S. R. BERGMAN.

REGULATING DEVICE FOR ALTERNATING CURRENT CIRCUITS.

APPLICATION FILED JUNE 14, 1905.

916,983. **Patented Apr. 6, 1909.**

2 SHEETS—SHEET 1.

Fig. 1.

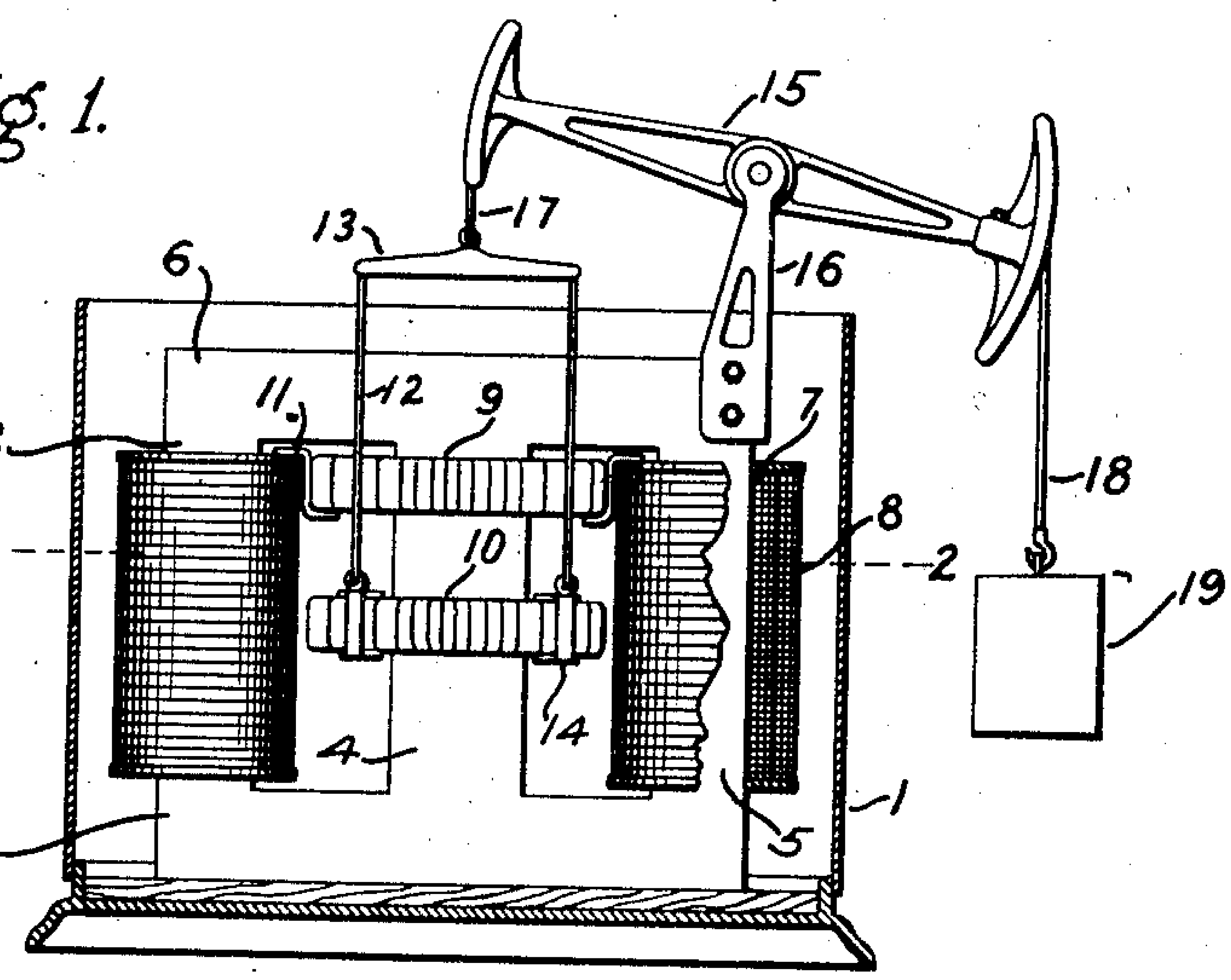
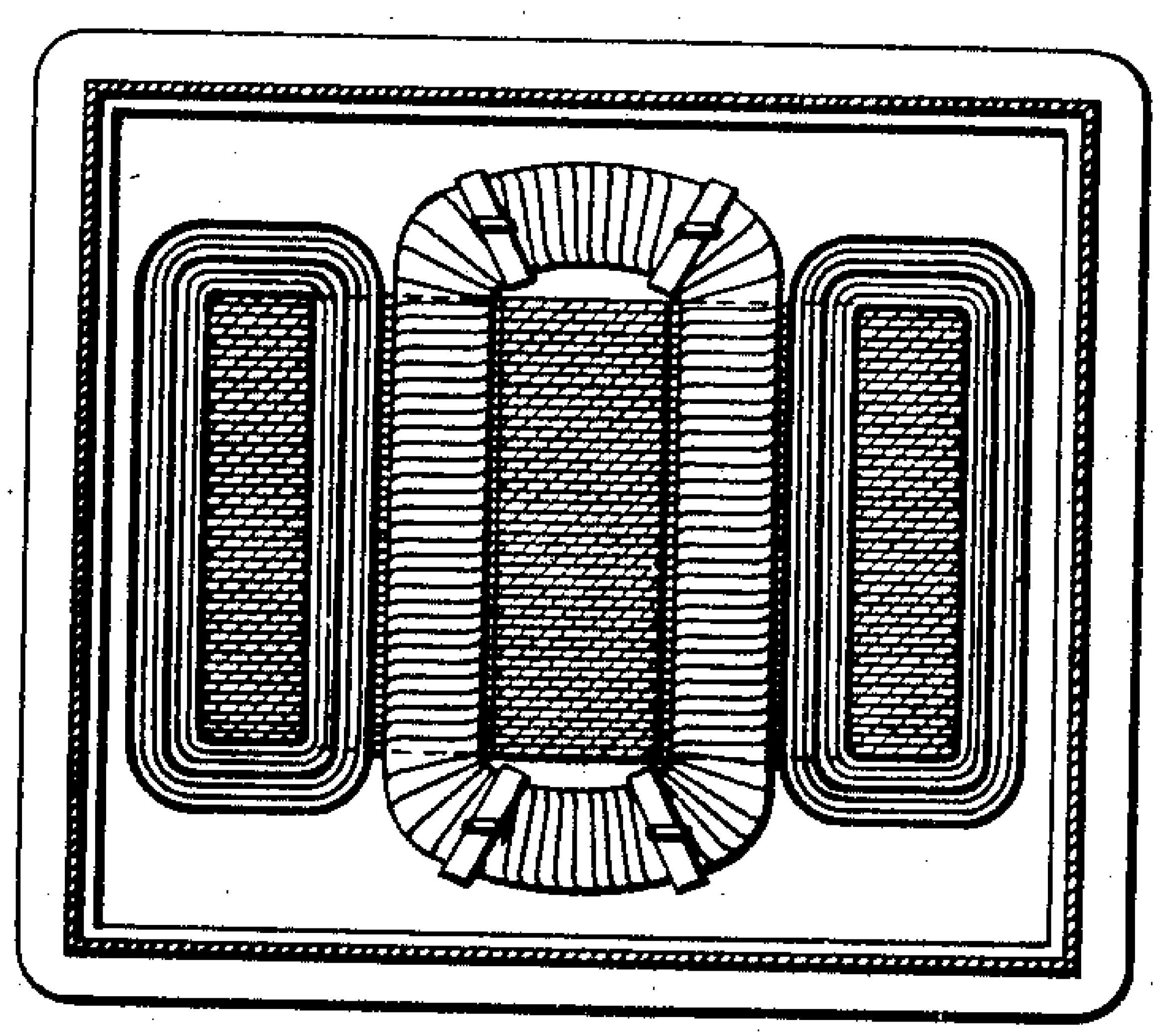


Fig. 2.



