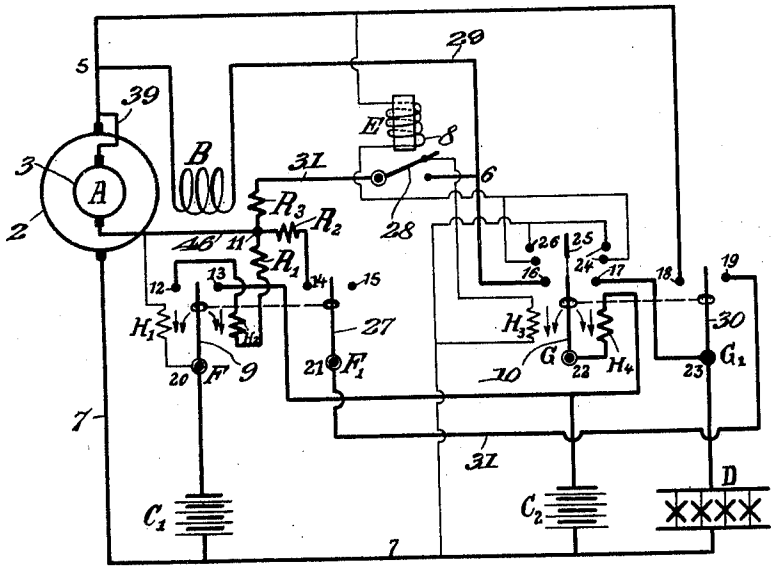
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SWITCHING-OVER DEVICE FOR ELECTRICAL LIGHTING INSTALLATIONS FOR RAILWAY TRAINS AND THE LIKE.

APPLICATION FILED NOV. 9, 1915.

1,348,171. Patented Aug. 3, 1920.



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UNITED STATES PATENT OFFICE.

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SWITCHING-OVER DEVICE FOR ELECTRICAL LIGHTING INSTALLATIONS FOR RAILWAY-TRAINS AND THE LIKE.

1,348,171. Specification of Letters Patent. Patented Aug. 3, 1920.

Application filed November 9, 1915. Serial No. 60,507.

To all whom it may concern:

Be it known that I, HUGO GROB, a citizen of the Republic of Switzerland, residing at Zurich, in the Canton of Zurich, Republic of Switzerland, have invented certain new and useful Improvements in Switching-Over Devices for Electrical Lighting Installations for Railway-Trains, and the like; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters of reference marked thereon, which form a part of this specification.

This invention relates to electrical lighting installations for railway trains, and with regard to certain more specific features, to a train-lighting system utilizing an axle-driven generator for lighting the train and charging one or more storage batteries which serve to light the train when the generator is at rest or is operating at too low a speed to generate sufficient voltage for the purpose.

One of the objects of the invention is to provide a simple and efficient train-lighting system in which the parts are automatically effective to accomplish their functions without the necessity for manual operation.

In axle-lighting systems for railway trains, it is ordinarily necessary to switch over or change over the circuits as the train comes to rest. Usually the diminishing potential of the dynamo is utilized in some way to effect this switching of the circuits. In such cases, when the potential is regulated by purely electrical action, as is done in installations constructed according to U. S. Patent No. 994,510, and U. S. patent application, Serial No. 605,629, certain practical difficulties arise, and consequently it has been customary in such installations to effect the changing over by means dependent upon the speed of the dynamo or train. But the necessary mechanical connection with the revolving dynamo shaft has rendered it often impracticable to accommodate the switching apparatus in the interior of the vehicle for the purpose of facilitating the control thereof. Accordingly, a further object of the present invention is to provide an improved switching-over or changing-over device for electric lighting installations wherein the dynamo and storage battery are alternately and temporarily in operation and wherein the changing over in the connections between battery and generator is effected by means dependent on the variation in the strength of the exciting current of the generator. Obviously a system employing means of this character permits of great freedom in the placing of the switching-over apparatus.

Another object is to provide in train-lighting apparatus of the above general type certain details of construction whereby the above and other advantageous results are attained.

Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the features of construction, combinations of elements and arrangements of parts which are to be exemplified in the structure hereinafter described, and the scope of the application of which will be indicated in the following claims.

