No. 895,914. PATENTED AUG. 11, 1908.

M. O. TROY.

VARIABLE VOLTAGE TRANSFORMER.

APPLICATION FILED DEC. 22, 1905.

3 SHEETS—SHEET 1.

Fig. 1.

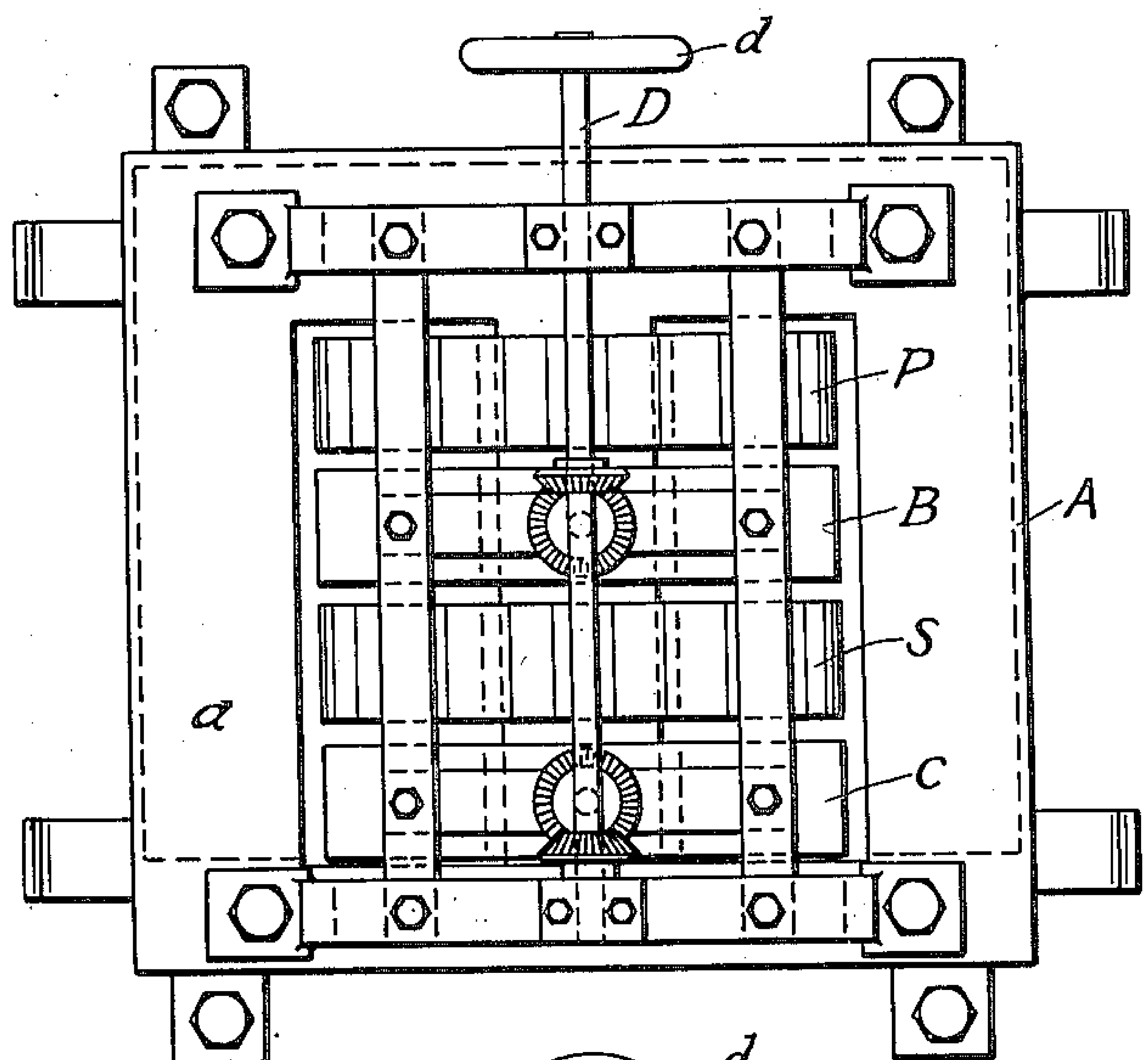
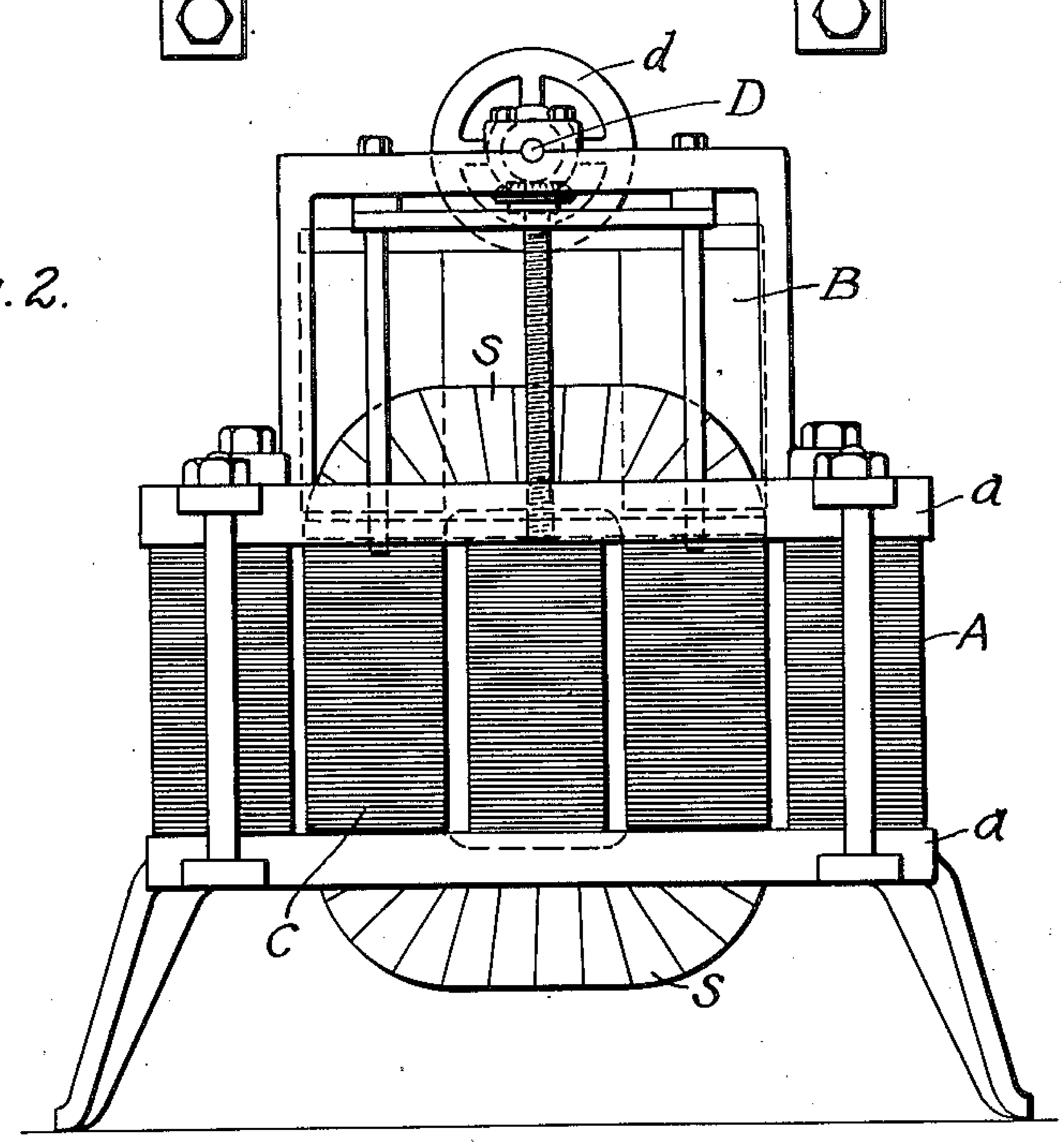


