No. 660,021. Patented Oct. 16, 1900.

W. M. MORDEY & G. C. FRICKER.

ELECTRICITY METER.

(Application filed May 19, 1900.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.

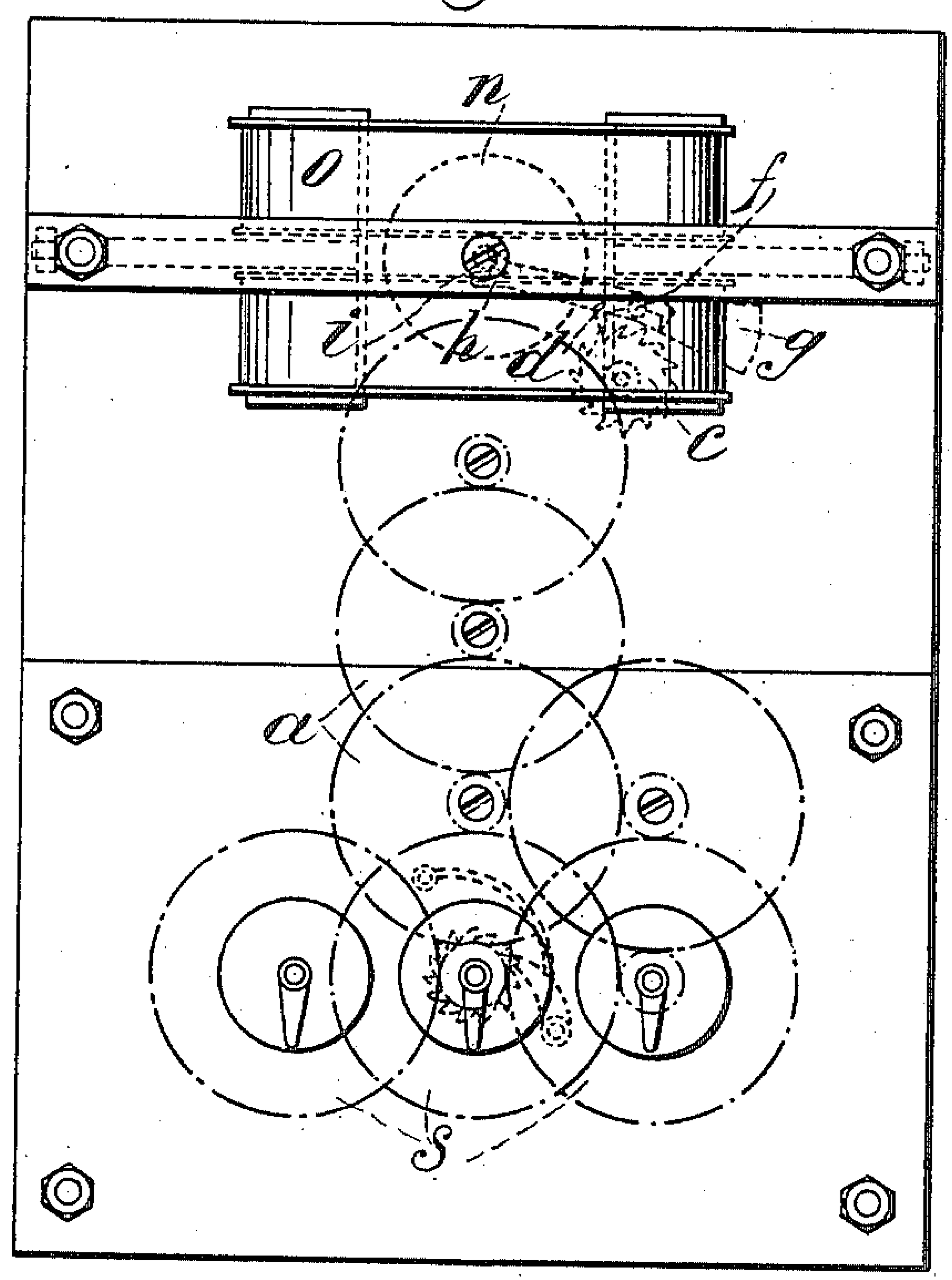
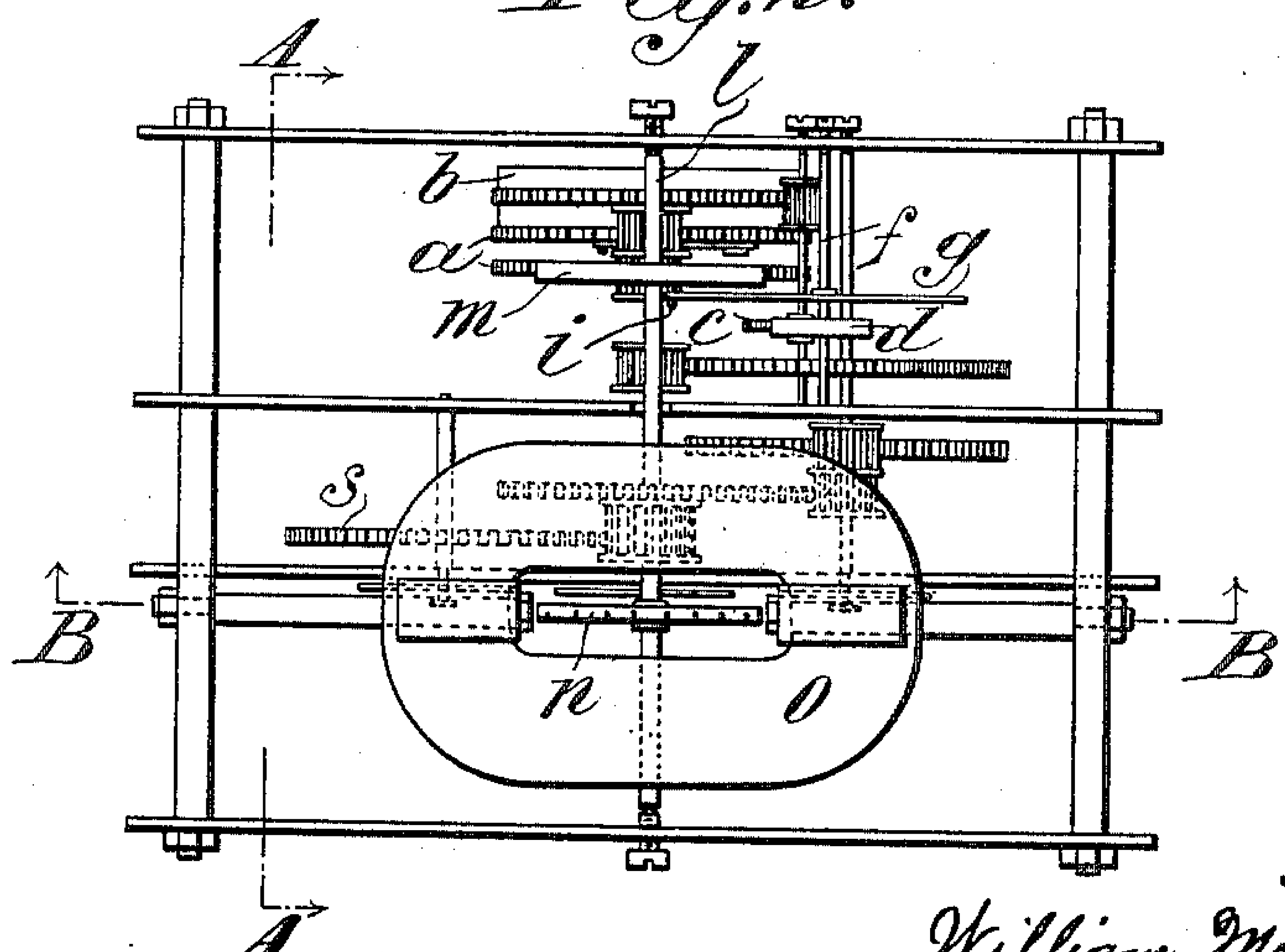


