No. 765,948. PATENTED JULY 26, 1904.

J. J. WOOD.

CURRENT REGULATOR.

APPLICATION FILED AUG. 17, 1903.

NO MODEL. 4 SHEETS—SHEET 1.

FIG. 1.

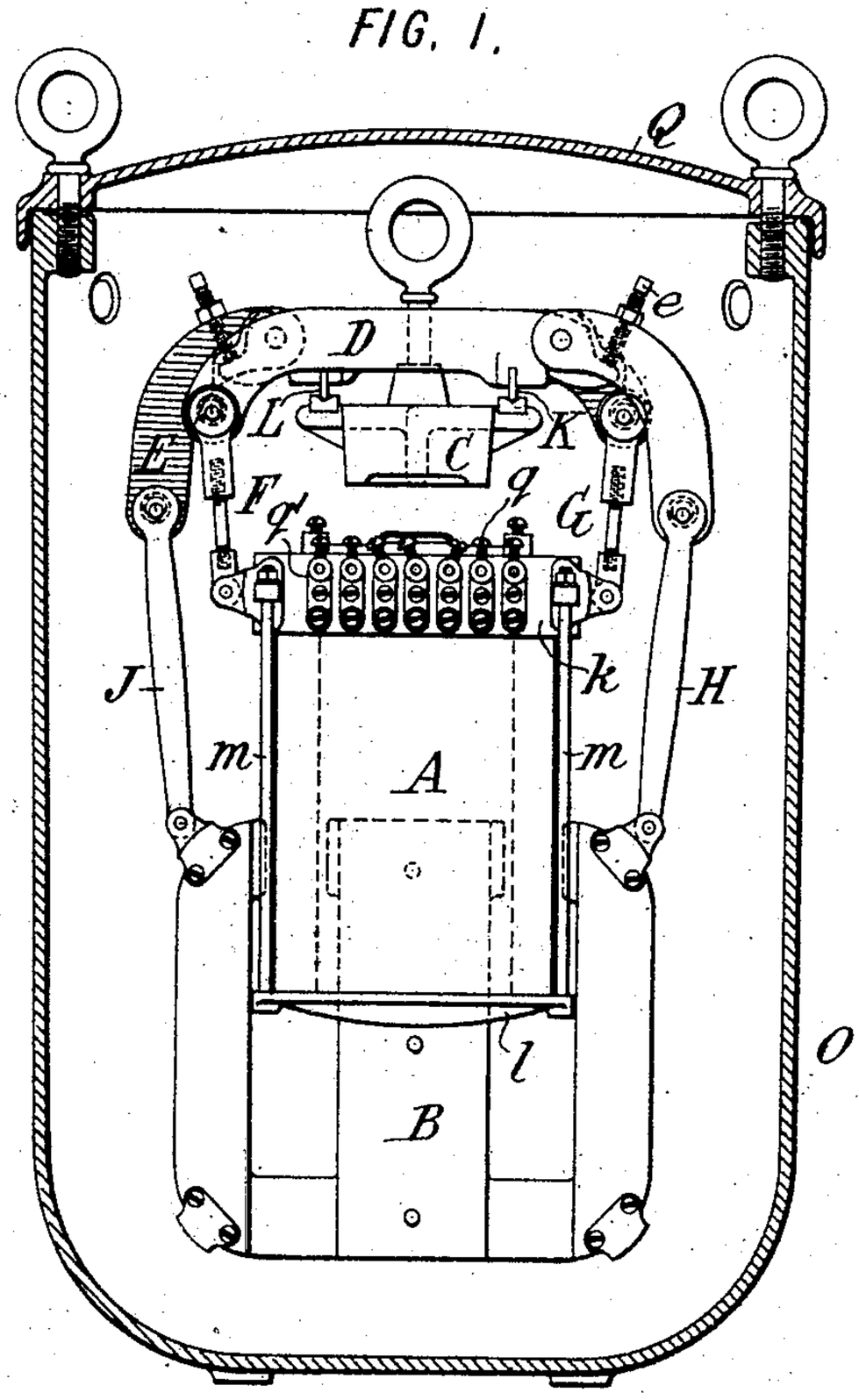
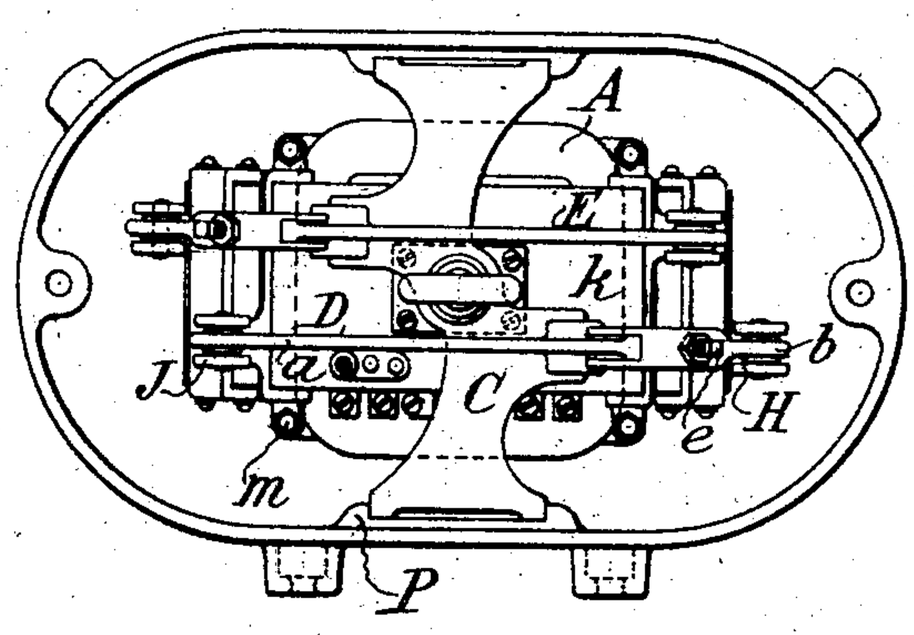



FIG. 2.

