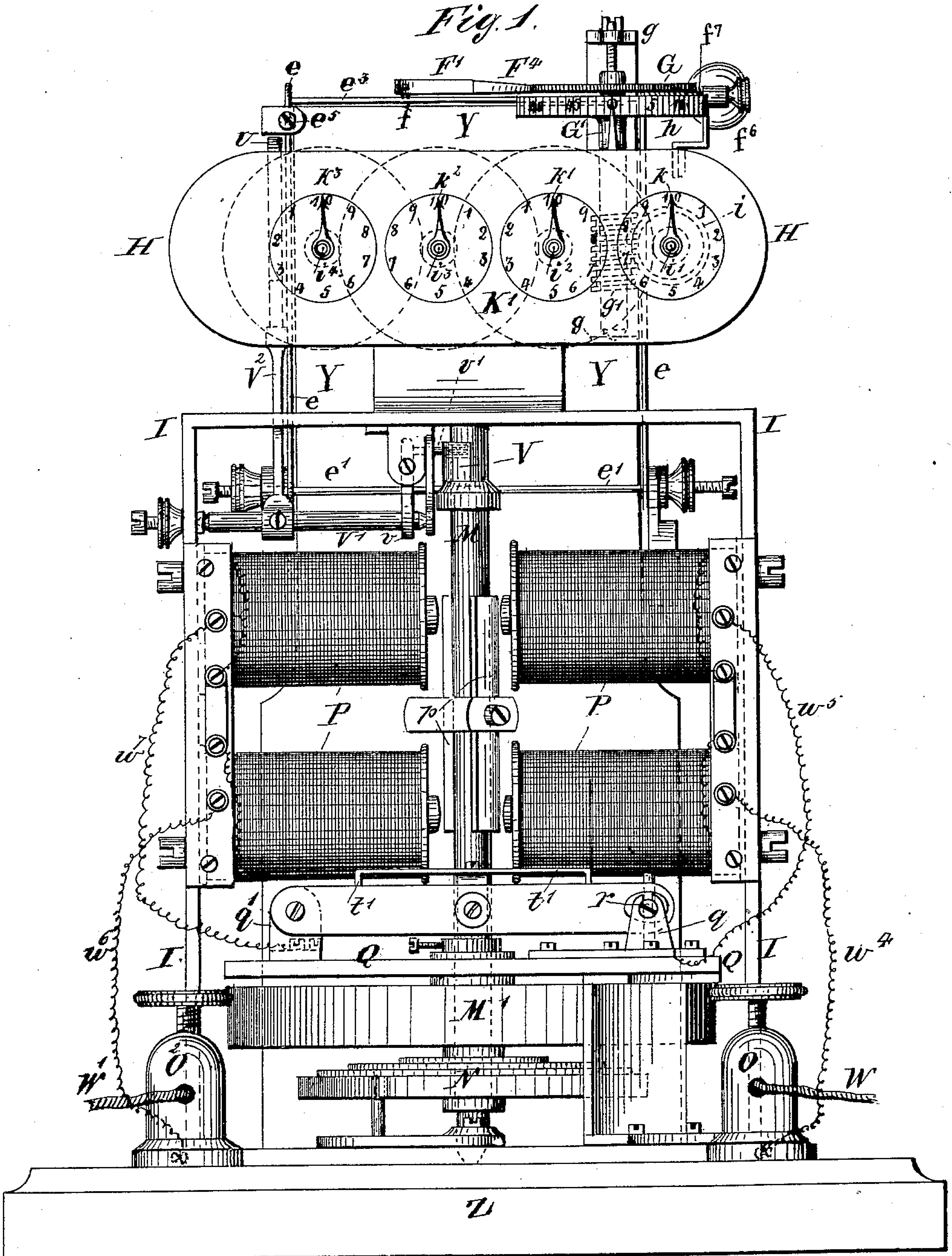
(No Model.) 8 Sheets—Sheet 1.

J. CAUDERAY.

ELECTRIC METER.

No. 318,166. Patented May 19, 1885.

Fig. 1.



Witnesses.
W. E. Boulter.
Samuel Owen Edmonds

Inventor
Jules Cauderay
pr Henry Orth
his atty

(No Model.)

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J. CAUDERAY.

ELECTRIC METER.

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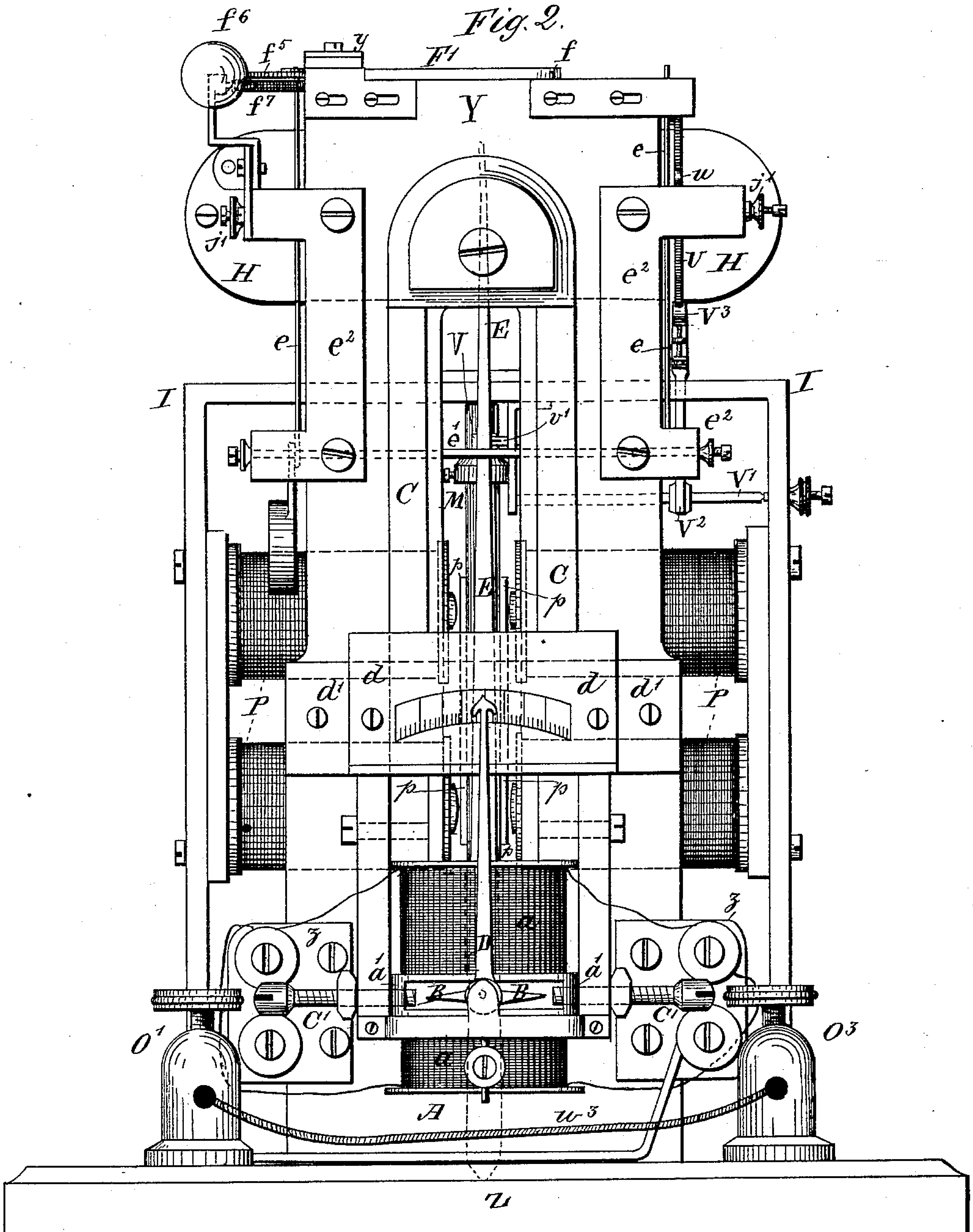
Fig. 2.



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(No Model.)

