H. L. VAN VALKENBURG.

AUTOMATIC VOLTAGE REGULATOR.

APPLICATION FILED JULY 30, 1906.

922,218.

Patented May 18, 1909.

2 SHEETS—SHEET 1.

Fig 1

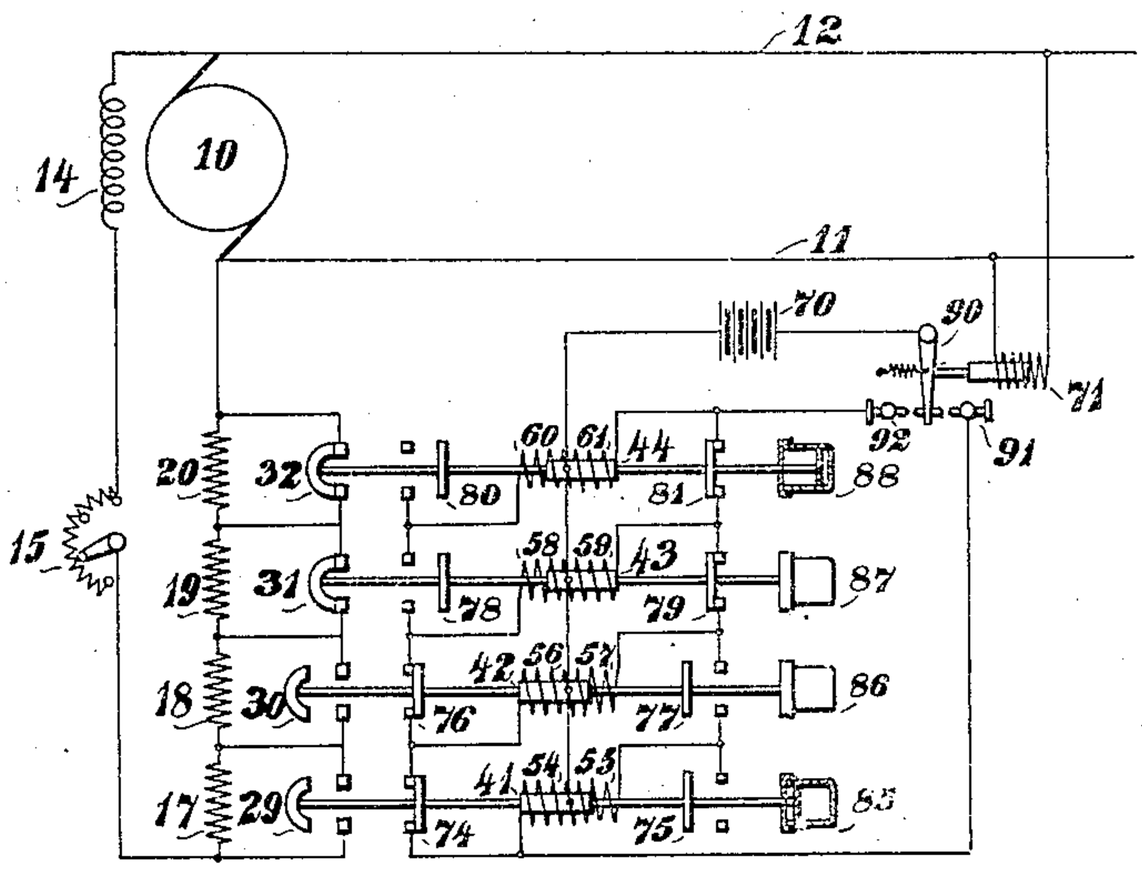
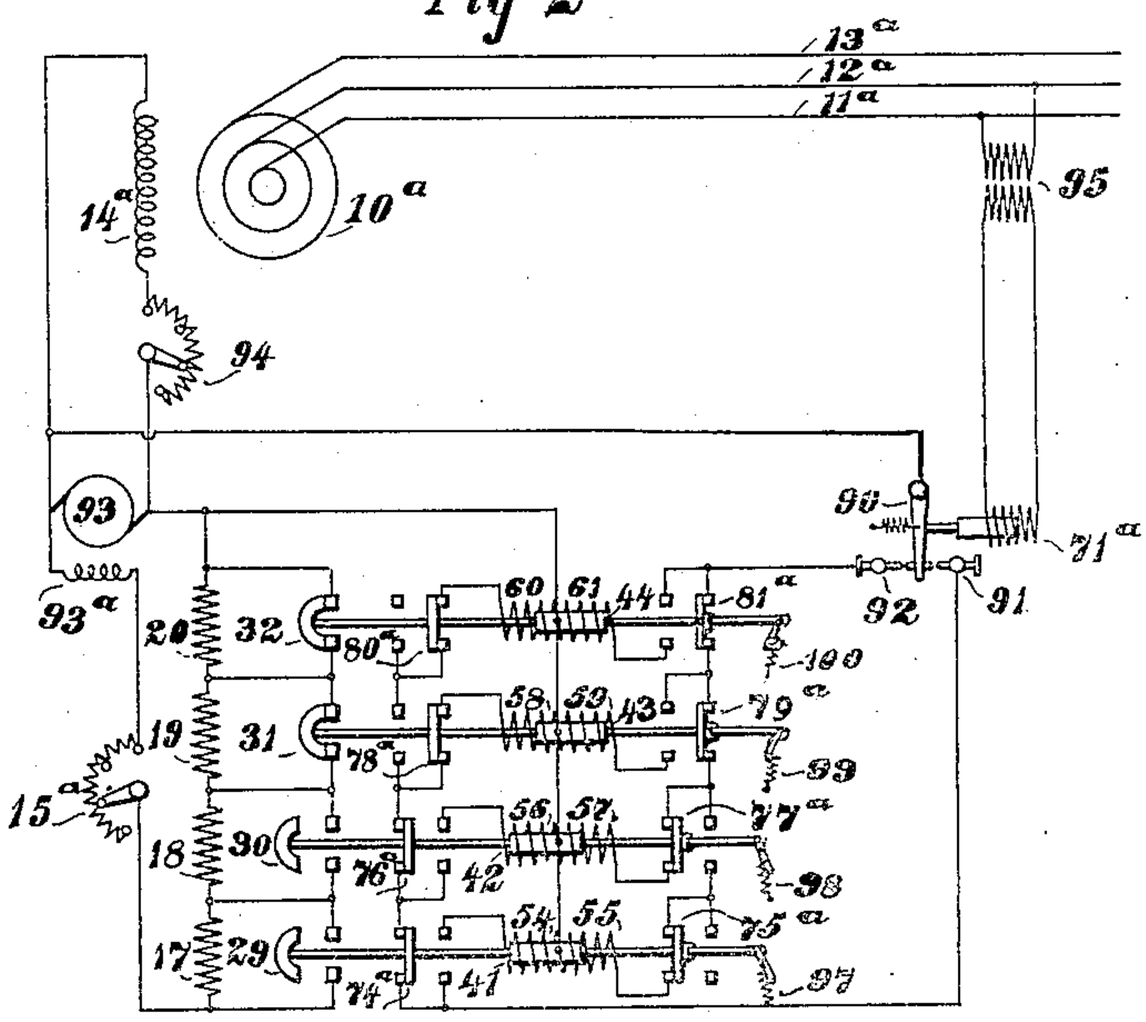