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WITNESSES:

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NO MODEL. 4 SHEETS—SHEET 2.

FIG. 3.

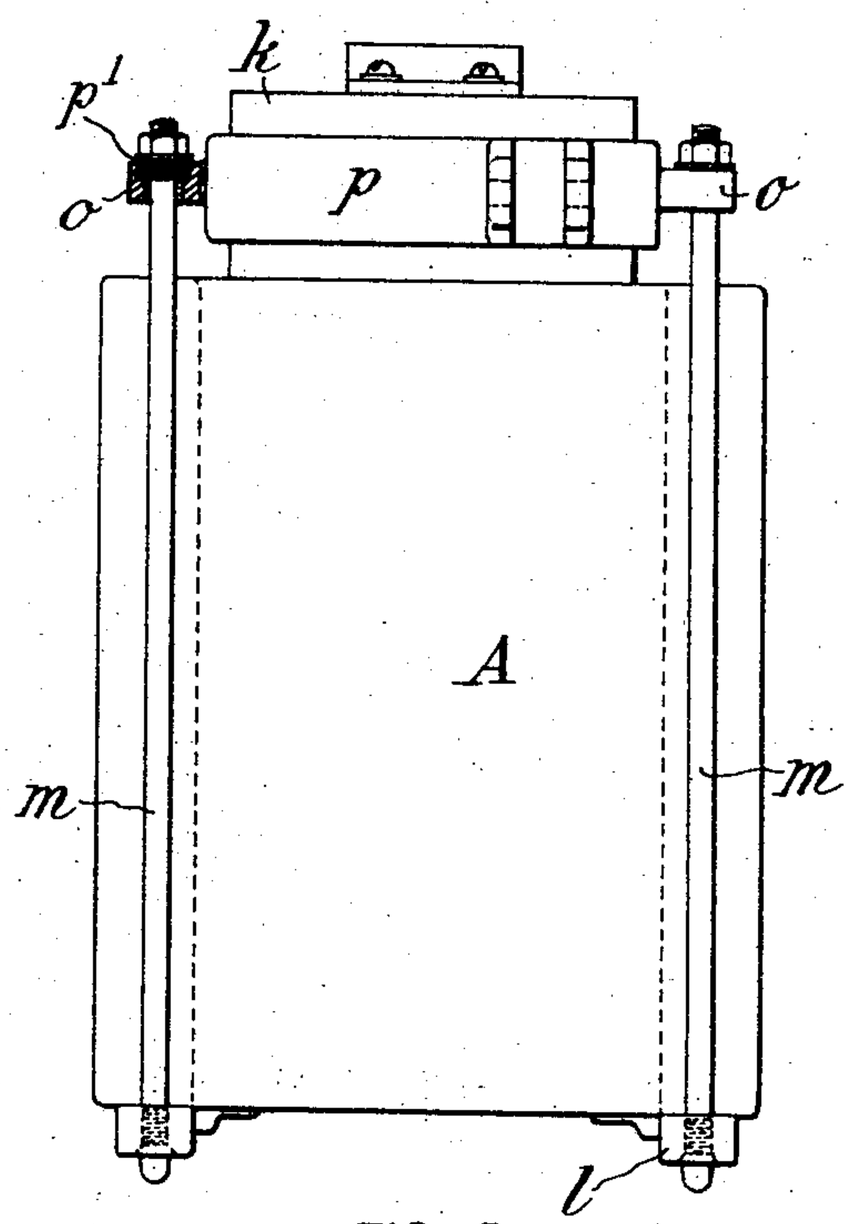



FIG. 4.

