May 9, 1939. M. A. WHITING ET AL 2,157,840

POWER SYSTEM

Filed Dec. 29, 1937

Fig. 1.

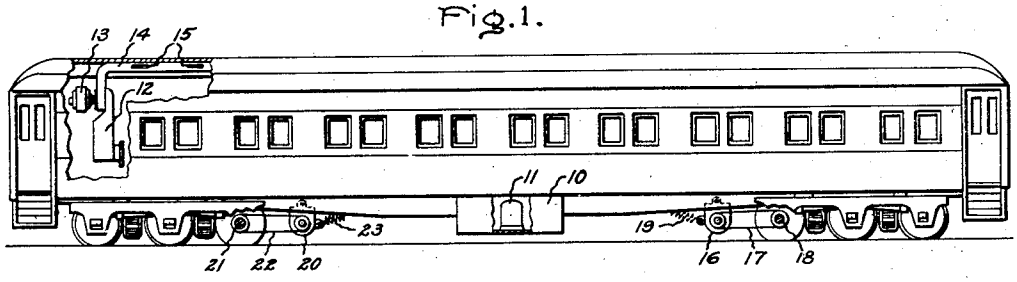


Fig. 2.

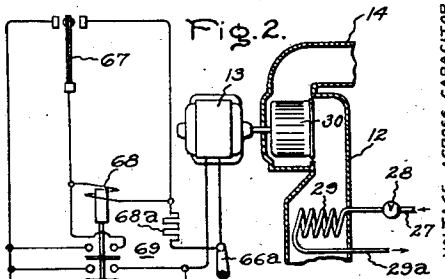
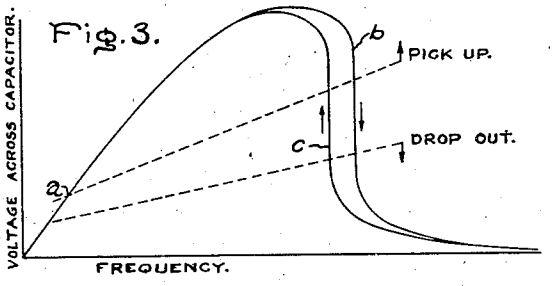


Fig. 3.



