

May 5, 1953

D. F. ALEXANDER

2,637,175

MODULATING REFRIGERATING APPARATUS

Original Filed Nov. 20, 1945

5 Sheets-Sheet 1

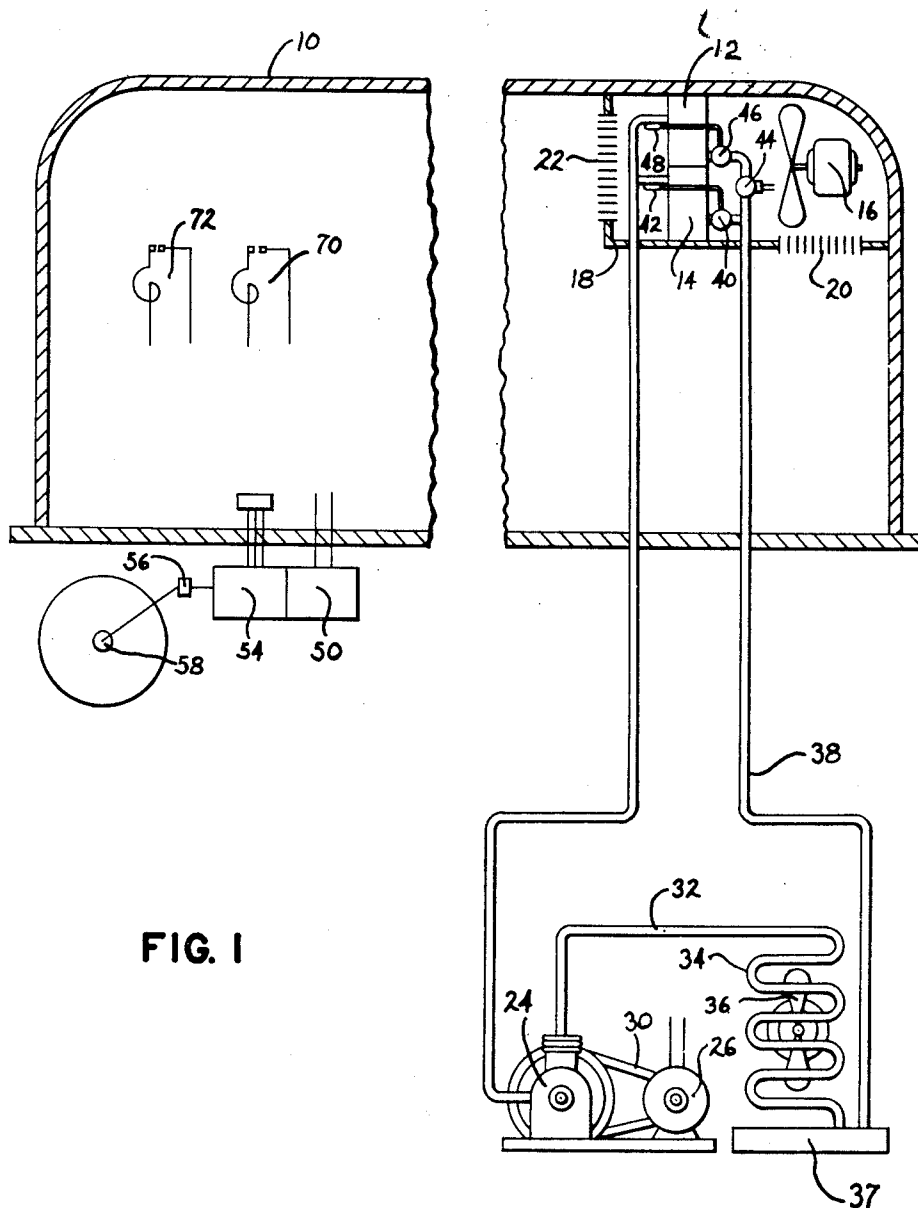


FIG. 1

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5 Sheets-Sheet 2

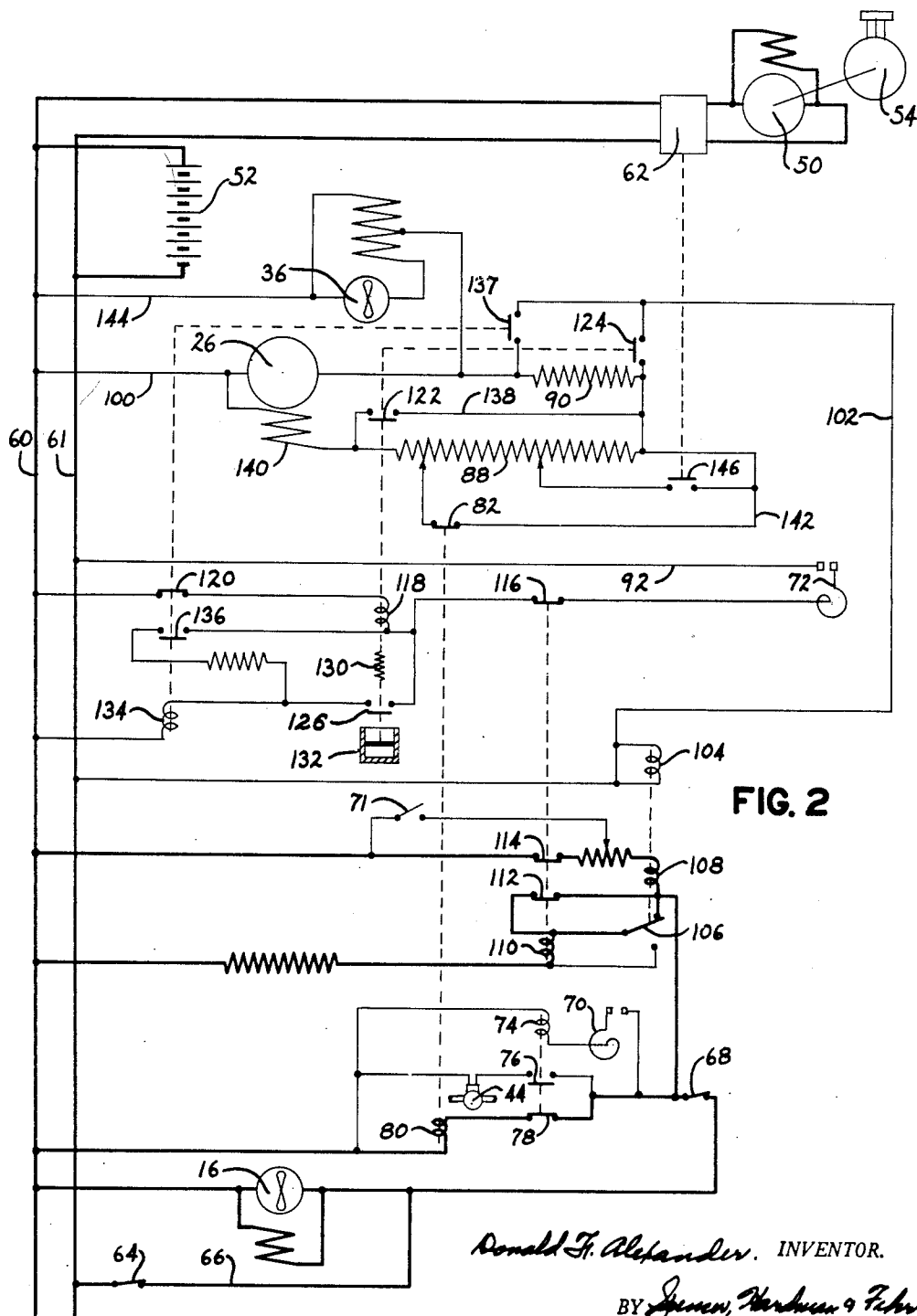


FIG. 2

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5 Sheets-Sheet 3

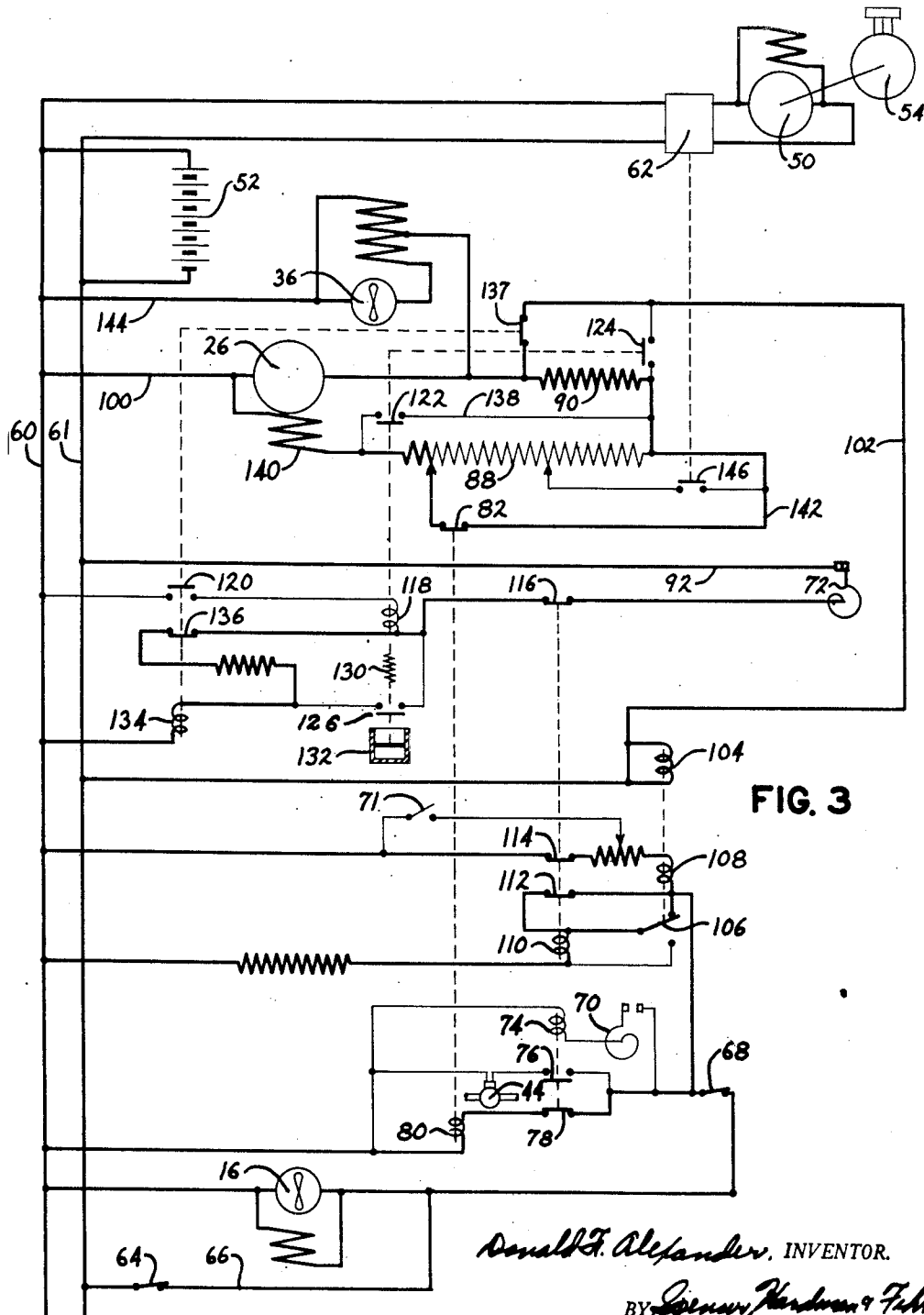


FIG. 3

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5 Sheets-Sheet 4

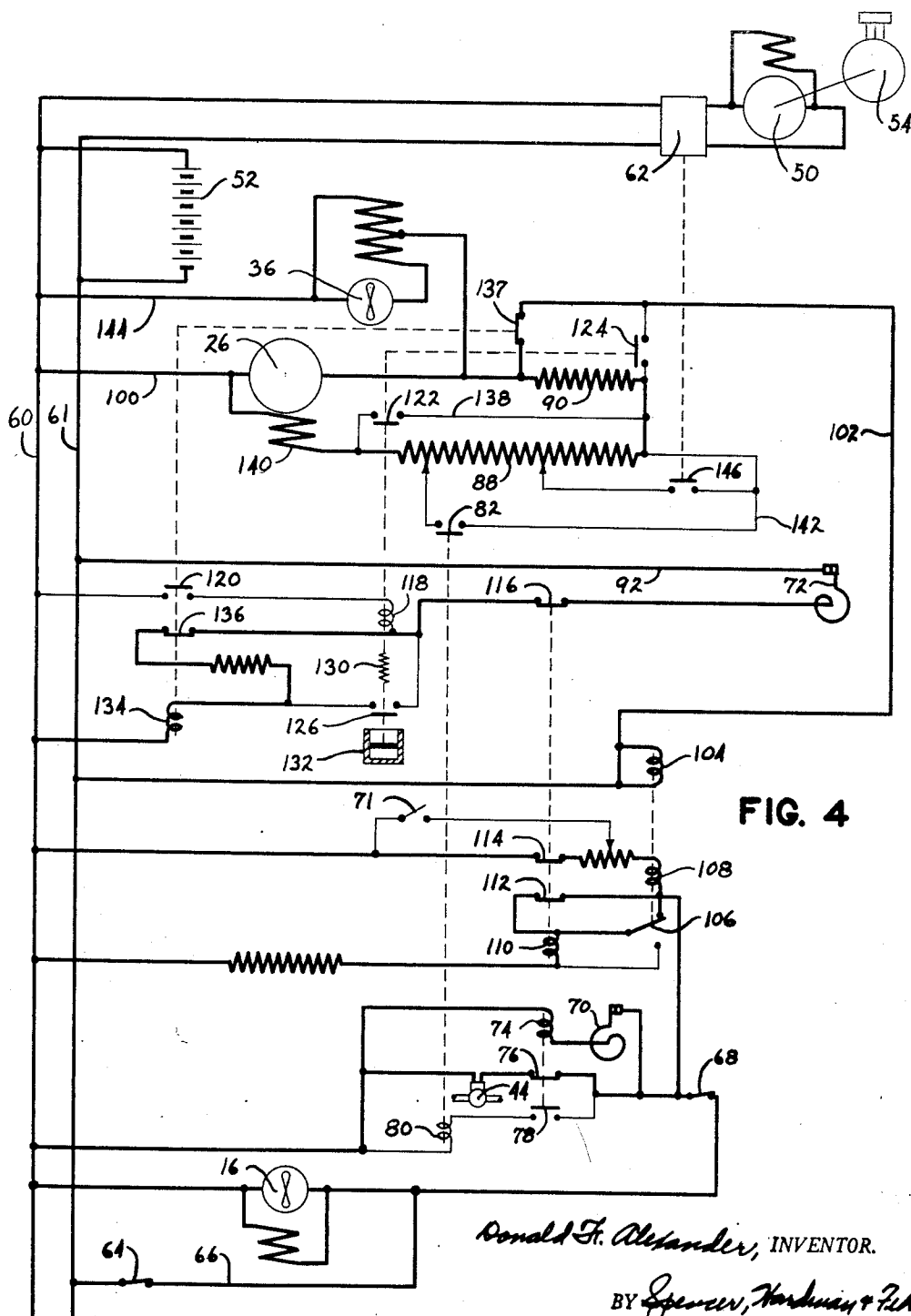


FIG. 4

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May 5, 1953

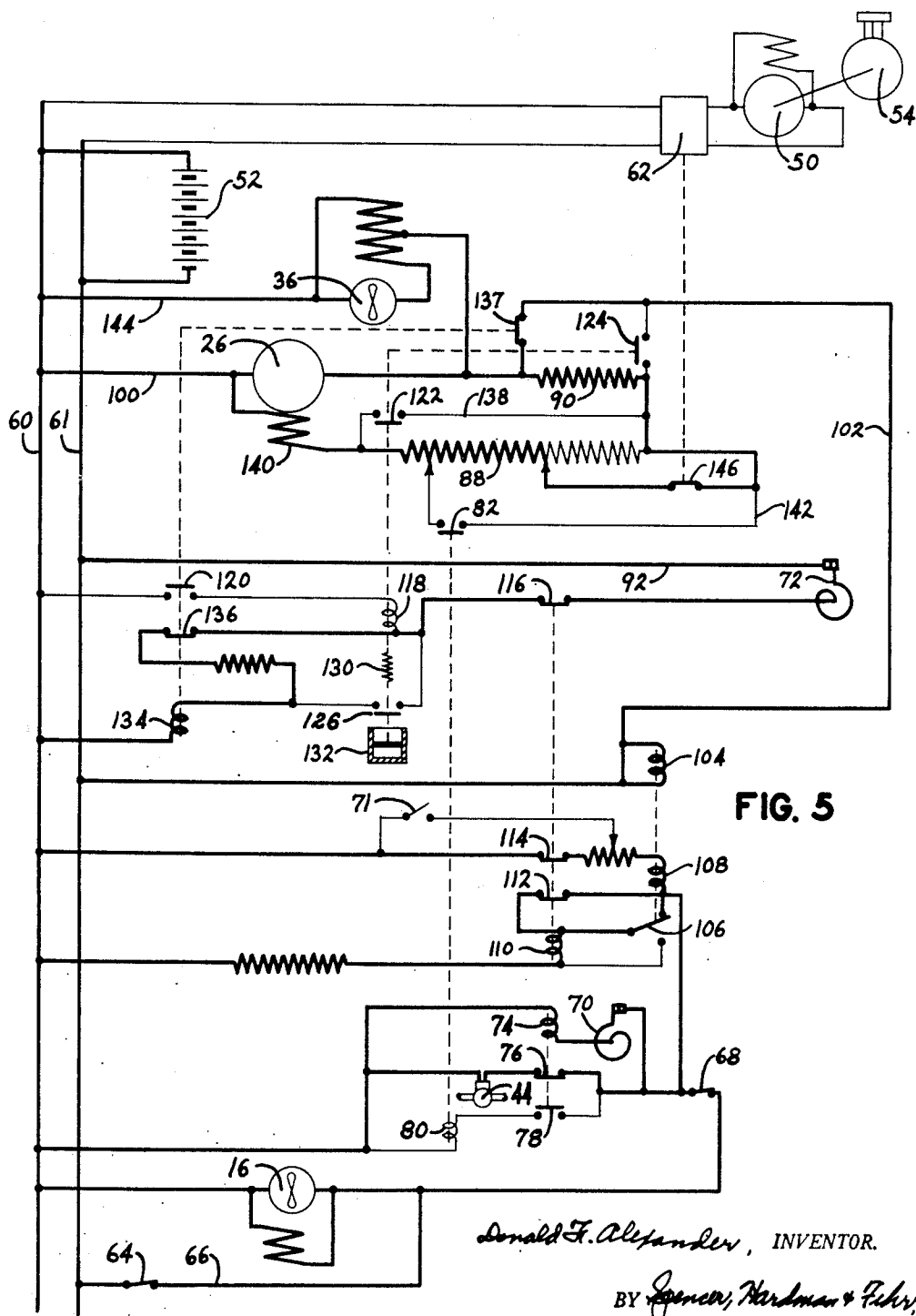
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MODULATING REFRIGERATING APPARATUS

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,637,175

MODULATING REFRIGERATING
APPARATUS

Donald F. Alexander, Oakwood, Ohio, assignor to
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Continuation of application Serial No. 629,757,