The accompanying drawing shows one of various possible embodiments of this invention and is a diagrammatic general view of the improved apparatus used in connection with a train-lighting installation in which there is provided a dynamo A of ordinary construction, with two independent armature windings represented by commutator circles, 2, 3 of which the larger one 2 generates, for example, thirty-two volts, and the smaller one 3 about seven volts. At B is shown conventionally the exciting winding of the machine; this consumes a small quantity of energy and has a resistance low enough so that a potential of only about one volt acting at its terminals is sufficient to excite the dynamo for full load at its lowest operative speed and with a comparatively small consumption of exciting current. For many if not all the purposes of the invention, the part B may equally well be the exciting winding of an exciting machine for the dynamo A. A battery is shown as comprising the two equal halves C^1, C^2, which are interchanged at suitable intervals, as after each stoppage of the train. The work circuit is illustrated at D. The switches F, G, whose armatures are preferably polarized, serve to effect the circuit changes to

accompany the changes in generator speed, as will be pointed out hereinafter. The switch E limits the voltage upon the work circuit, as hereinafter described.

At the initial conditions with the train at rest, switches F, G are inclined toward the right, whereby the two batteries C^1, C^2, are connected in parallel to supply current to the work circuit D through the low resistance coil H^4 of the switch G. The coil 8 of switch E, responsive to dynamo voltage, is of course deënergized, so that the blade 28 of said switch is in its lower position. The field winding B is likewise deënergized.

As soon as the train starts, the residual magnetism in the dynamo A builds up in the windings associated with the low voltage commutator 3 a voltage which sends current by way of the lead 46, thence through the ballast or constant current resistance R^3, the blade 28 of switch E, in its lower position, lead 29, field winding B, and lead 39, thus enabling the dynamo A to excite itself. Since the two commutators 2, 3 are connected in series, the lead 46 is at a potential equivalent to the sum of the voltages across the two commutators; assuming the negative lead 7 to be at zero volts potential, the normal pressure of thirty-two volts across the brushes of the commutator 2 would maintain the lead 39 at thirty-two volts, and the further normal pressure of seven volts across the brushes of the commutator 3 would maintain the lead 46 at thirty-nine volts. As soon as the potential at the lead 46 becomes higher than the potential at the blade 9 of the switch F, the coil H^1 thereof will change the direction of its current flow and will cause the switch blade 9 to move toward the left and establish a charging connection between the dynamo lead 46, through the ballast charging resistance R^1, current coil H^2, blade 9, to the battery C^1. The charging current which enters the battery C^1 as the dynamo voltage increases, flows through the current coil H^2 and holds the switch G firmly in its left-hand or charging position. At this moment only the battery C^2 is connected to the external lighting circuit.

The switch blade 27 is connected mechanically to the blade 9 of the switch F. The blade 30 is likewise connected mechanically to the blade 10 of the switch G. The blade 27, when in its left-hand position, connects the dynamo lead 46 through the lamp resistance R^2, blade 27, lead 31, and blade 30, to the load D in parallel with the battery C^2.

As the dynamo voltage increases, the load is assumed gradually by the dynamo, resulting in a corresponding decrease in the discharge current from the battery C^2, until finally the dynamo begins to deliver charging current into the battery C^2. The resulting reversal of current in the current coil H^4 of the switch G causes the blades 10 and 30 of the switch to be shifted into their left-hand positions, whereby, first, the battery C^2 is disconnected from the work circuit D and connected to the exciting winding B, and, second, the dynamo is made now to deliver the lighting current directly through the uppermost lead and switch blade 30, instead of through lead 46 and lamp resistance R^2.

