H. L. VAN VALKENBURG.

AUTOMATIC VOLTAGE REGULATOR.

APPLICATION FILED JULY 30, 1906.

922,219.

Patented May 18, 1909.

*Fig. 1*

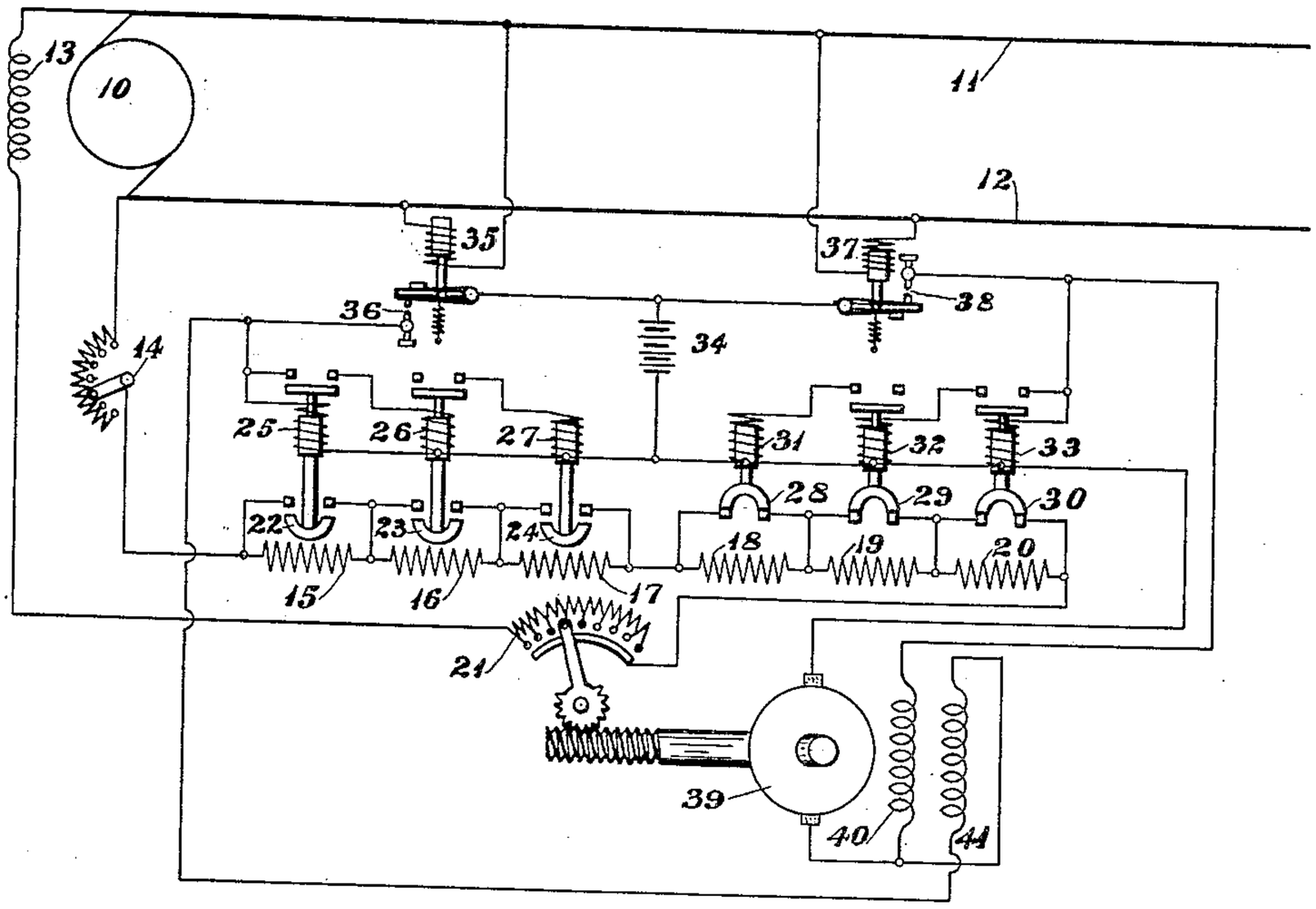
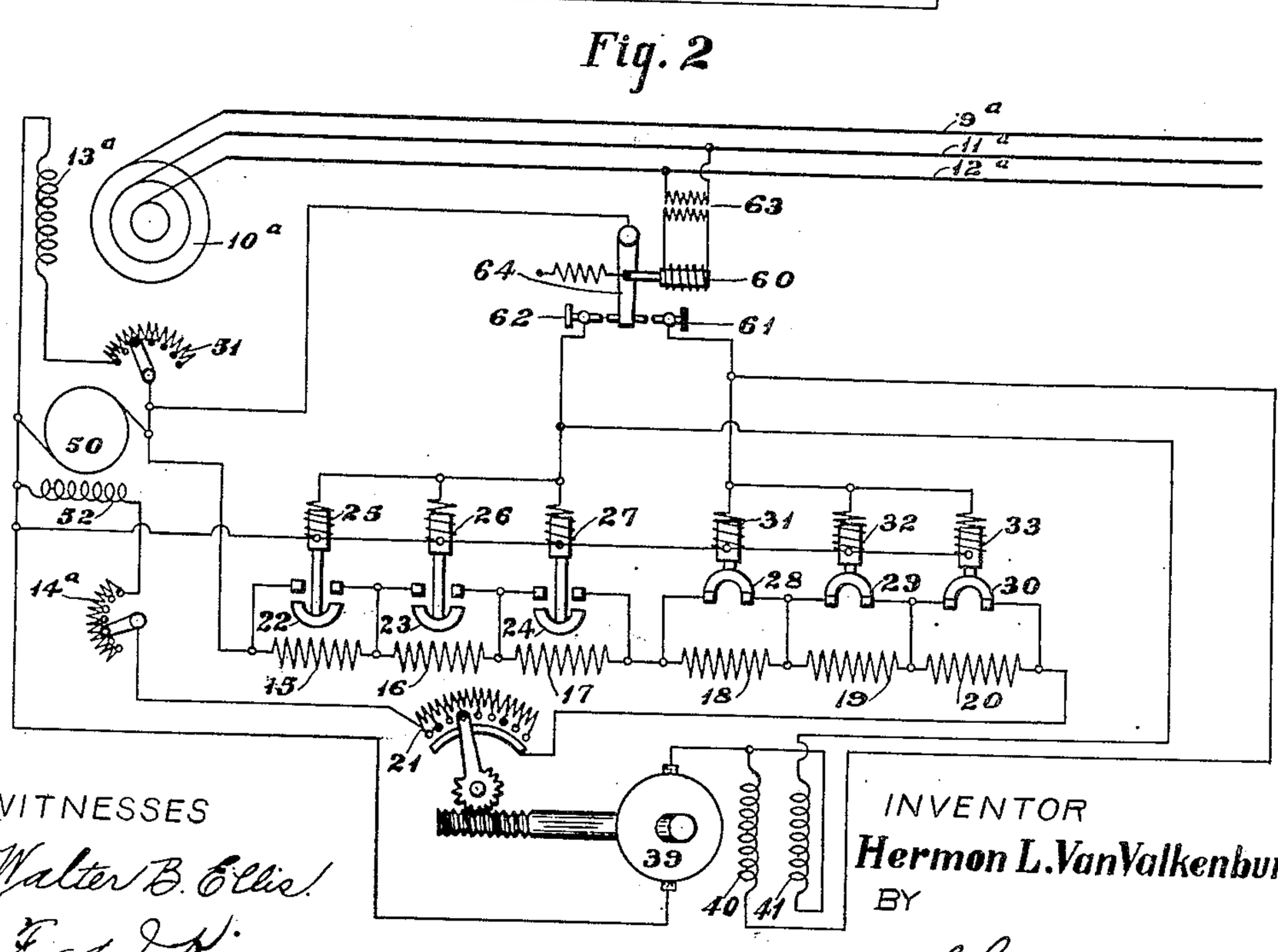