Fig 2



WITNESSES

Victor E. Julian

Fred J. Kinsey

INVENTOR

Hermon L. Van Valkenburg

BY

Chas. E. Lord

ATTORNEY

H. L. VAN VALKENBURG.

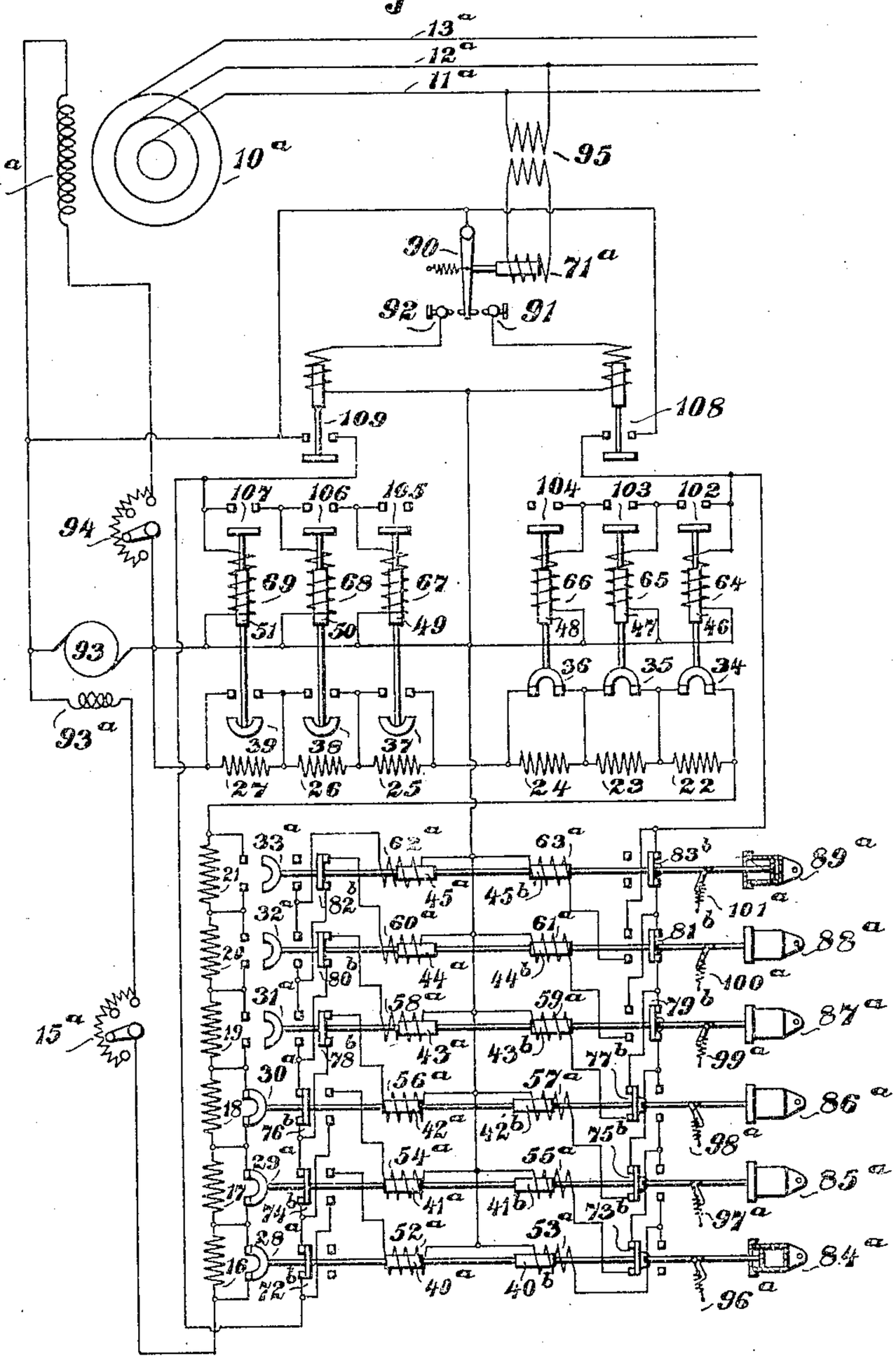
AUTOMATIC VOLTAGE REGULATOR.