Fig. 2.



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3 SHEETS—SHEET 2.

Fig. 3.

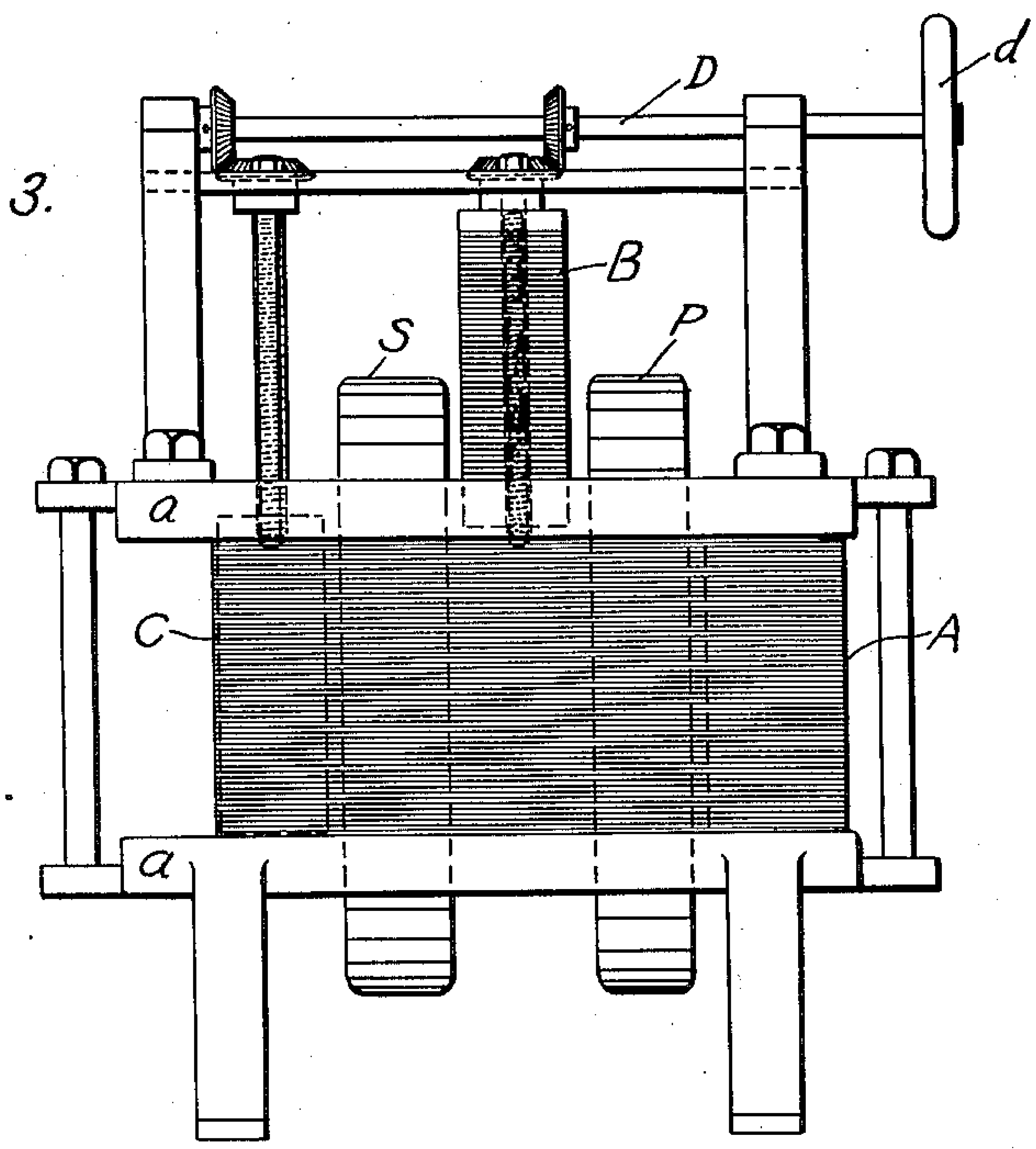
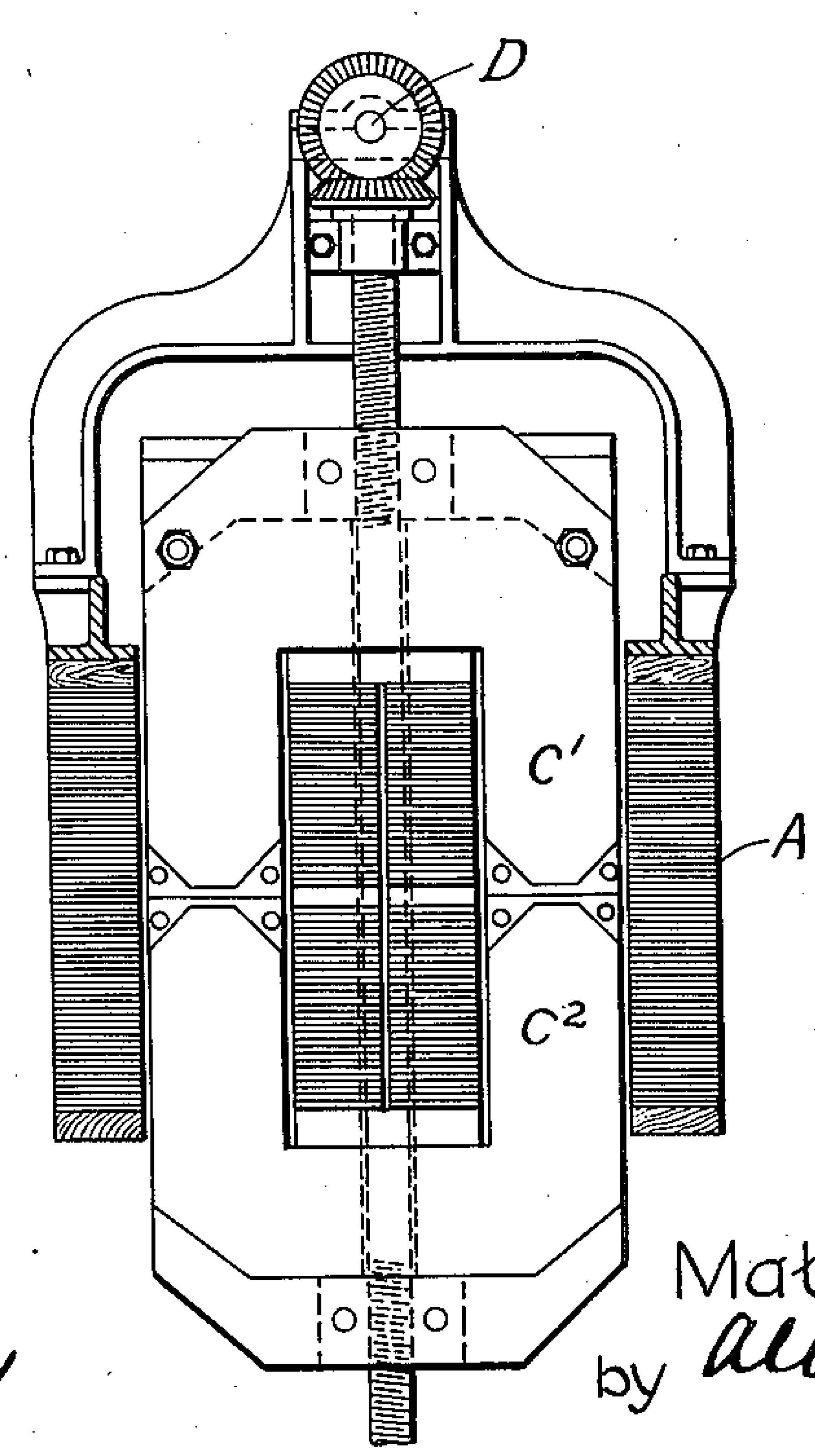


Fig. 4.



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3 SHEETS—SHEET 3.

Fig. 5.

