No. 641,322. Patented Jan. 16, 1900.

M. PFATISCHER.

METHOD OF REGULATING ELECTRIC CIRCUITS.

(Application filed July 7, 1899.)

(No Model.) 4 Sheets—Sheet 1.

FIG. 1.

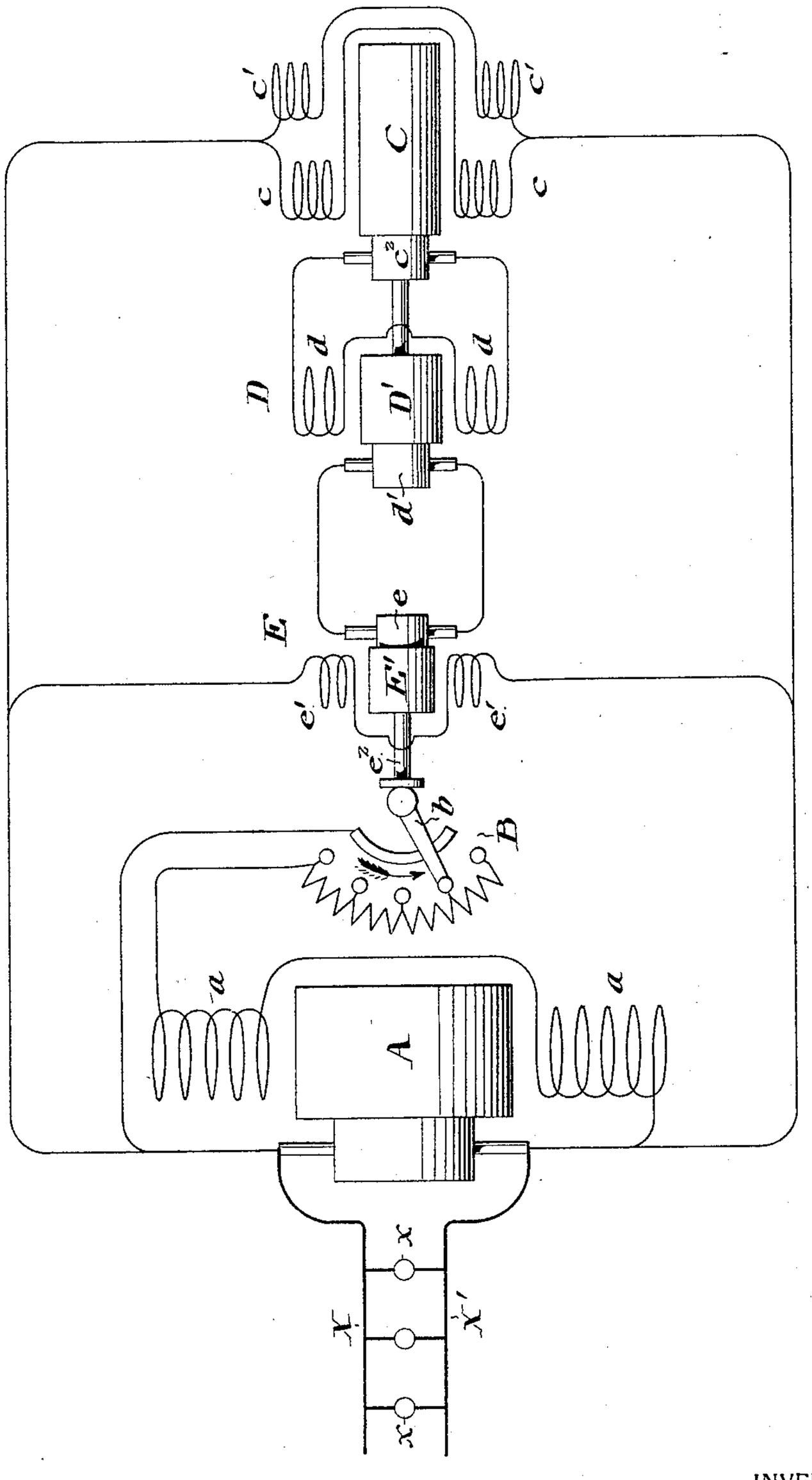

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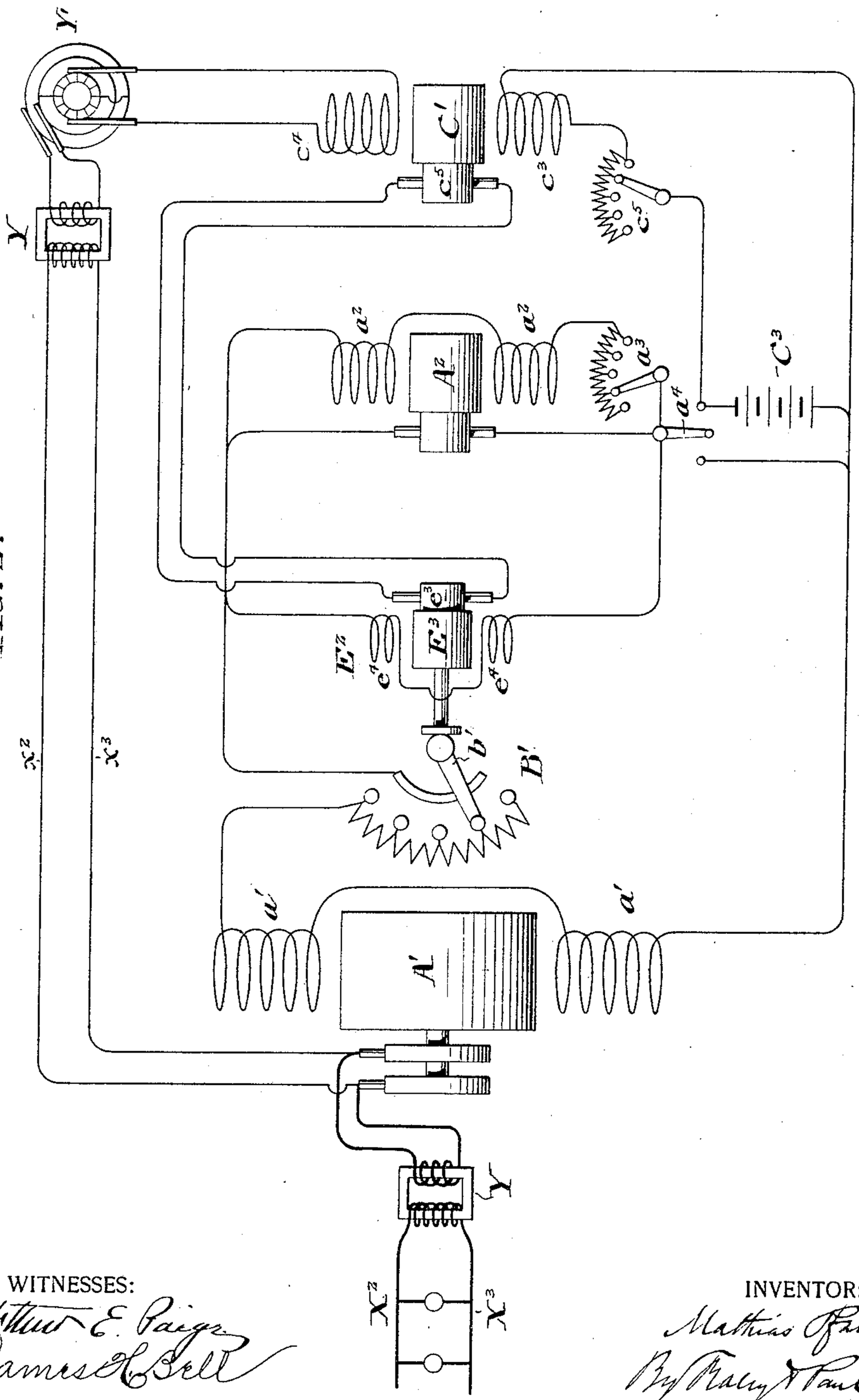
FIG. 2.



