(No Model.)

B. G. LAMME.

ALTERNATING CURRENT REGULATION AND DISTRIBUTION.

No. 582,131. Patented May 4, 1897.

Fig. 1.

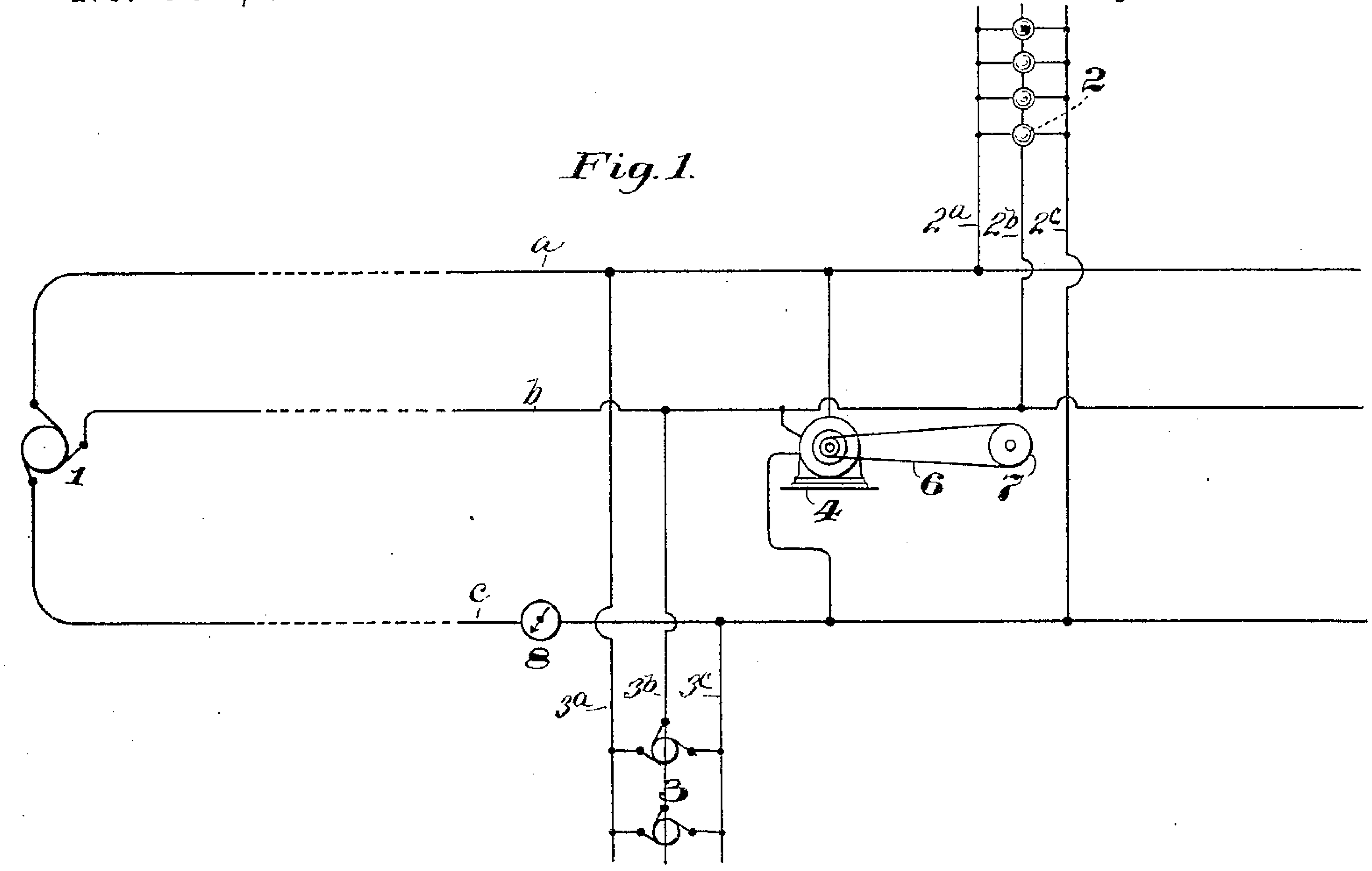
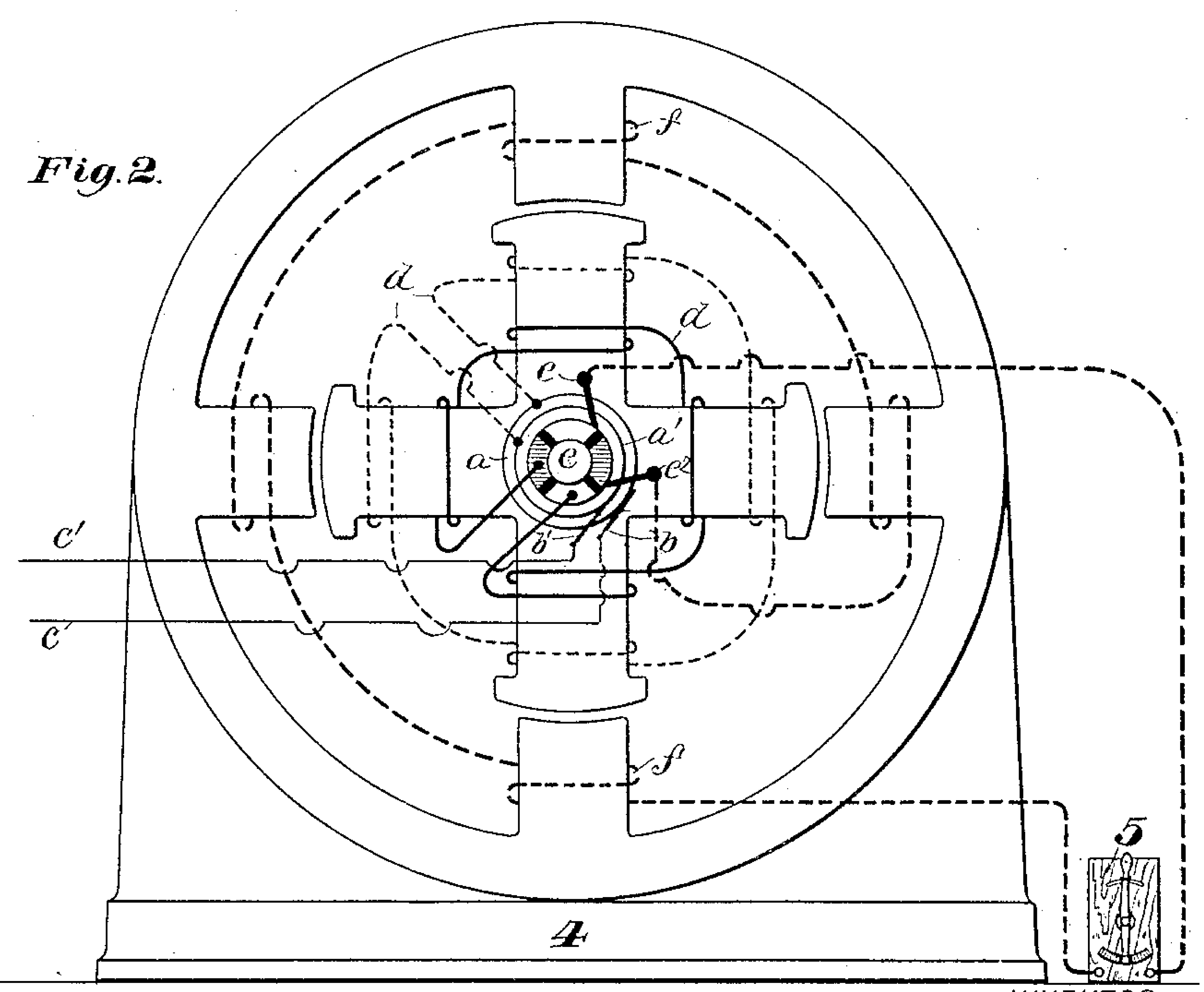