*Fig. 2*

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## AUTOMATIC VOLTAGE-REGULATOR.

No. 922,219. Specification of Letters Patent. Patented May 18, 1909.

Application filed July 30, 1906. Serial No. 328,324.

*To all whom it may concern:*

Be it known that I, HERMON L. VAN VALKENBURG, citizen of the United States, residing at Norwood, in the county of Hamilton and State of Ohio, have invented certain new and useful Improvements in Automatic Voltage-Regulators, of which the following is a full, clear, and exact specification.

My invention relates to electric regulators and particularly to automatic constant potential regulators for electric generators.

One object of my invention is to provide a system in which momentary fluctuations as well as those of long duration are quickly and accurately compensated for without undue sparking at the regulator contacts.

Other objects of my invention will appear hereinafter.

In one aspect my invention comprises an electric generator, and a plurality of devices responsive to changes in the generator potential for independently restoring said potential to normal.

In another aspect my invention comprises the combination of an electric generator, means for quickly compensating for temporary changes in the potential of the generator, and means for compensating for long continued variations in said potential.

In a more specific aspect my invention comprises an electric generator, resistances arranged to be cut in and out to vary the potential of said generator, means responsive to momentary variations of the potential of the generator for cutting in or out one of said resistances, and other means responsive to long continued variations of the generator potential for cutting in or out the other resistances.

In another aspect my invention comprises the combination in a system of electrical distribution, of means for momentarily correcting for a change of voltage in the system, and means for gradually correcting for said change of voltage in a relatively permanent manner.

In a still more specific aspect my invention consists of an electric generator, two series of resistances arranged to be cut in or out to vary the potential thereof, one of said series being normally in circuit and the other of said series being normally out of circuit, and means for cutting in upon rise in voltage those which are normally out of circuit, and means for cutting out upon fall in voltage those which are normally in circuit.

Other novel features of my invention will appear from the description and drawings and will be particularly pointed out in the claims.

Figure 1 represents one embodiment of my invention as applied to a direct current system; and Fig. 2 represents a modification showing the application of my invention to an alternating current system.

Referring now to Fig. 1, 10 is a direct current generator supplying current for any desired purposes through the mains 11 and 12. The generator 10 is shown with a self-excited field 13, in circuit with which are a manually operated rheostat 14, the resistance sections 15, 16, 17, 18, 19 and 20, and a rheostat 21. In shunt to the resistance sections 15, 16 and 17 are switches 22, 23 and 24, these switches being normally held open by gravity or otherwise, but arranged to be closed by solenoids 25, 26 and 27 respectively when the latter are energized. Connected in shunt to the resistances 18, 19 and 20 are switches 28, 29 and 30 respectively, these switches being normally held closed by gravity or otherwise, but arranged to be opened by solenoids 31, 32 and 33 respectively when the latter are energized. All of these solenoids are supplied with current by a battery 34 and controlled by the solenoids 35 and 37, connected across the mains 11 and 12 at the point where constant potential is to be maintained. Upon a decrease in the potential across mains 11 and 12 and the resulting weakening of solenoid 35 the switch 36 closes and the solenoids 25, 26 and 27 are successively energized. In the arrangement shown in Fig. 1, solenoid 25, when it closes its switch 22, also completes the circuit of solenoid 26, which in turn, upon closing its switch 23, completes the circuit of solenoid 27. Thus upon fall in voltage the resistances 15, 16 and 17 are successively short-circuited. Upon rise of voltage above normal, the solenoid 37 closes its switch 38 and the solenoids 33, 32 and 31 are successively energized in the order named to successively open switches 30, 29 and 28 to include resistances 20, 19, and 18 in the field circuit of the generator. When the voltage returns to normal the solenoids which have been energized are immediately deënergized,

and the switches under their control are returned to normal position by gravity or otherwise.

The rheostat 21 is operated by a reversible pilot motor 39, shown as having two oppositely connected series field coils 40 and 41, though obviously any kind of reversible motor may be used. It is not even necessary to use a rotary motor. The motor 39 is supplied with current by the battery 34, and its armature and the field coil 41 are energized when the switch 36 is closed upon fall of voltage, while its armature and field coil 40 are energized when the switch 38 is closed upon rise in voltage. When either field coil 40 or 41 and the armature of the pilot motor are energized, a comparatively small current also flows in a shunt path to the armature through the other field coil 41 or 40 in the proper direction to assist the first mentioned field coil 40 or 41 and on through the solenoid 25 or 33 as the case may be. The resistance of the armature is so much smaller than that of such shunt path, however, that the solenoid 25 or 33 does not lift its core. If desired, this shunt path around the armature of the pilot motor can easily be avoided in an obvious manner, but ordinarily this is not necessary, the simple arrangement shown sufficing.