Fig. 2.



Witnesses:
C. Holloway
W. C. Pinckney

Inventors:
William Morris Mordey,
Guy Carey Fricker,
By J. E. M. Bowen Attorney

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Fig. 3.

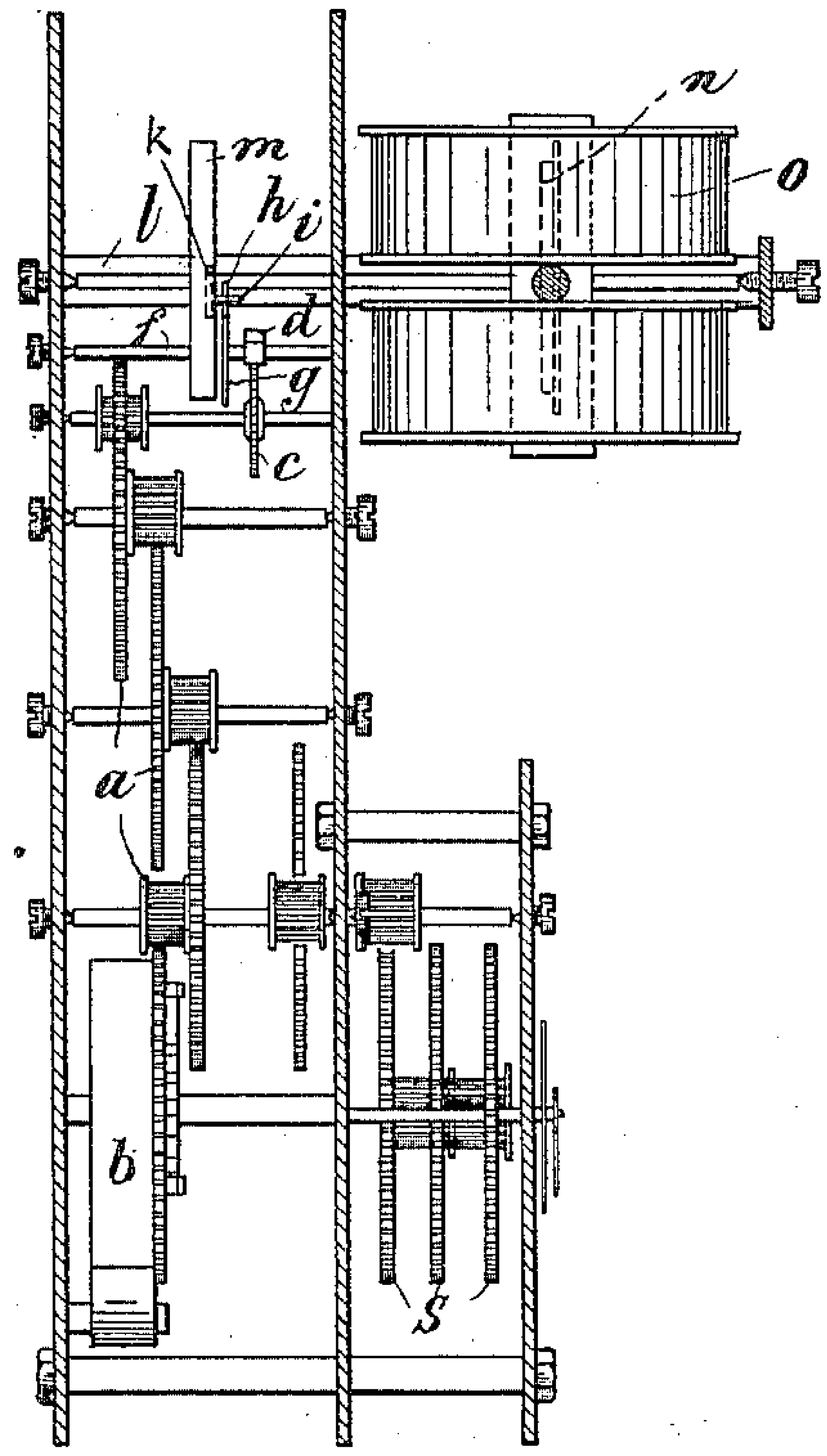

Fig. 4.

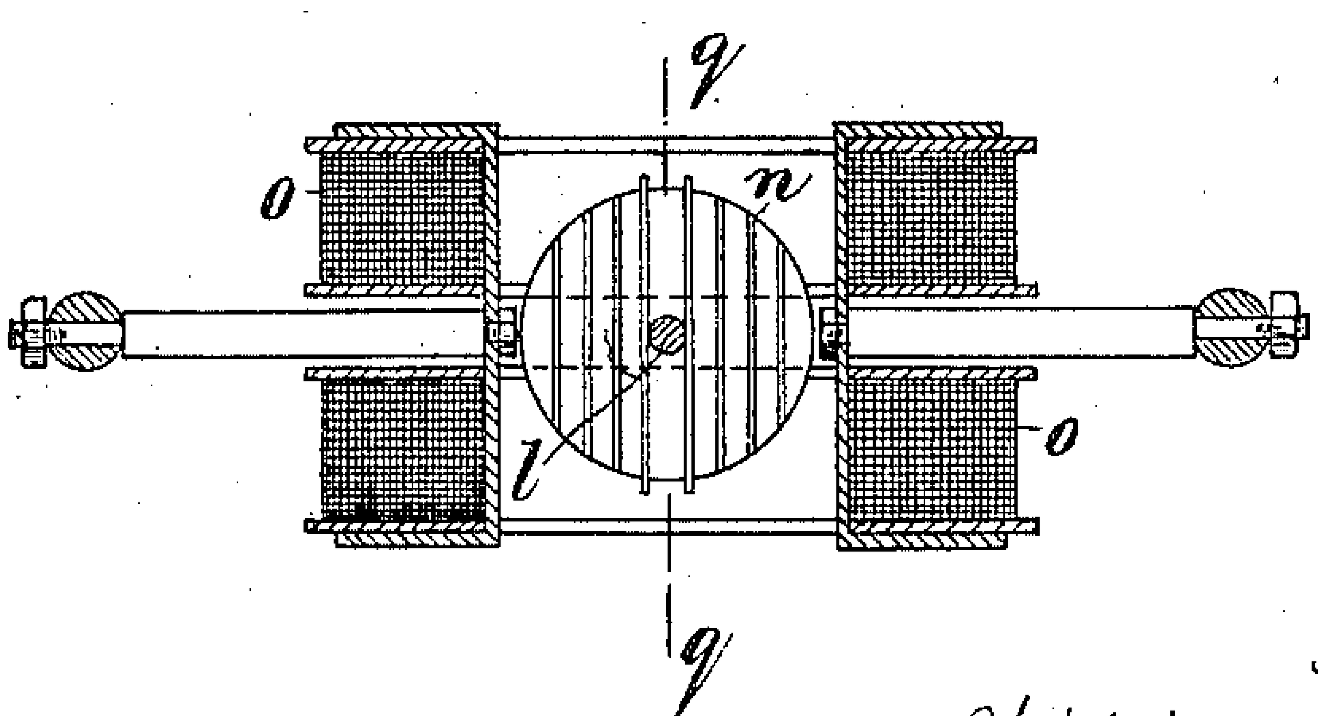

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Fig. 5.