APPLICATION FILED JULY 30, 1906.

922,218. Patented May 18, 1909.

2 SHEETS—SHEET 2.

Fig 3



WITNESSES

Victor E. Julien

Fred L. Kinsey

INVENTOR

Hermon L. Van Valkenburg

BY

Chas. E. Lord

ATTORNEY

UNITED STATES PATENT OFFICE.

HERMON L. VAN VALKENBURG, OF NORWOOD, OHIO, ASSIGNOR TO ALLIS-CHALMERS COMPANY, A CORPORATION OF NEW JERSEY, AND THE BULLOCK ELECTRIC MANUFACTURING COMPANY, A CORPORATION OF OHIO.

AUTOMATIC VOLTAGE-REGULATOR.

No. 922,218. Specification of Letters Patent. Patented May 18, 1909.

Application filed July 30, 1906. Serial No. 328,323.

To all whom it may concern:

Be it known that I, HERMON L. VAN VALKENBURG, a 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 generators.

One object of my invention is to provide a system in which fluctuations in voltage are quickly and accurately compensated for.

Other objects of my invention will appear hereinafter.

In one aspect my invention comprises the combination of a series of switches, a pair of solenoids for each switch, and connections whereby each solenoid when it operates its switch closes the circuit of the corresponding solenoid of the next pair.

In another aspect my invention comprises the combination of a plurality of resistance sections, a corresponding number of switches for cutting in or out said resistance sections, and a plurality of pairs of magnets for operating the respective switches, the corresponding magnets of the different pairs being arranged to be energized successively.

In still another aspect my invention comprises the combination of a series of switches, some of which are biased to closed position, some to open position, and some of which will remain in either position.

In a more specific aspect my invention comprises the combination of a generator, a plurality of resistance sections arranged to vary the generator voltage, quick-acting switches for cutting in or out some of said resistance sections to momentarily correct for a change in the generator voltage, and comparatively slow-acting switches for cutting in or out others of said resistance sections to gradually correct for said change in voltage.

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

Figure 1 represents one embodiment of my invention as applied to a direct current system; Fig. 2 shows a modification and illustrates the application of my invention to an alternating current system; and Fig. 3 shows a modification somewhat similar to that of Fig. 2, but with certain additions and modifications.

Referring first to Fig. 1, 10 is a direct current generator supplying current for any desired purpose through the mains 11 and 12. The generator 10 is shown with a self-excited shunt field 14, in circuit with which are a manually operated rheostat 15 and resistance sections 17, 18, 19 and 20. Connected in shunt to these several resistance sections are switches 29, 30, 31 and 32 respectively. These switches when closed short-circuit their respective resistance sections, but when open compel the current in the field circuit to flow through said resistance sections. The switches 29, 30, 31 and 32 are connected to movable cores 41, 42, 43 and 44 respectively. These cores are placed within pairs of solenoids 54 and 55, 56 and 57, 58 and 59, and 60 and 61 respectively, which are supplied with current by a battery 70 and have their circuits controlled by a solenoid 71, responsive to the voltage of generator 10, as by being connected across the mains 11 and 12 at the point where constant voltage is to be maintained. Moreover, by means of the switches 74 to 81 inclusive, the right hand solenoid of each pair is controlled by the corresponding solenoid next above, while each left hand solenoid is controlled by the corresponding solenoid next below. The right hand solenoids when energized move their respective cores to the right to close the switches 29 to 32, while the left hand solenoids move the cores to the left to open said switches. If desired, the action of these switches both in opening and in closing may be retarded by the dash-pots 85, 86, 87 and 88.

