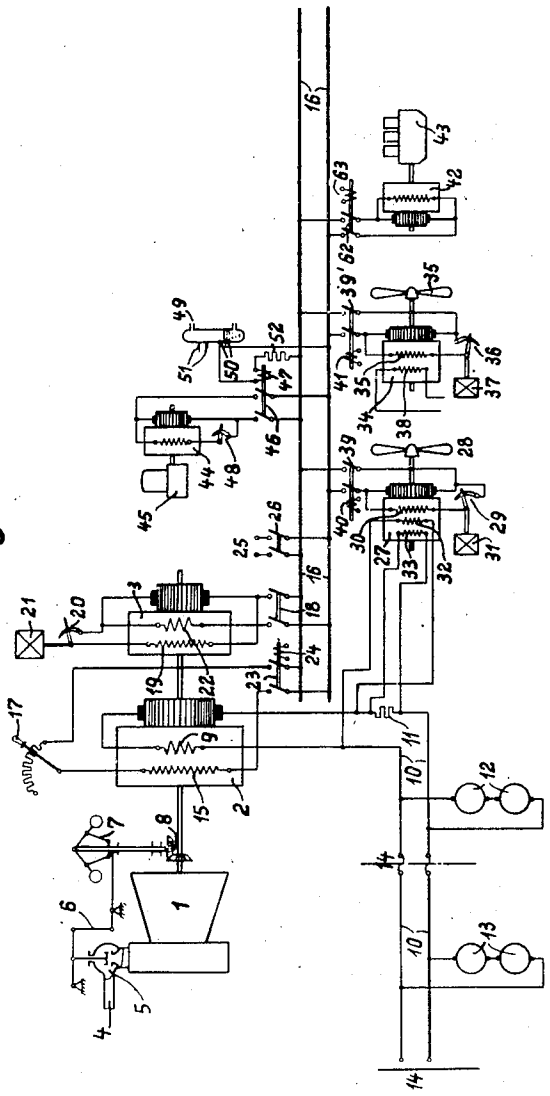
July 11, 1939. K. SCHMER 2,165,982

TURBO-ELECTRIC RAILWAY MOTORCAR

Filed March 17, 1938 2 Sheets-Sheet 1

Fig. 1



INVENTOR
KARL SCHMER
BY Harry E. Dunham
ATTORNEY

July 11, 1939. K. SCHMER 2,165,982

TURBO-ELECTRIC RAILWAY MOTORCAR

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Fig. 2.

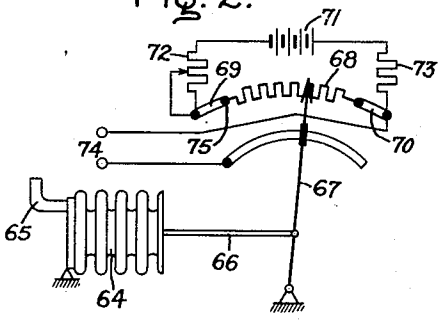


Fig. 3.

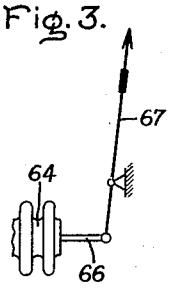


Fig. 4.

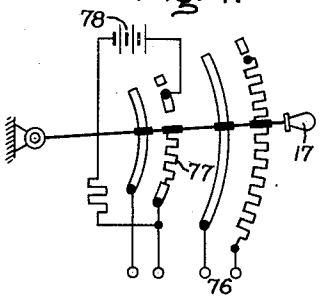


Fig. 5.

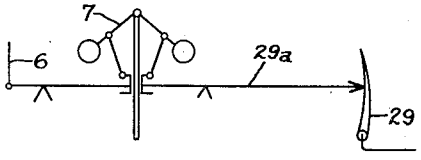
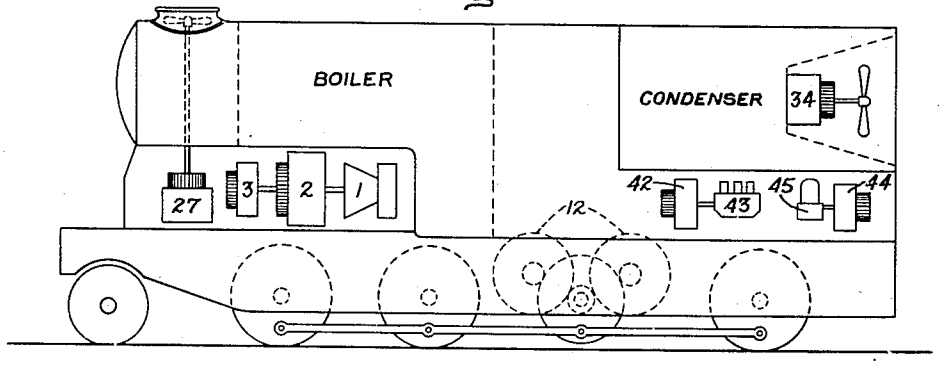


Fig. 6.



