United States Patent [19]

Simon

[11] E **Re. 29,579**

[45] Reissued **Mar. 14, 1978**

[54] **DUAL SOURCE AUXILIARY POWER SUPPLY**

[75] Inventor: **Martin Simon, Erie, Pa.**

[73] Assignee: **General Electric Co., Erie, Pa.**

[21] Appl. No.: **716,325**

[22] Filed: **Aug. 20, 1976**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **3,745,366**
Issued: **Jul. 10, 1973**
Appl. No.: **195,753**
Filed: **Nov. 4, 1971**

[51] **Int. Cl.**[2] **H02J 9/04**

[52] **U.S. Cl.** **307/68**

[58] **Field of Search** 307/47, 66, 67, 68, 307/80, 81, 84; 290/11, 17; 180/65; 105/35, 61, 62

[56] **References Cited**

U.S. PATENT DOCUMENTS

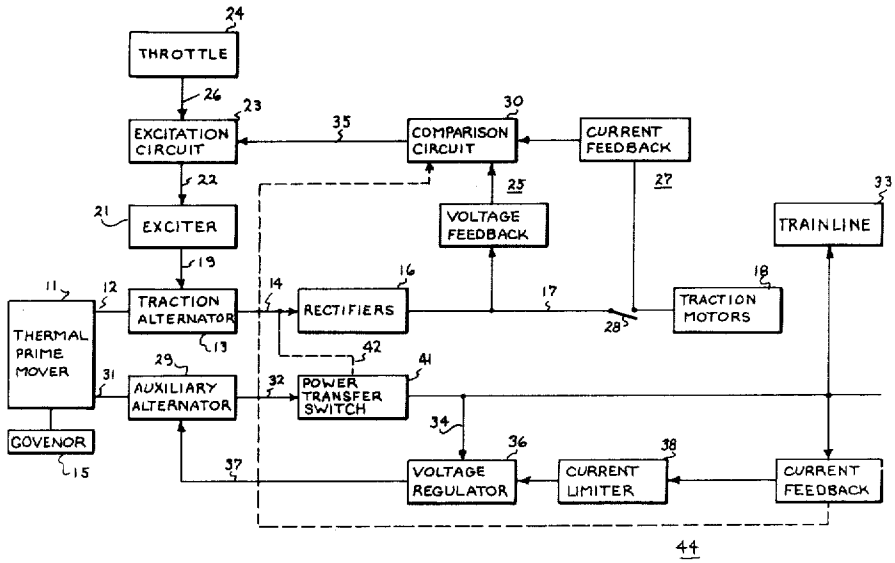
1,655,740	1/1928	Robson	105/62 A
1,750,297	3/1930	Candee	290/11
2,113,207	4/1938	Yingling	105/62 R
2,230,580	2/1941	Adams	105/62 R
3,547,044	12/1970	Lemaire	290/17

Primary Examiner—Robert K. Schaefer
Assistant Examiner—Eugene S. Indyk
Attorney, Agent, or Firm—James H. Beusse

[57] **ABSTRACT**

An auxiliary power supply system for providing controlled alternating current in an electric motor traction vehicle driven by a prime mover through a traction alternator. During normal traction operation the prime mover operates at a high constant rotational speed to directly drive an auxiliary alternator which provides the auxiliary power, while in standby operation the prime mover operates at a reduced constant rotational speed and the auxiliary power is obtained from the traction alternator at the desired frequency and voltage.

