No. 743,458. PATENTED NOV. 10, 1903.

E. E. F. CREIGHTON.

COMPENSATING SYSTEM.

APPLICATION FILED DEC. 20, 1902.

NO MODEL. 3 SHEETS—SHEET 1.

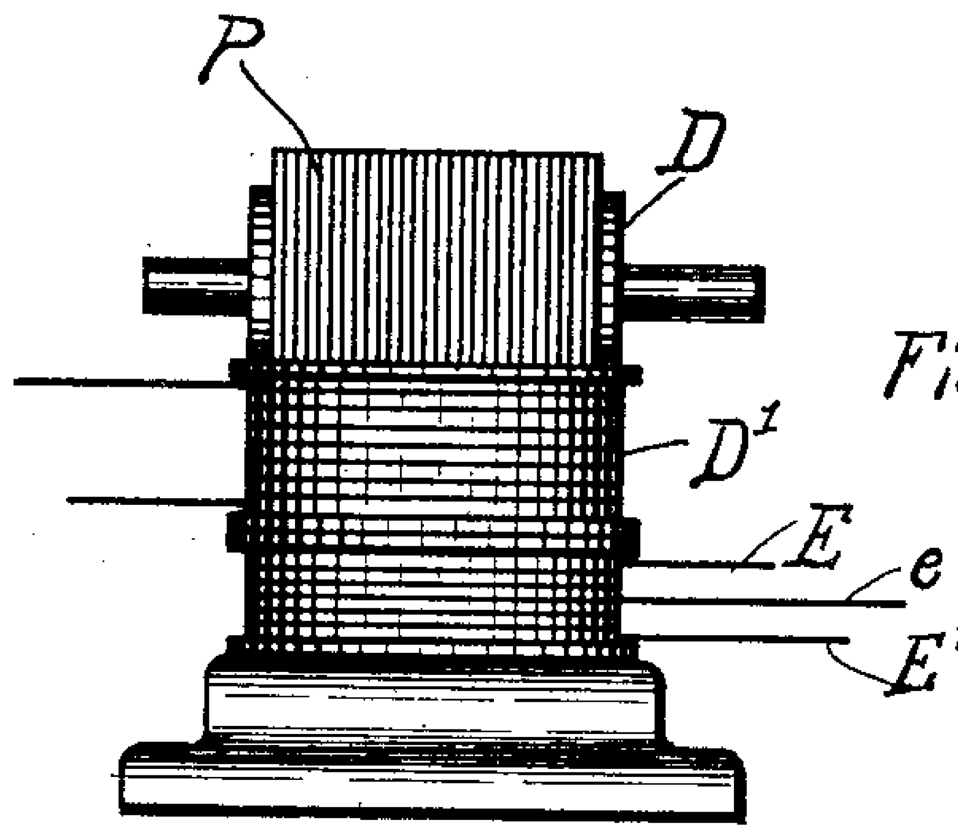

Fig. 4.