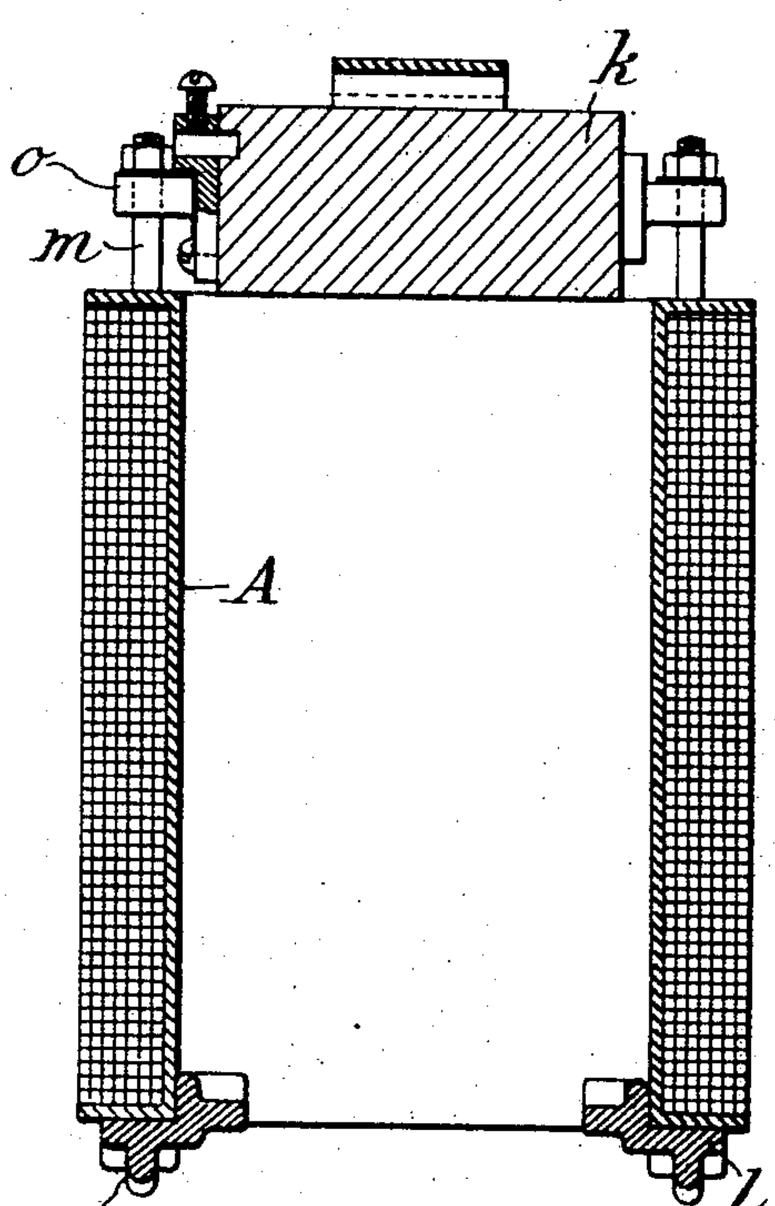



FIG. 5.

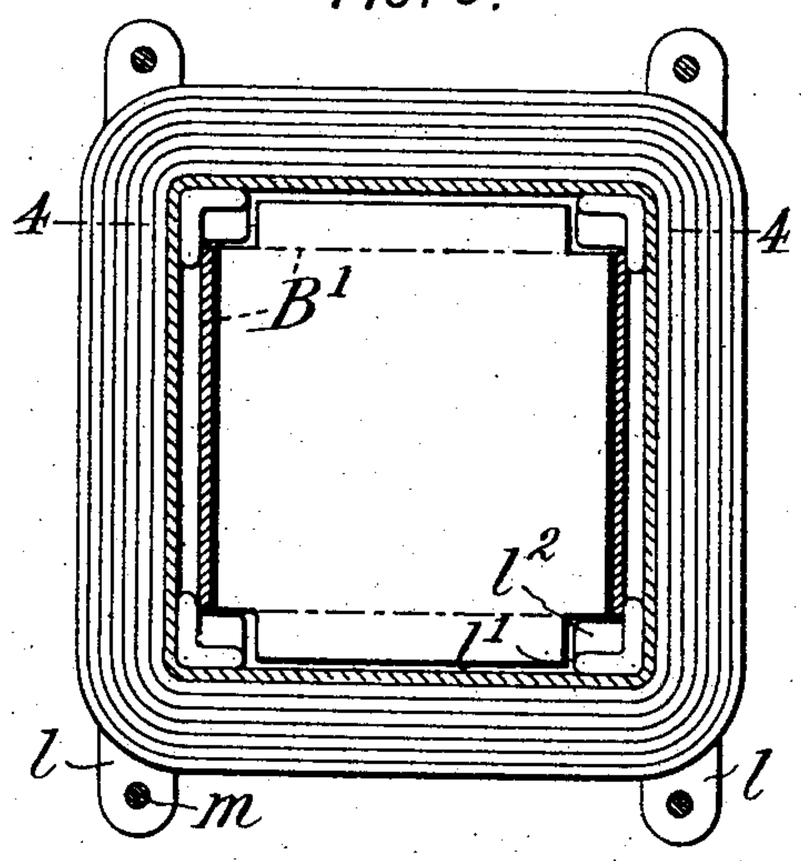



FIG. 6.

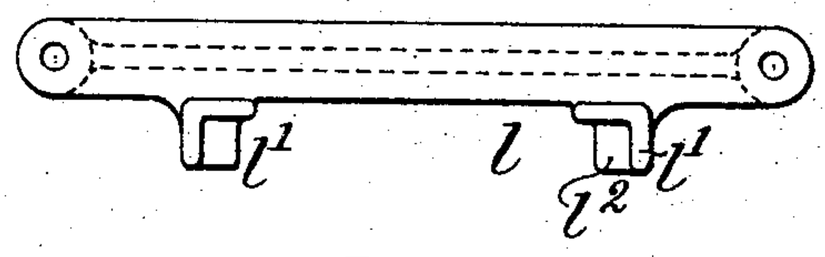
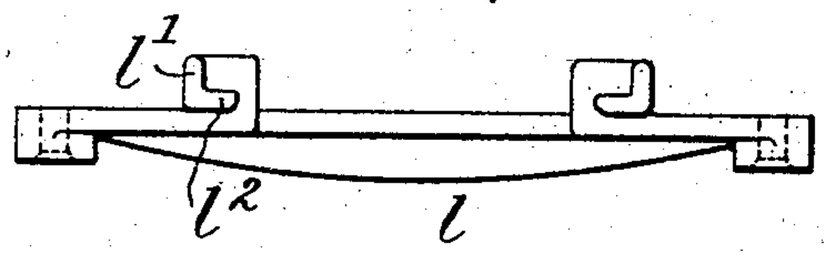



FIG. 7.

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NO MODEL. 4 SHEETS—SHEET 3.

FIG. 8.