3 Claims, 4 Drawing Figures



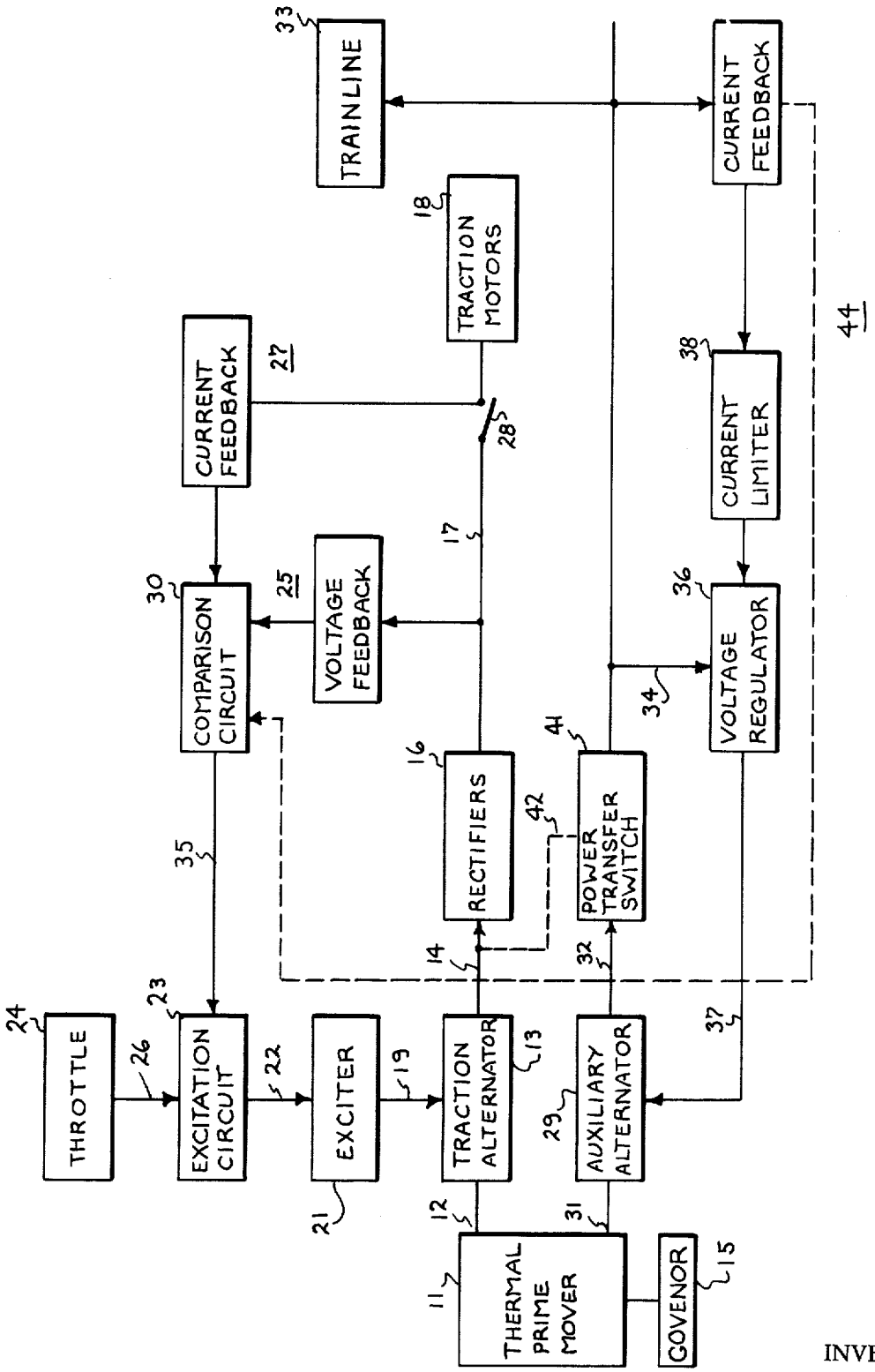


FIG. 1

INVENTOR.
MARTIN SIMON
BY
Walter C. Bernkopf
HIS ATTORNEY

FIG. 2b

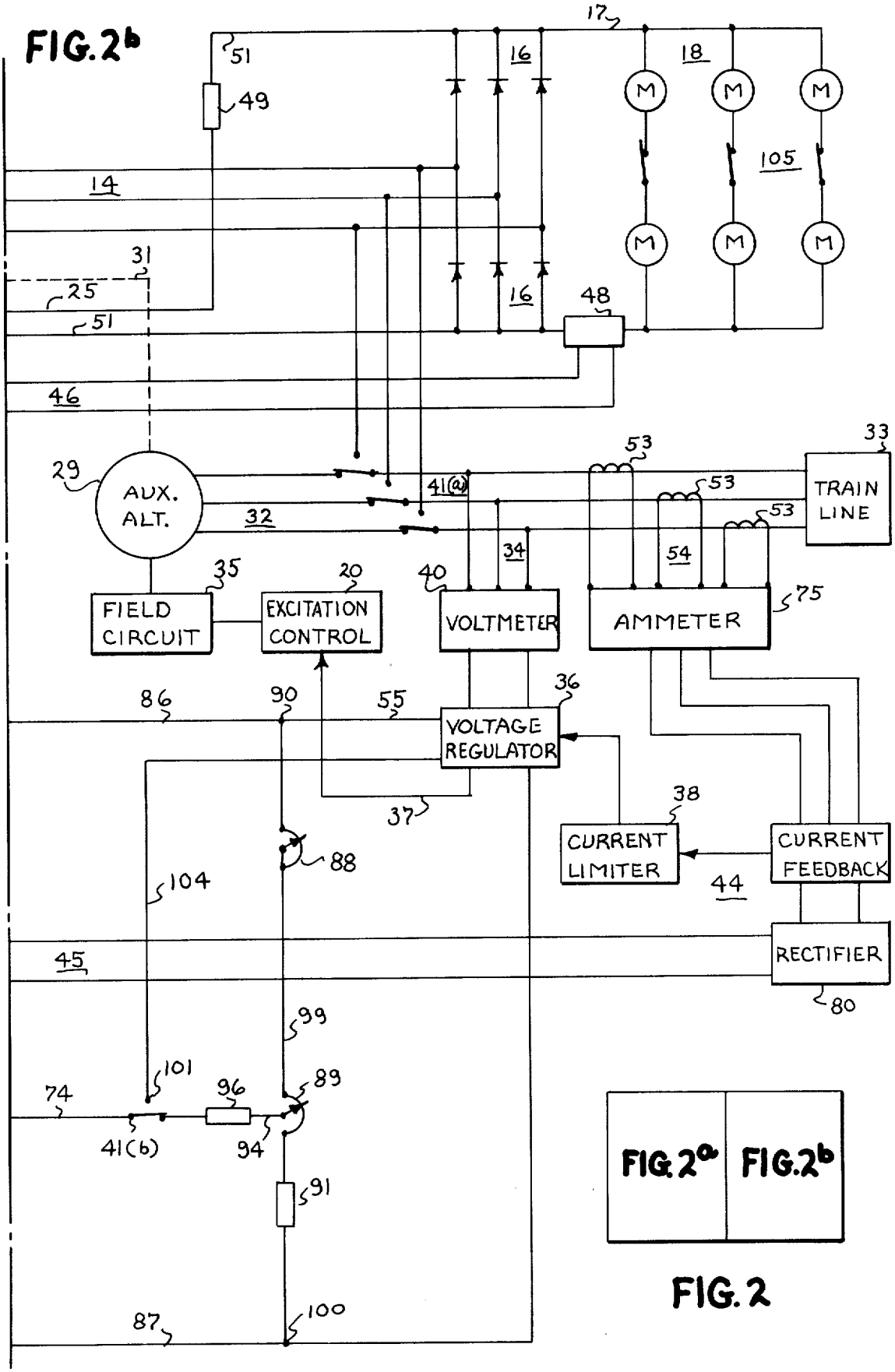
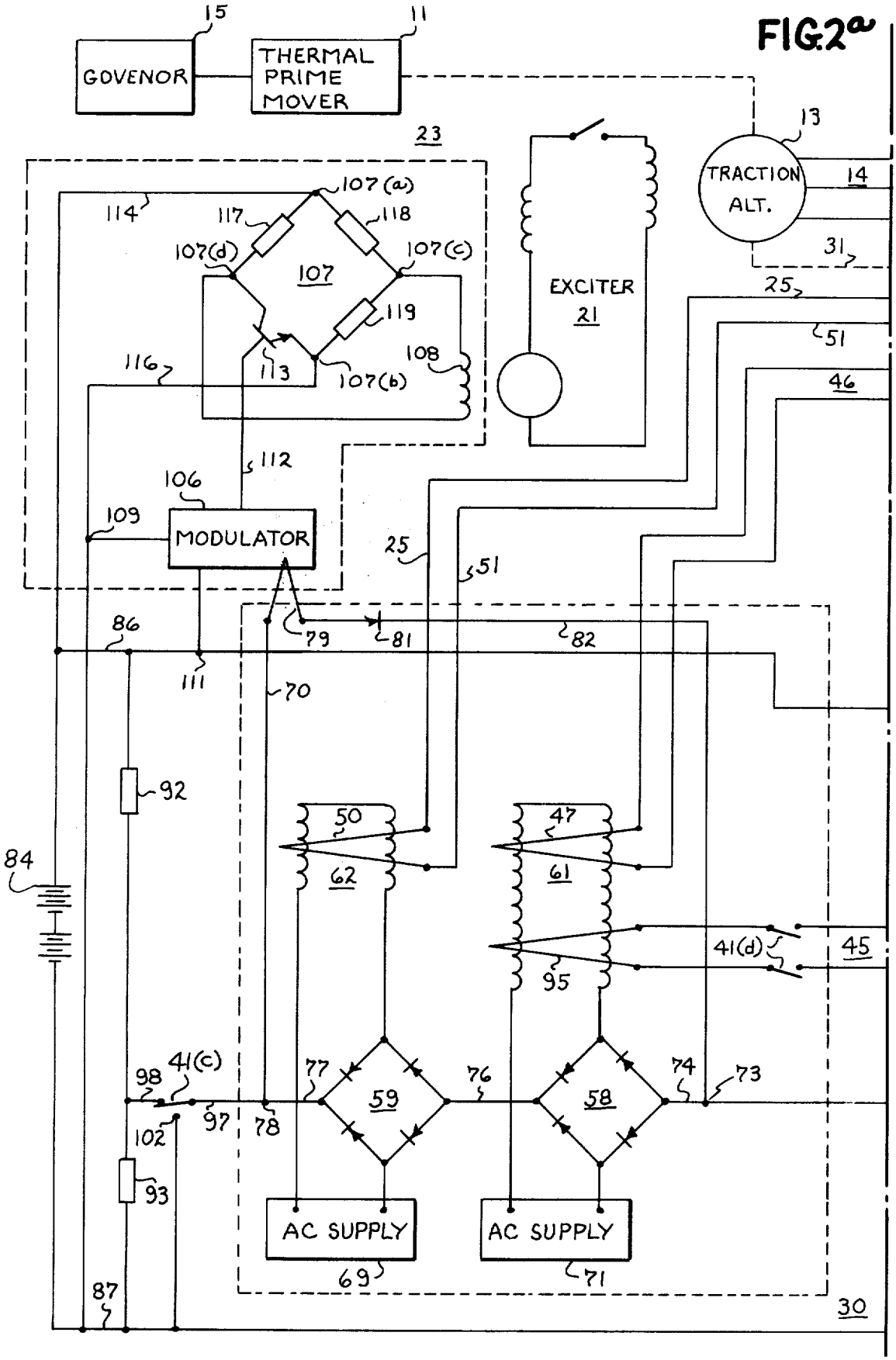


FIG. 2a FIG. 2b

FIG. 2


FIG.2a
15
GOVENOR
11
THERMAL PRIME MOVER
23
13
TRACTION ALT.
14
31
EXCITER 21
25
51
46
107(a)
114
117
118
107(d)
107
107(c)
119
116
113
107(b)
108
112
106
109
MODULATOR
25
51
86
79
81
82
111
70
92
50
62
47
61
84
41(d)
45
95
98
41(c)
77
59
76
58
74
73
97
78
102
93
AC SUPPLY
AC SUPPLY
69
71
87
30