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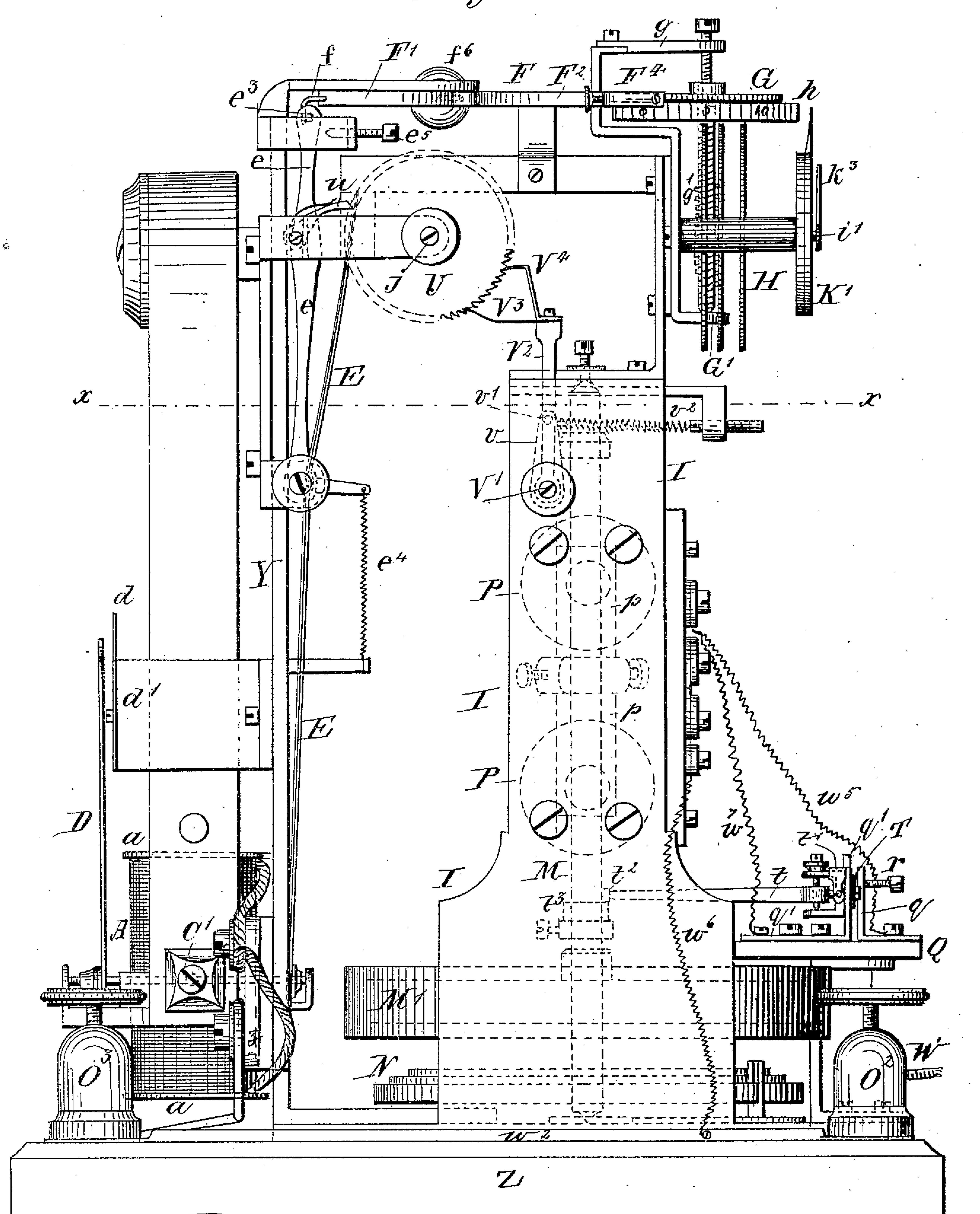
Fig. 3.



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(No Model.)

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J. CAUDERAY.

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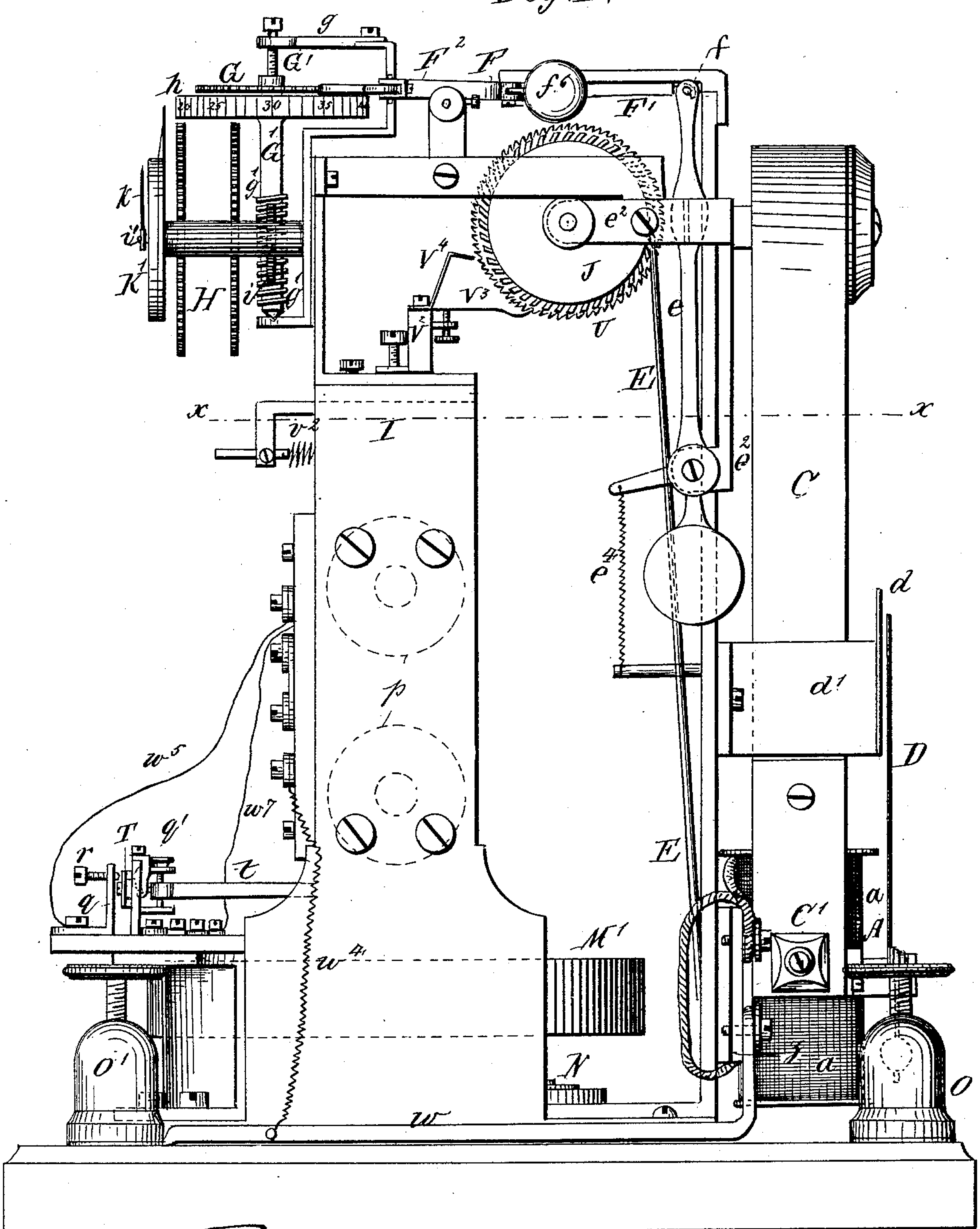
Fig. 4.



Witnesses

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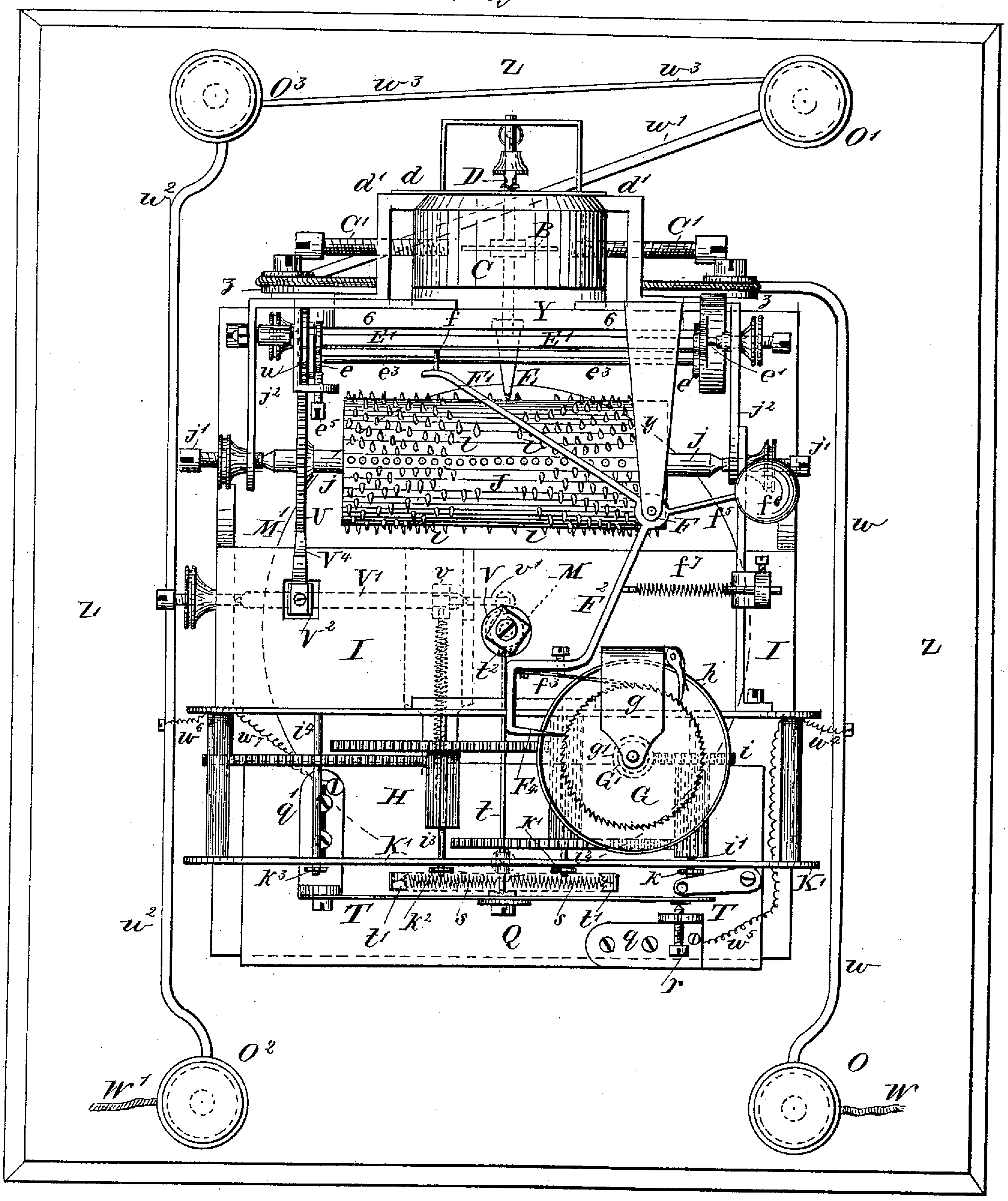
J. CAUDERAY.

