(No Model.) 4 Sheets—Sheet 1.

# J. J. WOOD.

## ELECTRIC METER.

No. 442,501. Patented Dec. 9, 1890.

FIG. 1.

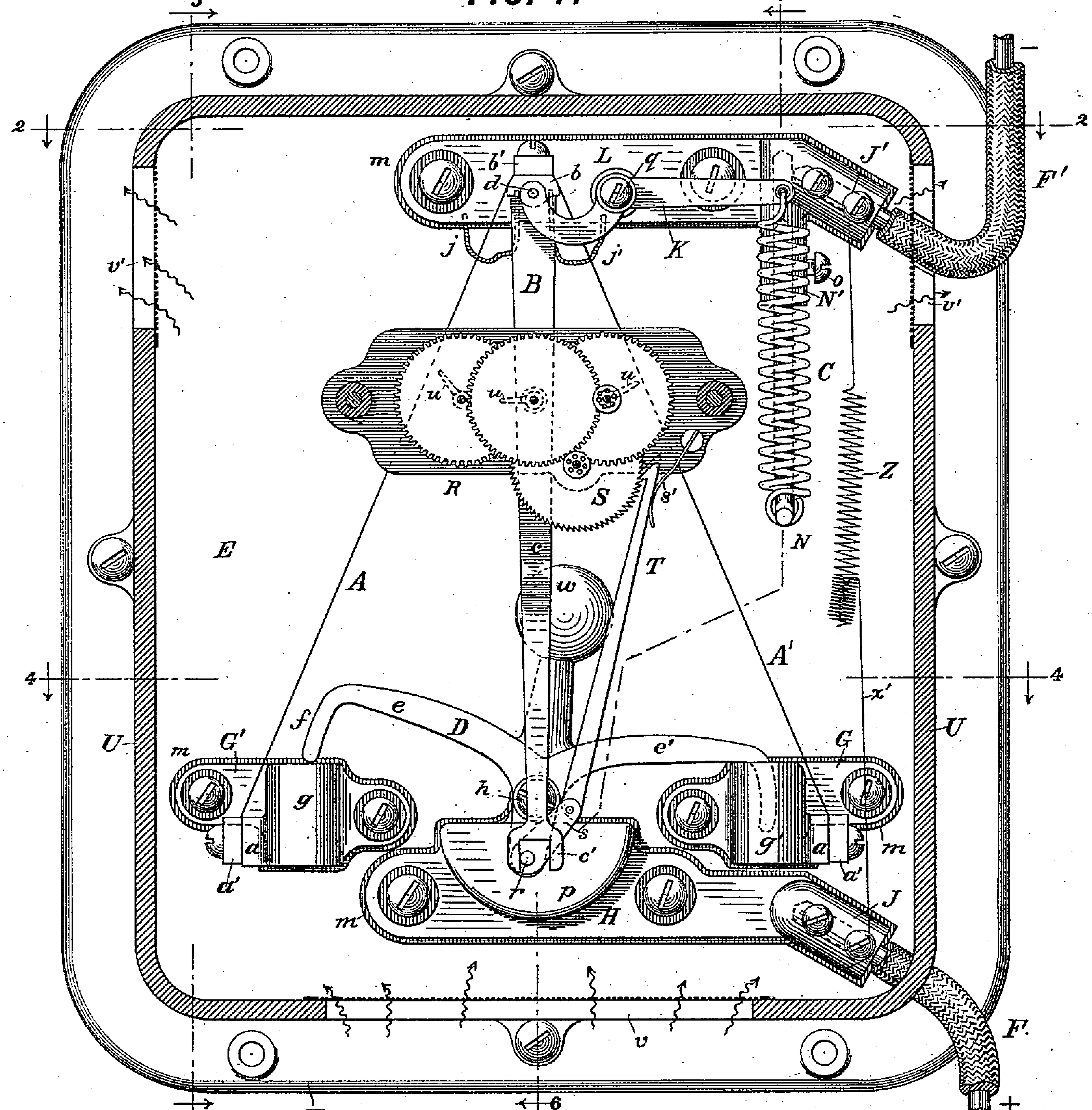
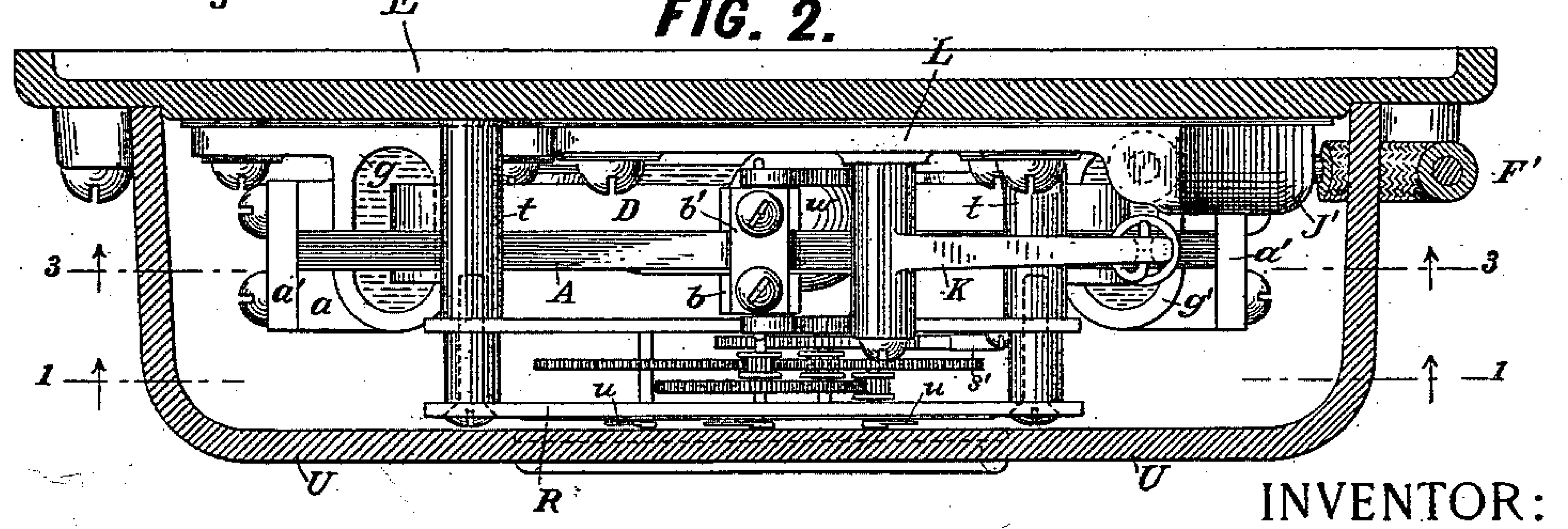


FIG. 2.



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(No Model.) 4 Sheets—Sheet 2.

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ELECTRIC METER.

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FIG. 3.