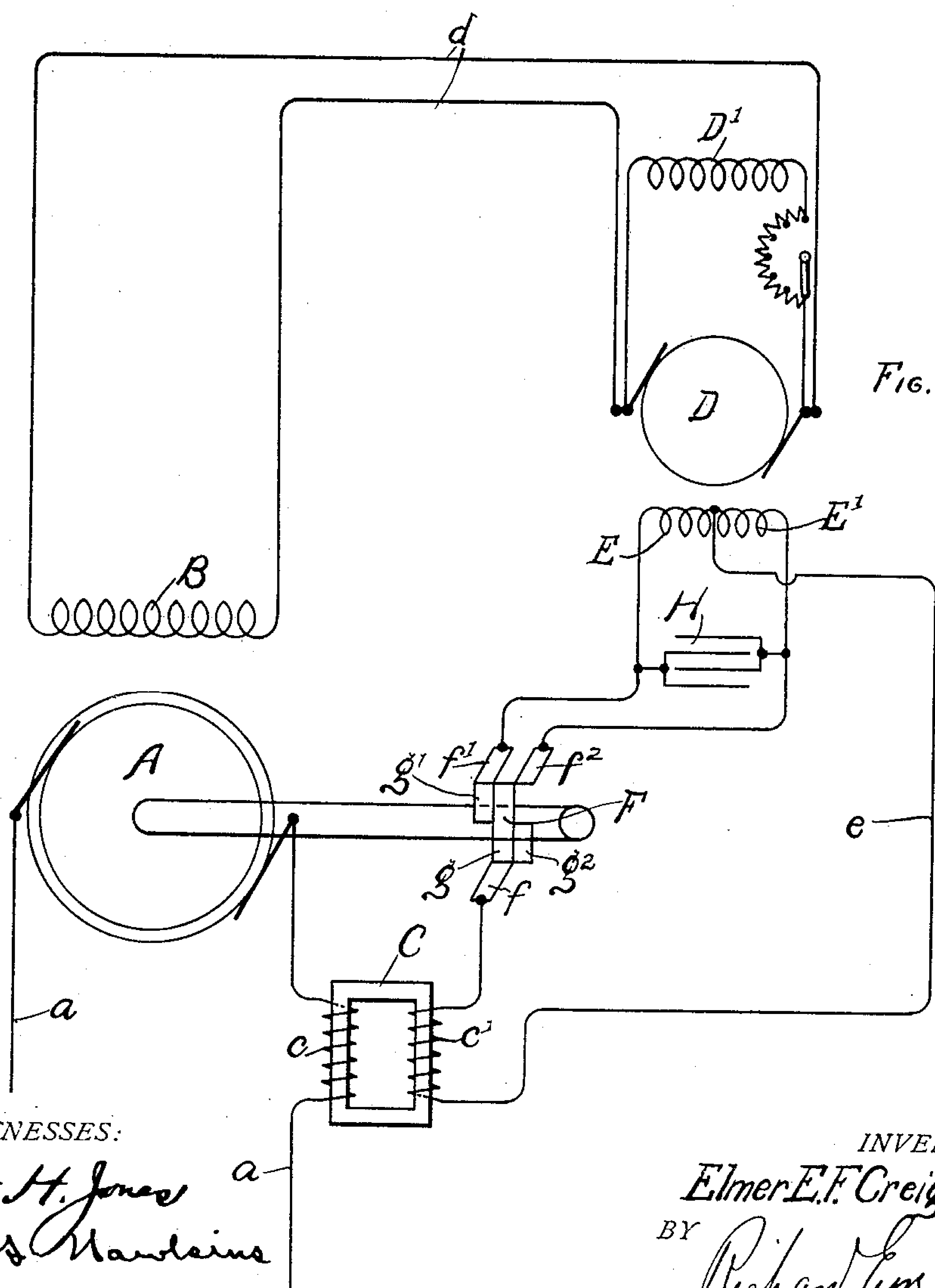

Fig. 1.

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NO MODEL. 3 SHEETS—SHEET 2.