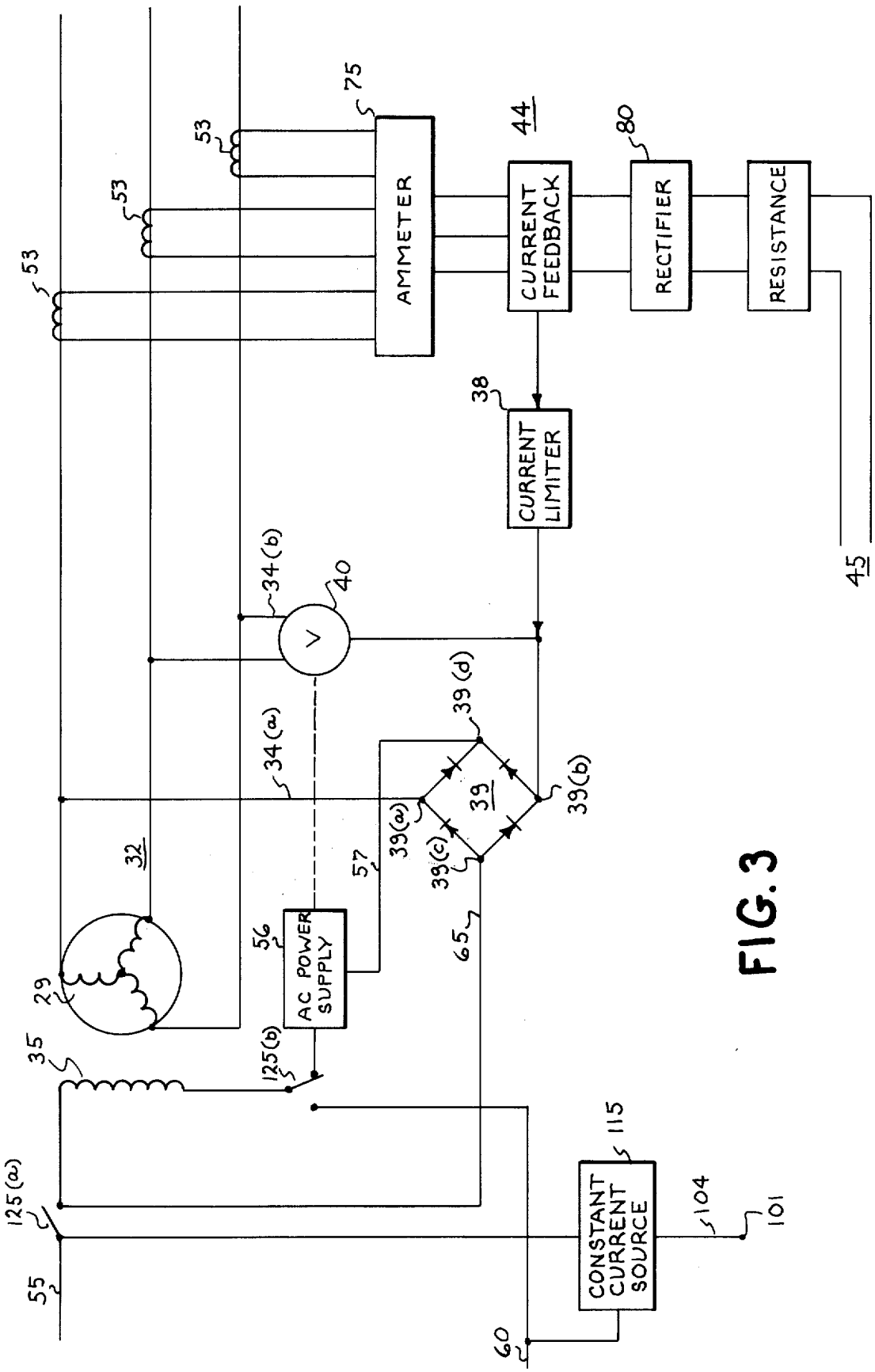

AMMETER
CURRENT FEEDBACK
RECTIFIER
RESISTANCE
CURRENT LIMITER
AC POWER SUPPLY
CONSTANT CURRENT SOURCE
V
39
53
75
44
80
38
45
34(b)
40
39(d)
34(a)
39(b)
39(a)
39(c)
32
57
56
65
29
35
125(b)
125(a)
55
115
104
101
60

FIG. 3

DUAL SOURCE AUXILIARY POWER SUPPLY

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

This invention relates generally to electrical power supply systems for electrically propelled traction vehicles and more particularly to alternating current auxiliary power supply systems utilized in electrically propelled vehicles, wherein alternating current generating means, driven by a thermal prime mover, energizes the propulsion motors of the vehicle.

Traction vehicles, such as diesel electric locomotives, commonly utilize a thermal prime mover to drive a traction alternator whose output provides electrical power to the traction motors. The prime mover, such as a diesel engine or the like is operated at various speeds by throttle control in accordance with the power requirements of the alternator.