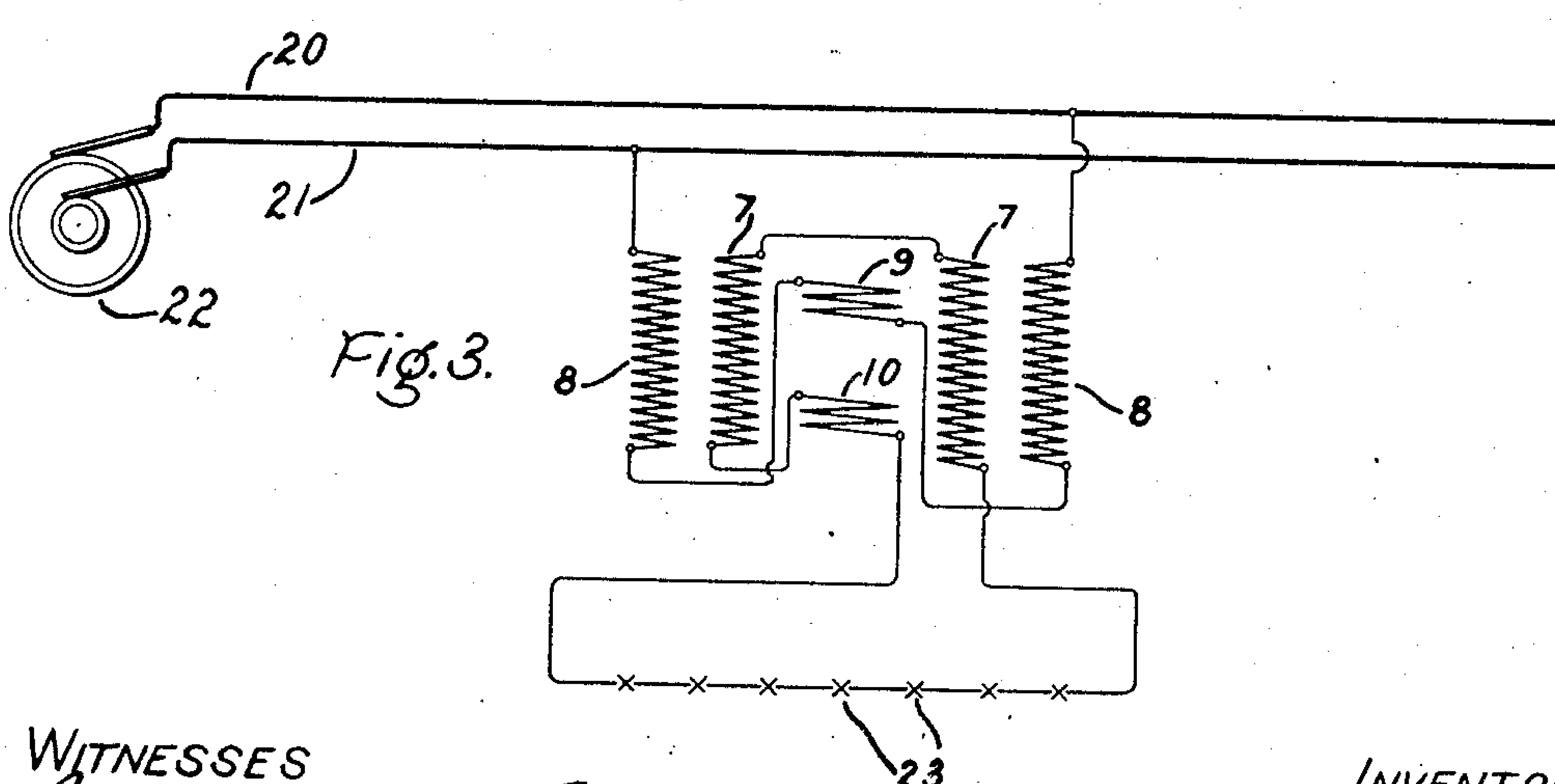


Fig. 3.