By this connection of the battery C^2 to the exciting winding B, the dynamo A is converted from a self-exciting shunt generator into a dynamo of constant voltage, the voltage of which is regulated on the principle embodied in my U. S. patent application, Serial No. 605,629. The regulation is accomplished by the use of the ballast or constant current resistance R^3 which is in series with the field winding B across the leads 46 and 39, the battery C^2 being connected to the junction between this resistance and field, with the other terminal of the battery connected to the lead 7. The ballast resistance R^3 permits a limited predetermined quantity of current to pass through it, and this current divides between field winding and battery. At a predetermined dynamo speed, the battery may be assumed to be floating. If now, the dynamo speed increases, the dynamo voltage tends to increase, and the battery takes an increasing amount of charging current. Since, however, the sum of the current to battery and field is constant (limited by the resistance R^3), the field current is reduced, thus reducing the dynamo voltage to its former and constant value. The dynamo voltage thus adjusts itself at every speed to such a degree that the regulating battery C^2 will take away from the constant current passing through the ballast resistance R^3 just such an amount that the remaining current flowing through the exciting coil B is just sufficient to produce the proper dynamo voltage. It will be readily understood that even at an excessively high speed of the dynamo, its voltage (disregarding residual magnetism) cannot rise high enough to cause the regulating battery C^2 to take the entire current which is allowed to pass through by the resistance R^3, since then the exciting current would have become equal to zero in the field circuit B.

In consequence of the smallness of the charging current which flows into the battery C^2, the counter electro-motive force of the battery will remain for a certain space of time in the neighborhood of about 2 to 2.2 volts per cell according to its condition of charge. The voltage across the brushes of the large commutator remains, practically uninfluenced by the speed of the dy-

namo, within these limits, but is reduced by the voltage drop of about one volt in the exciting winding B; this also applies to the lighting voltage. Then owing to the addition of the voltage of the small commutator, the battery C^1 also receives an approximately constant charging voltage of suitable intensity. The low ballast resistance R^1 is inserted in the charging lead for the purpose of setting an upper limit to the charging current.

Although the quantity of current flowing into the regulating battery C^2 is small, the counter electromotive force of this battery and therefore the voltage of the work circuit would in time assume a high value. In order to avoid this, there is inserted in the lead 31 the blade 28 of a switch E which comes into operation as soon as the voltage in the work circuit has attained a predetermined maximum value. Then the current supply through the resistance R^3 to the exciting winding B ceases, and the dynamo voltage drops until the battery C^2 is delivering current, through the current coil H^4, blade 10, lead 6 and field winding B, thereby replacing the former arrangement of obtaining the field current from the dynamo lead 46 through the ballast resistance R^3. The regulation of the voltage is now effected in accordance with my U. S. Patent No. 994,510. The negative terminal of the field winding B is connected to the lead 39 as before, and the positive terminal 6 of the field is connected, as before, to the positive terminal of the battery C^2, whose negative terminal is connected to the dynamo return lead 7. At the minimum operative dynamo speed, the battery may be assumed to be supplying a maximum current to the field. If now, the dynamo speed increases, the voltage across the leads 39—7 tends to increase; and since the voltage across the field is equal to the (constant) battery voltage minus the voltage 39—7, it is obvious that this increase in the voltage 39—7 reduces the voltage across the field, thus reducing the field current and thereby reducing the dynamo voltage to its former and constant level. In this manner the dynamo voltage at every speed is automatically adjusted to a value so much less than the voltage of the battery C^2, that a voltage difference is produced at the terminals of the exciting winding B, which difference is just sufficient to cause that amount of exciting current in the winding B which is necessary for generating the proper dynamo voltage. Since as hereinbefore stated, the potential across the field B for full generator load at minimum operative generator speed need not exceed one volt, the dynamo voltage across the leads 39—7 need never be more than one volt lower than the voltage across the battery C^2, even at the lowest operative speed of the dynamo. On the other hand even at an excessively high speed the dynamo voltage will never attain the magnitude of the battery voltage, since if this should be the case there would be no voltage difference across the exciting winding B, and therefore the exciting current, and consequently the dynamo voltage, would become equal to zero.

