(No Model.)

C. P. STEINMETZ.

REGULATOR FOR ALTERNATING CURRENTS.

No. 548,400. Patented Oct. 22, 1895.

FIG. 1.

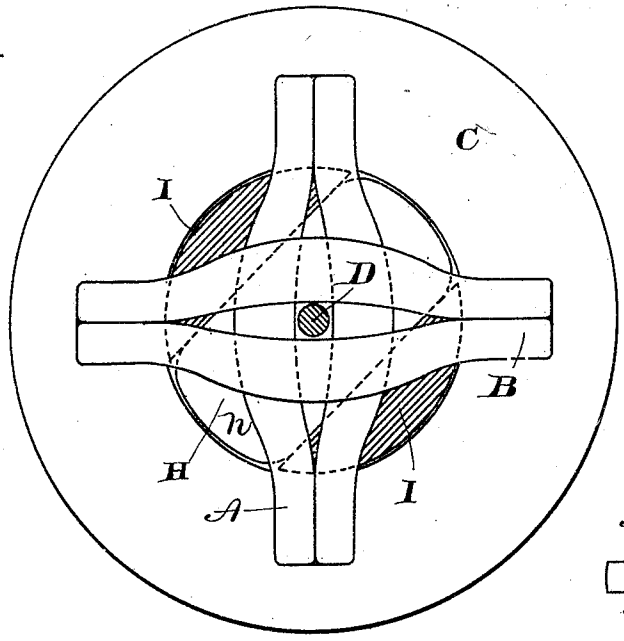


FIG. 4.

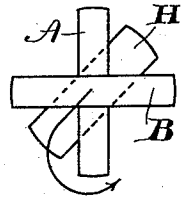


FIG. 2.

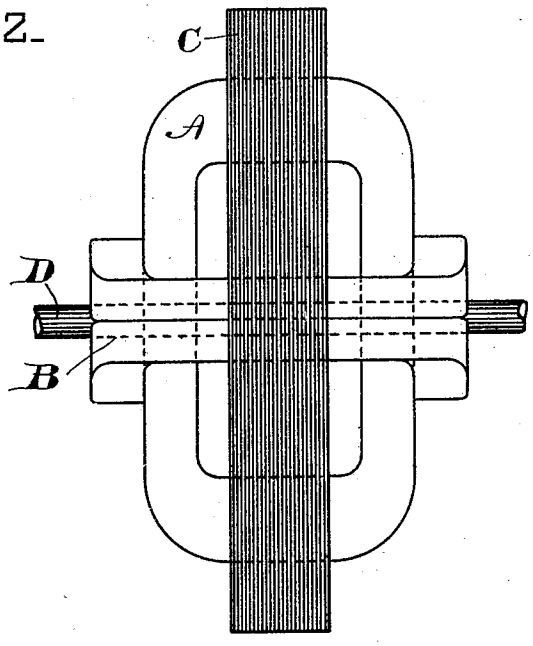


FIG. 5.

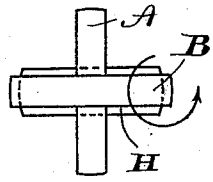


FIG. 6.

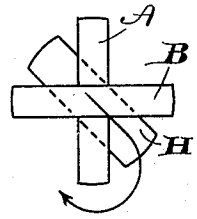
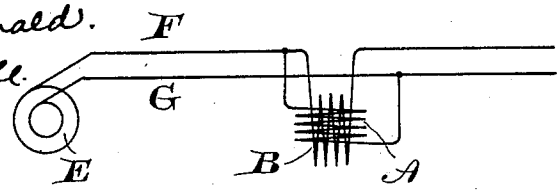


FIG. 3.



WITNESSES.

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by

Geo. R. Blodgett.

Atty.

UNITED STATES PATENT OFFICE.

CHARLES P. STEINMETZ, OF SCHENECTADY, NEW YORK, ASSIGNOR TO THE GENERAL ELECTRIC COMPANY, OF NEW YORK.

