No. 720,305. PATENTED FEB. 10. 1903.

J. J. WOOD.

CURRENT REGULATOR.

APPLICATION FILED DEC. 14, 1901.

NO MODEL. 3 SHEETS—SHEET 1

FIG. 2.

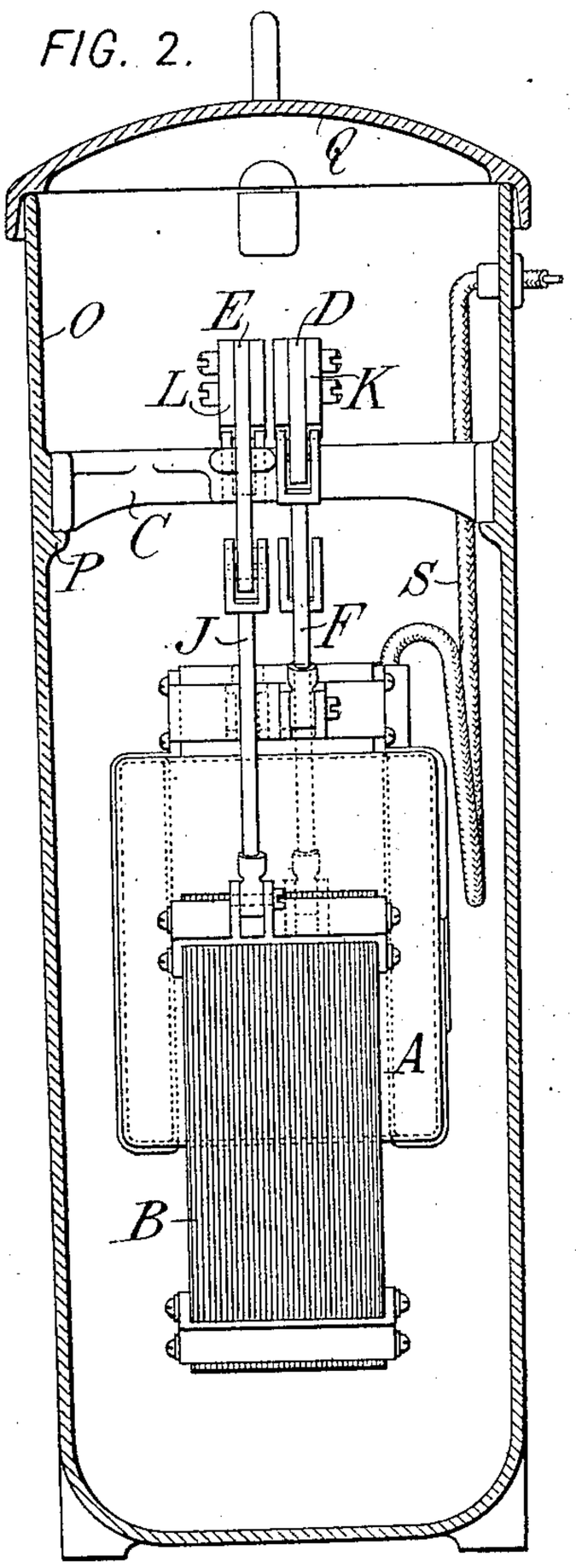


FIG. 1.

