No. 675,995. Patented June 11, 1901.

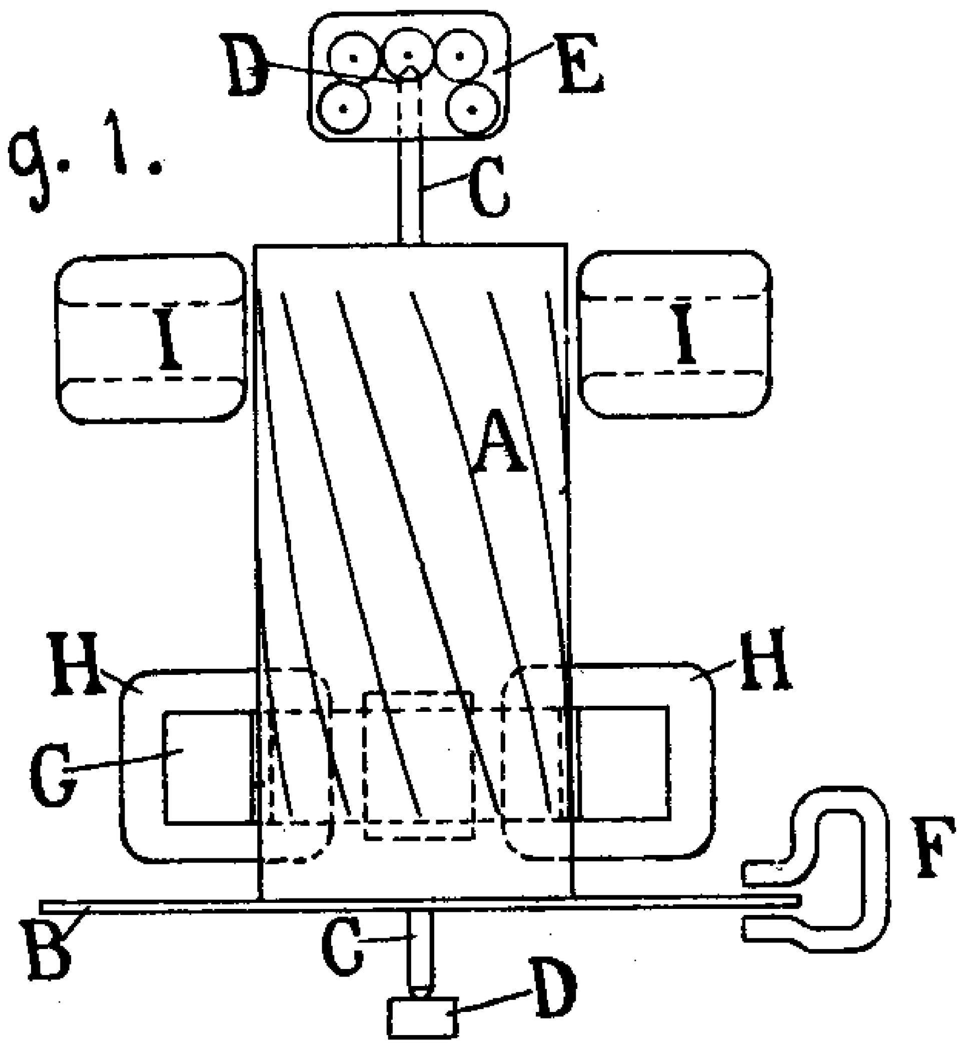
L. GUTMANN.

METHOD OF PRODUCING PHASE COMPENSATION.

(Application filed Jan. 28, 1901.)

(No Model.)

Fig. 1.