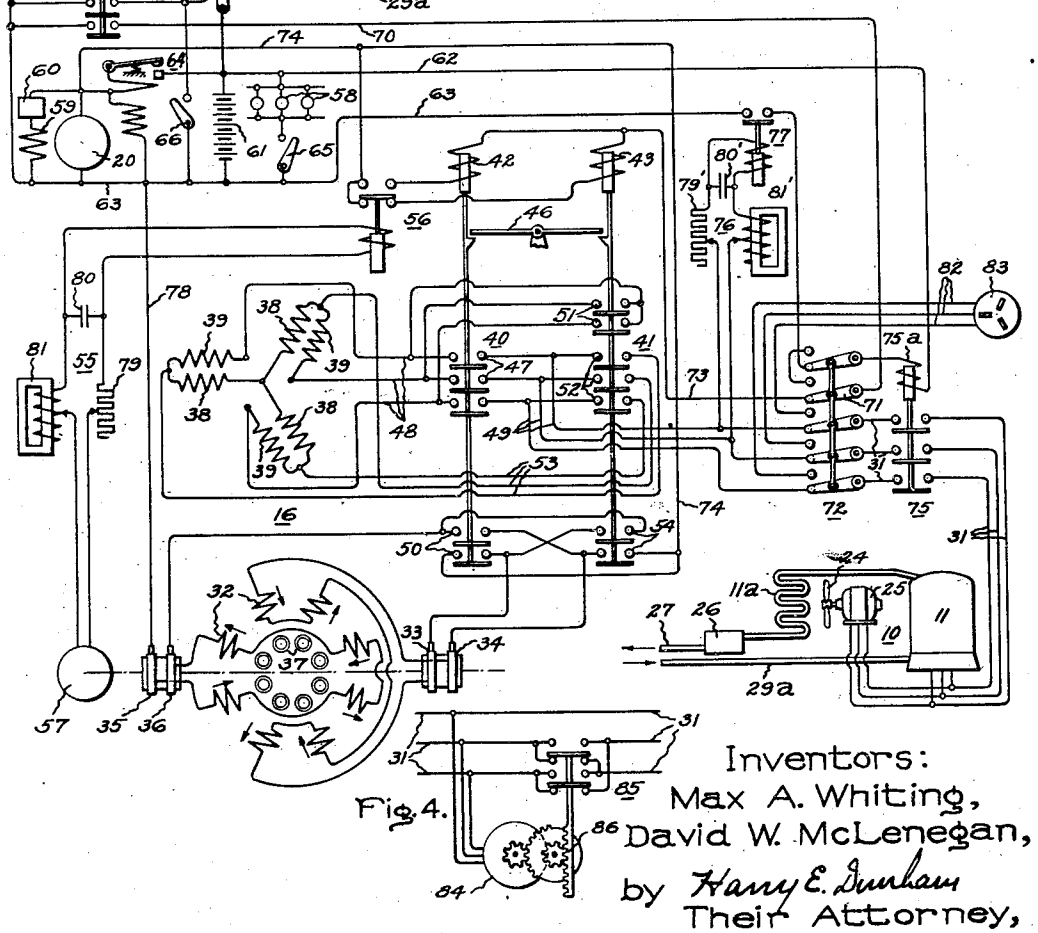


Fig. 4.

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UNITED STATES PATENT OFFICE

2,157,840

POWER SYSTEM

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Application December 29, 1937, Serial No. 182,266

18 Claims. (Cl. 171—313)

Our invention relates to alternating current power systems having variable speed prime movers, and particularly to such systems for supplying power to drive auxiliary apparatus on railway cars or other vehicles.

Vehicles, such as railway cars, are commonly provided with auxiliary devices including lights, fans, and air conditioning apparatus, which must be supplied with power from a suitable source located on the car or in another car of the train. Generally, it is more satisfactory to have each car a complete unit not dependent on a power supply located elsewhere in the train. It is, therefore, common practice to provide electric generators driven by one of the axles of the car. For lighting purposes and for most other purposes, it is satisfactory to provide direct current which makes it possible to use a storage battery for supplying power when the car is not in motion. However, some of the auxiliary apparatus is preferably driven by alternating current motors. The speed of an alternating current motor is dependent upon the frequency of the current supplied which in turn is dependent upon the speed of the generator. In order to utilize alternating current from a generator driven by the car axle, the speed of which must vary over a wide range, it is necessary to provide some arrangement for keeping the range of frequency of the generated current sufficiently narrow for satisfactory operation of the motors, since a wide variation of motor speed is undesirable. Alternating current motors are particularly desirable for driving motors of the refrigerating machines of air conditioning equipment, because an alternating current motor of the induction type can be arranged within a hermetically sealed casing, so that no shaft seals are necessary and the danger of leakage of refrigerant gas is minimized. A range of speeds of the refrigerant compressor of the same order as the range of speeds of the railway car would not give satisfactory operation and it is therefore necessary to provide some arrangement for making the range of frequency of the current supplied by the axle driven generator more narrow than the range of speeds of the car. Accordingly, it is an object of our invention to provide an improved alternating current power system having a variable speed prime mover or similar device, such as the axle of a railway vehicle, and having an arrangement whereby the frequency of the generated current varies within a narrower range than the range of speeds of the prime mover.

Another object of our invention is to provide an alternating current power system including a generator driven by a variable speed prime mover or device and provided with an improved arrangement for changing the number of poles of the generator so that the range of frequencies of the generated current is narrower than the range of speeds of the prime mover.

Further objects and advantages of our invention will become apparent as the following description proceeds, and the features of novelty which characterize our invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of our invention, reference may be had to the accompanying drawing in which Fig. 1 shows a passenger railway car provided with an electrically driven air conditioning system and an alternating current power system embodying our invention for supplying energy to the air conditioning apparatus; Fig. 2 is a wiring diagram of the power system utilized on the car shown in Fig. 1; Fig. 3 is a characteristic curve of the frequency responsive relays utilized in the power system shown in Fig. 2; and Fig. 4 is a diagrammatic illustration of a phase rotation responsive device for maintaining the same direction of phase rotation of the current in the power supply lines regardless of the direction of movement of the railway car.