November 20, 1945. This application Decem-
ber 16, 1949, Serial No. 133,366

15 Claims. (Cl. 62—4)

1

This application is a continuation of my co-
pending application Serial No. 629,757 filed No-
vember 20, 1945, which has become abandoned
since the filing of this application.

This invention relates to refrigerating appara-
tus and more particularly to an improved air
conditioning system suitable for use on a railway
car.

It is an object of this invention to provide im-
proved controls for the refrigerating apparatus
and the electrical equipment.

Another object of this invention is to provide
for a reduction in refrigeration output in re-
sponse to either a reduction in refrigeration re-
quirements or a reduction in the power available
for operating the compressor motor.

Another object of this invention is to provide
apparatus which is economical and trouble-free
in operation.

A still further object of this invention is to
provide means for reducing the electrical load
when the main generator is not in operation or
is operating at a low speed.

Still another object of this invention is to pro-
vide a control system for the compressor motor
which makes it possible to start the motor with
maximum field excitation regardless of the re-
frigeration requirements.

Reference is made to the following applica-
tions and patents owned by the same assignee:
S. N. 616,078, filed September 13, 1945, Donald F.
Alexander, applicant, Pat. 2,536,248, granted Jan-
uary 2, 1951; S. N. 652,514, filed March 7, 1946,
Donald F. Alexander and Calvin J. Werner, ap-
plicants, Pat. 2,541,904, granted February 13,
1951; S. N. 652,515, filed March 7, 1946, Donald F.
Alexander, applicant, Pat. 2,608,067, granted
August 26, 1952.

Further objects and advantages of the present
invention will be apparent from the following
description, reference being had to the accom-
panying drawings, wherein a preferred form of
the present invention is clearly shown.

In the drawings:

Fig. 1 is a diagrammatic view showing a rail-
way car provided with my improved air condi-
tioning system;

Fig. 2 is a diagrammatic view of the electrical
circuits showing in heavy lines those portions of
the circuit which are energized when the gener-
ator is in operation but no refrigeration is re-
quired and showing in light lines those portions
of the circuit which are deenergized;

Fig. 3 is a view similar to Fig. 2 showing in
heavy lines those portions of the circuit which

2

are energized when the generator is in operation
and only a small amount of refrigeration is
required;

Fig. 4 is a view similar to Figs. 2 and 3 showing
the circuit when the generator is in operation
and full refrigeration is required; and

Fig. 5 shows the circuit when the generator is
not in operation and the thermostats call for
maximum refrigeration available.

For purposes of illustration, I have shown my
invention applied to a conventional railway car
10 whereas some of the features of my invention
are equally applicable to other types of installa-
tions.