Inventor:
Karl Schmer,
by Harry E. Dunham
His Attorney.

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2,165,982

TURBO-ELECTRIC RAILWAY MOTOR CAR

Karl Schmer, Berlin-Mariendorf, Germany, assignor to General Electric Company, a corporation of New York

Application March 17, 1938, Serial No. 196,487
In Germany March 16, 1937

12 Claims. (Cl. 290—2)

A variety of suggestions for supplying the auxiliary devices of turbo-electric motor-cars, such as the boiler feed-pump, the smoke-gas fan, the circulation pump, the condenser fan, the air pump for the condenser, the compressor motor, and the like, with the requisite driving energy, and for regulating the devices concerned, has already been made, in most cases with the intention to employ as source for said energy a small live-steam turbine or an exhaust-steam turbine either regulated additionally in dependency of the load or remaining without any regulation as this is effected automatically by the amount of the exhaust-steam.

All those arrangements suffer, first of all, from the drawback that the complete power-plant with its appurtenances constitutes a complicated structure, and that furthermore, small auxiliary turbines operate uneconomically by reason of their large specific consumption of steam, and the regulation of the number of revolutions, or of the admission, is expensive and complicated, especially if it is to be effected from a remote place or automatically. Also housing these auxiliary turbines is, from spatial reasons, sometimes very difficult, especially as regards the requisite tubes for the live steam and for the exhaust steam; all these disadvantages become the more apparent, the smaller the driving performance and the available space are.

The present invention obviates all drawbacks and disadvantages hitherto experienced with the known constructions; the new constructions are distinguished by a highly economical consumption of steam, the arrangement and combination of their parts permits a convenient survey, as well as a convenient supply of the energy; the auxiliary devices pertaining to the equipment of the plant can be easily regulated and it is possible to operate them from a remote place and to watch them by inexpensive means. Besides, housing the driving motors for the auxiliary devices presents now no difficulties at all.

I attain the objects in view by employing the steam-turbine, besides for driving the main current-generator, also for driving an auxiliary current-generator rigidly coupled with said main current-generator and running with a constant number of revolutions and a constant voltage, said auxiliary current-generator being used for supplying with current the electromotors driving the auxiliary devices, for instance the smoke-gas or flue-gas fan blower, the auxiliary condensing devices, the pumps, the condenser, the fuel supply devices, and the like. This manner of driving the auxiliary devices presents in view of the facts that with turbo-electric railway motor-cars there is available on the one hand a comparatively great driving performance for the auxiliary machines and on the other hand a comparatively small driving performance for the driving axles the simplest solution of the various problems, in that it is the most economical one as regards steam-technics, the cheapest one as regards machine technics, and the simplest one as regards service-technics. In order to demonstrate the proportion between the performance demand of the auxiliary machines and the driving performances for the driving axles I mention that with a performance of the driving turbines of about 700 kw. the performance demand of all auxiliary machines together amounts to about from 120 to 140 kw.

The invention is illustrated diagrammatically and by way of example in the accompanying drawings in which Figure 1 shows a turbo-electric power plant in connection with the appertaining wiring diagram, Figures 2, 3 and 4 and 5 show certain details of pressure responsive and manually operated control devices for the motor driving auxiliary devices, while Fig. 6 is a diagrammatic view showing the arrangement of the apparatus in a locomotive structure.

The power plant of the locomotive consists of only one steam-turbine 1 which drives a main current-generator 2 delivering continuous current, as well as of an auxiliary current-generator 3 delivering continuous current and being firmly connected with the shaft of said main current-generator. The steam-turbine receives the steam through an inlet pipe 4 and a steam regulating valve 5 which is subjected to the action of a centrifugal regulator 7 by the intermediary of a rod 6. Said regulator is rotated from the turbine shaft by the intermediary of a gearing 8.