Referring now to the drawing, we have shown a railway car provided with a refrigerant condensing unit 10 including a hermetically sealed casing 11, in which is arranged a refrigerant compressor driven by an alternating current motor. The condensing unit 10 is arranged to supply liquid refrigerant to the cooling coils of an air conditioning system including a cooling chamber 12 and provided with a motor 13 for driving a fan to distribute cooled air from a conduit 14 through openings 15 into the upper portion of the passenger space of the car. In order to supply alternating current for energizing the compressor motor and other motors as required, we provide an alternating current generator 16 driven by a belt 17 from one of the car axles 18, or other suitable device, a spring 19 being provided to maintain tension in the belt 17. In order to provide field excitation for the generator 16 and also for energizing the lighting system of the car, and such apparatus as the motor 13, we provide a direct current generator 20 of the type which is standard on railway cars. The generator 20 is connected to be driven from an axle 21 by a belt 22, a spring 23 being provided

to maintain the belt tension. The alternating current generator 16 is arranged so that it may operate with a plurality of numbers of pairs of field poles, so that the frequency of the current produced thereby may be varied by changing the number of poles. A dynamo-electric machine of this type is disclosed and claimed in U. S. Letters Patent No. 1,491,451, April 22, 1924, Robert W. Wieseman, which is assigned to the General Electric Company, assignee of this invention. We provide a frequency responsive device for changing the number of poles of the generator in accordance with the speed of the car, so that the frequency of the current produced by the generator varies within a narrower range than the range of speeds of the car.

The arrangement and mode of operation of the above power system will readily be understood on reference to Fig. 2 in which we have shown the hermetically sealed motor and compressor unit 11 arranged to supply compressed refrigerant to a condenser 11a which is cooled by fan 24 driven by an alternating current motor 25. The compressed refrigerant is cooled and liquefied and flows into a liquid receiver 26. From the receiver 26 the liquid flows through a liquid line 27 and an expansion valve 28 to a cooling coil or evaporator 29 arranged within the cooling chamber 12. Air is circulated through the cooling chamber and into the duct 14 by operation of a fan 30 driven by the motor 13. The liquid refrigerant within the coil 29 is vaporized and returns to the casing 11 through a suction line 29a. The liquid line 27 and the suction line 29a are shown only in part. Three-phase alternating current for operation of the motor within the casing 11 and the motor 25 is supplied through lines 31, which are arranged to be connected to the three-phase alternating current generator 16. The generator 16 comprises a salient pole rotor having a field excitation system including a plurality of windings 32. The windings 32 are connected so that opposite pairs are in series, the pairs on the vertical axis being shown connected to slip rings 33 and 34 at the right, and the pairs on the horizontal axis are connected to slip rings 35 and 36 at the left. The field exciting winding has been illustrated with eight coils 32 providing a maximum number of eight poles. When the generator is operating with its full number of poles, the magnetic flux in adjacent poles is in the opposite direction as indicated by the arrows. When it is desired to operate the generator with one-half its full number of poles, the current in the group of coils connected to the right-hand rings 33 and 34 is reversed, it being evident that then the polarity of each of the coils of the reversed group is the same as that of the adjacent coil of the other group. This connection provides four groups of coils, each group comprising two coils in which the direction of flux is the same, and there are, therefore, four effective poles. Each of the salient poles is provided with a short circuiting ring or jacket 37 to damp the flux changes produced by the reversal of the fields when changing the number of poles of the generator. The stator of the generator 16 is provided with a plurality of windings 38 and 39 arranged to provide either a single-Y connection for the lower range of speeds or a double-Y connection for the upper range of speeds; this compensates for the change of voltage due to the change in the range of speeds. In order to change the number of pairs of poles on the rotor of generator 16 and in order to change the connection of the windings of the stator, we provide solenoid operated switches 40 and 41 having operating solenoids 42 and 43 respectively.

In the railway air conditioning system illustrated, the switches 40 and 41 in addition to effecting a change of the number of poles of the generator, connect the alternating current supply to the motor 25 and to the motor within the casing 11. The actuation of the switches 40 and 41 is controlled by a thermostat responsive to the temperature of the air within the passenger space of the car, and both switches are maintained open until there is a demand for cooling of the air. The switch 40 connects the generator to be operated with its full number of poles and with the stator windings connected in single-Y. This is the connection for the lower range of train speeds. The switch 41 connects the generator to operate with one-half the full number of poles, and with the stator windings connected in double-Y. This is the connection for the upper range of train speeds. A mechanical interlock bar 46 is provided to prevent concurrent actuation of the two switches. The switch 40 is provided with an upper group of contacts 47 for connecting the generator leads 48 to supply lines 49, and a lower group of contacts 50 for connecting the field exciting windings to operate with its full number of poles. The switch 41 is provided with an upper group of contacts 51 for connecting the generator windings in double-Y, a middle group of contacts 52 for connecting the generator leads 53 to the supply lines 49, and a lower group of contacts 54 for reversing the field exciting windings connected to slip rings 33 and 34, and thus connecting the generator field exciting winding to operate with one-half its full number of poles. Actuation of either of the groups of field contacts 50 and 54 connects the field exciting windings directly across the generator 20 through lines 74 and 78.