The refrigerating system used for cooling the
air comprises a pair of evaporator coils 12 and
14 which are preferably arranged in the upper
end zone of a car as shown in Fig. 1. A blower
unit 16 circulates air to be conditioned over the
coils 12 and 14. The evaporator coils and the
blower unit 16 are disposed within an enclosure
18 which is provided with a return air inlet 20
and an air outlet 22 arranged as shown. Ref-
erence numeral 24 designates a conventional re-
frigerant compressor which is operated by a direct
current motor 26 which drives the compressor
24 through the belt 30. Compressed refrigerant
leaves the compressor 24 through the line 32
which leads to a conventional condenser 34 over
which air is circulated by the fan unit 36. The
refrigerant condensed by the condenser 34 flows
into the receiver 37 from whence the liquid re-
frigerant is supplied to the evaporator coils 12
and 14 through the liquid line 38. The com-
pressor and condenser mechanism is preferably
mounted beneath the car so as not to require the
use of valuable passenger space.

A thermostatic expansion valve 40 controls the
flow of liquid refrigerant into the evaporator
section 14 in accordance with well-known prac-
tice. The expansion valve 40 is provided with
the usual thermostatic bulb 42 arranged in
thermal exchange with the outlet line leading
from the evaporator section 14 as shown. The
flow of refrigerant to the evaporator section 12
is controlled by a solenoid valve 44 and a con-
ventional thermostatic expansion valve 46 which
are arranged in series. The thermostatic ex-
pansion valve 46 is provided with the usual form
of thermostatic bulb 48 arranged in thermal ex-
change with the outlet line leading from the
evaporator 12.

As will be explained more fully hereinafter,
both of the evaporator sections are supplied with
liquid refrigerant when maximum refrigeration

is required but as the requirement for refrigeration decreases the solenoid valve 44 is closed with the result that only the surface of the evaporator section 14 is effective for cooling the air for the enclosure. By virtue of this reduction in the effective evaporator surface, the need for frequent cycling of the compressor is eliminated and a more uniform temperature and relative humidity may be maintained within the conditioned space.

The compressor motor 26 may be energized from the axle-driven direct current generator 50 or from the storage batteries 52. The generator 50 is preferably supported directly beneath the car and is direct connected to a standby motor 54 which may be either a direct current motor or an alternating current motor adapted to be plugged into a power supply at the station. The generator 50 and the motor 54 are preferably combined into a unit having a single frame requiring only one shaft and one set of bearings for the combined unit. A clutch 56 is provided between the unit and the axle 58 of the car 10 so that the motor 54 may be used for operating the generator 50 when the railway car 10 is standing still in the station. The motor 54 is preferably a three-phase alternating current motor which may be plugged in at any of the railway terminals provided with three-phase power. The generator 50 is a direct current generator which serves to charge the storage batteries 52 and to supply electrical energy to the electrical equipment on the car.

Referring now to the circuit diagram shown in Figs. 2 through 5, reference numerals 60 and 61 designate the main power lines which are arranged to receive power from either the battery 52 or the generator 50. A conventional reverse current relay 62 is provided in the lines leading from the generator 50 to the main power lines 60 and 61 as shown.

A manually operated master control switch 64 is provided in the line 60 for turning on and off the entire air conditioning system. The evaporator blower 16 is connected directly across the power lines and operates continuously as long as the switch 64 remains closed whereas the operation of the compressor motor 26 is further controlled by a manually operated switch 68 which in turn places the compressor motor 26 under control of the relay 62 and the thermostats 70 and 72. The thermostats 70 and 72 are preferably located so as to respond to the temperature within the conditioned space. The thermostat 70 is preferably set to remain closed at temperatures above 74° F. whereas the thermostat 72 is preferably set to remain closed at temperatures above 73° F. It is to be understood that these temperature values are given primarily for purposes of illustrations since the thermostats could be set to operate at other temperature values.

The thermostat 72 which is the first to close as the temperature becomes high enough to require refrigeration controls the starting and stopping of the compressor motor in a manner to be described hereinafter whereas the thermostat 70 is arranged in series circuit relationship with a solenoid 74 which serves to control the switches 76 and 78 which in turn reduce the speed of the motor and shut off the flow of refrigerant to the evaporator section 12 when the need for refrigeration decreases. The switch 76 is arranged in series with the solenoid valve 44 so that when the need for refrigeration again increases and the thermostat 70 closes the circuit through the sole-

noid 74, the switch 76 will close the circuit to the solenoid valve 44 thereby allowing the flow of refrigerant to the evaporator section 12. The switch 78 is arranged in series with the solenoid 80 which in turn controls the compressor motor field resistance 88 through operation of switch 82. The arrangement is such that the compressor motor is caused to operate at a reduced speed whenever the thermostat 70 is open and the thermostat 72 is closed.

The one side of the compressor motor 26 is connected to the main power line 60 through the line 100 whereas the other side of the compressor motor 26 is connected to the main power line 61 through the line 102. A low voltage relay device 104 is arranged in the line 102 and helps to hold the low voltage switch 106 in the raised position so long as the voltage supplied to the compressor motor does not fall below a predetermined value. A second low voltage coil 108 is arranged in circuit as shown and also exerts a control on the low voltage switch 106. A conventional low voltage reset switch 71 is provided as shown. Opening of the main switch 64 serves to deenergize the low voltage coils 104 and 108 with the result that prior to the closing of switch 64 the low voltage switch 106 will be in the down position, but just as soon as the switches 64, 68, and the low voltage reset switch 71 are closed the low voltage coil 108 will be energized, and if the voltage is high enough for proper operation of the equipment the switch 106 will be moved from its down position to its up position, thereby energizing the solenoid 110 which in turn closes the switches 112, 114, and 116. Closing of the switch 114 causes the low voltage coil 108 to remain energized even after the manually operated reset switch 71 has been reopened. Closing of the switch 116 is necessary before the thermostat 72 is capable of initiating operation of the compressor motor 26 as will be explained more fully hereinafter.