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2 SHEETS—SHEET 2.

Fig. 5.

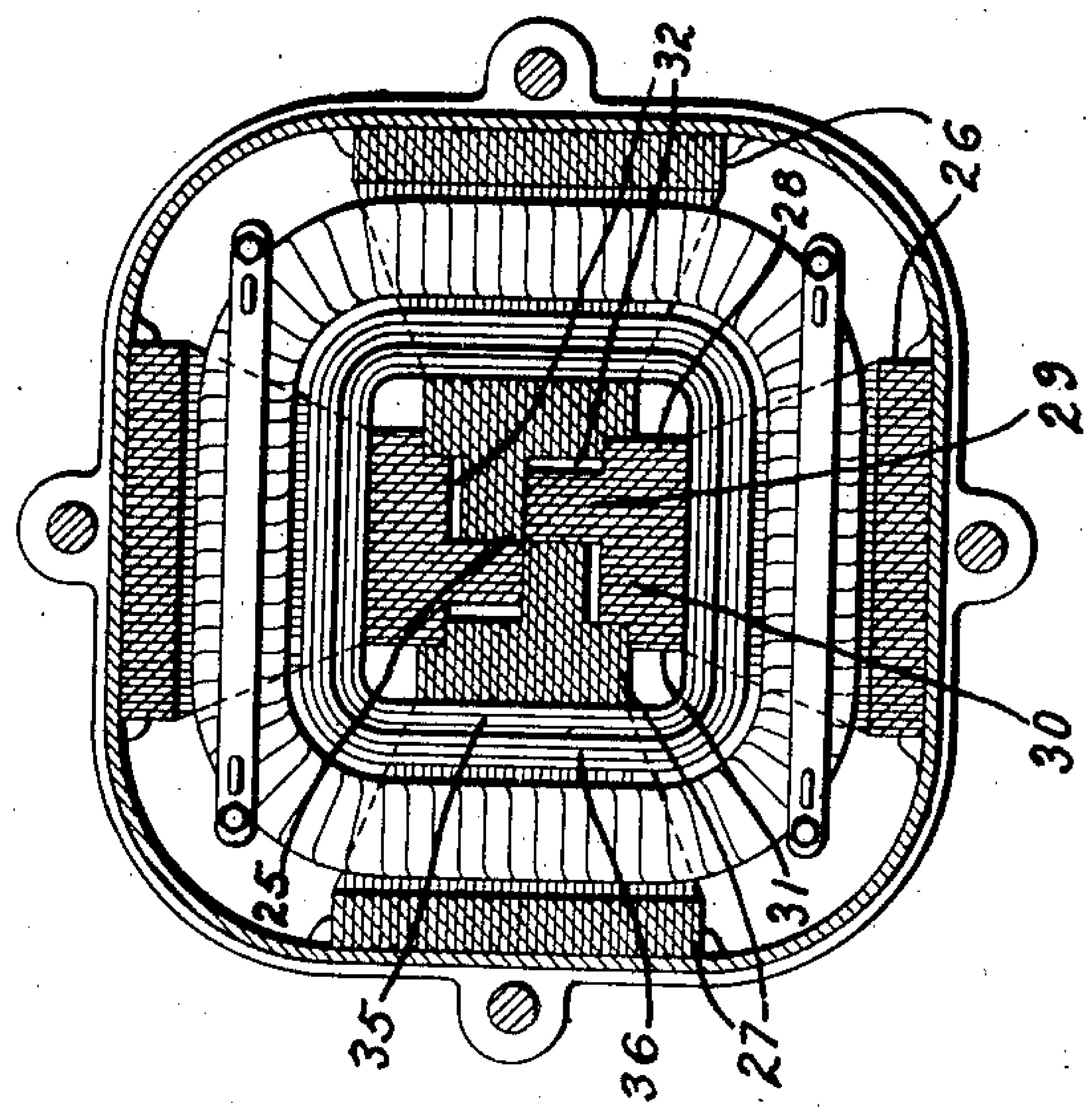
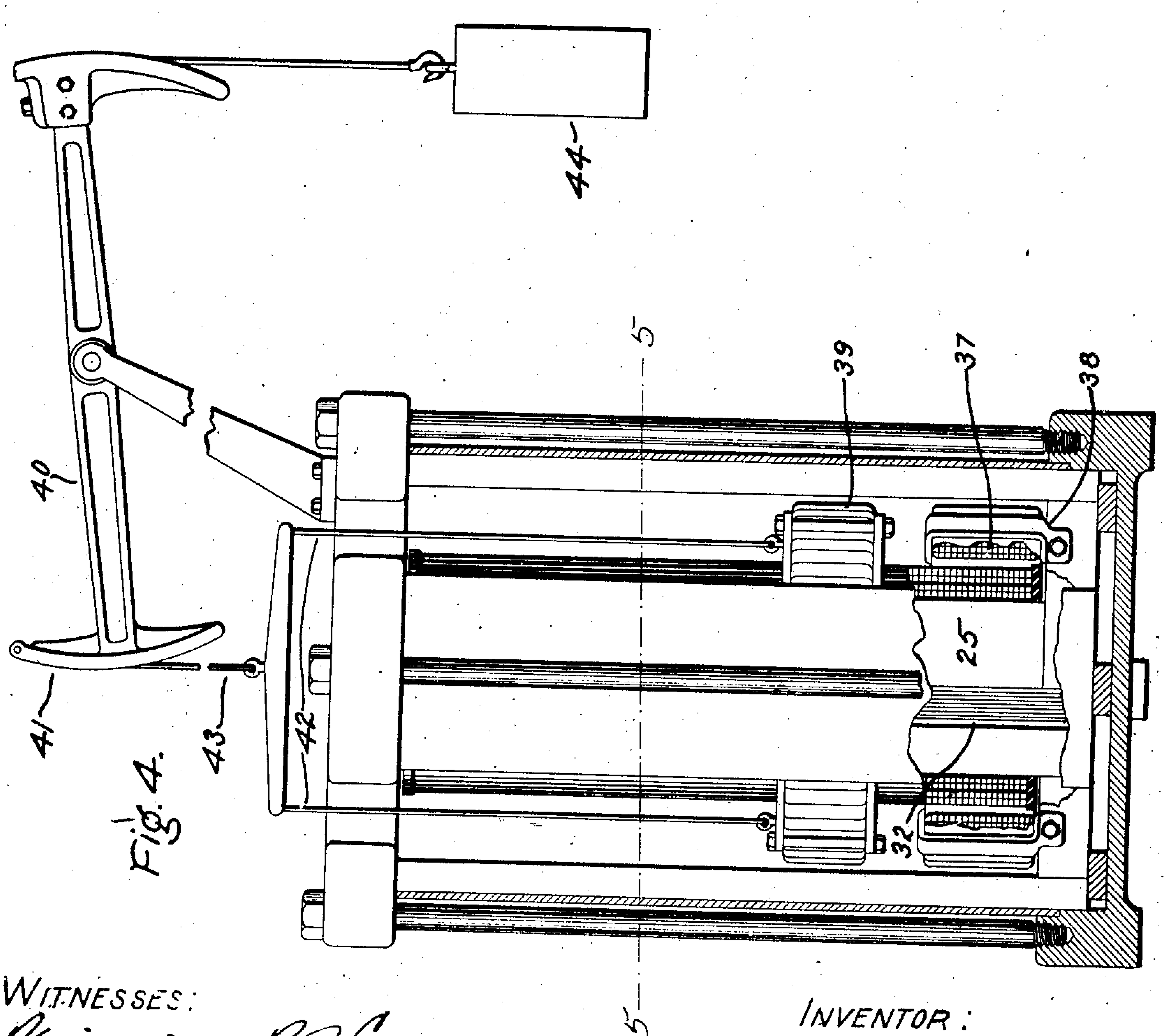


Fig. 4.