ELECTRIC METER.

No. 318,166. Patented May 19, 1885.

Fig. 5.



Witnesses
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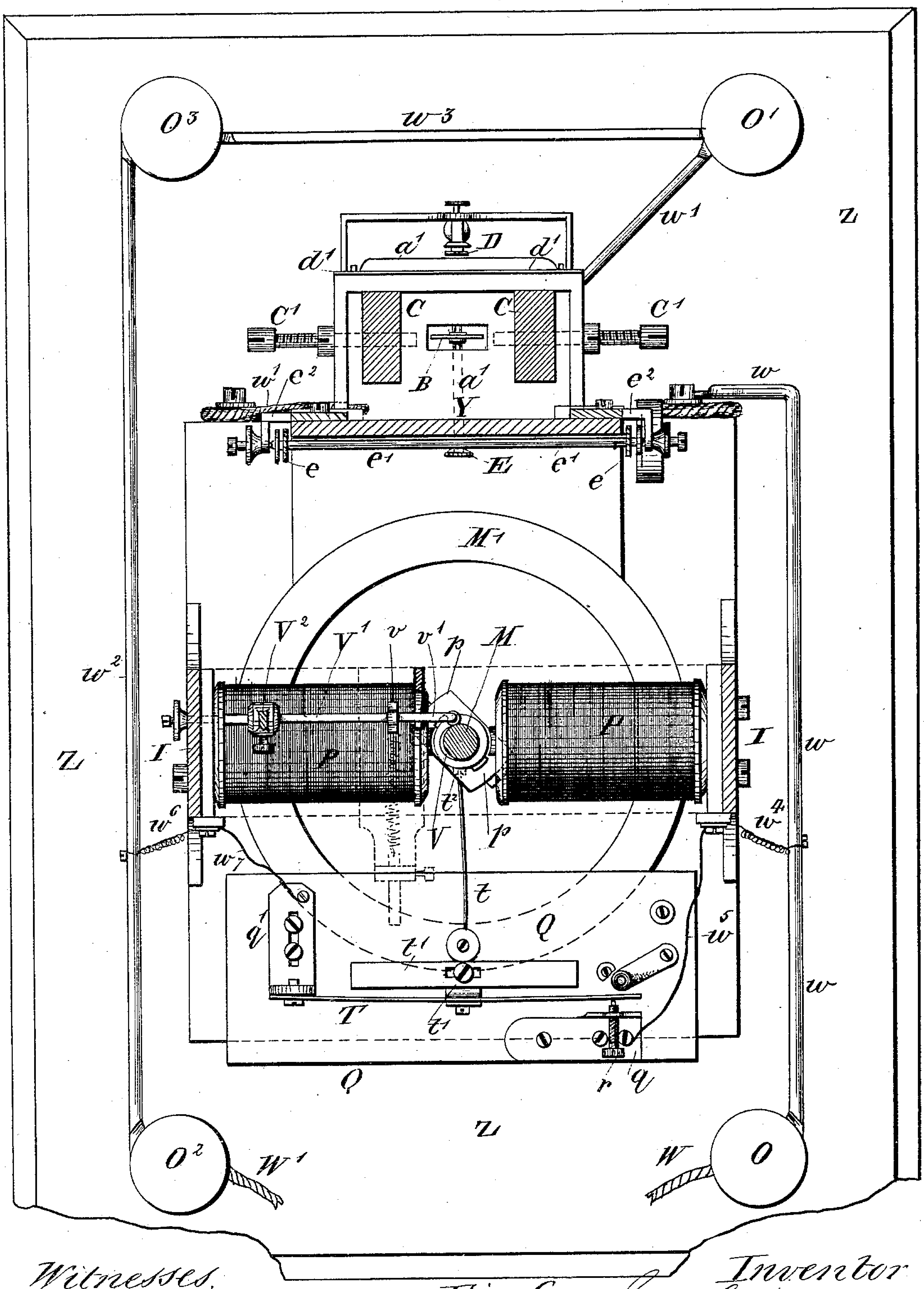

Fig. 6.

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J. CAUDERAY.

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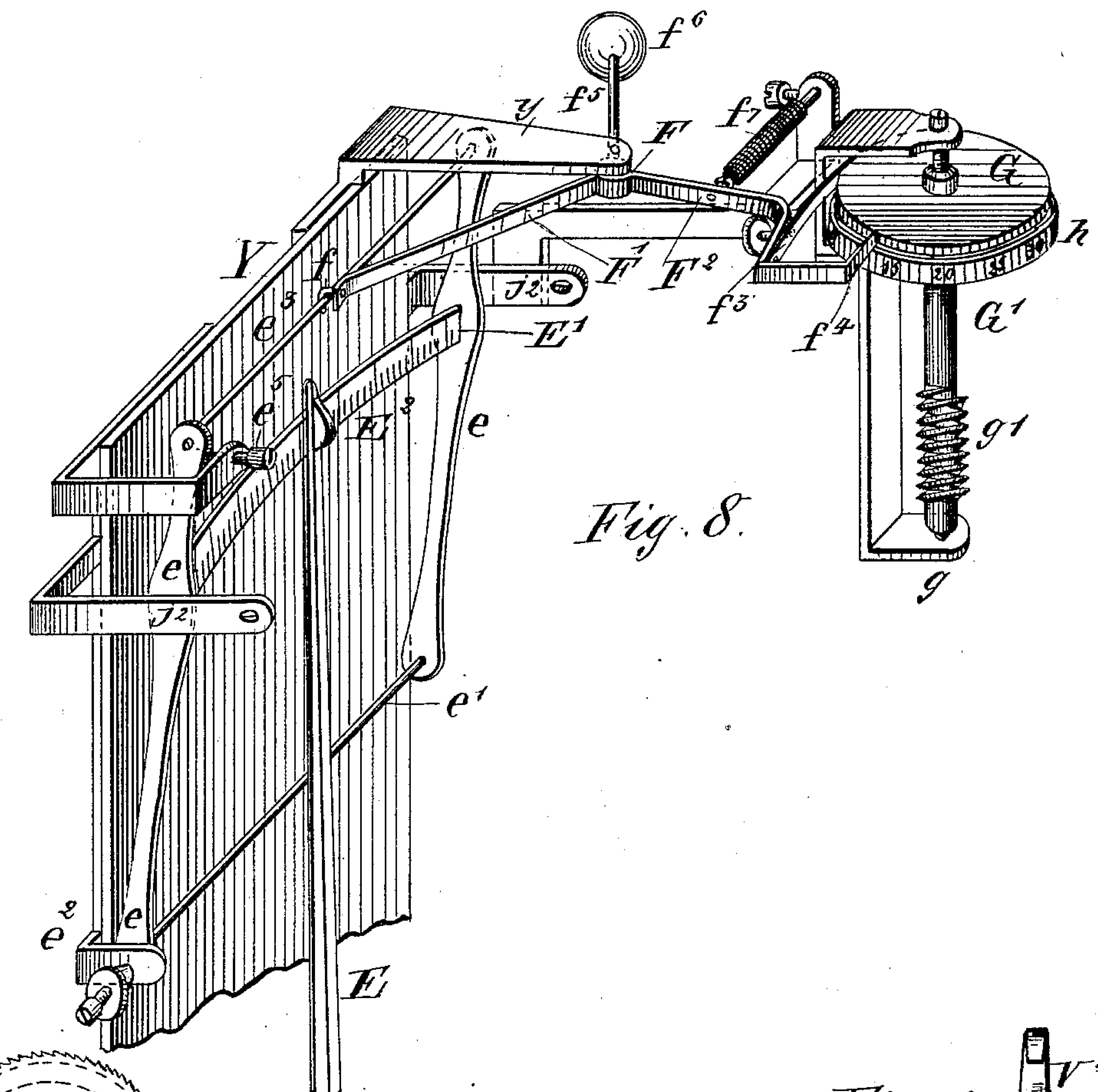

Fig. 8.