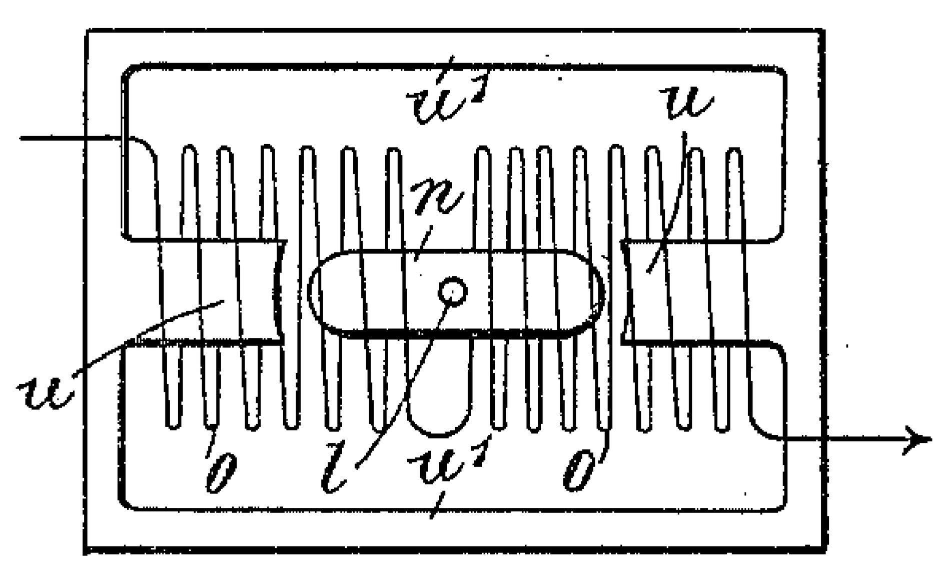


Fig. 6.

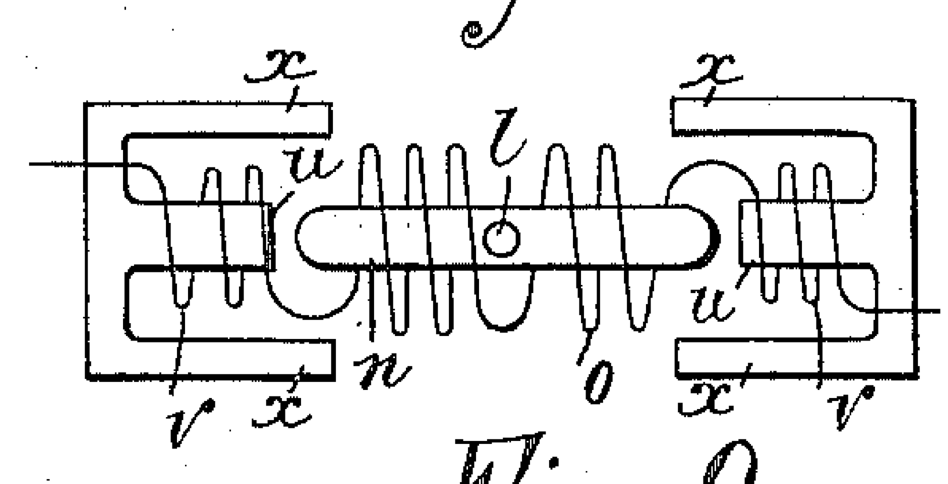


Fig. 9.

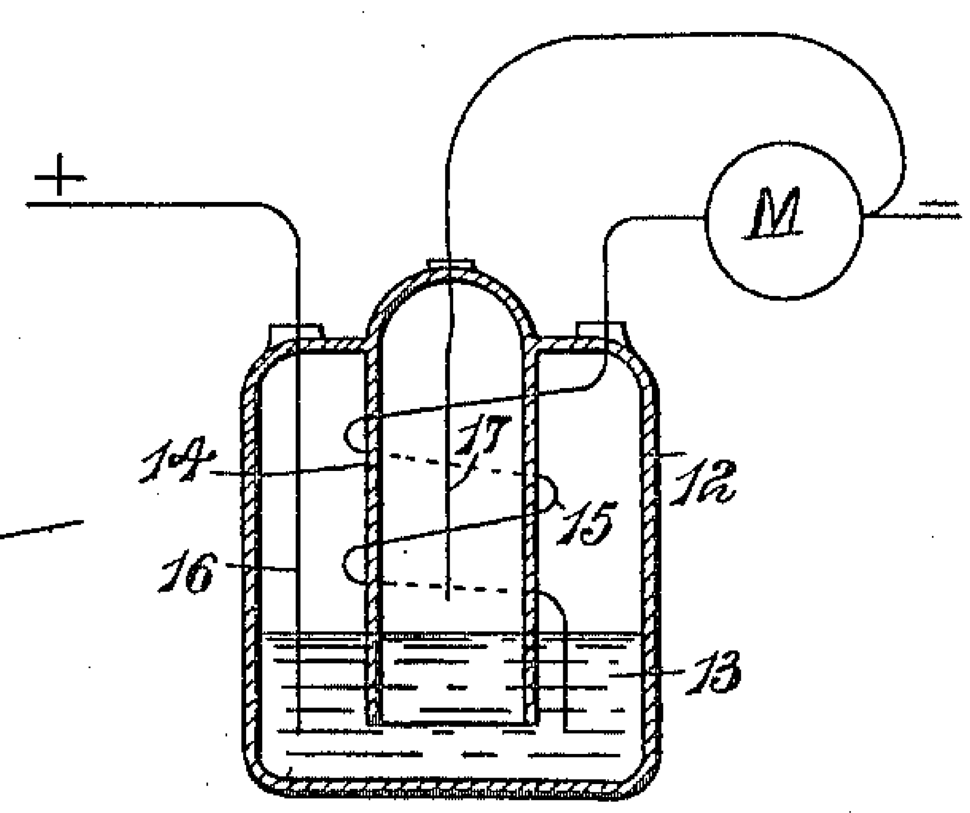


Fig. 7.

