No. 652,453. Patented June 26, 1900.

E. BATAULT.

ALTERNATING CURRENT ELECTRIC METER.

(Application filed Aug. 2, 1898.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1,

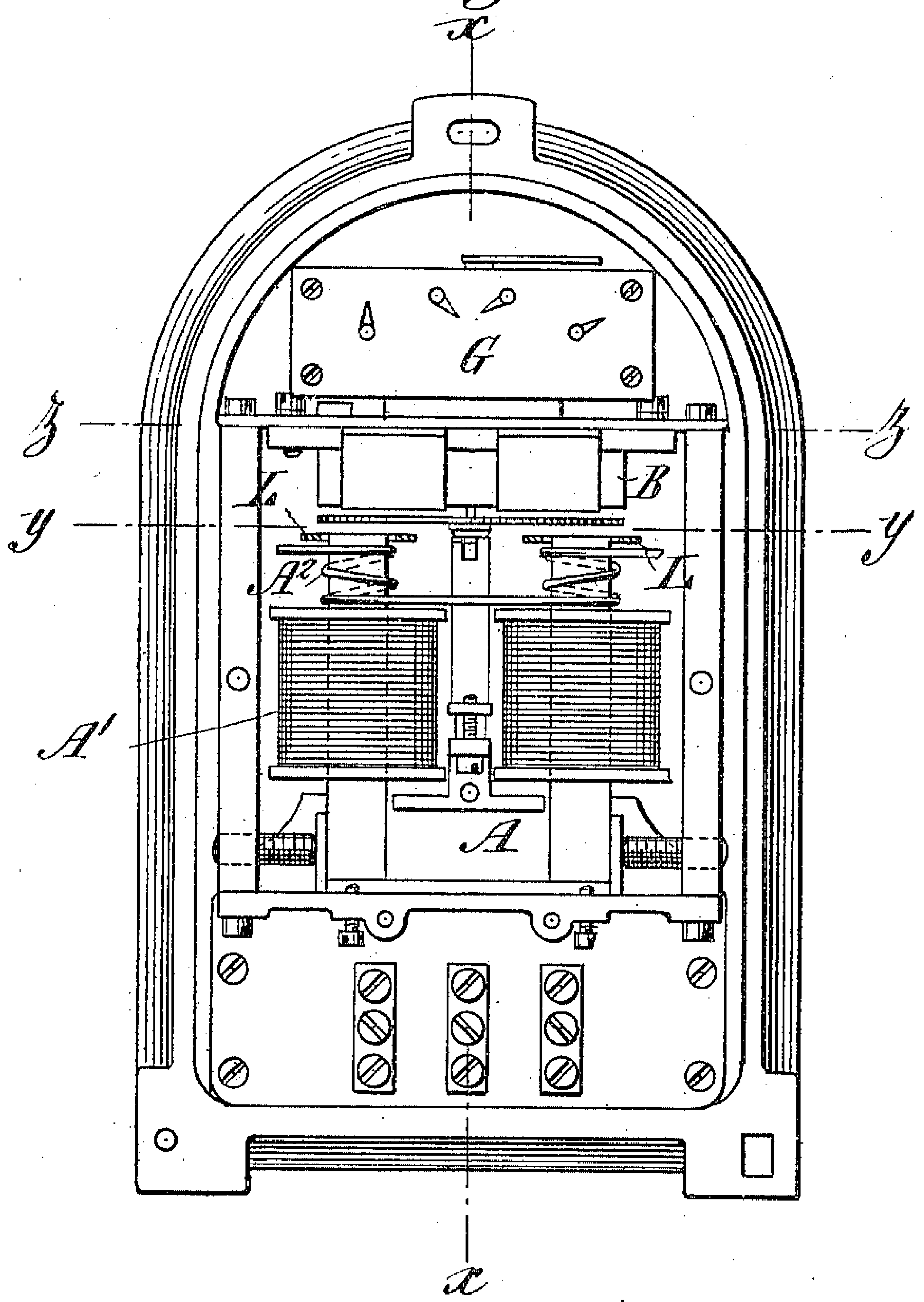


Fig. 2,

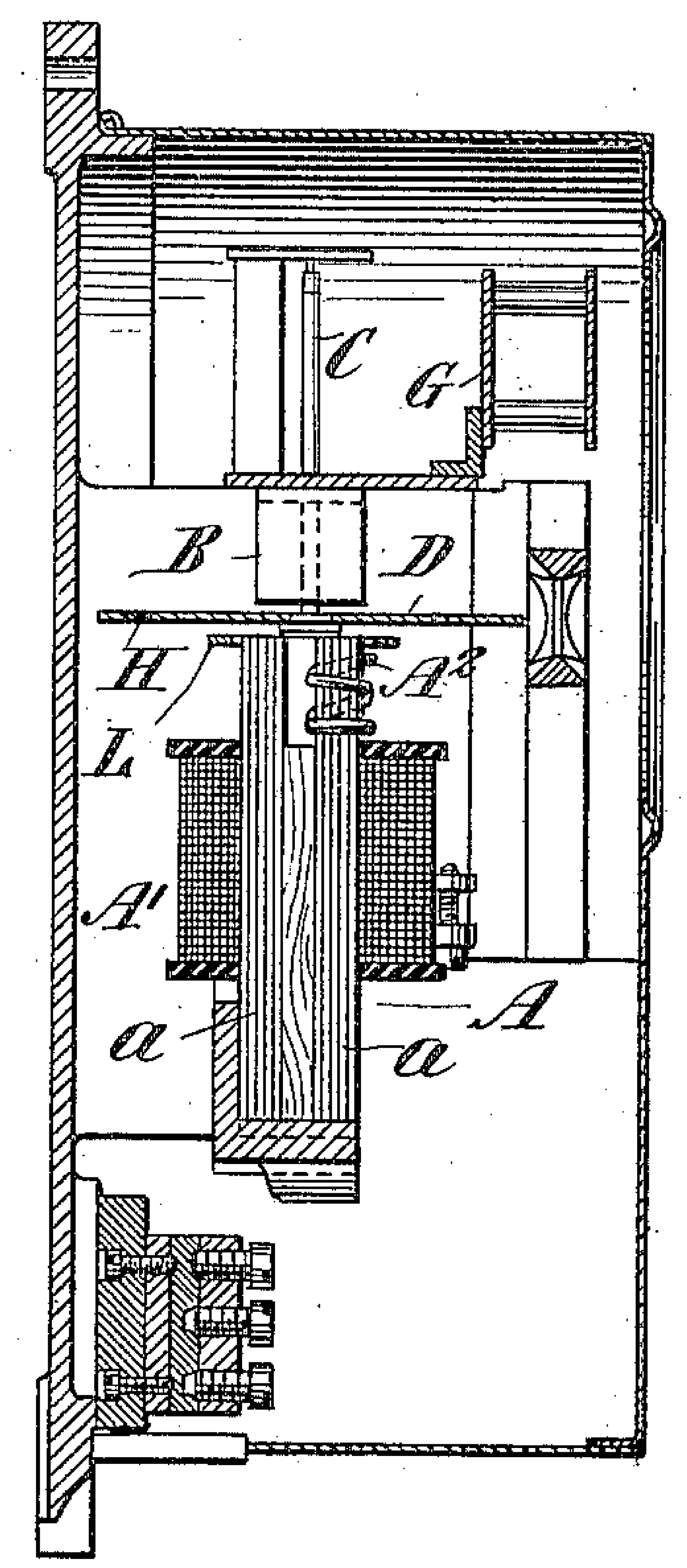


Fig. 3,

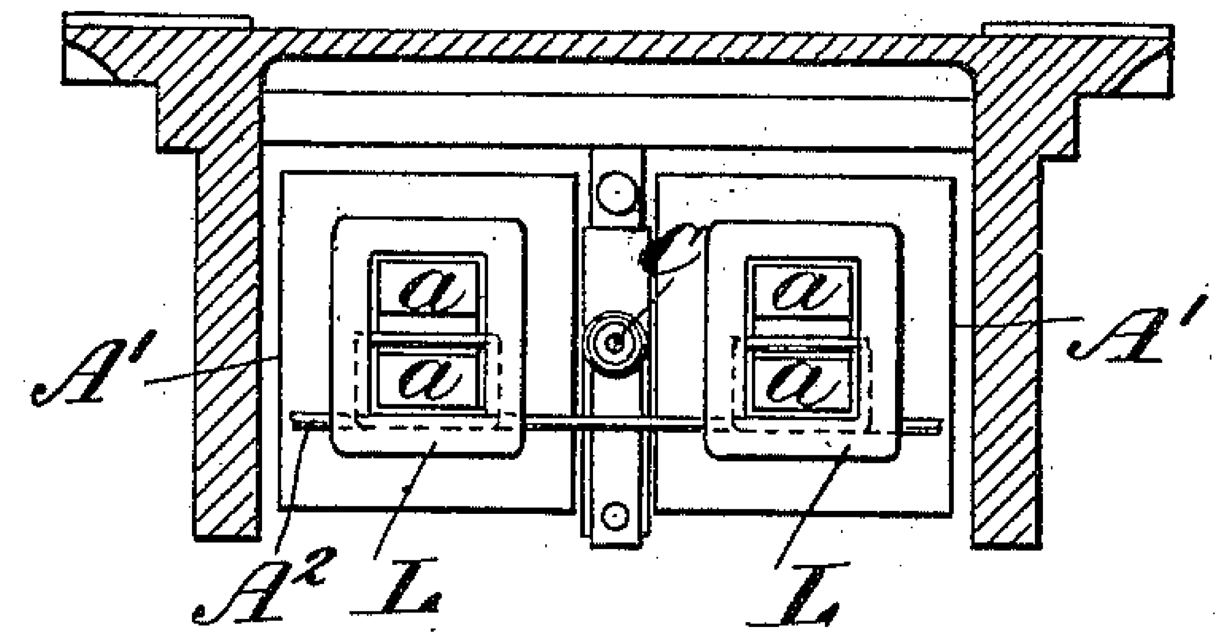
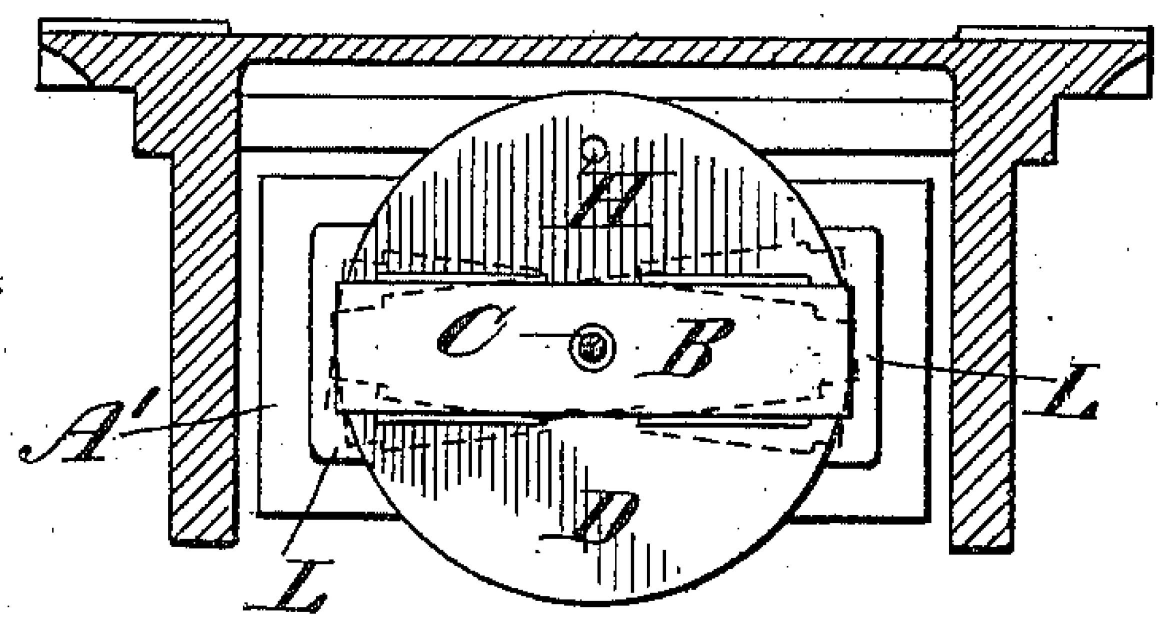