REGULATOR FOR ALTERNATING CURRENTS.

SPECIFICATION forming part of Letters Patent No. 548,400, dated October 22, 1895.

Application filed April 18, 1895. Serial No. 546,185. (No model.)

To all whom it may concern:

Be it known that I, CHARLES P. STEINMETZ, a subject of the Emperor of Germany, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Regulators for Alternating Currents, of which the following is a specification.

My invention relates to alternating-current systems of distribution, and has for its object to provide a means of regulating the potential in parts of such systems, and particularly in the feeders, by means simple and effective, yet admitting of variations of potential either up or down from that of the main generator. For the purposes set forth I employ a coil in series with the main circuit or feeder and a second coil in shunt thereto. Hereinafter I call the series coil the "secondary" and the coil in shunt the "primary." The primary coil is preferably wound with a considerable number of turns of comparatively fine wire and the secondary of fewer turns of a coarser wire. The mechanical construction is somewhat similar to that of the well-known induction-motor, in that I use a closed magnetic structure or ring of laminated iron, in the interior face of which the coils are received. Within the coils and surrounded by them I place a revoluble iron armature, which I may call a "magnetic bridge," by revolving which I may alter the magnetic circuits of the apparatus without altering the position of the coils, and thus may effect the changes of potential as desired. To prevent leakage of magnetic lines of force, or, as it is sometimes called, "stray-field," in which the lines do not cut both coils, I use a magnetic shield of copper or other non-magnetic metal, although the apparatus may be designed for successful operation without this precaution. It is, however, preferably employed.

In another application, made by Albert H. Armstrong and myself, Serial No. 538,630, filed February 16, 1895, is shown apparatus for effecting similar objects, and in that application the means employed consisted also of coils in shunt and in series, as herein pointed out; but in that application the magnetic structure is stationary and the coils are movable relatively to each other.

The accompanying drawings show an embodiment of my invention, Figure 1 being a side elevation of the essential parts of the apparatus; Fig. 2, an end elevation; Fig. 3, a diagram of the circuits; and Figs. 4, 5, and 6 being explanatory diagrams, showing the conditions of operation.

In Figs. 1 and 2 C is a structure of laminated iron. A is the primary coil composed, as already pointed out, of a number of turns of comparatively fine wire and coupled in shunt across the mains. Arranged at an angle of ninety degrees to the primary is the secondary coil B in series with the mains. Upon a shaft D is mounted a "shuttle," (as I prefer to call it) H of laminated iron, forming a magnetic bridge, which is the movable element of the magnetic circuit. Upon each side of the shuttle are copper plates I I, so that the whole forms substantially a cylinder occupying the otherwise vacant space in the laminated-iron structure C.

In Fig. 3 the circuits of the apparatus are represented, the coil A being shown in shunt to the mains F, G from the generator E, and the coil B being in series with the main F.

Referring now to Figs. 4, 5, and 6, I illustrate the operation of the apparatus. In these figures the rectangle H represents the shuttle or movable portion of the magnetic structure, and the primary and secondary coils are lettered A B, as in the mechanical figures. The directions of the curved arrows represent the direction of the magnetic lines of force, or, as it is commonly called, the "magnetic flux."

In Fig. 4, which corresponds to the position of the apparatus illustrated in Fig. 1, the direction of the magnetic lines is such as to assist the electromotive force in the coil B, the primary coil A setting up alternations of magneto-motive force in the magnetic structure, which, by the position of the movable element H, are so directed as to assist the coil B or generate in it electromotive force in addition to that already existing. In Fig. 5, however, the shuttle coincides in direction with one of the coils, and the magnetic flux therefore coincides in the two coils with their axes, so that no effect is produced by the apparatus, the electromotive force between the mains being neither raised nor lowered. In