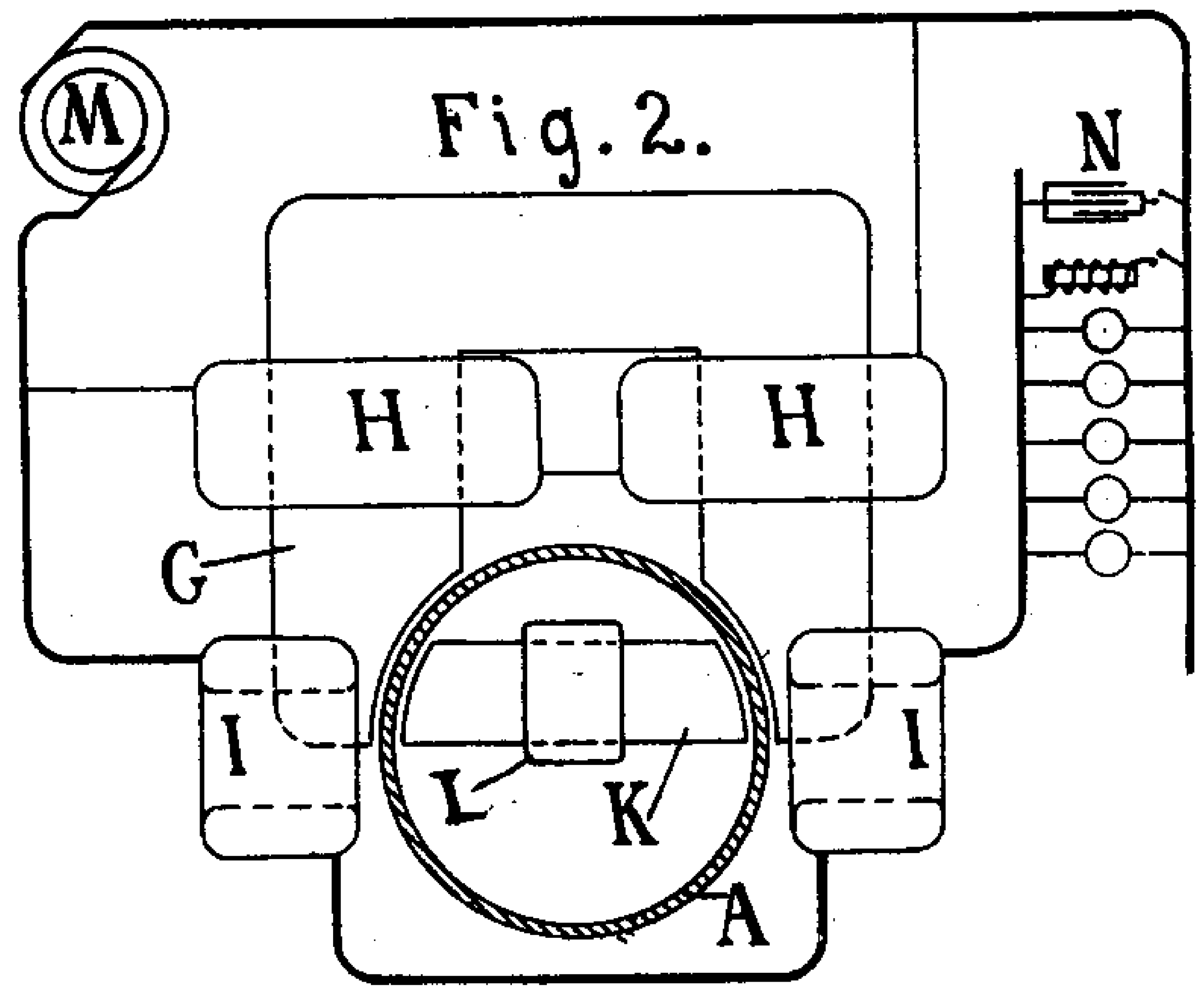


Fig. 3.

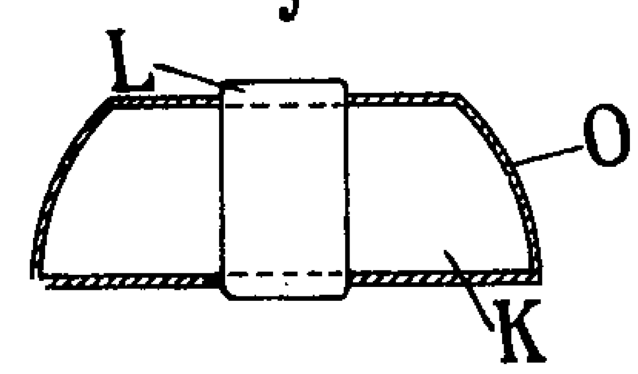


Fig. 4.