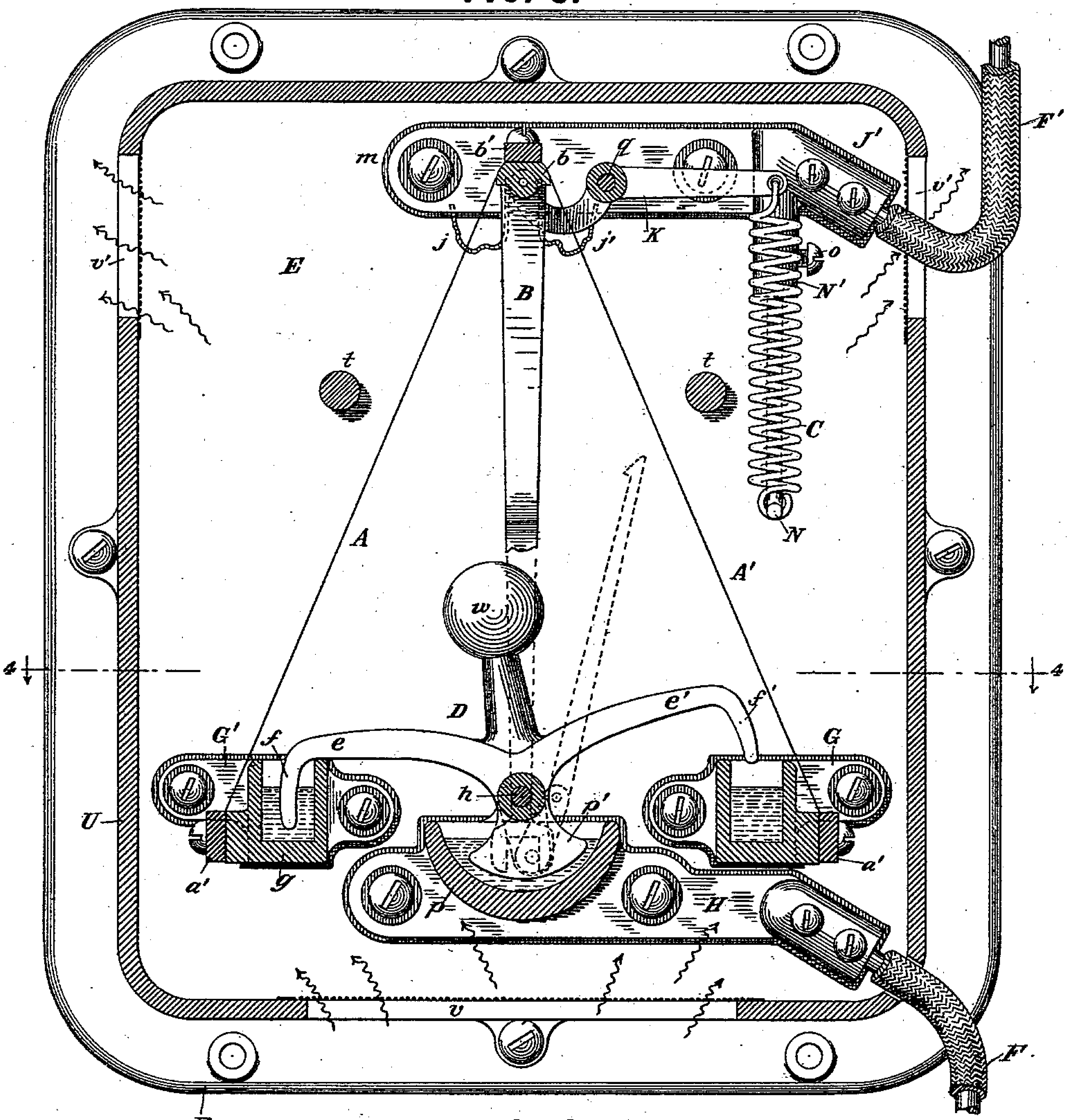
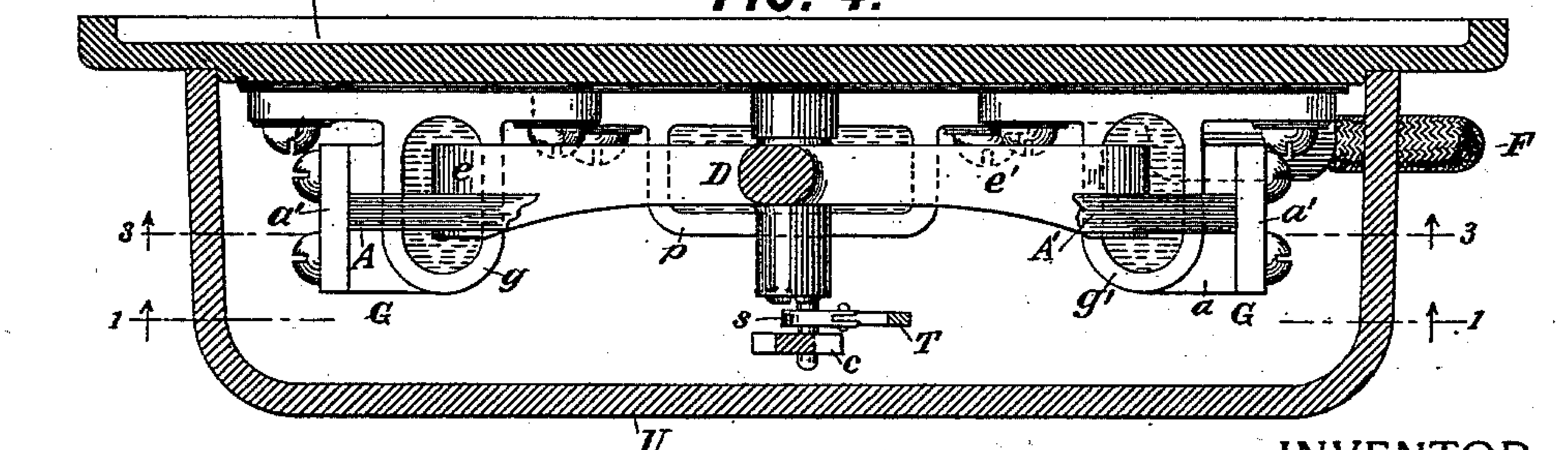



FIG. 4.

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## ELECTRIC METER.

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FIG. 5.

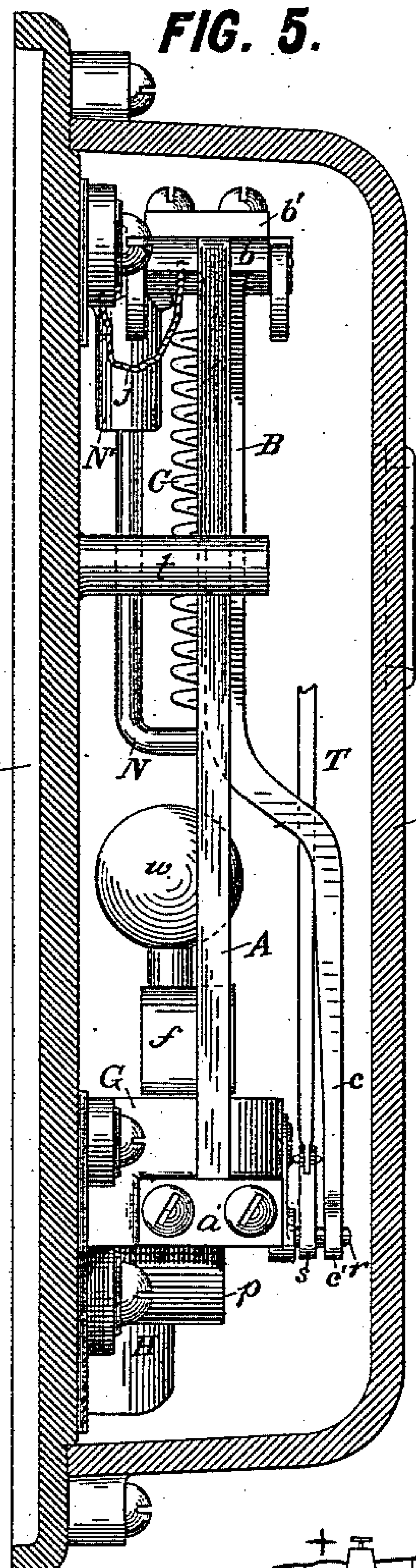


FIG. 7.

