June 7, 1932. P. H. DOWLING 1,862,212

ELECTRICAL TRANSLATING APPARATUS

Filed June 23, 1930

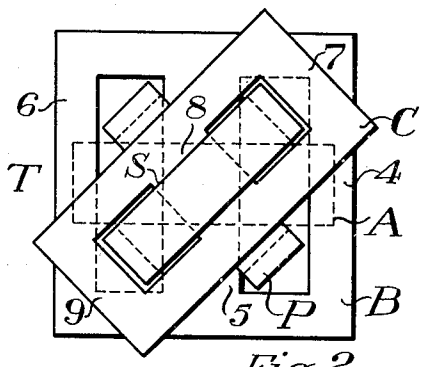


Fig. 2.

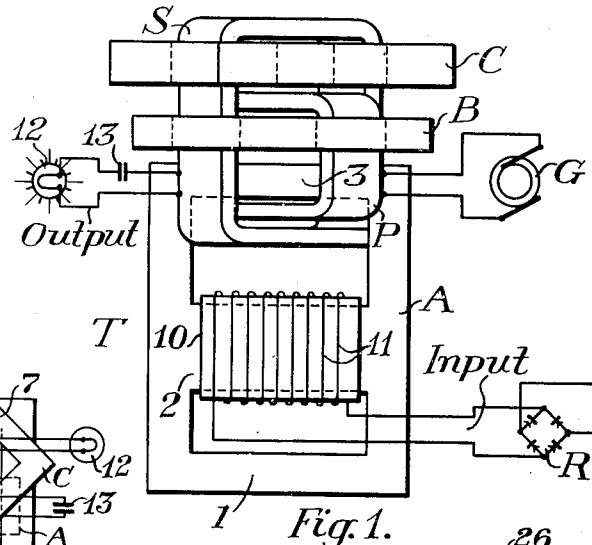


Fig. 1.

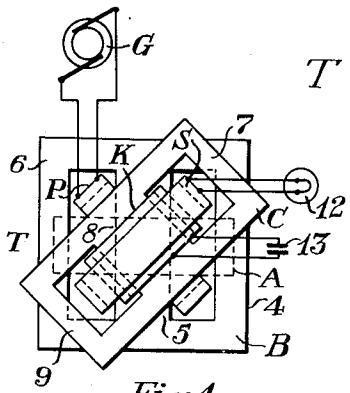


Fig. 4.

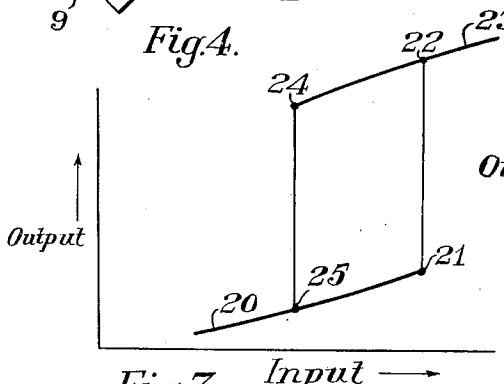


Fig. 3.

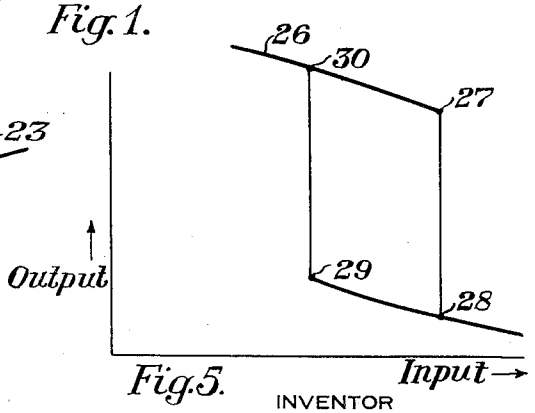


Fig. 5.