The operation of the system shown in Fig. 1 is as follows:—Assume that the parts are as shown in the drawing. When the voltage is normal the arm 90 is in its middle position. Upon rise of voltage above normal the strength of solenoid 71 increases to draw arm 90 to the right and into engagement with the adjustable contact 91, thus closing the circuits of those left hand solenoids 54, 56, 58, and 60 which have no closed switch 29, 30 or 31 below them. As shown, the

solenoids 54, 56, and 58 would be energized, and the last of these would move its core 43 to the left and thus open switch 31 to include resistance section 19 in circuit with the field coil 14. When it has done this it would close the circuit of solenoid 60 at switch 78, and this solenoid in turn would act on its core 44 to open switch 32 to cut in resistance section 20. This successive cutting in of the resistance sections starts with the lowermost of the switches 29 to 32 inclusive which is closed, and keeps on until the voltage is restored to normal, when the arm 90 leaves contact 91 and the further cutting in of the resistance sections ceases; but those which have been cut in remain in circuit. Upon fall of voltage below normal arm 90 engages the adjustable contact 92 to close the circuits of those right hand solenoids 61, 59, 57, and 55 which have no open switch 32, 31 or 30 above them. As shown, the solenoids 61, 59, and 57 would be energized, and the last of these would close switch 30 to cut out the resistance section 18. As the switch 30 is closed the circuit of solenoid 55 is completed at switch 77 to close switch 29 to short-circuit resistance section 17. This successive short-circuiting of the resistance sections starts with the uppermost one of the switches 29 to 32 which is open, and keeps on until the voltage is restored to normal, when arm 90 leaves contact 92. Those resistance sections which have been cut out remain so. Thus upon either rise or fall of voltage, the cutting in or out of the resistance sections immediately commences at the proper point, and is caused to be gradual by having each solenoid under the control of the preceding corresponding solenoid, and if desired also under the retarding action of the dash-pots.

In Fig. 2 the main generator 10^a is a three-phase generator supplying current through the three mains 11^a, 12^a and 13^a. The field coil 14^a of the generator is supplied by an exciter 93 and may be regulated by hand by the rheostat 94. The field coil 93^a of the exciter has in circuit therewith the rheostat 15^a and the resistance sections 17, 18, 19 and 20. The switches 29 to 32 are controlled by the solenoids 54 to 61 inclusive, arranged in pairs to move the switches to cut in or out the resistance sections. These solenoids are responsive to the generator voltage, as by being controlled by a solenoid 71^a connected across the mains 11^a and 12^a through a transformer 95, and instead of being supplied by a battery are in this case supplied from the exciter circuit, though a battery could be used if desired. Each solenoid when energized not only does its main work of moving the proper switch and closing the circuit of the next solenoid in the same series but also, by means of other contacts for the switches 74^a to 81^a inclusive, breaks its own circuit. The switches 29 to 32 are also arranged to have a snap action and are prevented from stopping anywhere but in their extreme positions by means of springs 97 to 100 respectively, acting on the switches through levers and links as shown. By means of this mechanism these switches will continue to move into their extreme positions even if the solenoids which move them cease to act as soon as they have passed their middle positions. If desired the contacts of the switches 74^a to 81^a may be spring mounted so that these switches engage one set of contacts before they leave the other set.

The operation of the system shown in Fig. 2 is much the same as that of the one shown in Fig. 1, the main difference being that the circuit of each solenoid is broken when that solenoid has completed its work. This feature may be omitted if desired because the arm 90 is never in contact for very long at a time with either of the adjustable contacts 91 and 92, and so no great waste of current occurs even if the circuits of the solenoids are not immediately broken by their own action as soon as they have completed their work. It is advantageous, however, in reducing the sparking at the contacts 91 and 92.

In Fig. 2 no dash-pots are shown, because often it is not necessary to have any retarding action on the movements of the solenoid cores, while in some cases it may be actually advantageous to have the switches 29 to 32 inclusive operate in rapid succession.

In Fig. 3 an alternating current system somewhat similar to the one shown in Fig. 2 is shown. The alternator 10^a supplies current for any desired purpose through the mains 11^a, 12^a and 13^a and has its field 14^a supplied by the exciter 93 and adjustable by the manual rheostat 94. In circuit with the field winding 93^a of the exciter are the rheostat 15^a, and resistance sections 16 to 27 inclusive. The resistance sections 16 to 21 inclusive are controlled by the switches 28^a to 33^a inclusive, these resistance sections and switches corresponding to the resistance sections 17 to 20 and the switches 29 to 32 of Fig. 2. The switches 28^a to 33^a inclusive are operated by the solenoids 52^a to 63^a inclusive, arranged in pairs and corresponding to the solenoids 54 to 61 of Fig. 2. In Fig. 3, however, the two solenoids of a pair, instead of acting on a common core as in Fig. 2, act on separate cores 40^a and 40^b to 45^a and 45^b. The two solenoids of a pair are therefore shown slightly separated instead of being practically continuous as in Fig. 2. The switches 28^a to 33^a are arranged to be opened by the right hand solenoids and to be closed by the left hand solenoids, in this respect being exactly the reverse of the arrangement shown in Figs. 1 and 2. By means of the switches 72^b to 83^b, each right hand solenoid when it actuates its main switch also closes the circuit of the next corresponding solenoid

