No. 769,342.

PATENTED SEPT. 6, 1904.

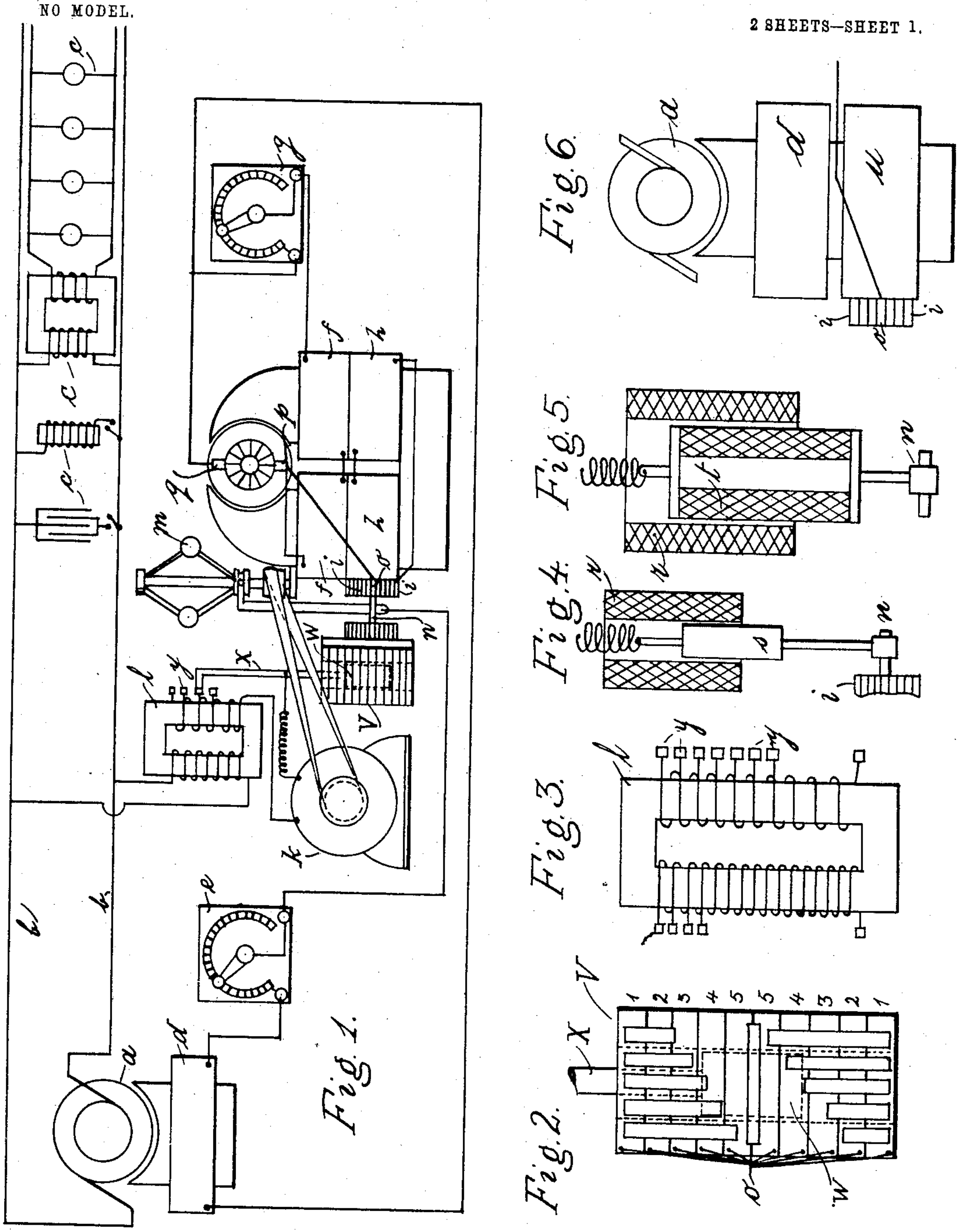
L. GUTMANN.

METHOD OF REGULATING ALTERNATING CURRENT GENERATORS AND CIRCUITS.

APPLICATION FILED JUNE 29, 1901.

NO MODEL.