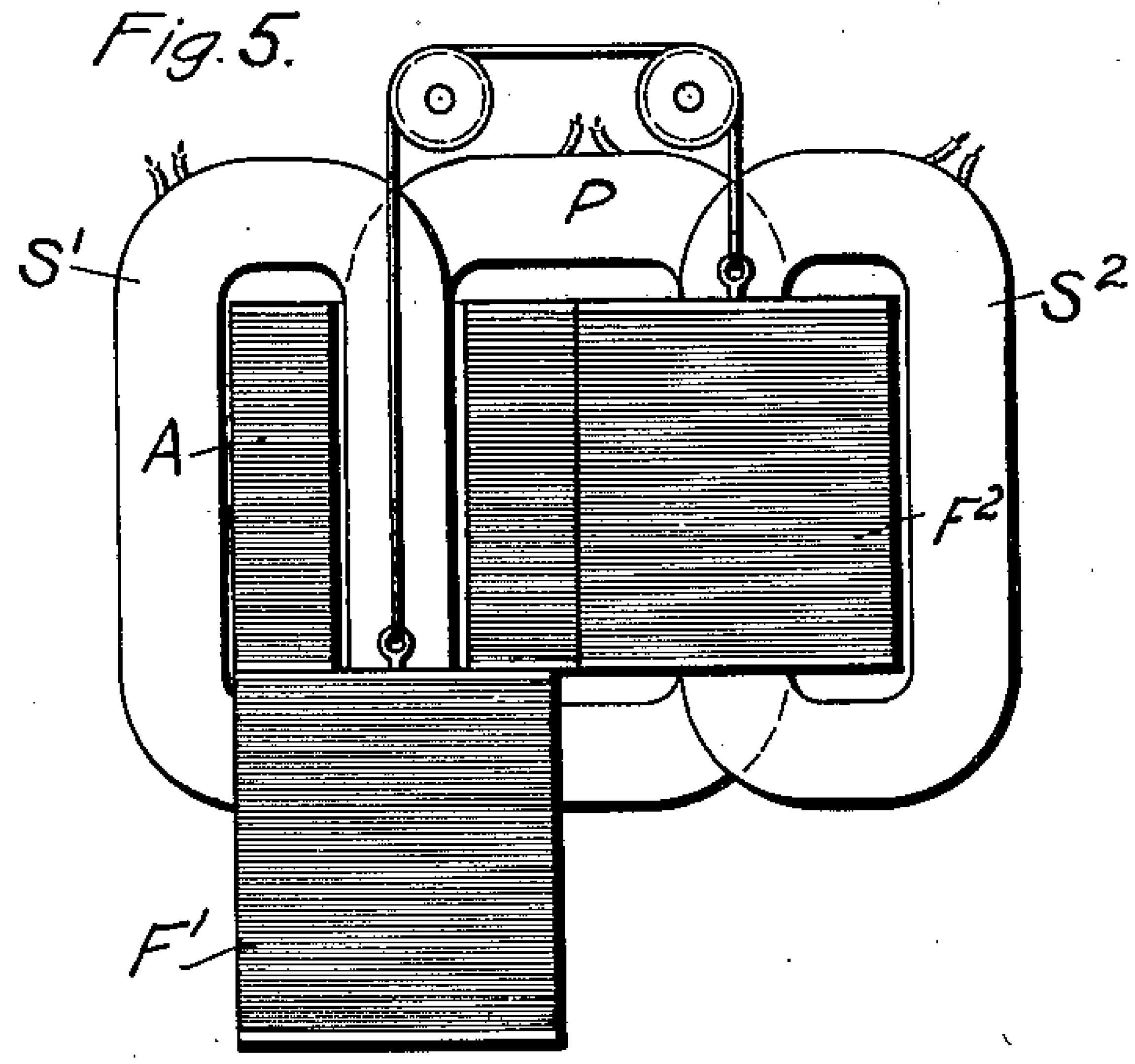


Fig. 6.

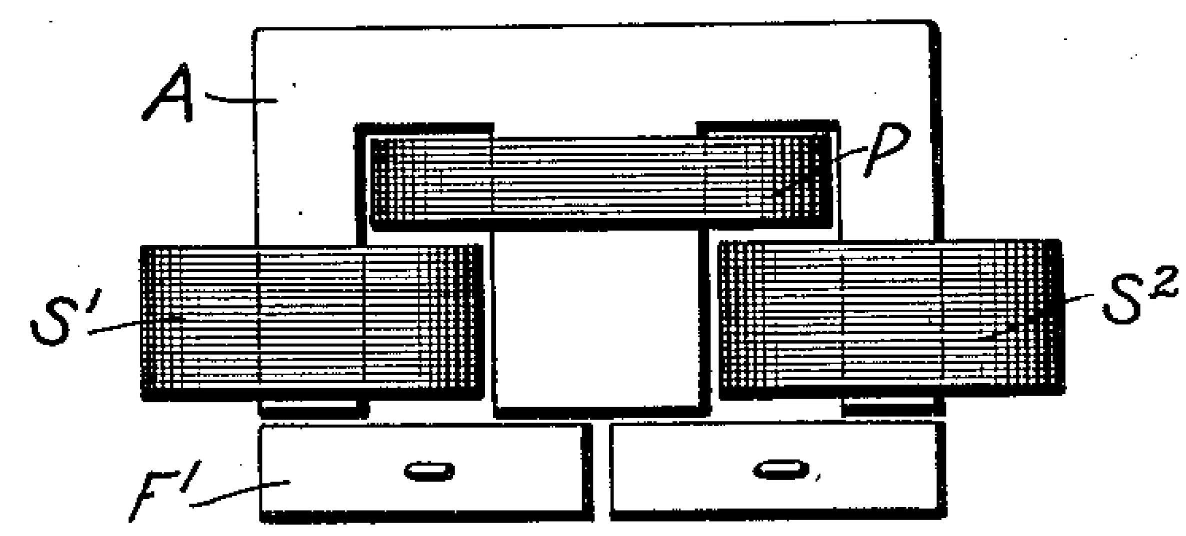


Fig. 7.