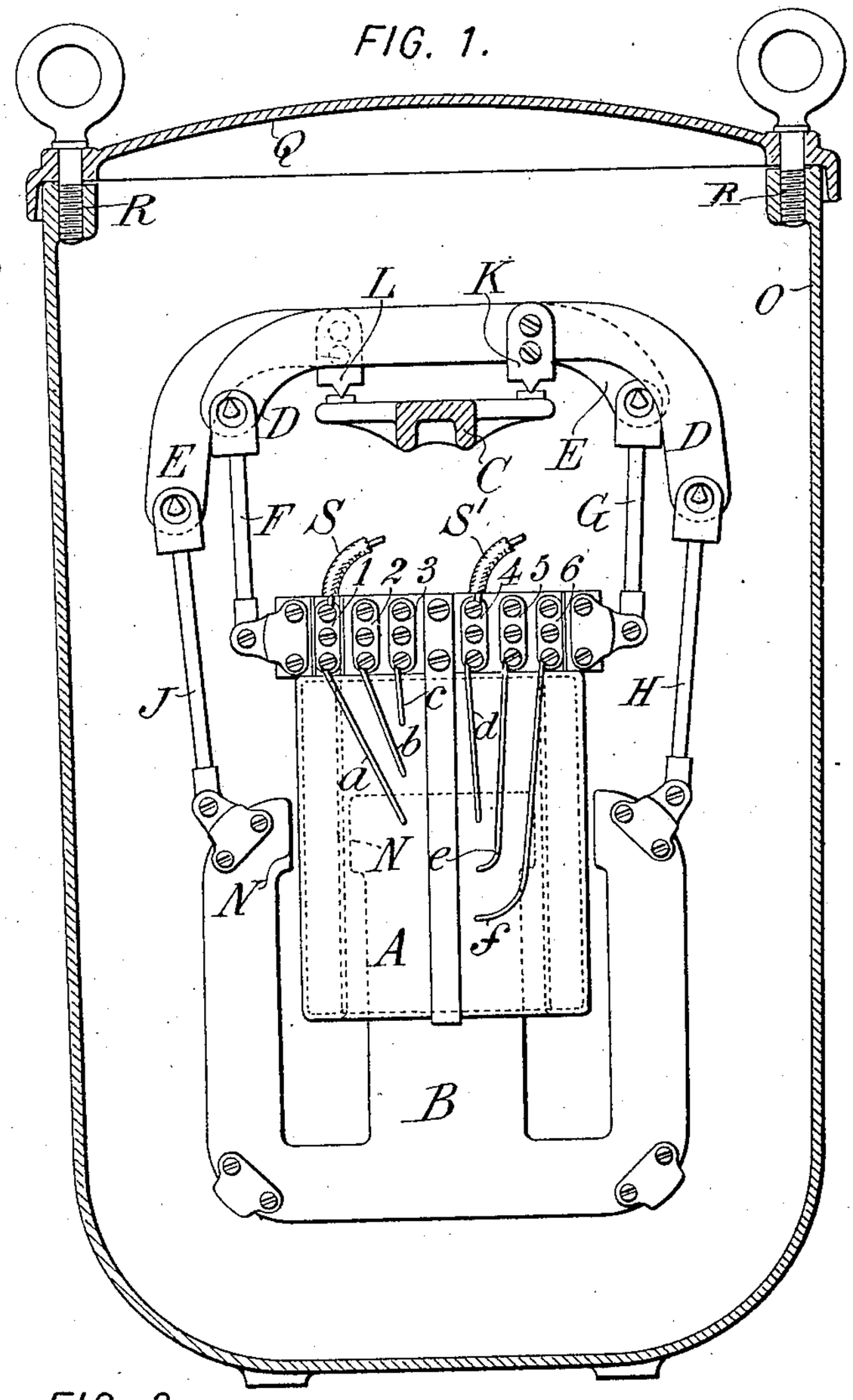
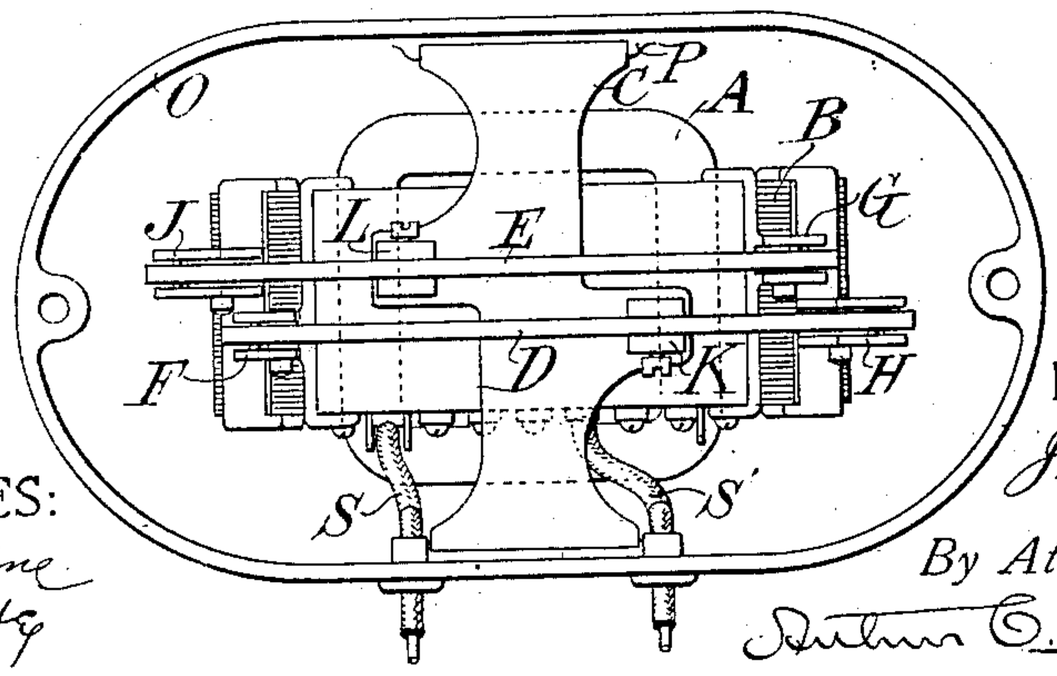