Fig. 4,



WITNESSES:

D. H. Haywood

Harry Marsh.

INVENTOR

Emile Batault

BY

E. M. Marble & Son

ATTORNEYS

No. 652,453. Patented June 26, 1900.

E. BATAULT.

ALTERNATING CURRENT ELECTRIC METER.

(Application filed Aug. 2, 1898.)

(No Model.) 2 Sheets—Sheet 2.

Fig. 5,

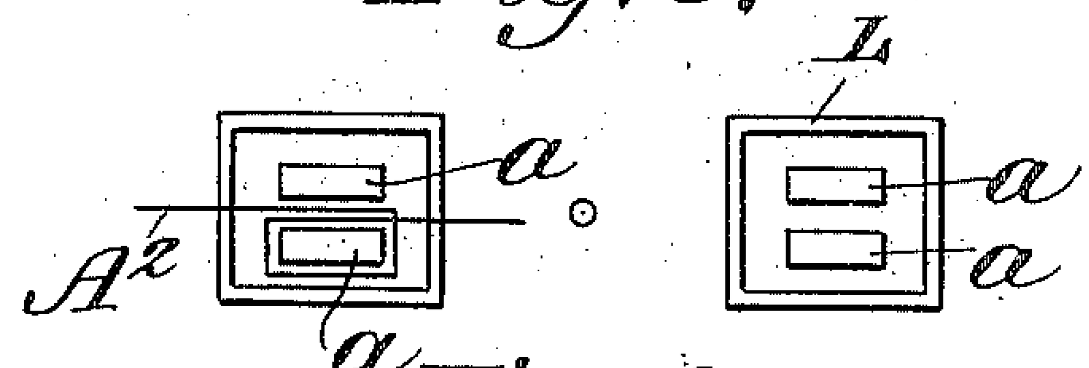


Fig. 6,

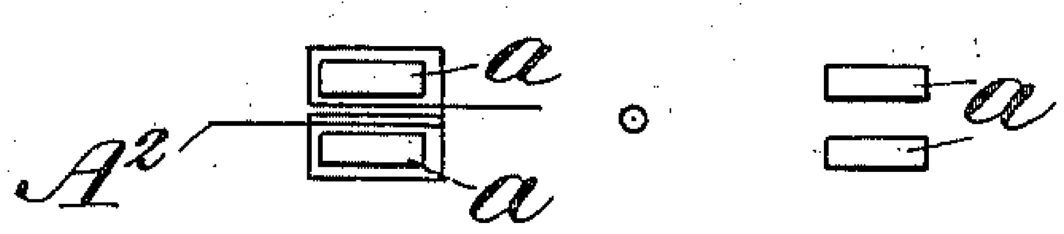


Fig. 7,

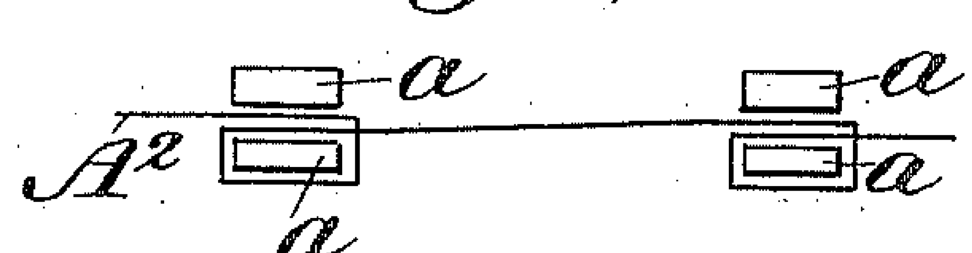


Fig. 8,

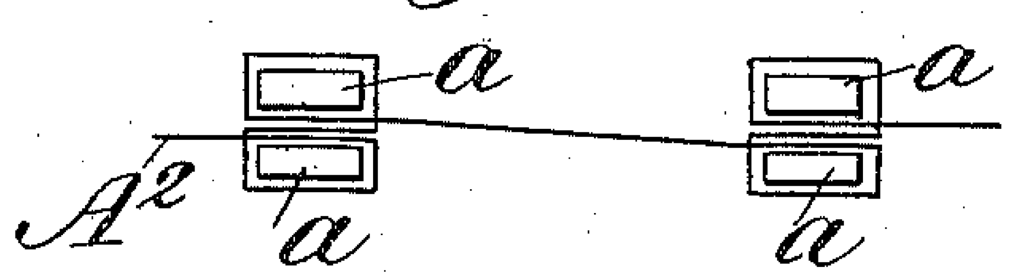


Fig. 9,

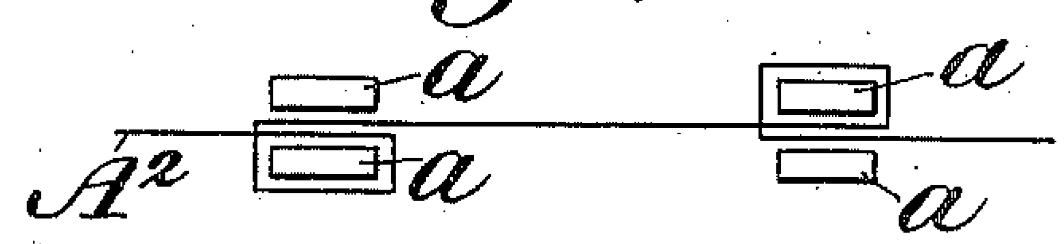


Fig. 10,

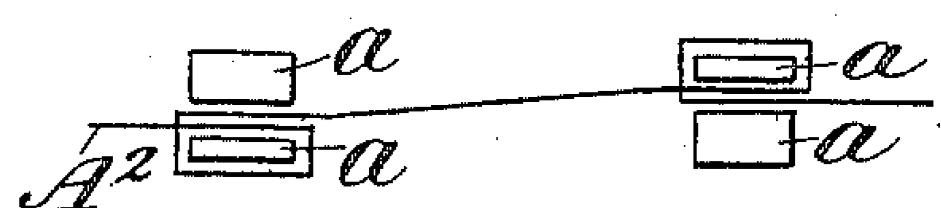


Fig. 11,

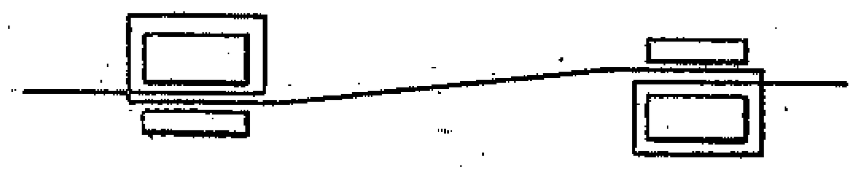


Fig. 12,

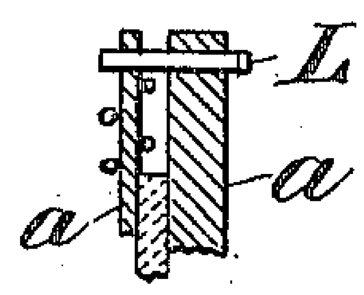


Fig. 13,