If the speed of the train drops below a certain value, both batteries C^1, C^2 are again reconnected to the work circuit D, and the connection between this latter circuit and the dynamo is broken. In order to do this automatically, the present invention provides for the control of the disconnecting devices by the change in the value of the exciting current flowing in the winding B. For this purpose, the operation of the switch G is made to take place responsively to a functional value of the exciting current. The exciting current is led directly through a current coil H^4 associated with the switch G so that the action of the latter is dependent upon the regulating current flowing through the battery C^2. This current flows into the regulating battery C^2 as long as the armature of the switch E is not attracted; when the coil 8 of the switch E is energized, the regulating battery C^2 then begins to discharge; as explained above. Hence the switch G is operated under either of two conditions; First, with switch E not fully energized and the blade 28 in its lower position, the field current is equal to the difference between the current through resistance R^3 and the automatically varying charging current to battery C^2 if the dynamo speed is sufficiently high, or, as in the present case, when the dynamo speed is assumed to be nearing its lower operative limit, the field current is equal to the current through this resistance R^3 plus the automatically varying discharge current from said battery C^2. Assuming for example ten amperes as the maximum permissible field current, and eight amperes as the current constantly delivered through the ballast resistance R^3, then the switch G should operate as soon as the battery current reaches two amperes. Second, with switch E energized, the field current is equal to the discharging current from the battery C^2, so that the switch G should operate when the battery current attains ten amperes. This operation of the switch G at two or ten amperes is effected by providing a voltage coil H^3 on the switch G, to be traversed by current only when the switch E is energized. This winding H^3 adds as many negative ampere turns as are necessary to counteract the action of eight amperes in the current coil H^4.

If the switch G is operated when the switch E is not sufficiently energized, the dynamo becomes an ordinary shunt dynamo,

whose potential drops with diminishing speed. After sufficient drop in the dynamo voltage a reverse current flows from the battery C^1 to the dynamo, and the switch F is thrown to the right by the reversed current in the coil H^2, the battery C^1 being thus connected again to the work circuit D.

On the other hand, if the switch G is operated when the switch E is energized, the dynamo is suddenly deprived of its excitation, and therefore its voltage falls very quickly. The switch F is operated immediately afterward. In such a case the battery C^1, which has been on charge, is connected suddenly to the work circuit D, and an upward flickering of the lights would occur. In order to avoid this, the switch G may be combined with a device which will interrupt the circuit of the coil 8 of switch E momentarily at every reversal of the switch G. This interrupting device is represented diagrammatically in the drawing by the pairs of contacts 24 and 26, and the insulated short circuiting piece 25. If the switch G changes its position while the coil 8 is energized, the latter will release its armature 28, and thereby connect the dynamo field to the dynamo lead 46 for self-excitation, and the voltage of the battery C^1 will fall so slowly as to give the battery time to reduce its own voltage before the operation of the switch F, thus avoiding a flickering of the lights. By providing for a closing of switch 28 prior to shifting of switch G, an interruption of the exciting current and consequent injurious sparking at the point of interruption is avoided.

Since both batteries have to supply the lighting current connected in parallel when the train is stationary, both batteries must naturally be charged; this is effected by interchanging the connections of the two batteries at suitable intervals, as for instance after every stoppage of the train, in the manner illustrated in my U. S. Patent No. 994,510 above mentioned.

It is important that the connection of the two batteries C^1, C^2 established during the stoppage of the train, does not contain the current coil H^4 of the switch G, since otherwise the switch G might be operated to its left-hand position by a compensating or equalizing current flowing between the batteries.

Great advantages are effected by changing the shunt excitation of the dynamo (switch G to the right) to regulation for constant voltage (switch G to the left), not before the dynamo has taken the entire load of the work circuit. In this manner, the belt reaches the limit of its capacity for transmitting power, before the dynamo has assumed the entire load, *i. e.*, while the dynamo is still running with shunt excitation; upon further increase of speed, the belt begins to slip in a perfectly stable manner, since when the belt slips the speed of the dynamo falls, and with shunt excitation the dynamo output will fall more rapidly than the speed, so that the dynamo will thereafter deliver just an amount of current corresponding to the power-transmitting capacity of the belt.

In the other case, *i. e.*, if the shunt excitation will be replaced by regulation for constant voltage before the dynamo has assumed the entire load, and if the belt is not capable of transmitting the entire load, then the slipping of the belt will be unstable. The more the speed of the dynamo falls, in consequence of belt-slipping, the more the retarding force of the dynamo increases, owing to the constancy of the power (constant volts $\times$ constant amperes) delivered by the dynamo. After a sufficient decrease of the speed, the dynamo will be switched out again, *i. e.*, completely discharged of load. Afterward a new rise of speed will take place until the dynamo is switched in again and so forth. In this manner there may take place an oscillating switching-in and switching-out of the controlling apparatus.