FIG. 3



WITNESSES:
Rene' Bruine
Fred Whitty

INVENTOR:
James J. Wood,
By Attorneys,
Arthur G. Brooks & Co

No. 720,305. PATENTED FEB. 10, 1903.

J. J. WOOD.

CURRENT REGULATOR.

APPLICATION FILED DEC. 14, 1901.

NO MODEL. 3 SHEETS—SHEET 2.

FIG. 4.

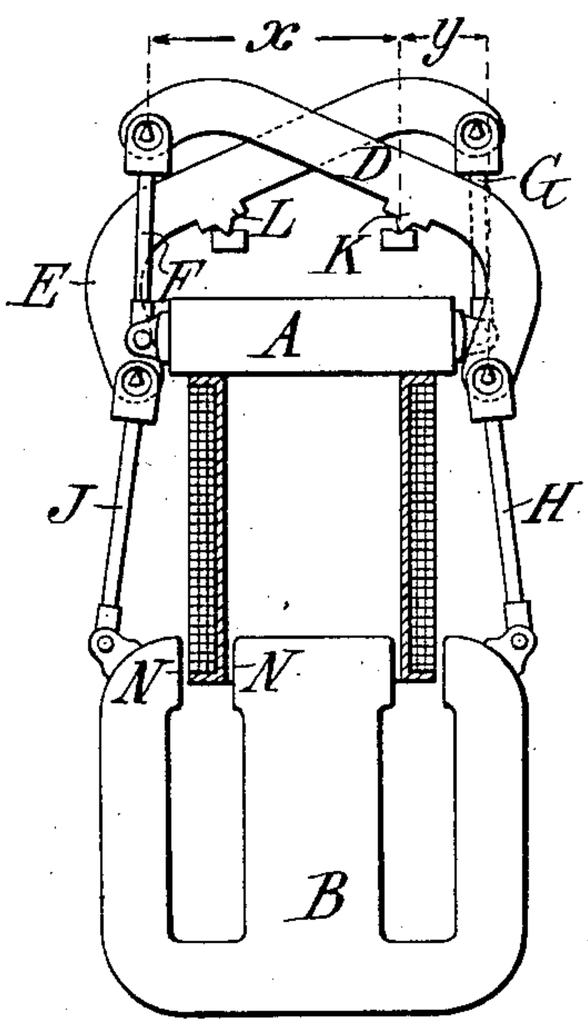


FIG. 5.