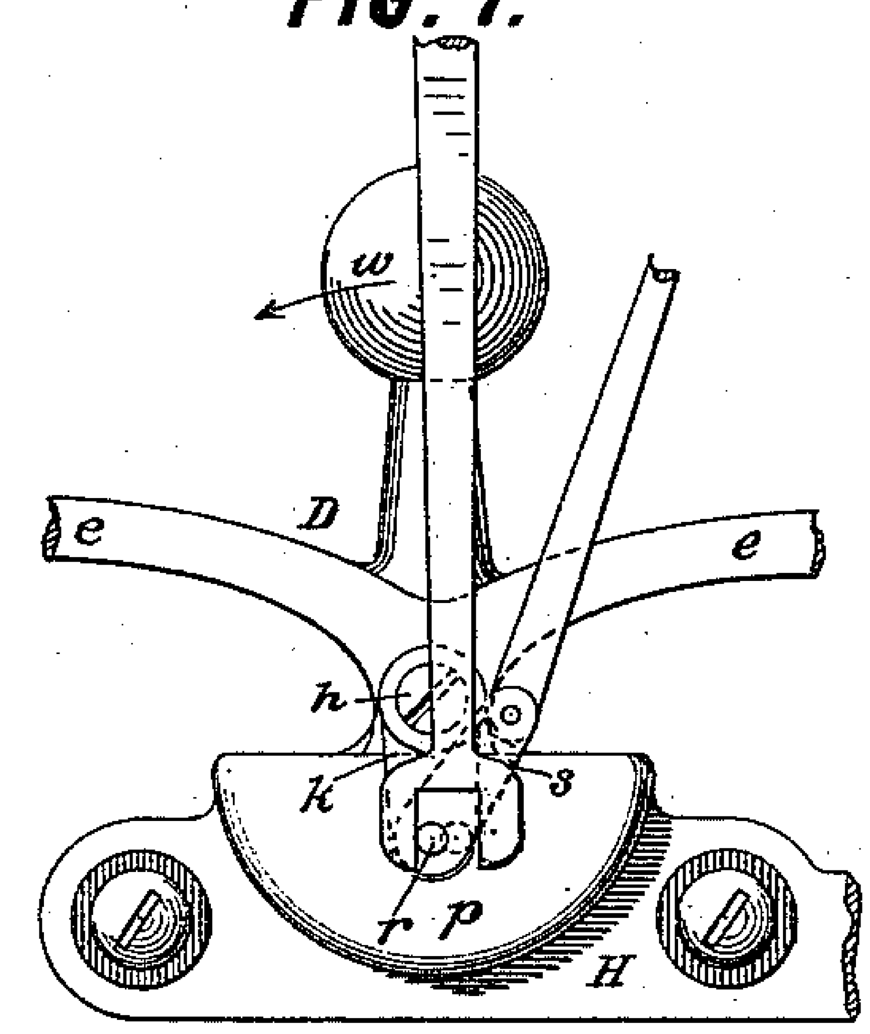


FIG. 6.

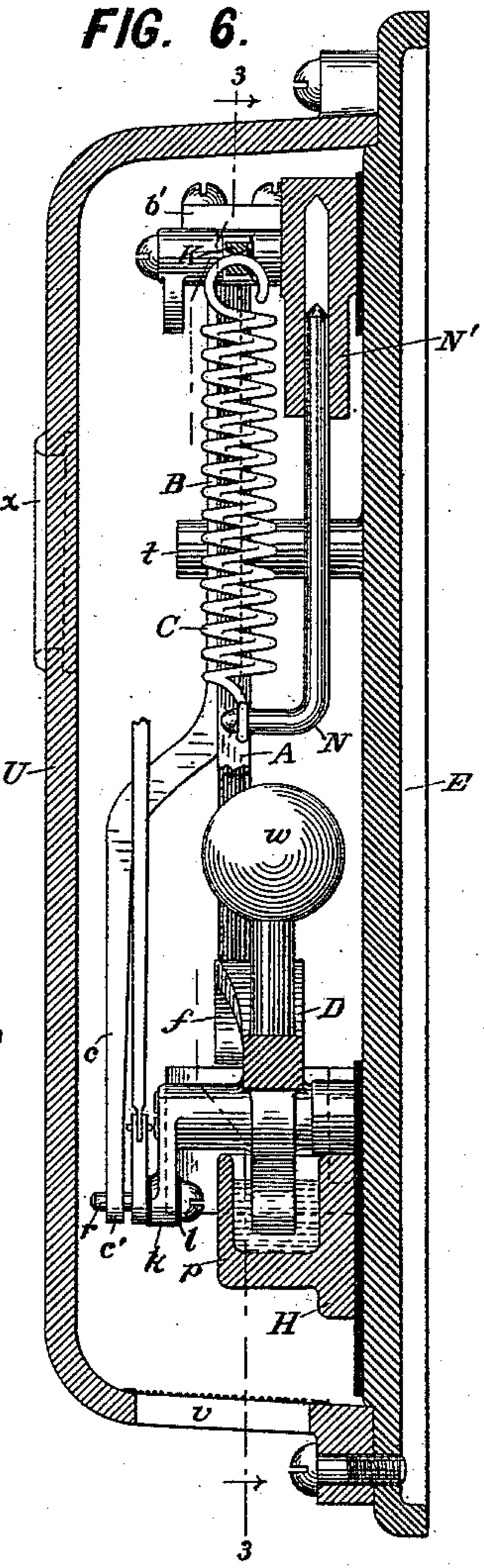


FIG. 8.

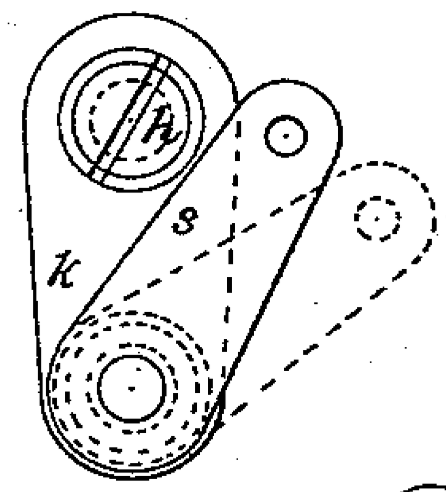
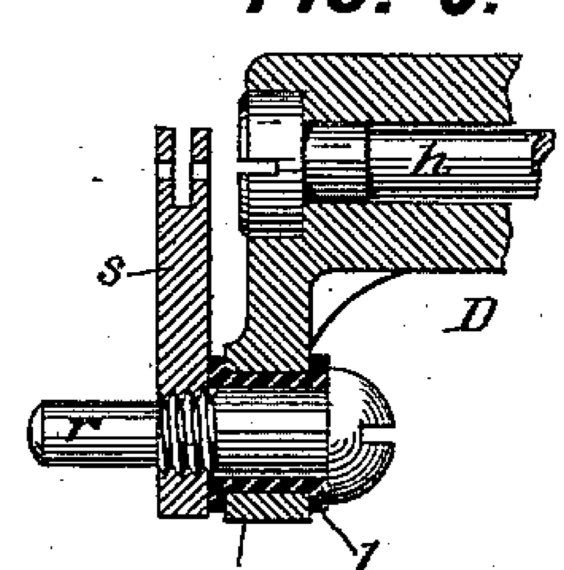


FIG. 9.