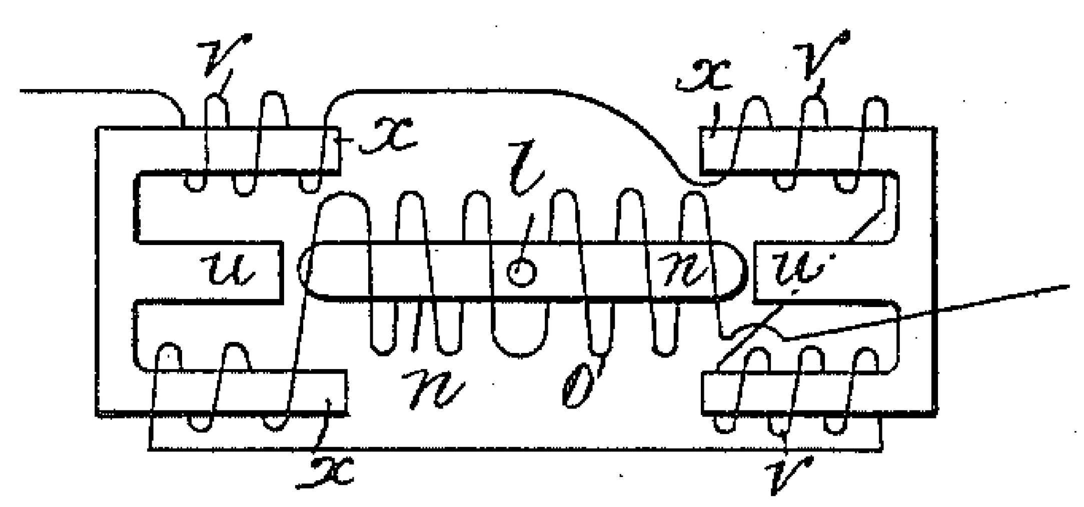
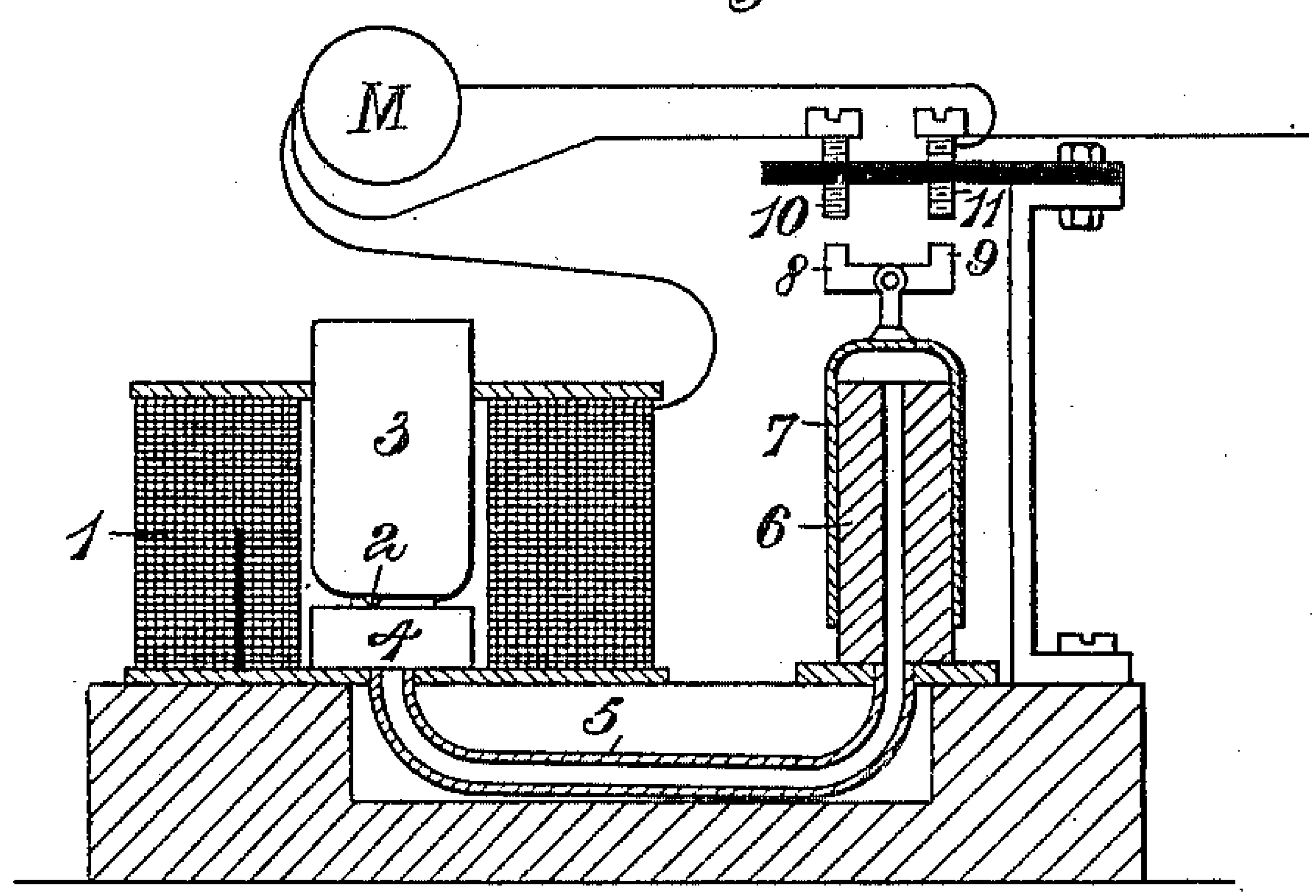


Fig. 8.