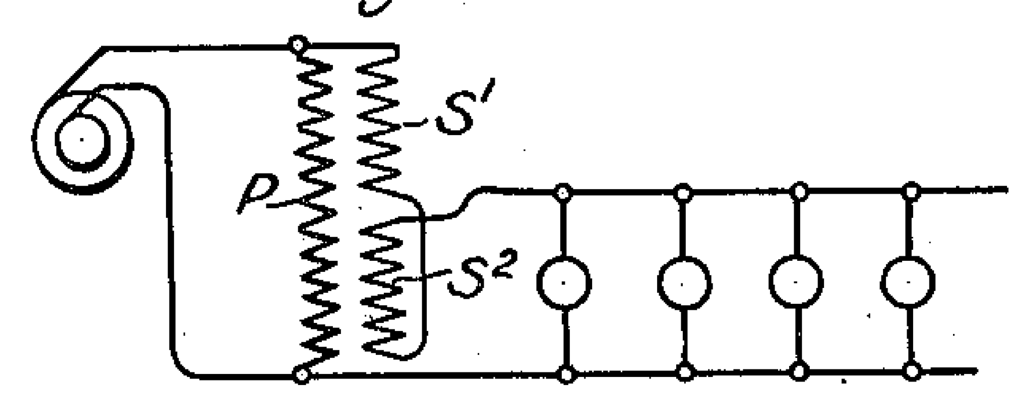


Fig. 9.

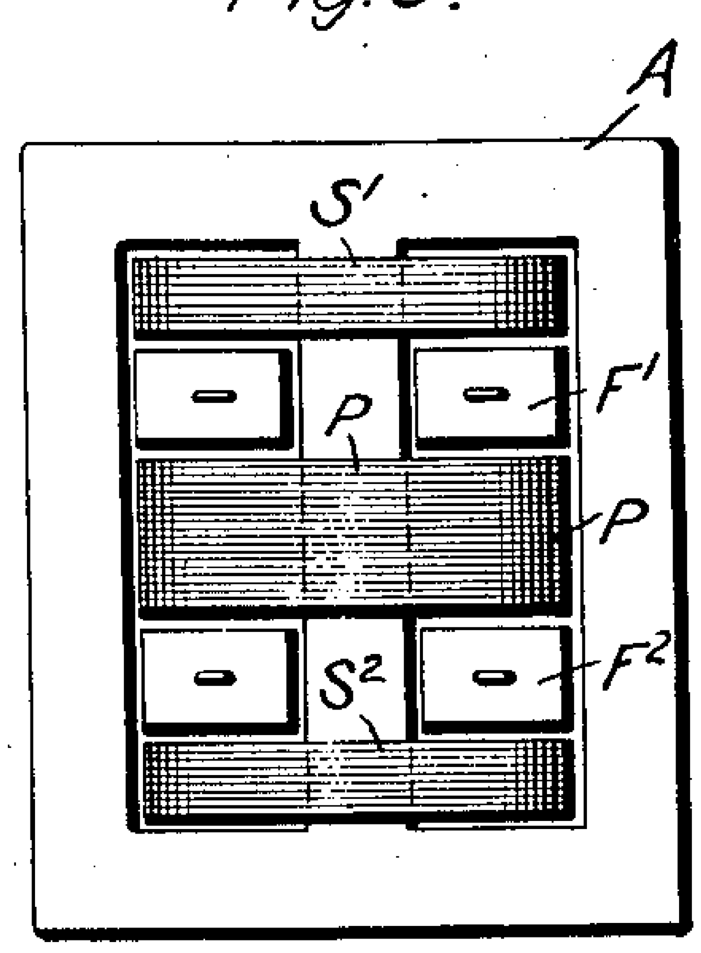


Fig. 8.