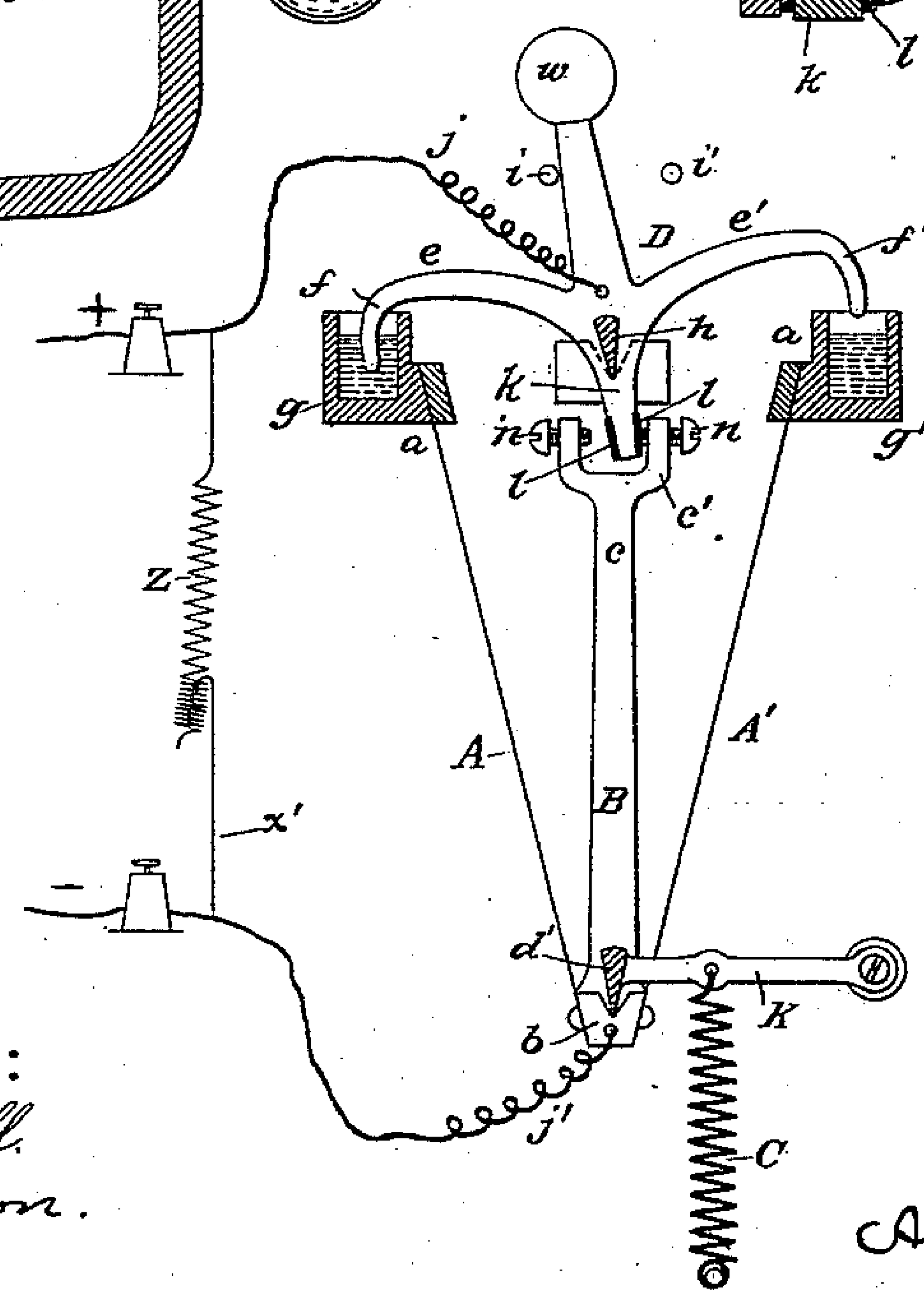


FIG. 10.

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(No Model.) 4 Sheets—Sheet 4.

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## ELECTRIC METER.

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FIG. 11.

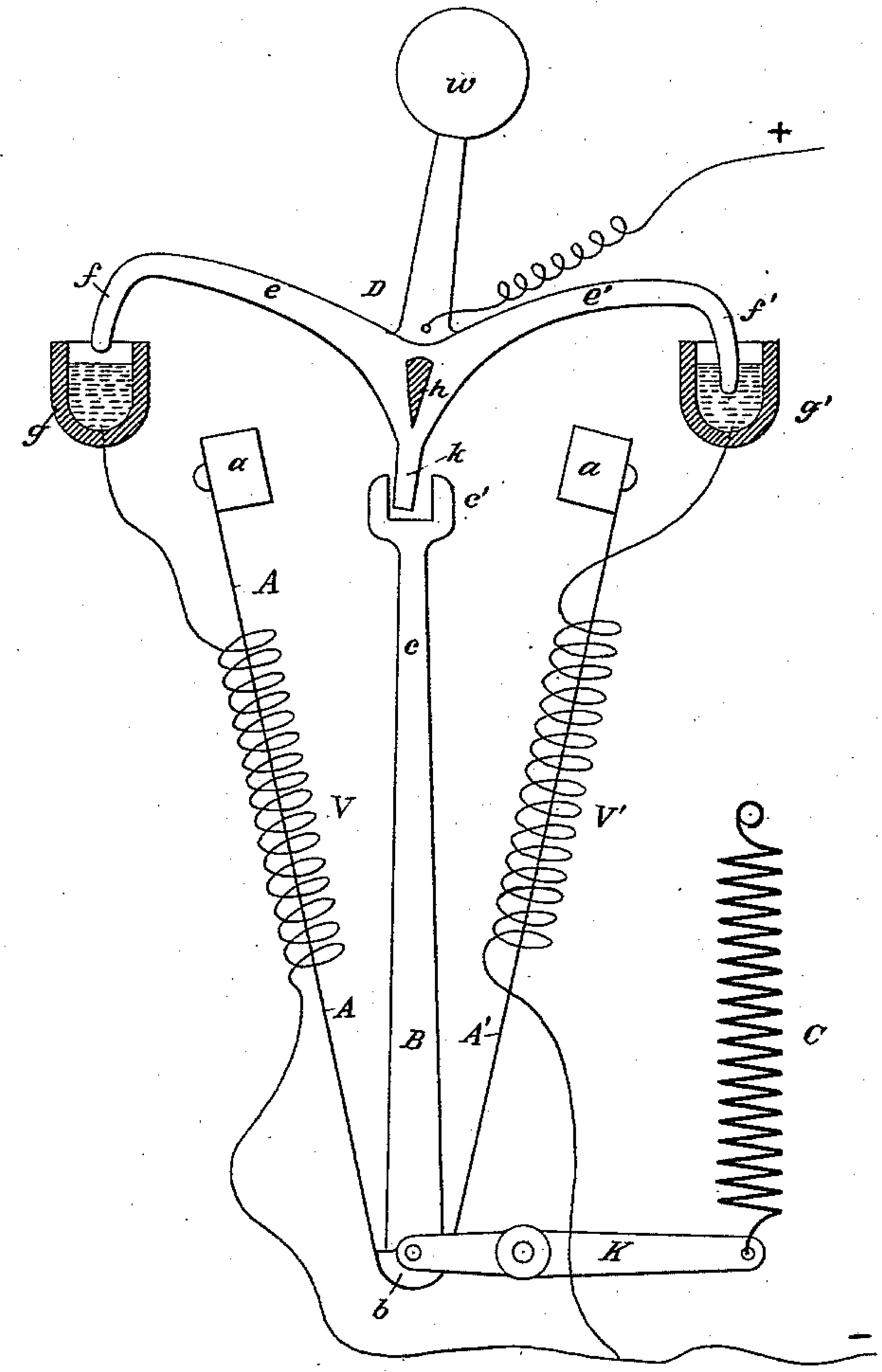
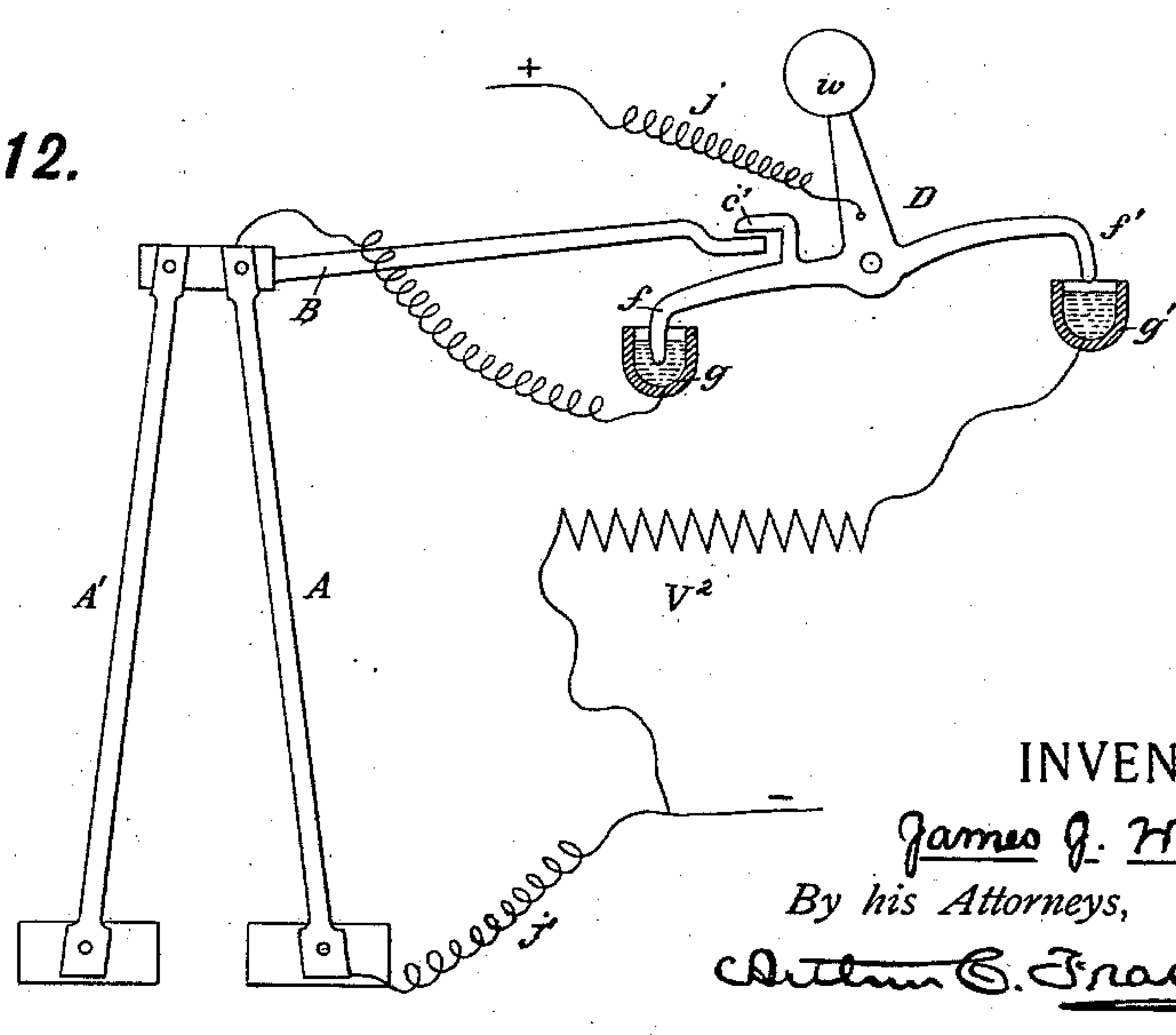