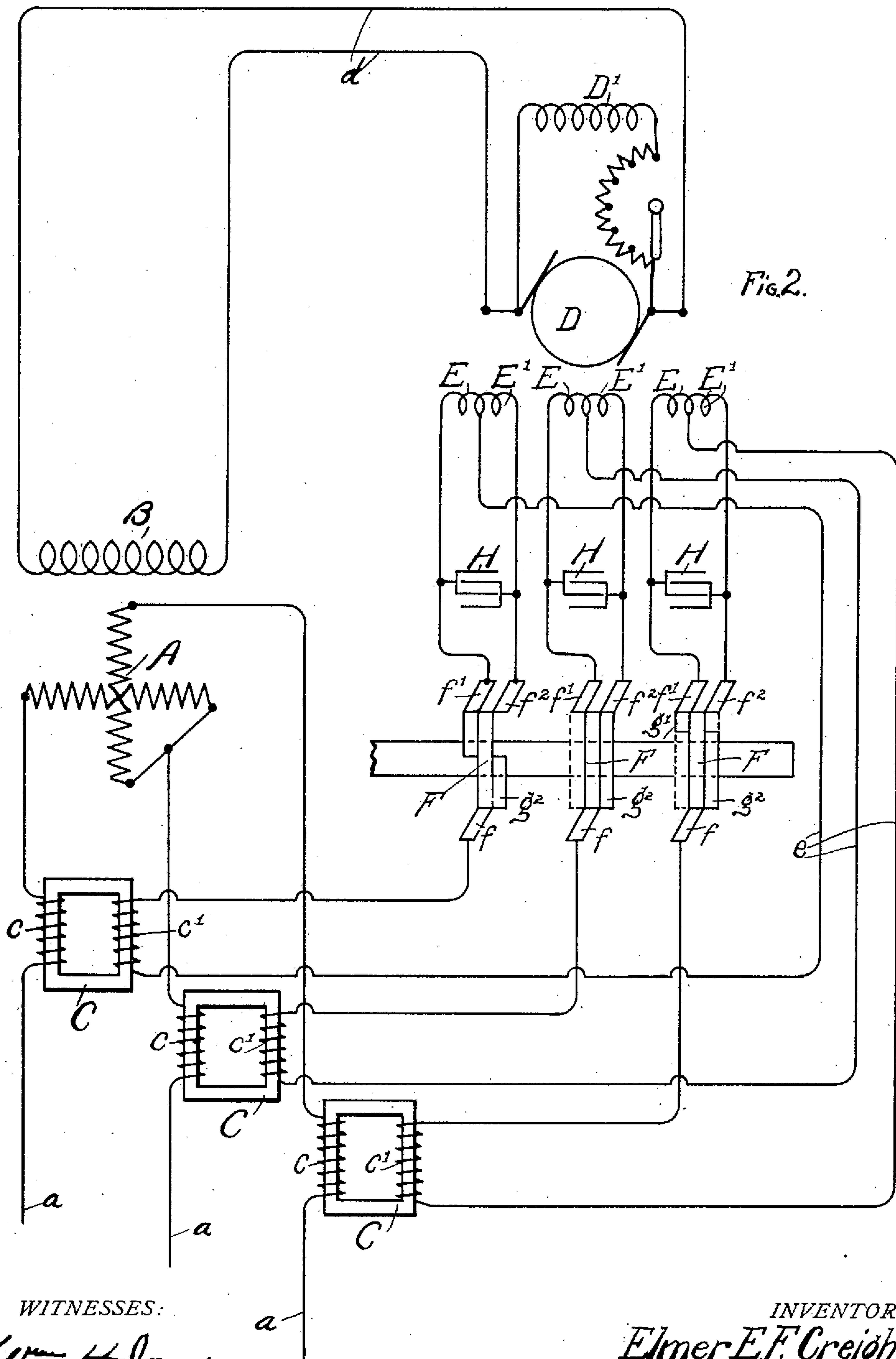

Fig. 2.

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NO MODEL. 3 SHEETS—SHEET 3.