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UNITED STATES PATENT OFFICE.

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REGULATING DEVICE FOR ALTERNATING-CURRENT CIRCUITS.

No. 916,983. Specification of Letters Patent. Patented April 6, 1909.

Application filed June 14, 1905. Serial No. 265,202.

To all whom it may concern:

Be it known that I, SVEN R. BERGMAN, a subject of the King of Sweden and Norway, residing at Lynn, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Regulating Devices for Alternating-Current Circuits, of which the following is a specification.

My present invention relates to means for regulating the current in a consumption circuit supplied with alternating current, and particularly to means for obtaining a substantially constant flow of current in a consumption circuit from a constant potential source of alternating current.

In carrying out my invention I have employed a primary winding and a secondary winding in fixed relation to each other forming in effect a constant potential transformer, and in conjunction with such windings and in inductive relation therewith, other relatively movable primary and secondary windings connected in series with the first-mentioned primary and secondary windings respectively. I arrange the two sets of primary and secondary windings in conjunction with a common magnetic circuit.

By the arrangement which I employ I am enabled to obtain a more efficient disposition of material than has heretofore been possible and hence to increase the regulation obtainable with apparatus of a given weight and size.

My invention comprises many novel features of construction and arrangement, all of which are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of my invention, however, reference may be had to the accompanying drawings and descriptive matter in which I have illustrated and described forms in which my invention may be embodied.

Of the drawings, Figure 1 is an elevation with parts broken away and in section of one form of my invention; Fig. 2 is a section on the line 2 2 of Fig. 1; Fig. 3 is a diagram showing the circuit connections of the form shown in Figs. 1 and 2; Fig. 4 is a view similar to Fig. 1 showing a modified form of my invention; and Fig. 5 is a section on the line 5 5 of Fig. 4.

Referring first to the construction shown in Figs. 1 to 3 inclusive, 1 represents a tank or receptacle for receiving the apparatus, and if desirable a bath of a cooling and insulating liquid such as oil. The core 2 which rests in the tank or receptacle 1 comprises three vertical legs 3, 4 and 5, and top and bottom yoke members or connecting portions 6. It will of course be understood that the core 2 may be composed of laminæ of magnetic material insulated from each other but connected together in the ordinary manner. About each of the outer legs 3 and 5 are placed an inner secondary winding 7 and an outer primary winding 8. The windings 7 and 8 it will be observed are in the form of comparatively long coils distributed along practically the entire length of the legs which they surround. Two coils or windings 9 and 10 which are short in comparison with the coils 7 and 8 are placed about the middle leg 4 of the core. The upper short coil 9 is supported in fixed relation to the core near the upper end of the leg 4 in any suitable manner as by means of hooks or arms 11 which engage the upper end of the coils on the outer legs. The lower short coil 10 is movably supported by means of cords or rods 12 which are connected at their upper ends to a cross-head 13 and at their lower ends to clips 14 secured to the coil 10. A lever 15 pivoted in any suitable manner to supports 16 which may be secured to the core 2, has one end secured to the cross-head 13 by a flexible member 17. The other end of the lever 15 carries by a flexible cord 18 a counterweight 19 arranged to overbalance the weight of the coil 10. The ends of the lever 15 may be made arc shaped in the usual manner so that the oscillation of the lever about its pivoted point of support will not change the lines of movement of the coil 10 and counterweight 19.