FIG. 12.

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# UNITED STATES PATENT OFFICE.

JAMES J. WOOD, OF BROOKLYN, NEW YORK.

## ELECTRIC METER.

SPECIFICATION forming part of Letters Patent No. 442,501, dated December 9, 1890.

Application filed November 3, 1888. Serial No. 289,857. (No model.)

*To all whom it may concern:*

Be it known that I, JAMES J. WOOD, a citizen of the United States, residing at Brooklyn, Kings county, New York, have invented certain new and useful Improvements in Electric Meters, of which the following is a specification.

My invention aims to produce an electric meter of such simple and cheap construction that it can be supplied at a price low enough to bring it into use, which shall be strong, durable, and not liable to accidental injury, and which shall be sufficiently accurate in its indication to afford a practicable basis for the computation of charges to consumers of electric power.

My invention also aims to provide a meter which shall be equally applicable to continuous and alternating currents.

My improved meter belongs to that class wherein the current to be measured is caused to heat a thermo-expansible wire, strip, or other body, over which the current passes intermittently, being switched around it when the body becomes heated to a certain expansion and again directed through it when it has become cooled to a certain contraction. The number of successive heatings of the thermic body being counted by a totalizing device indicate the total current that has passed.

My invention provides an improved construction of meter operating on this principle, designed to afford greater sensitiveness and to possess a greater range than thermic meters heretofore proposed.

My meter comprises two expansible strips, wires, or other extended bodies, which are heated alternately by the passage of the current, so that one is cooling while the other is heating, and which are connected to a lever which receives the tension of a spring, so as to continually stretch them. The lever has a long arm, which by its opposite vibrations, due to the alternate expansions of the respective wires, strips, &c., operates the switch which shunts the current through two branches alternately to heat the two strips or other bodies, and this lever also operates a counting or registering device, which indicates the total number of ampère hours or other units of electric energy that have passed through the meter.

Figures 1 to 9, inclusive, of the accompanying drawings show the preferred embodiment of my invention. The remaining figures illustrate modifications. Fig. 1 is a front elevation of my improved meter with its inclosing-case in section on the line 1 1 in Fig. 2. Fig. 2 is a plan view of the meter with its inclosing-case in section on the line 2 2 in Fig. 1. Fig. 3 is a front view in vertical section in the plane of the line 3 3 in Fig. 6. Fig. 4 is a horizontal section in the plane of the line 4 4 in Fig. 1. Fig. 5 is a left side elevation, the inclosing-case being in vertical transverse section on the line 5 5 in Fig. 1. Fig. 6 is a vertical section viewed from the right-hand side and cut in the plane of the line 6 6 in Fig. 1. Fig. 7 is a fragmentary front elevation showing the switch at mid-stroke. Fig. 8 is a front elevation, and Fig. 9 a vertical section, of a fragment of the switch on a larger scale. Of the remaining views illustrating modifications, Fig. 10 is a sectional front elevation showing a modified construction substantially similar in operation to the preferred construction shown in the previous figures. Fig. 11 is a similar view of a modification, wherein the thermo-expansion body and the resistant thermo-conductor are distinct parts. Fig. 12 is a similar diagrammatic view of a further modification.

Before describing the preferred construction shown in Figs. 1 to 9, inclusive, I will first describe the essential construction and operation of my meter with reference to the simplified construction shown in Fig. 10. Referring to this figure, A and A′ are two very thin metal strips of fine wires fastened at their upper ends to unyielding supports *a a* and at their lower ends to the head-piece or boss or short arm *b* of a lever B, the long arm *c* of which projects upwardly and terminates in a fork *c′*. Beneath the lever B is a strong spring C, which pulls against the lever in such direction as to stretch the strips A A′. The tension of the spring is communicated to the lever B through the medium of a lever K, having a knife-edge *d′*, which enters a notch in the boss *b* of the lever B, so that an approximately frictionless rocking joint is made.

