June 19, 1956 D. F. ALEXANDER 2,750,755

REFRIGERATING APPARATUS

Original Filed March 7, 1946 3 Sheets-Sheet 1

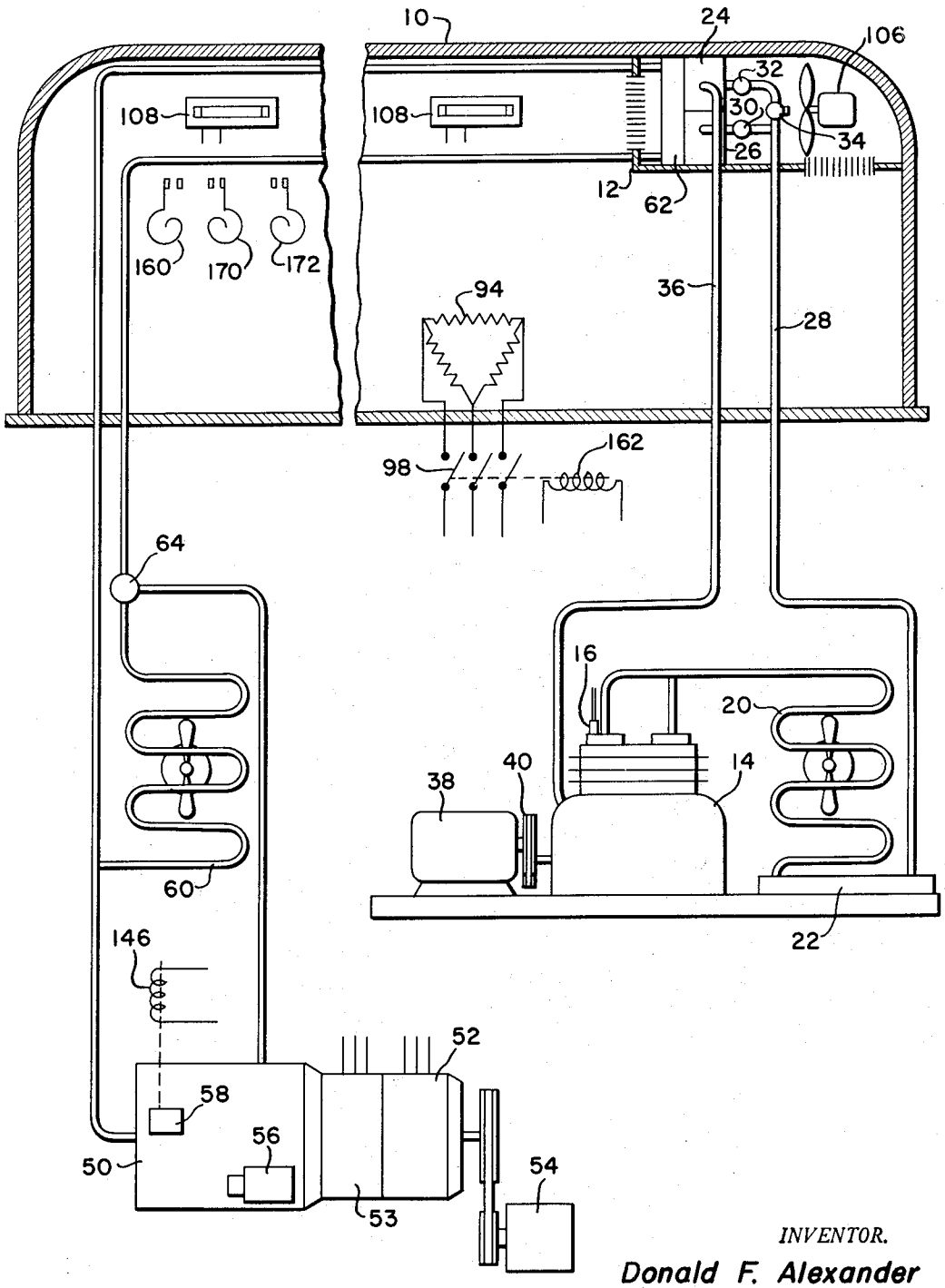


Fig. 1

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Original Filed March 7, 1946 3 Sheets-Sheet 2