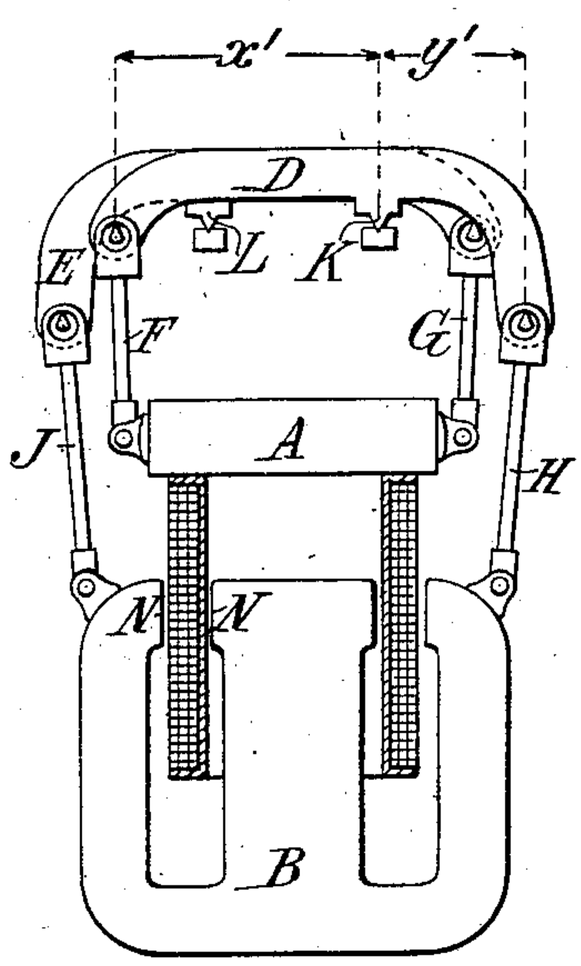


FIG. 6.

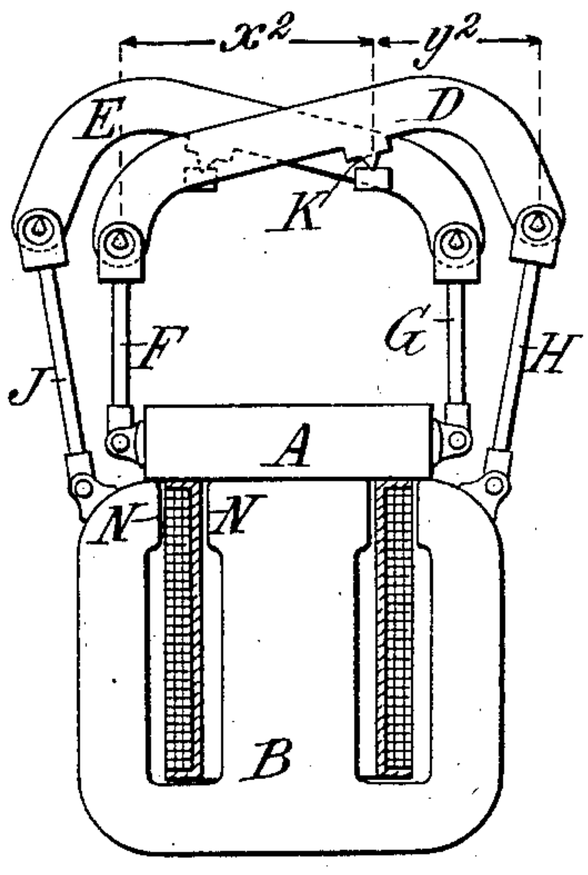
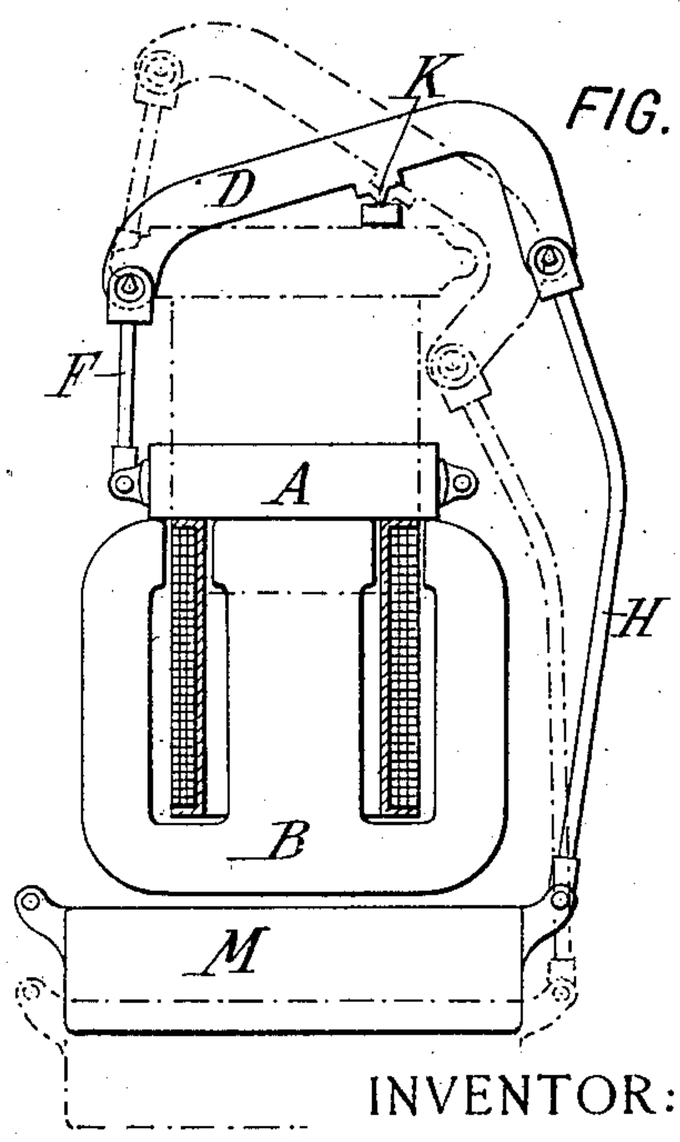


FIG. 7.