2 SHEETS—SHEET 1.



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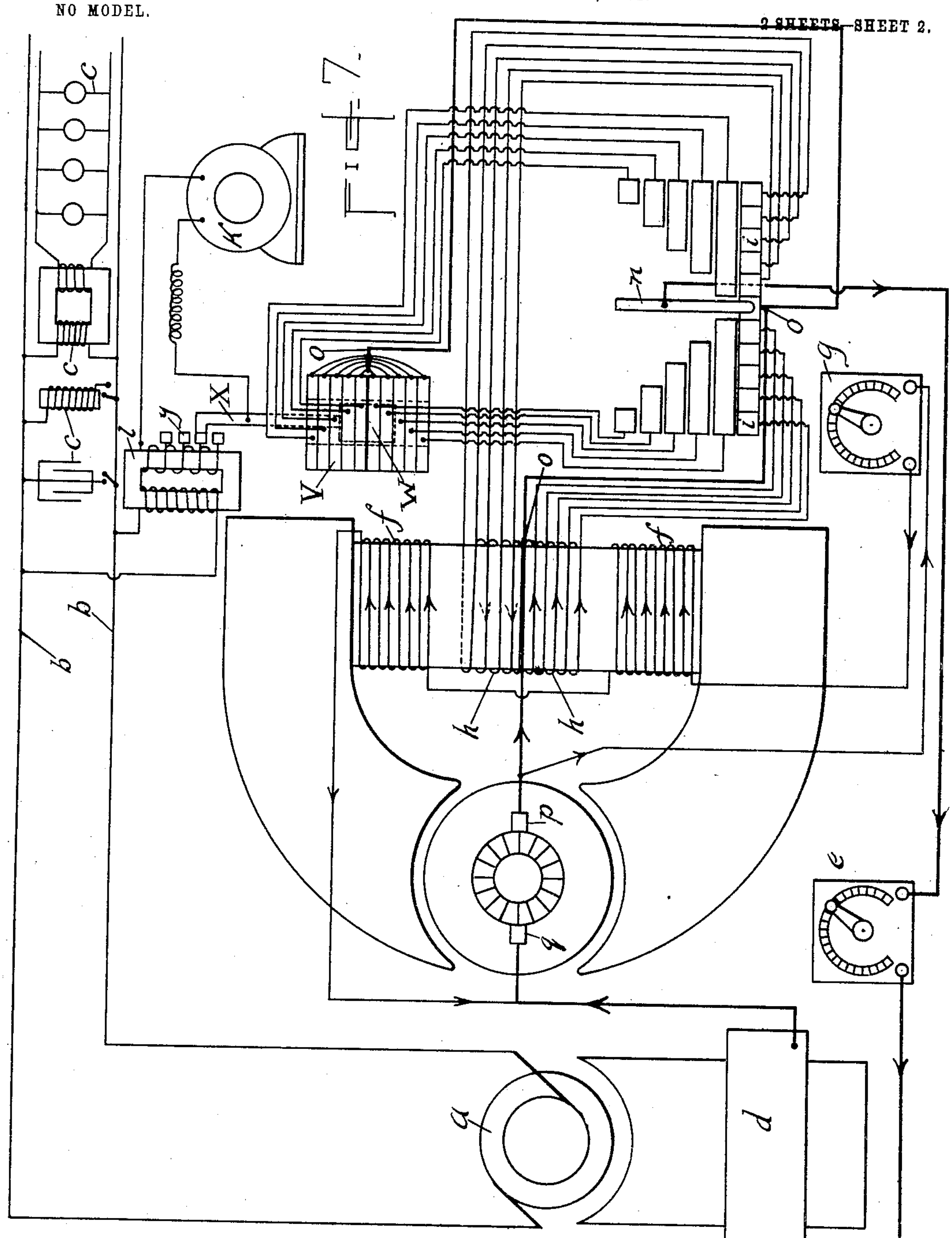

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No. 769,342. Patented September 6, 1904.

UNITED STATES PATENT OFFICE.

LUDWIG GUTMANN, OF PEORIA, ILLINOIS.

METHOD OF REGULATING ALTERNATING-CURRENT GENERATORS AND CIRCUITS.

SPECIFICATION forming part of Letters Patent No. 769,342, dated September 6, 1904.

Application filed June 29, 1901. Serial No. 66,500. (No model.)

To all whom it may concern:

Be it known that I, LUDWIG GUTMANN, a citizen of the United States, residing at Peoria, in the county of Peoria and State of Illinois, have invented a new Method of Regulating Alternating-Current Generators and Circuits, of which the following is a specification.

My invention relates to a simple mode of maintaining a practically constant pressure on a circuit fed from an alternating, pulsating, or intermittent current source regardless of the reaction of phase displaced or wattless currents in the line and also to the modification of the construction of the alternator or exciter for accomplishing the desired end; and, lastly, my invention consists in means susceptible to the changes in the line, which are influenced either directly by phase-displaced currents or indirectly by the altered line-pressure due to said currents for accomplishing the desired regulation.

The invention is set forth also in the claims, which are broader than the general description given below, and I refer to the claims forming part of this specification as describing specifically as well as generically the essence and novelty of my invention.

It is a well-known fact that currents displaced in phase, such as are produced by devices having reactance connected to a circuit, react on the alternator-armature and the latter on its field. If the nature of the consumption devices causes lagging components, the armature demagnetizes and weakens its field-magnets, and the armature-conductors cutting a flux less in strength than required for normal pressure cause the terminal voltage to drop, while when these component currents are leading with respect to the armature-current the latter produces a strengthening of the field-magnets whose flux is cut by the armature-conductors, resulting in a rise of pressure at the armature-terminals.