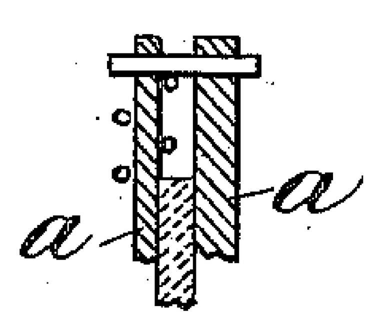


Fig. 14,

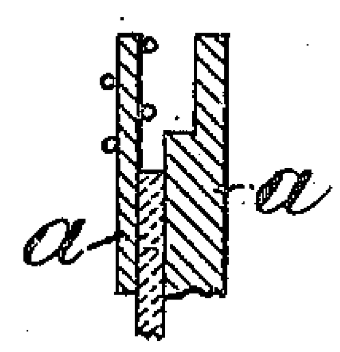


Fig. 15,

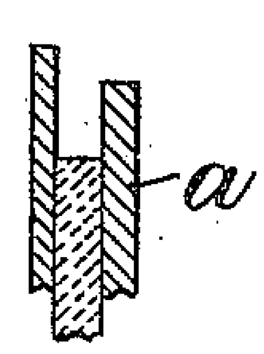


Fig. 16,

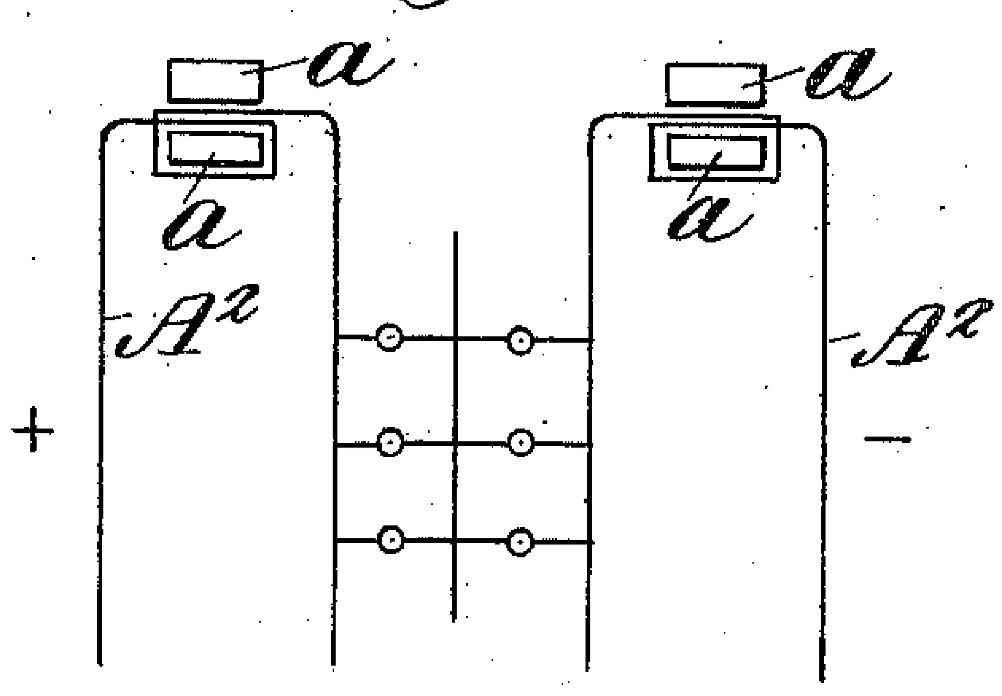
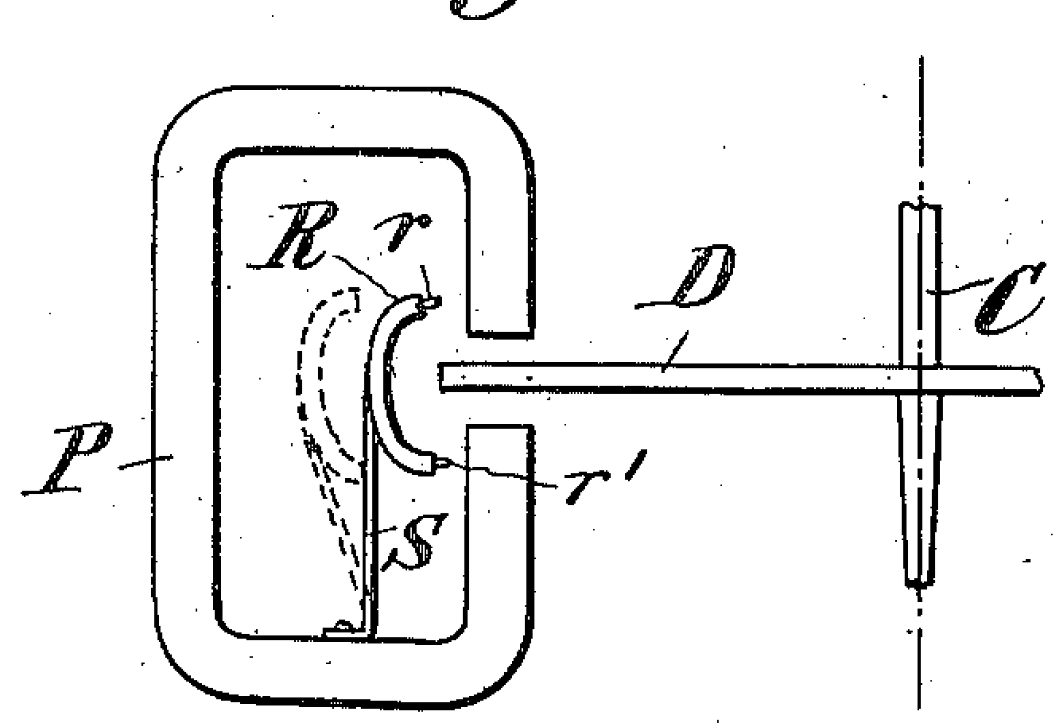


Fig. 17,



WITNESSES

D. N. Haywood

Harry Marsh.

INVENTOR

Emile Batault

BY

E. M. Marble & Sons

ATTORNEYS

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

EMILE BATAULT, OF GENEVA, SWITZERLAND.

ALTERNATING-CURRENT ELECTRIC METER.

SPECIFICATION forming part of Letters Patent No. 652,453, dated June 26, 1900.

Application filed August 2, 1898. Serial No. 687,559½. (No model.)

To all whom it may concern:

Be it known that I, EMILE BATAULT, a citizen of the Swiss Republic, residing at No. 6 Rue de Universite, Geneva, in the canton of Geneva, Republic of Switzerland, have invented a certain new and useful Improvement in Alternating-Current Electric Meters, of which the following is a specification.

My invention relates to improvements in alternating-current meters and electrical measuring instruments of similar character, and particularly to the class of meters wherein a register is actuated by a rotating body or armature, movement of which is effected by the resultant field produced by two magnetic fields differing in phase, one of said fields being due to and varying with the current in the work-circuit and the other field being due to and varying with the electrical pressure.