By disconnecting the dynamo from the external circuit only after the dynamo output has been reduced practically to zero, the belt is never slipping at the time the dynamo is disconnected, and no repeated operation of the cut-out switches occurs.

If the work circuit were connected to the terminals 39, 7 during the shunt excitation period, (switch F to the left, switch G to the right, and switch E deënergized), then with falling dynamo voltage the work-circuit voltage would drop to its permissible minimum of about 32 volts (and should be disconnected) sooner than the voltage at the charging battery C^1 drops to its permissible minimum of two volts per cell (32 volts), since the battery is across the high voltage mains 46, 7; this would require two switches, for load and battery respectively, operating at different times. According to the present invention however, the work circuit is connected to the high voltage terminals 46, 7, through the series resistance R^2 during the shunt excitation period, so that with falling dynamo voltage the work circuit voltage reaches its lower limit of 32 volts at the same time that the battery voltage reaches its lower limit of 32 volts, so that both the work circuit and the battery may be disconnected by a single switch mechanism as indicated at F, 9, 27. By this means it is possible to dispense with one of the prior art switches, and thus in spite of simultaneous connection of the charging circuit and work circuit to the dynamo, to effect a gradual transfer of the load to the dynamo during the starting

operation, and likewise to relieve the belt from load prior to disconnection during this shunt excitation period.

This invention is not restricted in its usefulness to railway trains, but may be adapted to other types of vehicles, such as motor vehicles, ships and the like, and also in stationary installations in which the dynamos work in conjunction with storage batteries which carry the load when the dynamos are at rest.

It is believed that the operation of the apparatus will be clear from the above description. However, by way of résumé, it may be assumed first, that the train is at rest. At this time switch F is in its right-hand position, switch G is at the right, and switch E is deënergized; hence both batteries C^1 and C^2 are connected in parallel to supply the work circuit D. If now the train starts, the dynamo field B is self-excited by virtue of its connection to the mains 39, 46 of the generator, through the ballast resistance R^3, switch blade 28 and leads 6, 29; the batteries C^1 and C^2 are still in parallel with the load. When the train speed is high enough so that current flows in the direction from the main 46 through the voltage coil H^1 to the positive terminal of battery C^1, switch F is shifted automatically to the left: this does not disturb the connections from battery C^2 to load through coil H^4 and switch blade 10, but it disconnects battery C^1 from the load, and connects this battery to the high-voltage or charging main 46 of the generator through the current coil H^2 and the ballast charging resistance R^1. Simultaneously the high-voltage main 46 of the generator becomes connected to the load in parallel with the battery C^2 through the load or lamp resistance R^2, switch blade 27, lead 31, and switch blade 30; the generator is still self-excited through the circuit 46, R^3, 28, 6, B, 39. When the train speed is high enough so that current flows from the main 46 through the lamp resistance R^2, switch blade 27, lead 31, switch blade 30, switch blade 10, and current coil H^4 into the positive terminal of battery C^2, the polarity of the coil H^4 is reversed and switch G is shifted automatically to the left. The battery C^1 is now still on charge through the ballast resistance R^1, current coil H^2, and switch blade 9; the connection between the high voltage main 46 of the generator and the battery C^2 and load D is broken at the switch blade 30, and instead, the low voltage or intermediate main 39 of the generator is connected to the load D through switch blade 30, without any intermediate lamp resistance; the battery C^2 is now connected, through the current coil H^4, switch blade 10 and lead 6, to the junction between the ballast field resistance R^3 and the field winding B, so that with variations of dynamo speed a variable amount of the constant current flowing through resistance R^3 is diverted from the field B into the battery C^2 and thus constant voltage is maintained at the generator irrespective of the generator speed, as hereinbefore explained. After a length of time depending upon the condition of the slowly charging battery C^2, the voltage of this battery reaches the point where the voltage coil 8 (whose strength is proportional to the voltage of battery C^2) becomes sufficiently energized to lift its switch blade 28. This operation disconnects the field winding B from the resistance R^3 and high-voltage main 46, and as a result the field is now excited by discharge current passing from the battery C^2 through the coil H^4, switch blade 10, main 6, and field winding B, to the intermediate or low-voltage main 39 of the generator, and, as hereinbefore explained, the exciting current is automatically decreased with any speed increase and the dynamo voltage thus maintained constant irrespective of the dynamo speed. If the dynamo speed drops below its minimum operative value at a time when the battery C^2 is thus discharging through the field B to the main 39 (switch E energized), the field current passing through the coil H^4 naturally increases with decreasing dynamo speed and when said current attains a predetermined maximum, such as for example, ten amperes, the switch G is automatically shifted to the right. The voltage coil H^3 is at this time energized and opposes the flux generated by current coil H^4 to such an extent that ten amperes of current through coil H^4 is required to shift the switch G toward the right; this shifting of the switch G toward the right interrupts for a moment at the contacts 26 the circuit of voltage coil 8 of switch E, which is thus compelled to retract its blade 28 and reëstablish the self-exciting field circuit 46, R^3, 28, 6, B, 39. In this manner, the field circuit B is not opened and the objectionable sparking attendant upon the opening of a field circuit is avoided.