In addition to traction power, it has also been necessary to provide auxiliary power for lighting, heating and air conditioning. Frequently, it is desirable to provide alternating current auxiliary power for this purpose. Historically, this power has been provided by an auxiliary alternator which is driven by an auxiliary prime mover at a constant rotational speed to ensure an auxiliary power supply of constant frequency and voltage. The auxiliary prime mover and alternator are thus operated continuously to provide the required power both during periods of normal traction operation and during standby operation, wherein the vehicle is standing idle as when awaiting call. During standby, auxiliary power is required, but to a much lesser extent than when in normal traction operation. This varying of the load on the auxiliary prime mover, which has traditionally been a diesel engine, causes considerable problems in maintenance with attendant costs. The expense of an extra diesel engine is thus substantial when considering original installation costs and subsequent overhaul demands.

It is therefore desirable to eliminate the auxiliary prime mover and to drive the auxiliary alternator directly from the traction prime mover which has sufficient available power. However, in conventional diesel electric vehicles the speed of the prime mover is varied during operation, by changing the setting of the throttle lever. This variation of prime mover speed would result in a change in auxiliary alternator speed with a corresponding change in output voltage and frequency.

Energization of the auxiliary power source by the prime mover is further complicated because of standby operation of the vehicle. During time periods wherein the vehicle is in a standby condition, the auxiliary power is still required, but the traction power is not, and thus the operation of the prime mover at the constant high speed is impractical. The resulting noise in residential areas is extremely undesirable. A reduction in prime mover speed will reduce the noise level, but would in turn excessively reduce the frequency of the auxiliary alternator. The use of gears to maintain the alternator speed while slowing the prime mover speed would involve unnecessary expense and difficulty.

It is therefore an object of this invention to provide an improved system for generating alternating current of substantially uniform frequency, for use as auxiliary power in a traction vehicle wherein alternating current generating means driven by prime [moving] *mover* means energizes propulsion motors.

It is another object of this invention to attain the aforesaid arrangement without requiring a prime mover additional to the prime [moving] *mover* means otherwise required to drive the propulsion alternating current generating means.

Yet another object of this invention is to provide an improved alternating current auxiliary power source providing substantially constant frequency and output voltage during periods of normal and standby operation of the vehicle.

Still another object of this invention is to achieve the aforesaid objectives without complex gearing and with use of components of the propulsion system of the traction vehicle.

A further object of this invention is to minimize the noise level of a traction vehicle operating in a standby condition.

SUMMARY OF THE INVENTION

The invention relates to an auxiliary power supply system utilizing a prime mover-driven, auxiliary alternator to provide polyphase power of predetermined voltage and frequency during normal traction operation, and utilizing the main-drive traction alternator to provide auxiliary power during standby operation, wherein the prime mover is operated at a considerably reduced speed. The system is amplifier controlled, and provides for voltage and current limits in both modes of operation.

In the drawings as hereinafter described a preferred embodiment is depicted; however, various other modification and alternate constructions can be made thereto without departing from the true spirit and scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified block diagram illustration of a traction vehicle power system showing the incorporated invention in dashed lines.

[FIG. **2**] *FIGS. 2a and 2b* is a simplified schematic circuit diagram of a preferred embodiment of the system.

FIG. **3** is a simplified schematic circuit diagram of the voltage regulator and auxiliary alternator excitation portion of the preferred embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference is now made to FIG. **1**. A thermal prime mover **11** such as a diesel engine has its output shaft **12** coupled to drive the traction alternator **13** whose output **14** passes through the rectifier **16** and lines **17** to energize the traction motors **18**. Field current for the traction alternator is supplied by lines **19** from an exciter **21** whose input power is supplied by lines **22** from an excitation circuit **23**. Adjustment of the throttle position **24** varies the input **26** to the excitation circuit, thus controlling the field current to the traction alternator and hence the load imposed on the prime mover. Accordingly, the output of the traction alternator is varied by changing the field current **19** through the excitation circuit **23**. A governor **15** is operably connected to the

diesel engine to control its speed at substantially a constant rotational rate.

A prime mover of the diesel engine type characteristically tends to deliver constant power output for a given diesel engine operating speed. Variations in the diesel engine speed result in variations of diesel output power. For reasons hereinafter discussed, it is desirable for certain traction vehicles such as those used on commuter trains, to operate the prime mover at a constant rate of speed regardless of the load.

The power output of the traction alternator is controlled to prevent excessive voltages and currents and additionally to prevent the power requirements of the traction alternator from exceeding the available power output of the diesel engine. Thus, limiting the electrical horsepower requirements of the traction alternator to the available horsepower output of the diesel engine substantially decreases diesel engine wear and avoids diesel engine speed variations and stalling. This limiting action is achieved by a control system wherein voltage and current feedback signals are applied from the line **17** through voltage feedback circuit **25** and current feedback circuit **27** to the comparison circuit **30**. The output of the comparison circuit is coupled to the excitation circuit **23** through leads **35** for regulating the excitation and thus the power output of the traction alternator.

The above described arrangement is well-known in the art (for example, in the pending application Ser. No. [859,848] *850,848* filed Aug. 18, 1969, of Thomas L. Vandervort, *now U.S. Pat. No. 3,621,370* and assigned to the assignee of this application).