The object of the invention is to provide an alternating-current meter of simple construction which is accurate both on non-inductive and on highly-inductive circuits, which consumes only a small amount of energy in its operation, which registers accurately loads ranging from those of extremely-small proportions through wide limits, and wherein the armature will be protected from any induction tending to operate it when no current is consumed in the work-circuit. To effect this object, I employ a registering mechanism of any suitable type and operate it through mechanical connections from a rotating armature the speed of which is directly dependent upon and proportional to the consumption of current in the work-circuit. The armature is subjected to two fields differing in phase, one produced by a shunt-coil influenced by the pressure and the other by a series coil in the work-circuit, a part or whole of the cores of the series coils being common to the cores of the shunt-coils—such, for instance, as by winding the series coil or coils around only a portion of the mass of the shunt-cores. By thus using common cores for the series and shunt coils the general construction of the meter will be simplified and its efficiency increased.

The invention also consists in details of construction and arrangement relating principally to means for preventing rotation of the armature when no energy is being consumed in the work-circuit, to means for securing accuracy of registration on highly-inductive circuits, to means for inducing a starting torque, whereby the armature will commence to rotate on very small loads, to means whereby a balance of the armature may be effected to overcome the starting friction thereof, and to specific improvements in the retarding or brake magnet used when the electromotive force on the circuits to be metered is subject to variations and by reason of which the energy of the retarding or brake magnet or magnets may be maintained practically constant, as well as in other details of construction and arrangement, all as will be more fully hereinafter described and claimed.

In order that my invention may be better understood, attention is directed to the accompanying drawings, forming part of this specification, and in which—

Figure 1 is a front view of the meter with the cover removed; Fig. 2, a vertical section on the line *x x* of Fig. 1; Fig. 3, a cross-section on the line *y y* of Fig. 1; Fig. 4, a horizontal section on the line *z z* of Fig. 1; Fig. 5, a cross-section through the end of the shunt-magnets, illustrating a single series coil on a portion of one of the shunt-cores and showing also the induction-rings used to secure accuracy of registration on highly-inductive circuits; Fig. 6, a similar view showing two series coils on the same shunt-core; Fig. 7, a similar view showing a winding like that shown in Fig. 1, a series coil being wound upon the corresponding section of each shunt-core to produce like fields in the armature; Fig. 8, a similar view showing four series coils, two on each shunt-core; Fig. 9, a similar view showing two series coils, one on the front section of one shunt-core and the other on the rear section of the other shunt-core, the series coils producing unlike fields in the armature; Fig. 10, a view similar to Fig. 9, but showing the portions of the shunt-cores on which the series coils are wound as being of less area than the unwound portions thereof; Fig. 11, a similar view the reverse of Fig. 10; Figs. 12, 13, 14, and 15, various longitudinal sectional views showing different modifications in the outer ends of one of the shunt-cores; Fig. 16, a diagram showing the connections with a three-wire circuit, and Fig. 17 a detail view showing a retarding or brake magnet and showing the means which I have invented for maintaining the energy thereof practically constant.

In all of the above views corresponding parts are represented by the same letters of reference.

A represents an electromagnet having preferably laminated or sectional legs, as shown.

A′ A′ are two shunt-coils carried by the magnet, said coils being connected across the circuit, so as to be influenced by the pressure. The shunt-coils A′ are wound to produce unlike poles in the armature. A^2 A^2 in Figs. 1, 2, and 3 represent two coils in series with each other and with the work-circuit. These coils are influenced directly by the current to be measured and are of relatively-coarse wire, with generally but three or four turns. The series coils are wound upon one or both of the sections *a a* of either or both of the shunt-cores. In Figs. 1, 2, 3, and 7 both series coils are wound upon the front section *a* of both of the shunt-cores, the winding being such that the series coils will induce fields of like polarity in the armature. In Fig. 5 only a single series coil is shown wound upon the front section of one of the shunt-cores. Obviously it may be wound upon the back section. In Fig. 6 two series coils are shown wound upon the two sections of one shunt-core, the windings being such as to produce magnetic fields of opposite polarity in the armature. In Fig. 8 four series coils are shown wound upon the two sections of both shunt-cores, each pair of coils inducing fields of unlike polarity in the armature. In Figs. 9, 10, and 11 two series coils are shown, one wound upon the front section of one shunt-core and the second upon the rear section of the other shunt-core, the windings being such that the series coils will induce fields of unlike polarity in the armature. The only difference between Figs. 10 and 11 is that in the former figure the section of each shunt-core upon which the series coil is wound is of less mass than the unwound section, while in the latter figure the reverse is true. Fig. 12 is a longitudinal section of Fig. 10, with the addition of one of the inductive rings, which I will refer to hereinafter. Fig. 13 is a longitudinal section of one of the cores shown in Fig. 9 with the same addition. Fig. 14 shows one of the sections of the shunt-core cut away opposite to the series core, and Fig. 15 shows one of the sections of the shunt-core of greater length than the other. In Fig. 16 I illustrate the connections which may be used when the meter is employed for measuring current on a three-wire system, the series coils being in circuit with the outside wires and being wound so as to produce fields of the same polarity in the armature.

It is obvious that the construction of the shunt-cores may be varied within wide limits and that the windings of both the shunt and series coils may be changed in many respects without departing from the essential spirit of the invention, which resides in the employment of a series coil which shall, in whole or in part, be common to a shunt-core.

Mounted above the coils of the magnet A is an armature B, pivoted in any suitable way so as to be adjustable on a center and located between the armature B and the poles of the magnet A, and carried upon a shaft C is a metal disk or armature D. This disk is made, preferably, of aluminium. The bearings for the shaft C are as frictionless as possible, as is common in the art. A register G, of any suitable character, connects through any desired mechanical gearing with the shaft C to register the rotations of the armature D.