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UNITED STATES PATENT OFFICE.

WILLIAM MORRIS MORDEY AND GUY CAREY FRICKER, OF LONDON, ENGLAND.

ELECTRICITY-METER.

SPECIFICATION forming part of Letters Patent No. 660,021, dated October 16, 1900.

Application filed May 19, 1900. Serial No. 17,215. (No model.)

To all whom it may concern:

Be it known that we, WILLIAM MORRIS MORDEY, residing at Westminster, London, and GUY CAREY FRICKER, residing at the city of London, England, subjects of the Queen of Great Britain and Ireland, have invented Improvements in and Relating to Electricity-Meters, of which the following is a specification.

This invention has for its object the construction of a simple and inexpensive registering electricity meter or counter suitable for either alternate or direct currents. For this purpose there is used in conjunction with a dead-beat escapement, such as that employed in an ordinary timepiece-movement, a suitably-shaped soft-iron piece, hereinafter referred to as the "armature," preferably laminated, attached to the balance-wheel or to the balance-wheel arbor, and a coil or winding of wire, through which is passed the current to be measured, or a proportion of it shunted from a suitable resistance. The armature is arranged to oscillate with the balance-arbor, and the wire coil is mounted in such a position relatively to the armature that on the passage of a current through the coil the armature is magnetized and attracted toward the center line or magnetic axis of the coil. When the armature is drawn toward the center line of the coil, the momentum of the armature and its attached mountings, together with the action of the escapement, carries the armature past the said center line toward the other extreme point of the stroke or throw, after which the magnetizing action of the coil draws the armature back toward the center line, across which it is again impelled, as before. Thus without any "make" or "break" of the electric circuit the armature is caused to oscillate to and fro across the center line of the coil so long as the current flows and until the escapement runs down, the rate of oscillation being proportional to the current through a range sufficient for the desired purpose. The number of oscillations is recorded by any suitable counting-gear. When no current is flowing, the clockwork stops and the armature takes up a position of rest (under the control of the escapement) at or near one or other of the extreme positions of its stroke or throw. The escapement is preferably arranged to impart its impulse to the balance-wheel before the armature has reached the middle position of its stroke.

In the accompanying illustrative drawings, Figure 1 is a front elevation, Fig. 2 a plan, and Fig. 3 a sectional elevation on the line A A of Fig. 2, showing one construction of electricity-meter according to this invention. Fig. 4 is a section on the line B B of Fig. 2. Figs. 5 to 9, inclusive, are diagrammatic views, hereinafter referred to.

In the arrangement shown in Figs. 1, 2, and 3, *a* is an ordinary train of clockwork having at one end the spring-drum *b* and at the other end the escapement-wheel *c* of an ordinary lever-escapement. Two or more spring-drums may, if desired, be used to enable the meter to run for a long time without rewinding. *d* is the anchor of the escapement, fixed on a spindle *f*, to which is fixed the escapement-lever *g*, the forked end *h* of which alternately engages with and is engaged by the pin *i* of the disk *k* on the balance-arbor *l*, which may also carry the balance-wheel *m*, which is without a hair-spring. *n* is the armature, consisting of a thin bar or preferably of a number of bars or wires of iron, as shown, carried on the arbor *l* in such a position that when no current is flowing through the meter the escapement, owing to the absence of a hair-spring, holds the armature in one or other of its extreme positions with the iron bar or bars inclined to the axis of the coil or winding *o*, which is arranged to surround the armature *n* in the manner of a galvanometer-coil, as shown, so that when traversed by the electric current to be measured, or a proportion thereof, it tends to move the said armature into the central vertical position indicated by the line *q q*. Thus the armature in consequence of its momentum and that of any attached mountings, together with the action of the escapement, is, as hereinbefore stated, caused to oscillate, the oscillations being at a rate that is proportional to the current flowing through the coil for a sufficient range of current for practical requirements. The coil *o* is shown made in two halves to allow room for the arbor *l*. The counting-train is shown at *s*. It may be of any convenient kind, preferably an ordinary counting-train having three or four dials, and be driven from any suitable part of the train of clockwork *a*.