The purpose of the present invention is to maintain a practically constant terminal pressure regardless of the nature of the reaction on the generator of the translating devices connected to the distribution-circuit. This is accomplished by automatically readjusting the pressure when changed from normal, raising it to normal if due to lagging currents, the voltage drops, or lowering it if due to leading currents or capacity effects the voltage rise above normal.

A further purpose of my invention consists in compounding for variations of load and overload and overcompensating or overcompounding the alternator to overcome the reaction due to the self-induction or capacity of the line. I accomplish this result by inexpensive and simple means readily applied to any system.

My invention consists in varying the field ampere-turns of the exciter in such a manner that its armature-current supplies such an excitation to the field-magnet of the alternator that the field-magnet furnishes the required flux for the armature-conductors at normal speed in spite of the armature reaction to produce the normal effective pressure at the armature-terminals.

The nature of my invention will be understood more clearly by referring to the description, in connection with the drawings, in which—

Figure 1 shows the organization in diagram. Fig. 2 shows a novel form of controlling-solenoid. Fig. 3 shows a preferred form of transformer. Figs. 4 and 5 are modified controllers over that shown in Fig. 1, and Fig. 6 shows in diagram a part of the invention applied to an alternator instead of to the exciter. Fig. 7 is an amplified diagram of the circuits of the apparatus shown in Fig. 1 and illustrates more fully the circuits of the regulator and exciter shown in said figure.

In Fig. 1 the armature *a* of the alternator is connected to the main line *b b*, supplying current to translating devices *c*, inductive as well as non-inductive or possessing capacity. *d* is the alternator field-energizing winding, which is connected with a specially-constructed exciter. Its shunt field-coils *f* may include in their circuit the rheostat *g*. Additional coils *h* are provided on the magnet-core of the exciter. These may constitute an additional shunt-winding or else a series winding. The winding *h* acts partly with and partly differentially to the shunt-energizing winding. A certain number of turns of this winding act when energized by a current due to the position of contact n with relation to terminal o to produce a flux in the same direction as the shunt flux, and the remaining turns located on the opposite side of terminal block o when energized by a current due to the changed position of contact n relatively to o will produce a flux opposed to that of the shunt-winding, as is well understood in the art. Depending on the predominance of the reaction due to lagging or leading currents of the line and their relative values, the compensating turns and relative number are determined. For convenience it may be assumed that the winding h is a series winding and carries the total armature-current. The winding is subdivided and each subdivision provided with a contact-terminal i. k is any suitable motor—for instance, a series motor—which may be of small capacity and which is connected to the main line b through the transformer l or otherwise connected thereto so as to be responsive to variations in the voltage on said line. This motor operates a centrifugal governor m, which carries the movable contact-arm n over the terminals i. Let o be the terminal to which the exciter-brush p is connected and the series coils be so wound that the magnetic flux of the part below o will assist the shunt-winding by strengthening the magnets of the exciter and the portion above contact o produce when included in the circuit a flux opposed to that of the shunt-winding, thereby weakening the magnet excitation. The external circuit of the exciter when n makes contact with o will be as follows: The current travels over brush p, contact o, traveling arm n, series rheostat e, exciting-spool d of alternator, and brush q back to the armature. In this position no series winding is in the circuit and the exciter works with the shunt alone. This is the condition for normal voltage on non-inductive loads. The motor k runs at its normal speed and due to the extended governor-balls holds n in contact with o. If now, due to inductive load, the line voltage drops, the speed of the motor will fall, the governor-balls will close somewhat, and arm n contacts with the terminals below o, introducing a number of series turns, thereby increasing the ampere-turns of excitation on the field-magnet, which in turn raise the voltage at the brushes of the exciter. The increased pressure causes a heavier current to flow round the alternator field-winding d, thereby presenting to the alternator-armature a heavier flux, which induces an increased voltage at its terminals. To prevent the motor from seesawing back and forth, due to the moving contact n, a differential electromagnet v (see Fig. 2) of peculiar design is placed also in contact with arm n. v is an electromagnet consisting of coils superimposed upon one another, having one of their terminals joined and the others open, but so arranged that the descending arm n will place them in parallel. The middle terminal is connected to terminal o, and if now arm n is cutting in more compensating turns on the field it places more coils of solenoid v in parallel to these series turns, and the more of these coils are placed in parallel the lower is their resistance and the heavier becomes the current flowing through them with the increase of ampere-turns of coils h. The magnet-core w of this solenoid v is connected with an arm x, making contact with subdivisions of the transformer l, whose secondary supplies motor k. The calibration of the solenoid is so adjusted that the pull of magnet v changes the secondary turns in circuit with the motor so as to maintain the same voltage as was produced by the armature reaction on the circuit. For instance, assuming that the regulating-motor or other controller device is operated by current from a potential-reducing transformer, before the reaction of the alternator-armature the line voltage was, say, one thousand, that of the secondary of one hundred. Due to inductive load the line voltage drops to, say, nine hundred, that at the secondary to ninety, volts. The ampere-turns cut in at the field at h exert a pull at solenoid v by the shunted current as to reduce the transformer ratio, so that at normal pressure the secondary would show but ninety volts, and although the current in the line is raised again to one thousand volts by means of the compensating-winding h the motor maintains the lower speed until, due to the change in the line-currents and armature reaction, the voltage rises or falls. If it falls, more series turns are added to the excitation and more coils are placed in parallel in solenoid v to reduce the terminal voltage of the motor. If the line voltage rises, the motor speed increases, arm n reduces the exciter excitation and increases the voltage on the regulating-motor k. If capacity or currents leading with respect to the currents of the alternator are on the line, the pressure would rise above normal, the motor speed would rise, and arm n with it. It will make contact above o with turns tending to demagnetize the field. This causes a weakening of the exciter field-magnet, a reduction of pressure at the brushes, weaker excitation of coil d on the alternator, and a reduction at the alternator-terminals until again the normal effective pressure is reached. The core in magnet v is attracted upward, coils are placed in parallel, and the secondary voltage is held high as long as demagnetizing-currents are required.