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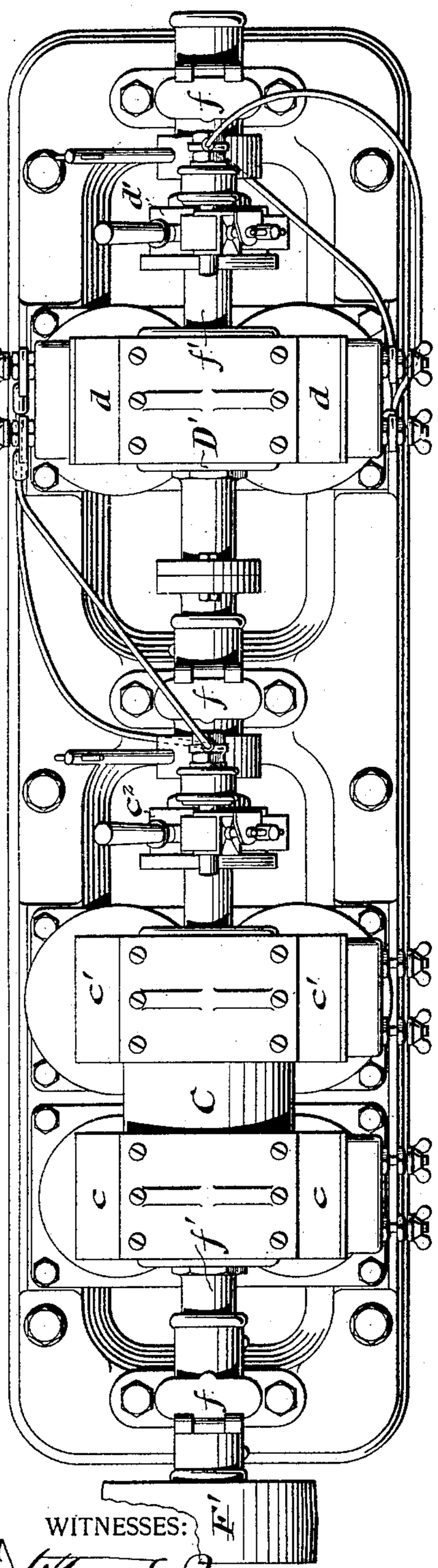

FIG. 3.