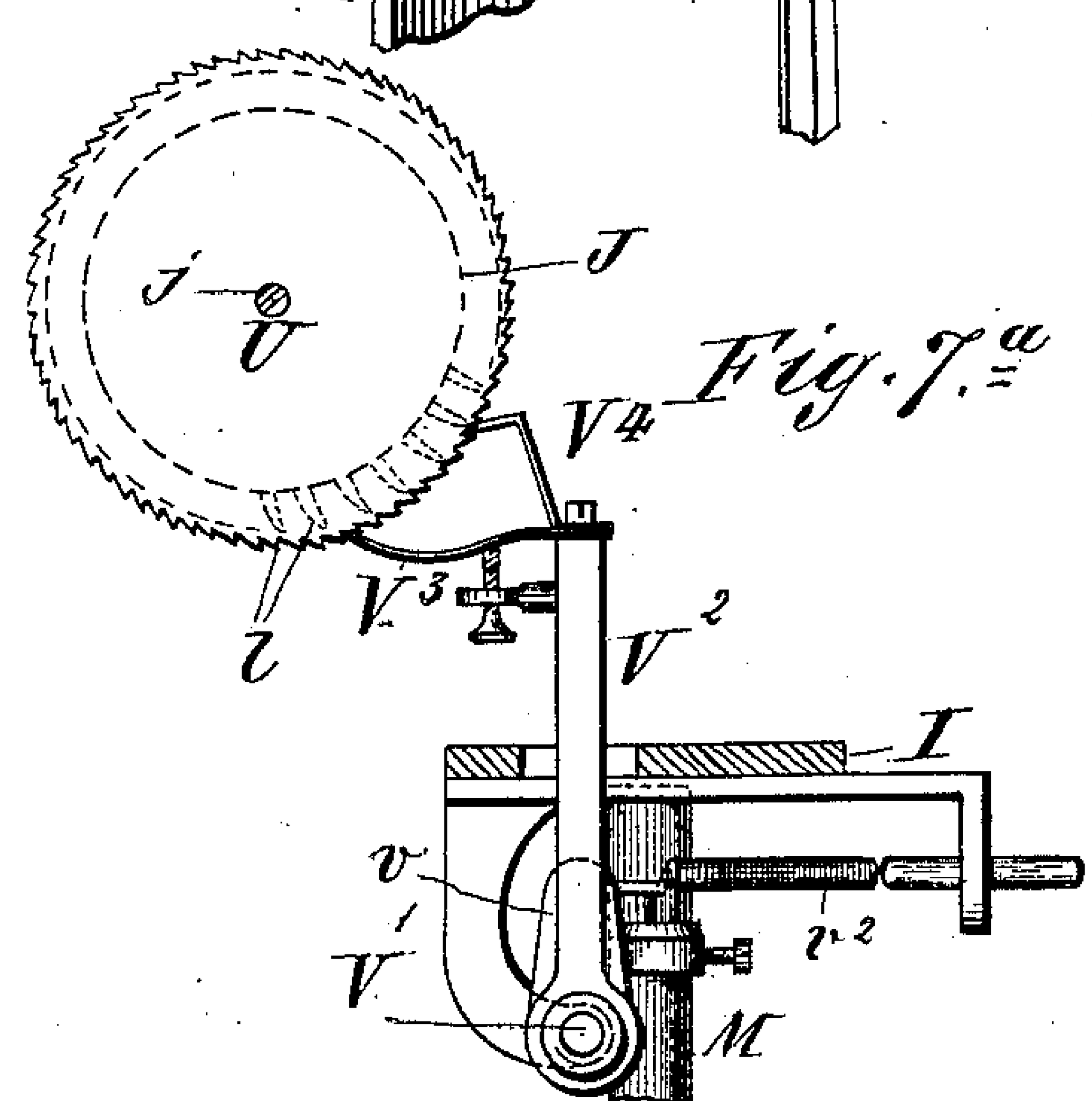

Fig. 7.ª

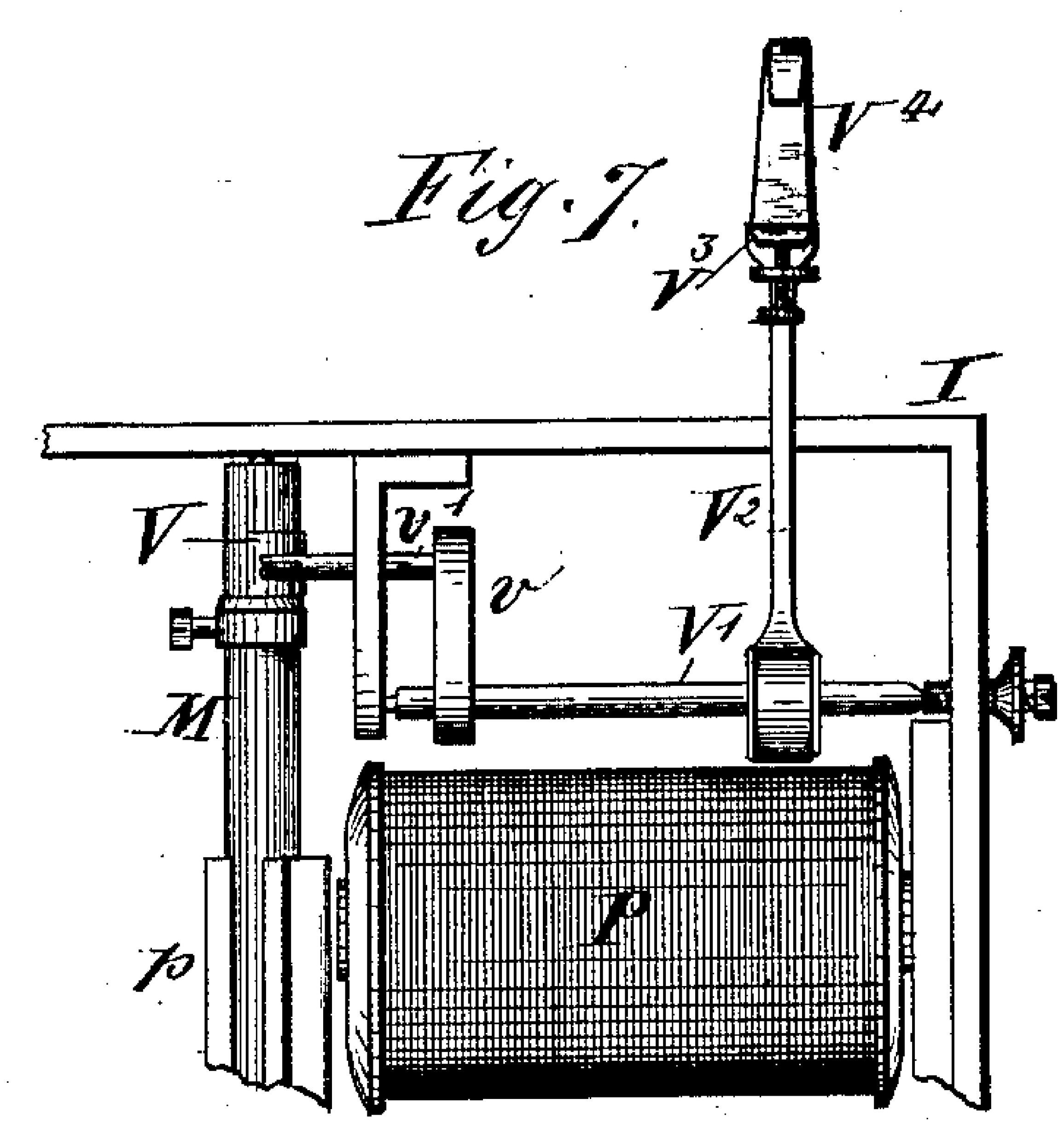

Fig. 7.

Witnesses
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(No Model.)

8 Sheets—Sheet 8.

J. CAUDERAY.

ELECTRIC METER.

No. 318,166.

Patented May 19, 1885.

Fig. 12.

