

July 1, 1924.

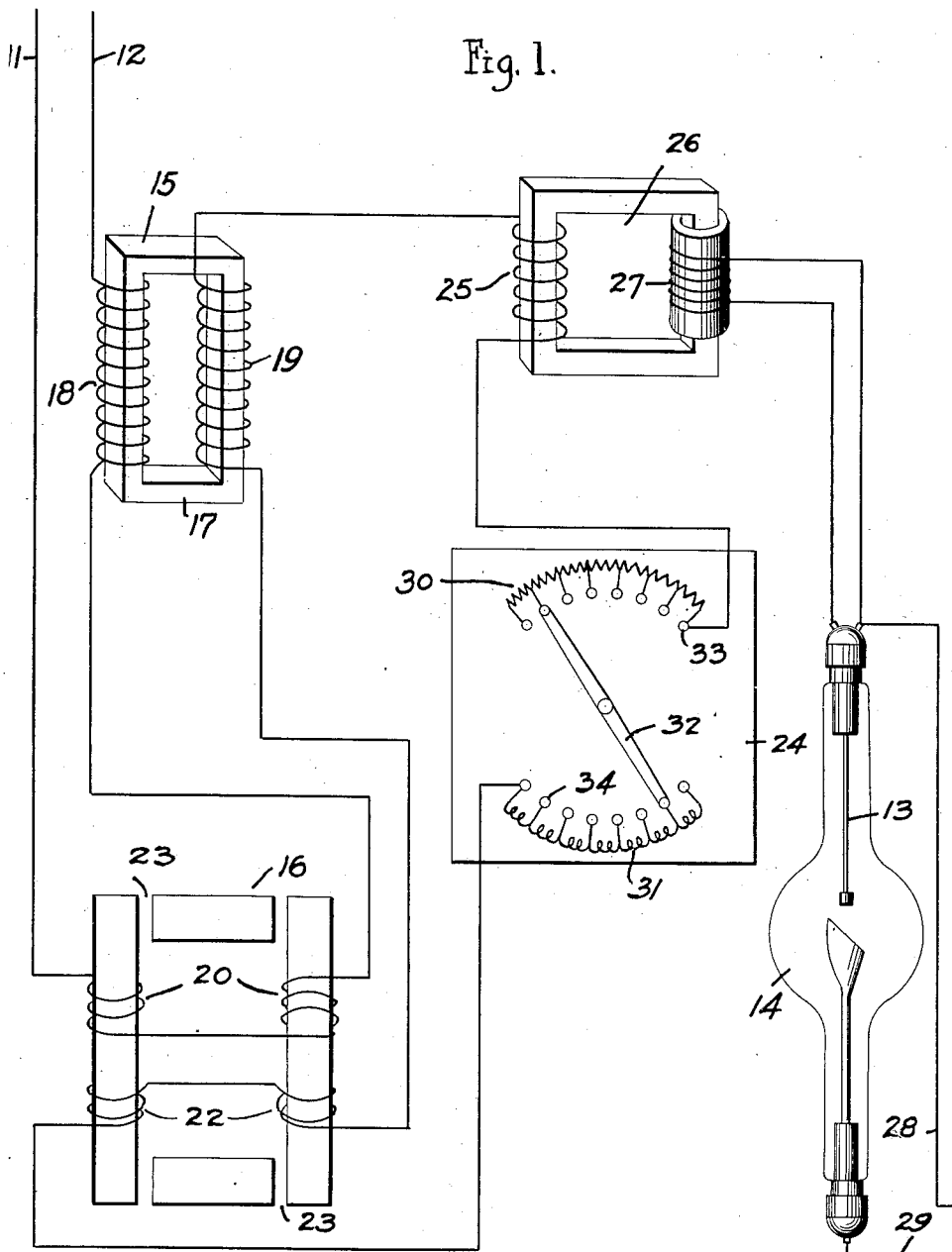
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F. RIEBER

ALTERNATING CURRENT SYSTEM

Filed Sept. 26, 1921

3 Sheets-Sheet 1



WITNESS

H. Sherburne,

INVENTOR

FRANK RIEBER.