Fig. 2.



WITNESSES:

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UNITED STATES PATENT OFFICE.

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ALTERNATING-CURRENT REGULATION AND DISTRIBUTION.

SPECIFICATION forming part of Letters Patent No. 582,131, dated May 4, 1897.

Application filed March 27, 1893. Serial No. 467,752. (No model.)

To all whom it may concern:

Be it known that I, BENJAMIN G. LAMME, a citizen of the United States, residing in Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Alternating-Current Regulation and Distribution, (Case No. 545,) of which the following is a specification.

My invention relates to systems of alternating-current distribution; and it has for one of its objects to provide a method of and a means for electrodynamically controlling and adjusting the phase relation between the current and electromotive-force waves in such systems.

Another object of my invention is the diminishing of losses due to the magnetizing-current which passes through the coils of certain classes of translating devices at all times, whether they be at work or idle.

Another object of my invention is the regulation of lights and kindred translating devices wherein changes in potential drop are occasioned by changes in load or otherwise.

In the feeding of translating devices from an alternating-current system the relation between the current and electromotive-force waves has an important bearing upon the regulation of the generator by reason of its effect upon the magnetic reaction between the armature and field-magnet. If the current and electromotive-force waves could be kept in step, the reaction of the armature upon the field-magnet would be practically zero, inasmuch as the point of maximum current, and therefore of maximum magnetization, would occur half-way between adjacent poles. If, however, from any cause the current-wave lags behind the electromotive-force wave, the field-magnet of the generator is weakened by the reaction of the armature magnetism, and regulation is to that extent disturbed. On the other hand, when the current-wave is in advance of the impressed electromotive-force wave the opposite effect is produced upon the field-magnets, and they are strengthened by the reaction of the armature magnetism.

While the current-wave in any alternating-current system is always in step with a resultant electromotive-force wave which has a theoretical existence as the outcome of the interaction of the impressed and the counter electromotive force in any given system wherein counter electromotive force exists, such resultant electromotive-force wave may be either a little later than the impressed electromotive-force wave in attaining its maximum or it may precede the occurrence of maximum in the impressed electromotive-force wave. In the former case this resultant electromotive-force wave and the current-wave which goes with it are said to lag behind the electromotive-force wave, by which is meant the main or impressed electromotive-force wave, and in the latter case the resultant and the accompanying current-wave are said to be in advance of or to precede the electromotive-force wave. Either of these results, when present in the circuit fed by a given generator, imparts a disturbing element to the regulation of such generator, the one, as shown above, resulting in the weakening of the field-magnet and a consequent drop in the potential of the machine for a given armature speed and the other having the opposite effect.

Where non-synchronous motors or other translating devices having self-induction are present in an alternating system, there is at all times a choking-coil effect due to the self-induction of their windings. This varies with the work done, but is present whether work is being done or not. This choking-coil effect serves to make the current-wave lag behind the impressed electromotive-force wave, and therefore produces a disturbing effect in the generator and the external circuit, as noted above. It is one purpose of my invention to counteract this effect, so as to reduce to a minimum disturbances in the generator and in the external circuit due to the presence in the circuit of translating devices having self-induction.

I have found that by employing one or more synchronous motors in connection with circuits supplying non-synchronous motors or other translating devices having self-induction I am able to compensate for the lagging effect due to such self-induction. Such motors may also be employed for correcting the difference in phase between current and electromotive-force waves in a circuit where the current-wave is in advance of the electromotive-force wave, provided such a condition exists. If a synchronous motor be included in an alternating-current circuit with a given load thereon, it will take a minimum current from the line for a particular degree of field-magnet excitation, provided there is no other appreciable load upon the circuit, but a variation of the field excitation of the motor either above or below this critical degree of excitation will cause an increased flow of current. If the load remains constant and the field-magnet excitation of the motor is less than is required to enable it to take the minimum amount of current from the circuit, it must act as a choking-coil in the circuit by reason of the fact that its invariable speed precludes it from taking the excess of current supplied to the circuit. If, on the other hand, the field-magnet of the synchronous motor be excited above the degree required for the minimum current, thus producing an excessive counter electromotive force, such counter electromotive force will have the opposite effect to that above described—*i. e.*, it will create a lead of the current over the impressed electromotive force or, as it is sometimes termed, a "negative" lag. It will thus be seen that the counter electromotive force of the synchronous motor may be so regulated as to counteract any displacement of phase between current and electromotive force which may exist in the circuits with which it is connected and thus prevent disturbances in the main generator due to such existing phase displacement.