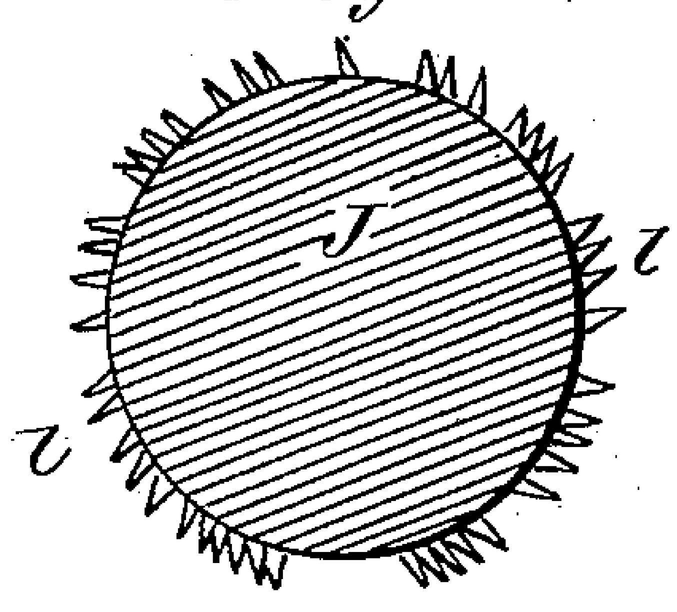


Fig. 13.

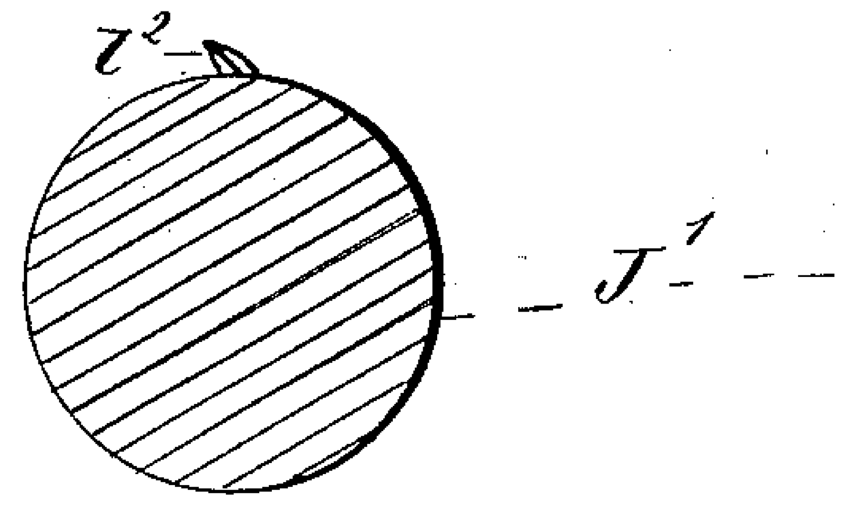


Fig. 16.

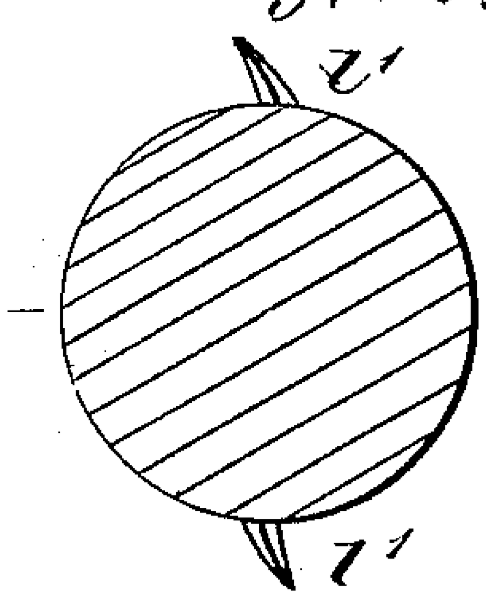


Fig. 14.

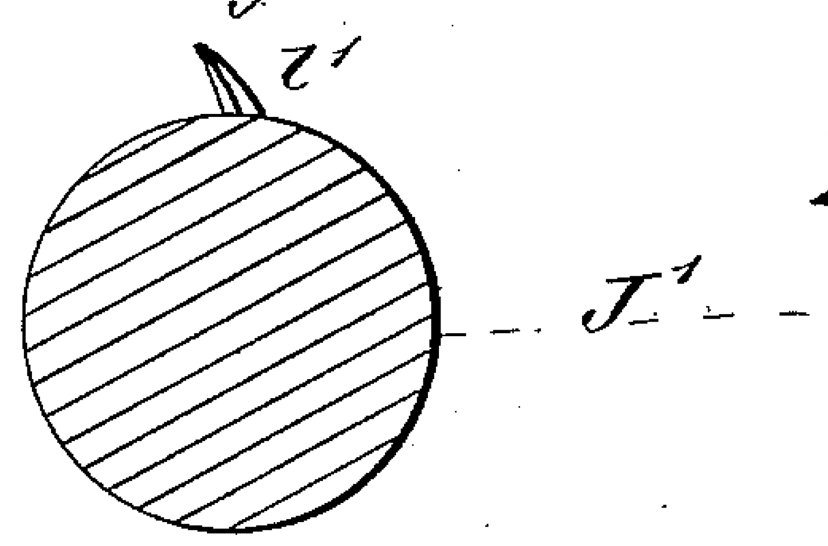


Fig. 17.

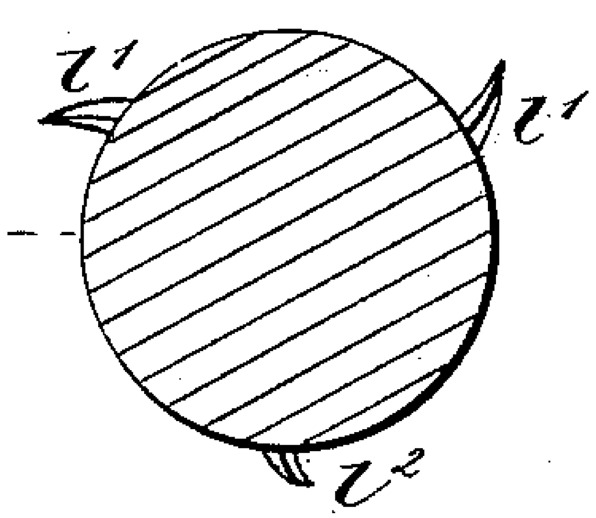


Fig. 10

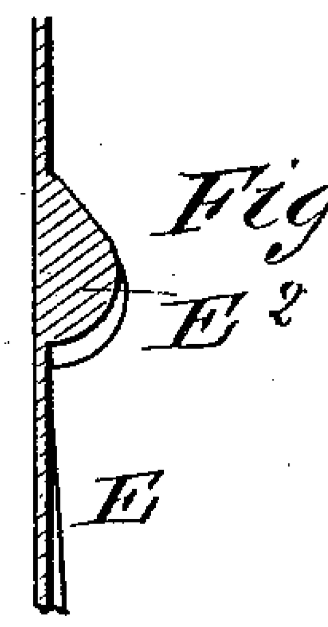


Fig. 15.

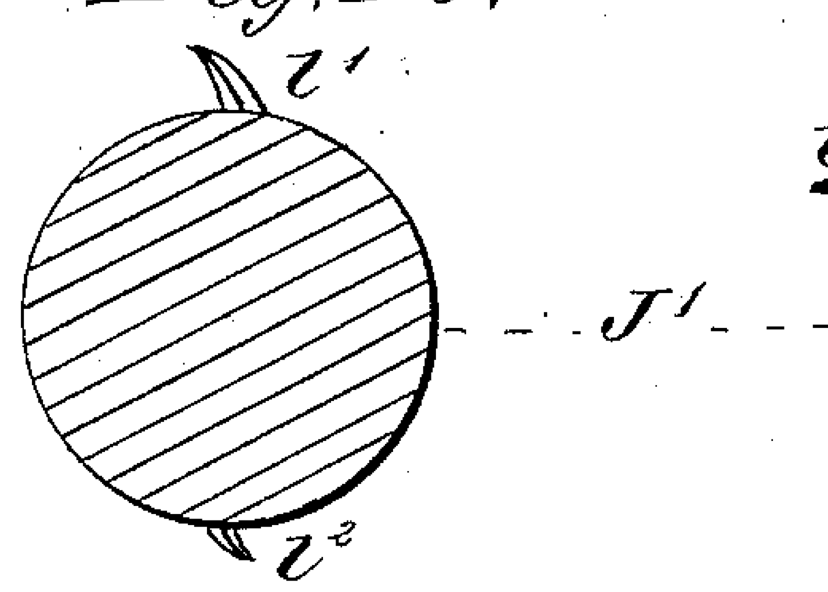


Fig. 18.