The metal strips A A′ constitute high-resistance conductors for the electrical current. They constitute also thermo-expansion devices, which by their differential expansion or contraction impart motion to the lever B. Thus if an electric current of sufficient volume be sent through one of the strips—say, for example, the strip A—without being sent through the other, that strip will be heated by the current and will expand, while the strip A′ not being heated will remain unchanged in length. The elongation of the strip A will relax the left-hand side of the boss or short arm *b* of the lever, so that the tension of the spring C, acting against the middle of this boss, will tilt the lever and carry its arm *c* toward the left. The strip A′ thus constitutes a support for receiving the reaction of the lever, the point of connection of its lower end with the right-hand side of the boss constituting for the moment the fulcrum on which the lever turns. The deflection of the lever will be directly proportional to the elongation of the strip A due to the heating effect of the current, since the strip A′, which is not heated by the current, is exposed to the same surrounding temperature as the strip A, so that whatever expansion or contraction is due to variations of external temperature or weather affects both strips A and A′ equally, so that the strip A′ becomes a compensating thermo-expansible support for receiving the reaction of the lever. If upon the strip A reaching a certain temperature or having become expanded to a certain elongation the electric current is shunted through the strip A′ and cut off from the strip A, the strip A′ will become heated by the passage of the current and the strip A will simultaneously cool by radiation. The resulting expansion of the strip A′ and the contraction of the strip A will effect an oscillation of the lever B in the opposite direction, its arm *c* being deflected toward the right. Upon a certain deflection being reached the current can be again shunted back to the strip A, thereby again reversing the operation. There will then result from these alternations in the path of the current a back-and-forth vibration of the lever B, which vibration may be utilized for imparting motion to the switch, by which the alternate shunting of the current is effected. Since these vibrations of the lever B occur with a frequency approximately proportional to the varying strength of the current, they may be utilized for the purpose of operating a recording or registering or totalizing mechanism, which will accordingly afford an approximately correct indication of the total current which has traversed the instrument during a certain time.

The electric switch for effecting the necessary alternations in the current should be of the character known as a "quick-action switch," or one wherein the first part of the movement by which the switch is actuated in either direction is employed to store up power, which toward or at the end of the movement is made effective to suddenly make or break the electrical connection. Such switches operate usually either by gravity or by the tension of a spring, and are of various constructions, exhibiting more or less complications.

The switch shown in Fig. 10 is one of the simplest forms of quick-action switches. It consists of a tilting lever D, having laterally-extending arms *e* and *e′*, terminating in fingers *f* and *f′*, arranged to dip alternately in two mercury cups or baths *g* and *g′*, respectively. The lever D is pivoted on a knife-edge *h* and has an upwardly-projecting arm carrying a weight *w*. The lever D may vibrate or tilt to either side between stops *i* and *i′*. When it is in its mid-position, it is in unstable equilibrium, the center of gravity of its weight *w* being directly over its pivotal axis. When tilted to either side, one of its fingers *f f′* is immersed in its mercury-cup, while the other finger is lifted entirely out of its cup, and in throwing over the lever D from one side to the other the one finger enters the mercury before the other leaves it. The switch thus described is substantially a well-known construction of tilting quick-action switch.

In attaching this construction of switch to my improved meter I connect the lever D to one binding-post by means of a flexible wire *j* or otherwise, and connect the mercury-cups *g* and *g′* to the upper ends of the strips A and A′, respectively, and I connect the lower ends of these strips by means of a wire *j′* or otherwise to the other binding-post. The latter connection is best made by connecting this wire to the lever B, with which the lower ends of the strips A A′ are in metallic connection, while the connection between the mercury-cups and the strips is best made by forming the cup integrally with or attaching it to the metallic support *a*, to which the upper end of the strip is fastened.

In order to impart motion to the switch-lever D, it is formed with a pendent tail or crank-arm *k*, which enters between the jaws of the forked end *c′* of the lever-arm *c*. The lever B must be insulated from the switch-lever in some way, the interposition of insulating-plates *l l*, fixed against opposite sides of the crank-arm *k*, being one suitable method. There must be a certain amount of lost motion between the fork *c′* and crank-arm *k*, and for the adjustment of this motion the fork *c′* may be provided with adjusting-screws *n n*, passing through its jaws, as shown.

When the lever D is tilted to the left, as shown, the current flows through the positive binding-post and wire *j*, through the switch-arm *e*, finger *f*, mercury-cup *g*, and strip A, and out through the lever B and wire *j* to the negative binding-post. In so doing it heats and expands the strip A, whereupon by the tension of the spring C the lever B is tilted, moving its arm *c* to the left, whereupon the right-hand screw *n* encounters the crank-arm

$k$ and presses the latter toward the left, thereby tilting the switch-lever D to the right and making connection between its finger $f'$ and the mercury-cup $g'$, while breaking connection between the finger $f$ and cup $g$. The current is thus switched through the opposite metal strip A', which it heats while the strip A is permitted to cool, which shortly gives rise to another deflection of the lever B and to a tilting of the switch D back to its first position. The tilting of the switch from one side to the other will thus occur at more or less frequent intervals in proportion to the greater or less quantity of current traversing the instrument.

The principle and essential construction of my improved meter being now understood, I will proceed to describe the preferred construction thereof, as illustrated in Figs. 1 to 9. It will be seen that the apparatus is here inverted relatively to Fig. 10, the switch D being arranged at the bottom and the strips A and A' and lever B being turned the other side up. The whole instrument is mounted upon a back plate or base E. The mercury-cups $g$ $g'$ are made integral with plates G and G', respectively, which plates are fastened to the base E by screws, the plates being insulated from the base by sheets $m$ $m$ of insulating material placed behind them and by insulating sheaths and washers for separating them from their attaching-screws. These plates G G' are provided, also, with means for attaching the fixed ends of the metal strips A A', such means consisting of metal clamping-bars $a'$, clamped by screws against a faced-off boss $a$, projecting outwardly from the mercury-cup. The switch-lever D is pivoted on a screw-stud $h$, Fig. 9, which is screwed fixedly into a plate H, which plate is fastened to the base E, but insulated therefrom by an insulating-sheet $m$ and insulations surrounding its attaching-screws, as in the case of the plates G G. The plate H is prolonged toward one side, and its end is made tubular in order to form a binding-post J, which we may assume to be the positive binding-post, and into which the bared end of the conductor F is fastened. Thus the plate H forms itself the electrical conductor or connection between the positive binding-post and the switch-lever D. To provide, however, a better electrical connection than that through the pivotal stud $h$, I construct a mercury-cup $p$, Fig. 3, in one piece with the plate H, and provide the switch-lever D with a downward projection $p'$, entering the mercury in this cup, so that the current has an easy path through the mercury and this projection into the lever D.

The two expansible strips A A', which are essentially distinct, are, in fact, in the preferred construction, made both in one piece, bent at its middle over the boss $b$ of the lever B, and fastened thereto by solder, or preferably by being clamped thereto by a bar $b'$, fastened by screws to the boss $b$. The spring C is arranged for compactness to one side of the lever B, its tension being communicated thereto through the medium of a rock-lever K. This lever is pivoted on a screw-stud $q$, fastened in a plate L, which plate is fastened to the base E, but insulated therefrom by a sheet of insulating material $m$, as in the case of the other plates. The lever K is forked to the left of its pivotal boss, as shown in Fig. 2, the boss $b$ of the lever B entering between the two arms of its fork and being pivoted thereto by a slender steel pin $d$. To the right of its pivotal boss the lever K is formed with a single arm, to the end of which the spring C is connected. The tension of this spring is adjustable by means of a rod N, to which its lower end is hooked, and which rod slides vertically in an elongated socket N', formed integrally with the plate L, a set-screw $o$ being provided to clamp the rod N in any position to hold the spring C more or less distended. The negative binding-post J' is formed as a tubular boss integral with the plate L, into which the bared end of the negative conductor F' is fastened. Thus the plate L forms part of the electrical connection between the negative binding-post and the upper portion of the expansion-strips A A'. Light flexible cables $j'$ $j'$, joined to the boss $b$ at one end and to the plate L at the other, are provided to make a good electrical connection between the plate and the boss and avoid the necessity of the current flowing solely through the guide-lever K and pivot-pin $d'$.

The general construction of the switch-lever D is the same as already described with reference to Fig. 10. It is formed with a crank-arm $k$, projecting downwardly from the front end of its pivotal boss and in front of and apart from the mercury-cup $p$. In this crank-arm is fixed a crank-stud $r$, which is insulated from the crank $k$ through the medium of an interposed insulating-sheath $l$. This stud $r$ is screw-threaded, and on it screws one end of a crank-arm $s$, as best shown in Figs. 8 and 9, this crank-arm serving as a nut for clamping the stud $r$ against the ends of the insulating-sheath $l$. The fork $c'$ on the bottom end of the lever-arm $c$ engages directly with the end portion of the stud $r$.