BY

White Frost & Sons
his ATTORNEYS

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Fig. 2.

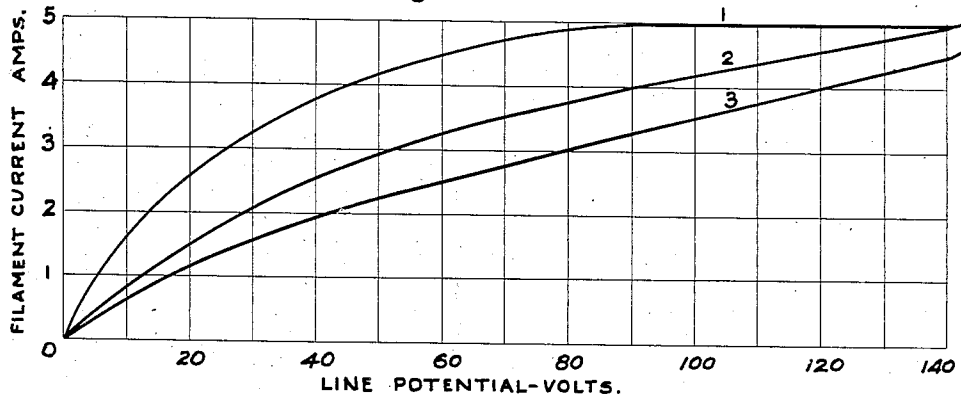


Fig. 3.

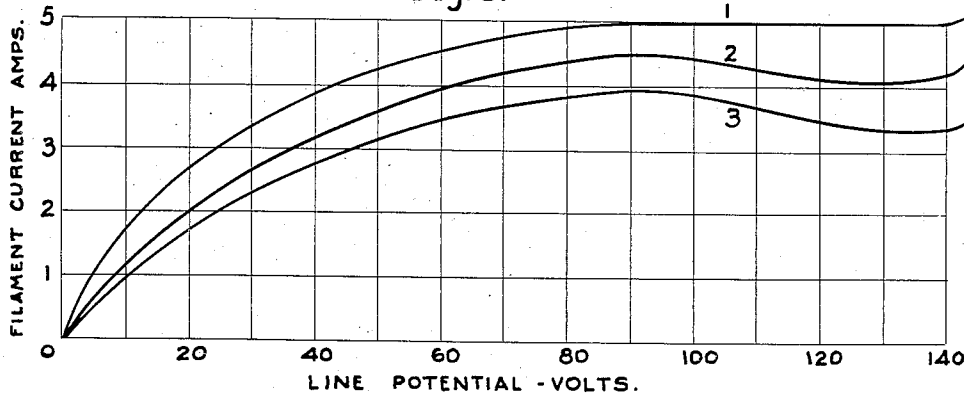
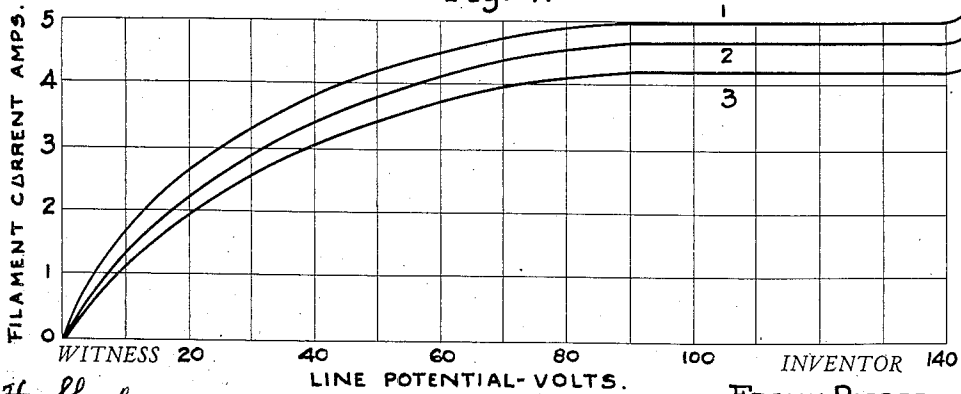


Fig. 4.