Another object which is attained by the use of the invention is the virtual supply of the magnetizing-current taken by non-synchronous motors by means of the synchronous-motor counter electromotive force. This magnetizing-current which passes at all times through non-synchronous or Tesla motors and other translating devices having self-induction connected in a working circuit, even when they are carrying no load, involves considerable losses when it is carried through long mains from a distant generator, as has heretofore been the case. By the use of my invention this current is virtually supplied from the non-synchronous motor itself, and as this motor may be located near the coils which take the magnetizing-current the loss of energy on the mains is greatly lessened.

It will thus be seen that my invention contemplates a system of regulation whereby disturbances in potential at the generator are substantially avoided and whereby energy otherwise lost is, to a great extent, saved. Of course my invention is adapted to a system having converters in line as well as to one wherein current is directly transmitted from a primary generator.

My invention is illustrated in the accompanying drawings, wherein—

Figure 1 is a diagram illustrating the principle of the invention, and Fig. 2 is a diagrammatic illustration in detail of a regulator embodying one means whereby its counter electromotive force may be varied.

In Fig. 1 of the drawings, 1 is the main source of current, which is shown as a three-phase generator-supplying current to three-phase distributing-mains 1^a 1^b 1^c, but it will be understood that the invention is not limited to systems of distribution having any specific number of phases. Lamps or kindred translating devices 2 are shown as supplied with current from mains 1^a 1^b 1^c, through branches 2^a 2^b 2^c, and motors of the non-synchronous or Tesla type 3 are shown as supplied from the main conductors through branches 3^a 3^b 3^c.

4 is a synchronous motor which is connected across the three-phase circuit 1^a 1^b 1^c and is employed for correcting the phase difference between the current and electromotive force in such circuit. The motor 4 is also shown as proved with a belt 6 for transmitting mechanical energy to a pulley 7. It will thus be seen that one or more synchronous motors may be employed in a system of electrical distribution for both phase regulation and power production.

Another use for my invention is in connection with lights 2, wherein changes of load occasioned by cutting lamps in or out may be effected and where this change of load produces changes in potential drop requiring changes of impressed electromotive force. Instead of effecting this regulation at the main generator, and thus changing the potential upon the whole system fed therefrom, the potential on these lights may be controlled by the regulation of the counter electromotive force of the motor 4. I may also provide an ammeter 8, so placed in one of the main branches leading to the synchronous motor and translating devices as to measure all the current utilized by the same. Under any given conditions of load there will be a critical counter electromotive force opposed by the motor 4 corresponding to a minimum current supplied, which it is desirable to maintain, as has been already stated. By observing the ammeter 8, therefore, and occasionally varying the field-magnet strength of the motor 4 to secure and maintain a minimum reading of the ammeter the proper regulation may be secured.

In Fig. 2 I have shown, on an enlarged scale, a synchronous motor 4^a, provided with an adjustable rheostat 5, for varying its field-magnet excitation. For convenience of illustration a single-phase motor is shown, which is provided with two collecting-rings a a' and with brushes b b', bearing thereon. The driving-current for the motor is supplied to the brushes b b' through conductors c c'. The main armature-winding d is connected at its respective ends to the rings a a', and a supplemental armature-winding d' is connected at its ends to the segments of a commutator-cylinder *e*. Brushes e' e^2 coöperate with the commutator *e* and supply current to the field-magnet winding *f* through the adjustable rheostat 5.

It will be understood from this construction and arrangement that the field-magnet excitation, and consequently the counter electromotive force of the motor 4, may be varied at will.

It will also be understood that the motor field-magnet may be excited either partially or wholly by current from an independent source, if desired.

My invention comprises, broadly, the methods of regulation which are herein disclosed, as well as electrodynamic phase-controllers of any construction suitable for effecting the results hereinbefore set forth.