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UNITED STATES PATENT OFFICE

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ELECTRICAL TRANSLATING APPARATUS

Application filed June 23, 1930. Serial No. 463,020.

My invention relates to electrical translating apparatus, and particularly to apparatus of the type comprising an input circuit which is at times supplied with current and an output circuit in which the flow of current is controlled in accordance with the current supplied to the input circuit.

One feature of my invention is the provision of electrical translating apparatus of the type described, in which the output current varies discontinuously with the input current.

I will describe two forms of electrical translating apparatus embodying my invention, and will then point out the novel features thereof in claims.

In the accompanying drawing, Fig. 1 is a view partly diagrammatic and partly in elevation, showing one form of electrical translating apparatus embodying my invention. Fig. 2 is a top plan view of the apparatus shown in Fig. 1. Fig. 3 is a diagram illustrating the behavior of the apparatus shown in Figs. 1 and 2 under certain conditions. Fig. 4 is a view similar to Fig. 2 but on a somewhat reduced scale showing a modified form of apparatus embodying by invention. Fig. 5 is a diagram illustrating the behavior of the apparatus shown in Fig. 4 under certain conditions.

Similar reference characters refer to similar parts in each of the several views.

Referring first to Figs. 1 and 2, the reference character T designates a transformer comprising three magnetizable shell type cores A, B and C. The core A comprises three legs 1, 2 and 3, and leg 3 is linked by a primary winding P which is supplied with periodic current from some suitable source, here shown as an alternating current generator G. The primary winding P also links the middle leg 5 of core B, so that the primary flux delivered by winding P threads the outer legs 4 and 6 of core B.

The reference character S designates a secondary or output winding which may supply energy to any suitable load, here shown as an electric lamp 12. The secondary winding S links the leg 3 of core A and the leg 5 of core B, and the parts are so disposed that the primary fluxes created in cores A and B by current in winding P thread winding S in opposite directions. As shown in the drawing, this is accomplished by disposing the cores A and B at right angles, and by also disposing the windings P and S at right angles, so that the electromotive force induced in secondary winding S by primary flux in core A is opposed by the electromotive force induced in winding S by primary flux in core B. It should be pointed out however, that this particular angular disposition of the parts is not essential.

The distribution of flux in the transformer T is controlled by an input winding 11 located on the middle leg 2 of core A. This leg 2 also carries a conducting sleeve 10, which operates to prevent the passage of primary flux from winding P through the middle leg 2. The input winding 11 may be supplied with control current from any suitable source, and, as here shown, this winding is supplied with unidirectional current from the secondary of a transformer 14 through a rectifier R. The primary of transformer 14 may be connected with any suitable source of alternating current not shown in the drawing. The parts are preferably constructed in such manner that when no current is supplied to the input winding 11, the primary flux P divides equally between cores A and B, so that the resultant electromotive force induced in winding S is zero, and no current is supplied to load 12. When the input winding 11 is supplied with current, however, the flux created thereby decreases the permeability of core A, and hence increases the proportion of the primary flux from winding P which traverses core B. The normal balance of electromotive force induced in winding S is therefore destroyed, and a current flows to the load 12, the magnitude of this current being a function of the current supplied to the input winding.

I have discovered that if a condenser 13 is inserted in series with the secondary winding S and the load 12 with a capacity which will not balance the reactance of winding S for comparatively low values of output current but which will balance the reactance of

this winding, when such reactance is reduced by the effect of comparatively high output currents, the output circuit is rendered unstable under certain conditions. This characteristic can be accentuated by employing the core C having its middle leg 8 linking winding S but not winding P, so that the flux produced by current in the secondary winding traverses the end legs 7 and 9 of core C. The effect of core C is, of course, to increase the effective reactance of winding S.