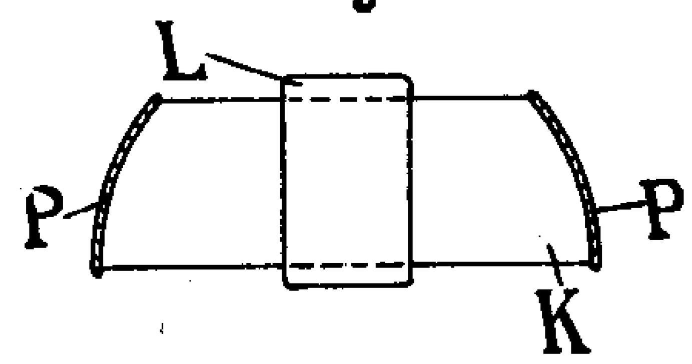


Fig. 4a.

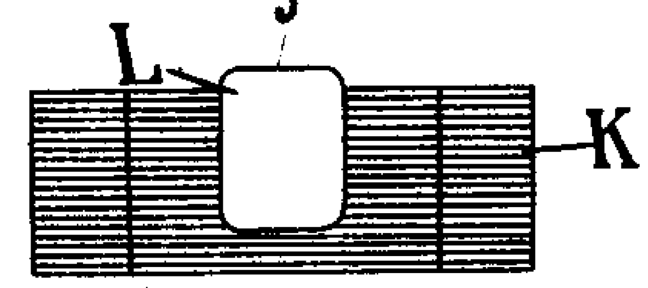


Fig. 5.

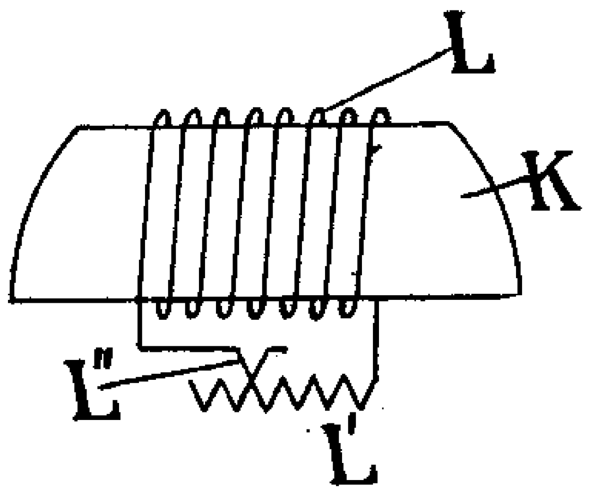


Fig. 6.

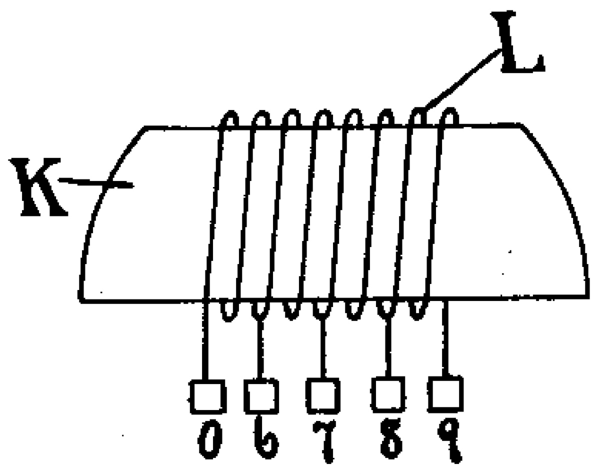


Fig. 7.

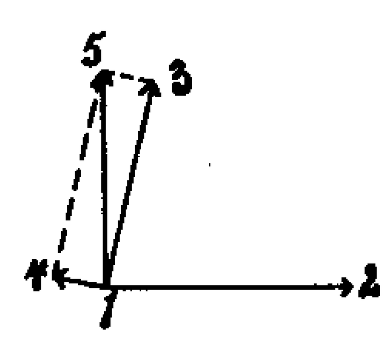


Fig. 8.

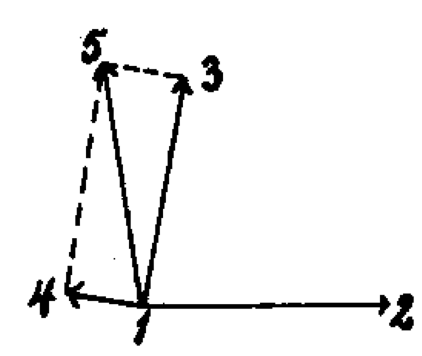


Fig. 9.