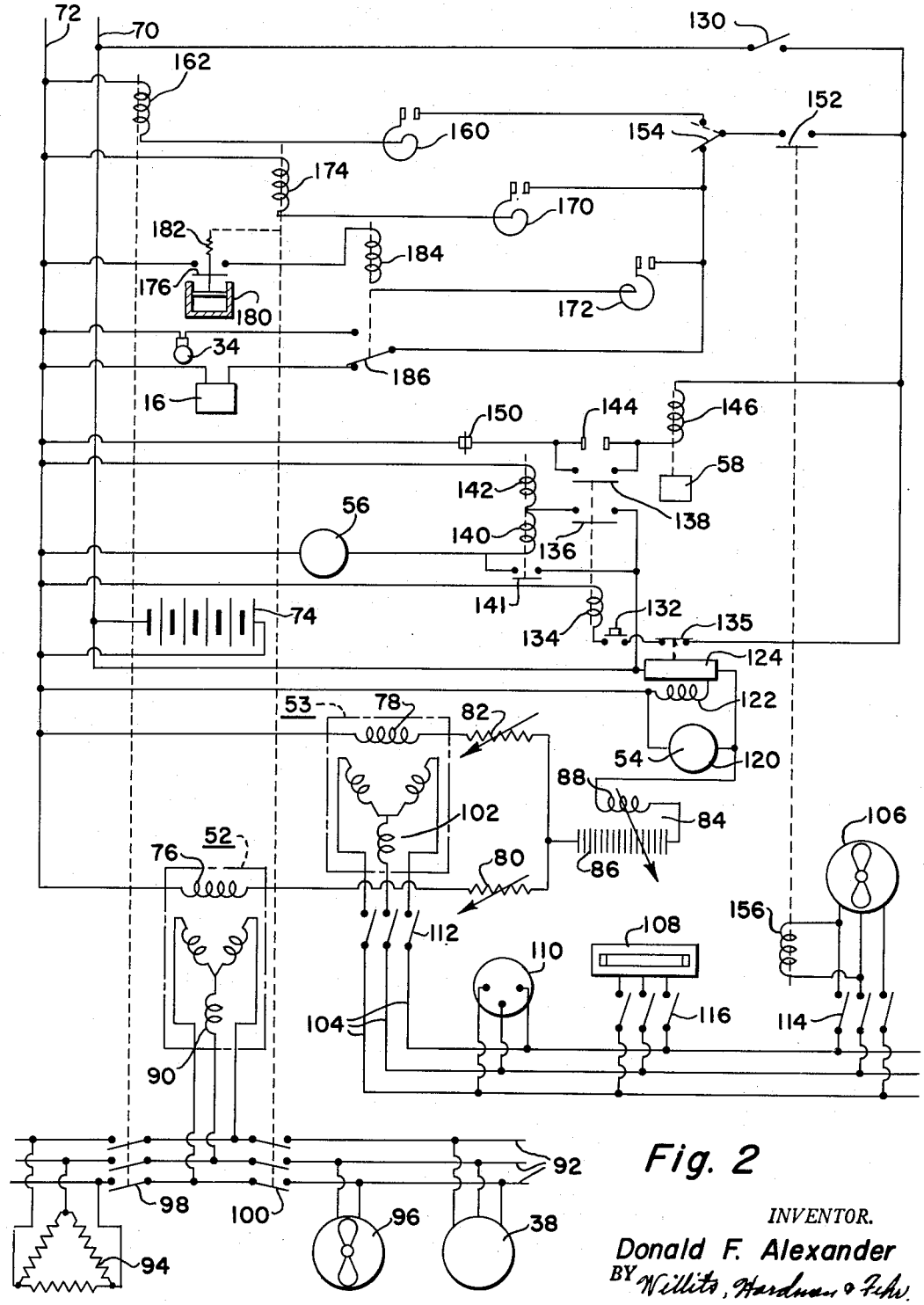


Fig. 2