Traction vehicles such as commuter trains or the like require, in addition to traction power, an auxiliary power system to be provided for the auxiliary machinery used for lighting, heating, and air conditioning of the cars. The power generally required is of the a-c type having a controlled voltage and frequency. During normal operation auxiliary power is provided by an auxiliary alternator **29** driven by the prime mover **11** through a coupling means **31**, such as a drive shaft or the like. The constant speed operation of the prime mover during normal operation permits direct mechanical coupling of the auxiliary alternator to the prime mover, thus obviating the separate prime mover in order to maintain a constant power frequency. The output **32** from the auxiliary alternator is applied through power transfer switch **41** to an auxiliary power output circuit, i.e. the trainline **33**, for driving the auxiliary machinery. In a preferred embodiment the output is 512 volts at 64 Hz. As previously stated, the prime mover is operated at a constant rotational speed, which include preferred embodiment is 960 rpm, and hence, the auxiliary alternator is also operated at a constant speed, thus ensuring a constant frequency power supply to the trainline. The voltage appearing across the line **32** is applied by the line **34** to a voltage regulator **36**. The output of the voltage regulation is directed along line **37** to the auxiliary alternator **29** for which it provides a field current.

A current feedback circuit **44**, hereinafter described is provided principally for standby operation wherein the current feedback circuit **27** is open circuited.

A current limiter **38** may be interconnected between the current feedback circuit **44** and the voltage regulator **36** for use during normal operation.

Because of the necessity for maintaining an auxiliary power output for providing heating and cooling during standby operation, it is necessary to maintain operation of a prime mover during this period. However, while continued operation of the diesel engine and regulated output of auxiliary power is required, there is generally a need to reduce the noise level of the prime mover. This noise level is reduced by reducing the speed of the prime mover, and if the speed is reduced and held to a fixed predetermined speed, it will permit use of the main alternator to provide the auxiliary power of constant frequency, thereby eliminating the need for an auxiliary prime mover.

During time periods wherein the traction vehicle is in a standby condition, such as when standing in the yard at night, the power transfer switch **41** is thrown, thereby disconnecting the output of the auxiliary alternator and connecting the output of the traction alternator through line **42** (indicated by a dashed line in FIG. **1**). During this period of operation, the prime mover operates at a reduced constant rotational speed, for example 600 rpm, and the auxiliary power to the trainline is obtained from the traction alternator output **14**, a typical output being 480 volts at 60 Hz, as shown in FIG. **1**. In a standby condition, the traction alternator field is controlled so as to maintain the appropriate auxiliary voltage and to limit output current to a predetermined magnitude. The current feedback circuit **44** sends current feedback signals from the traction alternator output to the comparison circuit, thereby controlling the amount of current being delivered to the line **42** in a manner discussed hereinafter. During standby operation the voltage feedback circuit **25** continues to function, but the current feedback circuit **27**, which is responsive to current being delivered to the traction motors **18** is rendered inactive by the switch assembly **28**.

The auxiliary power frequency should be maintained within a reasonable range such as ± 12 percent. Frequency output of auxiliary power during standby and normal operation is maintained within that range by appropriate selection of poles of the auxiliary alternator vs. poles of traction alternator. Since the frequency of an alternator. in Hz, is related to the number of poles and the speed, as expressed by the equation f[=] ∝ (number of poles) X (speed), the auxiliary alternator is selected to have a number of poles approximately represented by the equation

(number of poles of *auxiliary* alternator) = [(RPM standby)/(RPM normal)](Number of poles of traction [motor] *alternator*)

An 8 pole, 3 phase auxiliary generator operating at 960 rpm will have a 64 Hz, 512 volt output, whereas a 12 pole, 3 phase, traction alternator operating at 600 rpm will produce a 60 Hz, 480 volt output. Accordingly, the speed of the traction alternator is reduced from 960 rpm to 600 rpm when changing from normal traction operation to standby operation. Thus, an output may be obtained from the traction alternator operating at low speeds which has nearly the same characteristics as the output of the auxiliary alternator operating at higher speeds.

Referring now to FIG. **2**, the control circuitry of a preferred embodiment is illustrated in partial schematic form and includes in greater detail, the excitation circuit **23**, and the comparison circuit **30** (indicated by dashed line boxes) with the corresponding voltage feedback circuit **25** and the current feedback circuits **27** and **44**, as well as the relative placement of the contacts of the power transfer switch **41**.

The traction alternator **13**, which is driven by the prime mover **11**, provides three-phase power to leads **14**. During normal traction operation of the vehicle the current passes through the rectifiers **16** and hence to the traction motors **18** for driving the vehicle. Provided in the propulsion circuit is a current limit and voltage limit arrangement responsive to the propulsion current feedback circuit **27** and the propulsion voltage feedback circuit **25** respectively. The propulsion current limit is maintained by an ACCR *(armature current control reactor)* reactor **61** which is responsive to the current flow through a shunt **48** placed in the flow of the drive current. The shunt **48** which is adapted to receive a large current and passes a representative current through lines **46** to the reaction control winding **47** which is responsive to limit the current flow in the circuit as will be hereinafter described. The propulsion voltage limitation is provided by applying a voltage feedback control signal to the traction alternator exciter **21**. The output of the rectifiers **16** is coupled by lines **17** and **51** to the control winding **47** of the VCR *(voltage control reactor)* **62**. The resistor **49** in series circuit therewith limits the feedback current. Voltage and current control circuits are well-known in the art as shown by the description in the referenced Vandervort application.