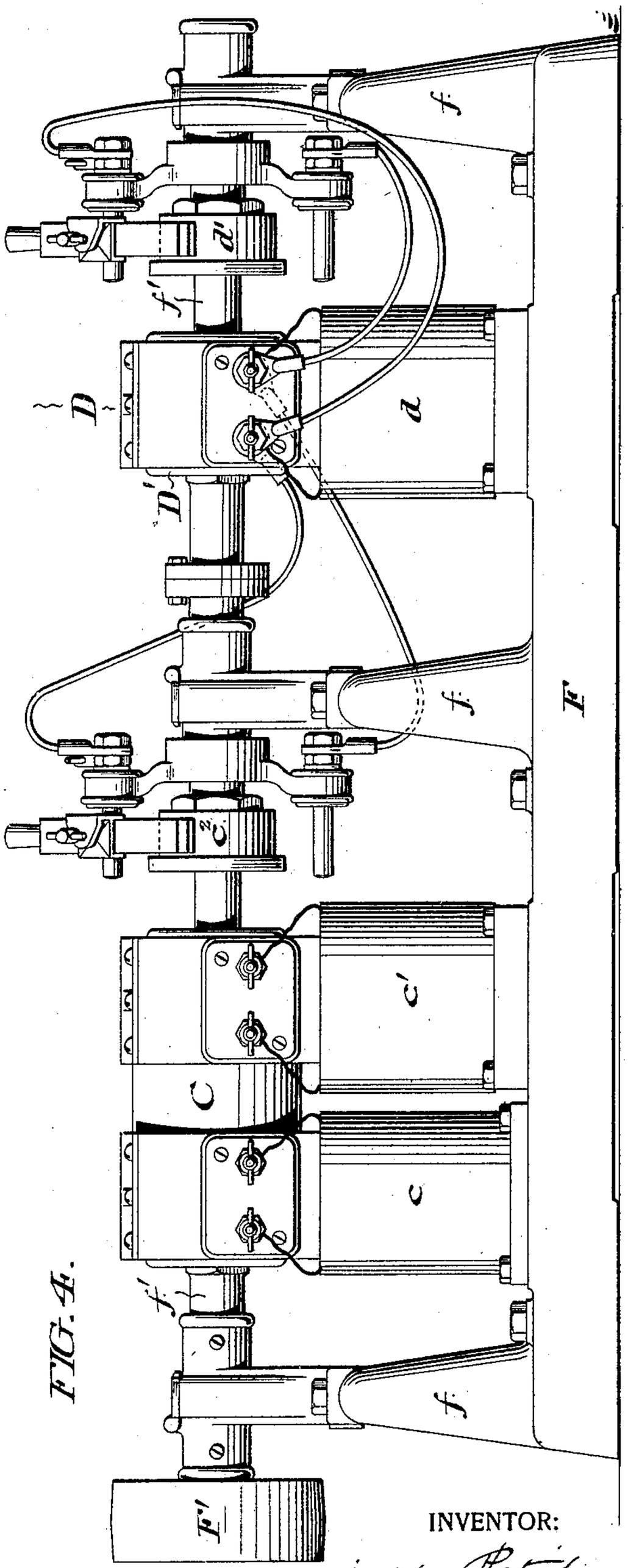

FIG. 4.

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(No Model.) 4 Sheets—Sheet 4.

FIG. 5

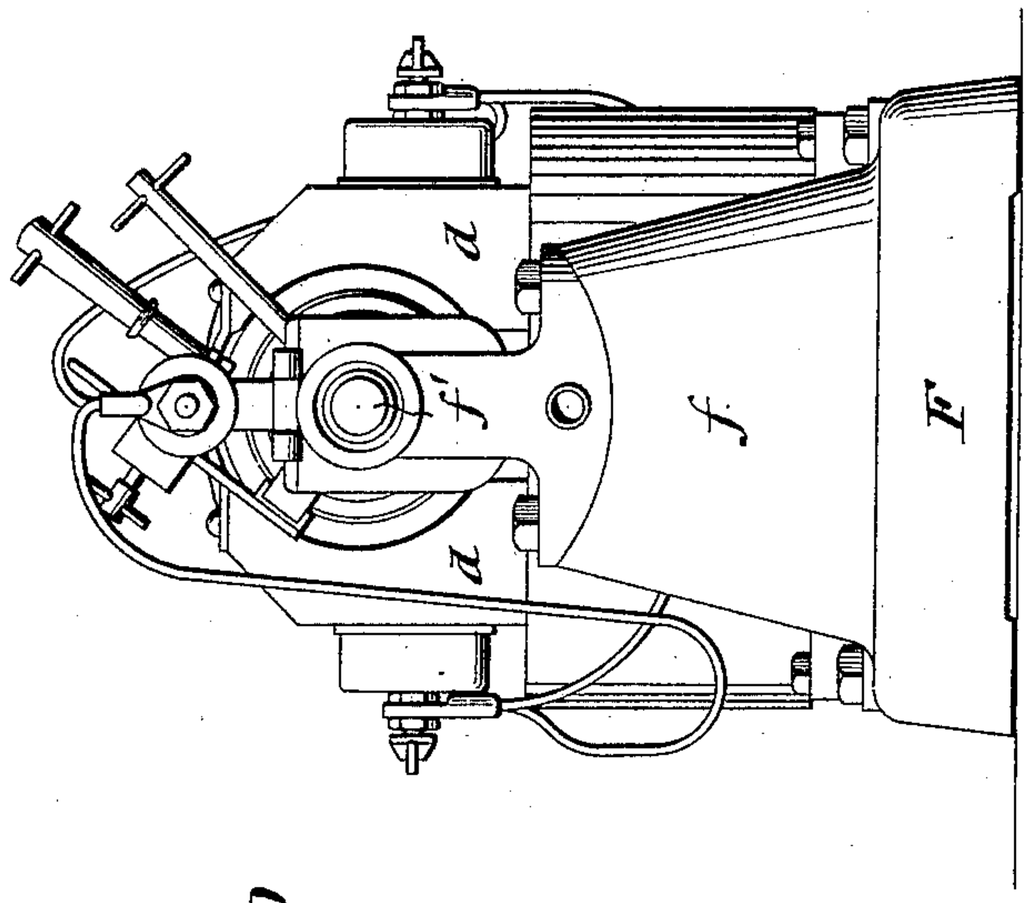


FIG. 10.