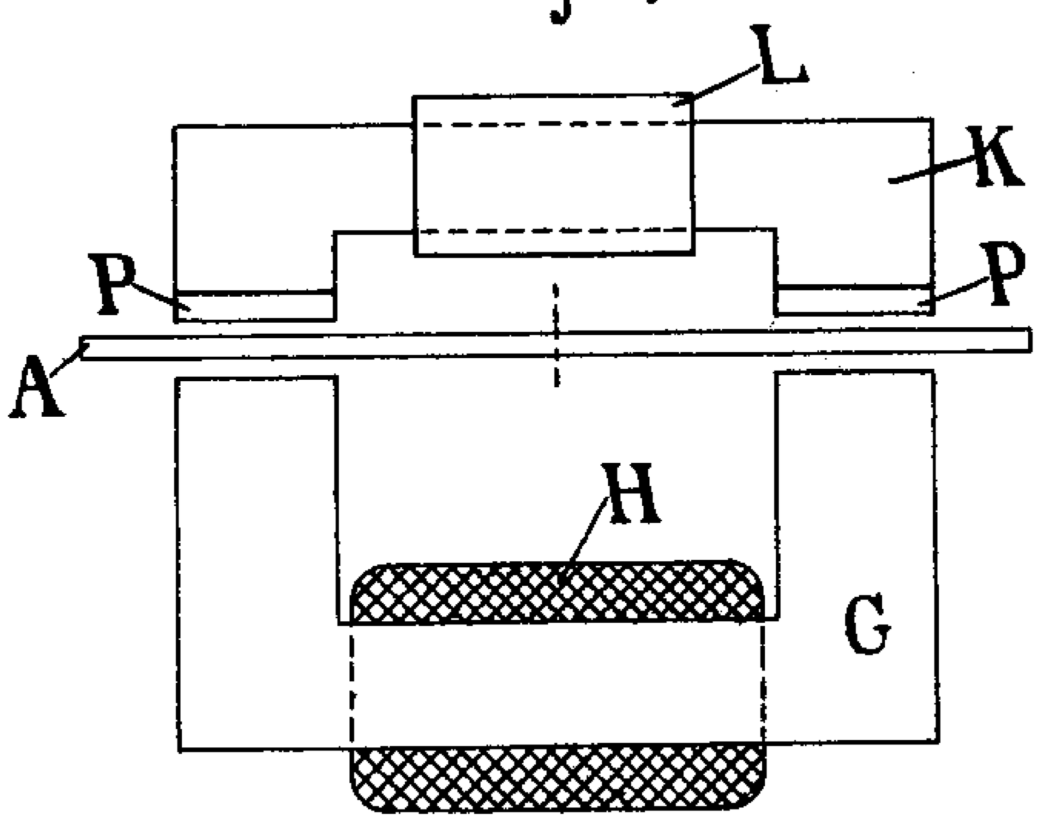
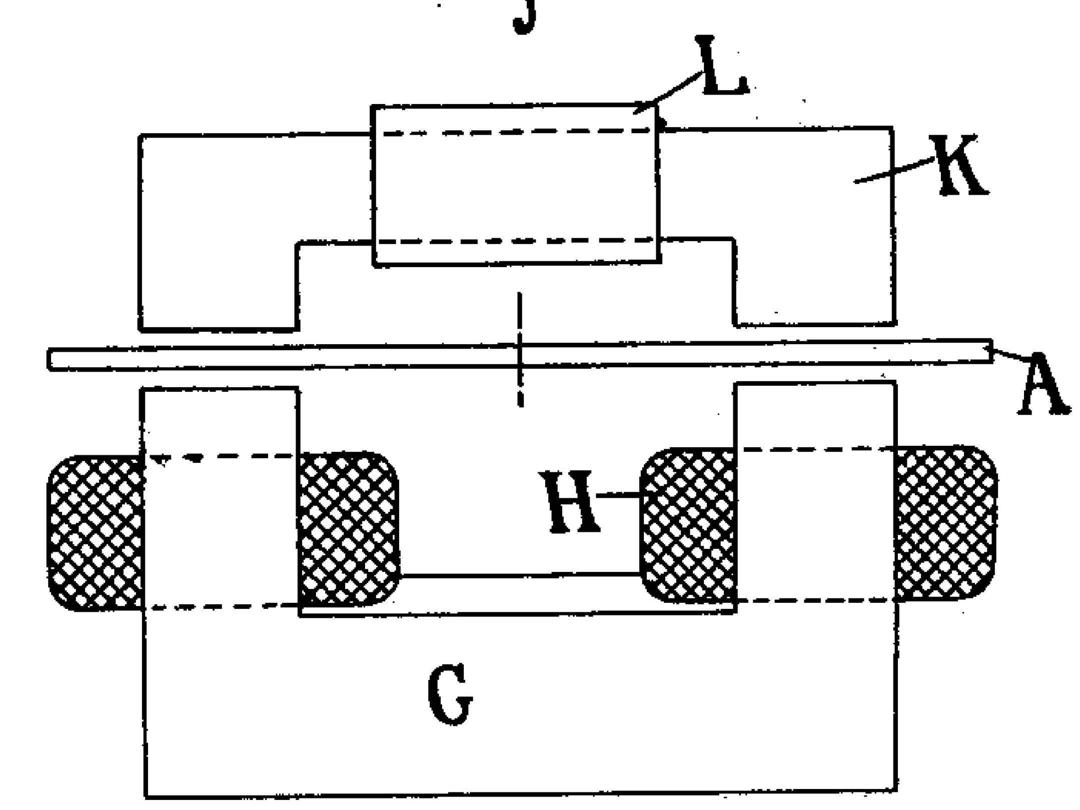