Reference is now made to the control portion of the system which includes the comparison circuit **30** and the excitation circuit **23**, each identified in FIG. **2** by a dashed line box.

COMPARISON CIRCUIT

The comparison circuit is of the type described in the previously referenced Vandervort application and includes two bridge rectifier circuits **58** and **59** and associated current and voltage measuring reactors, **61** and **62** respectively. The outputs of the rectifier bridges are serially connected across a unidirectionally conducting output comparison circuit **30**. This comprises in series circuit, first output circuit terminal **73**, line **74**, rectifier bridge **58**, line **76**, rectifier bridge **59**, line **77** and second output terminal **78**. The output circuit, connected to terminals **73** and **78** comprises serially connected line **70**, the primary winding of a pulse width modulator **79**, a rectifier **81** and line **82**. The rectifier **81** is poled to permit the conduction of the rectified feedback current through the output circuit.

The reference current entering the first output circuit terminal **73** through line **83** is supplied from two different sources depending on whether the vehicle is operating in a normal traction mode or whether it is operating in a standby condition. In the normal operating condition the reference current is supplied from a circuit comprising a d-c power source **84** connected across line **86** and **87**, with a locomotive throttle potentiometer **88** whose arm movement is controlled by the locomotive throttle **24**, diesel engine governor load control potentiometer **89**, and a dropping resistor **91** connected serially between terminal **90** and **100** and lines **86** and **87** respectively. Also, connected between lines **86** and **87** are the serially connected resistors **92** and **93**, the resistor **92** having a substantially greater resistance than that of resistor **93**. The actual reference current then flows through a circuit serially comprising the governor control **89**, line **94**, resistor **96** power transfer switch **41b**, line **83**, the comparison circuit **30**, line **97**, power transfer switch **41c**, line **98**, resistor **93**, line **87**, power source **84**, line **86**, terminal **90**, throttle **88** and line **99** to the governor. As the throttle is opened, the resistance is decreased and the reference current to the comparison circuit is increased, thereby providing a greater current and voltage limit. Similarly, the setting of the governor load control, and hence its resistance value, is a function of the capability of the diesel engine. The governor load control circuit has as its function to correct any momentary reductions of engine speed by unloading the prime mover. Accordingly, during normal operation the resistance is at a minimum, while at time of overloading the engine speed is reduced, the resistance of the governor control is increased, and the reference current, and hence the voltage and current limit are reduced.

The current signal in line **70** enters the excitation panel **23** through a PWM *(pulse width modulation)* winding **79**. The excitation panel comprises a pulse width modulator **106**, a power transistor bridge circuit **107**, and an exciter coil **108**. The pulse width modulator which is electrically connected across the d-c power source **84** at terminals **109** and **111**, has an outlet line **112** which carries an amplified signal to the base of a power transistor **113** of the bridge circuit **107**. The bridge circuit has input terminals **107a** and **107b** and output terminals **107c** and **107d**, the input terminals being connected across the d-c power source by leads **114** and **116**, and the output terminals having connected therebetween the exciter coil **108**. The NPN power transistor is connected between the terminals **107b** and **107d** with its emitter nearest the terminal **107b**. Connected in the other legs of the bridge circuit are the resistors **117**, **118** and **119** connected between terminals **107d** and **107a**, **107a** and **107c**, and **107c** and **107b**, respectively. The PWN is a self-saturating reactor with a main a-c winding and several d-c control windings. The a-c winding is connected from one output of an oscillator to the power transistor, and the d-c windings are connected to line **70**. The oscillator provides a square wave a-c to turn the transistor off and on at approximately 800 times a second. The PWM responds to the feedback signals in line **70** and causes the transistor to turn off and on in response thereto, the ratio of off to on time being determined by the power demand and varied accordingly by the signals from the ACCR and VCR. The exciter field is thus fed from the vehicle battery in relation to the transistor on and off control, and the alternator output is varied accordingly.

During normal operation of the traction vehicle, the auxiliary alternator **29**, driven by the prime mover at a constant speed through coupling **31**, provides three-phase current through its output leads **32** to the trainline **33**, and through the power transfer switch contacts **41(a)** which are set in the indicated position. Voltage limitation is provided wherein voltage feedback signals pass through leads **34** to the input of voltage regulator **36**. In the voltage feedback system the leg having the highest voltage is used to generate a limiting signal. The voltage regulator applies one of the three line-to-line voltages to an excitation control circuit **20** which provides a d-c current to the field winding circuit **35**. Various known circuits may be used to accomplish this regulation, FIG. **3** shows one arrangement which is commonly used in the art and includes a bridge rectifier **39**, voltage measuring means **40**, and an a-c power source **56**. The bridge rectifier **39**, is connected to legs **34a** and **34b** at its terminals **39a** and **39b**. The alternating inputs from these legs is rectified to enter line **57** through the output terminal **39d**. A d-c current is thus provided to the field winding **35** and returns along line **65** to the rectifier input terminal **39c**. The a-c power

supply **56**, such as a chopper or oscillator or the like, is responsive to the voltage measuring means **40** to increase or decrease the flow of current to the exciter field winding **35**. The output of the auxiliary alternator **29** is thus voltage regulated. Locomotive battery current from the d-c source **84** is provided by lines **55** and **60** to supply the field current for the initial alternator build-up. The switches **125a** and **125b** are actuated and displaced from the positions shown in FIG. **3** during initial build-up, and are returned to their indicated positions by relays when sufficient current is being provided by the alternator **29** to maintain the field. The current being delivered to the trainline is limited by a conventional current limiter circuit **38** which receives current feedback signals through an ammeter **75** from the current transformers **53** connected to the respective legs of the three-phase output. A rectifier **80** is connected to the output of the current limiter to provide a d-c signal to the current control winding **95** along lines **45**.