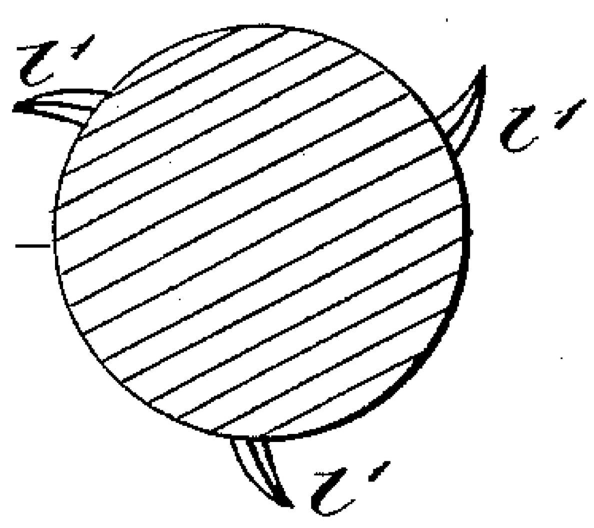


Fig. 9.

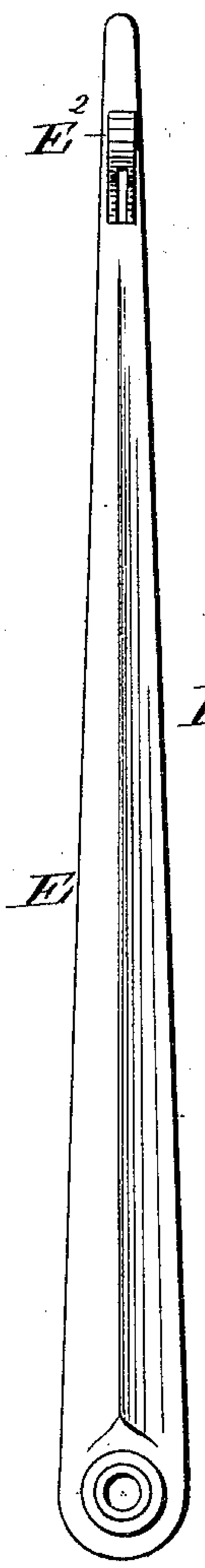
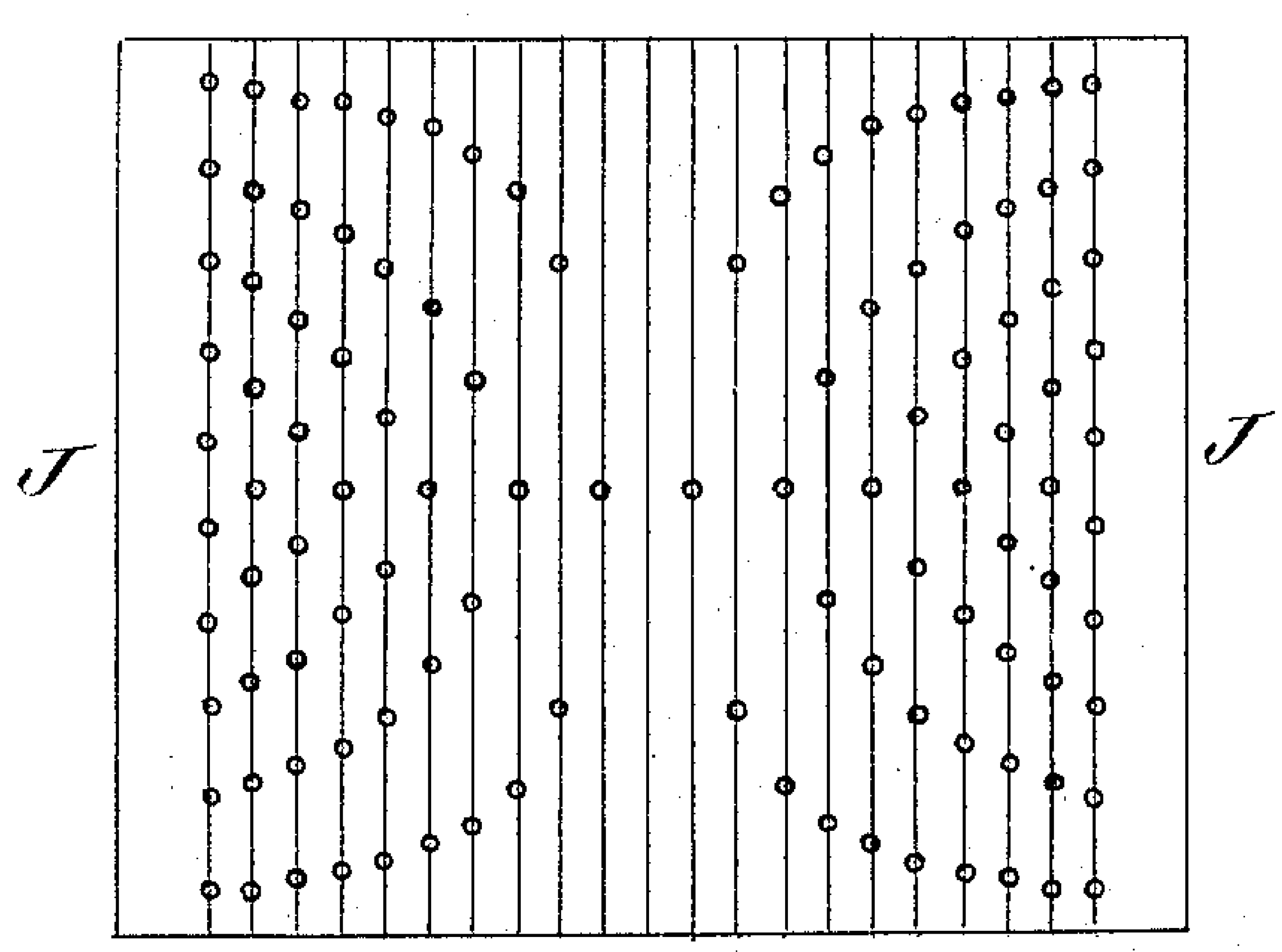


Fig. 11.



Witnesses.

W. E. Boulter

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N. PETERS, Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

JULES CAUDERAY, OF LAUSANNE, SWITZERLAND.

ELECTRIC METER.

SPECIFICATION forming part of Letters Patent No. 318,166, dated May 19, 1885.

Application filed November 15, 1884. (No model.) Patented in France March 17, 1883, No. 154,362; in Belgium April 2, 1883, No. 60,946, and July 3, 1883, No. 61,911; in Germany July 9, 1883, No. 26,90[illegible]; in Italy August 23, 188[illegible], No. 15,793; in Spain November 16, 1883, No. 4,791, and in England May 9, 1884, No. 7,515.

To all whom it may concern:

Be it known that I, JULES CAUDERAY, a citizen of Switzerland, residing at Lausanne in the canton of Vaud, Switzerland, have invented certain new and useful improvements in Electric Meters; and I do hereby declare the following to be a full, clear and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification.

This invention relates to an apparatus for measuring and registering the quantity of electric current flowing upon a conductor in a given time.

The object of the improvement is to resolve the indications of ampères or units of current strength as given by an amperemeter or suitably-graduated galvanometer into indications of quantity or coulombs, this object being accomplished by means of a novel combination of a galvanometer, a registering mechanism, and a time mechanism. The improvement is based upon the rule of electric measurement, that the flow of an electric current of the strength of one ampère during one second is equal to one coulomb of quantity, and the construction and operation of the apparatus will be readily understood from the following particular description, in connection with the accompanying drawings, in which—

Figure 1 is a front elevation of my improved electric meter. Fig. 2 is a rear elevation of the same. Figs. 3 and 4 are respectively opposite side elevations. Fig. 5 is a plan view. Fig. 6 is a horizontal section on line *x x* of Figs. 3 and 4. Fig. 7 and 7[a] are detail front and side views of the mechanism for rotating the cylinder. Fig. 8 is a detail perspective view of the devices for transmitting motion from the galvanometer to the register. Fig. 9 is a detached view of the pointer, and Fig. 10 an enlarged detail view of its projecting point. Fig. 11 is a diagram illustrating the arragement of the teeth on the toothed cylinder. Fig. 12 is a cross-section of the toothed cylinder at its mid-length; and Figs. 13, 14, 15, 16, 17 and 18 are diagrams illustrating the several toothed circles of a modified form of the cylinder.

In the drawings, the letter A designates a vertical galvanometer the coils *a a* of which are respectively above and below an open flat frame, *a'*, in which is pivoted transversely an arbor upon which is fixed a non-polarized needle, B. The galvanometer is arranged between the depending legs of a permanent horseshoe-magnet, C, the ends of said legs being secured to the ends of the open frame *a*, while the magnet is secured to a vertical back plate, Y. Horizontally through the tips of the magnet-legs, and also through the end walls of the open frame *a'*, are arranged iron screws C' C', which form laterally-adjustable pole-pieces for the magnet, and the tips of which may be adjusted in any desired proximity to the ends of the needle B. The needle is magnetized by induction from the screw pole-pieces, and the strength of its magnetization is regulated by adjusting said pole-pieces for a purpose which will be hereinafter referred to.