Referring to the diagram shown in Fig. 3, 20 and 21 represent conductors, connected to some source of alternating current such as a generator 22, between which a substantially constant potential difference is maintained. The long coils 8 and the short coil 9 forming the primary winding of the transformer are connected in series with each other between the lines 20 and 21. The long coils 7 and the short coil 10 forming the secondary winding are connected in series with each other and in series with translating devices such as a number of arc lamps 23.

It will of course be understood that each coil 8 tends to magnetize the central leg 4 of the core in the same direction.

The device described above operates substantially in the same manner as a constant potential transformer in series with a constant-current transformer. When the apparatus is taking care of the maximum load, that is, when the maximum number of arc lamps 23 are connected in series with the coils 7 and 10, the coil 10 approaches the coil 9 for reasons well understood by those skilled in the art. The coils 7 and 10 then generate electromotive force tending to drive current through the lamps 23. As the load is decreased, that is, some of the arc lamps are cut out, the coil 10 gradually moves away from coil 9. When all the lamps are cut out and the windings 7 and 10 are short-circuited upon each other, the coil 10 reaches the lower limit of movement in which the mutual induction between the coils 9 and 10 is at a minimum. In this condition of the apparatus the coils 10 and 7 generate only enough current to drive the ordinary current through the coils and the short-circuiting connection. At the same time the coils 8 act practically as short-circuited conductors, and the voltage on the primary short coil 9 is practically that between the lines 20 and 21. The electromotive force generated at full load by the coil 10 is to the electromotive force generated in the coil 7 substantially in the ratio of the number of turns in the coil 10 to the number of turns of the coil 7. In order to obtain satisfactory results it is necessary to properly proportion the windings with respect to each other and to the core. In general I employ windings so proportioned that the above noted ratio is substantially unity or rather is about 55 to 45.

It will of course be obvious that one of the outer legs of the core shown in Figs. 1 and 2, and the windings thereon could be dispensed with without affecting in any way the theory of action described above though it might be desirable to change the ratio of the windings somewhat.

With the arrangement shown practically the same number of ampere turns are necessary as in the ordinary case in which there is one stationary coil and one movable coil. By reason of the fact however, that practically half the turns may be in the long coils, the bulk of the short coils is reduced. As a result the depth of the short coils measured transversely to the axis of the coils, can be less than in the old form. On this account the mean length of turn in the short coils is decreased. Moreover, this decrease in the depth of the short coils allows of a better circulation of the cooling fluid along them. It will be obvious that the mean length of turn of the long coils is much less than would be the case if the same number of turns were added to the short coils. Moreover the use of the long coils improves the cooling both by increasing the cooling surface and by improving its disposition. A further advantage of the use of the long coils arises from the fact that adjacent turns in each coil require less insulation between them than would be the case if the turns were embodied in the short coils. The decrease in bulk of the short coils is also advantageous in that the circulation of the air between the coils is facilitated. It will thus be seen that use of the long coils decreases the copper necessary in a transformer with a given number of ampere turns in its windings, and also allows of better ventilation.