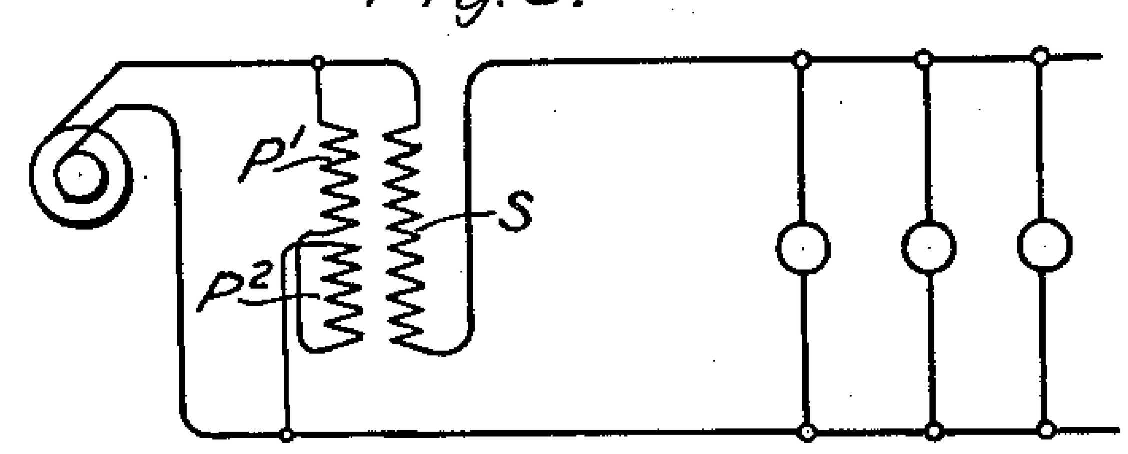
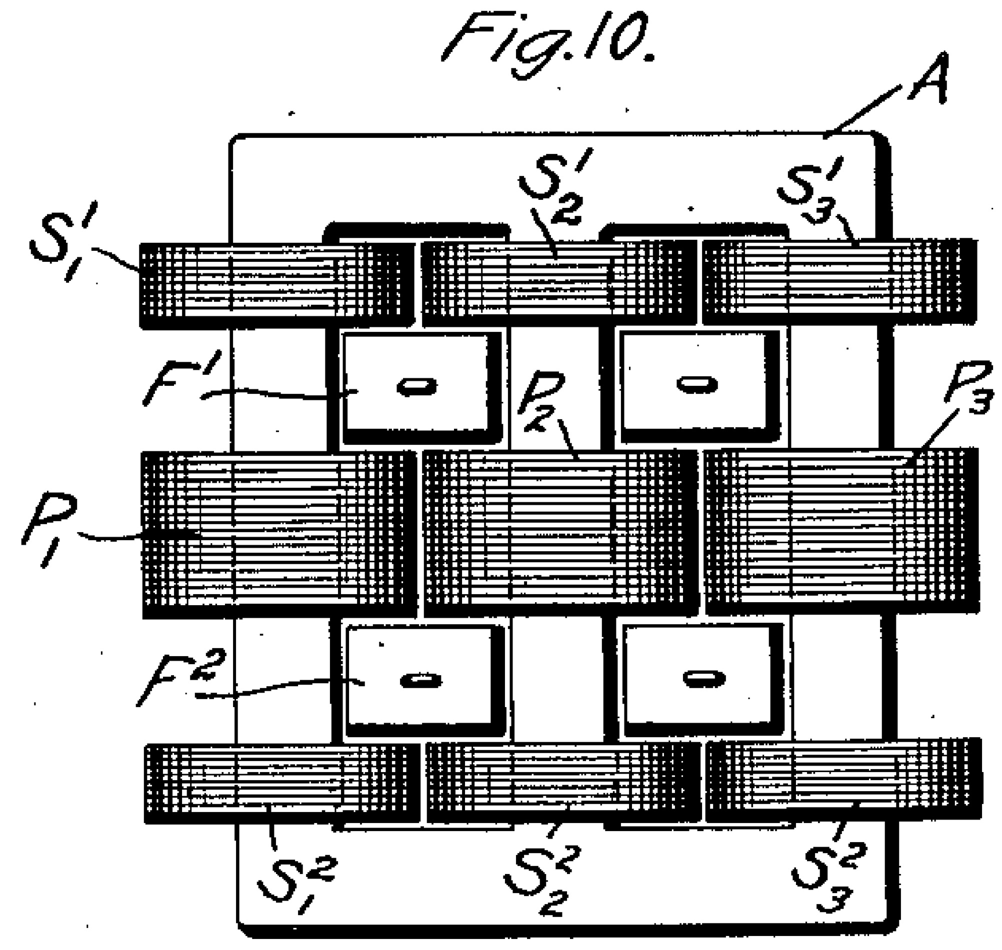


Fig. 10.



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UNITED STATES PATENT OFFICE.

MATTHEW O. TROY, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

VARIABLE-VOLTAGE TRANSFORMER.

No. 895,914. Specification of Letters Patent. Patented Aug. 11, 1908.

Application filed December 22, 1905. Serial No. 292,906.

To all whom it may concern:

Be it known that I, MATTHEW O. TROY, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Variable-Voltage Transformers, of which the following is a specification.

My invention relates to transformers adapted to give a wide range of secondary voltage, and consists in an improvement in the transformer described in my former application, Serial No. 116,208, filed July 19, 1902. In that former application I described a transformer in which the primary and secondary coils are spaced apart on the core and a portion of the core is movable to shunt the secondary coil, and thereby to vary the induced secondary voltage.

My present invention in one aspect consists in providing means not only for magnetically shunting the secondary coil, but also for varying the reluctance of the magnetic circuit passing through the secondary coil. When the magnetic shunt is removed and the device is so arranged as to give a low reluctance for the magnetic circuit passing through both primary and secondary coils the leakage is comparatively small and the induced secondary voltage is high, as in the case of the transformer described in my former application; and when the secondary coil is shunted and the reluctance of this magnetic circuit is made very high, practically no flux passes through the secondary coil, and consequently the induced voltage is reduced almost to zero. By varying the reluctance of the magnetic circuit of the secondary coil, as well as the magnetic circuit shunting the secondary, I am able to get a much greater range of secondary voltage than is otherwise possible.

In another aspect, my invention consists in magnetically balancing the means for shunting the flux around the secondary coil. More specifically stated, I provide two movable members, one arranged to vary the reluctance of the magnetic circuit of the secondary coil and the other to vary the reluctance of the shunting magnetic circuit, and connect both members to an operating means adapted to move them simultaneously and in opposite direction. In this way, the magnetic pulls upon the two members oppose each other, and comparatively small effort is required for operating the device.