below and opens the circuit of the next corresponding solenoid above, and each left hand solenoid when it actuates its main switch also closes the circuit of the next corresponding solenoid above and opens the circuit of the next corresponding solenoid below. The switches 28ª to 33ª are prevented from stopping anywhere but in their extreme open or closed positions by means of springs 96ª to 101ª inclusive, acting on the switches through levers and links as shown, and are given a retarded action by dash-pots or other retarding means 84ª to 89ª inclusive.

The resistance sections 22 to 24 are normally short-circuited by switches 34 to 36 inclusive. These switches are biased to closed position, but are arranged to be opened by solenoids 64 to 66 inclusive acting respectively on cores 46 to 48 inclusive. The solenoids 64 to 66 are energized successively, for each solenoid besides opening its main switch also closes the circuit of the next solenoid to the left by means of the switches 102 to 104 inclusive. The resistances 25 to 27 inclusive are normally in circuit but are arranged to be short-circuited by switches 37 to 39 inclusive. These switches are biased to open position, but can be closed successively by the solenoids 67 to 69 inclusive acting on cores 49 to 51 inclusive to close their respective switches and also to close the circuit of the next solenoid to the right by means of the switches 105 to 107 inclusive. The circuits of the right hand solenoids 53ª, 55ª, 57ª, 59ª, 61ª, 63ª, 64, 65 and 66 are controlled by the relay 108, which is normally open, but is arranged to be closed when the circuit of its operating solenoid is completed upon rise in voltage by the engagement of arm 90 with the adjustable contact 91. The circuits of the left hand solenoids 52ª, 54ª, 56ª, 58ª, 60ª, 62ª, 67, 68 and 69 are controlled by the relay 109, also normally open, but arranged to be closed when the circuit of its operating solenoid is completed upon fall in voltage by the engagement of arm 90 with the adjustable contact 92. The arm 90 is controlled by a solenoid 71ª responsive to the voltage of the alternator 10ª, as by being connected across the mains 11ª and 12ª through transformer 95.

The operation of the system shown in Fig. 3 is as follows:—Assume that the parts are as shown. Upon fall of voltage below normal the arm 90 engages the contact 92 to cause the closing of relay 109. This relay upon closing completes the circuit of solenoid 69, and of the closing or left hand solenoids of the uppermost closed and lowermost open switches of the group of switches 28ª to 33ª inclusive, in this case solenoids 56ª and 58ª. The solenoid 69 is quick-acting and immediately closes its switch 39 and completes the circuit of solenoid 68, which in turn closes switch 38 and energizes solenoid 67 to close switch 37. The solenoid 58ª starts to close switch 31ª but is retarded in this by the dash-pot 87ª. The closing of switches 37 to 39 inclusive cuts out the resistance sections 25 to 27 and over-corrects for the fall in voltage, thus causing arm 90 to leave contact 92 and the relay 109 to open to deënergize all of the solenoids which it had before energized. If the variation in voltage is only momentary, the action ceases at this point, but if the tendency to decrease in voltage continues, the same set of actions is repeated a number of times in whole or in part, thus alternately cutting out and in the resistance sections 25 to 27 inclusive or part of them. Repeated energization of solenoid 58ª causes it to close its switch 31ª and to break the circuit of solenoid 56ª and complete the circuit of solenoid 60ª which latter solenoid in turn slowly closes its switch 32ª, breaks the circuit of solenoid 58ª, and completes the circuit of solenoid 62ª. This continues until enough of the resistance sections 16 to 21ª are cut out to exactly compensate for the tendency of the voltage to fall and until the voltage is restored to normal in a relatively permanent manner. When this result is obtained the repeated cutting in and out of the resistance sections 25 to 27 ceases and switches 37 to 39 are relieved of their work of correcting for the change in voltage. Upon rise in voltage the arm 90 intermittently engages with the contact 91 to close the circuit of relay 108, which controls the circuits of the right hand solenoids to repeatedly cut in and out the resistance sections 22 to 24 inclusive and to gradually cut in the resistance sections 21 to 16 inclusive until the voltage is restored to normal in a relatively permanent manner, when the switches 34 to 36 are relieved of their work of cutting in and out the resistance sections 22 to 24 inclusive. The switches 34 to 36 are biased to closed position by gravity or otherwise and will return to such position when their solenoids are deënergized while the switches 37 to 39 are biased to open position by gravity or otherwise and will return to such position when their solenoids are deenergized. The switches 28ª to 33ª will remain in either extreme position in which they are put, but on account of the springs 96ª to 101ª will not remain in any position save their extreme positions. Any of the well known means for preventing the springs 96ª to 101ª inclusive from getting on a dead center may be used. Upon either rise or fall of voltage the cutting in or out of the resistance sections 16 to 21 inclusive immediately commences at the proper point and gradually continues until the desired result is obtained. The field resistance is thus first repeatedly over-corrected for any change in voltage by the repeated cutting in of the resistances 22 to 24 or the repeated cutting out of the resistances 25 to 27, and if said changed condition

continues is then exactly corrected by the proper cutting in or out of the resistances 16 to 21 inclusive.