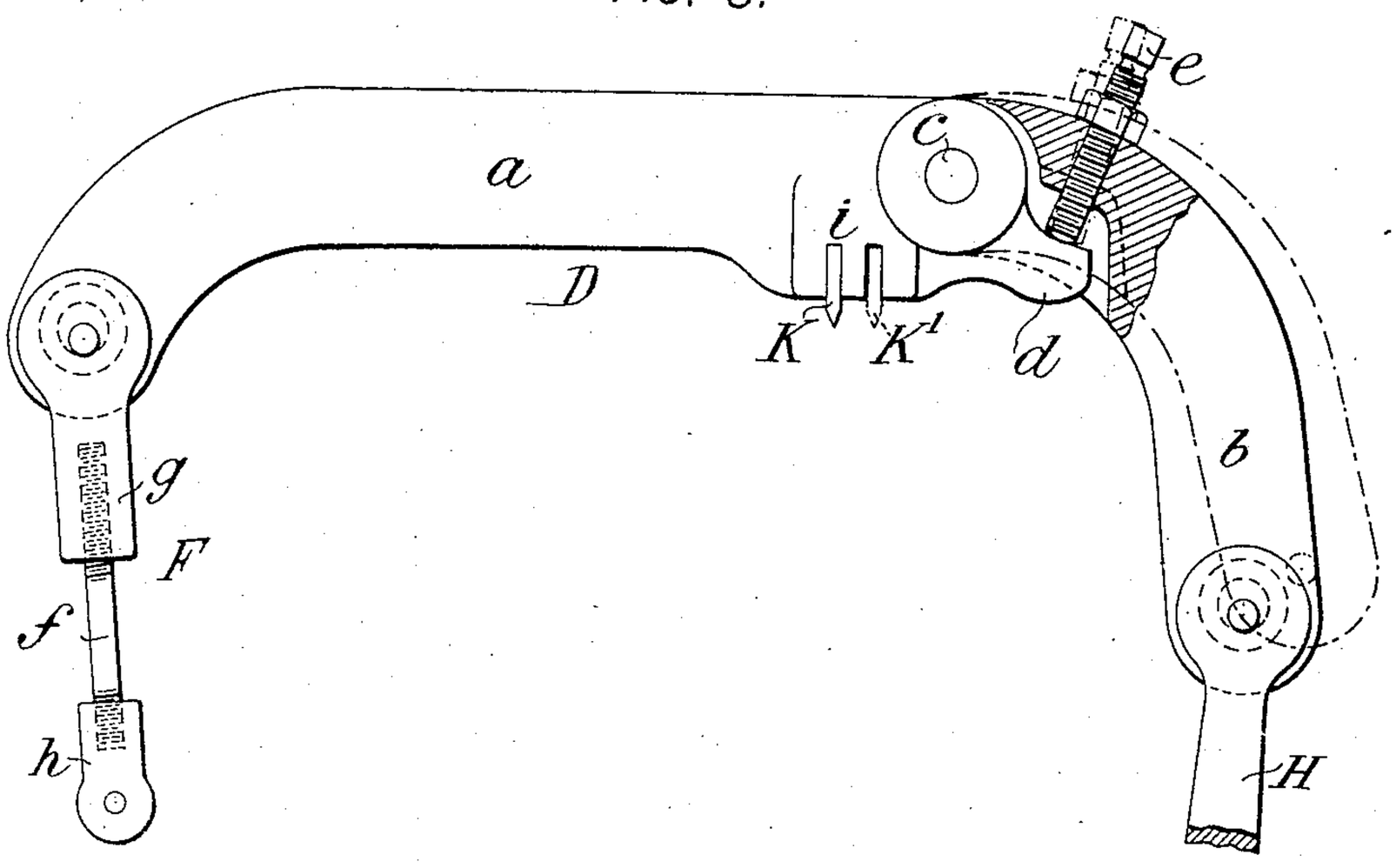



FIG. 9.

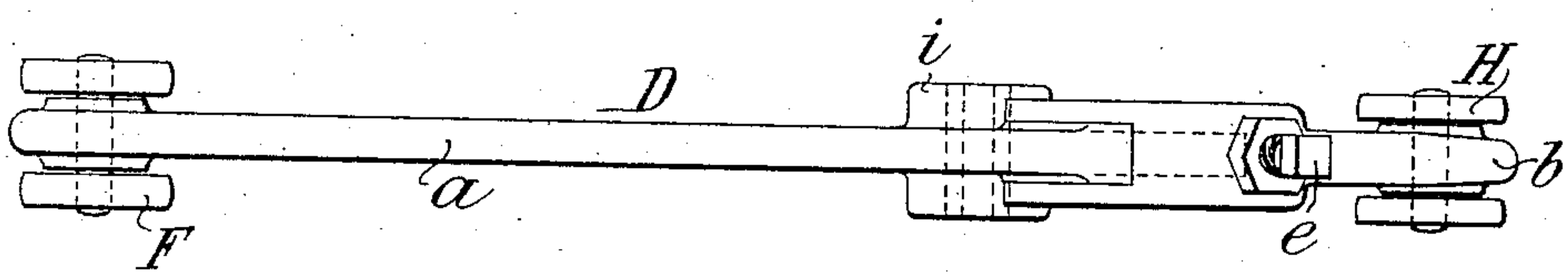



FIG. 10.