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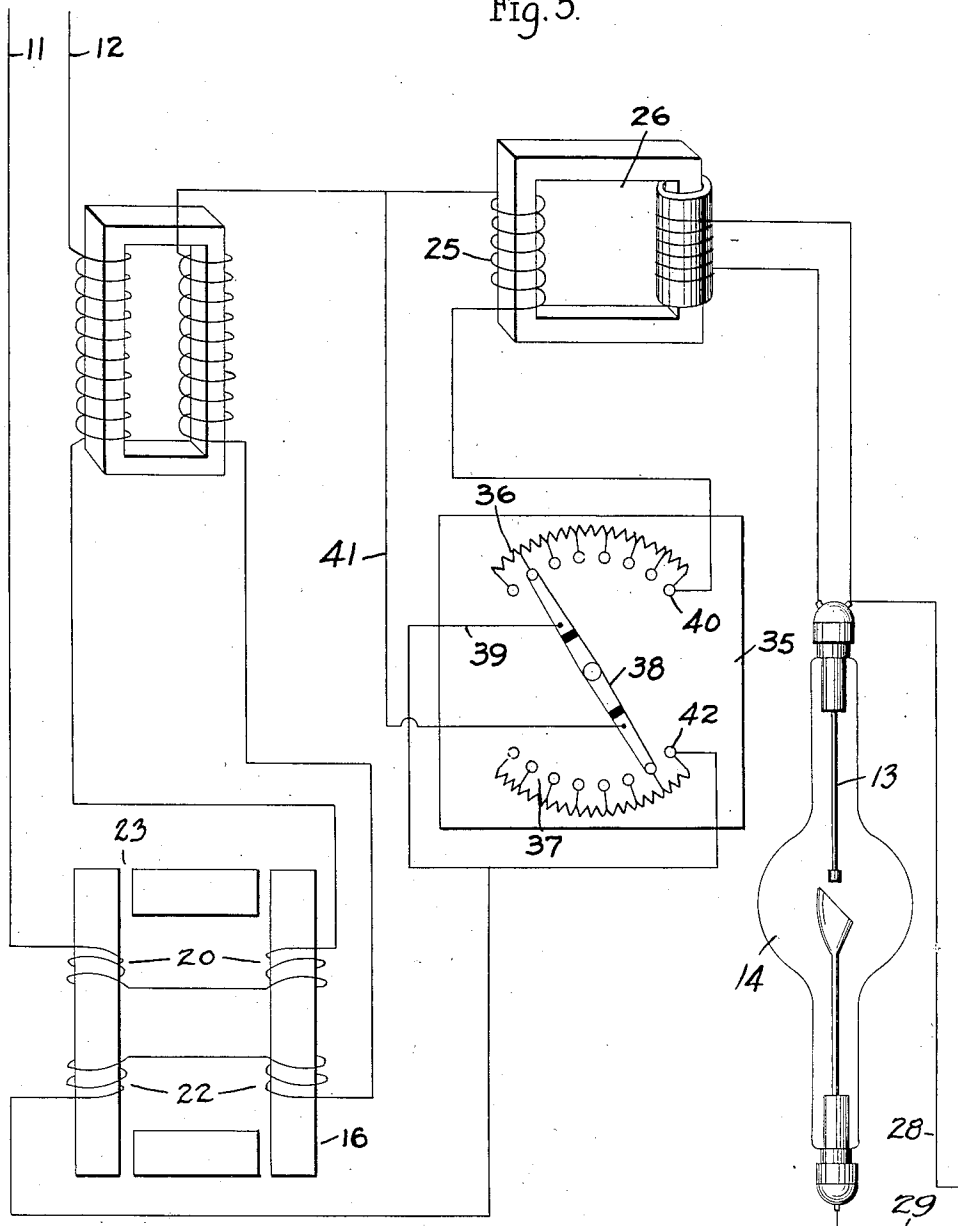
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Fig. 5.