If desired the group of solenoids 64 to 66 may be simultaneously instead of successively energized upon rise in voltage and the group of solenoids 67 to 69 similarly simultaneously energized upon fall in voltage.

In Fig. 3 the various controlling solenoids are supplied with current from the exciter circuit, but obviously, if desired a battery could be used as shown in Fig. 1, and in Fig. 1 the controlling solenoids could be energized from the main circuit.

In Figs. 1 and 2, the two solenoids of each pair might be separated if desired and act on separate cores as in Fig. 3, while in Fig. 3 if desired, an arrangement corresponding to Figs. 1 and 2 could be used.

In Fig. 3 relays are used in controlling the circuits of the solenoids 52^a to 63^a and 64 to 69. This feature however is merely to reduce the current which the delicately adjusted magnetic switch 90 must carry, and if desired may be omitted from the arrangement shown in Fig. 3 or used in the arrangements shown in Figs. 1 and 2.

In Fig. 1 none of the solenoids 54 to 61 are cut out when they have done their work. In Fig. 2 each solenoid interrupts its own circuit when its work is completed, while in Fig. 3 each solenoid when it does its work interrupts the circuit of the preceding corresponding solenoid. These last two arrangements are to economize current and to minimize the sparking at the contacts which control these solenoids. Obviously, however, any of these three arrangements may be used in any of the figures.

In the claims, the term "any change" is intended to mean any change within the limits of sensibility of an electromagnetic switch and not to include mere infinitesimal changes. The term "continued change" is intended to mean any changed condition which does not immediately cease.

Many modifications and substitutions will readily occur to one skilled in the art and in the following claims I aim to cover all of those modifications which may be made without departing from 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 switches, two operating solenoids for each switch and connections whereby each of said solenoids when it operates its switch closes the circuit of the corresponding solenoid of the next switch.

2. In combination, an electric generator, resistance sections, a switch for each resistance section, a pair of magnets for each switch, and connections whereby the corresponding magnets of the pairs are successively energized upon variation in voltage to successively cut the resistance sections into or out of circuit to vary the field strength of the generator.

3. In combination, an electric generator, a plurality of resistance sections, a switch for each resistance section, two series of solenoids, each series having one solenoid for each of the switches, and means responsive to changes in the voltage of the generator and arranged to energize the solenoids of one series successively upon a rise in said voltage and the solenoids of the other series of the solenoids successively upon a fall in said voltage.

4. In combination, a dynamo-electric machine, a series of resistances for varying the field strength of said dynamo-electric machine, a series of switches in shunt respectively to the resistances, a series of solenoids arranged to be successively energized upon rise in voltage to successively actuate said switches in one direction, and a second series of solenoids arranged to be successively energized upon fall in voltage to successively actuate said switches in the other direction.

5. In combination, a series of switches, a solenoid for each switch when energized tends to close said switch, a second solenoid for each switch which when energized tends to open said switch, and connections whereby each solenoid when energized completes the circuit of the corresponding solenoid of the next switch.

6. In combination, a series of switches, a solenoid for each switch which when energized closes said switch, a second solenoid for each switch which when energized opens said switch, connections whereby each solenoid when energized completes the circuit of a corresponding solenoid of the next switch, and a controlling relay for said solenoids operated on variations in voltage in the controlled circuit.

7. In combination, a series of switches, a pair of solenoids for each switch, connections whereby each solenoid when it operates its switch closes the circuit of the corresponding solenoid of the next switch, and means for preventing each switch from stopping anywhere except in one of its extreme positions.

8. In combination, a series of switches, a pair of solenoids for each switch, and connections whereby each solenoid when it operates its switch closes the circuit of the corresponding solenoid of the next switch in advance and breaks the circuit of the corresponding solenoid of the next switch in the rear.

9. In combination, a series of separately actuated switches, some of which are biased to closed position, some to open position, and some arranged to remain in either open or closed position, and a voltage regulating device controlled by said switches.

10. In combination, an electric generator,

a plurality of resistances in the field circuit thereof, separately actuated switches in shunt respectively to said resistances, some of said switches being biased to open position, some to closed position, and some arranged to remain in either position.

11. In combination, a series of separately actuated switches, some of which are biased to open position, some to closed position, and some arranged to remain in either extreme position and there only, and a potential regulator controlled by said switches.

12. In combination, an electric generator, a plurality of resistances in the field circuit thereof, separately actuated switches in shunt respectively to said resistances, some of said switches being biased to open position, some to closed position, and some arranged to remain in either extreme position and there only.