WITNESSES:
René Bruine
Fred White

INVENTOR:
James J. Wood,
By Attorneys,
Arthur G. Draper & Co.

No. 720,305. PATENTED FEB. 10, 1903.

J. J. WOOD.

CURRENT REGULATOR.

APPLICATION FILED DEC. 14, 1901.

NO MODEL. 3 SHEETS—SHEET 3.

FIG. 8.

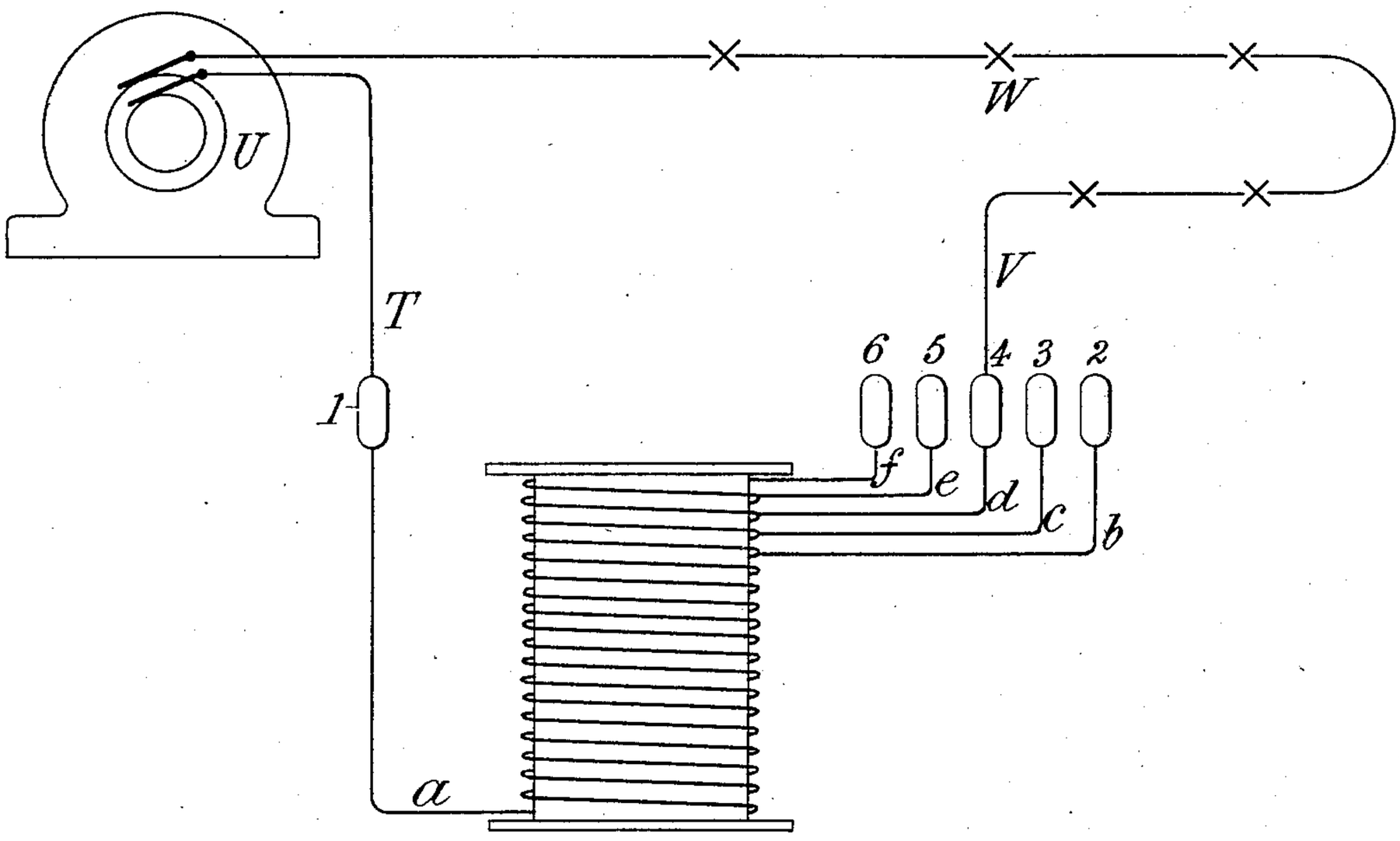
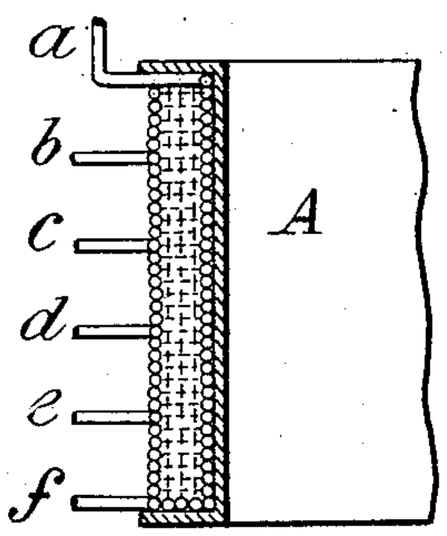