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UNITED STATES PATENT OFFICE.

FRANK RIEBER, OF BERKELEY, CALIFORNIA.

ALTERNATING-CURRENT SYSTEM.

Application filed September 26, 1921. Serial No. 503,369.

To all whom it may concern:

Be it known that I, FRANK RIEBER, a citizen of the United States, and a resident of Berkeley, county of Alameda, State of California, have invented a certain new and useful Alternating-Current System, of which the following is a specification.

This invention relates to an alternating current system, and more particularly to a system in which it is necessary that the current supplied be maintained very nearly constant at any one of a number of optional values.

Such systems are required in connection with the heating of the filament in vacuum discharge tubes, such as Coolidge or X-ray tubes. The characteristics of tubes of that class are such that as the temperature of the heated filament varies a slight amount, the space current through the tube, which is a function of this temperature, varies to a considerable extent. The variation of this current is objectionable in many classes of work, as for instance in taking X-ray exposures. It is sometimes advantageous to adjust the temperature of the filament so as to obtain varying effects, but no matter which optional value of temperature is chosen, it is essential that it be maintained constant at that value. Where a commercial alternating current source only is available, the fluctuations of voltage may be so great as to interfere materially with the adjustment of the heated filament temperature which is dependent upon the current flowing through it and, therefore, the potential impressed upon it.

It is possible to provide an arrangement whereby these voltage fluctuations are nullified for one isolated value only of the current supplied to the filament. If it be attempted to adjust the temperature of the heated filament in such an arrangement by any ordinary means, fluctuations of potential of the source would no longer be nullified, and the heated filament would be supplied with current varying over a range commensurate with the range of variation of the supply voltage. It is one of the objects of my invention to make it possible to vary the filament temperature, or in other words, the current supplied to it, without causing any disturbance in the voltage regulation. Another object of my invention is to make it possible to set the value of the current supplied to the load at any one of

several optional values and to keep it there independently of fluctuations in the source voltage.

The invention possess other advantageous features, some of which, with the foregoing, will be set forth at length in the following description, where I shall outline in full those forms of the invention which I have selected for illustration in the drawings accompanying and forming part of the present specification. In the drawings are shown several embodiments of my invention, but it is to be understood that I do not limit myself to such forms, since the invention, as expressed in the claims, may be embodied in other forms as well.

Referring to the drawings:

Figure 1 indicates the wiring diagram of one form of my invention applied to an X-ray tube;

Fig. 2 is a chart showing how the current in the heated filament varies under variations of supply voltage and of resistance in the load circuit;

Fig. 3 is a chart showing how the current in the heated filament varies under variations of supply voltage and of inductive reactances in the load;

Fig. 4 is a chart showing how the current varies under varying conditions when that form of my invention is utilized which is illustrated in Fig. 1; and

Fig. 5 is a wiring diagram of another form of my invention.