Fig. 10.



Witnesses:–

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UNITED STATES PATENT OFFICE.

LUDWIG GUTMANN, OF PEORIA, ILLINOIS.

METHOD OF PRODUCING PHASE COMPENSATION.

SPECIFICATION forming part of Letters Patent No. 675,995, dated June 11, 1901.

Application filed January 28, 1901. Serial No. 44,994. (No specimens.)

To all whom it may concern:

Be it known that I, LUDWIG GUTMANN, a citizen of the United States, residing in Peoria, county of Peoria, and State of Illinois, have invented a new and useful Method of Producing Phase Compensations, (Case No. 101,) of which the following is a specification.

My invention in general relates to means of producing automatic compensations to a magnetic flux having a phase displacement with relation to another flux or an electromotive force. The method may be applied to motors as well as to meters, and with particular reference to the latter it relates to the compensation of alternating, pulsatory, or intermittent magnetic fluxes displaced in phase from that of the electromotive force of the energizing-current.

My invention consists in producing certain magnetic actions and reactions adapted to produce the desired result in a reliable, simple, and inexpensive way.

The following description, in connection with the accompanying drawings, will clearly disclose the nature of my invention.

Figure 1 is a side elevation illustrating the construction of a meter equipped in accordance with my invention. Fig. 2 is a plan view of the structural parts illustrated in Fig. 1, the relation of the instrument to a system of distribution being shown diagrammatically. Figs. 3, 4, 4ᵃ, 5, and 6 show modifications of the complemental core and its winding. Figs. 7 and 8 show vector diagrams illustrating current-pressure and magnetic-field phase relations. Figs. 9 and 10 show my invention when applied to a disk armature.

Like parts are indicated by similar characters of reference throughout the different figures.

In a concurrent application, Serial No. 19,282, this subject-matter is described with special reference to an alternating-current-meter construction, Patent No. 614,225, granted to me November 15, 1898, in which a slotted cylinder-armature is used.

Referring more particularly to Fig. 1, the armature A therein illustrated is constructed in accordance with the aforesaid patent granted to me, being preferably provided with a damping-disk B at its lower end, the armature and damping-disk being mounted upon a common spindle C, journaled in upper and lower bearings D D. The armature may be cup-shaped, as illustrated. The instrument shown is a recording-wattmeter, a counting-train E being shown in operative engagement with a spindle or shaft C. Damping-magnet F is in inductive relation to the disk B to properly retard the rotation of the armature. A magnetizable laminated core G is shown in the form of a horseshoe and is located upon the exterior of the armature, this core being provided with a shunt-winding which constitutes a primary winding and is subdivided into two coils H H, each disposed upon a leg of the core. The shunt core and coils are shown at the lower part of the armature arranged in a plane parallel with the plane of rotation of the armature, the series or current coils I I being located above the shunt-coils and preferably near the top of the armature. Any suitable means may be employed for supporting the coils of the instrument. Where the structure is employed in a meter, the current-coils I I may be unprovided with magnetizable cores. By the arrangement illustrated the windings H and I do not coöperate to produce a rotating field. The core G forms one part of the magnet system. The complementary core portion K for approximately closing the magnetic circuit of this core system is contained within the armature and is preferably located in the same plane with the core G and at right angles to the contiguous legs of the latter core. This core portion K not only serves to reduce the reluctance of the magnetic circuit for the flux due to the shunt-winding, but also serves, in combination with a closed conductor L, to maintain the resultant pressure-field in quadrature with the impressed pressure. The closed conductor L may be in the form of a conducting-band, of suitable metal, as copper, or may be in the form of a number of turns of wire and, as illustrated in Fig. 5, included in a closed circuit with a resistance L′. Properly speaking, this magnetic system consists of two distinct and independent cores, each having its winding for generating a given flux of approximately fixed phase relation, while the core of the one serves the purpose of as nearly as possible closing the magnetic circuit of the other.