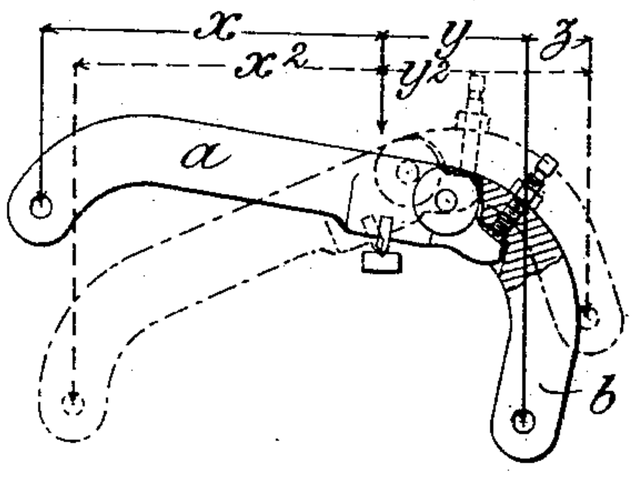
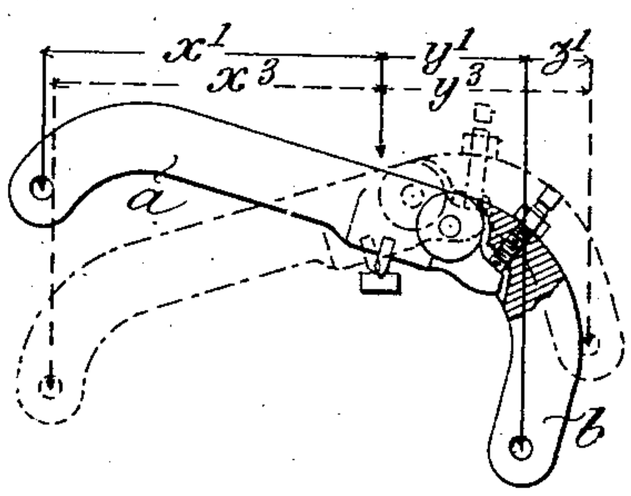



FIG. 11.

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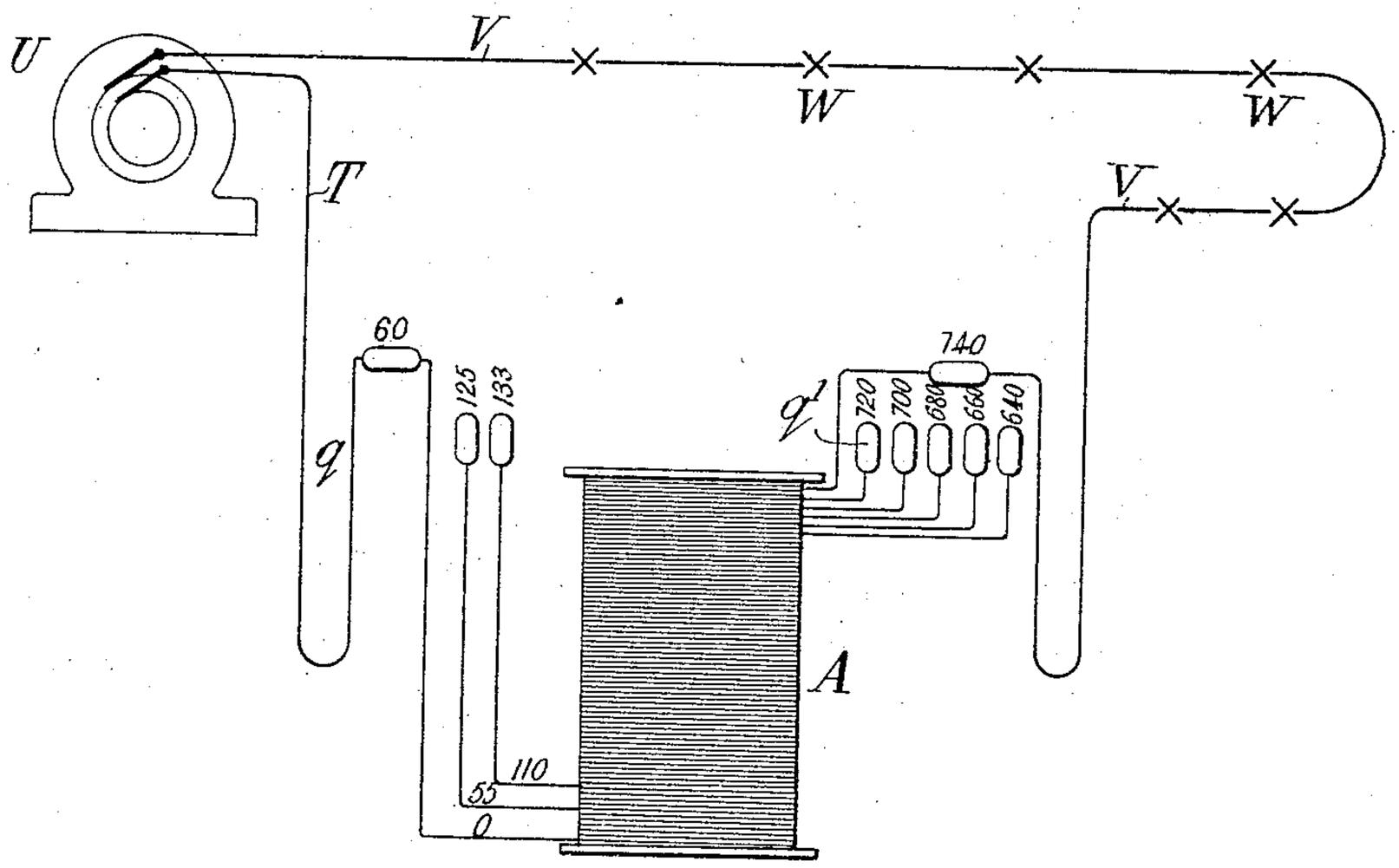
NO MODEL. 4 SHEETS—SHEET 4.

FIG. 12.

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No. 765,948. Patented July 26, 1904.

# UNITED STATES PATENT OFFICE.

JAMES J. WOOD, OF FORT WAYNE, INDIANA.

## CURRENT-REGULATOR.

SPECIFICATION forming part of Letters Patent No. 765,948, dated July 26, 1904.

Application filed August 17, 1903. Serial No. 169,839. (No model.)