As will be seen, the device for changing the number of turns on the secondary is but a convenient and well-known means of adjusting the voltage on the terminals of the motor k or other electroresponsive device, and it would be within my invention to use other means for adjusting or modifying the current-flow in said motor or other electroresponsive device or otherwise modifying its action, so that it shall maintain its changed condition so long as the line conditions as to lagging or leading components require a change of alternator excitation.

It is desirable to be able to over-compound the system or to compensate not only for the reaction of the consumption devices, but also for the self-induction or capacity of the line, especially in installations where currents of large volume are transmitted. For this reason I prefer to use in connection with motor *k* a transformer *l*, (see Fig. 3,) whose ratio of primary and secondary turns may be varied and adjusted for each particular case. For a line having itself considerable self-induction the transformer may be adjusted for a potential so much above normal that the line reaction at full load is taken care of by the altered excitation of the exciter. If leading currents predominate on the line, the pressure furnished to the motor may be below normal and the intermediate variations due to reactions on the line are taken care of by the relative position of arm *n* and the introduction of a variable number of ampere-turns.

It is essential that the governor should respond quickly to variations of lagging and leading current influences, and any non-synchronous motor may be used that is designed to be readily affected by the slightest change in the line-pressure or phase-displaced currents. It may be mentioned here that the diagram refers to a single-phase system of distribution and that when speaking of "currents displaced in phase" or "lagging" or "leading" currents throughout this specification or claims the wattless components of the currents are referred to. However, this same mode of compensation, although shown in connection with a single-phase circuit and alternator, may be applied to bi and poly phase circuits and generators.

My invention is susceptible to numerous modifications. For instance, the motor and centrifugal regulator may be replaced by a simple electromagnet *r*, actuating the arm *n*, (see Fig. 4,) or the core *s* of that electromagnet may be substituted by another solenoid, *t*, (see Fig. 5,) or, again, the motive device may be of the biphase type, (not shown,) having one of its energizing-windings in series with the line, the other in shunt to the same, and its armature being actuated by the difference in phase between the two currents in the two circuits, as is well known and understood in the art. For the sake of clearness that mode has been presented in the drawings which, owing to its mechanical construction and changes of position due to variations, can be most readily explained and understood, although some of the other modes within the scope of the invention are preferred, due to their greater responsiveness and simplicity. Further, instead of making the exciter a compound-wound machine and the exciting-winding *d* of the alternator of sufficient section to safely carry the maximum exciting-current the matter may be reversed. The exciter may be built as a plain shunt-machine of ample capacity and the compound winding applied to the alternator as shown in Fig. 6. In this case winding *u* may be connected in parallel to *d* or in any other suitable way. The winding *u*, with contact-terminals *i*, is adapted to furnish additional ampere-turns, depending on the position of contact *n*, which, according to requirements, will assist the winding *d* or oppose it. The additional ampere-turns required for the alternator may readily be predetermined; similarly the pressure variation at different power factors. It is therefore evident that the subdivision of the windings *h* or *u*, as also the variations of transformer ratios, can readily be predetermined by methods well understood in the art, and the only device requiring experimental determination is the solenoid *v*, whose dimensions are influenced by the distance to be traveled by arm *x* and core *w* to make contact between extreme contacts *y*. It may also be mentioned conveniently at this place that while a variable-ratio transformer is shown the same may be substituted by an electromagnet in series with the motor, which mode of voltage control is well known and understood in the art. The additional excitation may be obtained from a second exciter, as is readily understood, and need not be referred to or shown in the drawings.

A single and common arm *n* is shown to make contact with the terminals of coils *h* and electromagnet *v*. It will be readily understood that each may be provided with its own contact-arm and, if necessary, may be made to travel not at the same rate of speed or through the same distance.