Upon further decrease of dynamo speed, the switch F shifts to the right (when reverse current from battery C^1 into main 46 reverses the effect of the current coil H^2), and the conditions existing with the train at rest (switches F and G to the right, switch E deenergized) are thus restored. If, however, the dynamo speed drops below its minimum operative value at a time when the battery C^2 is connected to the junction between field resistance R^3 and field winding B (switch E deënergized), the field current, part of which (for example, eight amperes) is supplied by the constant current resistance R^3 and the rest of which is supplied by the battery C^2, naturally increases with decreasing dynamo speed, and when said field current attains a predetermined maximum, such as ten amperes (of which two amperes is pass-

ing through the coil H^4 from the battery C^2), the switch G is automatically shifted to the right. The voltage coil H^3 is at this time de-energized, and therefore offers no opposition to the coil H^4, so that two amperes of discharge current flowing through the coil H^4 from the battery C^2 is sufficient to shift the switch G toward the right. Upon further decrease in train speed, the reverse current from battery C^1 into the main 46 reverses the current coil H^2 and shifts the switch F to the right. The conditions corresponding to zero train speed, are thus restored, namely, switches F and G to the right, and switch E deënergized, with the two batteries in parallel serving the load.

From the above it will be seen that the several objects of the invention are realized and other advantageous results obtained.

As various changes might be made in the above construction, and as the above invention might be embodied in different forms, it is intended that all matter set forth in the above description and in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

What I claim is—

1. In apparatus of the class described, in combination, a generator, a field coil therefor, a substantially constant current resistance connecting one end of said coil to one of the terminals of said generator, a battery connecting said same end to another terminal of said generator, and protective means for disconnecting said battery when a maximum field current is reached.

2. In apparatus of the class described, in combination, a generator, self-exciting and external exciting means therefor, adapted to operate separately or conjointly, and a device controlling said external means, to limit the maximum total excitation of said generator to a predetermined value whether said external means is operating solely or conjointly with said self-exciting means.

3. In apparatus of the class described, in combination, a generator having two commutators in series, providing thereby a positive, intermediate and negative terminal, an exciting winding, one pole of which is connected to said intermediate terminal, a battery, one pole of which is connected to said negative terminal, means for connecting and disconnecting the other pole of the exciting winding and the other pole of the battery, and means for disconnecting the exciting winding from the battery when the exciting current has attained a predetermined value.

4. In apparatus of the class described, in combination, a generator having two commutators in series, providing thereby a positive, intermediate and negative terminal, an exciting winding, one pole of which is connected to said intermediate terminal, a battery, one pole of which is connected to said negative terminal, and means for connecting the other pole of the exciting winding to the other pole of the battery automatically when the generator has assumed the load, said connection from exciting winding to battery being automatically broken upon a sufficient decrease of generator speed.