The instrument is shown at rest in Figs. 1 to 6. In this position, the arm $c$ of the lever B being at its mid-stroke, the stud $r$ is in contact, or nearly so, with one of the jaws of its fork $c'$. When the current is turned on, and the arm $c$ is consequently deflected by the expansion of one of the strips A or A', its fork $c'$ in moving laterally pushes the stud $r$ with it, and thereby tilts the lever D, as shown in Fig. 7, until this lever is carried beyond the center, whereupon its counter-weight $w$ throws it, over to the opposite side. In so doing its stud $r$ is carried from the position shown in full lines to that shown in dotted lines in Fig. 7. The fork $c'$ should be wide enough so that its opposite jaw shall not be struck by the stud $r$ in thus going over, but no wider, which would entail lost motion of the lever B.

Instead of separate stops $i\ i'$ being provided to limit the motion of the switch-lever D, it is stopped by the contact of its arms $e\ e'$ with the tops of the mercury-cups $g\ g'$, respectively.

R in Figs. 1 and 2 designates the recording or registering mechanism, which consists, preferably, of a totalizer such as is used in gas-meters where a train of wheels proportioned decimally are driven from a ratchet-wheel and carry on their spindles hands or pointers which stand in front of separate graduated dials. Any other recording mechanism may, however, be substituted—such, for example, as the well-known mechanism employed in recording thermometers, barometers, anemometers, &c., where a line is traced on a moving sheet of paper.

In the construction shown the register consists of a train of wheels with their spindles carried in bearings in two vertical plates, which plates are mounted on posts $t\ t$, projecting from the back plate E, and being either cast integrally therewith or screwed or otherwise attached thereto. The hands or pointers $u\ u$ (shown in dotted lines in Fig. 1) are carried on the several spindles and turn against a series of graduated dials applied to the front of the forward plate. The initial spindle carries a ratchet-wheel S, the teeth of which are engaged by a pawl T, which is jointed to the outer end of the crank-arm $s$, its free end being pressed into the ratchet-teeth by a spring $s'$. As the switch-lever D is tilted back and forth, the crank $s$, being fixed to the crank $k$, moves with it and consequently pushes the pawl T up or down to an extent corresponding to the movement of the free end of the crank $s$.

The construction of the crank $s$ is such as to provide a ready adjustment for the throw of the pawl T, in order to make it operate correctly in the ratchet-teeth. To effect this adjustment the screw-stud $r$ may be loosened sufficiently to enable the crank $s$ to be turned with its free end closer to or farther from the center of the stud $h$, as shown either in full or dotted lines in Fig. 8. The closer this free end is brought to the axial center the shorter will be the movement of the pawl, and vice versa. Each complete movement of the switch D back and forth moves the ratchet-wheel S a distance of one tooth, which moves the register one unit or a fraction or multiple thereof.

In order to inclose and protect the mechanism, I provide a case U, which is placed against the base E and fastened thereto by screws.

In order to insure a rapid and uniform cooling of the metal strips A A', the case U is formed with openings to admit a circulation of air through it. I have shown an opening $v$ at the bottom and two openings $v'\ v'$ on opposite sides near the top, each of the openings being covered with wire-gauze, in order to exclude dirt and prevent tampering with the mechanism.

The case U has an opening $x$ in its front covered with glass, through which the dials of the register may be seen.

The guide-lever K has the function not only of transmitting the tensile pressure of the spring C to the lever B, but also of guiding the lever B and affording a lateral reaction for the fulcrum thereof, so that its fulcrum may move vertically but not laterally. This lateral guiding (which might be accomplished in many other ways, although not otherwise with such freedom from complication as by the pivoted lever) is of practical importance, in order to enable the free end of the lever B to exert considerable pressure against the switch D in order to tilt the latter.

It will be understood that the lever B might be modified to no longer resemble a lever in the sense of having a projecting arm to be vibrated by the differential expansion and contraction of the strips A A'; but any device which is oscillated by the expansion or contraction of these strips will be essentially equivalent to the lever B.

I have shown the strips A A' as diverging widely at their fixed ends and approaching quite close to one another at the ends, which are fastened to the lever B. Their divergence is preferable, in order that the strips may be as far removed from each other as possible, so that the heating of one shall not by radiation retard the cooling of the other, as would be apt to occur if they were parallel and close together. The strips must be in somewhat close proximity at their point of attachment to the lever B, in order to sufficiently multiply the motion derived from their minute contraction and expansion resulting from changes of temperature.

It may be understood that my improved meter may be connected electrically in any way in which electric meters have heretofore been connected or in any other way in which any other meter is capable of being used. For example, the meter may be connected with the main circuit, over which flows the entire current to be measured, or it may be connected in a branch leading into a subscriber's building, the current in which branch alone is to be measured; or in either case the meter may be traversed by only a portion of the current to be measured by connecting it in a derivation or shunt having a resistance bearing a certain definite proportion to the resistance on the circuit or branch the current in which is to be measured, so that the indications of meter may be multiplied by the ratio of difference; or in the case of alternating or pulsatory currents the meter may be connected in a distinct circuit, the current in which is derived inductively from that in the circuit to be measured through the medium of a transformer, or the meter may be used to measure the discharge from a secondary battery, which has been charged by connection with the circuit to be measured, or the connection may be made in any other possible way.

In the construction which I have thus far described the motive power has been due to the expansion and contraction of a resistant conductor, through which the current is passed intermittently. In lieu thereof, however, the motive power may be derived from the expansion and contraction of any solid body which is heated and cooled through the agency of the electric current either directly or indirectly, it being immaterial whether the current be actually passed through the expanding and contracting body or not.

In Fig. 11 I have shown a modification wherein the thermo-expanding strips A A′ are not conductors, but are heated by radiation from resistance-coils V V′ in the respective branches of the circuit. The current through one of the coils heats it to a high temperature and the heat radiated from it expands one of the strips A A′, whereby the lever B is deflected and the switch D tilted, whereupon the same action takes place with the other coil and strip. In other respects the construction is substantially the same as shown in Fig. 10. The heating action of the current may thus be communicated indirectly to any suitable elongated solid body having a sufficient coefficient of expansion to effect the requisite motion and sufficiently good conducting properties to radiate its heat and become cooled with the desirable rapidity.

It is essential to my invention that the mechanical motion which operates the meter shall be derived from the expansion and contraction of a solid body in contradistinction to a fluid or gas. The expansion of a solid body is more certain and energetic than the expansion and contraction of a gaseous or liquid substance.

It is not essential to my invention that the two expanding bodies A and A′ shall be acted upon alternately by the electric current, as one alone may be utilized for measuring the current, the other serving solely as a means of compensating for changes of temperature. In such case the meter will measure the current during approximately one-half of the time.

Fig. 12 shows a construction wherein the thermo-expanding strip A alone is acted upon by the electric current, the strip A′ being merely a compensator. This figure illustrates, also, the employment of stiff or rigid rods in place of flexible strips under tension. The rods are sufficiently rigid to maintain themselves erect and effect the proper movement of the lever B, which is connected rigidly to their upper ends, so that the spring C is omitted. The free end of the lever B, by working in a fork in the switch-lever D, tilts the latter to either side.

To compensate for the resistance to the passage of the current through the rod A, a rheostat $V^2$ is provided in a shunt around this rod, so that the current meets with equal resistance through whichever branch it may be traveling.

The thermo-expansion bodies or conductors A and A′ may be made in any suitable form and of any suitable material. I prefer a thin strip or foil because of its large radiating-surface, which enables it to cool quickly; but in lieu thereof a group of separate minute wires may be used, or a ribbon made by laying wires parallel, or in any other way the material may be given sufficient electrical resistance and sufficient capacity for expansion and contraction to render it suitable for the purpose.