The above-described arrangement is one which we have found to give very good results in practice, but it is to be understood that the invention is not limited to the particular arrangement shown. For example, the magnetic circuit may be arranged in various ways and the forms thereof may be variously modified; but there are certain essential conditions relating to the strength and form of the magnetic field, to the shape and weight of the oscillating armature, and to the forces exerted by the escapement which must be observed in order to obtain a satisfactory result. We will therefore fully explain the conditions which are essential to the success of meters of this type in order that the invention may be fully understood and successfully carried out. With respect to these conditions, if the field is too strong or its distribution is not uniform, but is such as to cause an excessive induction through the armature in the central portion of its swing, the armature will have an early tendency to be arrested in the central position and so be held against the force of the escapement, which should serve to throw it over toward the limit of its stroke in either direction. The same tendency occurs if the armature, together with its mountings or balance-wheels, is too heavy and has considerable inertia in proportion to the force of the escapement or if it is too light, so as not to assist the escapement by a certain amount of momentum. Further, as the amplitude of the swing of the armature diminishes as the force of the magnetic field is increased it is necessary to provide for a considerable angular displacement from the central position with the smallest initial current, and consequently the induction must be sufficiently strong over the whole of this angular space to start the armature from its position of rest without having such density at the center as to hold the armature in the central position. This maximum angle is greater than that necessary for the action of the escapement. Further, to secure a proportional rate of oscillation of the armature it is necessary that the strength of magnetization both of the oscillating armature and of the fixed iron portion (if any) shall be directly proportional to the current to be measured. We have made a long experimental study of these problems, during which we have investigated the action of a great many forms of apparatus and have devised means for avoiding or greatly reducing the detrimental effects referred to. All the above-required conditions are well complied with and in a very simple and inexpensive way by the arrangement shown in Figs. 1 to 4, inclusive, wherein the magnetizing coil or winding *o* is arranged like an ordinary galvanometer-coil to embrace the armature *n* and has sufficient internal diameter to permit the full swing of the latter within it, the magnetic circuit being completed in air. The armature may consist simply of a thin bar or bundle of wires resembling an ordinary needle of a galvanometer; but the form we have devised to best comply with the conditions already explained is that shown at *n* in Figs. 1, 2, 3, and 4. It consists of a number of iron wires arranged parallel, as shown, in the form of a disk or grating mounted in any suitable way, preferably on a frame or disk of ebonite or other non-conducting material, the wires being parallel to the axis of the coil when the armature is in the middle of its stroke. With this arrangement the armature intercepts practically the whole magnetic induction through the coil in all positions of its swing. Thus magnetic leakage is almost entirely avoided, and the oscillations are proportional to the current until the saturation effect commences. At the same time the armature is enabled to start with a very small current.

If iron is used for the external fixed part of the magnetic circuit and the winding traversed by the current to be measured is confined to the same, so that the armature is magnetized by induction across the air-spaces at its extremities, the condition of proportionality is not easy to attain, even very approximately, because of the magnetic leakage between the poles of the excited portion of the circuit, unless the air-gaps between the said poles and the armature are each made extremely small, in which case the armature tends to pull up at the center of its swing. In such forms of the meter the winding should therefore be placed over the air-gaps at the polar extremities and should also embrace the oscillating armature. Figs. 5, 6, and 7 show such arrangements. In Fig. 5 the fixed poles *u u* are connected externally by the iron parts *u' u'*. The winding *o* is fixed, the part inclosing the armature *n* being made with sufficient internal space to allow of the oscillation of the armature. In Fig. 6 the armature *n* is arranged to oscillate within the stationary coil *o* across a line joining the two central magnet-poles *u*. A winding *v* on the poles *u u* is in series with the coil *o*. Laterally-arranged repelling-poles *x x* are provided to start the oscillation of the iron bar with a minimum initial current. The winding *v* in this form of the instrument may also be arranged as in Fig. 7, care being taken in both arrangements of winding that an equal magnetizing force is applied to the fixed and oscillating parts.

In the arrangements shown in Figs. 5, 6, and 7 the wire-disk form of armature is less suitable, and we therefore use in such arrangements a thin strip or bar of iron or a bundle of iron wires.

The escapement may be driven in any customary way—as, for example, by a spring, as in the arrangement shown in Figs. 1, 2, and 3, or by a weight wound up by hand or by any suitable self-winding mechanism, such as an electromagnetic winding arrangement energized by closing a circuit momentarily when the driving mechanism has run down to a given point, as well understood.

In order to guard against the armature being accidentally held in the central position by a momentary increase of current or overload, we may provide an electromagnetic or electrothermal device, whereby on any sudden increase of current the meter-winding is temporarily short-circuited, and the armature in consequence is released and allowed to return to one or other extreme position of its swing under the control of the escapement. The armature may be held by an overload or even by an increase of current within the working range of the meter if it happens that the increase is large in relation to the momentum of the armature at the moment and occurs at a moment when the armature is at or very near its central position and is moving at a slow rate under a previous small load. The momentum of the armature may not under such conditions be sufficient to carry it over the magnetic dead-center at the middle position, although it would do so if the same current were switched on when the armature happened to be at or near one of the extreme side positions. Figs. 8 and 9 show devices for effecting a temporary short circuit in order to overcome the effect in question. Fig. 8 illustrates an electromagnetic device for this purpose. 1 is a solenoid or electromagnet arranged in series with the electricity-meter (represented by the letter M) and provided with an elastic diaphragm 2, on which rests a core or armature 3. The diaphragm 2 is arranged to form the flexible top of an air-chamber 4, that communicates by a passage 5 with the interior of a pillar 6, on which loosely fits a cap 7, carrying a contact device having two contact-arms 8 and 9, that are arranged opposite fixed contacts 10 and 11, connected to the two terminals of the meter. The arrangement is such that on a sudden increase of current in the solenoid or electromagnet 1 the core 3 will be depressed and the cap 7 lifted by the compression of the air in the chamber 4, the lifting of the cap causing the contact-arms 8 and 9 to bear against the contacts 10 and 11 and so short-circuit the meter M until the escape of the air between the pillar 6 and cap 7 allows the latter to return to its normal position. An electrothermal device for the same purpose is shown in Fig. 9. It comprises a closed vessel 12, preferably of glass, having some mercury 13 at the bottom. Fixed hermetically in this vessel is a smaller vessel 14, that is closed at the top and has its lower open end arranged to dip into the mercury 13. 15 is a conductor placed in the vessel 12 and having one end dipping into the mercury, and 16 is another conductor, also placed in the vessel 12 and dipping into the mercury and connected to one terminal of the meter M, so as to be in series therewith. In the vessel 14 is a conductor 17, the lower end of which is normally slightly above the level of the mercury 13, and the other end of which is connected to the opposite terminal of the meter. The arrangement is such that on sudden increase of current through the conductor 16 the latter becomes heated and heats and expands the air in the vessel 12, and thereby causes the mercury to rise in the vessel 14 and make contact with the conductor 17, thereby short-circuiting the meter M until the temperature of the air in the vessel 14 becomes equal or nearly equal to that in the vessel 12, when the level of mercury within the vessel 14 will fall and open the short circuit. Thus an increase of current causes merely a temporary short circuit of the meter. The conductors 15, 16, and 17 are preferably of iron.