FIG. 9.



WITNESSES:

René Bruine

Thomas F. Wallace

INVENTOR:

James J. Wood

By Attorneys,

Dustin & Orrell Co.

UNITED STATES PATENT OFFICE.

JAMES J. WOOD, OF FORT WAYNE, INDIANA.

CURRENT-REGULATOR.

SPECIFICATION forming part of Letters Patent No. 720,305, dated February 10, 1903.

Application filed December 14, 1901. Serial No. 85,922. (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, State of Indiana, have invented certain new and useful Improvements in Current-Regulators, of which the following is a specification.

My invention aims to provide an improved current-regulator for maintaining a substantially constant current on an alternating-circuit such as that used for arc-lamps, and in which the regulator has less weight and is much more compact than those heretofore in use.

My invention aims to provide also an improvement in such regulators, whereby the operation is rendered more certain.

My invention aims also to provide an improvement in such regulators which avoids the necessity of the usual dash-pot for cushioning the shock of the movable parts when the current is cut of or changed.

My invention aims to provide also various improvements in detail, which are hereinafter referred to.

Referring to the accompanying drawings, illustrating embodiments of my invention, Figure 1 is a vertical section through the casing of one of my improved regulators, showing the same in face view. Fig. 2 is a similar figure showing the regulator in edge view. Fig. 3 is a plan of the regulator in its casing, the cover of the latter being removed. Figs. 4, 5, and 6 are diagrammatic illustrations showing the operation of the regulator. Fig. 7 is a diagrammatic illustration of another embodiment of the invention. Fig. 8 is a diagram of an entire circuit.. Fig. 9 is a section of the coil.

My current-regulator includes a reactance device—such, for example, as the usual core—with a coil surrounding the same and movable longitudinally thereof, 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 of 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, it being only necessary that one shall be movable relatively to the other. It is common to have the core fixed and the coil movable and to counterbalance the coil by a lever which carries a weight at its opposite end. According to my invention I provide a counterbalance which is arranged to move in the same vertical line with such movable part and which may be a weight and may be connected by a lever connection with such movable part. The counterbalance is preferably arranged so as to evenly balance the movable member of the reactance device when the current is cut off. For compactness I preferably use a pair of levers connected to the movable part at opposite sides thereof and preferably extending side by side across the regulator, so that they pass each other and have their counterbalanced ends adjacent to the side of the movable member opposite to that to which they are attached. In the simplest embodiment of my invention and most compact the coil and the core are arranged to counterbalance each other.