I claim as my invention—

1. The method of harmonizing the phase relation between current and electromotive force in an alternating-current circuit, which consists in counteracting the existing displacement of phase by adding to the existing waves of current and electromotive force, independent corrective waves which are generated by the inductive action between the armature and field of an electrodynamic phase-controller, and which bear such relation to the existing waves as to establish a substantially harmonious relation.

2. The method of advancing an alternating current relatively to the electromotive force which produces it, and so overcoming the lag of such current by establishing a relation of substantial harmony, which consists in generating by the inductive action between the armature and field of an electrodynamic phase-controller an independent corrective current in the circuit which bears an advanced relation to the existing electromotive force sufficient to overcome or neutralize the lag, as set forth.

3. The method of regulating the potential in an alternating-current circuit, which consists in adding to or superimposing upon the existing waves of current and electromotive force in the circuit independent corrective or modifying waves of such phase relation as to advance the main current relatively to its electromotive force and varying or regulating the action of such modifying waves in accordance with changes in the nature and amount of the load in the circuit, as set forth.

4. The method of compensating for drop of potential due to increase of load in an alternating-current system which consists in advancing the current relatively to the electromotive force so as to maintain it in leading relation to the electromotive force, by the inductive action in an electrodynamic mechanism independent of the main source of current and connected to such circuit, and thereby, in effect, creating a negative inductance of the proper amount.

5. The method of controlling the phase relation between current and electromotive force in an alternating circuit, which consists in adjusting the field strength of a synchronous dynamo-electric machine in correspondence with the phase relation desired, and thereby producing such corrective or modifying influence as will establish the desired phase relation, as set forth.

6. The method of controlling the phase relation between current and electromotive force in an alternating circuit, which consists in increasing or diminishing the field strength of a synchronous dynamo-electric machine coupled in shunt in said circuit, until the lead or lag of phase thereby secured establishes the desired resultant relation between current and electromotive force, as set forth.

7. The method of preventing disturbances in regulation of a generator of alternating currents, due to phase lag; which consists in putting a synchronous motor in circuit with said generator, and adjusting the field-magnet strength of said motor so as to produce an advance-wave displacement equal to the lag to be overcome, substantially as described.

8. The method of regulating electric systems of distribution independently at various points of translation without materially affecting the voltage of the common generator; which consists in putting into circuit one or more synchronous motors at or near such points of translation, and varying the counter electromotive force of such motor or motors to regulate the currents utilized, substantially as described.

9. The method of regulating electric systems of distribution independently at various points of translation; which consists in putting into circuit one or more synchronous motors at or near such points of translation and varying the counter electromotive force of such motor or motors so as to keep the current supplied at a minimum, substantially as described.

10. The combination with an alternating-current electric circuit or systems possessing self-induction, of a synchronous motor having its armature connected with the circuit and adapted or adjusted by the excitation of its field to impress an electromotive force in advance of that of the current in the circuit that will neutralize the lagging component of the current, as set forth.

11. The combination in an alternating-current circuit with a translating device possessing self-induction, of a synchronous motor, the armature of which is in a shunt-circuit to the translating device, and means for increasing the excitation of its field to a degree that will neutralize the lagging component of the current in the circuit, as set forth.

12. In a system of electrical distribution, an alternator and independent groups of translating devices deriving energy therefrom, in combination with one or more syn-

chronous motors in circuit at or near each of said groups, and means whereby the counter electromotive force of such motor or motors may be varied, substantially as described.

13. In a system of electrical distribution, an alternator, and translating devices fed thereby, the current phase of which is later than the electromotive-force phase of said alternator, in combination with a synchronous motor in the circuit of said alternator, near said translating devices, said motor having a counter electromotive force superior to the potential difference on the line at the translating devices, substantially as described.

14. In a system of electrical distribution, an alternator, and translating devices fed thereby which at times take up more or less wattless current or current about ninety degrees out of phase with the impressed electromotive force, in combination with a synchronous motor in the circuit of said alternator, near said translating devices, said motor having a sufficient surplus counter electromotive force to supply such wattless current, substantially as described.

In testimony whereof I have hereunto subscribed my name this 24th day of March, A. D. 1893.

BENJ. G. LAMME.

Witnesses:
JAMES WM. SMITH,
HAROLD S. MACKAYE.