In order to actuate the switch 40 during the lower range of train speeds and the switch 41 during the upper range of speeds, we provide a frequency responsive relay 55, including a two-position switch or contactor 56, and connected to be energized by an alternating current pilot generator 57. The construction and operation of the frequency responsive relay 55 is explained more fully hereinafter. In its upper position, the switch 56 connects the solenoid 42, so that the switch 40 will be actuated upon operation of the thermostat 67; and in its lower position, the switch 56 connects the solenoid 43 so that the switch 41 will be actuated upon operation of the thermostat 67. The pilot generator 57 is connected on the same shaft as the alternating current generator 16, and the frequency produced thereby is directly proportional to the speed of the car axle, and relay 55, therefore, operates in response to the speed of the train.

Direct current is supplied by the generator 20 for energizing the control circuits and the field of the alternator 16 and any auxiliary apparatus, such as the motor 13 and a plurality of lights 58. The generator 20 is of the type commonly employed on railway cars and is provided with a shunt field winding 59 and a field regulator 60. A storage battery 61 is provided to supply direct current when the train is not in motion; the battery is permanently connected to supply lines 62 and 63. A cutout 64 is provided to connect the battery to the generator for charging whenever the voltage of the generator is greater than that

of the battery, this arrangement being generally employed for railway lighting circuits. The lights 58 may be connected across the lines 62 and 63 by a switch 65, and the motor 13 may be connected across the lines 62 and 63 by a switch 66 in the event it is desired to run the motor 13 continuously. A switch 66a is provided so that the circuit of the motor 13 may be opened to prevent automatic starting of the motor and draining of the battery when the car is out of service.

The thermostat for controlling the air conditioning system is indicated at 67. When the thermostat calls for cooling it moves to the left and connects a coil 68 across the battery in series with a resistor 68a to actuate a switch 69. The upper contact of the switch closes a holding circuit for the coil 68, the middle contact connects the motor 13 across the battery, and the lower contact connects the generator 20 with a supply line 70 connected to an arm 71 of a manual switch 72. This connection completes a circuit to one side of the solenoids 42 and 43 through a line 73. One of the coils 42 and 43 is energized by being connected between lines 73 and 74, the coil selected depending upon the position of the switch 56, and the corresponding one of the switches 40 and 41 is therefore operated, the field exciting windings of the generator 16 energized, and the generator 16 connected to the supply lines 49. The supply lines 49 are connected to the motor lines 31 through the three lower arms of the switch 72 and therefore supply power for operating the alternating current motors of the air conditioning system.

The speed of the alternating current motors depends upon the frequency of the current supplied by the generator 16 and, although the pole changing arrangement described above insures operation of the generators to produce current within a range of frequencies less than the range of speeds of the train, nevertheless, excessively high speeds of the train might result in too high a frequency for proper operation of the motors. It is, therefore, desirable to provide some arrangement for preventing overspeed of the motors in the event the train is operated at speeds substantially in excess of normal full speed. A switch or contactor 75 is, therefore, provided in the lines 31, and is arranged to be actuated by a frequency responsive relay 76 having a switch or contactor 77 in the circuit of an operating solenoid 75a of the switch 75, the solenoid 75a being arranged to be connected across the lines 62 and 63. The relay 76 is similar to the relay 55, but is connected across the lines 49, so that it is responsive to the frequency of the current supplied by the generator 16 to the alternating current motors of the air conditioning system. The relay 76 may also be utilized to prevent the connecting of the motors to the generator 16 when the frequency of the generated current is lower than a predetermined desired minimum frequency for operation of the motors. In order to accomplish this, the relay 76 is designed not to pick up the switch 77 until a predetermined frequency has been attained. The relay 76 will then maintain the motor circuit 31 closed during the normal range of frequencies of the current supplied by the generator 16, and will open to prevent energization of the motors at frequencies either above or below the desired range.