My invention further comprises certain novel arrangements of the core and coils, so as to adapt the transformer for special purposes.

My invention will best be understood by reference to the accompanying drawing, in which

Figure 1 shows a plan view of a variable-voltage transformer arranged in accordance with my invention; Fig. 2 shows an end elevation of the same; Fig. 3 shows a side elevation; Fig. 4 shows an end elevation of a modified construction; Figs. 5 and 6 show a modified arrangement of coils adapted for certain purposes; Figs. 7 and 8 show diagrams of coil connections; Fig. 9 shows still another modification; and Fig. 10 shows a variable-voltage transformer arranged for use on polyphase circuits.

Referring first to Figs. 1, 2 and 3, A represents a magnetic core built up of laminations clamped between the end-plates *a a*. This core is essentially E-shaped, as appears from Fig. 1, in which the outline of the laminations is shown in dotted lines. Primary and secondary coils P and S are mounted on the central leg of the E, the primary coil being at the inner end and the secondary coil spaced a certain distance from the primary coil. B and C represent two vertically movable magnetic members on opposite sides of the secondary coil S. The member B, by its movement, varies the reluctance of a magnetic circuit for the flux of the primary coil shunting the secondary coil in the same manner as in my former application. The member C on the other hand, varies the reluctance of the magnetic circuit passing through both coils P and S. Consequently when member B is raised and member C is lowered, as shown in the drawings, the primary leakage flux is comparatively small and the induced secondary voltage is at its maximum value. If, however, the member C is raised and the member B lowered, practically no flux will pass through the secondary coil and the induced secondary voltage will be almost zero. That is, the arrangement shown gives a voltage variation from maximum down practically to zero.

In order to move the two members B and C, I provide a rotatable shaft D with a hand-wheel *d* operatively connected to both members in such a manner that one member is moved down as the other is moved up. Since both members are attracted by the flux in the core A, the pull of either core when it is raised is approximately balanced by the pull of the other core, which is being simultaneously lowered. In other words, the device is magnetically balanced and requires little effort for operation. The bearings for shaft D are mounted directly on one of the clamping plates *a*, which in turn is bolted to the other clamping plate, thereby giving a very rigid mechanical construction.

In Fig. 4 I have shown a slight modification of the movable members. In this figure, I have shown the member C of Fig. 2 divided in the middle and the top and bottom portions provided with right and left-hand screw-threads so that the two portions are drawn apart instead of the whole member moving in one direction. Furthermore, I have shown the laminations of the members C^1 and C^2 in a plane at right angles to the main core A. This arrangement is not as good electrically as that shown in Fig. 2, but it is sometimes more comvenient mechanically.

A variable-voltage transformer of the type described above is applicable wherever a wide range of voltage is required; as, for instance, for testing purposes or for thawing water pipes. A perfectly even variation is obtained instead of the step-by-step variation obtained by resistance control or by varying the number of turns of one winding. This is especially important in testing cables or other devices possessing capacity on account of the danger of suddenly striking resonant conditions in a step-by-step control.

For certain purposes, special arrangements of coils are especially convenient and desirable. For instance, I have shown in Figs. 5 and 6 an arrangement of coils which is particularly adapted for controlling the voltage of an alternating-current load circuit. In this arrangement I have shown two secondary coils S^1 and S^2, so arranged on the core A that when the flux of the primary coil P is diverted from one secondary coil, it is passed through the other. Such an arrangement of coils may be connected as shown in Fig. 7 for controlling the voltage of an alternating-current load circuit. The two coils S^1 and S^2 are connected in series with each other and with the load circuit, but in opposition to each other with respect to their induced voltages. By shifting the members F^1 and F^2, shown in Figs. 5 and 6, the voltage supplied by the secondary coils to the line in series with the line-voltage may be controlled both in amount and in direction. Obviously, the same result is obtained if the coils S^1 and S^2 in Figs. 5 and 6 are primary coils and the coil P a secondary coil. Fig. 8 shows the connections in such a case. The two primary coils are connected in series, and in opposition with respect to voltage, in the same way that the secondary coils are connected in Fig. 7, while the secondary coil is connected directly in series with the line.

The construction shown in Figs. 5 and 6 would produce a strong horizontal pull on the cores F^1 and F^2, so that in practice I prefer the arrangement shown in Fig. 9, which is electrically the equivalent of the arrangement of Figs. 5 and 6; but in which the moving members are magnetically balanced not only against each other, but with respect to horizontal pulls.

Fig. 10 shows a modification of the arrangement of Fig. 9 adapted for use on polyphase circuits. In this figure the core A is arranged with a plurality of magnetic circuits like the usual three-phase transformer, three primary coils P_1, P_2 and P_3 being mounted on the several legs of the core with the secondary coils S^1_1, S^2_1, S^1_2, S^2_2, S^1_3, S^2_3, also mounted on the several legs of the core. Two secondary coils S^1_1, S^2_1, are mounted on the same leg with the primary coil P_1, and the other coils for the other phases are similarly arranged. The movable members F^1 and F^2 are arranged to move simultaneously but oppositely, as heretofore explained, and each member serves both to shunt simultaneously the secondary coils of all three phases adjacent to it, and also to vary the reluctance of the magnetic circuits passing through the secondary coils at the opposite end of the core.

Other arrangements of coils and cores may be employed to meet varying requirements, and consequently I do not desire to limit myself to the construction and arrangement of parts here shown, but aim in the appended claims to cover all modifications which are within the scope of my invention.