5. In apparatus of the class described, in combination, a generator having a positive terminal, a negative terminal, and a terminal of voltage intermediate the voltage of the positive and negative terminals, an exciting winding for the generator connected to the intermediate terminal and the positive terminal through a constant-current resistance, means for interrupting the connection between said winding and said positive terminal when the generator voltage has attained a predetermined value, and a battery whose poles are connected respectively to the negative terminal of the generator and to the positive terminal of the exciting winding.

6. In apparatus of the class described, in combination, a generator, an exciting winding therefor connected to said generator through a constant-current resistance, a battery connected to said exciting winding and to said generator so that the battery voltage and the generator voltage are opposed to each other, and means for interrupting the connection between said winding and a terminal of said generator when the battery voltage has attained a predetermined value.

7. In apparatus of the class described, in combination, a generator having a positive terminal, a negative terminal, and a terminal of voltage intermediate the voltage of the positive and negative terminals, an exciting winding for the generator connected to the intermediate terminal and the positive terminal through a constant-current resistance, whereby the current through said resistance normally divides between exciting winding and battery to maintain the generator voltage constant with varying speed, and means for interrupting the connection between said winding and said positive terminal, whereupon the current in said winding is proportional to the difference between battery voltage and the voltage across the intermediate and negative terminals of the generator, whereby the generator voltage is maintained constant with varying speed.

8. In apparatus of the class described, in combination, a generator having two commutators in series, providing thereby a positive, intermediate and negative terminal, an exciting winding for the generator connected to said intermediate terminal and to a battery whose other pole is connected to the negative terminal of the generator, a connection between the positive terminal of the generator and the junction between exciting winding and battery, voltage-controlle

means for breaking said connection, and means for restoring said connection automatically prior to disconnection of the battery from the exciting winding.

9. In apparatus of the class described, in combination, a generator, a field winding therefor, a battery adapted to be automatically connected to the generator for charging thereby, means for simultaneously connecting the generator to a work circuit through a resistance, means automatically effective after the generator has assumed the load, for breaking said connection to the work circuit and connecting said work circuit to generator terminals carrying only a fraction of the total generator voltage, and means for re-connecting the work circuit to the generator through said resistance prior to disconnection of the generator entirely from the work circuit.

10. In apparatus of the class described, in combination, a generator having three terminals, namely, a negative terminal, an intermediate terminal and a positive terminal, the voltage between negative terminal and positive terminal being higher than the voltage between negative terminal and intermediate terminal, an exciting winding, one pole of which is connected with said intermediate terminal and the other pole with said positive terminal, a resistance in the connection between said positive terminal and said exciting winding, a magnetic interrupter adapted to break said connection between positive terminal and exciting winding, said interrupter having a voltage coil across the negative terminal and the intermediate terminal, a battery whose negative pole is connected to said negative terminal of the generator, a work circuit whose negative pole is connected to said negative terminal of the generator, an auxiliary connecting line, a magnetic switch connecting in its working position the positive pole of said battery with the second pole of said exciting winding and connecting the positive pole of the work circuit with the intermediate terminal of the generator, said switch connecting in its rest position the positive pole of the battery with the positive pole of the work circuit and connecting the latter with said auxiliary connecting line, said switch shifting to its working position when current flows into said battery, said switch shifting to its rest position when a predetermined current flows from said battery, a device connected with said switch for momentarily interrupting said voltage coil as said switch shifts its position, a current coil adapted to shift said switch to its working position when current flows through said coil into said battery, said coil being adapted to shift said switch to its rest position when a predetermined current flows therethrough from said battery, a second coil on said switch and connected in a circuit which is closed when said interrupter has interrupted said connecting line, said second coil opposing said first coil; a second battery whose negative pole is connected to the negative pole of the generator, a second switch connecting in its working position the positive pole of the second battery with the positive terminal of the generator and connecting said auxiliary connecting line with the positive pole of the generator, said second switch connecting in its rest position the positive pole of the second battery with the positive pole of the first battery, means for shifting said second switch into its working position when the voltage of the positive terminal of the generator exceeds the voltage of the positive pole of the second battery, means for shifting said second switch into its rest position when reverse current flows from said second battery to said generator, a resistance in the connecting line between the positive pole of the generator and said second switch, and a resistance in said auxiliary connecting line.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

HUGO GROB.

Witnesses:
HERMANN HUBER,
CARL GUBER.