The main current-generator is equipped with a weak counter compound coil 9 which may however, be dispensed with, if desired. Said generator supplies current to the main net 10 in which a small resistance 11 intended for regulating purposes is provided. Connected up to said net are motor groups 12 and 13, of which the first 12 drives the driving axle of the locomotive, whereas the motors of the second group 13 act on the driving axles of one or more trail cars of the train. The motors of said groups are continuous-current shunt-motors permitting regulations of their numbers of revolution. Into the main net 10 is inserted, between the said two motor groups, a strong-current coupling 14

by means of which the motor group 13 can be disconnected from said net or be connected up to the same. In the drawings (Fig. 1) is shown that another strong-current coupling 14 may be provided behind the motor group 13.

The main current generator has a main exciting coil 15 which is supplied with current from the auxiliary net 16 (fed in turn by the auxiliary current-generator 3) across the speed regulator 17. The regulation of the driving performance and of the running speed is effected by means of the known Ward-Leonard control.

The auxiliary current-generator is of such a size that its output suffices to drive all auxiliary devices pertaining to the equipment of the plant. Connected up to the auxiliary net 16 which is supplied with current from the auxiliary current-generator 3 across an excess current remote-control switch are the individual auxiliary devices pertaining to the equipment of the plant. The auxiliary current-generator is so regulated that its voltage and therefore, also the voltage of the auxiliary net 16 remains constant independent of the load existing at the time being. For this purpose there is, for instance, the shunt exciting coil 19 of the auxiliary current-generator regulated across the field regulator 20 by means of a voltage regulator 21 of any desired construction.

In the constructional form of the invention illustrated in the drawings by way of example the following auxiliary devices are supplied with current from the net 16:

1. The main exciting coil 15 of the main current-generator 2

In the supply lead for the existing coil 15 is inserted a switch 23 which can be remote-controlled by a switching-on and switching-off device or coil 24 of any desired suitable construction. The switch 23 is closed when the turbine has attained its nominal number of revolutions and the car is ready for running.

2. The control device 25

The control device 25 is supplied with current across a switch 26.

3. The driving motor for the flue-gas fan or blower 28

The motor 27 is a continuous-current shunt-motor with regulable number of revolutions, and the regulation may be effected wholly or partly in dependency of the load. This may be effected in the most varied manners, for instance in dependency of the position of the inlet-valve, or of the position of the centrifugal governor, or of the steam-pressure, or of the current of the main current-generator, or of the product of the voltage of this current, or of the product of the strength and the voltage of the current i. e., of the delivered output of the main current-generator. The impulse-giving devices active at the time being act indirectly or directly on the field regulator 29 of the motor 27, as will be more fully explained hereinafter in connection with the Fig. 2. In Fig. 1 is shown by way of example suitable means for regulating the number of revolutions in dependency of the load. These means are designed as follows:

The fan motor 27 has a shunt main exiting coil 30 supplied with current from the net 16 across the field regulator 29 which can be re-adjusted by a device 31. But it is also well possible to subject said device 31 to the action of one or several of the above-mentioned regulating impulses. Fig. 5 shows the field regulator 29 connected through a linkage 29*a* for operation by the centrifugal regulator 7 so as to vary the speed of the motor 27 in dependency of the load, i. e., inversely with the speed of the turbine.

The fan motor is, furthermore, equipped with additional exciting coils 32, 33, counteracting the coil 30. As appears from Fig. 1 the additional action of the field coil 32 on the number of revolutions of the fan motor 27 takes place in dependency of the performance of the main current-generator up to the net 10 so that the additional exciting current is proportional to the voltage of the current-generator 2. The additional exciting coil 33 is connected up to the binding posts of the regulating resistance 11 inserted in to the main net 10. The drop of voltage at the resistance 11 and, therefore, also the excitation of the coil 33 are proportional to the current of the main current-generator 2.

With the above described device is obtained, in correspondence with the demand for air of the furnace and with consideration of the characteristic of the fan 28, a load-dependent regulation of the number of revolutions of the smoke-gas fan motor 27 in approximate correspondence with the following law:

$$n=a+bN=cN^2$$

In this formula n means the number of revolutions of the motor 27, N the performance of the current-generator 3, whereas the magnitudes a, b and c are constant or nearly constant and can predetermine at liberty by a corresponding selection of the resistances of the individual exciting circuits, and by the dimensions of the motor 27. The law expressed by the above formula can be approximately responded to by a corresponding selection of the saturation proportions of the motor or by a corresponding ununiform stepping of the field-regulator resistances.