*To all whom it may concern:*

Be it known that I, JAMES J. WOOD, a citizen of the United States, residing at Fort Wayne, in the county of Allen and State of Indiana, have invented certain new and useful Improvements in Current-Regulators, of which the following is a specification.

This invention relates to current-regulators for maintaining substantially constant currents on alternating circuits.

My present invention constitutes mainly an improvement upon the regulator set forth in my Patent No. 720,305, granted February 10, 1903, although it is in part applicable to other constructions of regulators.

The accompanying drawings illustrate the preferred embodiment of my invention.

Figure 1 is a side elevation of the regulator, its inclosing case being in vertical section. Fig. 2 is a plan of the regulator and case with the cover of the latter removed. Fig. 3 is an elevation of the coil. Fig. 4 is a vertical section thereof on the line 4 4 in Fig. 5. Fig. 5 is a horizontal section through the coil and its supports. Fig. 6 is a plan of one of the supporting cross-bars and guides for the coil, Fig. 7 being an elevation thereof. Fig. 8 is a sectional elevation of one of the levers with its connected parts. Fig. 9 is a plan thereof. Figs. 10 and 11 are elevations of the lever, showing different positions and varying adjustments. Fig. 12 is a diagram illustrating the electrical connections.

The current-regulator to which my invention is applied includes a relatively movable coil and core, the coil being in the circuit whose current is to be regulated. As the current increases or decreases the coil moves farther onto or off from the core, the latter choking the current in proportion to the distance to which it enters into the coil. Either the coil or the core, or both, may be movable. In some such regulators the core is fixed and the coil movable, being counterbalanced by a lever which carries a weight at its opposite end, this being a well-known construction. According to the preferred construction set forth in my aforesaid patent the coil and core are both movable, the core serving as the counterbalance for the coil, both moving vertically and being connected through the medium of a pair of levers constituting a differential connection, the levers being shaped and proportioned to progressively increase the tendency of the coil and core to separate as they depart from the position of maximum load. The mode of operation of such compensating levers is fully set forth in my said patent.

Referring to the drawings, A indicates a coil, and B a core, both being shown as movable and supported from a fixed support C.

D and E are a pair of levers connected, respectively, to opposite sides of the coil A, as by means of links F and G, and the opposite arm of each lever connected to the counterbalancing core B, as by means of links H and J, respectively. The levers are provided with fulcrums K and L, carried on the support C, these being shown as knife-edged fulcrums. The levers are shaped and proportioned so as to change the leverage of the core with respect to the coil as the current changes, so as to compensate for the varying pull of the magnetic reaction. The levers are arranged symmetrically, so as to balance each other and give a direct vertical movement to both the coil and core.

Ordinarily the regulator is placed in a casing O, having a cover Q. The support C is received within the casing, its ends entering sockets or resting on ledges P therein.

The coil A is connected in any suitable way in the circuit, flexible cables being used to admit of the vertical movements of the coil. The connections will be readily understood from Fig. 12.

So far as described my present invention does not differ from that set forth in my said Patent No. 720,305. I will now proceed to describe the improvements introduced by my present invention.

In my former patent the compensating levers consisted each of a long and a short arm rigidly connected and incapable of relative adjustment except by shifting their fulcrum-points. According to my present invention I connect the long and short arms adjustably in order by adjusting their relative positions to vary the ratio of change of leverage between the arm holding the coil and the arm

holding the core. By these means I am enabled to so adjust the regulator as to give either an absolutely-constant current or a current which gradually increases with the load or a current which gradually decreases with the load. This will be apparent with respect to the lever D, which is shown separately in Fig. 8. For convenience I will refer to the long arm or the arm supporting the coil by the letter *a*, and the short arm or that supporting the core by the letter *b*. These two arms are jointed together by a pivot *c*, placed at any convenient location, preferably near the fulcrum. The arm *a* has a projection or lug *d* beyond the pivot, and the arm *b* carries an adjusting-screw *e*, the end of which engages this lug, so that by turning the screw the arm *b* will be raised or lowered. Raising it carries its lower end, to which the link H is connected, outward, as shown in dotted lines, thereby effectively lengthening the arm *b*. This adjustment increases the effectiveness of the core as a counterbalance and varies the compensating ratio of the lever. Of course a like adjustment is made on both levers.

By reason of the change in leverage due to the adjustment of the arm *b* the coil is raised as the arm *b* is lengthened, Fig. 10, or lowered as the arm is shortened, Fig. 11, independently of any change in current or load—that is to say, adjusting the arm *b* outward by increasing the leverage at which the core acts has the effect of raising the coil, which (if previously in correct relation to the core) will be brought too high upon reaching a position of equilibrium. To enable the coil without disturbing its balance with the core to be readjusted to the correct height relatively to the core corresponding to the position of full load, I provide a second adjustment—namely, I make the coil-suspending links F G adjustable in length. This may be variously done, but preferably is accomplished by the construction shown, where the intermediate section *f* has its ends screw-threaded and may be screwed in or out of threaded sockets in the end pieces or pivot-pieces *g h*, respectively, of the link. Hence if the coil is too high when in proper balance with the core it is only necessary to lengthen the links F G sufficiently to lower the coil to the proper position. On the other hand, if the levers are adjusted so as to move in or shorten the arms *b* the links F G must be shortened.

With the adjustments described it is possible to get any regulating results desired—that is to say, with an intermediate adjustment the current will be maintained constant notwithstanding any variations of load, or by turning the screws *e* to the right from said intermediate adjustment the current may be caused to gradually increase with the load, or by turning them to the left the current may be caused to gradually decrease with the load.