During periods of standby operation, wherein the traction alternator is providing auxiliary power, the drive switches **105** are opened thereby opening the circuits to the traction motors and to the current feedback shunt **48**. Similarly, the power transfer switch is actuated and contacts **41b** and **41c** as well as **41(a)** are actuated and displaced from the position shown in FIG. **2** thereby connecting terminals **101**, **102** and **103** respectively. The reference current then is a constant current signal coming from the voltage regulator **36** through line **104**, which current is directed through the comparison circuit **30** to the terminal **102** through the line **106**, to line **87**, the power source **84**, line **86**, terminal **90** and hence back to the voltage regulator **36**. The reference current is provided to line **104** from a constant current source **115** which is connected to the vehicle battery **84**, across the lines **55** and **60**. This constant current source is obtained by conventional circuitry and its output value is appropriately chosen to be equal to the current that flows through the VCR **62** when a specified voltage appears at the output of the traction alternator, (for example, 21 milliamps when the voltage is 480 volts). Similarly, the rectified current feedback in the circuit **44** is adjusted in amplitude by resistors **120** so as to obtain the desired milliamp/volt relationship, wherein when the current being delivered to the trainline reaches a specific predetermined level the ACCR will generate the proper signal to reduce the excitation to the traction alternator, thereby limiting the trainline current to the desired level.

As previously discussed, during normal traction operation, a voltage feedback signal originates at the rectified portion of the traction circuit and is applied by line **25** to the control winding **47** of the voltage measuring reactor **62**. During standby operation, this feedback signal continues to be applied from the rectifiers **16**. Thus, a voltage limit control is maintained in the same manner as in normal operation.

As stated hereinbefore, current limit control during normal operation is maintained through the control winding **47**. However, during periods of standby operation, the opening of the drive switches acts to switch out the shunt **48** and hence the reaction control winding **48**. It is necessary, therefore to provide another current feedback circuit when the power transfer switch contacts **41d** are closed. When a circuit is provided for a current feedback signal to enter from the voltage regulator, along line **45**, to the control winding **95** whose signal changes the primary winding impedance and hence modulates the a-c signal from the supply **71**.

The current feedback signal output of the current measuring reactor **61** is thus applied to the bridge rectifier **58** and the voltage feedback signal output of the VCR **62** is applied to the bridge rectifier **59**. The output of the bridge rectifiers are connected serially by lines **83**, **76** and **77** in the reference current circuit. Accordingly, a comparison is effected between the reference current and the voltage or current feedback signal having the larger magnitude. If the voltage and/or current feedback signals exceed the reference current signal in magnitude, a current signal proportional to the difference between the greater one of the feedback signals and the reference current, is applied to the PWM winding through line **70**, which PWM winding responds thereto by causing a reduction in excitation to the traction alternator and thus a reduction in voltage. This arrangement limits the maximum voltage and current outputs of the traction generator in reference to current and voltage being delivered to the auxiliary machinery. The excitation circuit is one such as is commonly used in the art and is not considered to be unique. The embodiment which is hereinafter described represents only one manner of controlling the excitation to the traction alternator.

What I claim as new and desire to secure by Letters Patent of the United States are:

1. In a traction vehicle of the type wherein thermal prime mover means drives a traction alternator having a predetermined number of [commutating] poles and adapted to energize traction motor means, an auxiliary power arrangement adapted to produce alternating current, the combination comprising:

a. an auxiliary alternator having a plurality of [commutating] poles [greater] *less* than the number of poles of said traction alternator;

b. means for mechanically coupling said prime mover means to said auxiliary alternator;

c. governor control means for maintaining the shaft speed of said prime mover at a first predetermined shaft speed during normal operation of said traction vehicle and at a second predetermined reduced speed during standby operation of the traction vehicle;

d. an alternating current circuit having an output adapted to energize auxiliary power circuits and an input;

e. switching means to connect said input to the output of said auxiliary alternator during normal operation of said traction vehicle, and to connect said input to the output of said traction alternator during standby operation of said traction vehicle;

f. wherein the number of [commutating] poles of said auxiliary alternator is substantially equal to the product of the number of [commutating] poles of said traction alternator and the ratio of said [first] *second* predetermined shaft speed to said [second] *first* predetermined shaft speed.

2. The auxiliary power source of claim **1** and including control means having an input connected to be responsive to the traction power applied to said traction motors and an output connected to regulate the excitation of said traction alternator, wherein during standby operation of said vehicle, said control means is connected to be responsive to the output of said alternating current circuit.

3. A traction vehicle propulsion system as defined in claim **2** wherein said control means is effected by a reference current, said reference current during normal operation being variably responsive to said governor control means and during standby operation being a constant current of [of] a predetermined magnitude.

* * * * *