In the embodiment illustrated, the supply of current at too low a frequency for proper operation of the alternating current motors on the car tends to be prevented, because the generator 20 does not build up its voltage, hence the various contactors do not close, until substantial speed has been reached. It is, therefore, not essential in all cases to provide the additional function of the relay 76. It will, therefore, be evident that although the thermostat 67 has closed the switch 69 by connecting the coil 68 across the battery, nevertheless, since the voltage of the generator 20 has not built up, the solenoids 42 and 43 cannot be energized to operate the switches 40 and 41. The alternating current generator 16 is not, therefore, connected to the lines 49 nor is its field energized until the car has reached sufficient speed for the voltage of the generator 20 to build up.

The operation of the compressor motor in the casing 11 and the motor 25 in response to a call for cooling continues until the thermostat 67 is satisfied, at which time the thermostat moves to the right and short circuits the coil 68 thereby causing the switch 69 to drop out and deenergize the circuit of the switches 40 and 41 thereby disconnecting the alternating current generator 16 from the motors.

It is apparent that the alternating current motors of the air conditioning system will be actuated at frequencies within a predetermined range, the upper limit of which is determined by the relay 76, and the lower limit either by the relay 76 or by the speed at which the generator 20 builds up its voltage, and furthermore, that the frequency of the current supplied to the motors through the lines 31 will vary within range less than the range of speeds of the car, because of the operation of the switches 40 and 41, as determined by the frequency responsive relay 55.

Any suitable frequency or speed responsive device may be used to actuate the pole changing switches 40 and 41, and to determine the limits of speed within which the motors are to operate. However, we prefer to use frequency responsive relays of the non-linear, resonant type disclosed and claimed in Patent No. 2,021,753, Chauncey G. Suits on November 19, 1935, which is assigned to the General Electric Company, assignee of this invention. The relay 55, for example, comprises an adjustable resistance 79, a capacitance 80, and an iron core inductance 81, the relay coil for operating the switch 56 being connected in shunt across the capacitance. The corresponding resistance, capacitance, and inductance of the relay 76 are designated 79', 80' and 81' respectively. The resistances 79 and 79' and the inductances 81 and 81' are made adjustable in order that the critical frequencies which govern the operation of the relays may be varied. By proper proportioning of the inductance, capacitance, and resistance of the relay circuit, a characteristic curve similar to that shown in Fig. 3 may be obtained. The curve is plotted with voltage across the capacitance as its ordinate, and applied frequency as its abscissa. The "pick up" and "drop out" curves of the switch solenoid are shown in dotted lines. As the frequency is increased from zero, the voltage will rise to some point *a* on the "pick up" curve and the relay will pick up. The voltage will then continue to rise until it reaches the top of the curve when it will start to decrease until it reaches a point *b* when a further increase of frequency results in a sudden fall of voltage across the capacitance to a value below the "drop out" curve and the relay drops out. Further increase of frequency produces little change in voltage.

When the frequency is decreased, the position of the curve in the critical region where there is a sudden change in voltage does not coincide with the curve on rising frequency. The frequency will decrease until a frequency *c* somewhat less than that of *b* is reached, when there will be a sudden rise in voltage to a value above the "pick up" curve and the relay will pick up; on further decrease in frequency the voltage will continue to rise until it reaches the curve for rising frequency and the two curves coincide thereafter. Further decrease in frequency produces decreased voltage until the voltage falls to a value below the "drop out" curve and the relay drops out. The resistance **79** and inductance **81** are made adjustable in order that they may be changed to alter the critical frequencies *b* and *c* of the relay. To increase the critical frequencies, the inductance **81** should be decreased by reducing the number of turns in the winding, the turns cut out being left open circuited. Decrease of the critical frequencies is, of course, obtained by increase of inductance. In order to change the difference between the frequencies *b* and *c*, the resistance **79** is varied, an increase in resistance increasing the difference between frequencies; an appreciable difference should be selected in order to avoid chattering of the relay due to momentary changes in frequency.

In designing the non-linear, resonant relay **55**, the critical frequencies *b* and *c* are selected at approximately one-half maximum car speed, so that the alternating current generator **16** will operate with its full number of poles until the train reaches one-half its maximum speed, when the generator will be shifted to one-half its full number of poles for speeds above one-half the maximum speed.

It will be understod that the relay **76** is so designed that it will pick up at a value of frequency corresponding to the lowest desired frequency for operation of the alternating current motors at a point corresponding to *a* in Fig. 3, and will drop out at the maximum desired frequency at a point corresponding to *b* in Fig. 3. The relay **76** is, therefore, selected to operate so that the frequencies on its characteristic curve corresponding to the points *a* and *b* in Fig. 3 are the limiting minimum and maximum frequencies for the operation of the alternating current motors of the air conditioning system.