The effect of the adjustments of the arms *b* of the levers will be apparent from an examination of Figs. 10 and 11. In Fig. 10 the arm *b* is shown at its extreme inward adjustment; in Fig. 11 it is shown at its extreme outward adjustment. In both figures the full lines show the lever in the position of maximum load, while the dotted lines show it in the position of minimum load. (The positions shown in full lines answer to Fig. 4 of my former patent. Those in dotted lines answer to Fig. 6 thereof.) In Fig. 10 the relative effective lengths of the arms *a b* at maximum load are indicated by the arrows *x y*, at minimum load by the dotted arrows $x^2$ $y^2$. In Fig. 11 the effective lengths of the arms *a b* at maximum load are indicated by the arrows $x'$ $y'$, at minimum load by the dotted arrows $x^3$ $y^3$. The effect of the varying adjustments of the arm *b* is indicated in Fig. 10 by the arrow *z* and in Fig. 11 by the arrow $z'$, the difference being slight, but of considerable effect. For a given weight of coil and core the relative effective lengths of the arms *a b* in the position of equilibrium or full load is invariable, since the lever will tilt to such position as to restore equilibrium. Hence the result of any change of adjustment of the arm *b* is to change the rate at which the compensating preponderance of the core over the coil increases with the increase of current in the coil.

In Fig. 8 I have shown the knife-edge fulcrum K in one position in full lines and in another position, K′, in dotted lines. The purpose of these two positions is to allow for different relative weights of coil and core. In a regulator of small size where the core is of lighter weight in proportion to the weight of the coil the knife-edge is placed at K. For a larger size where the core is heavier in proportion to the weight of the coil it is placed at K′. Any intermediate position may be selected, according to their relative weights, for a given adjustment of the arm *b*. Hence the same lever-casting answers for regulators of different size by forming the casting with a single thickened portion *i*, (see Fig. 9,) into which to cut a notch or notches for the knife-edges. These notches may be cut as shown in Fig. 8 and the knife-edge placed in either notch, or, as shown in Fig. 1, only the one notch needed may be cut, it being cut where required.

The coil A is hung from a connection-board *k*, which in turn is hung from the links F G. For thus supporting the coil I place beneath it two cross-pieces *l l*, preferably of the construction shown in detail in Figs. 6 and 7, and connect their ends by bolts *m m* to ears *o o*, projecting from the end plates *p p* of the connection-board. The bolts *m m* are insulated, so that no closed circuit can be formed through them. This insulation is preferably made by inserting an insulating-bushing *q* into the socket in each eye *o* and so as to project out

of the socket, so that neither the bolt nor its nut can touch the eye.

My invention provides a mode of accurately guiding the coil in its movements relatively to the core, so as to prevent any contact of the coil with the core which might cause damage to the insulation. As in my patented regulator, the coil incloses the middle leg of the core and moves into the spaces between the middle and outer legs, the three legs having approaching pole-pieces which closely approach the coil to localize and concentrate the magnetic field. If the coil and core were able to move or swing laterally so that an inturned pole-piece on an outer leg of the core would rub or touch the exterior of the coil, it would wear the insulating-covering of the wire. It is also desirable to avoid rubbing of the polar projections on the middle leg against the coil. Hence I provide at or near the bottom end of the coil a guide engaging the middle leg of the core, which is adapted to keep this middle leg centrally within the coil. I form these guides as ears or projections $l'$ on the cross-pieces $l$, these projections having upturned angular flanges to fit up within the corners of the coil and having a plate or web $l^2$ to engage the core. The operation is indicated in Fig. 5, where the dotted line B′ designates the middle leg of the core, the corners of which enter the angles of the guides $l'$. The width of the plate or web $l^2$ allows for the projection of the pole-piece.

I provide means also for adapting my regulator for use on circuits carrying currents of different frequencies. It is well understood that for a low frequency, say sixty cycles, a greater length of active wire is required in the coil than for high frequencies, say one hundred and twenty-five cycles to one hundred and forty cycles. It is also desirable to be able to cut in more or less wire for variations in voltage. For example, on a small regulator the range may be from one thousand to twelve hundred volts and on a large regulator from two thousand to two thousand four hundred volts. In my former patent I provided means for cutting in or out a greater number of turns of wire on the coil in order to admit of adjustment for different frequencies or voltages. According to that construction, however, the circuit was connected permanently to one end of the coil, and more or less windings at the opposite end of the coil were cut off according to the length of wire desired for any required condition of either voltage or frequency. I now provide a more effective means of adjustment by which connections can be made for an increased or diminished voltage or for higher or lower frequency without interfering the one with the other. This feature of my invention is illustrated in the diagram, Fig. 12, where U designates the alternating generator, T and V the main-circuit wires or leads from the opposite terminals thereof, and W W the successive lamps or other energy-translating devices connected serially in the circuit. The coil A is provided with a series of terminal plates or binding-posts $q\ q'$, which are distinguished by numbers. These terminals $q\ q'$ are carried on the connection-board $k$, Fig. 1. The opposite ends of the coil are connected, respectively, to terminals numbered "60" and "740." At intermediate points the coil is tapped out by wires leading to the other successive terminals. For example, taking the end of the coil which is connected to terminal 60 as zero, and assuming the coil to have seven hundred and forty turns the terminal marked "125" may be connected at fifty-five turns, number "133" at one hundred and ten turns, and number "640" at six hundred and forty turns, while the remaining terminals $q'$ are connected at the number of turns corresponding with their numbers—namely, "660," "680," "700," "720," and "740," respectively. The connections on one side or toward one end of the coil are to provide for variations in voltage. Thus for any given frequency the lead T is to be connected with the terminal of the series $q$, which is numbered according to the frequency required. For example, for one hundred and twenty-five cycles it is connected to terminal number "125." Quite independently of the frequency the opposite lead V is connected into one or another of the series of terminals $q'$, according to the length of wire or number of turns required for any given voltage, as may be ascertained by calculation or experiment. If the regulator is required to be used for any different frequency, it is only necessary to change the lead T to the correspondingly-numbered terminal $q$ without necessarily changing the voltage connection. Conversely, if it is required to use the regulator with any different voltage it is only necessary to change the lead V to a different terminal $q'$ without necessarily making any change in the frequency connection. Of course any system of numbering or otherwise designating the successive terminals $q\ q'$ may be employed, as desired. This system of double adjustment enables any desired combination of connections to be made, so as to adapt the regulator to any condition that is liable to occur in practice. In my former patent there was only a single series of connections, one circuit-lead being connected permanently with one end of the coil, while my present invention provides, in effect, a double series of connections, affording a much greater range of adjustment and enabling one adjustment to be made without interfering with another.