As illustrated in Fig. 2, the meter is connected in circuit with a suitable source of alternating current M, supplying translating devices N, which may be either inductive or non-inductive or both inductive and non-inductive, the meter serving to measure properly the true watts, irrespective of the nature of the load. The current and pressure coils are shown conductively included in circuit, the current-coils being included in one of the mains, while the pressure-coils are in shunt to the mains. By locating the closed conductor upon the complemental core K a supplemental component magnetic field is created that is displaced nearly one hundred and eighty degrees from the impressed electromotive force and from the current when the load is non-inductive, being in quadrature with the current in the shunt-winding.

Referring to the vector diagram illustrated in Figs. 7 and 8, it will be readily understood in what manner the phase adjustment or compensation is secured. The line 1 2 in each figure represents the impressed electromotive force, which is in phase with the current in the main line when the load is non-inductive. Line 1 3 represents the phase angle of the current in the shunt-coils H and the strength and phase displacement of the magnetomotive force in the total core system due to coils H. Line 1 4 represents the strength and phase angle of a superimposed magnetomotive force over the same core system due to the winding L.

Due to the mechanical construction of the magnetic circuit shown in Fig. 2 and the phase relation of the fluxes caused by coils H and winding L it will be clear that we deal with two distinct magnetic fields, whose poles face each other and whose magnetic paths are complemental and act on the same portion of the armature common to them and located between them. The maxima of the two fields do not coincide, as shown by the angle 4 1 3. However, the effects produced by both together may be conveniently illustrated by completing the parallelogram of forces, in which the diagonal in direction and length represents the equivalent magnetomotive force and its resultant phase angle with relation to the impressed electromotive force.

In Fig. 7 the equivalent or resultant of the two fields is shown in quadrature with the impressed electromotive force, while in Fig. 8 it is slightly greater than ninety degrees, this adjustment being determined by the ohmic resistance of the closed conductor of the inner core. I secure this result by making the core portion K detached from the core G, separating it by air-gaps from same. Thereby two distinct magnetic fields are produced, one due to coils H and core K and the other due to winding L and core G. Core K is initially threaded by lines of force from the core G, having additional magnetic flux superimposed upon the initial flux by means of the closed conductor L. Thereby the phase of the flux flowing through the core K is modified sufficiently to secure the desired resultant pressure-field. The complemental core K may be constructed as shown in Fig. 2, where a core of readily-magnetizable laminated iron homogeneous throughout is illustrated, or the construction illustrated in Fig. 3 may be employed, where I have illustrated the core inclosed by a conducting-sheathing O. The construction illustrated in Fig. 4 may be employed, if desired, where the pole-faces of the core K are alone provided with metallic-faced plates P. These separately-applied facings of the core K are well adapted for the generation of Foucault currents. These facings supplement the action of the closed secondary conductors about the core K and serve to still further increase the lag between the impressed pressure and the component field due to the core K, as they act in the capacity of closed conductors. To secure this result, these facings are placed transversely to the flux. For specific compensations either the conductor L or the facings P may be alone employed.

The form illustrated in Fig. 5 may be used for meters or motors where an adjustment of the phase and current may be desired by establishing a circuit with contact L'' on a greater or shorter length of the resistance L'.

Fig. 6 shows a modified form of secondary conductor in which different fixed and predetermined currents and fluxes may be obtained by connecting two or more of the terminals 6, 7, 8, 9, and 0 with one another.