In operation it will be observed that the shunt and series coils induce fields in the armature D which, being of different phases, cause said armature to rotate under the effect of the Foucault currents induced therein. The phases of the magnetization induced by the shunt-coils lag behind the phases of the magnetization induced by the series coils on account of the great self-induction of the former. The torque produced by the differences in phase of the fields thus induced in the armature and which results in its rotation is proportional to the current influencing the series coils when the electromotive force is constant. The speed of the armature is in consequence proportional to the current to be measured. It will be observed that if the shunt-coils alone were used Foucault currents would be simultaneously induced in the armature at diametric points therein, and no movement thereof would be effected; but if the disk is caused to rotate by another influence the Foucault currents so generated oppose such rotation, the checking or braking effect varying directly as the speed. If, on the other hand, the series coils were wound entirely around the cores and alone used, the same effect would be produced, while if with the series coils as so disposed shunt-coils were employed there would still be no movement of the disk, since the two fields induced by the shunt and series coils, though different in phase, will be superimposed. For this reason it has been the practice in constructing meters of this type to employ separate cores for the shunt and series magnets. I have found that by placing the series coil or coils on only a portion of the area of the mass of the shunt-magnet a rotating field may be obtained in an armature to rotate the latter at a speed proportional to the consumption of energy in the work-circuit, while at the same time retaining the braking action of the Foucault currents generated by the shunt-coils, whereby the relative speed of rotation to the current to be measured holds good within wide variations.

As stated, if the shunt-coils alone were used the Foucault currents generated thereby at diametric points in the armature exert no tendency to rotate the same; but when the series coils are carried upon a portion of one or both of the shunt-coils the shunt-coils tend to induce currents in the series coils when no current is energizing the work-circuit, and the eddy-currents so induced in the series coils tend to induce in the armature Foucault currents of different phase from those induced directly by the shunt-coils, and in consequence there is in some instances a tendency of the disk to rotate under the action of the rotating field so produced, which manifestly must be avoided. The tendency of the disk to thus rotate under the effect of Foucault currents induced directly and indirectly by the shunt-coils and differing in phase is dependent largely upon the kind of winding used. It will be observed that when the series coils are disposed as in Figs. 1, 2, 3, 6, 7, and 8 this tendency will be very small and will, in fact, depend upon any slight structural differences in the series coils. For instance, with Figs. 1, 2, 3, and 7 it will be noted that the eddy-currents induced by the shunt-coils in the series coils are such that in one coil they have a tendency to move the armature in one direction and in the other coil a tendency to move it in the other direction, since both coils are on the same side of the armature thereof. When, however, the series coils are influenced directly by a current flowing in the work-circuit, the fields induced thereby in the armature will, as stated, be of like polarity, whereby rotation will be effected. The same is true with the arrangement shown in Fig. 6. Eddy-currents induced in the series coils by the adjacent shunt-coil counteract or oppose each other, while currents induced by the series coils under the effect of current energizing the same supplement one another and effect rotation of the armature. With the arrangement shown in Figs. 5, 9, 10, and 11 the tendency of the armature to rotate when no current is influencing the work-circuit is very much greater, since the series coils are placed on opposite sides of the diameter of the armature, and the tendency to rotate is the same whether the fields induced in the armature by the series coils are caused by induction from the shunt-coils or by current in the work-circuit. In all instances, therefore, it is desirable, in some instances it is necessary, to provide means whereby any tendency of eddy-currents induced in the series coils by the shunt-coils to affect the armature may be overcome. I find in practice that by employing the armature B, between which and the magnet A the rotating armature D is located, this tendency of the armature to rotate is largely neutralized. By shifting the position of the armature B, as shown in dotted lines, Fig. 4, the starting torque of the motor can be regulated, due probably to the fact that the lines of force established by the shunt-coils pass through the rotating armature D to reach the pivoted armature B and in so doing develop eddy-currents in the armature. These currents on account of their self-induction lag behind the currents in the shunt-coil, causing the armature to be rotated, which movement can be accelerated by adjusting the armature B in the direction of rotation.

My meter so far as I have explained it is substantially accurate on non-inductive circuits, but develops an error or defect of registration when used on highly-inductive circuits, as is the case with nearly all alternating-current meters. The reason is that the phase differences with highly-inductive circuits, particularly under light loads, are very small and, in fact, are sometimes reversed, so that the armature turns in the wrong direction. I have discovered that this error in alternating meters of the type under consideration may be entirely overcome by surrounding the poles of the core of the shunt magnet or magnets by a metallic ring L of suitable size. The proper section of this ring is determined by experiment. Instead of rings L, I may use suitably-proportioned short-circuit windings or closed coils for the same purpose. The currents induced in the rings L or other device induce in the armature D eddy-currents, which differ more than ninety degrees in phase from the current in the series coils when non-inductive, so that the action upon the armature of the field thus produced by the rings L and of the field produced by the series coils tends to rotate it, which tendency is greater with inductive currents than with non-inductive currents, for the reason that non-inductive currents in the series coils having a phase difference of more than ninety degrees from the field induced by the rings L would have a tendency to move the armature in the opposite direction. In other words, with non-inductive currents the rings L introduce a checking action. On the other hand, the action of the currents generated in the armature by the shunt and series coils is greater with non-inductive currents than with inductive currents on account of the greater phase difference between them. Thus a proper combination of the two actions noted results in a true energy-meter, the proper balance between the two actions being obtained by experimental adjustment of the position and section of the rings L. To additionally provide, or as a substitute provision, against the rotation of the armature when no current is flowing through the work-circuit, it may be provided with a plug H, of copper, silver, or other metal different from that of which the armature is formed. When the armature is composed, as is preferable, of aluminium, the approach of the plug H toward either core of the magnet results in a slight acceleration of the speed, or the passage of the plug H away from the pole results in a slight retardation of the speed. In this way a checking action is produced on the armature which varies, of course, with the size of the plug H. In this way I am enabled to counterbalance the retarding effect of friction for small currents by adjusting the meter so that there shall be a constant tendency of the armature to rotate, which tendency will be exactly counterbalanced by the retardation produced by the plug H when receding from one of the magnet-cores unless the current strength is above a definite minimum.

