T. BODDE.
TRANSFORMING DEVICE.
APPLICATION FILED APR. 13, 1916.

1,298,443. Patented Mar. 25, 1919.

Fig. 1.

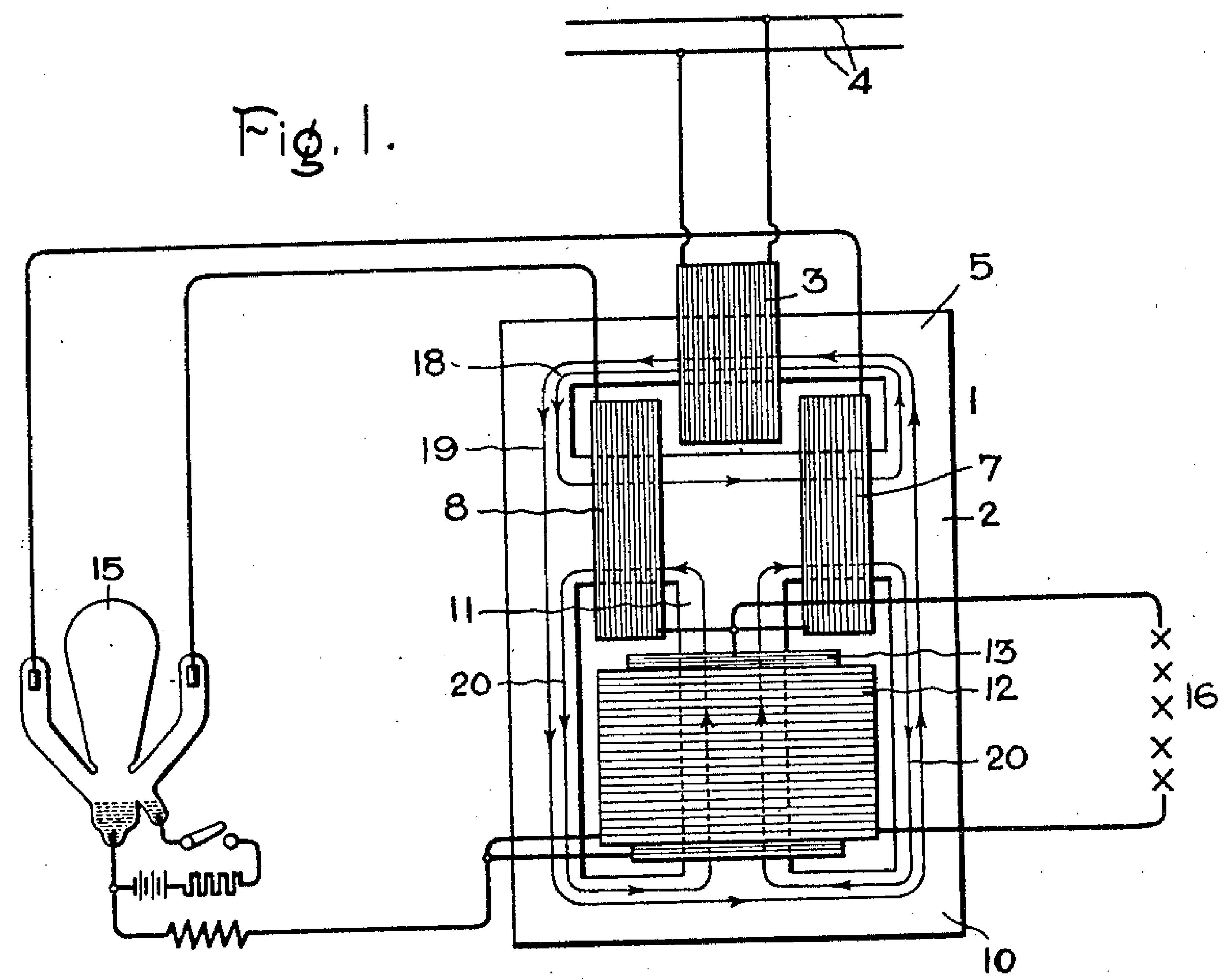
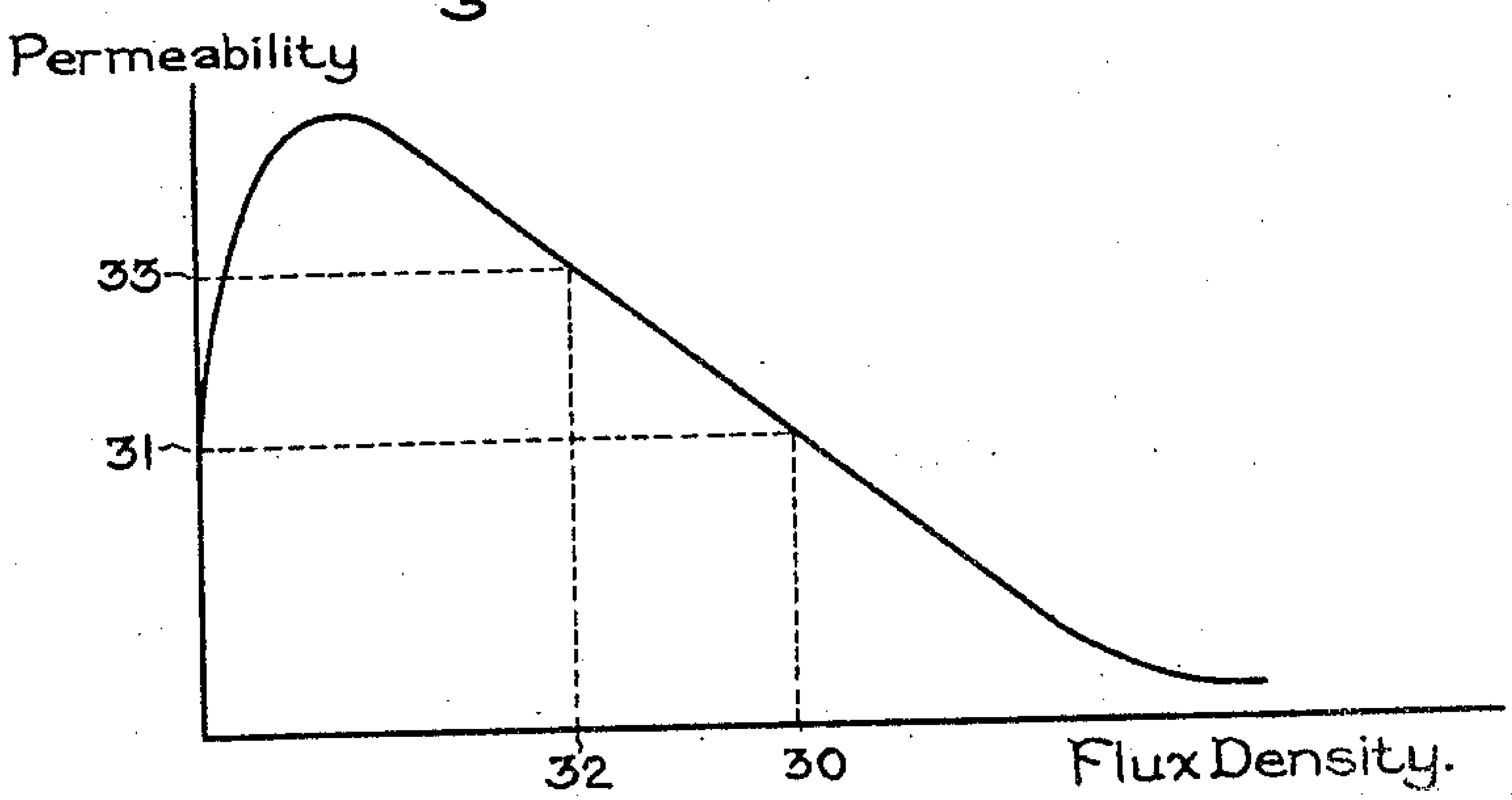