When refrigeration is first needed after a period of shutdown, the thermostat 72 closes whereby current will flow from the power line 61 through the line 92, the thermostat 72, switch 116, the starting solenoid 118 and the switch 120. Energization of the starting solenoid 118 first causes the switches 122 and 124 to close. Energization of the solenoid 118 also serves to operate the delayed action switch 126 but the switch 126 is provided with a spring connection 130 and a dash-pot mechanism 132 with the result that the compressor motor is given a chance to at least partially come up to speed before the switch 126 closes.

Closing of the switch 126 causes energization of the solenoid 134 which in turn closes the switches 136 and 137 and opens the switch 120. The switch 120 is arranged in series with the solenoid 118 with the result that the solenoid 118 becomes deenergized when the switch 120 opens and deenergization of solenoid 118 causes opening of the switches 122, 124, and 126. Before the solenoid 118 becomes thus deenergized, current will begin flowing from the power line 61 through the line 102, switch 124, armature resistance 90 and the armature of the motor 26. A portion of the current flowing through the switch 124 will flow through the line 138, switch 122, and the field coil 140 of the compressor motor 26. By virtue of this circuit arrangement, it is obvious that maximum field excitation is provided by the motor during the starting period, and it is also obvious that the armature resist-

ance 90 is arranged in series with the armature of the motor so as to cut down the armature current during the starting period, but just as soon as the delayed action switch 126 closes so as to energize the solenoid 134, the solenoid 118 becomes deenergized and the switches 122 and 124 together with switch 126 itself are opened.

With switches 136 and 137 closed and switches 122 and 124 open (see Fig. 3), the armature current flows directly to the armature through the closed switch 137 but the field current is required to flow, via the switch 137, through the armature resistance 90, line 142, switch 82, and that portion of the field resistance 88 shown energized in Fig. 3. It will be noted that during the initial starting period when the switch 124 is momentarily closed, the condenser fan motor 36 is supplied with current via the switch 124 and armature resistance 90. It will also be observed that upon closing of the switch 137 the condenser fan motor 36 is connected directly across the power lines by means of the conductors 144 and 102. Those portions of the circuit which are energized when the generator is in operation and the thermostat 72 is closed but the thermostat 70 is open have been shown in heavy lines in Fig. 3 of the drawing.

As the temperature within the conditioned space increases from 73° to 74° the thermostat 70 will close with the result that the circuit connections will be as shown in Figure 4. Closing of the thermostat 70 causes energization of the solenoid 74 which in turn opens the switch 78 and closes the switch 76. Opening of the switch 78 deenergizes the solenoid 80 thereby causing opening of the switch 82. The effect of opening switch 82 is to place the full field resistance 88 in series with the field 140 of the compressor motor thereby causing the compressor motor to operate at full speed. Closing of the switch 76 causes energization of the magnetic valve 44 with the result that refrigerant will be supplied to both sections of the evaporator and full refrigeration capacity will be available so long as the thermostat 70 remains closed.

In the event that the generator 50 does not operate at a speed high enough to effectively generate current, the reverse current relay 62 will function and will cause the switch 146 to close, thereby short-circuiting a portion of the field resistance 88. This in turn causes the motor 26 to operate at a slower speed and to reduce the power required. It is recognized that operation of the compressor motor at the slower speed will tend to reduce the capacity of the refrigeration system due to the decrease in the compressor capacity. This reduction in capacity takes place irrespective of the temperature within the conditioned space but takes place only when the generator is not in operation such as when the train is traveling slowly or is standing at the station without any standby motor operation. The standby motor 54 may be used at the stations for operating the generator so as to provide full generator capacity and full refrigeration when necessary.

Résumé of operation

The air conditioning apparatus may be set into operation by closing the manually operated switches 64, 68 and 71. Closing of the manually operated switch 64 will cause the blower motor 16 to circulate air within the vehicle irrespective of temperature conditions existing in the vehicle. Closing of the switch 68 and the reset

switch 71 will place the compressor motor 26 under control of the thermostats 72 and 70 which are set to remain closed at temperatures above 73 and 74 respectively.

Assuming that the temperature conditions within the space to be conditioned cause closing of the thermostat 72, the compressor motor 26 will be placed in operation. When the thermostat 72 first closes, the field resistance 88 will be short-circuited by the switch 122, and the armature resistance 90 will be placed in series with the compressor motor armature but after the motor has had a chance to get started the armature resistance 90 will be cut out of the armature circuit by closing of the switch 137 and opening of the switch 124 with the result that the armature resistance 90 will be placed in series with any portion of the field resistance 88 which may be connected in series with the motor field 140. When the thermostat 72 only is closed and the thermostat 70 is open, the compressor motor will be operated with a strong field with the result that the motor will operate at a reduced speed. Under these same conditions only one of the evaporator sections is effective for cooling the air.

As the temperature within the conditioned space increases enough to cause closing of the thermostat 70, the solenoid valve 44 will be energized with the result that both sections of the evaporator will be in operation. Closing of the thermostat 70 also causes opening of the switch 82 with the result of an introduction of more field resistance which in turn causes an increase in the speed of the compressor motor 26. In the event that the generator is ineffective, the switch 146 will open and the speed of the motor 26 will be partially reduced so as to conserve on the power required during battery operation. It will be noted that if the generator 50 discontinues operating when the thermostat 70 is in its open position thereby calling for only partial refrigeration capacity, operation of the switch 146 will have no effect on the compressor motor speed since the compressor motor speed will be reduced sufficiently to avoid excessive battery discharge rate. By virtue of this arrangement it is apparent that the system economizes on the battery whenever necessary. It is also apparent that the compressor motor is never permitted to be brought up to speed immediately since the circuit provides for maximum field excitation during the starting period irrespective of the position of the thermostats.