13. In combination, a series of separately actuated switches, some of which are biased to open position, some to closed position, and some away from an intermediate position between closed position and full open position, and voltage regulating means controlled by said switches.

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

15. In combination, a series of magnetically operated switches, some of which are biased to closed position, some to open position, and some arranged to remain in either position, and voltage regulating means controlled by said switches.

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

17. In combination, a series of magnetically operated switches, some of which are biased to open position, some to closed position, and some arranged to remain in either extreme position and there only, and a potential varying device controlled by said switches.

18. In combination, an electric generator, a plurality of resistances in the field circuit thereof, magnetically operated switches in shunt respectively to said resistances, some of said switches being biased to open position, some to closed position, and some arranged to remain in either extreme position and there only.

19. In combination, a series of magnetically operated switches, some of which are biased to open position, some to closed position, and some away from an intermediate position between closed position and full open position, and a potential varying device controlled by said switches.

20. In combination, an electric generator, a plurality of resistances in the field circuit thereof, magnetically operated switches in shunt respectively to said resistances, some of said switches being biased to open position, some to closed position, and some away from an intermediate position between closed position and full open position.

21. In combination, an electric generator, a plurality of quick-acting switches for compensating for temporary changes in the potential of the generator, and a plurality of slow-acting switches for compensating for long-continued variations in said potential.

22. In combination, an electric generator, resistances arranged to be cut in and out to vary the field strength of said generator, a plurality of quick-acting switches responsive to momentary variations of the potential of the generator for cutting in and out some of said resistances, and a plurality of slow-acting switches responsive to long continued variations of the generator potential for cutting in and out others of said resistances.

23. In combination, an electric generator, a plurality of separately actuated quick-acting switches for compensating for temporary changes in the potential of the generator, and a plurality of separately actuated slow-acting switches for compensating for long-continued variations in said potential.

24. In combination, an electric generator, resistances arranged to be cut in and out to vary the field strength of said generator, a plurality of separately actuated quick-acting switches responsive to momentary variations of the potential of the generator for cutting in and out some of said resistances, and a plurality of separately actuated slow-acting switches responsive to long-continued variations of the generator potential for cutting in and out others of said resistances.

25. In combination, an electric generator, a plurality of quick-acting magnetic switches for compensating for temporary changes in the potential of the generator, and a plurality of slow-acting magnetic switches for compensating for long-continued variations in said potential.

26. In combination, an electric generator, resistances arranged to be cut in and out to vary the field strength of said generator, a plurality of quick-acting magnetic switches responsive to momentary variations of the potential of the generator for cutting in and out some of said resistances, and a plurality of slow-acting magnetic switches responsive

to long continued variations of the generator potential for cutting in and out others of said resistances.

27. In combination, an electric generator, a plurality of resistances in the field circuit thereof, quick-acting switches for cutting in and out some of said resistances, and slow-acting switches for cutting in and out others of said resistances.

28. In combination, an electric generator, a plurality of resistances in the field circuit thereof, quick-acting magnetic switches for cutting in and out some of said resistances, and slow-acting magnetic switches for cutting in and out others of said resistances.

29. In combination, an electric generator, a plurality of resistances arranged to be cut in and out to control said generator, quick-acting switches arranged for cutting in and out some of said resistances, slow-acting switches for cutting in and out others of said resistances, and means responsive to the generator voltage for controlling both the quick and slow acting switches.

30. In combination, an electric generator, a plurality of resistances arranged to be cut in and out to control said generator, quick-acting switches arranged for cutting in and out some of said resistances, slow-acting switches for cutting in and out others of said resistances, and means responsive to the generator voltage for controlling both the quick and slow acting magnetic switches.

31. In combination, a series of separately actuated switches, some of which act in quick succession and some in slow-succession, and a potential regulating device controlled by said switches.

32. In combination, a series of magnetically operated switches, some of which act in quick succession and some in slow succession, and potential regulating means controlled by said switches.

33. In combination, an electric generator, a plurality of resistances in the field circuit thereof, and a series of separately actuated switches in shunt respectively to said resistances, some of said switches acting in quick succession and some in slow succession.

34. In combination, an electric generator, a plurality of resistances in the field circuit thereof, and a series of magnetically operated switches in shunt respectively to said resistances, some of said switches acting in quick succession and some in slow succession.

35. In combination, an electric generator, and a plurality of switches for correcting for changes in the potential of said generator, some of said switches acting in quick succession and some in retarded succession.

36. In combination, an electric generator, and a plurality of magnetically operated switches for correcting for changes in the potential of said generator, some of said switches acting in quick succession and some in retarded succession.

37. In combination, an electric generator, resistances arranged to be cut in and out to vary the field strength of said generator, a plurality of switches arranged to cut in and out some of said resistances in rapid succession, and a plurality of switches arranged to cut in and out others of said resistances in retarded succession.