4. The driving motor 34 for the condensing fan 35

There is nothing to prevent the driving of this motor with a constant number of revolutions without any regard to the load at the time being. This presents the advantage that in the case of small loads the vacuum in the condenser is higher than if the load is large, but the provision must be made that the condenser pressure does not exceed a certain predetermined maximum value. When this maximum value has been attained, the power plant must be stopped or the output of the main current-generator 2 must be reduced. This manner of operation presents the advantage that the fan motor 34 continues to run with its full performance also if the loads are small or if the plant runs idle. Anyhow, service conditions are imaginable in which it may be advantageous to regulate also the fan motor 34 load-dependent in such a manner that the number of revolutions decreases if the load is small and increases if the load is large. The performance demand of a fan decreases, or increases respectively, in correspondence with the third power of the number of revolutions, in consequence whereof a comparatively small regulation range of about from 20 to 40% of the nominal number of revolutions of the motor 34 will suffice for the additional regulation of the number of revolutions.

This additional regulation of the number of revolutions of the fan motor 34 can be effected

in a manner similar to the regulation of the fan motor 27. The main exciting coil 35 is connected up to the auxiliary net 16 across the field regulator 36. The device 37 re-adjusting this regulator corresponds with the similarly constructed device 31 of the fan motor 27, and similarly as with the motor is also the motor 34 provided with an additional exciting coil 38, with the aid of which the number of revolutions of the motor is regulated and through which passes a current proportional to the regulation impulses employed at the time being. In comparison to the motor 27, however, another method must be used with the pressure dependent regulation of the motor 34. Whilst, namely, if the regulation of the motor 27 takes place in dependency of the boiler pressure or of the pressure of the live steam, the number of revolutions of this motor must become smaller if the pressure rises, and larger if the pressure falls, matters are the reverse if the regulating impulse does not originate from the pressure of the live steam, but from the condenser pressure in which case the number of revolutions of the motor 34 must rise with the rise of the condenser pressure and must fall with the fall of this pressure.

Both motors, 27 and 34, are connected up to the auxiliary net across switches 39 and 39' respectively. These switches are operated by coils or devices 40 and 41 respectively.

5. The electromotor 42 for the brake-air compressor 43

This motor is likewise connected up to the auxiliary net 16 across a protective switch 62 having a control device 63.

6. The electromotor 44 for the boiler feed pump 45

The number of revolutions of this motor insofar as the regulation is to take place automatically, is regulated in such a manner that the water level in the boiler is kept as constant as possible. This can be attained by connecting up the motor 44 to the auxiliary net 16 across the switch 46. This switch is controlled by the device 47. The shunt-field of the motor 44 is regulated by means of a field regulator 48. The motor 44 is so controlled that it is switched on and off in dependency of the level of the water in the boiler. This can be attained in a simple manner by providing at the level indicator 49 two contacts 50 which are bridged by the water itself, as soon as the level has risen to a certain height. When the control circuit of the switch 46 is closed, the motor will be switched off, but it will be switched on as soon as the water level has become so low that the contacts 50 are disconnected from one another. Above these contacts another pair of contacts 51 is provided at the level indicator, these contacts serving for switching on an alarm device when they are conductively connected with one another by the water level having risen above the admissible maximum height.

In the control circuit of the switching device or coil 47 is, furthermore, provided a series-resistance 52.

If the regulating impulses assisting in the additional re-adjustment of the number of revolutions of the individual motors are not constituted by, or based on, electrical measuring agents, provision must be made to transform the regulating impulse employed at the time being into a continuous current proportional to them. Two constructional forms of means suited for this purpose are shown by way of example in Figs. 2 and 3, designed for use in connection with a pressure regulator. In Fig. 2 the device is intended for regulation of the number of revolutions in dependency of the boiler pressure, so as to maintain a predetermined steam pressure supply for the turbine 1, whereas Fig. 3 shows a modified design to be used if the regulation of the number of revolutions is to take place in dependency of the condenser pressure. In both examples particular means, likewise illustrated by way of example, are provided for attaining that the admissible maximum number of revolutions of the motors for the auxiliary devices is not surpassed.

The pressure gauge 64 consisting, for instance, of a yieldable box of undulated sheet-metal is subjected to internal pressure through the pipe 65. Corresponding to the height of the steam pressure the box 64 re-adjusts by the intermediary of a rod 66 a regulation-indicator co-operating with a voltage-divider consisting of a resistance contact path 68 provided with a left-hand sliding member 69 and a right-hand sliding member 70. Further appertaining members are a battery 71 and current limit resistances 72 and 73.