While no means has been shown for varying the speed of the fan motors when the compressor motor speed is changed, it is obvious that the speed control arrangement used for the compressor motor could be extended to control the fan motors. For example, the solenoid 30 could operate a speed varying resistance (not shown) in one or more of the fan motor circuits.

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 claims which follow.

What is claimed is as follows:

1. A single enclosure, refrigerating apparatus for cooling said enclosure including refrigerant liquefying and evaporating means connected in an operative refrigerant circuit, said evaporating means being located in heat exchange relation with said enclosure, a motor for driving said refrigerant liquefying means, said motor being

provided with a speed regulating means, a first thermostatic means responsive to refrigerating requirements of said enclosure for initiating the operation of said motor, said thermostatic means including a starting control means for controlling said speed regulating means to provide a limited motor starting speed for a given length of time and an additional control means for controlling said speed regulating means to provide a higher motor speed for operation after the given length of time, and a second thermostatic means responsive to greater refrigerating requirements of said enclosure than said first thermostatic means for controlling said speed regulating means to provide a still higher motor speed for operation under greater refrigeration requirements.

2. A single enclosure, refrigerating apparatus for cooling said enclosure including refrigerant liquefying and evaporating means connected in an operative refrigerant circuit, said evaporating means being located in heat exchange relation with said enclosure, a single motor for driving said refrigerant liquefying means, said motor being provided with a speed regulating means, a first thermostatic means responsive to moderate refrigerating requirements of said enclosure for controlling said speed regulating means to provide a moderate motor speed for the moderate requirements, and a second cycling thermostatic means responsive to greater refrigerating requirements of said enclosure to control said speed regulating means to provide an increased motor speed whenever and only as long as the greater refrigerating requirements continue above a certain value and the power supply is ample, said second cycling control means being ineffective below said certain value, said evaporating means including a normally effective portion and a second portion, both portions being located in heat exchange relation with said enclosure, and a control means for preventing evaporation in said second portion, said second cycling thermostatic means including means operable coincidentally with the change in said speed regulating means for rendering ineffective said control means so as to permit evaporation in said second portion.

3. Refrigerating apparatus including refrigerant liquefying and evaporating means connected in an operative refrigerant circuit, a direct current electric motor for driving said refrigerant liquefying means, said motor including a field circuit and an armature circuit, a resistance means connected to said field circuit, control means responsive to refrigerating requirements for controlling said motor, said control means including means effective during the starting of the motor for transferring said resistance means from said field circuit to said armature circuit for a controlled length of time and then returning said resistance means to the field circuit at the end of the controlled length of time.

4. Refrigerating apparatus including refrigerant liquefying and evaporating means connected in an operative refrigerant circuit, a direct current electric motor for driving said liquefying means, said motor including a field circuit, a resistance means of sufficient value to cause the motor to operate at the maximum desired speed, said resistance means being connected to the field circuit, a battery and a generating means for supplying current to the battery and to the motor, cycling means responsive whenever the refrigerating requirements are below a certain

value for reducing the effective value of said resistance means to increase the field strength in the motor for operation at reduced speed under reduced refrigerating requirements, and means responsive to a reduction below a certain value in the rate of generation by said generating means for reducing the effective value of the resistance means to reduce the field strength and the current consumption and the discharge of the battery.

5. Refrigerating apparatus comprising in combination, an evaporator having a plurality of sections, means for flowing air in thermal exchange with said evaporator, means including a refrigerant compressor for supplying refrigerant to said evaporator, a multiple speed motor for operating said compressor, a generator for supplying energy to said motor, a battery for supplying energy to said motor when said generator is ineffective to operate said motor, means including a thermostat responsive to changes in refrigeration requirements in the conditioned space for rendering one of said sections of said evaporator inactive to cool the air, and for causing said motor to operate at a reduced speed when the temperature within the conditioned space falls below a predetermined value, and means responsive to energization of said motor solely from said battery for causing said motor to operate at a reduced speed irrespective of temperature conditions within said space.

6. Air conditioning apparatus comprising in combination, an evaporator having a plurality of independently controlled sections, means including a refrigerant compressor for supplying liquid refrigerant to said evaporator sections, a motor for operating said compressor comprising a field circuit, means for varying the resistance of said field circuit so as to vary the speed of said motor, means operable when the refrigeration requirements fall below a predetermined value for rendering one of said sections of said evaporator inactive and for reducing the speed of said motor by increasing the field excitation, switch means for starting and stopping said motor, and means operable in response to closing of said switch means for insuring maximum field excitation during the starting of said motor regardless of the refrigeration requirements.

7. Air conditioning apparatus comprising in combination, an evaporator, a condenser, a compressor, refrigerant flow connections between said evaporator, compressor, and condenser, a motor for operating said compressor comprising a field circuit, means for varying the resistance of said field circuit so as to vary the speed of said motor, control means responsive to refrigeration requirements operable when the refrigeration requirements fall below a predetermined value for reducing the speed of said motor by increasing the field excitation thereof, switch means for starting and stopping said motor, and means operable in response to closing of said switch means for insuring maximum field excitation during the starting of said motor regardless of the refrigeration requirements.

8. In combination, an evaporator, a compressor, a condenser, refrigerant flow connections between said evaporator, condenser, and compressor, a motor for operating said compressor comprising a field circuit, means for varying the resistance of said field circuit so as to vary the speed of said motor, a first source of electrical energy for energizing said motor, a second relatively limited source of electrical energy for energizing said

motor, means operable when said motor is energized from the first of said sources of electrical energy for decreasing the field excitation so as to operate said motor at maximum speed, switch means for starting and stopping said motor, and means operable in response to closing of said switch means for insuring maximum field excitation during the starting of said motor regardless of which source of electrical energy is used for energizing said motor.