The manual switch **72** is provided in order that the alternating current motors may be supplied from a suitable source available in the station when the train is at a standstill. In order to connect the air conditioning system for operation from the station supply, the switch **72** is moved to its upper position. The lower three arms then connect the lines **31** to supply lines **82**, which are connected to a receptacle **83** for receiving the station alternating current supply. The arm **71** and the top arm of the switch **72** connect the coil **75***a* between the lines **62** and **70**. This places the coil **75***a* under control of the thermostat **67**, it being evident that when the thermostat calls for cooling and operates the switch **69**, the coil **75***a* will be connected across the battery **61** through the lines **62** and **70**. Therefore, when the train is in the station, the air conditioning system may be operated from the station supply under control of the thermostat **67**.

Some types of refrigerant compressors employed in mechanical refrigerating systems may be designed to operate equally well regardless of the direction of rotation of the driving motor. However, when alternating current fan motors, such as the motor **25** are employed, or when non-reversible compressors are used in the system, some arrangement must be provided to prevent reversal of the direction of phase rotation of the voltage supplied to the motors, so that the motors will always rotate in the same direction. Various suitable electrical and mechanical arrangement may be provided. However, we prefer to use a control device which is responsive to the phase rotation of the voltage at the supply terminals which is either the voltage of the alternating current generator **16**, or the station alternating voltage plugged in at the receptacle **83**. The control device illustrated comprises a small polyphase induction motor **84** having a relatively high resistance squirrel cage rotor, or any suitable device having similar characteristics; we have indicated the device diagrammatically in Fig. 4. The polyphase induction motor **84** is connected across the lines **31** and a reversing switch **85** arranged to be operated by the motor. This device may be connected in the lines **31** between the switch **72** and the switch **75**. The windings of the motor **84** are connected to be energized by the voltage at the three lower blades of switch **72**. When the phase rotation is in one direction, the motor tends to rotate in a clockwise direction and move the switch **85** to its upper position through a train of gears and a rack **86** arranged to actuate the switch **85**. When the phase rotation is in the other direction, the motor **84** turns in a counter-clockwise direction and moves the switch to the position shown in Fig. 4. The characteristics of the motor **84** are so designed that the motor may be stalled without taking a heavy current, and during the operation of the control device, the motor is stalled when the switch **85** reaches either of its positions, and remains stalled until there is a reversal of phase rotation. The switch **85** is arranged to reverse the two lower lines **31**, and thereby reverse the phase rotation of the lines **31** to the right of the switch whenever the switch is operated. It will therefore be evident that the control device shown in Fig. 4 is available to maintain the same direction of phase rotation in the lines **31** leading to the motors **11** and **25** regardless of the direction of phase rotation at the terminals of the switch **72**. Although the control device is shown in Fig. 4 operating the phase reversing contacts directly, it will be understood that the phase rotation responsive device may be constructed as a relay to control contactors for the necessary reversal of two of the phase leads.

During the operation of the power system described above, when the car leaves the station, manual switch **72** is closed in its lower position, thereby connecting the supply lines **49** to the motor lines **31**. As soon as the car attains sufficient speed, the voltage of the direct current generator **20** will build up and will rise to a value sufficient to close the cutout **64** and connect the generator to charge the battery **61**. The pilot generator **57** is designed to produce at this speed a frequency somewhat above that at the point *a* on the curve in Fig. 3, and the relay **55** picks up its armature at **56**. Should the thermostat **67** call for cooling the switch **69** will be closed to energize the solenoid **42** and close the contacts of the switch **40**. This excites the field of the alternating current generator **16** through field switch contacts **50** and connects the field with