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

1. In a variable-voltage transformer, a stationary primary coil and a stationary secondary coil, a core adapted to afford two magnetic circuits, one passing through both coils and one shunting one coil, and magnetically-balanced means for varying the reluctance of each magnetic circuit.

2. In a variable-voltage transformer, a stationary primary coil and a stationary secondary coil, a core adapted to afford two magnetic circuits, one passing through both coils and one shunting one coil, and magnetically-balanced means for simultaneously and oppositely varying the reluctances of both magnetic circuits.

3. A variable-voltage transformer comprising a core, stationary coils spaced apart on said core, and two movable magnetic members magnetically balanced arranged to vary the reluctance respectively of a magnetic circuit passing through one of said coils and of a magnetic circuit shunting said coil.

4. A variable-voltage transformer com-

prising a core, stationary coils spaced apart on said core, two movable magnetic members magnetically balanced arranged to vary the reluctance respectively of a magnetic circuit passing through one of said coils and of a magnetic circuit shunting said coil, and means for simultaneously moving said members.

5. A variable-voltage transformer comprising a core, a stationary primary coil and a stationary secondary coil spaced apart on said core, and two movable magnetic members magnetically balanced arranged to vary the reluctances respectively of the magnetic circuit of the secondary coil and of a magnetic circuit shunting said coil.

6. A variable-voltage transformer comprising a core, a stationary primary coil and a stationary secondary coil spaced apart on said core, two movable magnetic members magnetically balanced arranged to vary the reluctances respectively of the magnetic circuit of the secondary coil and of a magnetic circuit shunting said coil, and means for simultaneously moving said members.

7. A variable-voltage tranformer comprising a core, stationary coils spaced apart on said core, two movable magnetic members magnetically balanced arranged to vary the reluctances respectively of a magnetic circuit passing through one of said coils and of a magnetic circuit shunting said coil, and a rotatable shaft operatively connected with both members.

8. A variable-voltage transformer comprising a core, stationary coils spaced apart on said core, two movable magnetic members magnetically balanced arranged to vary the reluctances respectively of a magnetic circuit passing through one of said coils and of a magnetic circuit shunting said coil, a rotatable shaft operatively connected with both members, and a hand-wheel for rotating said shaft.

9. A variable-voltage transformer comprising a core, stationary coils spaced apart on said core, two movable magnetic members magnetically balanced arranged to vary the reluctances respectively of a magnetic circuit passing through one of said coils and of a magnetic circuit shunting said coil, a rotatable shaft, and operative connections between said shaft and both members whereby said members are moved in opposite directions when said shaft is rotated.

10. In a variable-voltage transformer, a core arranged to afford a plurality of magnetic circuits, a coil on a portion of said core common to two magnetic circuits, two coils on two other portions of the core each included in only one of said two magnetic circuits, and means for varying the reluctance of each of said magnetic circuits.

11. In a variable-voltage transformer, a core arranged to afford a plurality of magnetic circuits, a coil on a portion of said core common to two magnetic circuits, two coils on two other portions of the core each included in only one of said two magnetic circuits, said two coils being electrically connected in series and in opposition with respect to their voltages, and means for varying the reluctance of each of said magnetic circuits.

12. In a variable-voltage transformer, a core arranged to afford a plurality of magnetic circuits, a coil on a portion of said core common to two magnetic circuits, two coils on two other portions of the core each included in only one of said two magnetic circuits, said two coils being electrically connected in series and in opposition with respect to their voltages, and means for varying simultaneously and oppositely the reluctances of said two magnetic circuits.

13. In a variable-voltage transformer for polyphase circuits, a core affording a plurality of magnetic circuits, a polyphase arrangement of primary and secondary coils carried on said core, and magnetically balanced movable magnetic members adapted by their movements to vary simultaneously the mutual induction of primary and secondary coils of the several phases.

14. In a variable-voltage transformer for polyphase circuits, a core affording a plurality of magnetic circuits, a polyphase arrangement of primary and secondary coils on said core, and two movable magnetic members one arranged to vary the reluctance of the magnetic circuits passing through both coils of each phase and the other to vary the reluctance of magnetic circuits shunting the secondary coils of the several phases.

15. In a variable-voltage transformer for polyphase circuits, a core affording a plurality of magnetic circuits, a polyphase arrangement of primary and secondary coils on said core, two movable magnetic members one arranged to vary the reluctance of the magnetic circuits passing through both coils of each phase and the other to vary the reluctance of magnetic circuits shunting the secondary coils of the several phases, and means for simultaneously moving said members.

16. In a variable voltage transformer, a core, coils spaced apart on said core, and magnetically-balanced means adapted to shift the flux from one portion of said core to another.

17. In a variable voltage transformer, a core, primary and secondary coils spaced apart on said core, and magnetically-balanced means for shunting the flux around the secondary coil.

18. A variable voltage transformer comprising a core formed of laminations clamped between end-plates, a stationary primary

and a stationary secondary coil spaced apart on said core, two movable magnetic members magnetically balanced arranged to vary the reluctances respectively of a magnetic circuit passing through both primary and secondary coils and a magnetic circuit shunting the secondary coil, a rotatable shaft operatively connected with both members, bearings for said shaft secured to one of said end-plates, and a hand-wheel for rotating said shaft.

In witness whereof, I have hereunto set my hand this 20th day of Decemebr, 1905.

MATTHEW O. TROY.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.