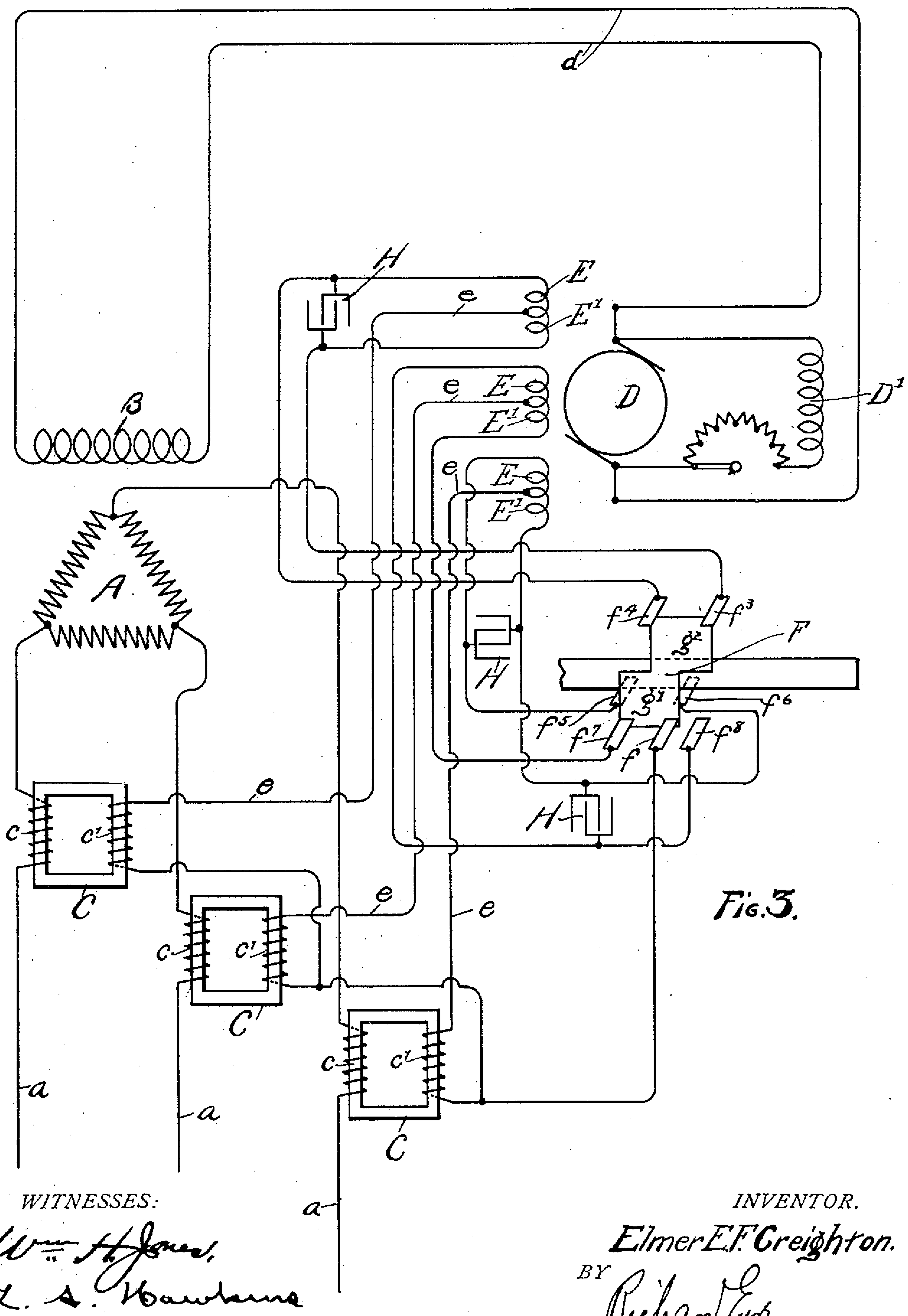

FIG. 3.

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No. 743,458. Patented November 10, 1903.

UNITED STATES PATENT OFFICE.

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COMPENSATING SYSTEM.

SPECIFICATION forming part of Letters Patent No. 743,458, dated November 10, 1903.

Application filed December 20, 1902. Serial No. 135,983. (No model.)

To all whom it may concern:

Be it known that I, ELMER E. F. CREIGHTON, of Pittsfield, county of Berkshire, and State of Massachusetts, have invented certain new and useful Improvements in Compensating Systems, of which the following is a specification.

My invention relates to compensating systems for alternating-current generators in which means are supplied to increase the voltage of the generator when the current lags due to the presence of an inductive load or when the current increases in the circuit. In these systems it has been proposed to provide a local circuit in which a current is produced bearing a substantially constant volume relation to the current in the main circuit produced by the generator. The current in this local circuit is an alternating current, and means have been provided or suggested to cause this alternating current to act directly or indirectly upon a magnet, such magnet being connected and arranged so that its magnetism affects the voltage of the main circuit. The lag is compensated for by providing a switch or commutator that will divide each cycle of the current in the local circuit in such a way that the magnet-winding will receive a nearly equal volume of current in each direction when no lag is on the line, while the presence of a lag automatically provides an excess of current in one direction over that of the other, producing magnetism in said magnet and increasing the voltage of the main line. The greater the lag the greater this excess. Hitherto it has either been necessary to provide a commutator, which gives considerable trouble, or it has been necessary to utilize only half the current produced in the local circuit.

It is one of the objects of my invention to utilize all of the current of the local circuit and yet avoid commutation of such current, and I thereby eliminate the commutator and the troubles arising from the employment of a commutator. To this end I provide a novel form of switch, which shifts the current in the local circuit periodically first into one and then into another branch circuit or subcircuit. These subcircuits comprise the two ends of an energizing-coil, or, in other words, two energizing-coils, and the switch directs the current of the local circuit alternately into these two coils and in relatively opposite directions therethrough. I thus have what may be broadly referred to as a "magnetism" commutator rather than an "electrical" commutator. By the provision of this apparatus operating on this principle I have been enabled to much simplify the apparatus of compensating systems and make their operation more efficient and certain and more perfectly regulatable.

A further improvement of my present invention is to shunt the switch referred to, as well as the magnet-coils, with one or more condensers, by means of which I have substantially eliminated the sparking and the inductive effects on the magnet-windings and also increased the efficiency of the system.