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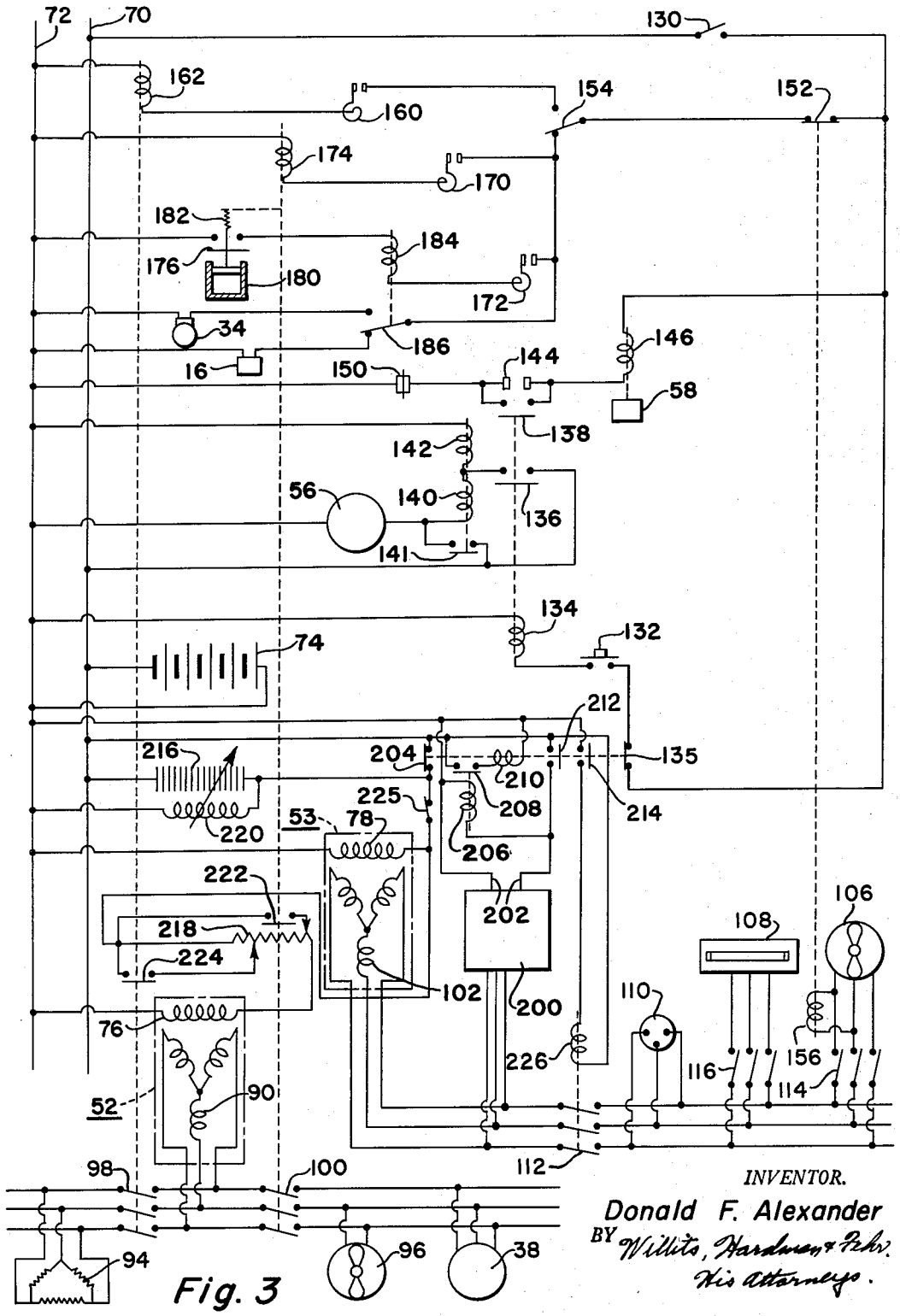