Referring now more in detail to the drawings, the leads 11 and 12, in Fig. 1, are adapted to be connected to an alternating current source of the ordinary commercial sort. As is well known, such sources do not maintain an absolutely uniform potential, so that if this source be utilized immediately to supply a load, such as to heat the filament 13 of a vacuum or X-ray tube 14, variations in the temperature would be quite pronounced. Especially is this the case since the heat generated in an electric circuit of constant resistance varies in proportion to the square of the impressed voltage. One manner in which voltage fluctuations can be minimized or nullified for one particular value of the current, is by the means illustrated in Fig. 1, in which a main transformer 15 and a bucking auxiliary transformer 16 are used. The transformer 15 has a closed core 17 which is so proportioned that it is saturated at a voltage value some-

what below the normal voltage of the alternating current source to which it is connected. The primary coil 18 is supplied from the source, while the secondary coil 19 is used to supply the heated filament 13 with current. Even if no other means be utilized to minimize the voltage fluctuations, a large variation in the primary volts of transformer 15 causes a smaller variation in the secondary voltage, due to the saturation of the core. However, the auxiliary transformer 16 may be so arranged that, for a certain isolated value of secondary current, it nullifies even this slight variation.

This auxiliary transformer has a primary coil 20 arranged in two sections, one on each limb of the core 21. These coils are fed from the source, in the present instance, in series with the primary coil 18 of the main transformer 15. The secondary coil 22 of the auxiliary transformer 16 is likewise shown as made up of two sections, one on each limb, and is connected in series with the secondary coil 19 of the main transformer 15 and in such a way that these two coils buck each other. The auxiliary transformer 16 is arranged to produce a relatively low potential in the secondary coil 22, and substantially in proportion to the voltage impressed on the primary coil 20. This last effect may easily be obtained by making the core 21 with one or more comparatively large air gaps 23. Furthermore, the voltage produced in the secondary coil 22 is made to be of such value that it substantially nullifies the change in voltage in the main secondary coil 19 due to a change in the supply voltage. This is made possible since the magnetization of the main core is always at such a stage that it is above the knee of saturation, and beyond that point the magnetization, as the voltage increases, increases as if there were a large air gap in the core. Thus by utilizing a transformer properly constructed and having a large air gap, it is possible to balance exactly this increase in potential beyond the knee of saturation, for a particular value of secondary current.

It is sometimes desirable, especially in X-ray tubes, to adjust the temperature of the heated filament 13. This may be most conveniently performed by varying the current flowing therethrough which in turn may be accomplished by varying the potential applied to it. In Fig. 1, the secondary current is conducted through a controlling device 24, to the primary 25 of an insulator transformer 26, the secondary 27 of which is directly connected to the heated filament 13. The insulator transformer 26 serves to insulate the alternating current system from the high potential system 28, 29, connected across the electrodes of the tube 14. If it be attempted to vary the current in

the filament 13 by simply a resistance in series with it or with the secondary 19, the result would be that variations in the supply voltage would no longer be nullified. This effect may be best appreciated from a study of the chart in Fig. 2.

In this chart, the abscissæ represent the supply potential in volts and the ordinates represent filament current in amperes. Curve #1 may represent the relation between current and volts when there is a minimum resistance in the circuit. It is seen that between 90 and 140 volts the current remains constant at 5 amperes. The normal voltage in this case is 110. Curve #2 represents an attempt to set the current value to 4.5 amperes with the aid of additional resistance in the circuit. It is seen that the current now varies between about 4 amperes and about 5 amperes as the supply potential varies from 90 to 140 volts. Upon a further increase in the resistance, the current behaves as shown in curve #3, and varies between about 3.3 amperes and 4.5 amperes for a variation in supply voltage from 90 to 140 volts. It is thus seen that any attempt at choosing any one of a number of optional values of the heating current by means of resistance control fails, since the current does not stay at the chosen value as the supply potential fluctuates.

The disadvantages attendant upon the use of resistance for the control are also present when inductive reactance is used to vary the heating current. The effect of varying the inductive reactance in the heating circuit is well brought out in the chart shown in Fig. 3. The same coordinates are used in this figure as in Fig. 2. Curve #1 of Fig. 3 shows how the heating current behaves when a certain definite value of reactance is used and for which value the main transformer 15 and the auxiliary transformer 16 function best. Curve #2 shows what happens when the value of the inductive reactance is increased. The filament current now varies between 4.5 and 4 amperes for the limits of 90 and 140 volts of the source of supply. With the use of reactance, however, the effect is to give the curve a downward slope. Upon a further increase in reactance, the current behaves as shown by curve #3 and varies from about 4 amperes to about 3.2 amperes.