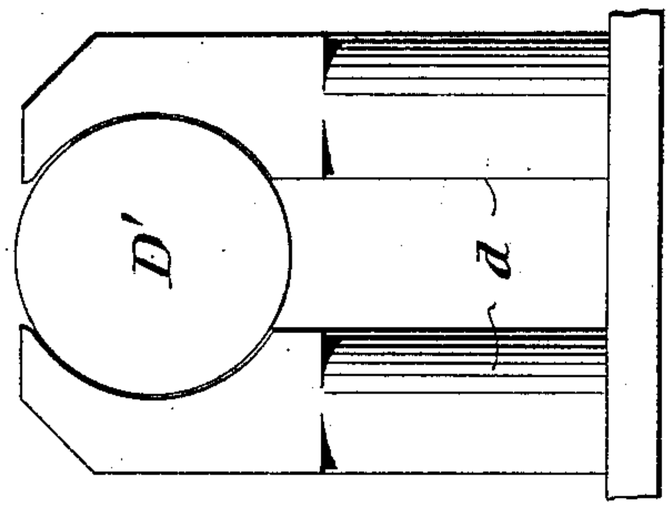


FIG. 11.

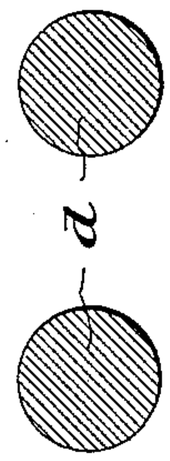


FIG. 8.

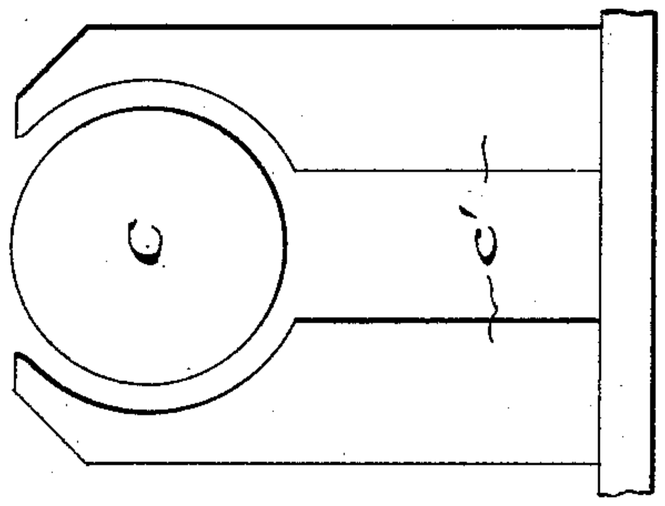


FIG. 9.

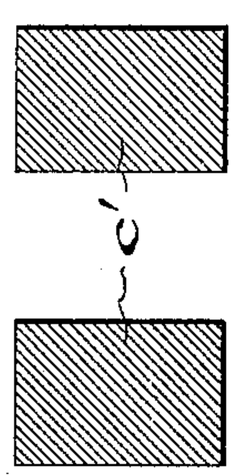


FIG. 6.

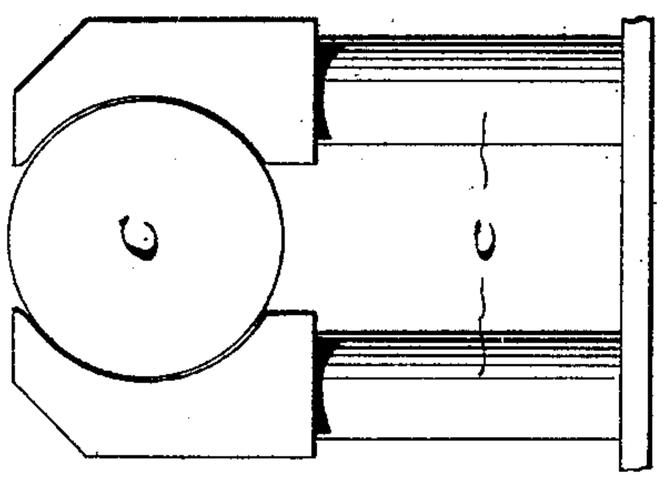
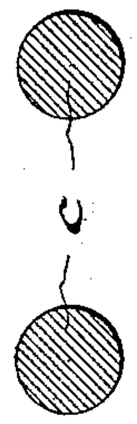


FIG. 7.



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UNITED STATES PATENT OFFICE.

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METHOD OF REGULATING ELECTRIC CIRCUITS.

SPECIFICATION forming part of Letters Patent No. 641,322, dated January 16, 1900.

Application filed July 7, 1899. Serial No. 723,034. (No model.)