Fig. 2.




Inventor:
Theodore Bodde,
by Albert G. Davis
His Attorney.

# UNITED STATES PATENT OFFICE.

THEODORE BODDE, OF LYNN, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

## TRANSFORMING DEVICE.

**1,298,443.** Specification of Letters Patent. **Patented Mar. 25, 1919.**

Application filed April 13, 1916. Serial No. 90,856.

*To all whom it may concern:*

Be it known that I, THEODORE BODDE, a subject of the Queen of the Netherlands, residing at Lynn, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Transforming Devices, of which the following is a specification.

My invention relates to transforming devices for supplying constant current from constant potential sources; more particularly my invention relates to stationary transformers and rectifiers for supplying direct currents of constant values from alternating current sources of constant potentials. It includes both a method of operation and a particular form of apparatus operating according to that method. An object of my invention is to obtain such constant currents without the employment of devices having moving parts.

Apparatus in which my invention is employed comprises a stationary transformer in which the flux common to or threading both the primary and secondary windings is varied in proportion to the load variations by varying the permeability of a magnetic circuit of said transformer. To obtain rectified constant current two opposing direct current coils, respectively in shunt to and in series with the direct current side of the rectifier, may be used to control the permeability of a magnetic shunt or other suitable circuit on said transformer.

In the accompanying drawings I have illustrated one form of apparatus embodying my invention and which operates according to the method thereof. Figure 1 diagrammatically illustrates a stationary transformer supplying direct current of constant value to a load through a mercury rectifier; Fig. 2 is a permeability curve of assistance in understanding the operation of the apparatus of Fig. 1.

In Fig. 1 the transformer 1 comprises the core 2 carrying the windings; the primary winding 3 receives alternating current from the lines 4 and supplies the energy for the rectifier and load. The core 2 provides a magnetic circuit 5 common to the primary winding 3 and the secondary winding which is in two portions 7 and 8. The two secondary windings 7 and 8 in series supply the rectifier 15 which may be of any type. The core 2 also provides a magnetic shunt 10 for the primary and secondary windings. Between a mid-point of this magnetic shunt and the portion of the core between the secondary windings 7 and 8 is provided a part or member 11, also of magnetic material. This part or member 11 carries two direct current windings 12 and 13. The direct current winding 12 is connected in series with the load 16. The direct current winding 13 is connected in shunt to the rectifier and secondary windings 7 and 8. It is connected as shown in the drawings, between the midpoint connection of the rectifier and the midpoint of the secondary windings 7—8. The current carried by the direct current winding 12 therefore is proportional to the current supplied to the load, whereas the current supplied to the direct current winding 13 is proportional to the direct voltage impressed on the load. The two windings 12 and 13 are so wound or connected that their magnetic actions oppose each other, the voltage coil 13 predominating.

The lines carrying the arrows indicate the courses of the magnetic fluxes through the core. At some certain instant the magnetic flux common to or linking both the primary and secondary windings may be represented by the line and arrows 18. The alternating current leakage flux at the same instant is indicated by the line and arrows 19. The direct current flux resulting from the predominance of the voltage coil 13 passes through the member 11 and shunt 10 as indicated by the lines and arrows 20. It will be observed that the shunt 10 is traversed both by the leakage alternating flux and by the direct flux; it will also be observed that the direct current coils 12 and 13 are not subject to alternating flux and hence have no alternating voltages induced in them for the member or part 11 is so disposed that no alternating flux traverses it.

The apparatus as thus outlined is adapted to supply constant current to the load 16 irrespective of variations in the resistance of this load and irrespective of variations in the voltage of the alternating current supply 4. It will be understood that although the alternating current supply 4 is of the so-called constant potential type as before indicated, the voltage of this source may be subject to more or less abrupt and continued voltage changes within limits, due to the operation of other devices connected to the same source 4 or for other reasons; and also that the voltage of the source 4 may be found when the apparatus is installed, to be somewhat different from the voltage contemplated in the design of the apparatus. Now when the resistance of the load falls or the voltage of the source 4 runs higher than contemplated, the current through the load tends to assume a higher value than desired; likewise, when the resistance of the load increases or the voltage of the source runs below that contemplated, the current through the load tends to assume a correspondingly lower value. These tendencies of the load current to change, by their effects on the magnetic flux result in the regulation desired. As will be observed from Fig. 2, and as is well known, the permeability of magnetic material as iron or steel, varies considerably with the flux density; it will be assumed that the permeability of the shunt 10 is represented by this curve, the flux density represented being the total flux density of the magnetic shunt 10, the combination of the alternating and direct fluxes therein. The apparatus of Fig. 1 may be so designed that at full load the flux density of the shunt 10 is of the value of the point 30 of Fig. 2. The permeability of the shunt 10 is then low and of the value represented by the point 31 on the permeability curve; the value of certain leakage alternating flux, and therewith the flux common to the primary and secondary windings, is determined by the permeability of the shunt 10, and hence is influenced by the direct current coils 12 and 13 and their direct flux. If now some of the devices of the series load 16 are removed from the circuit or if for any other reason the current tends to increase, the voltage impressed on the load should fall to a corresponding extent in order that the current may be maintained at its original value. This result is obtained by decreasing the flux common to the primary and secondary windings proportionally to the change in load or other change, as change in the voltage of the source, by increasing the permeability of the magnetic shunt 10 and hence providing for the passage therethrough of a greater value of leakage flux. The complete action is complicated and involves the superposition of the alternating and the direct fluxes. The action may be sufficiently understood, however, from a consideration of the action of the direct currents and fluxes. For example, as the current tends to increase as some of the load devices 16 are taken from the circuit, the direct current series winding 12 tends to more strongly oppose the voltage coil 13 and hence reduce the direct flux; this accomplishes the increase in permeability of the shunt 10 as will be apparent from Fig. 2. This increase in permeability in the shunt 10 is accompanied by an increase in the leakage alternating flux, a corresponding decrease in the flux common to the primary and secondary windings, and hence a decrease in voltage induced in the secondary winding, 7 and 8, and hence also in a decrease in the voltage applied to the load and an ultimate decrease in the current,—that is the permeability changes in substantially inverse proportion to changes in the load resistance, whence there is a return of the current toward its original value so to speak. At some value of load voltage, the effects of this voltage and the load current in the direct current coils 12 and 13 again balance each other, any further tendency of the current to change being opposed by a corresponding change in voltage in the opposite direction. Thus, after a given decrease in load the flux density in the shunt 10 may be of the value of the point 32 of Fig. 2, the permeability of the shunt having been increased to the value of the point 33. By properly proportioning the two direct current windings 12 and 13 the change in total flux density and permeability in the shunt 10 is made such that the current supplied to the load has substantially the same value for all values of load. If later the load is increased again to something more nearly full load value, the opposite action takes place as will be understood.