Short-circuiting devices acting as and for the purpose described may be used with various kinds of electricity-meters that are liable to be stopped by a momentary increase of current or overload.

It will be evident that other changes could be made in the details of construction of the meter without departing from the spirit and scope of the invention so long as the mode of operation described in the specification is preserved.

What we claim is—

1. An electricity-meter comprising a pivoted armature, a coil or winding adapted to be traversed by the electric current, or a proportion thereof, to be measured and arranged to directly magnetize and operate said armature so as to tend to bring the axis thereof into the same plane as the axis of the coil or winding, and means for mechanically imparting a sufficient auxiliary impulse to said armature in each direction of its stroke or throw to carry it past the said axial plane of the coil or winding.

2. An electricity-meter comprising a pivoted armature, a coil or winding adapted to be traversed by the electric current, or a proportion thereof, to be measured and to surround said armature, and means for mechanically imparting a forward impulse to said armature as it approaches the mid-position of its stroke or throw in each direction.

3. An electricity-meter comprising an arbor, escapement mechanism arranged to operate and control said arbor, an armature connected to said arbor so as to move therewith, and a coil or winding adapted to be traversed by the electric current, or a proportion thereof, to be measured, and arranged to directly magnetize and operate said armature so as to tend to bring the axis of the armature into the same plane as the axis of the coil or winding, and counting mechanism adapted to record the number of oscillations of said armature.

4. An electricity-meter comprising an arbor, an escapement device arranged to operate and control the same, an armature con-

nected to said arbor, a coil surrounding or inclosing said armature and adapted to be traversed by the current to be measured, and counting mechanism adapted to record the number of oscillations of said armature.

5. In an electricity-meter, the combination of an armature mounted to oscillate, means for mechanically imparting a forward impulse to said armature as the same approaches the middle position of its stroke or throw in each direction, a coil adapted to be traversed by current, or a proportion thereof, to be measured and arranged to surround and inclose said armature and magnetic material arranged external to said coil so as to improve the magnetic circuit thereof.

6. In an electricity-meter, the combination of an armature mounted to oscillate, means for mechanically imparting a forward impulse to said armature as the same approaches the mid-position of its stroke or throw in each direction, a coil adapted to be traversed by current, or a proportion thereof, to be measured and arranged to move said armature into its mid-position, and magnetic poles arranged to repel said armature from each of its extreme positions.

7. The combination with an electricity-meter of means adapted to temporarily short-circuit said meter in the event of its being stopped by a momentary increase of current or overload.

8. In an electricity-meter, the combination of an armature mounted to oscillate, means for mechanically imparting a forward impulse to said armature as the same approaches the mid-position of its stroke or throw in each direction, a coil adapted to be traversed by current to be measured and arranged to move said armature into its mid-position, and a short-circuiting device adapted to short-circuit said coil in the event of its overcoming the means used for imparting a forward impulse to said armature.

9. In an electricity-meter, the combination of an armature mounted to oscillate, means for mechanically imparting a forward impulse to said armature as the same approaches the mid-position of its stroke or throw in each direction, a coil adapted to be traversed by current to be measured and arranged to move said armature into its mid-position, and a thermo-electric device adapted under predetermined conditions to temporarily short-circuit said coil, substantially as described.

10. In an electricity-meter, the combination of an arbor, an escapement device arranged to operate and control the same, a coil traversed by current to be measured, and an armature connected to said arbor, arranged to be operated by said coil and composed of iron wires arranged parallel to one another, substantially as described.

11. In an electricity-meter, the combination with the arbor and escapement mechanism of a clockwork-movement, of an armature fixed to the arbor, a coil inclosing said armature and arranged to be traversed by current, or a proportion thereof, to be measured, and counting mechanism driven from the clockwork-movement, substantially as described.

12. In an electricity-meter, the combination with the balance-wheel and escapement mechanism of a clockwork-movement, of an armature fixed to the balance-wheel arbor and composed of parallel iron wires or strips, a coil inclosing said armature and arranged to be traversed by current, or a proportion thereof, to be measured, and counting mechanism driven from the clockwork-movement, substantially as described.

Signed at 77 Cornhill, in the city of London, England, this 28th day of April, 1900.

WILLIAM MORRIS MORDEY.
GUY CAREY FRICKER.

Witnesses:
EDMUND S. SNEWIN,
WM. O. BROWN.