Fig. 6, however, the movable element H is at a right angle to its former position, and the effect of the secondary coil B is reversed, magnetic lines cutting it in the opposite direction and setting up in it a counter electromotive force tending to cut down the effect of that coil and diminish the potential in the circuit. In connection with these figures and with Fig. 1 the office of the copper plates or bands upon the laminated shuttle or movable magnetic element H will be readily understood. The current generated in these copper plates tends to set up a field of force which, in accordance with well-known principles, acts to "beat back" or deflect the magnetic lines tending to pass through the plates, and thus, referring to Fig. 1, the circuit would be from one end of the shuttle H (for instance, the upper end) around through the laminated structure C, passing outside of the coils B to the lower end of the coil A, returning into the other end *h* of the movable magnetic element, the copper in the lower part of the movable element acting to prevent the lines passing in their circuit between the coils B and A and compelling them to make a complete circuit.

Although illustrated herein with reference particularly to a single-phase alternating circuit, it is manifest that by ordinary modifications within the scope of the electrical engineer I may apply my device to circuits of other numbers of phases, or I may embody it in a structure having more than the two poles illustrated. Its proportions may be varied within reasonable limits to obtain any effect desired, and all such modifications or changes I aim to embrace in the claims, which include in their scope any structure in which by changing the path of the magnetic lines of force between the series and the shunt coils (the coils being preferably stationary) to correspond to varying conditions of running, and thus causing more or less of them to cut the series coil in either one direction or the other, the electromotive force between the mains is raised or lowered from that usually maintained by the generator.

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

1. The method of regulating the electromotive force supplied to an alternating current system of distribution, which consists in varying the path of the magnetic lines of force passing between stationary coils in inductive relation, part of the coils in series in the main circuit, the remainder in shunt thereto, thereby causing more or less of the lines to cut the series coil in one or the other direction as desired, thus developing an electro-motive force therein either assisting or counteracting the main potential.

2. A feeder regulator for an alternating current system of distribution, comprising a secondary coil in series in the mains, a primary coil in shunt thereto, the coils being stationary and arranged at an angle of ninety degrees, and a magnetic structure surrounding the coils and provided with a rotatable member adapted to vary the path of the lines of force and thereby the inductive effect of one coil upon the other.

3. A feeder regulator for an alternating current system of distribution, composed of two stationary coils arranged at an angle to each other, a laminated iron magnetic structure furnishing a path for the lines of force between the coils, and a movable magnetic member arranged to vary the path of the lines of force, as set forth.

4. A regulator for an alternating current system of distribution, comprising a plurality of coils in inductive relation, part in series in the main circuit, part in shunt thereto, a magnetic structure surrounding the coils, and a movable magnetic member inclosed by the coils and adapted to vary the path of the lines of force and thus the inductive effect of the coils; the movable magnetic member being composed of laminated iron occupying a part of the opening between the coils and a non-magnetic shield of good electric conductivity occupying substantially the remainder of the opening.

5. A regulator for an alternating current system of distribution, comprising a plurality of coils in inductive relation, part in series in the main circuit, part in shunt thereto, a magnetic structure surrounding the coils, and a movable magnetic member inclosed by the coils and adapted to vary the path of the lines of force and thus the inductive effect of the coils; the movable magnetic member being composed of laminated iron occupying a part of the opening between the coils and a non-magnetic shield attached to and moving with the iron occupying substantially the remainder of the opening.

6. An alternating current apparatus, comprising a magnetic structure carrying coils in inductive relation, part in series with the mains, and part in shunt thereto and an element or bridge forming part of the magnetic circuit and movable relatively to the coils, the bridge varying by its changes of position the magnetic flux between the coils in direction and amount, and thereby regulating the electro-motive force maintained in the induced coil between maximum in one direction and maximum in the other direction, as set forth.

In witness whereof I have hereunto set my hand this 16th day of April, 1895.

CHARLES P. STEINMETZ.

Witnesses:

B. B. HULL,

A. F. MACDONALD.