The regulator set forth in my former patent with the addition of the improvements herein set forth has the advantages that it is readily adjustable to operate satisfactorily on any frequency. It can be adjusted for any ordinary variation in voltage. By a simple

adjustment of the levers it can be set to give a constant current through the full range of the apparatus or to give a gradually increasing or decreasing current with the load. This regulator may be connected in the circuit remote from the power-station, as it requires no extra wires running back to the point of supply.

The regulator works perfectly with arc-lamps or incandescent lamps or with arc and incandescent lamps in any proportion to its maximum capacity in series.

What I claim is—

1. In a current-regulator comprising a coil and a core one movable relatively to the other, the combination with a movable member thereof of a counterbalance therefor, and a differential connection between said member and counterbalance adapted in operation to vary the tendency of said movable member to separate from its complementary member so that the same shall increase progressively as the regulator departs from the position of maximum load, said connection being adapted for adjustment to alter the rate of separation for a given variation of the load.

2. In a current-regulator comprising a coil and a core one movable relatively to the other, the combination with a movable member thereof of a counterbalance therefor, a differential compensating lever adapted in operation to vary the tendency of said movable member to separate from its complementary member so that the same shall increase progressively as the regulator departs from the position of maximum load, and means for adjusting said lever to alter the rate of separation for a given variation of the load.

3. In a current-regulator comprising a coil and a core one movable relatively to the other, the combination with a movable member thereof of a counterbalance therefor, a differential lever between said member and counterbalance adapted in operation to vary the tendency of said movable member to separate from its complementary member so that the same shall increase progressively as the regulator departs from the position of maximum load, said lever being in two parts pivoted to each other to permit adjustment thereof to alter the rate of separation for a given variation of the load.

4. In a current-regulator comprising a coil and a core, one movable relatively to the other, the combination with a movable member thereof of a counterbalance therefor, a differential connection between said member and counterbalance adapted in operation to vary the tendency of said movable member to separate from its complementary member so that the same shall increase progressively as the regulator departs from the position of maximum load, said connection being adapted for adjustment to alter the rate of separation for a given variation of the load, and means for varying the normal positions of said members relatively to each other.

5. In a current-regulator comprising a coil and a core, one movable relatively to the other, the combination with a movable member thereof of a counterbalance therefor, a differential connection between said member and counterbalance adapted in operation to vary the tendency of said movable member to separate from its complementary member so that the same shall increase progressively as the regulator departs from the position of maximum load, said connection being adapted for adjustment to alter the rate of separation for a given variation of the load, and an adjustable supporting connection for said complementary member.

6. In a current-regulator comprising a coil and a core one movable relatively to the other, the combination with a movable member thereof of a counterbalance therefor, a differential compensating lever adapted in operation to vary the tendency of said movable member to separate from its complementary member so that the same shall increase progressively as the regulator departs from its position of maximum load, and said lever having an adjustable arm.

7. In a current-regulator, comprising a vertical coil and a core the one movable vertically relatively to the other, means attached to one of said parts and engaging the other for guiding the movable part to restrain it from swinging laterally and thereby prevent the core from coming into contact with the coil.

8. In a current-regulator, comprising a coil and a core one movable relatively to the other, the core having a leg extending within and a leg extending outside of the coil, and means projecting within the coil and engaging the core for guiding the movable member so that the core shall not come into contact with the coil.

9. In a current-regulator, in combination, a coil, a core, the one movable relatively to the other and a supporting member for the coil having ears projecting inward and forming guides for engaging the core.

10. In a current-regulator, in combination, a coil, a core, the one movable relatively to the other, and a support for the coil comprising cross-pieces *l l* having ears *l'* projecting within the coil.

11. In a current-regulator, in combination, a coil, a connection-board at the upper end thereof, and supporting-bolts holding up the coil attached to the connection-board at their upper ends and insulated at said point of connection.

12. In a current-regulator, in combination, a coil, a connection-board therefor, clamping members at the lower end of the coil having ears fitting inside of the coil, and supporting-

bolts connected at the bottom to said clamping members and at the top to said connection-board, said ears serving to guide the core.

13. In a current-regulator for maintaining a constant current on alternating-current circuits and including a coil and a core one movable relatively to the other, whereby to maintain a constant current, a series of terminals connected to suitable points of said coil to permit adjustment for different voltages, and a series of terminals connected to suitable points to permit adjustment for different frequencies.

14. In a current-regulator for maintaining a constant current on alternating-current circuits and including a coil and a core one movable relatively to the other, whereby to maintain a constant current, a series of terminals connected to suitable points toward one end of said coil to permit adjustment for different voltages, and a series of terminals connected to suitable points toward the other end of said coil to permit adjustment also for different frequencies.

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

JAMES J. WOOD.

Witnesses:
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D. C. DAVIS.