The operation of the apparatus will now be understood. The magnetic core G is energized by the shunt-winding H, polar regions opposite the armature being established at the ends of the core. Magnetic flux passes through the core K due to the inductive action of the core G, this core K being subjected to a secondary magnetization due to the closed conductor L'. The poles of the inner core face those of the outer core, a difference in phase existing between the poles of the inner core and the poles of the outer core which serves to secure the desired phase relation between the resultant magnetic field due to these cores G and K and the impressed pressure, the component fields due to the cores, however, serving in no wise to effect rotation of the armature. This is an important feature of my present invention, as by this means I am enabled to secure the required phase adjustment without causing the armature to rotate on no load, which it would be liable to do if these component fields of displaced phase acted to secure rotation. Any meter that has no automatic compensation is liable to run backward when the power factor of the circuit is low, because in such event the shunt-current will lead, while with non-inductive loads the shunt-current lags behind the series current. The effective result is accomplished by the double function of the core system and the application of the windings on separate cores. The main magnet acts as a shunt-magnet, which is but slightly influenced by the inner core. This separate core and winding, influenced by the shunt-magnet, produces an effect on the armature similar to that of a secondary of a transformer, and its presence makes the armature very sensitive. The disposition selected is such as to exclude the flux of the series winding from the core system, whose phase is variable, may be lagging or leading, and which influence would be a factor variable in quantity and sign.

In Figs. 9 and 10 are shown two modified magnet systems in accordance with my invention applied to a disk armature. The magnetic circuit consists of two core parts, one of which receives its magnetization inductively only from the other, this latter being primary to the former, polar plates P being also indicated. The conductor is shown centrally located on core K; but of course it may be applied at any convenient part of this core without departing from the nature of the invention.

My invention is open to numerous modifications, and although the best effects have been obtained in the meter with the core K, as shown in Figs. 1, 2, 5, and 6, other forms may be selected without departing from the nature of the invention—for instance, a form which may allow some of the lines to cross to the opposite pole without threading the closed conductor, as shown in Fig. 4ª.

In applying the principle to power-motors, which mostly are of the multipolar type, it is evident that core K must be modified if it should remain symmetrical with the field-magnet and with the changed core form. The close-circuited conductor L may assume any desired form of single or multiple of closed circuits which will enable the production of secondary poles located in fixed and predetermined relation to the primary energizing-poles.

My invention has been described in connection with motors and integrating watt-meters; but it is evident that the same mode of phase compensation can be applied to a variety of devices, such as indicating and recording instruments, and also to transformers and such other devices where undesirable phase changes are caused by external influences, and I therefore do not wish to limit myself to apply the method only to those devices shown.

What I claim as my invention is—

1. The method of producing a flux of required angular displacement from the electromotive force impressed upon a circuit, which consists in producing a flux of smaller angular displacement than required, by means of a current in a coil embracing a magnetizable core, inducing by said flux a secondary magnetic flux through the agency of a close-circuited conductor, in a core external to its core proper, superimposing said secondary flux upon the magnetic core of the primary flux and thereby producing a magnetizing effect equivalent to the required angular displacement.

2. The method of providing a phase adjustment displaced ninety degrees from the impressed alternating pulsatory or intermittent electromotive force of a circuit, which consists in producing a flux of smaller angular lag than desired, by means of a current in a coil surrounding a core of low magnetic reluctance, inducing by such flux secondary currents in a closed winding mounted on a core separated by air-gaps from the core named first, but so located with respect to the same that the flux-paths are the same, although the time of maximum effect is not coincident and by this superimposing of primary and secondary fluxes acting through air-gaps upon a common conductor producing a magnetizing effect equivalent to a displacement of ninety degrees.

3. The method of securing a definite phase adjustment, displaced from the impressed electromotive force, which consists in energizing by alternating, pulsatory or intermittent electric currents an open magnetic circuit of high inductance, thereby producing a magnetomotive force of smaller angular displacement than desired, sending said flux through a core located near the poles or in the air-gap of said open magnetic circuit, inducing secondary currents in a winding within inductive influence of said core, producing by said secondary currents a secondary flux in said core setting up additional magnetomotive forces in said gap, that the combined action of magnetomotive forces produce in said gaps as a resultant a magnetomotive force and flux displace from the impressed electromotive force the required definite angle.

4. The method of producing a magnetic flux differing by ninety degrees from the electromotive force of a circuit, which consists in producing an energizing-current of smaller angular phase displacement, thereby inducing in a magnetic core a magnetomotive force, inducing in another core inductively related to said first-named core, a magnetomotive force, inducing by the latter secondary currents in a conductor or system of conductors inductively related to said core, producing by said secondary currents secondary magnetomotive forces in said core, reacting with the latter upon the first-named core and combining the primary and secondary magnetomotive forces so as to produce at the poles of said cores a joint resultant or effective flux differing in phase ninety degrees from the electromotive force of the circuit.