To all whom it may concern:

Be it known that I, MATHIAS PFATISCHER, of Philadelphia, in the State of Pennsylvania, have invented certain new and useful Improvements in Methods of Regulating Electric Circuits, whereof the following is a specification, reference being had to the accompanying drawings.

The ultimate object of my invention is to regulate the flux in an electric circuit in accordance with the demands upon the latter, so as to maintain a substantially constant voltage in said circuit despite variations in the amount of energy therein utilized.

For a typical illustration of the invention I have indicated the method of regulation as applied to a circuit through the mediation of the generator which supplies the current thereto, and I have also selected a rheostat of the ordinary movable contact-lever type included in the field-circuit of the generator as a typical device by which the regulation may be effected. It is to be understood, however, that the regulation need not be effected in this particular manner and also that the term "regulator" (hereinafter applied to such rheostat) is equally comprehensive of any device comprising a movable member whose motion serves to modify the flux in an electric circuit.

Generally stated, the embodiment of my invention consists in a system of coördinated devices, whereby the actuation of the regulator is accomplished, such actuation being effected by means of an electric motor driven by an independently-generated current whose polarity (and the consequent rotation of the motor in one direction or the other) is determined by variations above or below the normal voltage in the circuit to be regulated. The mode of operation whereby said motor-current is independently generated may be stated, broadly, as consisting in the proper subjection of a positively-rotated armature to the influence of opposing magnetic fields, said fields being so related to one another and to the line-circuit as that under normal conditions of the latter they shall balance one another, and thus fail to affect the armature, while any variation from the normal in said line-circuit shall modify one of said fields to a relatively greater extent than the other, and thus create a magnetic preponderance either in favor of or against the modified field. Such preponderance will affect the armature in a direction and to an extent corresponding with the differential value of the opposed fields, and consequently the rotation of said armature will develop a current in one direction or the other, according to the nature of said differential. As the resultant armature-current directly due to said differential field influence is necessarily minute it is preferably not immediately applied to the movement of the regulator, but is utilized as an excitant for the fields of an auxiliary dynamo whose armature is maintained in continuous rotation, but whose field is neutral save when thus excited, and the current generated by said auxiliary dynamo upon excitation of its field is utilized as the motor-current for effecting the actuation of the regulator.

Within the limits of the general system just outlined it will be found that there are various possible modifications in detail, and I have therefore in the foregoing general statement ignored those details wherein chiefly variations are to be found.

The main principle upon which the invention depends is the creation of a preponderance in one or the other of two normally-balanced magnetic fields, as the manifestation of variations in the circuit to be regulated and the utilization of the preponderant field for the production of a current which indirectly or directly shall afford a motor-current for the regulator.

In the accompanying drawings, Figure 1 diagrammatically illustrates the application of my invention to a shunt-wound dynamo adapted for the production of direct currents. Fig. 2 diagrammatically illustrates the application of my invention to a dynamo having a separately-excited field and adapted for the production of alternating currents. Fig. 3 is a plan view of a convenient embodiment of the opposed fields and auxiliary dynamo comprised in my invention. Figs. 4 and 5 are respectively side and end elevations of the structure shown in Fig. 3. Figs. 6 to 11, inclusive, show convenient relative proportions of the opposing normally-balanced fields and the field of the auxiliary dynamo.

Referring to Fig. 1, A is the dynamo whose output to the line-circuit X X′ is to be regulated, and *a* is the field of said dynamo, which is in shunt relation with said line-circuit and includes the rheostatic regulator B. The armature C is common to the differential opposing fields *c c′* and is continuously rotated. Both of said fields *c c′* are in shunt relation with the line-circuit X X′, but are so wound as to be oppositely polarized, and in the normal condition of the line-circuit X X′ balance one another, and thus fail to affect the armature C. Said fields *c c′* are so related that the normal current therein derived from the line-circuit X X′ exceeds the limit of saturation of the magnetic circuit of the field *c* by an amount sufficient to permit of the desired range of fluctuation above said limit, and said normal current is so much less than is sufficient to saturate the magnetic circuit of the field *c′* as to permit of the desired range of fluctuation below said limit of the latter, and therefore variations in the voltage of the line, and consequently in the shunt-current supplied to both of said fields, materially affect the magnetic flux in the field *c′*, while the magnetic flux in the field *c* remains substantially constant, and each variation in the line-circuit is thereby manifested in a magnetic preponderance either in favor of the field *c′* as the voltage rises or against said field as the voltage falls.