Referring now to the accompanying drawings, A indicates a coil, and B a core, each being of any well-known or suitable construction, such as that shown. In Figs. 1 to 6 the coil and core are both movable, being supported from a fixed support C. A lever connection is provided between the two, so that when there is no current they balance each other, with the coil in its uppermost position relatively to the core, as shown in Fig. 4, and so that as the current is introduced and increases the tendency of the coil to move down upon the core is properly counteracted by the weight of the core, so that the amount of choking to which the current is subjected is just sufficient to maintain the current constant, whatever may be the load. Under maximum load the position of the parts is practically that shown in Fig. 4, the downward attraction of the core being very slight and approximately such as to bring its lower edge even with the lower edge of the pole-faces of the core. Preferably a pair of levers D and E is used, connected, respectively, to opposite sides of the coil A, as by means of links F and G, and each extending across the coil and connected at its opposite or counterbalance end to the core B, as by means of links H and J, respectively. The fulcrums K and L of the respective levers are carried upon the support C at such a distance from the

ends of the levers as shall be in proper proportion to the weights of the coil and core. The levers may be adjusted in the fulcrum-blocks by means of their fastening-screws to vary the lengths of the respective lever-arms. The position of the ends of each lever relatively to the fulcrum is such 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. As shown in Figs. 4, 5, and 6, the leverage of the core increases continuously from the position of minimum to that of maximum current. In these figures, x, x', and x^2 indicate the effective lengths of the lever-arm from which the coil is suspended, which varies but slightly for the minimum, middle, and maximum, while y, y', and y^2 indicate the effective lengths of the lever-arm from which the core is suspended, which increases continuously from the first to the last position. The two levers are arranged symmetrically with respect to each other and balance each other, so as to give a direct vertical movement of both the coil and the core.

A considerable degree of compactness and simplicity as compared with prior constructions may be obtained by applying the idea of my invention in other ways than in that shown in Figs. 1 to 6. A regulator in which the counterbalance is separate from the members of the reactance device and which embodies my broad invention is illustrated in Fig. 7, the lever E being omitted for the sake of clearness. In this case I have supposed the coil A movable and the core B fixed. The counterbalance instead of being the core is a separate weight M. I have illustrated the same sort of lever connection to this counterweight as to the core B in the previous figures; but it is understood that the connection also may be varied without departure from the invention and may consist of any means for transmitting movement from the movable member to the counterbalance. Instead of a weight M immediately below the reactance device I may arrange a weight or weights in many other positions in which the center of gravity moves in substantially the same vertical line with the center of the movable parts of the reactance device.

A feature of my invention which is of considerable value is the forming of the core with approaching poles, which reduce and localize the air-gap through which the coil moves, and which thus concentrate the magnetic flux and render the operation more uniform. Preferably the core B is W-shaped, as shown, and the poles of the center and outer legs approach each other, as shown at N. I provide also a very convenient arrangement for supporting the operative parts of the regulator in a casing, whereby they are suspended from the side walls, preferably near the top thereof, so as to be convenient of access for insertion or removal and so that the entire regulator may be lifted bodily out of the casing. For this purpose I preferably arrange the support C so that it extends across between the side walls of the casing O, which latter carries sockets P for receiving the ends of said support. As explained above, the levers which connect the movable member of the regulator with its counterbalance are fulcrumed upon the support C, so that as the support is lifted out of the surrounding casing the movable member and its counterweight, or, in the form illustrated, all the operative parts, are lifted out of the casing. A cover Q may be attached to the casing by means of screws R, the heads of which are adapted to be attached to any suitable suspending means.

Though I have described with great particularity of detail apparatus embodying my invention, yet it is to be understood that my invention is not limited to the particular embodiments shown and described. Various modifications of the same in the details and in the arrangement and combination of the parts are possible to those skilled in the art without departure from the invention.

The combination of the vertically-moving coil and core and the differential compensating levers results in a structure which in operation instantly adapts itself to a change of current by a "dead-beat" movement without over compensation or oscillation, so that a dash-pot or other steadying means is unnecessary. The utilization of the core itself as a counterweight is an important feature of my invention, contributing greatly to the compactness of the apparatus and reducing the total weight. The position of the support relatively to the other parts and the curve in the levers D and E permits of their ends swinging in so close to the vertical line through the supports—as shown, for example, in Fig. 4—as to produce an enormous change in the ratio of the effective lengths of the lever-arms of the weight and coil, respectively, from one extreme position to the other. It is only by such an enormous change that the counterbalance can cause a truly constant current under all loads. In prior devices employing straight-armed levers it is impossible to obtain the same change of ratio between the extreme positions, and the regulation is correspondingly imperfect. This effect is also assisted by the short lever-arm, which I am enabled to use by reason of the heaviness of the core and by the arrangement of this arm to turn through an arc, such that its point of connection with the core swings from nearly under the fulcrum to nearly level therewith.