From the description preceding it will be clear that the regulator to perform its function correctly, although susceptible to the line-current pressure or current-character variations, its changes, and voltage variations, should be independent from that of the main line and subject to and controlled by the compensating circuit. Preferably the motor *k* is connected to a transformer or its pressure derived from one. This enables its pressure to be altered regardless of that of the line and the use of comparatively simple devices at low tension. The primary circuit of the transformer *l*, although connected half-way between alternator *a* and translating device *c*, may be attached, depending on circumstances, either in the central station, near the dynamo, or at the center of distribution, near the consumption devices, or at any intermediate point. The independent voltage control of the motor having been shown in its preferred form, such control as would be required for changing the pressure when the motor or motive device is included directly in the main line has been omitted for the sake of clearness. Any of the well-known methods giving similar or equivalent results as the transformer may be used. At normal non-inductive load the pressure at the motor-terminals would either be that of the line or a proportionate amount of the same, depending on the ratio of the transformer's windings. This fixed voltage relation at normal or unit power factor between the line and motor terminals is described in the claims as a pressure equal to one another, and a change above this ratio is called a "pressure above that of the line" and a change of the ratio below that pressure is designated as a "pressure below that of the line."

Lastly, so far I have described the method of automatic regulation for constant potential only in connection with the exciter of Fig. 1 and the alternators, Figs. 1 and 6. It is of course well known in the art that a similar alternator and exciter may be used in connection with the distributing system as a synchronous motor, which may send into the line leading phase-currents to exactly counterbalance those lagging currents sent into the line by the translating devices or else send lagging currents into it if the predominating wattless currents are leading. In such case the same mode of variable excitation of the synchronous motor may be used as described above. If the motor *k* be one directly susceptible to the currents in phase with their electromotive force and those which are out of phase therewith, the motor or motive device *k* may change its direction of motion. In this case the contacts *i* are preferably arranged in a horizontal plane instead of a vertical one, as shown, and the device to be preferred for actuating-lever *n* would be of the type shown in Patent No. 614,225, Fig. 15, granted to me November 15, 1898. However, the shunt-windings should be so constructed as to cause no lag or no appreciable lag due to its own construction when a pressure-current circulates with respect to the non-inductive current flowing in the series winding of the device. It is evident that with such construction the device will remain at rest as long as the current of the line is in phase with its electromotive force, as is well understood in the art. The application of this same regulation therefore provides means for maintaining a constant-power factor on the line—for instance, unit-power factor. This condition would as a result also produce constant pressure on the line. Therefore I do not wish to limit myself to the exact disposition and organization shown, nor do I desire to limit myself in the claims when referring to the excitation of the alternator to this specific form, having described the variable and automatic excitation in connection with the exciter, nor is it intended to convey the "constant pressure or potential" to mean this exclusively; but is intended to cover also unit or any constant power factor as well. The results are obtained by identical means and identical modes in the cases enumerated.

What I desire, therefore, to protect by Letters Patent is—

1. The herein-described method of maintaining an approximately constant voltage on an alternating-current distribution-circuit supplied by an alternator, energized by a suitable exciter, which consists in subjecting a circuit-controlling device to the variations of the effective voltage of said circuit, varying by its changes the field excitation of said exciter in an inverse manner to the voltage variation of the line, thereby changing the alternator-field excitation to the required amount for producing normal voltage at said armature-terminals, and maintaining a different voltage at the terminals of said circuit-controlling device from that of the circuit, so long as abnormal conditions prevail.

2. The herein-described method of maintaining constant voltage on an alternating-current circuit, including an alternator (whose field is energized by a suitable exciter), translating devices and a circuit-controller which consists in reacting with the variable line-pressure on said circuit-controller, thereby altering its normal condition, changing the ampere-turns excitation of the field of said alternator, and reacting with the alternator-field-exciting circuit upon said circuit-controller, to maintain a pressure at its terminals, substantially different from that of the line as long as a different excitation than the normal one is required, as and for the purpose described.

3. The herein-described method of maintaining constant voltage on an alternating-current line, including an alternator, translating devices and a circuit-modifying means interposed between said alternator, and its source of current-supply for exciting its field-coils, which consists in controlling said circuit-modifying means by the exciting-circuit, reducing the pressure at its terminals below that of the line with any increase of excitation and increase of lag or decrease in lead, and raising the pressure at its terminals above that of the line, with a decrease of field excitation and decrease of lag or increase of lead in said line.

4. The herein-described method of maintaining an approximately constant voltage on an alternating-current distribution-circuit which consists in subjecting a circuit-controlling device to the variations of voltage of said circuit, varying by its changes the field excitation of an exciter in an inverse manner to the voltage variations of the line, thereby changing the field excitation of an alternator connected to said circuit to the required amount for producing a normal voltage on

said circuit, and maintaining a different ratio of voltage at the terminals of said circuit-controlling device as compared with that of the circuit so long as abnormal conditions prevail.

5. The herein-described mode of obtaining a predetermined circuit control between a fixed normal excitation and a superimposed one, which consists in deflecting or shunting from the normal excitation variable currents through branch circuits and thereby influencing means adapted to control the production of a superimposed excitation.