To the rear end of the arbor which carries the needle B is fixed a pointer, D, arranged to vibrate before a scale, *d*, on a plate, *d'*, in front of the magnet C, and to the front or inner end of said arbor is fixed a much longer pointer, E, the upper portion of which vibrates before a scale-plate, E', arranged in front of the vertical supporting-plate Y, and carried by upright arms *e e*, the lower ends of which are fixed to a horizontal rock-shaft, *e'*, pivoted between brackets e^2 e^2, fixed to the opposite edges of said vertical plate. The upper ends of the arms *e e* are connected by a rod, e^3, with which engages a hook, *f*, on the end of an arm, F', of a bent lever, F, the other arm, F^2, of which carries a spring-impelling pawl, f^3, which engages with a horizontal ratchet-wheel, G, mounted on a vertical shaft, G', mounted in a bracket, *g*, secured to the frame-work of a register, H, supported at the top of a frame, I, the further function of which will be hereinafter explained. The extreme end of the arm F^2 is bent to form a detent, F^4, which arrests the forward movement of ratchet-wheel G, and also prevents it from moving backward. From the elbow of the bent lever F extends an arm, f^5, carrying a weight, f^6, which gives steadiness to the movement of the lever on its pivot-pin, which extends downward from an arm, y, extending forward from the top of plate Y. A suitably-supported adjustable spring, f^7, draws the arm F^2 toward the ratchet-wheel G, and furnishes the power which causes the pawl f^3 to drive said ratchet-wheel.

Upon the shaft G′, below the ratchet-wheel G, is a disk, h, having a broad peripheral edge, which is graduated in a manner which will be presently explained. The lower portion of the shaft G′ carries a worm, g', which meshes with a toothed wheel, i, on a shaft, i', the front end of which projects beyond the front plate, K′, of the register, and carries an index or pointer, k, which revolves in front of a dial bearing a circular series of numerals, from 1 to 0, at equal distances apart. The register has three other indices or pointers, k' k^2 k^3, arranged to revolve before similar dials, and the shafts i^2 i^3 i^4 are so geared with the shaft i' after the usual well-known manner of multiplying registers that a complete revolution of any index-shaft causes the next index-shaft to the left to make a partial revolution, sufficient to carry its pointer over one numbered space on its dial. For instance, when the units-index makes a complete revolution in front of its dial the tens-index will have passed from 0 to 1, and so on. The gear-connections of the register are similar to those of the well-known register used in gas-meters, and need not be particularly described. The arms e and scale-plate E′ are held forward from plate Y by a spring, e^4, the forward movement of the arms being limited by an adjustable stop-screw, e^5, arranged in a bracket near the top of said plate Y, which itself limits the rearward movement of the arm, scale-plate, and connecting-rod e^3. When the arms e are moved to carry the connecting-rod e^3 toward the plate Y, the bent lever F will be swung on its pivot to cause the pawl f^3 to make a fresh engagement with the ratchet-wheel G, and on the said arms e being then released the spring f^7 will retract the bent lever and cause the pawl f^3 to give the ratchet-wheel a partial rotation equal to the number of teeth which it slips over in making each fresh engagement, the number of teeth being regulated by the movement of the connecting-rod e^3. In the present instance the movement of the part is supposed to be such that the pawl slips over two teeth at each movement, the wheel having one hundred teeth. The scale-disk h has fifty equal graduations, and two complete revolutions of this disk and its worm-shaft G′ are necessary to cause the units-pointer of the register to move one space.

I will now describe the devices by which the indications of the galvanometer are transferred to the register.

In front of the scale-plate E′ and the upper end of the long pointer E is arranged a cylinder, J, the shaft j of which has conical tips pivoted in suitable bearing-screws, j', arranged in arms j^2 on bracket e^2, projecting forward from the plate Y. This cylinder is provided with a number of annular series of teeth, l. The cylinder is graduated into a number of circles corresponding to the graduations of the scale-plate E, and the series of teeth of the cylinder are arranged according to the numerical graduations on said scale-plate. For instance, referring to the diagram, Fig. 11, on the circle or space of the cylinder opposite the middle or zero point of the scale-plate there are teeth on the cylinder. On each of the first circles, to the right and left of the zero-point, respectively, there is one tooth, on the next succeeding circle of the cylinder to the right and left there are two teeth diametrically opposite each other, and on the next circles each there are three teeth at equal distances apart around the cylinder, and so on. While the diagram does not show a complete cylinder, it illustrates the relative arrangement of the series of teeth in a manner which will be readily understood. Near its top the pointer E is provided with a forwardly-projecting point, E^2, which will be struck by such teeth of the cylinder as the pointer may stand opposite, and said pointer will be thereby forced against the scale-plate E′, and cause the arms e e and connecting-rod e^3 also to be moved toward the plate Y, thus causing motion to be transmitted through the bent lever F and its pawl f^3 to the registering mechanism, as before explained, the number of partial revolutions thus given to the ratchet-wheel G and disk h depending on the number of teeth which strike the projection of the pointer. The pointer takes its position according to the strength and direction of the electric current which traverses the coils of the galvanometer which is connected in the circuit the current on which is to be measured, such connection being made in the present instance for a particular reason in a manner which will be presently explained. The scale-plate E′ is graduated for ampères, and the circular series of teeth on the cylinder are arranged accordingly—that is, if a current having the strength of one ampère traverses the coils of the galvanometer the pointer E will be deflected from the zero-point, according to the direction of the current to the first graduation, to the right or left, and if it stands in this position while the cylinder J makes one revolution said pointer will be forced rearwardly once, as there is one tooth on said cylinder opposite the first ampère-graduation of the scale-plate. This movement is to be regulated so that it will cause the bent lever F and its pawl to give the ratchet-wheel G a partial rotation, sufficient to move the graduated disk h one space. As the disk has fifty spaces, it follows that the pointer must be forced rearwardly fifty times to move the disk one revolution, or one hundred times to cause the unit-index of the register to move one space.

In the present instance I will describe the cylinder J as controlled by devices which cause it to make a complete revolution in one hundred seconds of time, and it will therefore be seen that if the pointer stands during such revolution in a position to indicate a passing current having the strength of one ampère a single graduation of the disk *h* will indicate one hundred coulombs of quantity, and if the pointer should stand in this position long enough to cause the disk to make two complete revolutions ten thousand coulombs of quantity would be indicated, and the units-index of the register would move one space, indicating one myriacoulomb, which is equal to ten thousand coulombs. This indication of a myriacoulomb would show that during one hundred revolutions of the cylinder, occupying one hundred seconds each, the pointer of the galvanometer had stood in a position indicating a passing current having a strength of one ampère. If the pointer should stand in position to indicate a current of greater strength—say, for instance, three ampères—it would be forced rearward three times during one revolution of the cylinder, as said cylinder has three teeth on the circle corresponding to the position of the pointer when it indicates three ampéres, and therefore the disk *h* would be moved three spaces, indicating three hundred coulombs of quantity. All indications less than a myriacoulomb are read from the graduated disk *h*. Indications of ten myriacoulombs or less are read from the units-dial of the register, and multiples of ten myriacoulombs are read from the dials to the left successively in the usual manner.

I have adopted the myriacoulomb as a practical unit for measuring electric-lighting currents, from the fact that it has been demonstrated that ten thousand and eighty coulombs utilized in a lamp (Edison incandescent) of sixteen-candle power produce the same amount of light as a cubic meter of gas having the same candle-power; hence in practice a myriacoulomb may be considered the equivalent of a cubic meter of gas.

I will now describe the means by which the cylinder J is caused to make a complete revolution in one hundred seconds. I employ devices similar to the motive mechanism of an electric clock, as much preferable to mechanism driven by a spring or cord and weight, the electric mechanism having the advantage that it needs no winding up, and may be operated by an almost inappreciable derivation of the current to be measured, as will presently appear.