The field *d* of the auxiliary dynamo D is connected with the commutator c^2 of the armature C, so as to be excited by any current generated in the latter, and the armature D′ of said dynamo D being continuously rotated any current in its field *d* suffices to deliver a current of much greater magnitude from its commutator *d′* to the commutator *e* and armature E′ of the motor E, whose field *e′* is separately excited by a shunt connection with the line-circuit X X′. The shaft e^2 of said motor E is mechanically connected in any convenient manner with the contact-lever *b* of the rheostat B, so that rotation of the shaft e^2 in one direction or the other effects a corresponding traverse of said contact-lever *b*.

The devices above described are calibrated in correspondence with the normal voltage of the line X X′, in which are any number of devices, such as lamps *x x*, which demand a certain supply of current from said line. If, therefore, one of said lamps is extinguished or the demand upon said circuit X X′ is otherwise lessened, the terminal voltage thereof rises, and a magnetic preponderance of the variable field *c′* with respect to the substantially constant field *c* is created, and the consequent magnetic flux through the rotating armature C enables the latter to excite the field *d* of the auxiliary dynamo D with such polarity that the current delivered from the commutator *d′* to the armature E′ of the motor E rotates the latter and shifts the contact-lever *b* of the regulator-rheostat B in the direction of the arrow upon Fig. 1.

The described movement of the regulator B causes a decrease in the current shunted through the field *a*, and in correspondence therewith the output of the dynamo A is decreased until equilibrium between the demands upon the line-circuit X X′ and the supply thereto is reached.

If the demands upon the line X X′ are increased, of course the terminal voltage thereof falls below the normal, and the magnetic flux through the variable field *c′* being thereby lessened a magnetic preponderance is created in favor of the substantially constant field *c*, so that the contact-lever *b* is shifted in the direction opposite to the arrow upon Fig. 1, and the output of the dynamo A is accordingly augmented.

The devices above described are grouped in the manner shown in Fig. 1 merely for clearness of diagrammatic illustration, and may of course be arranged in any convenient manner in practice. I have, however, shown in Figs. 3, 4, and 5 a convenient arrangement of the differential fields *c c′* and the field *d* of the auxiliary dynamo D upon a single bed-plate F, provided with bearing-standards *f* for the shaft *f′*, upon which are fixed the armature C, commutator c^2, armature D′, and commutator *d′*, so that said armatures and commutators may be continuously rotated by means of the band-wheel F′.

It is obvious that a difference in the magnetic saturation of the fields *c c′* may be secured by making the respective cores thereof of different cross-sectional area or by making a difference in the extent of the air-gap between the pole-pieces of the respective fields and the armature C. I prefer, however, to use both of said means to secure the desired result, and I have shown a convenient proportion of the parts in Figs. 6 to 9, inclusive, wherein it appears that the cores of the field *c* are much less in cross-sectional area than the cores of the field *c′* and that the air-gap resistance of the former is much less than that of the latter. Figs. 10 and 11 show the proportion of the field *d* which I have found it convenient to employ with differential fields *c c′* of the proportions illustrated in the preceding figures.

In the form of my invention above described the normally-balanced magnetic fields are both excited by a current directly shunted from the line-circuit, which the differential action of said field serves to regulate. It is obvious, however, that the source of excitation of said differential fields is immaterial, provided that said fields balance each other magnetically under normal conditions and respectively preponderate one over the other in accordance with the rise or fall of the voltage of the line-circuit from its normal state. In Fig. 2 I have diagrammatically illustrated a modified form of my invention arranged for the regulation of an alternating-current dynamo.

In Fig. 2 A′ is the dynamo whose output to

the line-circuit X^2 X^3 is to be regulated, and a' is the field of said dynamo, which is energized by a separate exciter A^2 of ordinary construction, the latter being provided with a shunt-wound field a^2 and the usual field-controlling rheostat a^3. The rheostatic regulator B′ is included in the circuit connecting the exciter A^2 with the field a'.