5. The method of producing a flux of required angular displacement from the impressed electromotive force of a system of distribution, which consists in producing a magnetic flux of smaller angular displacement than required, by means of a current in

a coil, surrounding an open-circuit magnetic core, inducing by said flux a secondary magnetic flux in a core separated by air-spaces from the core first named, combining or superimposing said two fluxes upon a conductor common to both fluxes and thereby obtain a resultant action equivalent to a flux having the required angular displacement from the electromotive force of the system of distribution.

6. The method of producing an alternating magnetic flux displaced by ninety degrees from the electromotive force of the distribution system, which consists in energizing by an alternating current a core of open magnetic circuit of such high inductance as to produce a magnetomotive force lagging a predetermined angle approaching ninety degrees but smaller than this angle behind said electromotive force, inducing in another core separated by air-gaps from said open magnectic circuit a secondary magnetic flux, combining or superimposing said primary and secondary fluxes at the polar regions of said magnetic cores upon a conductor common to both fluxes and thereby produce a resultant action on said conductors equivalent to a flux from the first-named magnetic circuit, having a phase displacement of ninety degrees from the electromotive force of the distribution system.

7. The method of acting upon an electric conductor by a field displaced ninety degrees behind the impressed electromotive force, which consists in acting inductively on said conductor with a flux of smaller lag angle, inducing in a second core with this flux another flux displaced in phase from the former, compensating or supplementing the first-named flux by the second, by causing the latter to act inductively upon the same electric conductor and thereby produce in the air-gaps a resultant magnetomotive force and flux displaced ninety degrees from the impressed electromotive force.

8. The method of acting upon an electric conductor by an alternating magnetic field displaced ninety degrees behind the electromotive force of the circuit, which consists in energizing an open-circuit magnetic core by an alternating current producing thereby a flux lagging less than ninety degrees behind said electromotive force, acting simultaneously with said flux upon an electric conductor located in the air-gap of said open-circuit magnet and upon a magnetic core also located in said air-gap, producing in the latter a magnetomotive force and flux lagging behind the flux named first, reacting and superimposing the last-named flux upon said electroconductor, and thereby establish between the polar regions of said cores a magnetomotive force and flux, whose action is equivalent to a flux lagging ninety degrees behind the electromotive force of the circuit.

9. The method of reacting upon an armature with an alternating magnetic field, displaced ninety degrees from the electromotive force of a system, which consists in energizing an open-circuit magnet system by an alternating or undulating current, thereby producing a magnetic flux lagging less than ninety degrees, acting simultaneously with said flux on said armature and on a core provided with a winding, producing in said core by means of said winding a secondary flux, reacting with said secondary flux simultaneously upon said armature, and upon said open-circuit magnet system, and thereby producing a combined inductive effect upon said armature, equivalent to that of a flux displaced ninety degrees from the electromotive force of the system.

10. The method herein described of obtaining a magnetic field in quadrature, with the impressed electromotive force of a circuit, which consists in magnetizing a core by a current lagging less than the desired amount behind the impressed electromotive force, establishing thereby a magnetic flux, sending said flux through a second core, separated by air-space from the first, inducing exclusively by said flux a secondary current around said second core in a winding, and through the latter a secondary magnetic flux and reacting with the fluxes of both magnet-cores on the common air-space between them, and thereby producing a joint effect in said gap, substantially equal to a flux in quadrature with the impressed electromotive force.

11. The method of obtaining a magnetic field in quadrature with the impressed electromotive force of a circuit, which consists in producing a magnetic flux in an open-circuit core, by means of a winding surrounding said core, subjecting a supplemental unenergized core, located inductively to the open-circuit core to its flux, producing thereby a secondary flux, such, that when combined with the flux named first, shall produce in the gap between them a resultant flux displaced the required phase angle and jointly utilizing said fluxes, as and for the purpose described.

In testimony that I claim the foregoing as my invention I have signed my name, in the presence of two witnesses, this 25th day of January, A. D. 1901.

LUDWIG GUTMANN.

Witnesses:
FRANK S. FULTON,
C. E. COMSTOCK.