Fig. 3

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2,750,755

REFRIGERATING APPARATUS

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Original application March 7, 1946, Serial No. 652,515, now Patent No. 2,608,067, dated August 26, 1952. Divided and this application December 29, 1951, Serial No. 264,086

1 Claim. (Cl. 62—4)

This application is a division of my co-pending application S. N. 652,515 filed March 7, 1946, now Patent No. 2,608,067.

This invention relates to refrigerating apparatus and more particularly to an improved air conditioning and control system.

It is an object of my invention to provide an improved arrangement for varying the capacity of the refrigerating system so as to prevent frequent cycling.

It is another object of my invention to provide an improved system in which the air conditioning apparatus may be cycled and modulated.

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 view showing a railway car equipped with a system embodying features of my invention;

Fig. 2 is a diagrammatic view showing a preferred circuit arrangement; and

Fig. 3 is a diagrammatic view showing a modified circuit in which the usual exciter has been eliminated and a rectifier has been provided for supplying the necessary field excitation.

For purposes of illustration, the combination lighting and air conditioning system has been shown applied to a railway car whereas many features of my invention are equally applicable to stationary installations such as may be used in theaters and office buildings.

Referring now to Fig. 1 of the drawing, wherein a preferred embodiment of my invention has been shown, reference numeral 10 designates a conventional railway car provided with an air conditioning plenum chamber 12 located adjacent the one end of the car and within which a pair of refrigerant evaporators 24 and 26 are mounted as shown. The refrigerating system employs a multiple cylinder compressor 14 of the type adapted to be operated at a constant speed. The compressor 14 is provided with means 16 for rendering one or more of the cylinders inoperative when reduced capacity is desired. The cylinders may be rendered inoperative in any of several well known ways such as by lifting one or more of the discharge valves.

The compressed refrigerant is discharged into the condenser 20 from whence the condensed refrigerant flows into the receiver 22. Liquid refrigerant is supplied from the receiver 22 to the evaporator sections 24 and 26 through the line 28. A conventional thermostatic expansion valve 30 controls the flow of liquid refrigerant to the evaporator section 26 in accordance with well known practice. A similar thermostatic expansion valve 32 controls the flow of refrigerant to the evaporator section 24. A solenoid valve 34 has been provided in the liquid refrigerant line leading to the valve 32 for shutting off the supply of refrigerant to the evaporator section 24

when it is desired to operate the refrigeration system at a reduced capacity.

The refrigerant vapor leaving the evaporator sections 24 and 26 is conveyed to the compressor through the vapor line 36 as shown. The compressor 14 is driven by a 220 volt alternating current motor 38. The motor 38 may be directly connected to the compressor 14 or it may drive the compressor through a belt means 40 as indicated in Fig. 1.

Each railway car is provided with a complete power system which supplies all the necessary electrical energy for operating the refrigerating apparatus, car lights and all other electrical equipment. By providing such a separate power system on each railway car, the load on the head engine is very materially reduced with the result that more cars can be used in a single train and better acceleration can be obtained. In the modification shown in Fig. 1 of the drawing, a diesel engine 50 has been provided for operating the dual alternators 52 and 53 and the exciter 54. Reference numerals 56 and 58 designate the engine starter and the magnetically controlled engine throttle, respectively.

The heat generated in the diesel engine may be dissipated by the engine radiator 60 or it may be dissipated by the heat exchange unit 62 located in the plenum chamber 12. The heat exchange unit 62 may be used for reheating the air during the cooling season and for supplying heat to the conditioned space during the heating season. A three-way valve 64 has been provided for controlling the flow of heating medium to the heat exchangers 60 and 62. In order to simplify this disclosure the valve 64 has been shown as a manually controlled valve, whereas it may be automatically controlled in response to either the temperature, the relative humidity, or a combination of both within the conditioned space.