The operation of the system is as follows:— Upon fall of voltage below normal, the switch 36 closes to successively energize solenoids 25, 26 and 27 to short-circuit resistances 15, 16 and 17. If this variation is only momentary the switch 36 immediately opens, thus cutting resistance sections 15, 16 and 17 into circuit again when the action ceases. However, if the fall in voltage is long continued, the cutting out of the resistances 15, 16 and 17 over-corrects it momentarily and switch 36 opens to cut said resistances into circuit again. This causes the voltage to fall and the switch 36 again to close to cut out resistances 15, 16 and 17, or some of them. The vibration of switch 36 and the alternate cutting out and in of resistances 15, 16 and 17 in whole or in part would continue indefinitely were it not that the motor 39, under the influence of its field 41, revolves in the proper direction to gradually cut out enough of rheostat 21 to restore the voltage to normal in a relatively permanent manner. When the voltage has been restored to normal through the action of motor 39 on rheostat 21, the vibration of the switch 36 ceases, and the switches 22 to 24 are relieved of the work of correcting the voltage. Upon rise in voltage the switch 38 closes to energize successively solenoids 33, 32 and 31 to include resistances 20, 19 and 18 in field circuit 13 to momentarily over-compensate for the rise of voltage. The switch 38 will vibrate between its closed and open positions as long as a tendency to rise in voltage continues, thus causing the alternate cutting in and out of the resistances 20, 19 and 18, until the voltage is restored to normal. Also the motor 39, under the influence of its field 40, revolves in the proper direction to cut in gradually enough of the rheostat 21 to obtain such restoration. The motor-operated rheostat 21 therefore serves to compensate for long continued variations in voltage, thus preventing the continued sparking which would otherwise occur at the contacts of the switches 36 and 38. The rise and fall of voltage necessary to cause the repeated opening and closing of the controlling switches 36 and 38 may be made as small as desired by having a delicate adjustment of these switches, and although really a very slight rise and fall of voltage takes place this is so slight that the voltage curve of the system appears practically as a straight horizontal line.

In the modification shown in Fig. 2 the operation is very similar to that described above. The alternator $10^a$ supplies the three-phase mains $9^a$, $11^a$ and $12^a$. Instead of two solenoids 35 and 37, there is but one solenoid 60 supplied through a potential transformer 63. Upon rise in voltage the arm 64 is moved to engage with contact 61 to perform the same function as switch 38 in the arrangement shown in Fig. 1, and on fall in voltage to engage with contact 62 to perform the same function as the switch 36 in Fig. 1. The resistance sections 15 to 20 and the rheostat 21 are in the field circuit 52 of the exciter 50 instead of being directly in the field circuit of the main generator. The exciter 50 supplies the field coil $13^a$ of the main generator and may be regulated by hand by a rhoestat 51. The rheostat $14^a$ is in the circuit of the field 52. As in Fig. 1 the resistance sections 15 to 17 are controlled by solenoids 25 to 27, which in this case, however, are simultaneously instead of successively energized, while the resistance sections 18 to 20 are controlled by solenoids 31 to 33, also simultaneously energized. Resistances 15 to 20 are cut into and out of circuit to compensate for temporary fluctuations in voltage, while long continued variations, as in Fig. 1, are primarily compensated for by the repeated cutting in and out of resistances 15 to 20, and permanently compensated for by the rheostat 21 driven by the motor 39 in one direction or the other according as field 40 or 41 is energized.

In the modification shown in Fig. 2 the battery 34 is omitted, the solenoids 25, 26, 27, 31, 32 and 33 and the motor 39 being energized from the exciter circuit. It is obvious however that if desired a battery could be used to supply these parts with current as in Fig. 1, and that if desired the battery could be omitted from Fig. 1 and the parts supplied with current directly from the main generator.

Instead of having a plurality of resistances

to be repeatedly cut in and out upon a rise or fall of voltage, it is manifest that but one such resistance need be used in some cases, and that the sets of resistances 15 to 17 and 18 to 20 may each be replaced by such a single resistance.

Many other modifications and substitutions will readily appear to one skilled in the art, and in the following claims I aim to cover all of these modifications which come within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent is:—

1. In combination, a series of separately actuated switches, some of which are biased to open position and some to closed position, and a potential regulating device controlled by said switches.

2. In combination, an electric generator, a plurality of resistances in the field circuit thereof, and separately actuated switches in shunt respectively to said resistances, some of said switches being biased to open position and some to closed position.

3. In combination, a series of magnetically operated switches, some of which are biased to open position and others to closed position, and voltage regulating means controlled by said switches.

4. In combination, an electric generator, a plurality of resistances in the field circuit thereof, separate magnetically operated switches in shunt to said resistances, some of said switches being biased to open position and some to closed position.