I have also in developing my system for a three-phase system provided a novel switch, whereby in one structure of a simple character I have been enabled to combine the switching mechanism for all three phases and obviate the necessity of supplying three separate switches.

Referring to the drawings, Figure 1 shows in diagram my improved compensating system applied to a single-phase system. Fig. 2 shows a two-phase three-wire system in connection therewith, and Fig. 3 illustrates a three-phase system with my invention applied thereto. Fig. 4 illustrates features of the preferred form of exciter.

Referring to Fig. 1, A is an alternating-current generator generating the current for the main circuit, represented by the conductors *a*. B is the field-magnet winding of said generator. C represents a transformer the primary *c* of which is in series with one of the main conductors *a*, and *c'* is the secondary winding of such transformer. This secondary winding *c'* forms the source of power for the local compensating circuit, and the current produced in such secondary should bear a substantially constant volume relation to that flowing in the primary, and therefore to that of the main circuit. D represents the armature of an exciter which delivers the exciting-current through conductors d to the field-windings of generator A. D′ is a field-coil for such generator D, and the coils E E′ form a second winding for the said exciter. The center of this coil is connected by conductor e to one terminal of the secondary c'. This coil E E′ is the coil in the local circuit intended to affect the potential of the main circuit, in the present case indirectly through the exciter D. F is my rotating switch, which through brush f and ring g is constantly in connection with the opposite terminal of the secondary c'. g' and g^2 are segments adapted to make contact, respectively, with brushes f' and f^2, which, as shown, are connected to relatively opposite ends of coils E and E′. The switch F is connected to the generator A in such a way that its segments g' and g^2 rotate at the polar speed of the generator. Thus assuming the generator to be a two-pole generator, and the switch, as indicated in the drawings, to be connected directly to the shaft of the generator, the segments g' and g^2 are each one hundred and eighty degrees, so that one complete revolution of the switch is made for each revolution of the machine. Of course with many pole-machines it may be preferable to gear the switch to the moving part of the generator, so that it may rotate once for each change of phase of the generator, or each segment g' and g^2 of the switch may be divided into as many segments as will correspond to one-half the number of poles of the machine, the essential thing being that the segments g' and g^2 are displaced with reference to each other, so that the current coming in at the brush f will during half of each cycle pass out through brush f' and during half of each cycle through brush f^2.

In Fig. 4 I have shown somewhat diagrammatically an exciter having the coils E E′ and D′ on its field-magnet, the field-magnet pole being laminated. The laminated pole may be used with my compensating system, and I prefer its use, because the impulses in the local circuit correspond to those of the main circuit.

It will be seen from the foregoing description that the current generated in the secondary c' passes to the brush f, and first passes through contact g', brush f', and coil E to the secondary, and then is shifted so as to pass through segment g^2, brush f^2, and coil E′ to the secondary. It will also be seen that when the current is thus shifted to the other coil it produces an opposite magnetic effect relative to the direction of the current, since for any given direction of the current it will pass in an opposite direction through the coils E E′. By this means I am enabled to divide each cycle into two parts, the excess of current of each of which in one direction over that of another direction can be utilized to energize with the same resultant polarity the magnet of exciter D even though the excess passing through coil E is in one direction and the excess in coil E′ is in another direction. Thus assume that each cycle is so divided that the half directed to coil E has an excess of current in the positive direction, while the half directed to coil E′ has an excess in the negative direction, yet as the negative excess in coil E′ is directed through said coil in an opposite direction to that in which the positive excess is directed through coil E the magnetism produced by the two coils must be in the same direction. It should also be noted that the rotating switch is one of the simplest possible construction, the rotating parts of which do not have to be insulated from each other, while the spark cannot carry over from one segment to the other, since they are not only angularly displaced from each other, as in a commutator, but they are displaced in such a way that they never pass through the same circumference.

H shows a condenser placed in shunt to brushes f' and f^2 and also in shunt to coils E E′. This condenser reduces the sparks on switch f and very much increases the efficiency of the system, as it enables it to be operated more uniformly, since the character of the spark is no longer affected by local drafts and similar conditions. Moreover, the condenser eliminates the kick of the coils E E′ without taking any energy therefrom, since it delivers back whatever energy it takes to the coils.