6. The herein-described method of regulating the effective voltage of an alternator, influenced by lagging or leading currents of the circuit to which it is connected, which consists in altering the ampere-turns excitation on the exciter, to effect a change in opposition to that causing the change, sending the current produced by the altered magnetomotive force and pressure around the exciting-winding of the alternator, and maintaining and controlling said altered excitation by a separate circuit.

7. The herein-described method of maintaining the effective voltage of an alternator connected to a service-line, influenced by lagging or leading currents, which consists in influencing a regulator connected to the line by the changed pressure, caused by said currents, thereby altering the ampere-turns excitation on the exciter, to effect a change in opposition to that causing the change in pressure, and controlling said excitation as also the regulator terminal pressure by means actuated and controlled by currents from the exciter-circuit.

8. The herein-described method of maintaining the effective voltage of an alternator, connected to a service-line and influenced by lagging or leading currents, which consist in varying the ampere-turns excitation of an exciter by a device responsive to changes in the lagging or leading currents to produce an opposite change in field magnetization to that caused in the alternator by said line-currents, energizing said alternator with the exciter armature-currents generated in its modified field and controlling said alternator-field as well as the pressure at the terminals of the responsive device by additional means actuated by energy obtained from said exciter-energizing circuit.

9. The herein-described method of maintaining a fixed effective pressure on a line connected to an alternating-current source influenced by lagging or leading currents, which consists in changing a regulator from its normal condition by changing the line-pressure by means of said lagging or leading currents thereby varying the ampere-turns field excitation of the exciter of said source, inversely to the change in pressure on the line whereby a flux modification is obtained in the alternator-field, such that the useful flux of the field produces at the armature-terminals the same voltage as before the phase-displaced currents began to act and simultaneously controlling the terminal pressure of said regulator and said field excitation.

10. The herein-described method of compensating the pressure of an alternator, reacted upon by phase-displaced currents which consists in subjecting a regulator to the variation of the variable voltage, thereby changing its circuit connections with relation to the field-exciting winding of the exciter of said alternator, and controlling its position by said field-circuit.

11. The herein-described method of compensating the pressure of an alternator, reacted upon by phase-displaced currents which consists in subjecting a controlling device connected to the terminals of the alternator to the pressure variation produced, thereby altering its normal condition, in turn altering the ampere-turns of excitation of the exciter in a manner adapted to influence the alternator in exactly the opposite way as influenced by said phase-displaced currents, and simultaneously maintaining and controlling said excitation as well as the terminal pressure of said controlling device by means actuated by currents derived from said exciter.

12. The herein-described method of over-compensating an alternator, subject to the reaction of phase-displaced currents of a circuit, which consists in subjecting a regulating device connected directly or inductively to its circuit to a pressure normally higher than required for the reaction of the translating devices only, for virtually balancing the effect produced by said circuit, subjecting the pressure-adjusting device to the pressure variation of the line, thereby influencing the regulator and in turn altering the ampere-turns of the exciter-field excitation, substantially as described.

13. The herein-described mode of maintaining a constant voltage on an alternating-current distribution-circuit, supplied by an alternator energized by a suitable exciter, which consists in reacting with the line-current on a regulating device, changing it from normal, by said change modifying the ampere-turns excitation of said alternator, and also modifying the pressure controlling said regulating device.

14. The herein-described mode of maintaining approximately constant pressure on an alternating-current circuit, including an alternator subject to reactions from wattless currents, which consists in supplying translating devices and a regulator over said circuit, reacting with phase-displaced currents on said regulator, thereby modifying its condition, modifying a field excitation inversely to the reactions on the terminal pressure by means of said altered condition of said regulator, and

maintaining a different pressure on the terminals of said regulator from that of the circuit, after the normal voltage has been reëstablished, as and for the purpose described.

15. The herein-described mode of regulating the effective voltage of an alternator, influenced by lagging or leading currents of the circuit to which it is connected, which consists in altering the energy affecting a regulator connected to said circuit by the reaction of said phase-displaced currents on said alternator, modifying by means of the altered state of said regulator the field ampere-turns of said alternator, and separately controlling with the alternator-exciting circuit the terminal pressure of said regulator, substantially as described.

16. The herein-described mode of regulating the effective voltage of an alternator, influenced by lagging or leading currents or both, of the circuits, to which it is connected, which consists in altering the energy affecting a regulator connected to said circuit, by the reaction of the phase-displaced currents on said alternator and modfiying the circuit connections of said regulator with field-magnet-winding terminals, adapted to magnetize the field-magnets of said alternator.

17. The herein-described method of maintaining constant voltage on an alternating-current circuit, including an alternating-current generator, a regulator and translating devices which consist in reacting with some of the energy of the line, subject to phase-displaced currents, line-pressure variations or both, on said regulator, thereby varying it from normal condition, varying the alternator excitation by means of the modified regulator condition, and reacting upon the regulator by means of the modified excitation to maintain an energy-consumption through the same identical or approximately the same as that furnished by the line, prior to the variation of the alternator excitation.