The coil A may be variously connected in the circuit. I have shown it as provided with flexible cables S S′ passing out through the side of the casing. To admit of adjustment to varying conditions, the coil may be divided into sections connected by wires a b c, &c.,

to terminals 1 2 3, &c., Fig. 1, to one or other of which the cables may be connected. This matter will be understood best from the diagram of the entire circuit in Fig. 8 and the section of the coil in Fig. 9. According to the manner of winding shown in Fig. 9 the wire *a* is wound in any desired number of layers around the spool and terminates finally in the wire *f*. From the outer layer may be taken connecting-wires *b*, *c*, *d*, and *e* at any desired intervals. In actual use, for example, I may provide six hundred turns between the wire *a* and the wire *b* and twenty-five additional turns between each of the succeeding wires. The object of thus looping out the coil at several different points is to adjust the same for an increased or diminished voltage, current, or frequency above or below normal—that is to say, if for any reason the voltage of the circuit should be increased or the frequency reduced, then in order to maintain the current constant at a predetermined amount it will be necessary to cut in a greater number of coils, or, if the voltage is reduced or the frequency increased, to cut out coils. This is an especially advantageous feature of my improved automatic regulator, since it enables the current to be regulated without introducing wasteful impedance under maximum load, and hence without reducing the power factor. In the circuit of Fig. 8 one of the leads, T, coming directly from the generator U, is connected to the zero-terminal 1, while the other lead, V, coming from the generator through a number of lamps W, is connected to the terminal 4, so as to adapt the apparatus for use with a voltage intermediate between the maximum and the minimum for which the device is designed.

I claim as my invention—

1. In a current-regulator comprising a coil and a core movable relatively to each other, the combination with a movable member of said regulator, of a counterbalance therefor arranged to move in substantially the same vertical line therewith, and a differential connection between said movable member and said 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.

2. In a current-regulator, the combination of a coil and a core movable in a vertical line relatively to each other, and a differential connection between them so that each receives a part of the total movement which at the position of maximum load is substantially in inverse proportion to its weight, the tendency of said parts to separate by reason of their weight and manner of connection being increased progressively as the regulator departs from the position of maximum load.

3. In a current-regulator, the combination of a coil and a core movable in a vertical line relatively to each other, and connected to each other by differential compensating levers adapted in operation to vary the tendency of said parts to separate by reason of their weight so that the same shall increase progressively as the regulator departs from the position of maximum load.

4. In a current-regulator comprising a coil and a core movable relatively to each other, the combination with a movable member of said regulator, of a counterbalance therefor, and a pair of differential compensating levers connected to said movable member at opposite sides thereof and to said counterbalance, and adapted in operation to vary the tendency of said parts to separate by reason of their weight so that the same shall increase progressively as the regulator departs from the position of maximum load.

5. In a current-regulator comprising a coil and a core movable relatively to each other, the combination with a movable member of said regulator, of a counterbalance therefor, and a pair of levers connected to said movable member at opposite sides thereof, extending side by side across said movable member, and connected at their other ends to said counterbalance.

6. In a current-regulator, the combination of a coil, a core, and a pair of levers each of which is connected at one end to one side of said coil and at its other end to the opposite side of said core.

7. In a current-regulator, the combination of a coil and a core, the one movable relatively to the other, said core having approaching poles whereby to reduce and localize the air-gap.

8. In a current-regulator, the combination of a coil and a core, the one movable relatively to the other, said core having approaching poles whereby to reduce and localize the air-gap, and a differential compensating means adapted to exert upon the movable member a separating force which progressively increases as the coil and core are attracted together.

9. In a current-regulator, the combination of a coil and a core differentially counterbalancing each other, the core being arranged below the coil so as to be separated therefrom by a downward movement.

10. In a current-regulator comprising a coil and a core movable relatively to each other, the combination with a movable member of said regulator, of a counterbalance therefor arranged to move in substantially the same vertical line with said movable member, and a lever connecting said movable member and said counterbalance, said lever having its counterbalance-arm curved downwardly.

11. In combination with a circuit carrying alternating-current-translating devices in series, a current-regulator for maintaining a constant current comprising in combination a coil and a core movable relatively to each

other whereby to maintain a constant current, a series of terminals, and separate connections from said terminals to different points of said coil whereby to adjust the number of turns of the coil in said circuit to vary the current therein.

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

JAMES J. WOOD.

Witnesses:
A. L. HADLEY,
T. W. BEHAN.