A quick-action switch of any other kind than that shown may be employed in connection with my invention, or in the case of currents of very low electro-motive force it may be possible to employ an ordinary switch or circuit-closer in place of a quick-action switch.

In the manufacture of numbers of meters for service under like conditions it is necessary to provide some means for calibrating them, in order to reduce the indication of their respective registering mechanisms to equality. This calibration may be effected in various ways; but I prefer the arrangement shown in Fig. 1 and in diagram in Fig. 10. A coiled spring of fine wire Z is connected in a shunt between the binding-posts, one end of the spring being permanently connected to one binding-post and a hooked wire $x'$ being connected to the other binding-post, and this hooked end engaged with the spring Z at any desired point along its length, in order to include more or less of the resistance of the spring in the shunt-circuit thus formed. Normally the registering mechanism will be proportioned to register correctly when one-half of the resistance of the spring Z is included in this shunt-circuit; but if it be found that the instrument over-registers this defect will be corrected by decreasing the resistance in the shunt, in order that a greater proportion of the current may be deflected through the shunt and a less proportion pass through the instrument proper. On the contrary, if the instrument under-registers, the resistance included in the shunt will be increased by hooking the wire $x'$ into the spring Z lower down, so as to include more of its convolutions in the shunt, and thereby cause a greater proportion of the current to flow through the meter.

Any other construction of simple and easily-variable resistance may be employed in lieu of the one shown.

I claim as my invention the following-defined novel features and combinations, substantially as hereinbefore specified—namely:

1. In an electric meter, the combination of an elongated solid body arranged to be expanded by the heat generated by an electric current in encountering a resistance, a compensating expansible elongated body exposed

to the same variations of surrounding temperature, a lever to which both said bodies are independently connected at different points, whereby the lever is moved by the elongating and shortening of both said bodies and its angular movement corresponds to their differential elongation or contraction, so that the compensating body corrects the disturbing effect of changes in surrounding temperature, and a switch for directing the current intermittently through said resistance, connected to said lever to be operated by the angular movements thereof.

2. In an electric meter, the combination of two elongated solid bodies, each arranged to be expanded by the heat generated by an electric current in encountering a resistance, with an electric circuit divided into two branches, each including such a resistance, a lever to which both said expansible bodies are independently connected, whereby its movement is derived from their differential elongating movements, and a switch for directing the current through said branches alternately.

3. In an electric meter, the combination of two elongated solid bodies, each arranged to be expanded by the heat generated by an electric current in encountering a resistance, with an electric circuit divided into two branches, each including such a resistance, a lever to which both said expansible bodies are independently connected, whereby its movement is derived from their differential elongating movements, and a switch operated by the movement of said lever for directing the current through said branches alternately.

4. In an electric meter, the combination of a solid body arranged to be elongated by the heat generated by an electric current in encountering a resistance, a lever to which said body connects, a tension device tending to stretch said body, and a compensating expansible body receiving the reaction of said lever and exposed to the same variations of surrounding temperature as said first-named expanding body, whereby the disturbing effect of such variations is eliminated and the lever is vibrated by the differences of expansion between said bodies and with a strength proportional to that of the tension device.

5. In an electric meter, the combination of two solid bodies, each arranged to be expanded by the heat generated by an electric current in encountering a resistance, with an electric circuit divided into two branches, each including such a resistance, a lever acted upon by both said expansible bodies, whereby its movement is derived from their differential movements, a tension device acting against said lever and tending to stretch said expansible bodies, and a switch for directing the current through said branches alternately.

6. In an electric meter, the combination of an elongated conducting-body arranged to be expanded by the heat generated by its resistance to the passage of a current through it, a compensating expansible elongated body exposed to the same variations of surrounding temperature, a lever to which both said bodies are independently connected at different points, whereby the lever is moved by the elongating and shortening of both said bodies, and its angular movement corresponds to their differential elongation or contraction, so that the compensating body corrects the disturbing effect of changes in surrounding temperature, and a switch for directing the current intermittently through said conducting-body, connected to said lever to be operated by the angular movements thereof.

7. In an electric meter, the combination of two thermo-expansion conductors, a lever to which said conductors connect, a spring arranged to exert a tension against said lever between its points of connection with said conductors and in such direction as to exert a tensile strain on said conductors, the electric circuit divided into two branches, and a switch operated by the vibration of said lever for directing the current through said branches alternately.

8. In an electric meter, the combination of two flexible thermo-expansion conductors, a lever to which said conductors connect, a guide for said lever restraining it from lateral movement, but constructed to admit of its movement in direction longitudinally of said conductors, a spring arranged to act upon said lever at a point intermediate of its connection with said conductors and in direction to exert tensile strain thereon, the electric circuit divided into two branches, and a switch operated by the vibration of said lever for directing the current through said branches alternately.

9. In an electric meter, the combination of two thermo-expansion conductors spread wide apart at one end and fastened to fixed supports and converging at the other end, a lever to which the converging ends of said conductors connect, formed with a projecting arm, a spring arranged to act on said lever intermediate of its points of connection with said conductors and in a direction to exert a tensile strain upon the latter, and a switch arranged to be operated by the vibration of said lever-arm.

10. In an electric meter, the combination of two thermo-expansion conductors spread wide apart at one end and fastened to fixed supports and converging at the other end, a lever to which the converging ends of said conductor connect, formed with an arm projecting between the diverging ends thereof, a spring arranged to act upon said lever intermediate of its points of connection with said conductors and in a direction to exert a tensile strain upon the latter, and a switch arranged between the divergent ends of said conductors and operated by the vibration of said lever-arm.

11. In an electric meter, the combination of two thermo-expansion bodies fixed at one

end, a lever to which their other ends are fastened, a guide-lever on which said lever is fulcrumed at a point intermediate of its connection with said thermo-expansion bodies, and a spring acting against said guide-lever in a direction to exert a tensile strain upon said thermo-expansion bodies.

12. In an electric meter, the combination of two fixed insulated mercury-cups, two thermo-expansion conductors fastened thereto at one end, a lever to which the other ends of said conductors are fastened and which is vibrated by the differential expansion and contraction thereof, and a tilting switch having arms arranged to alternately enter said mercury-cups and adapted to be thrown over by the vibration of said lever.

13. In an electric meter, the combination, with a solid body arranged to be expanded by the heat generated by an electric current in encountering a resistance, a switch for directing the current through said resistance intermittently, and a recording mechanism, of a ratchet and pawl for operating said mechanism and an adjustable connection intervening between said expansible body and pawl, whereby a given expansion and contraction of the former may be made to communicate greater or less throw to the latter.

14. In an electric meter, the combination, with a tilting switch constructed with a crank-arm, of a secondary crank-arm fastened adjustably thereto so as to be set with its free end at different distances from the axis thereof, a recording mechanism including a ratchet-wheel, and the pawl for operating said ratchet-wheel jointed to said secondary crank-arm, whereby the throw of said pawl may be adjusted.

15. In an electric meter, the combination of two thermo-expansion conductors, each fixed at one end to a solid support, a lever to which their opposite ends are fastened, a conducting-plate, a flexible cable forming an electrical connection between said thermo-expansion conductors and said plate, and a spring acting upon said lever intermediate of its connection with said conductors and in such direction as to exert a tensile strain on the latter.

16. In an electric meter, the combination of two thermo-expansion conductors, each fastened at their one end to fixed supports, a lever to which their other ends connect independently at different points, and which is vibrated by their differential contraction and expansion, a spring acting against said lever in direction tending to stretch said conductors, and a switch for directing the current through said conductors alternately, consisting of a tilting lever and two mercury cups or contacts arranged to be entered alternately by said tilting lever and in connection, respectively, with said thermo-expansion conductors.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

JAMES J. WOOD.

Witnesses:

ARTHUR C. FRASER,
JNO. E. GAVIN.