The additional regulation current is drawn from the binding-posts 74, it is either conducted in the above described manner to a booster exciting coil of the auxiliary motors or to the re-adjusting device 31 or 37 of the field-regulators of these motors. If the boiler pressure is only low, the pointer 67 will be turned to the left so that the voltage drawn from the implement increases and in consequence thereof also the number of revolutions of the respective auxiliary motor increases correspondingly. If, however, the boiler pressure sinks below a predetermined height the pointer 67 gets onto the sliding member 69 of the contact path, in which case the regulating voltage at hand remains unvaried on its maximum value, that is to say, the auxiliary motor, for instance the fan motor 34 cannot surpass a certain definite maximum number of revolutions. By varying the position of the end-point 75 of the contact path 69 it is rendered possible to choose at liberty that maximum number of revolutions, or the pressure corresponding to that pressure. The maximum number of revolutions can be adjusted at will by changing the size of the series-resistance.

In the further example shown in Figure 3 which is intended for regulating the number of revolutions for the auxiliary motor in dependency of the condenser pressure, the pressure depending re-adjustment of the pointer 67 takes place in the reverse manner. Therefore, when the pressure rises, the pointer travels to the left and when the pressure falls the pointer travels to the right.

The limitation of the maximum number of revolutions of the auxiliary motors can be effected in known manner, for instance, in this way that if a certain definite and at liberty adjustable number of revolutions is surpassed a centrifugal switch becomes active and short-circuits a part of the field series resistance whereby a continuous amplification and a reduction of the number of revolutions is attained.

In the device shown in Fig. 4 is disclosed the manner in which the numbers of revolutions of the auxiliary motors can be varied also directly from the field regulator 17 (Fig. 1). Connected

up to the binding posts 76 is the field of the main current-generator 2. The field regulator 17 cooperates with a voltage divider 77 designed in a manner similar to the voltage divider shown in Fig. 2 and being supplied with current by a battery 78.

I claim:

1. A turbo-electric vehicle, comprising a steam turbine, electric motor driving means for said vehicle, a main current generator driven by said turbine, means for connecting said motor driving means to said main current generator, an auxiliary current generator connected to said turbine so as to be driven thereby, an auxiliary device on said vehicle, an auxiliary electric motor for driving said auxiliary device, means electrically connecting said auxiliary electric motors to said auxiliary generator, and means responsive to the voltage of said main generator for controlling the speed of said auxiliary motor.

2. A turbo-electric vehicle, comprising a steam turbine, electric motor driving means for said vehicle, the main current generator driven at a substantially constant speed by said turbine, means for connecting said motor driving means to said main current generator, an auxiliary current generator connected to said turbine so as to be driven thereby at a constant speed, a flue-gas blower on said vehicle, an auxiliary electric motor for driving said blower, means electrically connecting said auxiliary electric motor to said auxiliary generator, and means responsive to the speed of said turbine for regulating the speed of said auxiliary motor.

3. A turbo-electric vehicle, comprising a steam turbine, electric motor driving means for said vehicle, a main current generator driven by said turbine, means for connecting said motor driving means to said main current generator, an auxiliary current generator connected to said turbine so as to be driven thereby, auxiliary devices on said vehicle, auxiliary electric motors for driving said auxiliary devices, means electrically connecting said auxiliary electric motors to said auxiliary generator, field excitation means for said main generator connected to be energized from said auxiliary generator, and means responsive to the pressure of the steam supplied to said turbine for regulating the speeds of said auxiliary motors.

4. A turbo-electric vehicle comprising a steam turbine, speed responsive regulating means driven by said turbine for regulating the supply of steam to said turbine so as to cause said turbine to operate at a substantially constant speed, electric motor driving means for driving said vehicle, a main generator driven by said turbine, means for connecting said motor driving means to said main generator, an auxiliary generator connected to be driven by said turbine, a flue-gas blower on said vehicle, an auxiliary motor for driving said blower, means connecting said auxiliary motor to said auxiliary generator and means actuated by said regulating means for controlling the speed of said auxiliary motor.