its full number of poles. The switch 40 also connects the leads 48 of the generator to the supply lines 49 thereby connecting the generator stator winding in single-Y. Energy is therefore available for the motors; and if the frequency of the current generated is sufficiently high, the relay 76 will pick up the switch 77 thereby closing the switch 75 and energizing the motors to operate the refrigerating machine. It is to be noted here that the relay 76 acts as a safety device preventing the operation of the switch 75 in the event the relay 55 should fail to pick up the switch 56, which in its drop-out position, would connect the generator 16 with its lower number of poles to generate current of too low frequency at the lower train speeds. As the speed of the car increases, the frequency of the current produced by the alternating current pilot generator 57 will increase until it reaches the value at *b* when the switch 56 will drop out thereby deenergizing the coil 42 and energizing coil 43. This transfers the connections of the generator from the switch 40 to the switch 41 and the generator is thereby connected with its reduced number of poles, the field exciting winding being connected by the switch contacts 54 in series between the lines 74 and 78 with the direction of the field coils 32 connected to rings 33 and 34 reversed; the generator then operates with one-half its full number of poles. The stator is connected in double-Y through the contacts 51 and the generator leads 53 are connected to the supply lines 49 through the group of contacts 52. The frequency of the current supplied by the generator 16 to the motors is thereby reduced and as the car continues to increase in speed the frequency will remain sufficiently low for proper operation of the motors. Should the switch 56 fail to drop out and decrease the number of poles of the generator 16, or should the car attain excessive speed, the relay 76 will reach its upper critical value at the predetermined maximum frequency for which it is set and will drop out thereby deenergizing the solenoid 75*a* and opening the switch 75 to disconnect the motors from the generator. It is therefore evident that the relay 76 is available to protect the motors in the event of a failure of relay 55 at either end of its operating range. Should the demand for cooling be satisfied, the thermostat 67 will move to the right, short circuit the coil 68 and open the switch 69 thereby deenergizing the circuit of the solenoids 42 and 43 and disconnecting the generator 16.

From the foregoing, it is apparent that we have provided a power system for railway cars and other vehicles which makes possible the operation of alternating current auxiliary devices on the car, the frequency of the current supplied to the auxiliary devices varying within a range more narrow than the range of speeds of the car and further that excessive speeds of the motors are prevented and also energization of the motors at frequencies too low for proper operation.

While we have described our invention in connection with an air conditioning system for railway cars, other applications will readily be apparent to those skilled in the art. We do not, therefore, desire our invention to be limited to the particular construction shown and described, and we intend in the appended claims to cover all modifications within the spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent in the United States is:

1. A power system including an alternating current generator, a variable speed device operable over a relatively wide range of speeds and arranged to drive said generator, said generator having a plurality of pairs of field poles, an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto, means for supplying to said motor current produced by said generator to energize said motor, and means responsive to the speed of said device for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said device.

2. A power system including an alternating current generator, a variable speed device arranged to drive said generator, said generator having a plurality of pairs of field poles, an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto, means for supplying to said motor current produced by said generator to energize said motor, and means responsive to the speed of said device for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said device, said last mentioned means including means responsive to a predetermined speed of said device for decreasing the number of pairs of field poles of said generator and responsive to a decrease of the speed of said device from said predetermined speed to an appreciably lesser predetermined speed for restoring the number of said pairs of field poles to the original number thereof.

3. A power system including an alternating current generator, a variable speed device arranged to drive said generator, said generator having a plurality of pairs of field poles, an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto, means for supplying to said motor current produced by said generator to energize said motor, means responsive to the speed of said device for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said device, and means depending upon a predetermined maximum frequency of the current produced by said generator for disconnecting said motor from said generator.

4. A power system including an alternating current generator, a variable speed device arranged to drive said generator, said generator having a plurality of pairs of field poles, an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto, means for connecting said motor in circuit with said generator for supplying to said motor current produced by said generator to energize said motor, means preventing actuation of said connecting means below a predetermined frequency of the current produced by said generator and for disconnecting said connecting means in response to a predetermined maximum frequency of the current produced by said generator, and means for varying the effective num-

ber of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said device.

5. A power system including an alternating current generator, a variable speed device arranged to drive said generator, said generator having a plurality of pairs of field poles, an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto, means for supplying to said motor current produced by said generator to energize said motor, a second alternating current generator driven by said prime mover, and means responsive to the frequency of the current produced by said second generator for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said first mentioned generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said device.

6. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including an alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means for supplying to said motor current produced by said generator, and means responsive to the speed of said vehicle for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle.

7. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including an alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including a direct current generator for energizing said field poles, means utilizing movement of said vehicle to drive said direct current generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means for supplying to said motor current produced by said alternating current generator, and means responsive to the speed of said vehicle for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said alternating current generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle.

8. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including an alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including a direct current generator for energizing said field poles, means utilizing movement of said vehicle to drive said direct current generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means for supplying to said motor current produced by said alternating current generator, means including switching mechanism for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said alternating current generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle, and means responsive to the speed of said vehicle and utilizing energy produced by said direct current generator for operating said switching means.

9. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including an alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including a storage battery for energizing a portion of said auxiliary apparatus, means including a direct current generator for charging said storage battery and for energizing said field poles, means utilizing movement of said vehicle to drive said direct current generator, means including a cutout switch for preventing the discharge of current from said battery through said direct current generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving another portion of said auxiliary apparatus, means for supplying to said motor current produced by said alternating current generator, and means responsive to the speed of said vehicle including a switching mechanism having an electrically energizable operating coil for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said alternating current generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle, said operating coil of said switching mechanism being connected across the terminals of said direct current generator between said generator and said cutout switch.

10. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including a polyphase alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means for supplying to said motor polyphase alternating current produced by said generator, means for maintaining the same direction of phase rotation of the current supplied to said motor regardless of the direction of rotation of said generator, and means responsive to the speed of said vehicle for changing the effective number of pairs of field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle.

11. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including a polyphase alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including an alternating current motor the speed of which is de-

pendent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means for supplying to said motor polyphase alternating current produced by said generator, means for connecting to said motor a source of polyphase alternating current external to said vehicle and for disconnecting from said motor said alternating current generator, means for maintaining the same direction of phase rotation of the current supplied to said motor regardless of the direction of rotation of said generator and regardless of the direction of rotation of the phases of said external source of current, and means responsive to the speed of said vehicle for changing the effective number of pairs of field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle.

12. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including an alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means for supplying to said motor current produced by said generator, and means responsive to the speed of said vehicle for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle, said last mentioned means including means responsive to a predetermined speed of said vehicle for decreasing the number of pairs of field poles of said generator and responsive to a decrease of the speed of said vehicle from said predetermined speed to an appreciably lesser predetermined speed for restoring the number of said pairs of field poles to the original number thereof.

13. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including an alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means for supplying to said motor current produced by said generator, means responsive to the speed of said vehicle for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle, and means depending upon a predetermined speed of said vehicle for disconnecting said motor from said generator.

14. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including an alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means including a switch for supplying to said motor current produced by said generator, means depending upon a predetermined minimum speed of said vehicle for preventing operation of said switch to energize said motor when the speed of said vehicle is below said predetermined speed, and means responsive to the speed of said vehicle for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle, said last mentioned means including means responsive to a predetermined speed of said vehicle for decreasing the number of pairs of field poles of said generator and responsive to a decrease of the speed of said vehicle from said predetermined speed to an appreciably lesser predetermined speed for restoring the number of said pairs of field poles to the original number thereof.

15. A power system including an alternating current generator, a variable speed device operable over a relatively wide range of speeds and arranged to drive said generator, an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto, means for supplying to said motor current produced by said generator to energize said motor, said generator having a plurality of pairs of field poles, and means responsive to the speed of said device for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said device, said speed responsive means including a relay adapted in its "drop out" position to connect said generator to have its least number of pairs of field poles.

16. A power system including an alternating current generator, a variable speed device arranged to drive said generator, said generator having a plurality of pairs of field poles, an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto, means for supplying to said motor current produced by said generator to energize said motor, means responsive to the speed of said device for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said device, means for connecting said generator to said motor, and means dependent upon a predetermined maximum frequency of the current produced by said generator for disconnecting said generator from said motor, said last mentioned means including a relay adapted in its "drop out" position to effect the disconnecting of said motor and also arranged to be picked up initially at a predetermined minimum frequency of the current produced by said generator.

17. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including an alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means for supplying to said motor current produced by said generator, and means responsive to the speed of

said vehicle for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle, said speed responsive means including a relay adapted in its "drop out" position to connect said generator to have its least number of pairs of field poles.

18. A vehicle having electrically driven auxiliary apparatus thereon, a power system for supplying energy to said auxiliary apparatus including an alternating current generator having a plurality of pairs of field poles, means for utilizing movement of said vehicle to drive said generator, means including an alternating current motor the speed of which is dependent upon the frequency of the current supplied thereto for driving said auxiliary apparatus, means for supplying to said motor current produced by said generator, means responsive to the speed of said vehicle for changing the effective number of pairs of said field poles to vary the frequency of the current produced by said generator and for maintaining the range of speeds of said motor more narrow than the range of speeds of said vehicle, and means depending upon a predetermined speed of said vehicle for disconnecting said motor from said generator, said last mentioned means including a relay adapted in its "drop out" position to effect the disconnecting of said motor and also arranged to be picked up initially at a predetermined minimum frequency of the current produced by said generator.

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