18. The herein-described method of maintaining constant line-pressure on an alternating-current circuit, including an alternating-current generator, translating devices and a regulator, which consists in subjecting the regulator to the variations of the line between non-inductive and inductive loads, thereby causing suitable compensation of excitation of said alternator, and reacting on said regulator in a predetermined proportion to the alteration of the excitation from the same non-inductive load.

19. The herein-described method of maintaining constant pressure on an alternating-current circuit containing a source of alternating current, a regulator and translating devices which consist in subjecting said regulator to the line variations, caused by the introduction, operation and cutting out of such translating devices, thereby modifying circuit connections of said regulator, and reacting upon the said regulator by means of said modified circuit connections in a manner different from its effects on the generating source and circuit.

20. The herein-described method of maintaining constant line-pressure on an alternating, pulsating or intermittent current circuit, including an alternator, translating devices and a regulator, which consists in subjecting the regulator to the line variations, thereby changing some of its circuit connections, causing suitable modifications of the excitation of said alternator, and reacting upon said regulator by the amount of variation of excitation from normal, as and for the purpose described.

21. The herein-described method of maintaining constant line-pressure on an alternating-current line, containing an alternator, translating devices, a regulator and a transformer interposed between said regulator and said line which consists in subjecting said transformer and said regulator to the variations of the line, reacting thereby on said regulator and modifying circuit connections in exciting-circuit of said alternator, and in turn modifying by the amount of said exciting-circuit modifications, the ratio of the windings of said transformer, as and for the purpose described.

22. The herein-described method of maintaining constant line-pressure on an alternating-current line, containing an alternator, translating devices, a regulator and regulator-pressure adjuster, which consists in subjecting said regulator and pressure-adjuster to the variations of the line, thereby modifying the conditions of said regulator, changing thereby circuit connections in the exciter-circuit of said alternator and its excitation, and thereby modifying the pressure actuating said regulator.

23. The herein-described method of maintaining constant line-pressure on an alternating-current line, containing a generator, translating devices, a regulator and a regulator-pressure adjuster which consists in modifying the condition of said regulator by the variations in the line, thereby modifying circuit connections in the exciter-circuit of said alternator, and changing its excitation from a given normal and modifying by this difference of excitation the pressure actuating said regulator.

24. The herein-described method of maintaining constant pressure on an alternating-current circuit containing a generator, translating devices and a regulator, which consists in modifying the conditions of said regulator by pressure or energy variations in said circuit, thereby modifying the excitation of the generator from a given normal and modifying by this difference of excitation the energy actuating said regulator, to prevent pressure fluctuations.

25. The herein-described mode of maintaining constant pressure on an alternating, pulsating or intermittent current system of distribution, supplied by a suitable source and the latter energized by a suitable exciter, which consists in actuating a regulating device controlling the exciter-circuit by currents flowing in said system of distribution and reciprocally modifying the excitation or energy admittance to the winding or windings of said regulating device, by means under the influence of a current from said exciter.

26. The herein-described mode of maintaining constant pressure on an alternating-current circuit, including a generator, translating devices and a regulator which consists in reacting upon said regulator by said circuit, modifying the regulator and its connections in the exciting-circuit of said generator, shunting currents from said exciting-circuit in a given proportion to the difference of normal non-inductive load, and the same load at a given power factor and reacting with this energy upon said regulator.

27. The herein-described mode of maintaining constant pressure on an alternating-current circuit, including a generator, translating devices and a regulator, which consists in reacting with said circuit on said regulator, modifying its state, thereby changing circuit connections in the exciting-circuit of said generator, and reacting upon said regulator at a rate determined by the difference of the alternator excitation when supplying a non-inductive load, and when supplying an inductive or capacity load of the same watt output.

28. The herein-described mode of maintaining constant voltage on an alternating-current circuit including a generator, translating devices and a regulator which consists in subjecting said regulator to variations of pressure or current, or both of said circuit, thereby actuating the same from a normal state and modifying circuit connections in the generator-exciting circuit, and in consequence varying the ampere-turns excitation of said exciting-circuit, and reacting upon said regulator with the difference of ampere-turns excitation between normal non-inductive load and that required with inductive or capacity load.

29. The herein-described mode of maintaining constant voltage on an alternating-current circuit, including a generator, translating devices and a regulator which consists in subjecting said regulator to the influence of lagging currents in the circuit, thereby changing it from its normal state, changing circuit connections in the exciting-circuit of said generator, thereby increasing the ampere-turns excitation of said generator, thereby raising the line-pressure of the same to normal, and reacting with the difference of the increased excitation of said generator over normal excitation on said regulator, to maintain the reduced terminal pressure, despite the increased line-pressure as long as the increased amount of excitation is required.

30. The herein-described mode of maintaining practically constant line-pressure on an alternating-electric-current circuit, including a generator, translating devices and a regulator, which consists in subjecting said regulator to the influence of leading currents in the circuit, thereby changing it from its normal state, modifying circuit connections in the exciting-circuit of said generator, thereby decreasing the ampere-turns excitation of said generator and in turn reducing the line-pressure to normal, and reacting on said regulator, to maintain the activity of said regulator, equal to that before the altered exciter-circuit connections were established in spite of the altered line-pressure, and maintaining this reaction on said regulator so long as the modified excitation is required.