Referring to Fig. 2, I have given the same parts the same reference-letters, and it will be noted that I have triplicated the parts of the compensating system, putting one of the transformers C in each of the three wires of the two-phase three-wire system. One of such transformers and its corresponding switches and exciting-coils could be eliminated if desired, this being a matter principally dependent upon the character of the exciter. If the exciter has solid poles, it is advantageous to multiply the impulses as far as possible, so as to produce a substantially continuous magnetizing effect, whereas if the exciter has laminated poles, as in Fig. 4 and as I prefer to construct it, it is better to have only two local circuits, so that the impulses may correspond with the main current.

Referring to Fig. 3, the generator A is a three-phase generator, and the tranformers C are, as before, connected one to each of the three mains. One terminal of each of the secondaries c' are connected together, and the other terminals of these secondaries are connected to the central portions of the three coils E E′. F′ is the moving part of the rotating switch, and this moving part is always connected through the brush f with one terminal of three secondaries c'. The relatively opposite ends of the coils E E′ are connected to three sets of brushes, the sets being angularly disposed to each other. These brushes are lettered f^3 to f^8, inclusive. The three sets of brushes are one hundred and twenty degrees from each other. It will be seen, therefore, that the current from the secondary passes to brush *f*, thence to the moving part F′, which, as before, consists of a continuous ring for the brush *f* and displaced segments g' and g^2 to make contact alternately with the brushes connected to the coils E E′. By the relative position of the brushes it will be seen that the current entering the moving part of the switch will be constantly dividing, there always being two of the brushes engaging one of the segments and one brush engaging the other segments. Each of the three sets of coils E E′ will therefore be constantly receiving current from one or the other of the brushes connected therewith, so that while a single switch is provided precisely the same results are effected in each of the three sets of coils as is produced in the single set of coils in Fig. 1. As before, the condensers H are placed across the coil-terminals and also across a pair of brushes.

I do not desire to be limited to the specific embodiments of my invention herein shown or to the various details which I have shown in order to explain how my invention may be embodied in practical form, since my invention is much broader than such details and may be applied to various conditions with such modifications as would naturally occur to those skilled in the art.

Having thus fully described my invention, what I claim, and desire to protect by Letters Patent, is—

1. The combination of an alternating-current generator, a local circuit, means for producing current therein the volume of which bears a substantially constant relation to that of the main current, a switch in said local circuit rotating at the polar speed of said generator and connected and arranged to periodically shift the current from one to another of a plurality of magnet-windings, and means for causing the magnetism thus produced to increase the potential of the main current.

2. The combination of an alternating-current generator, a local circuit, means for producing current therein the volume of which bears a substantially constant relation to that of the main current, a switch in said local circuit rotating at the polar speed of said generator, a magnet adapted to affect the potential of the main circuit, two windings thereon and connections from said switch to the magnet, adapting the switch to periodically shift the current in the local circuit from one of said magnet-windings to the other.

3. The combination of an alternating-current generator, a local circuit, means for producing current therein, the volume of which bears a substantially constant relation to that of the main current, a magnet adapted to affect the potential of the main circuit, two energizing-windings thereon, a constant connection from relatively opposite ends of both of said windings to a terminal of the source of current in the local circuit and a switch mechanically connected to the main generator so as to be moved thereby and having contacts and connections arranged to alternately connect the opposite ends of said windings with the other terminal of the source of current in the local circuit.

4. The combination of an alternating-current generator, a local circuit, means for producing current therein the volume of which bears a substantially constant relation to that of the main current, a switch in constant connection with one terminal of the source of current for said local circuit, two segmental contacts on said switch rotating in synchronism with the said generator, a brush for each of said contacts making contact therewith alternately, a magnet having two windings thereon, connections from said brushes to relatively opposite ends of said windings, and a constant connection between the opposite ends of said windings and the other terminal of said source of current for the local circuit.

5. In a compensating system, a magnet for affecting the potential of an alternating-current generator, two energizing-windings thereon, means for producing a current whose volume bears a substantially constant relation to that of the main current, and means for directing such current alternately through the two windings in a relatively opposite direction in one winding to that in the other.

6. The combination of an alternating-current generator, a local circuit, means for causing the current in the main circuit to produce a current in said local circuit, a switch having alternating segments and rotating in synchronism with the generator, a double exciting-coil and connections between the foregoing elements substantially as described.