9. In combination with a vehicle having a live axle, a generator, torque transmitting means between said generator and said live axle, said torque transmitting means including a clutch for declutching said generator from said live axle, a standby motor for operating said generator when said live axle is ineffective to drive said generator, a first evaporator coil, a second evaporator coil, fan means for flowing air to be conditioned for said vehicle in thermal exchange with said evaporator coils, a condenser, a compressor, refrigerant flow connections between said compressor, condenser, and said evaporator coils whereby liquid refrigerant is supplied to said evaporator coils, a motor for operating said compressor, circuit means for supplying electrical energy from said generator to said compressor motor, a battery in said circuit means adapted to be charged by said generator and adapted to supply electrical energy to said compressor motor when said generator is not operating at generating speeds, first means responsive to refrigeration requirements for starting and stopping said compressor motor, second means responsive to refrigeration requirements for rendering one of said evaporator coils ineffective and for reducing the speed of said compressor motor when the refrigeration requirements fall below a predetermined value, and means responsive to the output of said generator for reducing the speed of said compressor motor irrespective of refrigeration requirements when the generator output falls below a given value.

10. Air conditioning apparatus comprising in combination, an evaporator, means for flowing air to be conditioned in thermal exchange with said evaporator, a compressor, a condenser, refrigerant flow connections between said evaporator, condenser, and compressor, a motor for operating said compressor, a source of electrical energy, said compressor motor comprising a field circuit and an armature circuit, circuit connections between said motor and said source of electrical energy, said circuit connections comprising a first resistance means, means for connecting said first resistance means in series with the field circuit of said compressor motor, a second resistance means, means for selectively connecting said second resistance means either in series with said armature circuit or in series with said first named resistance and said field circuit, means responsive to refrigeration requirements for varying said first resistance means, and time delay means operable upon starting of said motor for short-circuiting said first resistance means for a predetermined length of time during the starting period of said motor.

11. A single enclosure, refrigerating apparatus for cooling said enclosure including refrigerant liquefying and evaporating means connected in an operative refrigerant circuit, said evaporating means being located in heat exchange relation with said enclosure, a single motor for driving said refrigerant liquefying means, said motor being provided with a two speed regulating means providing a moderate speed and full speed, a first

thermostatic means responsive to a definite moderate temperature of said enclosure for controlling said speed regulating means to provide said moderate motor speed for the moderate requirements, and a second cycling thermostatic means responsive to a definite higher temperature than said moderate temperature of said enclosure to control said speed regulating means to provide full motor speed whenever and only as long as the temperature of the enclosure is above said higher temperature and the power supply is ample, said second cycling control means being ineffective below said higher temperature.

12. A single enclosure, refrigerating apparatus for cooling said enclosure including refrigerant liquefying and evaporating means connected in an operative refrigerant circuit, a direct current electric motor for driving said liquefying means, said motor including a field circuit, a resistance means connected in series with the field circuit, a first thermostatic means responsive to a moderate temperature of said enclosure for shunting a definite part of said resistance means in series with said field circuit to increase the field strength in said motor, and a second cycling thermostatic means responsive to a higher temperature than said moderate temperature of said enclosure for connecting all of said resistance means in series with said field circuit to reduce the field strength in said motor whenever and only as long as the greater refrigerating requirements continue above a certain value and the power supply is ample.

13. A single enclosure, refrigerating apparatus for cooling said enclosure including refrigerant liquefying and evaporating means connected in an operative refrigerant circuit, a direct current electric motor for driving said liquefying means, said motor including a field circuit, a resistance means of sufficient value connected in series with the field circuit to cause the motor to operate at full speed, and cycling thermostatic means responsive whenever the temperature of said enclosure is below a certain value for shunting at least a part of said resistance means to increase the field strength in the motor to cause the motor to operate at a reduced speed under reduced refrigerating requirements, and a second thermostatic means responsive whenever the temperature of said enclosure is below a further reduced value for stopping the operation of said motor as long as the refrigerating requirements are below the reduced value.

14. Refrigerating apparatus including refrigerant liquefying and evaporating means connected in an operative refrigerant circuit, means for preventing evaporation in one portion of said evaporating means, a direct current electric motor for driving said liquefying means, said motor including a field circuit, a resistance means of sufficient value to cause the motor to operate at full speed, said resistance means being connected to the field circuit, and cycling thermostatic means responsive whenever the refrigerating requirements are below a certain value for reducing the effective value of said resistance means to increase the field strength in the motor to cause the motor to operate at a reduced speed under reduced refrigerating requirements, said cycling thermostatic means also having interlock means operable coincidentally with the reduction in effective value of said resistance means for effectively operating said means for preventing evaporation in one portion of the evaporating means

while the remaining portion remains effective for evaporation.

15. Refrigerating apparatus including refrigerant liquefying and evaporating means connected in an operative refrigerant circuit, a direct current electric motor for driving said refrigerant liquefying means, said motor including a field circuit, a resistance means connected to said field circuit, control means responsive to refrigerating requirements for controlling said motor, said control means including means effective during the starting period of the motor for decreasing the effective value of said resistance means and time delay means interlocked with said means for decreasing said resistance means effective after a

given length of time for increasing the effective value of said resistance means at the end of said given length of time.

DONALD F. ALEXANDER.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,148,868	Luger -----	Feb. 28, 1939
2,216,690	Madden -----	Oct. 1, 1940
2,243,615	Werner -----	May 27, 1941
2,281,244	Milar -----	Apr. 28, 1942
2,432,587	Ramsey -----	Dec. 16, 1947