The preferred electrical arrangement has been diagrammatically shown in Fig. 2 of the drawing, wherein reference numerals 70 and 72 designate the main direct current power lines from whence power is supplied to the various automatic controls to be described hereinafter. Reference numeral 74 designates a conventional storage battery which is connected across the lines 70 and 72 for supplying emergency direct current power when the exciter 54 is not in operation.

The dual alternators 52 and 53 are direct connected to the diesel engine 50 so as to be operated thereby whenever the engine 50 is in operation. The engine 50 is preferably a constant speed engine capable of operating the alternators at uniform speed irrespective of the load placed on the alternators. The alternator 52 is provided with a field coil 76 which is connected in circuit with the exciter 54 as shown. The alternator 53 is similarly provided with a field coil 78 which is connected in parallel circuit relationship with the field coil 76. Adjustable resistances 80 and 82 are provided for manually varying the resistances of the respective field circuits in accordance with well known practice. The flow of current to the field coils 76 and 78 is controlled by means of the constant current regulator 84 which comprises a carbon pile 86 and a solenoid 88 which is used for varying the resistance of the carbon pile 86 so as to maintain the flow of current through the regulator 84 substantially constant at all times.

The alternator 52 is provided with an armature 90 which supplies three phase, 60 cycle, 220 volt current to the power lines 92 for energizing the car heating elements 94, the compressor motor 38, the condenser fan motor 96 as well as any other heavy duty electrical equipment which it might be found desirable to have on the car. The flow of current to the electric heaters 94 is controlled by the switch 98 and the flow of current to the compressor motor 38 and the condenser fan motor

96 is controlled by the switch 100 arranged in the circuit as shown.

The alternator 53 is provided with an armature 102 which supplies 3 phase, 60 cycle, 110 volt power to the 110 volt power lines 104 which in turn supply power to the evaporator fan motor 106, the fluorescent car lights 108, and the car jumper connection 110. A switch unit 112 is provided for disconnecting the 110 volt equipment from the alternator 53. This switch makes it possible to disconnect the armature 102 from the circuit when it is desired to energize the 110 volt equipment from a similar alternator provided on an adjacent car. The jumper connection 110 is intended to be used only in emergencies for connecting the 110 volt equipment on one car with the 110 volt equipment on an adjacent car so as to provide car lighting and air circulation on two adjacent cars from a single alternator when only one of the diesel engines is in operation. The blower motor 106 is controlled by the manual switch 114 and the lights are controlled by the manual switch 116.

By virtue of the above described alternator arrangement, it becomes practical to provide a low voltage jumper connection for directly connecting the lights and blower motors from two separate cars to a single alternator without using any transformers. In the prior art systems using a single high voltage alternator for supplying current to the heavy duty air conditioning apparatus and the lighting equipment, it is necessary to provide special voltage regulators for preventing light flicker when the heavy duty equipment is turned on, and it is also necessary to provide transformers for supplying 110 volts to the lights, etc. Voltage regulators and transformers require frequent servicing by specially trained men and are not too dependable. Thus it is apparent that many service difficulties may be eliminated by providing one high voltage alternator for supplying the heavy duty apparatus and by providing a separate low voltage alternator for supplying current to the lighting and generating circuits. Even though two alternators are provided, only one prime mover, one storage battery, and only one exciter need be provided when using the system disclosed herein.

The exciter 54 keeps the battery 74 charged and energizes the field windings 76 and 78 of the two alternators. It comprises the usual armature 120, field coil 122, and voltage regulator and reverse current relay 124 all of which function in their well known manner and need no further description.