5. A turbo-electric vehicle comprising a steam turbine, speed responsive regulating means driven by said turbine for regulating the supply of steam to said turbine so as to cause said turbine to operate at a substantially constant speed, electric motor means for driving said vehicle, a main generator driven by said turbine, means for connecting said motor means to said main generator, an auxiliary generator connected to be driven by said turbine, a flue-gas blower on said vehicle, an auxiliary motor for driving said blower, a condenser fan on said vehicle, an auxiliary motor for driving said condenser fan, means connecting said auxiliary motors to said auxiliary generator and means actuated by said regulating means for controlling the speed of each of said auxiliary motors.

6. A turbo-electric vehicle, comprising a steam turbine, electric motor means for driving said vehicle, a main current generator driven by said turbine, means for connecting said motor means to said main current generator, an auxiliary current generator connected to said turbine so as to be driven thereby, a fan on said vehicle, an auxiliary electric motor for driving said fan, means electrically connecting said auxiliary electric motor to said auxiliary generator and speed regulating means for said auxiliary motor responsive to the pressure of the steam supplied to said turbine.

7. A turbo-electric vehicle comprising a steam turbine, electric motor means for driving said vehicle, a main current generator driven by said turbine, means for connecting said motor means to said main current generator, an auxiliary current generator connected to said turbine so as to be driven thereby, a flue-gas blower on said vehicle, an auxiliary electric motor for driving said blower, means electrically connecting said auxiliary motor to said auxiliary generator and means responsive to the pressure of the steam supplied to said turbine for controlling the speed of said auxiliary motor so as to maintain said steam pressure at a predetermined value.

8. A turbo-electric vehicle comprising a steam turbine, electric motor means for driving said vehicle, a main current generator driven by said turbine, means for connecting said motor means to said main current generator, an auxiliary current generator connected to said turbine so as to be driven thereby, a flue-gas blower on said vehicle, an auxiliary electric motor for driving said blower, means electrically connecting said auxiliary motor to said auxiliary generator and means responsive to the voltage of said main generator for controlling the speed of said auxiliary motor.

9. A turbo-electric vehicle comprising a steam turbine provided with a steam condenser, electric motors for driving said vehicle, a main current generator driven by said turbine, means for connecting said motor means to said main current generator, an auxiliary current generator connected to said turbine so as to be driven thereby, a blower for the condenser on said turbine, an auxiliary motor for driving said blower, means electrically connecting said auxiliary motor to said auxiliary generator and means responsive to the pressure in the condenser for controlling the speed of said auxiliary motor.

10. A turbo-electric vehicle comprising a steam turbine, a constant speed regulator for said turbine, electric motor means for driving said vehicle, a main current generator driven by said turbine, means for connecting said motor means to said main generator, an auxiliary generator connected to be driven by said turbine, a flue-gas blower on said vehicle, an auxiliary motor for driving said blower, a connection connecting said auxiliary motor to said auxiliary generator, a main exciting field winding for said auxiliary motor connected to said auxiliary generator through a regulating resistance, a second field winding on said auxiliary motor connected to said main generator so as to be energized in response to the voltage of said main generator and

a third field exciting winding on said auxiliary motor energized in response to the current supplied by said main generator, said second and third field windings being connected to act in opposition to said main field winding.

11. A turbo-electric vehicle comprising a steam turbine, a constant speed regulator for said turbine, electric motor means for driving said vehicle, a main current generator driven by said turbine, means for connecting said motor means to said main generator, an auxiliary generator connected to be driven by said turbine, a flue-gas blower on said vehicle, an auxiliary motor for driving said blower, means connecting said auxiliary motor to said auxiliary generator, a regulating resistance, a main exciting field winding for said auxiliary motor connected to said auxiliary generator through said regulating resistance, a second field winding on said auxiliary motor connected to said main generator so as to be energized in response to the voltage of said main generator, a third field exciting winding on said auxiliary motor energized in response to the current supplied by said main generator, said second and third field windings being connected to act in opposition to said main field winding and means responsive to the pressure of the steam supplied to said turbine for operating said regulating resistance so as to vary the speed of said blower and thereby maintain said steam pressure at a predetermined value.

12. A turbo-electric vehicle comprising a steam turbine provided with a boiler, electric motor means for driving said vehicle, a main current generator driven by said turbine, means for connecting said motor means to said main current generator, an auxiliary current generator connected to said turbine so as to be driven thereby, a boiler feed pump on said vehicle, an auxiliary electric motor for driving said pump, means electrically connecting said auxiliary motor to said auxiliary generator and means responsive to the water level in the boiler for controlling the speed of said auxiliary motor so as to maintain a predetermined water level.

KARL SCHMER.