The armature C′ is continuously rotated with respect to the differential fields c^3 c^4, and the former is maintained substantially constant and the latter varied in accordance with fluctuations in the line X^2 X^3 by reason of the following arrangement: The field c^3 is excited by the storage battery C^3 and the magnetic flux therein determined by the rheostat c^5. As a matter of convenience I have arranged the battery C^3 so that it may be recharged from the exciter A^2 by way of the switch a^4. The field c^4 is excited by shunt connection with the line-circuit X^2 X^3, so that variations in the terminal voltage of the latter are manifested in an increase or decrease of the magnetic flux in said field. It being usual in alternating systems of wiring to distribute the current from the dynamo to the line-circuit through static transformers, I have indicated such devices at Y in the line-circuit X^2 X^3 and in the shunt-circuit x^2 x^3, and from the latter the alternating current is delivered to the field c^4 as a direct current through the medium of the synchronous rotary transformer Y′.

The operation of the differential fields c^3 c^4 is identical with that of the differential fields c c' previously described in that the magnetic flux through the field c^3 remains substantially constant, and each variation in the line-circuit is manifested in a magnetic preponderance either in favor of the field c^4 as the voltage rises or against said field as the voltage falls, and in accordance therewith the continuously-rotated armature C′ is enabled to deliver a current from its commutator c^5 to the commutator e^3 and armature E^3 of the motor E^2. The polarity of said current delivered to the motor-armature being determined by the magnetic preponderance of one or the other of said fields c^3 c^4, the contact-lever arm b' is caused to traverse in accordance therewith and effect an increase or decrease in the current from the exciter A^2 effective in the field a' of the dynamo A′, and thus regulate the output of the latter. The field e^4 of the motor E^2 is conveniently energized by shunt connection with the exciter A^2.

It is to be noted from the foregoing that whereas the normally-balanced differential fields may be excited from a common source, such as I have illustrated in Fig. 1, and be permanently calibrated without the use of a variable resistance, such as I have illustrated at c^5 in Fig. 2, yet the employment of the latter not only facilitates the initial calibration of the magnetic flux, but also permits of a considerable adjustment thereof.

It is obvious that without departing from the spirit of my invention various modifications may be made in the mode of applying the regulation to the line-circuit, in the character of the regulator, and in the embodiment of the normally-balanced or neutral field, which constitutes the essential feature thereof. I therefore do not desire to limit myself to the precise method or arrangement which I have illustrated.

I claim—

1. The hereinbefore-described method of operating the regulator of an electric line-circuit, which consists in the creation of a preponderance in one of a plurality of opposed normally-balanced magnetic fields, as the manifestation of variations in the circuit to be regulated; subjecting a rotating armature to the action of the preponderant field and thus generating a current in accordance with the differential value of said fields, and utilizing the current thus generated for the movement of the regulator, substantially as set forth.

2. The hereinbefore-described method of operating the regulator of an electric line-circuit, which consists in opposing two normally-balanced differential fields in such relation with a continuously-rotating armature that the magnetic preponderance of one of said fields, with respect to the other, shall produce a current of corresponding polarity in said armature; maintaining the magnetic circuit of one of said fields substantially constant; varying the magnetic circuit of the other of said fields in accordance with the fluctuations in the voltage of said line-circuit; and utilizing the resultant armature-current to shift said regulator, substantially as set forth.

3. The hereinbefore-described method of operating the regulator of an electric line-circuit, which consists in opposing two normally-balanced differential fields in such relation with a continuously-rotating armature that the magnetic preponderance of one of said fields, with respect to the other, shall produce a current of corresponding polarity in said armature; energizing both of said fields by shunt connection with said line-circuit, in such relation therewith that one of said fields shall be excited beyond its magnetic saturation limit, and that the other of said fields shall be excited below its magnetic saturation limit; and deriving from the differential magnetic flux of said fields, consequent upon variations in the voltage of said line-circuit, a current for shifting said regulator, substantially as set forth.

4. The hereinbefore-described method of operating the regulator of an electric generator, which consists in opposing two normally-balanced differential fields in such relation with a continuously-rotating armature that the magnetic preponderance of one of said fields, with respect to the other, shall produce a current of corresponding polarity in said armature; maintaining the magnetic circuit of one of said fields substantially con-

stant; varying the magnetic circuit of the other of said fields in accordance with fluctuations in the terminal voltage of said generator; exciting the field of an auxiliary electric generator by means of the resultant armature-current; actuating a motor by means of the current thereby generated; and shifting said regulator by the action of said motor, substantially as set forth.

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