A master control switch 130 controls the supply of power from the line 70 to the various control circuits as shown. In order to start the diesel engine, it is first necessary to close the switch 130 and then operate the push button 132 which is arranged in series with the solenoid 134. Energization of the solenoid 134 lifts the starting motor switch 136 and the throttle operating switch 138. Closing of the switch 136 directly energizes the heavy current or pull-in coil 140 and the voltage or holding coil 142 so as to initiate operation of the starting motor 56 in accordance with conventional practice. After the diesel engine 50 has been brought up to speed, the oil pressure within the diesel engine will cause closing of the oil pressure operated switch 144 with the result that the throttle solenoid 146 will remain energized even after the push button 132 has moved to the open position and the switches 136 and 138 have dropped into the open circuit position. Energization of the voltage coil 142 and the pull-in coil 140 causes closing of the switch 141 with the result that the pull-in coil 140 will be short circuited and the switch 141 will be held closed merely by the holding coil 142. A safety switch 150 is provided in circuit with the throttle solenoid 146 and is adapted to be opened immediately in the event that the diesel engine overheats. The relay 124 holds open the switch 135 at all times when the exciter and consequently the engine 50 are in operation.

The cooling and heating control circuits are controlled by the switch 152 arranged in series with the manually operated change over switch 154. This latter switch is used to turn on either the heating equipment or the cooling equipment depending on which form of air conditioning is required. The switch 152 is under control of the solenoid 156 which in turn is automatically energized whenever the blower motor 106 is turned on by the manual switch 114. Closing of the switch 114 causes closing of the switch 152. The change over switch 154 may be manually operated or it may be automatically operated in response to the outside temperature or any other condition which might be used to indicate the need for either heating or cooling. By moving the switch 154 from the full line position in which it is shown in Fig. 1 to the dotted line position, the thermostat 160 is placed in control of the solenoid 162 which in turn controls the switch 98 and the flow of current to the electric heater 94. The thermostat 160 is adapted to close at a given temperature which indicates the need for heating.

When the change-over switch 154 is in its full line position, it connects the motor control thermostat 170 and the modulating thermostat 172 in circuit. The thermostat 170 is designed to close when the temperature in the car first exceeds that temperature at which the air conditioning apparatus should turn on. Closing of the thermostat 170 energizes the solenoid 174 which then closes the compressor motor control switch 100. The solenoid 174 is also arranged to operate the time delay switch 176 which is adapted to close approximately five seconds after the compressor motor 38 has been energized. The five second delay allows the compressor motor to come up to speed before the switch 176 closes. A dashpot 180 has been provided for delaying the closing of the switch 176. The spring connection 182 has been provided so as to allow the switch 100 to close without waiting for the switch 176 to move to its uppermost position.

The thermostat 172 is adapted to close at a slightly higher temperature than the thermostat 170 and is arranged in series with the solenoid 184. Before the solenoid 184 can be energized it is necessary that both the switch 176 and the thermostat 172 be in their closed circuit position. When the solenoid 184 is first energized, it moves the switch 186 into its upper position, in which position the circuit to the solenoid valve 34 is closed. This causes the valve to open so as to allow the flow of refrigerant to the evaporator section 24, whereby both evaporator sections are effective to cool the air for the space to be conditioned. Lifting of the switch 186 also deenergizes the unloader 16 whereby the compressor is operated at full capacity. When the switch 186 returns to its lowermost position, the refrigerant valve 34 shuts off the flow of refrigerant to the one evaporator section and the unloader solenoid 16 becomes energized whereby the compressor is operated at a reduced capacity.

A slightly modified circuit arrangement has been shown in Fig. 3. The system shown therein is substantially the same as the system shown in Fig. 2 except that a rectifier 200 has been provided for energizing the fields of the alternators in lieu of the direct current generator or exciter 54 shown in Fig. 2. The same reference numerals have been used to designate corresponding elements in Figs. 2 and 3 and unless otherwise indicated the elements shown in Fig. 3 function in the same manner as the corresponding elements shown in Fig. 2.