5. In combination, an electric generator, a series of resistances for varying the field strength of said generator, means for repeatedly cutting in and out some of said resistances when the generator voltage varies above normal, and means for repeatedly cutting in and out others of said resistances when the generator voltage varies below normal.

6. In combination, an electric generator, means for quickly compensating for temporary changes in the potential of the generator, and automatic means for compensating for long continued variations in said potential.

7. In combination, an electric generator, resistances arranged to be cut in and out of circuit to vary the field strength of said generator, means responsive to momentary variations of the potential of the generator for cutting in and out some of said resistances, and other means responsive to long continued variations of the generator potential for varying another resistance.

8. In combination, an electric generator, a plurality of resistances in the field circuit thereof, separately actuated switches for cutting in and out some of the resistances, and a motor for gradually varying others of the resistances.

9. In combination, an electric generator, a plurality of resistances arranged to be cut in and out to control the generator, separately actuated switches for cutting in and out some of the resistances, a motor for gradually varying others of the resistances, and means responsive to the voltage of the generator for controlling the separately actuated switches and the motor.

10. In combination, an electric generator, a plurality of resistances in the field circuit thereof, solenoid switches for cutting in and out some of the resistances, and a motor-driven rheostat arm for cutting in and out others of the resistances.

11. In combination, an electric generator, a plurality of resistances arranged to be cut in and out to control the generator, magnetically operated switches for cutting in or out some of the resistances, a motor-driven rheostat arm for cutting in and out others of the resistances, and means responsive to the generator potential for controlling the switches and the motor.

12. In combination, an electric generator, a resistance section and a rheostat in the field circuit thereof, a switch constructed and arranged to repeatedly cut in and out the resistance section when the generator potential varies from normal, and a motor arranged to gradually move the rheostat arm at the same time.

13. In combination, an electric generator, a plurality of resistance sections and a rheostat arranged to control the generator, a switch arranged to repeatedly cut in and out one of the resistance sections when the generator voltage is below normal, a second switch to repeatedly cut in and out another of the resistance sections when the generator voltage is above normal, and a reversible motor for moving the arm of the rheostat when the generator voltage varies from normal.

14. In combination, an electric generator, a plurality of resistance sections and a rheostat arranged to control the generator, means for repeatedly cutting in and out some of said resistance sections when the generator voltage is below normal, means for repeatedly cutting in or out others of said resistance sections when the generator voltage is above normal, and a reversible motor for moving the arm of the rheostat when the generator voltage varies from normal.

15. In combination, an electric generator, and a plurality of devices responsive to changes in the generator potential for independently restoring said potential to normal.

16. In a system of electrical distribution, automatic means for momentarily correcting for a change of voltage in the system, and automatic means for gradually correcting for said change in voltage in a relatively permanent manner.

17. In a system of electrical distribution, means for momentarily correcting for a change of voltage in the system, and automatic means for gradually correcting for said change in voltage in a relatively permanent manner if the tendency to such change in voltage continues.

18. In a system of electrical distribution, means for momentarily over-correcting for a change in voltage in the system, and automatic means for gradually and exactly correcting for said change in voltage.

19. In a system of electrical distribution, means for momentarily over-correcting for a change in voltage in the system, and independently operating automatic means for gradually and exactly correcting for said change in voltage.

20. In a system of electrical distribution, means for momentarily correcting for a change of voltage in the system, means for gradually correcting for said change in voltage in a relatively permanent manner, and means connected to said system for controlling both of said correcting means.

21. In a system of electrical distribution, means for momentarily correcting for a change of voltage in the system, means for gradually correcting for said change in voltage in a relatively permanent manner if the tendency to such change in voltage continues, and means connected to said system for controlling both of said correcting means.

22. In a system of electrical distribution, means for momentarily over-correcting for a change in voltage in the system, means for gradually and exactly correcting for said change in voltage, and means connected to said system for controlling both of said correcting means.

23. In a system of electrical distribution, means for momentarily over-correcting for a change in voltage in the system, independently operating means for gradually and exactly correcting for said change in voltage, and means connected to said system for controlling both of said correcting means.

24. In combination, a generator, means for momentarily correcting for a change in generator voltage, and automatic means for correcting for said change in voltage in a relatively permanent manner.