31. The herein-described mode of maintaining practically constant line-pressure on an alternating, pulsating or intermittent current circuit, including a generator, translating devices, and a regulator which consists in subjecting said regulator to the influence of phase-modified currents, thereby changing it from its state maintained under normal non-inductive load, modifying the excitation of said generator, reacting with the modified exciting-current on said regulator to maintain it in the condition that caused modification of said excitation, and maintaining this reaction on said regulator so long as the modified excitation is required.

32. The herein-described mode of reacting on a device at a predetermined ratio of a superimposed excitation to the normal excitation, which consists in carrying the superimposed current through an energizing-circuit, conveying from said circuit currents into another external circuit adapted to vary its ampere-turns at a predetermined ratio to that of the independent energizing-circuit, and reacting with this variable external circuit on said device, as and for the purpose described.

33. The method of regulating the pressure at the terminals of an alternator connected to a circuit, which consists in automatically maintaining its terminal pressure by field-flux modifications, increasing said flux with any increase of load, lag of current in the circuit or decrease of lead, decreasing said flux with a decrease of load, lag of current in the circuit or increase of lead, and maintaining the flux modifications by means under the influence of the exciter producing said flux modification, as long as out-of-phase currents flow in the external circuit of said alternator.

34. The herein-described method of counterbalancing the reaction of lagging or leading currents or voltage variations in a distribution-circuit, which consists in establishing changes in a supplemental circuit susceptible to the variations of said distribution-circuit pro-

ducing in a second supplemental circuit inductively related to said distribution-circuit, by the supplemental circuit named first, compensating reactionary forces and reacting with said second supplemental circuit on a controlling device adapted to act in a contrary sense on the two circuits first named.

35. The herein-described method of regulating reactions of lagging or leading currents or voltage in a main or distribution circuit, whose potential is controlled by an energizing or exciting circuit, which consists in influencing an intermediate supplemental circuit by the currents flowing in the main or distribution circuit, modifying the current flowing in said exciting-circuit in contrary sense to the change of potential at the terminals of said supplemental circuit and controlling the variations of the currents in the last two named circuits reciprocally substantially as described.

36. The herein-described method of controlling a generator for constant voltage or constant power factor, which consists in influencing a supplemental circuit, susceptible to line variations conductively or inductively connected with said generator, modifying by said supplemental circuit the current-flow in the exciting-circuit of said generator, and reacting with said exciting-circuit simultaneously and in contrary sense on said generator and said supplemental circuit.

37. The herein-described method of maintaining constant voltage on an alternating-current circuit, which consists in reacting with the variable-line pressure on a circuit-controller, thereby altering its normal condition, changing the ampere-turns excitation of the field of an alternator connected to the circuit, and reacting with the alternator field-exciting circuit upon said circuit-controller, to maintain its pressure at its terminals, whose ratio compared to that of the line is different from the normal ratio so long as a different excitation than the normal one is required, as and for the purpose described.

38. The herein-described mode of maintaining approximately constant pressure on an alternating-current circuit, including an alternator subject to reactions from wattless currents, which consists in supplying translating devices and a regulator over said circuit, reacting with phase-displaced currents on said regulator, thereby modifying its condition, modifying a field excitation inversely to the reactions on the terminal pressure by means of said altered condition of said regulator, and maintaining a pressure on the terminals of said regulator, whose ratio as compared with that of the circuit, is different from that prevailing under normal conditions of the circuit so long as abnormal conditions prevail, as and for the purpose described.

39. The herein-described method of compensating for the reactions produced by phase-displaced currents, consisting in subjecting a controlled device to the effective pressure variations on the circuit thereby altering its normal condition, in turn altering the ampere-turns of an exciting-coil in a manner adapted to influence an alternator connected to the circuit of said currents in exactly the opposite way to said phase-displaced currents and simultaneously maintaining and controlling said excitation and the terminal pressure of said controller device.

40. The herein-described method of compensating the pressure of an alternator reacted upon by phase-displaced currents consisting in subjecting a controlled device to the effective pressure variations on the circuit thereby altering its normal condition, in turn altering the ampere-turns of an exciting-coil in a manner adapted to influence the alternator in exactly the opposite way to said phase-displaced currents and simultaneously maintaining and controlling said excitation and the terminal pressure of said controller device.

41. The herein-described method of compensating for the reactions of lagging or leading currents or voltage in a main or distributing circuit upon the field of an alternator supplying said circuit, consisting in changing a controller or regulator device from its normal condition by means of said lagging or leading currents thereby modifying its condition, and modifying thereby the field excitation of an alternator connected to the circuit and maintaining the modified condition of said regulator device so long as the abnormal conditions prevail on the circuit as and for the purpose described.

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

LUDWIG GUTMANN.

Witnesses:

Frank S. Fulton,

C. E. Comstock.