In the construction shown in Figs. 4 and 5 the core comprises a central leg 25 and four outer legs 26 similar to each other and symmetrically disposed about the central leg. Each outer leg and a quarter of the central leg is composed of units 27, each of the units, which are identical in construction, in the construction being formed of four bundles 28, 29, 30 and 31 which are secured together. The width of the portions of the laminæ forming a part of the central leg are not all the same, though all the laminæ in each bundle are the same width. As shown, the inner portion of the laminæ in the bundle 29 is twice as wide as the corresponding portions of the bundles 28 and 30, and the width of the inner leg of the laminæ in the bundle 31 is half that of the corresponding portion of the bundles 28 and 30. The thickness of the bundle 29 is less than the width of the portions of the laminæ in the bundle 29 which overlap the bundles 28 and 30. As is clearly shown in the drawings in the construction disclosed each unit engages two adjacent units, thus forming a central interlocked core in which are formed ventilating ducts 32 rectangular in cross-section which extend longitudinally through the interlocked core. In this form of my invention two cylindrical distributed windings 35 and 36 surround the central leg of the core. A short coil 37 which also surrounds the central leg is secured at its lower end by supports 38. A movable short coil 39 is supported from one end of a lever 40 through a cross-head 41, rods 42, and flexible member 43. This portion of the construction is substantially identical with that shown in Fig. 1, a counterweight 44 being secured to the opposite end of the lever 40. In this case, however, the counterweight does not overbalance the weight of the movable coil. The short coil 39 and the cylindrical coil 36 are connected in series with each other and in the consumption circuit, these windings forming the secondary windings of the device. The short coil 37 and the cylindrical coil 35 are connected in series with each other between the conductors supplying alternating current of constant potential. The diagram of connections in Fig. 3 applies equally well to this method of construction by omitting one pair of windings, and substituting for the numerals 7, 8, 9 and 10, numerals 36, 35, 37 and 39, sespectively. The operation of this form of my invention is practically the same in theory as that of the form of my invention shown in Figs. 1 to 3 inclusive, and possesses the advantages herein before pointed out. In this form of my invention I prefer to have the number of turns in each long coil in the ratio of about 45 to 55 to the number of turns in the short coil in series with it. The core construction shown in Figs. 4 and 5 gives a very efficient disposition of material and for many purposes I regard it as superior to that shown in Figs. 1 to 3.

What I claim as new and desire to secure by Letters Patent of the United States, is,

1. In a constant-current reactive device, two long coils and two short coils in inductive relation with each other, said long coils being in fixed relation to each other and said short coils being movable with respect to each other, one of said long coils and one of said short coils being connected into a source of constant potential, and the other of said coils being connected in series with each other to supply current to translating devices.

2. In a constant-current reactive device, a magnetic core, two long coils surrounding said core and fixed with respect thereto, a pair of short coils also surrounding said core, one of said short coils being stationary and the other of said short coils being movable with respect to said core, one of said short coils and one of said long coils being connected in series with each other into a constant potential circuit, and the other of said coils being connected in series with each other into a constant-current circuit.

3. In combination, a magnetic core, a winding in inductive relation with said core comprising a portion in fixed relation thereto, and another portion axially movable with respect to said core, and a second winding fixed with respect to said core in inductive relation to both portions of the first winding.

4. In combination, a magnetic core, a winding comprising a distributed portion surrounding said core and in fixed relation thereto, and a second portion surrounding the first and movable with respect thereto, said second portion being short as compared with said distributed portion, and a second winding fixed on said core in inductive relation to both portions.

5. In a constant-current transformer, a core formed of magnetic material, an axially elongated coil surrounding said core, an axially short coil also surrounding said core, said coils being connected in series, and a second winding consisting of an axially elongated coil surrounding said core and a movable axially short coil surrounding said core, said windings being connected in series in inductive relation to the first winding.

6. In a constant-current transformer, a core of magnetic material, and a primary winding and a secondary winding therefor, said secondary winding comprising an axially elongated coil and an axially short coil, said short coil being axially movable.

7. A constant-current transformer comprising a core portion of magnetic material, two long tubular coils placed one within the other and surrounding said core portion, a short stationary coil surrounding said long coil and core portion, and fixed at one end thereof, said short coil being connected in series with one of said long coils, a second short coil connected in series with the other of said long coils and also surrounding said core and said long coils, said second short coil being axially movable with respect to said core and said long coil.

8. In an inductive apparatus, a core portion of material formed of interlocked units composed of bundles of laminated magnetic material, the bundles being of different widths, with one bundle in each unit projecting by the other bundles in the unit toward the center of the core, the width of the projecting portion being unequal to its thickness whereby ventilating ducts extending longitudinally through the core portion are formed.

In witness whereof, I have hereunto set my hand this tenth day of June, 1905.

SVEN R. BERGMAN.

Witnesses:

JOHN A. McMANUS, Jr.,

HENRY O. WESTENDARP.