25. In combination, a generator, automatic means for momentarily correcting for a change in generator voltage, and automatic means for correcting for said change in voltage in a relatively permanent manner if the tendency to such change in voltage continues.

26. In combination, a generator, means for momentarily over-correcting for a change in generator voltage, and automatic means for gradually and exactly correcting for said change in voltage.

27. In combination, a generator, resistances for momentarily correcting for a change in generator voltage, other resistances for gradually correcting for said change in voltage in a relatively permanent manner, and means for automatically controlling said latter resistances.

28. In combination, a generator, resistances for momentarily correcting for a change in generator voltage, other resistances for gradually correcting for said change in voltage in a relatively permanent manner if the tendency to such change in voltage continues, and means for automatically controlling all of said resistances.

29. In combination, a generator, resistances arranged to be cut in and out to overcorrect for a change in generator voltage, other resistances for gradually and exactly correcting for said change in voltage, and means for automatically controlling said latter resistances.

30. In combination, a generator, resistances arranged to be cut in and out by separately actuated switches to momentarily correct for a change in generator voltage, and resistances arranged to be cut in or out automatically by other means to gradually correct for said change in voltage.

31. In combination, a generator, resistances arranged to be cut in and out automatically by separately actuated switches to momentarily correct for a change in generator voltage, and resistances arranged to be cut in or out automatically by other means to gradually correct for said change in voltage if the tendency to such change in voltage continues.

32. In combination, a generator, resistances arranged to be cut in and out automatically by separately actuated switches to momentarily over-correct for a change in generator voltage, and resistances arranged to be cut in or out automatically by other means to gradually and exactly correct for said change in voltage.

33. In a system of electrical distribution, means for rapidly over-correcting for a change in voltage in the system, and automatic means for gradually and exactly correcting for said change in voltage.

34. In combination, a generator, resistances arranged to be cut in and out to maintain the voltage of said generator constant, means for rapidly automatically cutting in or out some of said resistances to immediately correct for a variation in voltage, and means for gradually automatically cutting in or out others of the resistances to exactly correct for said variation in voltage.

35. In combination, a generator, a resistance arranged to be quickly cut into circuit when the generator voltage rises above normal and to be quickly cut out of circuit when said voltage returns to normal, and another resistance arranged to be gradually increased

when the generator voltage rises above normal and to remain constant when said voltage returns to normal, both of said resistances controlling the generator voltage.

36. In combination, a generator, a resistance arranged to be quickly cut out of circuit when the generator voltage falls below normal and to be quickly cut into circuit when said voltage returns to normal, and another resistance arranged to be gradually decreased when the generator voltage falls below normal and to remain constant when the said voltage returns to normal, both of said resistances controlling the generator voltage.

37. In combination, a generator, a resistance arranged to be quickly cut into circuit when the generator voltage rises above normal and to be quickly cut out of circuit when said voltage returns to normal, another resistance arranged to be quickly cut out of circuit when the generator voltage falls below normal and to be quickly cut into circuit when said voltage returns to normal, and a third resistance arranged to be gradually increased or decreased as the generator voltage rises above or falls below normal and to remain constant when said voltage returns to normal, all of said resistances controlling the generator voltage.

38. In a system of distribution, means for correcting for a change of voltage in said system, and automatic means for relieving said first means of the work of such correcting.

39. In combination, a generator, automatic means for momentarily correcting for a change in the generator voltage, and automatic means for relieving said first means of the work of such correcting.

40. In a system of electrical distribution, a series of separately actuated switches for momentarily correcting for a change in voltage in the system, and automatic means for gradually correcting for said change.

41. In a system of electrical distribution, a series of separately actuated switches for momentarily correcting for a change in voltage in the system, and a motor-driven rheostat for gradually correcting for said change.

42. In combination, an electric generator, a plurality of resistances arranged to be cut in and out to vary the field strength of said generator, means for cutting in or out some of said resistances in quick succession, and automatic means for cutting in or out others of said resistances in slow succession.

43. In combination, an electric generator, a plurality of resistance sections for controlling the generator, a switch arranged to repeatedly cut in and out one of the resistance sections when the generator voltage is below normal, and a second switch arranged to repeatedly cut in and out another of the resistance sections when the generator voltage is above normal.

In testimony whereof I affix my signature, in the presence of two witnesses.

HERMON L. VAN VALKENBURG.

Witnesses:

GEO. B. SCHLEY,

FRED J. KINSEY.