside said enclosure rendering said electric heating means inoperative when the outside temperature is above a predetermined value, an outside source of electric energy for energizing said electric heating means, and means for automatically rendering said outside temperature control means inoperative upon connection of said electric heating means to said outside source of electric energy.

3. Air conditioning apparatus for use in conditioning an enclosure comprising in combination, an internal combustion engine for supplying power, a generator driven by said engine, means utilizing waste heat of said engine for heating air for said enclosure including means located above the normal head room of said enclosure for supplying heat to the upper portion of said enclosure and means located below the normal head room of said enclosure for supplying heat to the lower portion of said enclosure, means responsive to the temperature within said enclosure controlling the application of heat in the upper portion of said enclosure and means responsive to the temperature within said enclosure for controlling the application of heat to the lower portion of said enclosure, means responsive to the outside air temperature preventing the application of heat to the lower portion of said enclosure within a predetermined outside temperature range within which some form of heating is required, electric heaters energized from said generator for heating air for said enclosure only when said waste heat is insufficient for heating said enclosure, and means responsive to the outside temperature controlling said electric heaters.

4. In combination with an enclosure, an internal combustion engine, a generator driven by said engine, electric heaters for heating air for said enclosure, means for supplying electrical energy from said generator to said electric heaters, coil means for heating air for said enclosure, means for transferring waste heat generated by said internal combustion engine to said coil means, means for cooling air for said enclosure,

means for flowing said cooled air in thermal exchange with said coil means, means responsive to the temperature in said enclosure controlling said coil means, and means responsive to the temperature outside said enclosure preventing operation of said electric heaters when the outside temperature is above a predetermined value.

5. In combination, means for heating an enclosure including means for supplying heat to the upper portion of the enclosure and a second means for supplying heat adjacent the floor of the enclosure and control means for said first and second named means comprising thermostatic means responsive to the temperature in the upper portion of said enclosure controlling the application of heat to the upper portion of said enclosure, thermostatic means responsive to the temperature in the lower portion of said enclosure controlling the application of heat adjacent the floor of said enclosure, and means responsive to the outside temperature for turning off the supply of heat adjacent the floor and for changing the control point of the temperature responsive means in the upper portion of said enclosure as the outside temperature increases above a predetermined value.

6. In combination, first means for heating the air in the upper portion of an enclosure, second means for heating the air in the lower portion of said enclosure, third means for heating air in the lower portion of said enclosure, means responsive to the temperature within said enclosure for controlling the heat supplied to the upper portion of said enclosure, means responsive to the temperature outside said enclosure preventing operation of the second named means for supplying heat when the outside temperature is above a predetermined value, and means preventing heating by said third named means until after said first and second means have been called on to supply heat.

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