38. In combination, an electric generator, resistances arranged to be cut in and out to vary the field strength of said generator, a plurality of magnetically operated switches arranged to cut in and out some of said resistances in rapid succession, and a plurality of magnetically operated switches arranged to cut in and out others of said resistances in retarded succession.

39. In combination, an electric generator, resistances arranged to be cut in and out to vary the field strength of said generator, a plurality of switches arranged to cut in and out some of said resistances in rapid succession, a plurality of switches arranged to cut in and out others of said resistances in retarded succession, and means responsive to the generator voltage for controlling all of said switches.

40. In combination, an electric generator, resistances arranged to be cut in and out to vary the field strength of said generator, a plurality of magnetically actuated switches arranged to cut in and out some of said resistances in rapid succession, a plurality of magnetically actuated switches arranged to cut in and out others of said resistances in retarded succession, and means responsive to the generator voltage for controlling all of said switches.

41. In a system of electrical distribution, a plurality of separately actuated switches for momentarily correcting for any change in voltage in the system, and a plurality of separately actuated switches for gradually correcting for any continued change in voltage in a relatively permanent manner.

42. In a system of electrical distribution, a plurality of magnetically actuated switches for momentarily correcting for any change in voltage in the system, and a plurality of magnetically actuated switches for gradually correcting for said change in voltage in a relatively permanent manner if the tendency to said change in voltage continues.

43. In a system of electrical distribution, a plurality of separately actuated switches for momentarily over-correcting for any change of voltage in the system, and a plurality of separately actuated switches for gradually and exactly correcting for any continued change in voltage.

44. In a system of electrical distribution, a plurality of separately actuated switches for

momentarily correcting for any change in voltage in the system, a plurality of separately actuated switches for gradually correcting for any continued change in voltage in a relatively permanent manner, and means connected to the system for controlling all of said switches.

45. In a system of electrical distribution, a plurality of magnetically actuated switches for momentarily correcting for any change in voltage in the system, a plurality of magnetically actuated switches for gradually correcting for said change in voltage in a relatively permanent manner if the tendency to said change in voltage continues, and means connected to the system for controlling all of said switches.

46. In a system of electrical distribution, a plurality of separately actuated switches for momentarily over-correcting for any change of voltage in the system, a plurality of separately actuated switches for gradually and exactly correcting for any continued change in voltage, and means connected to the system for controlling all of said switches.

47. In combination, a generator, a plurality of separately actuated switches for momentarily correcting for any change in generator voltage, and a plurality of magnetically operated switches for gradually correcting for any continued change in voltage in a relatively permanent manner.

48. In combination, a generator, a plurality of magnetically operated switches for momentarily correcting for any change in generator voltage, and a plurality of separately actuated switches for gradually correcting for said change in voltage in a relatively permanent manner if the tendency to said change in voltage continues.

49. In combination, a generator, a plurality of magnetically operated switches for momentarily over-correcting for a change in generator voltage, and a plurality of magnetically operated switches for gradually and exactly correcting only for any continued change in voltage.

50. In combination, a generator, a plurality of separately actuated switches for momentarily correcting for any change in generator voltage, a plurality of magnetically operated switches for gradually correcting only for any continued change in voltage in a relatively permanent manner, and means responsive to the generator voltage for controlling all of said switches.

51. In combination, a generator, a plurality of magnetically operated switches for momentarily correcting for any change in generator voltage, a plurality of separately actuated switches for gradually correcting for said change in voltage in a relatively permanent manner if the tendency to said change in voltage continues, and means responsive to the generator voltage for controlling all of said switches.

52. In combination, a generator, a plurality of magnetically operated switches for momentarily over-correcting for any change in generator voltage, a plurality of magnetically operated switches for gradually and exactly correcting for any continued change in voltage, and means responsive to the generator voltage for controlling all of said switches.

53. In a system of electrical distribution, a plurality of quick-acting switches for momentarily correcting for any change in voltage in the system, and a plurality of slow-acting switches for gradually correcting for any continued change in voltage in a relatively permanent manner.

54. In a system of electrical distribution, a plurality of switches acting in rapid succession for momentarily over-correcting for a change in voltage in the system, and a plurality of switches acting in retarded succession for exactly correcting for said change in voltage.

55. In a system of electrical distribution, means for momentarily correcting for any change of voltage in the system, and a plurality of switches for gradually correcting for any continued change in a relatively permanent manner.

56. In combination, a generator, means for momentarily over-correcting for any change in generator voltage, and a plurality of separately actuated switches for gradually and exactly correcting for any continued change in voltage.

57. In combination, a generator, quick-acting means for momentarily correcting for any change in generator voltage, and a plurality of slow-acting switches for gradually correcting for any continued change in voltage in a relatively permanent manner.

58. In combination, a generator, quick-acting means for momentarily over-compensating for any change in generator voltage, and a plurality of switches acting in slow succession for gradually and exactly correcting for any continued change in voltage.

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

HERMON L. VAN VALKENBURG.

Witnesses:
GEO. B. SCHLEY,
FRED J. KINSEY.