7. The combination of an alternating-current generator, a local circuit, means for producing current therein the volume of which bears a substantially constant relation to that of the main current, a magnet acting to affect the potential of the main circuit, a winding thereon, a connection from the center of said winding to a terminal of the source of local current, rotating segments connected to the other terminal of said source, a brush adjacent to each segment and adapted to alternately make contact with their respective segments, and connections from said brushes to the ends of said winding.

8. The combination of an alternating-current generator, a local circuit, means for producing current therein the volume of which bears a substantially constant volume relation to that of the main current, an exciter for said generator, a plurality of magnet-windings therefor in said local circuit, and a switch in said local circuit rotating at the polar speed of said generator and connected and arranged to periodically shift the current from one to another of said magnet-windings.

9. The combination of an alternating-current generator, a local circuit, means for pro-

ducing current therein the volume of which bears a substantially constant volume relation to that of the main current, an exciter for said generator having laminated poles, a plurality of magnet-windings therefor in said local circuit and a switch in said local circuit rotating at the polar speed of the said generator and connected and arranged to periodically shift the current from one to another of said magnet-windings.

10. In a compensating system, an exciter for the main alternating-current generator, two energizing-windings thereon, means for producing a current whose volume bears a substantially constant relation to that of the main current, and means for directing such current alternately through the two windings in a relatively opposite direction in one winding to that in the other.

11. In a compensating system, an exciter for the main alternating-current generator, said exciter having laminated poles, two energizing-windings thereon, means for producing a current whose volume bears a substantially constant relation to that of the main current and means for directing such current alternately through the two windings in a relatively opposite direction in one winding to that in the other.

12. The combination of an alternating-current generator, a transformer whose primary is in the main circuit thereof, a contact rotating at the polar speed of the generator and constantly connected to the secondary of said generator, an exciter for the said generator, a winding thereon, a connection from said winding to the other terminal of the secondary, and intermittent connections between the ends of said windings and said rotating contact.

13. The combination, in a compensating system having a main circuit and a local circuit, of an exciter, magnet-windings thereon in the local circuit, and a condenser in shunt to said windings.

14. The combination, in a compensating system having a main circuit and a local circuit, of an exciter, magnet-windings thereon in a local circuit, a switch controlling the current in the magnet-windings and a condenser in shunt thereto.

15. The combination of a multiphase generator, a local circuit for each phase, means for producing currents therein the volumes of which bear a substantially constant relation to the volumes of the main currents, a switch common to all the local circuits rotating at the polar speed of said generator and connected and arranged to periodically shift the current in each local circuit from one to another of a plurality of magnet-windings, and means for causing the magnetism thus produced to affect the potential of the main current.

16. The combination of a multiphase generator, a local circuit for each phase, means for producing currents therein the volumes of which bear a substantially constant relation to the volumes of the main currents, a switch in constant connection with one terminal of each of the sources of current for said local circuits, two segmental contacts on said switch rotating in synchronism with the said generator, pairs of brushes bearing one on each of said contacts, the number of pairs of brushes being equal to the number of local circuits and the pairs being angularly displaced from each other correspondingly to the angular displacement of the main currents from each other, a magnet having a pair of windings thereon for each local circuit, connections from each pair of brushes to relatively opposite ends of one pair of windings, and a constant connection between the other ends of each of said pair of windings and the other terminals of the said sources of current for the local circuits.

17. The combination of a multiphase generator, a local circuit for each phase, means for causing the currents in the main circuits to produce currents in said local circuits, a switch having alternating segments and rotating in synchronism with the generator, a multiplicity of double exciting-coils equaling in number the number of phases, and connections substantially as described between the said switch and said exciting-coils and the source of current for the local circuit, substantially as described.

18. In a compensating system, an exciter for the main multiphase generator, double energizing-windings thereon equal in number to the number of the phases of the main generator, means for producing currents the volumes of which bear a substantially constant relation to the currents in the mains, and means for directing each of such currents alternately through the parts of one of the double windings in relatively opposite directions in one part to that in the other.

19. The combination, in a compensating system, of an exciter, double magnet-windings thereon in local circuits, a switch controlling the currents in the double magnet-windings, and a condenser in shunt to each double magnet-winding.

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

ELMER E. F. CREIGHTON.

Witnesses:
L. A. HAWKINS,
R. E. HAYNES.