If the electromotive force in the circuit to be measured is constant, the braking effect may be secured entirely by the action of the shunt-magnet, as before noted; but if the electromotive force is subject to variation a separate retarding or braking magnet P may be employed, as shown in Fig. 17, the poles of which are arranged in proximity to the surface of a disk D, as is common. In order to maintain practical uniformity in the energy of the magnet P, I employ an armature R, carried by a spring S at a convenient distance from the magnetic poles, which armature being attracted by the magnet will short-circuit a greater or less number of lines of force through it. As the strength of the magnet P decreases, the armature R will slowly recede, short-circuiting a smaller number of lines of force, and thus equalizing the effect on the brake-disk D. The armature R is provided with two non-magnetic pins r r' to prevent actual contact of the armature and the magnetic poles.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is as follows:

1. In an induction alternating motor-meter, the combination with a revoluble armature, of two shunt-coils diametrically disposed to the armature and inducing fields of opposite polarity therein, whereby a checking effect is produced on the rotating armature, and means to induce fields of different phase in, and effect rotation of, the armature, substantially as set forth.

2. In an induction alternating motor-meter, the combination with a revoluble armature, of two shunt-coils diametrically disposed to the armature and inducing fields of opposite polarity therein, whereby a checking effect is produced on the rotating armature, and series coils for inducing fields of different phase in the armature, substantially as set forth.

3. In an induction alternating motor-meter, the combination with a revoluble armature, of two shunt-coils diametrically disposed to the armature and inducing fields of opposite polarity therein, whereby a checking effect is produced on the rotating armature, and series and closed coils for inducing fields of different phase in the armature, substantially as set forth.

4. In an induction alternating motor-meter, the combination with a revoluble armature, of two shunt-coils diametrically disposed to the armature and inducing fields of opposite polarity therein, whereby a checking effect is produced on the rotating armature, and two series coils coöperating with the shunt-coils and arranged on the same side of the diameter of the armature, substantially as set forth.

5. In an induction alternating motor-meter, the combination with a revoluble armature, of a shunt-coil for producing a magnetic field in the armature, a series coil located eccentrically to the field of influence of the shunt-coil and producing in the armature a magnetic field of a different phase, whereby rotation of the armature is effected, and a closed conductor located between the series coil and the armature, substantially as set forth.

6. In an induction alternating motor-meter, the combination with a revoluble armature, of a shunt-coil producing a magnetic field therein, a core for said coil, a series coil wound on a portion only of said core, and a closed conductor surrounding the core and located between the series coil and the armature, substantially as set forth.

7. In an induction alternating motor-meter the combination with a revoluble armature and means for rotating the same in a magnetic field of a conducting non-magnetic piece of a different but better conducting metal carried by the moving body and so located that by the movement of the armature said conducting-piece approaches toward and recedes from the magnetic poles, thereby producing an acceleration and retardation of its movement, substantially as set forth.

8. In an induction alternating motor-meter, the combination with a revoluble armature, of shunt and series coils inducing magnetic fields therein of different phase, and a circular plug of different but non-magnetic metal in the armature for producing an acceleration and retardation of its movement, substantially as set forth.

9. In an induction alternating motor-meter, the combination with a core having split extremities, shunt-coils and secondary closed coils wound around the entire core, and series coils on portions thereof, of a revolubly-mounted conducting-body located in the field of the magnetic core, substantially as set forth.

10. In an induction alternating motor-meter, the combination with a revolubly-mounted conducting-body and means for rotating the same, of a permanent magnet producing a field of force through which the conducting-body passes, a movable armature for the magnet arranged to divert a portion of the lines of force to weaken the field in which the conducting-body rotates, and means to automatically withdraw the armature away from the magnet to maintain its field practically uniform, substantially as set forth.

11. In an induction alternating motor-meter, the combination with a revolubly-mounted conducting-body and means for rotating the same, of a permanent magnet producing

a field of force through which the conducting-body passes, a movable armature for the magnet arranged to divert a portion of the lines of force to weaken the field in which the conducting-body rotates, and a spring to automatically withdraw the armature away from the magnet to maintain its field practically uniform, substantially as set forth.

12. In an induction alternating motor-meter, the combination with a core and series and shunt coils thereon, the series coil being wound about a portion only of the cross-section of the core, and a pivoted armature for said magnet situated in front of the pole-pieces and adapted when moved to one side with respect to the pole-pieces to vary the starting torque of the motor, of a revolubly-mounted conducting-body located between the magnet and its armature and adapted to be rotated by reason of the influence of the fields produced by alternating currents energizing the series and shunt coils, substantially as set forth.

In testimony whereof I affix my signature in the presence of two witnesses.

EMILE BATAULT.

Witnesses:
THEODORE BRET.
F. BADEL.