In my invention I overcome the difficulties of controlling the current, so that it remains at the value set irrespective of the ordinary voltage fluctuations of the supply. The controlling device 24 is utilized for this purpose, and takes the form, in Fig. 1, of a variable resistor 30 and a variable inductor 31, both in series with the secondary circuit of the main transformer 15 and the auxiliary transformer 16. These are preferably so ar-

ranged as to be simultaneously variable by means of a dial switch arm 32 and the two series of contacts 33 and 34, disposed around a circle in the path of the extremities of the arm 32. By moving the arm 32 in one direction, the values of the resistor and of the inductor are made greater, and there is a reverse effect when the arm 32 moves in the opposite direction. Other arrangements may obviously be utilized. By properly proportioning the resistor and inductor steps, I have found it to be possible to adjust the filament current value and to keep it there when transformers of the sort shown in Fig. 1 are used. In Fig. 4, a chart shows how this current varies as the supply potential varies. Curve #1 in this figure shows that the current stays substantially constant at 5 amperes when the supply voltage varies between 90 and 140 volts. Curve #2 shows the current values after both the resistor 30 and inductor 31 had been increased somewhat. This current stays at about 4.7 amperes for the usual variation in the supply potential. A further increase in the resistor 30 and inductor 31 carries the current down to the value shown in curve #3, where it has a value of about 4.2 amperes for the usual voltage variation.

In order that the beneficial results be obtained from the combined use of a resistor and an inductor, it is necessary to choose properly the values of resistance and inductance between the series of contacts 33 and 34. To do this, the entire arrangement is first adjusted so as to give constant current when arm 32 is in its extreme right-hand position, corresponding to minimum resistance and inductance in the system. This adjustment may be made by proper design of the two transformers 15 and 16. Now the arm 32 is turned so as to include one small section of resistance and a small section of reactance. Then the supply voltage applied to mains 11 and 12 is varied to find out if the heating current stays constant. If the current increases as the voltage increases, the reactance should be slightly increased in this first step. A new trial will show whether still more reactance is necessary. Another way of obtaining the steps is by adjusting the resistance instead of the reactance. After the first step is properly obtained on controller 24, the arm may be moved to the next step and the process repeated. In this way, small variations in the heating may be obtained without danger that voltage fluctuations will upset the adjustments.

In Fig. 5 I show a somewhat different form of controlling device 35. In this case two variable resistors 36 and 37 are used, one in series in the filament supply circuit, and the other parallel to it. The dial arm 38 is so arranged that as one is increased, the

other is decreased. The values of the resistance are so chosen that the load on the stabilizer comprising the two transformers 15 and 16 is constant, even if the filament current varies. The series resistor 36 is controlled by the upper portion of the arm 38 which is insulated as shown, and to which is connected the lead 39 directly from the secondary 22 of auxiliary transformer 16. One end 40 of the resistor 36 is connected to the primary 25 of the insulator transformer 26, so that that section of resistor 36 between the contact portion of the upper end of arm 38, and the end 40, is in series in the main circuit. A parallel circuit to the main circuit is completed by lead 41 connecting to the lower insulated portion of arm 38, and that portion of resistor 37 which is between the contact of the lower end of arm 38 and the point 42. It is evident that as arm 38 is turned to the right, the series resistor 36 is decreased and the parallel resistor 37 is increased. By properly proportioning the steps in these resistors, a constant load may be drawn from the source irrespective of the value of the heating current. Thus, it is merely necessary to construct the stabilizer to take care of but one current value.

I claim:

1. In an alternating current system for supplying current to a load in such a way that the current stays substantially constant at any one of a number of optional values, means for selecting the value of the current to be supplied, and means for causing this current value to be independent of fluctuations in the supply voltage.