The letter M indicates a vertical balance-staff having a balance-disk, M′, and an impelling-spring, N, these parts being so far similar to the balance-staff, wheel, and spring of a watch, but, of course, much larger, the disk M′ weighing about seven hundred grams and making one complete or to-and-fro oscillation per second as controlled by the regulation of the spring. The motive power which keeps up the operation of this balance-disk is derived from the electro-magnets P P, supported by the frame I and acting on the armatures *p p* on the staff M. These armatures stand normally in a plane oblique to the poles of the magnets, but will be caused to stand in the axial plane of the magnets by the attraction of the cores when said magnets are energized. The magnets are in a circuit derived from the main circuit, or that the current upon which is to be measured, the connection being made as follows: The binding-posts O O′ on the base Z of the apparatus are respectively connected with the opposite terminals of the galvanometer-coils by means of large wires *w* and *w′*, leading to the metallic plates *z z*, supported by but insulated from the plate Y, and connected directly to the terminals of said coils in the usual manner. Binding-posts O^2 O^3 are connected together by a large wire, w^2. In practice the binding-posts O′ and O^3 are to be connected together—as, for instance, by the wire w^3. The main-line wires, or W W′, are to be connected to posts O and O^2. One of the magnets P has its coils connected from one terminal by a wire, w^4, to the large wire *w*, and from the other terminal by a wire, w^5, to a metallic bracket, *q*, mounted on a non-conducting platform, Q, and carrying an adjustable contact-screw, *i*. The other magnet is connected from one terminal by a wire, w^6, to the large wire w^2 connecting the posts O^2 O^3, while the other terminal of the coils of this magnet is connected by a wire, w^7, to a bracket, *q′*, on non-conducting platform Q. To the bracket *q′* is secured one end of a horizontal strip-spring, T, the free end of which lies opposite the tip of the contact-screw *r*. Upon the rear side of the strip-spring T is a bracket, *t′*, in which is pivoted one end of light metallic arm *t*, which extends toward and terminates close to the balance-staff M. When this staff stands in its normal position, the inner end of the arm *t* will engage with one of the notches of a double-notched lug, t^2, carried by a collar, t^3, which is fixed upon the shaft M. The projection of this lug from the shaft is such that it forces the arm *t* endwise, and the arm in turn forces the free end of spring T against the tip of contact-screw *r*, though when the arm is out of engagement with the lug the spring will not make contact with said screw. The pivoted arm *t* points directly to the balance-staff normally, and is held in such position by two springs, *s s*, which permit it to yield laterally in both directions, but tend to bring it back to its normal position. The spring T is provided with a platinum face where it contacts with the screw *r*. This spring, when in contact with the screw *r*, closes the derived circuit in which the magnets P P are included. This derived circuit is closed in two cases—viz., first, when the apparatus is at rest, and, secondly, when, the apparatus being in operation, the amplitude of oscillation of the balance-disk begins to shorten from loss of momentum. In this latter case there comes a time when the lug t^2 will not brush past the end of arm t, as it does when the disk makes full oscillations, and the end of said arm will remain caught in one of the notches of the lug. The arm is therefore pressed endwise, and carries the tip of spring T against the contact-screw r, thus closing the derived circuit. The contact continues but a short time, say, during about one-fourth of an oscillation; but while it continues the electro-magnets are energized and attract their armatures p p, thus imparting to the balance-staff and disk a fresh impulse sufficient to enable them to make full oscillations for from seven to twelve seconds, when the renewed impulse is again given, as before. The balance being at rest, it will be set in motion as soon as an electric current passes on the main circuit, as the derived circuit will then be closed and will receive its due proportion of the current. This proportion may be so small as not to appreciably affect the strength of the main current. The electro-magnets may have a resistance of one thousand ohms, so that when operating with a main current of one hundred volts electromotive force an intensity of only one-tenth of an ampère will traverse the magnet-coils for one-fourth of a second at intervals of, say, seven to twelve seconds. When operating with main currents of less than eighty or one hundred volts, the magnets may be connected in multiple arc in a well-known manner so as to properly reduce the resistance sufficiently to obtain the required proportion of current on the derived circuit for efficient action of said magnets. The variation of from seven to twelve or fifteen seconds, during which the balance-shaft and disk will make full oscillations without renewal of impulse, may be due to two causes—viz., to the greater or less electrical force with which the apparatus is operated, or in different machines the difference of distance between the magnet-poles and the armatures. Near the top of the balance-staff is a collar carrying a curved plate, V, fitted partially around the shaft to form an eccentric.

V′ is a rock-shaft having a radial upright arm, v, from which projects a horizontal arm, v', in the end of which is mounted a small friction-wheel, which is caused to bear against the balance-staff by a spring, v^2, and is acted on by the eccentric plate V when the staff oscillates, thus giving a rocking motion to shaft V′. A long arm, V^2, rises from shaft V′ through an opening in the top piece of frame I, and at its upper end this long arm carries a spring-impelling pawl, V^3, which engages with the teeth of a ratchet-wheel, U, on the shaft j of the cylinder J. The arm V^2 also carries a detent-pawl, V^4, which prevents the ratchet-wheel from being carried too far by momentum. Backward movement of the wheel is prevented by a detent-pawl, u. The wheel U has one hundred teeth, and the throw of the eccentric V is such that at each oscillation of the balance-shaft the pawl V^3 will be caused to advance the ratchet-wheel one tooth, thus giving the wheel and the cylinder J a complete revolution in one hundred seconds.

With a view to reducing the number of teeth in the cylinder and lessening the risk of hindering the free movement of the pointer E, I propose to use a cylinder of the modified construction illustrated in Figs. 13, 14, 15, 16, 17, and 18. The two halves of the cylinder on opposite sides of the zero-space are identical, therefore a description of one half will suffice. Upon the first circle, or that next from the center circle, there is one tooth three millimeters long, which I call a "half-tooth," and upon the next succeeding or second circle, instead of two teeth, I fix one tooth four millimeters long, which I call a "full tooth," and then upon the next or third circle I fix one full tooth and one half-tooth, upon the next or fourth two full teeth, and upon the fifth circle two full teeth and one half-tooth, and so on for the remaining circles, one full tooth answering to two half-teeth. When a half-tooth forces rearward the pointer E, arms e e, and rod e^3, the lever F will move its pawl to engage only one tooth of ratchet-wheel G, so that the spring will then move said wheel the space of only one tooth and the disk h one-half of a graduated space, or one one-hundredth of a revolution, as the wheel G has one hundred teeth. When a full tooth acts upon the pointer, the wheel G will be moved the space of two teeth and the disk h will be moved one full graduation. In using such a cylinder, I place the tooth-circles a distance apart corresponding to half-ampère deflections of the pointer, and therefore the first half-tooth, in causing the disk h to move one one-hundredth of a revolution, gives the indication of fifty coulombs, and the first full tooth causes the indication of one hundred coulombs, while on the next circle the full tooth and half-tooth, being equal to three half-teeth, cause the indication of one hundred and fifty coulombs. The multiple indications are given to the register indices in a corresponding manner.

J′ indicates the modified cylinder, l' the full teeth, and l^2 the half-teeth.

For exactness in operation, I prefer to give the cylinder-teeth the form of a pyramid of triangular cross-section, one of the angles being turned in the direction of rotation, and the tooth somewhat inclined in the opposite direction. The projecting point of the galvanometer-pointer is preferably curved on its under edge, which has a **V**-shaped longitudinal groove into which the teeth take. The width of the point is such that when it moves laterally from any series of teeth or tooth-circle it will be certainly in position to encounter the teeth of the next circle. It will be now understood the current on the main circuit will flow from post O or O^2 through the galvanometer-coils and cause the needle and pointer to be deflected from zero in a direction according to the direction of the current, the derived current passing through the magnet-coils will cause the balance or clock mechanism to rotate the cylinder once in a hundred seconds, the teeth of the cylinder will operate on the pointer such a number of times in one hundred seconds as corresponds to the pointer's position, and a corresponding number of indications will be made by the register.

Having now fully described my invention, and explained the operation thereof, I claim—

1. In an electric meter, the combination, with a galvanometer, and a registering mechanism, of intermediate mechanical connections whereby the deflection of the galvanometer-needle will be caused to transmit a corresponding movement to the register, substantially as described.

2. In an electric meter, the combination, with a galvanometer and a registering mechanism, of intermediate mechanical connections arranged to transmit motion from the galvanometer-needle to the register, and a time mechanism arranged to modify the operation of said intermediate mechanical devices, substantially as described.

3. The combination, with the galvanometer having a pointer connected with its needle, and a registering mechanism, of the toothed cylinder arranged to operate upon the pointer, an intermediate series of mechanical devices arranged to transmit motion from the said pointer to the register, and a time mechanism arranged to give the toothed cylinder a complete rotation in a given period, substantially as and for the purpose set forth.

4. The combination, with the toothed cylinder and the non-polarized pointer of the galvanometer actuated thereby, of the balance-staff oscillating in given periods, and intermediate mechanical connections for transmitting rotary motion to the cylinder from said balance-staff, substantially as described.

5. The combination, with the balance-staff provided with suitable armatures and a returning spring, of the electro-magnets arranged to attract said armatures, and a circuit-closer operated by said staff for closing an electric circuit through the coils of said magnets, substantially as described.

6. In an electric meter, the combination, with a galvanometer in a main circuit, a registering mechanism, intermediate connections for transmitting motion from the galvanometer-needle to the register, and a time mechanism controlled by electric devices in a circuit derived from said main circuit and arranged to modify the operation of the said intermediate motion-transmitting devices, substantially as described, and for the purpose set forth.

7. The combination, with the galvanometer having its needle provided with a pointer, and the registering mechanism, of intermediate mechanical devices for transmitting motion from the pointer to the said registering mechanism, and the cylinder having full teeth and fractional teeth for operating said pointer, substantially as and for the purpose set forth.

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

J. CAUDERAY.

Witnesses:
G. WOHLERS,
C. WINAUDY.