As indicated in Fig. 3 of the drawing, a rectifier 200 has been provided for supplying direct current to the power lines 70, 72 during normal operation of the diesel engine and the alternators driven thereby. The alternator 53 supplies alternating current to the rectifier 200 which rectifies the current and supplies direct current to the rectifier output lines 202. Since the rectifier 200 is incapable of supplying power until after the alternator 53 has started generating current, it is necessary to energize the field of the alternator directly from the storage battery

until the rectifier output is sufficient to properly excite the fields of the alternators.

The switch **204** has been provided in the circuit as shown for directly connecting the fields **76** and **78** of the alternators **52** and **53** across the storage battery until the output of the alternator **53** is sufficient to supply the rectifier with enough power to energize the relay **206** which is arranged across the output lines **202** of the rectifier. Energization of the relay **206** causes closing of the switch **208**. The switch **208** is arranged in series with the solenoid **210** which, when fully energized, opens the switches **135** and **204** and closes the switches **212** and **214**. Opening switch **204** places the carbon pile rheostat **216** in series with the field windings **76** and **78** of the alternators **52** and **53** respectively. The carbon pile rheostat **216** is controlled by the voltage coil **220** which is arranged in circuit as shown. The resistance **218** which is in series with the field coil **76** is controlled by the switches **222** and **224**. The switch **222** which is operated by the solenoid **174** shorts out a portion of the resistance **218** when the solenoid **174** closes the switch **100** leading to the compressor motor **38** and the condenser fan **96**. By virtue of this arrangement the field excitation of the alternator **78** is automatically adjusted to take care of the change in load on the alternator **52** when the refrigerator equipment is turned on.

A switch **224** has been provided for shorting out a portion of the field resistance **218** when the electric heaters **94** are turned on in response to a demand for electric heating. A switch **225** has been provided for disconnecting the alternator fields **76** and **78** when the diesel engine is not in operation. The switch **225** may be a manually operated switch or it may be operated automatically to open the circuit in response to stopping of the diesel engine.

Closing of the switch **212** by the solenoid **210** connects the output of the rectifier **200** to the direct current power lines **70**, **72** so as to make it possible to charge the storage battery **74** from the rectifier. Closing of the switch **214** energizes the solenoid **226** which automatically closes the switch **112** leading to the car jumper **110**, the fluorescent car lights **108** and the evaporator blower **106**. By virtue of this switching arrangement, it is apparent that the alternator **53** is not called upon to supply power to the car lights, etc., until after the rectifier has been supplied with enough power to properly excite the fields of the alternators.

The relay **210** operates much like a reverse current relay in that it is capable of holding the switches **212** and **214** closed only so long as the rectifier is supplying direct current to the lines **202**. Thus, when the diesel engine

and the alternators are stopped, the rectifier becomes ineffective to supply the necessary voltage required for properly energizing the relay **210** with the result that the switches **212** and **214** open and the switches **135** and **204** close.

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, as may come within the scope of the claim which follows.

What is claimed is as follows:

Air conditioning means for an enclosure including a multiple cylinder compressor, a condensing means, a multiple section evaporating means, a motor for driving said compressor, an electrically operated unloading means for unloading at least one but not all of said cylinders, electrically operated fluid control means for disconnecting and rendering inoperative at least one but not all of the sections of the evaporating means, a first thermostatically controlled switch means responsive to the temperature of said enclosure for starting and stopping said motor, an electrically operated two-position switch means having a deenergized position for controlling the energization of the unloading means and the fluid control means to cause the unloading means to be in the unloading position and to cause the fluid control means to render inoperative at least one but not all of the sections of the evaporating means, said two-position switch means having an energized position for controlling the energization of the unloading means and the fluid control means to cause the unloading means to be in the loading position and to cause the fluid control means to be in the open position, a time delay switch means and a second thermostatically controlled switch means connected in series circuit relation with the electric operating means of said two-position switch means, said time delay switch means including switch closing means operable to closed position a predetermined period after the closing of said first switch means, said higher temperature switch means being operable to closed position in response to a higher temperature of said enclosure than the temperature at which said first means closes.

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