While I have described the principle of my invention and the best mode I have contemplated for applying this principle, other modifications will occur to those skilled in this art and I aim in the appended claims to cover all modifications which do not involve a departure from the spirit and scope of my invention.

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

1. The method of producing a current of constant value from a constant potential alterating current by means of a stationary transformer having a core provided with a stationary magnetic shunt which consists in dividing the primary magnetic flux into two portions one threading the secondary windings, the other threading the magnetic shunt, and in changing the permeability of the magnetic shunt in substantially inverse proportion to changes in the load resistance.

2. The method of producing a direct current of constant value from a constant potential alternating current by means of a stationary transformer and a rectifier which consists in supplying the rectifier from the secondary winding of the transformer and varying the flux common to the primary and secondary windings proportional to the load variations by varying the permeability of a magnetic circuit of said stationary transformer by the opposing actions of the rectified current and rectified voltage.

3. The combination with a rectifier and means for supplying alternating current, of a transformer comprising a primary winding connected to said means, a secondary winding supplying said rectifier, two opposing windings connected respectively in shunt to and in series with the load terminals of said devices, and a core of magnetic material providing a common magnetic circuit for said primary and secondary windings, a magnetic shunt therefor and a member carrying said two direct current windings extending between a midpoint of said magnetic shunt and a point on said first mentioned magnetic circuit at the middle of one of said alternating current windings.

4. The combination with a constant potential source of alternating current, of a transformer comprising a magnetic core, primary and secondary windings carried thereby, said core being provided with a stationary magnetic shunt, and series and shunt windings on said core arranged for magnetically changing the permeability of said magnetic shunt in substantially inverse proportion to changes in the load resistance.

5. The combination with a constant potential source of alternating current, of a transformer comprising a magnetic core, primary and secondary windings carried thereby, said core being provided with a stationary magnetic shunt, and means energized by the load current for magnetically changing the permeability of said magnetic shunt in substantially inverse proportion to changes in the load resistance.

6. The combination with a constant potential source of alternating current, of a transformer comprising a magnetic core, primary and secondary windings carried thereby, said core being provided with a stationary magnetic shunt, a rectifier connected with said secondary windings, two windings connected respectively in shunt and in series with the load terminals and across said rectifier; said last named windings arranged to have opposing magnetic actions in said magnetic shunt whereby the permeability of the magnetic shunt is changed in substantially inverse proportion to changes in the load resistance.

7. The combination with a source of alternating current, of a transformer comprising a magnetic core, primary and secondary windings carried thereby, a source of direct current connected to be supplied by said secondary windings and windings on said core connected in series and in shunt with the load supplied by said source of direct current, and arranged to have a differential magnetizing effect for changing the permeability of said core in substantially inverse proportion to changes in the load resistance.

In witness whereof I have hereunto set my hand this 10th day of April, 1916.

THEODORE BODDE.