2. In an alternating current system for supplying a current to a load in such a way that the current stays substantially constant at any one of a number of optional values, a variable inductor and a variable resistor in the circuit for selecting the value of the current supplied to the load, and means for causing this current value to be independent of fluctuations in the supply voltage.

3. In an alternating current system for supplying current to a load in such a way that the current stays substantially constant at any one of a number of optional values, an inductor in the circuit, a resistor in the circuit, means for simultaneously varying the value of the inductor and the resistor whereby the value of the current supplied to the load is determined, and means for causing this current value to be independent of fluctuations in the supply voltage.

4. In an alternating current system for supplying current to a load in such a way that the current stays substantially constant at any one of a number of optional values, an inductor in series with the load, a resistor in series with the load, means for

simultaneously varying both the inductor and the resistor whereby the value of the current supplied to the load is determined, and means for causing this current value to be independent of fluctuations in the supply voltage.

5. In an alternating current system for supplying current to a load in such a way that the current stays substantially constant at any one of a number of optional values, a transformer having a closed core, a primary coil adapted to be connected to a source of supply, and a secondary coil, the core being so proportioned that it is saturated when the voltage of the source is somewhat below normal, an auxiliary transformer adapted to be supplied from the same source having a primary and a secondary coil, this transformer being so proportioned that for variations from normal of the supply voltage, the secondary potential stays substantially proportional to the primary potential, the secondary coils of the main and auxiliary transformers being connected in series to the load, a resistor and an inductor in the load circuit, and means for simultaneously varying the resistor and inductor, whereby the value of the current supplied is determined.

6. In an alternating current system for supplying current to a load in such a way that the current stays substantially constant at any one of a number of optional values, means for stabilizing the system for one of the current values so that variations in the supply voltage have no effect upon this value, and means for adjusting the current to any other of the values in such a way that the voltage variations will not have any effect upon these values.

7. In an alternating current system for supplying current to a load in such a way that the current stays substantially constant at any one of a number of optional values, means for stabilizing the system for one of the current values so that variations in the supply voltage have no effect upon this value, a variable resistor and a variable inductor in the circuit, and means for varying the inductor and resistor in such a way that a different current value will be obtained, which will remain constant irrespective of fluctuations in the supply voltage.

8. In an alternating current system for supplying current to a load in such a way that the current stays substantially constant at any one of a number of optional values, a main transformer adapted to operate with its core above the knee of saturation so that variations in the supply voltage cause relatively small and substantially proportional changes in the secondary voltage, an auxiliary transformer having a large air gap in its magnetic circuit and connected in series bucking relation with the main transformer, said auxiliary transformer being proportioned so that its secondary voltage substantially entirely neutralizes the proportional changes in the secondary voltage of the main transformer for a definite value of current consumption, a device utilizing electrical energy derived from the secondaries of the transformers, and means for varying the current supplied to the device while maintaining the voltage fluctuation neutralizing effect of the transformer.

9. In an alternating current system for supplying current to a load in such a way that the current stays substantially constant at any one of a number of optional values, a main transformer adapted to operate with its core above the knee of saturation so that fluctuations in the supply voltage cause relatively small and substantially proportional changes in the secondary voltage, an auxiliary transformer having a large air gap in its magnetic circuit and connected in series bucking relation with the main transformer, said auxiliary transformer being proportioned so that its secondary voltage substantially entirely neutralizes the proportional changes in the secondary voltage of the main transformer for a definite value of current consumption, a device utilizing electrical energy derived from the secondaries of the transformers, and means for varying the current supplied to the device while maintaining the voltage fluctuation neutralizing effect of the transformers, comprising a resistor, an inductor, both in series relation with the secondaries of the transformers, and means for simultaneously adjusting the resistor and the inductor.

In testimony whereof, I have hereunto set my hand.

FRANK RIEBER.