With the parts constructed in the manner described, as the input current in winding 11 increases, the output current supplied to the load 12 also increases gradually along some such line as 20, in the curve shown in Fig. 3. As the input current continues to increase, the output current also increases along line 20 until some point, such as 21, is reached, for which the current in secondary winding S alters the magnetization of core C to a point sufficient to bring the reactance of winding S into substantial balance with the capacity of condenser 13. Under these conditions, if the inductance, capacity and resistance are properly adjusted, the output circuit impedance will become too small to satisfy Ohm's law for the values of current and electromotive force in the secondary circuit, and the current in the output circuit will jump discontinuously from its value at point 21 in Fig. 3 to some higher value, such as 22. After this sudden change, further increase in the input current in winding 11 will cause variation of the output current along some line such as 23, and a decrease in the input current below the value corresponding to the discontinuous change represented by line 21—22 will decrease the output current, but still along line 23. If the input current is decreased, however, to some value considerably lower than that at which the output current increased discontinuously, as indicated by the conditions at point 24, the decreased flux in core C caused by the decreased current in winding S will cause the system to become unstable, and the output current will jump discontinuously to some value, such as indicated by 25, and the apparatus will thereafter again respond to variations in the input current along the line 20.

It will be apparent from the foregoing, that by properly proportioning the parts, the apparatus may be arranged to materially and suddenly increase its output in accordance with a comparatively small increase in the input current above a definite value. After this sudden increase has taken place, the input current may be reduced materially below such definite value with only comparatively small changes in the output current. If the input current is subsequently reduced, however, below a definite value which is lower than the value which caused the sudden increase in output current, the apparatus again becomes unstable and a sudden and material decrease in output current will result from a comparatively small change in input current.

The operation of the transformer T, shown in Figs. 1 and 2, is therefore analogous to the operation of electromagnetic relays of the ordinary type which have definite "pick-up" and "drop-away" values of input current. That is to say, a higher value of input current is necessary to raise the output to a high value than is necessary to maintain the output at such value after the apparatus has once been operated.

Magnetic amplifiers having discontinuous characteristics may also be constructed by employing parallel resonance as well as the series resonance described above. For example, in the modified form of apparatus shown in Fig. 4, the load 12 is connected directly with the secondary winding S, but an additional winding K is located upon the middle leg 8 of core C. The condenser 13 is connected across winding K and the parts are so proportioned that under certain conditions the circuit including K and 13 pulls into resonance.

Referring now to Fig. 5, the conditions in the amplifier shown in Fig. 4 may be represented by the line 26 for one set of input and output current values. This condition may be obtained, if the amplifier is very slightly unbalanced, by increasing the voltage applied to the primary winding to a point at which the flux produced in core A overbalances the flux produced in core B by an amount sufficient to create in the secondary S a current which produces effective resonance in the output circuit. If, now, the input current increases the flux linking core B varies as explained in connection with Figs. 1 and 2. This will decrease the unbalance between the fluxes, and hence will decrease the output current. Due, however, to the tuning effect of the condenser 13 and the winding K, the current actually delivered to the load 12 decreases along the line 26 until some point 27 is reached at which the current in the load decreases discontinuously along the line 27—28 until equilibrium is reached at point 28 where the output current is comparatively small. If the input current is now decreased, the current increases very slowly until conditions represented by point 29 are reached, whereupon the output current increases sharply along line 29—30, as effective resonance of the output circuit is again produced.

The difference between the operations of the two forms of amplifiers indicated by the curves in Figs. 3 and 5 can probably be explained by the fact that in the amplifier shown in Figs. 1 and 2, the output circuit is untuned when no input is present, but is pulled into resonance as a result of the re-

distribution of flux accompanying the supply of current to winding 11. In Fig. 4, however, the output circuit is effectively tuned for the no-input condition, and is detuned when the input current is increased. In other words, the two modifications are operated to approach the critical region where the discontinuous characteristics are exhibited, from opposite sides of this critical region.

It will be observed that in the amplifier shown in Fig. 4, an increase of current in the input circuit causes a decrease in the output current. The present application contains no claim for this feature, because magnetic amplifiers of this type are claimed broadly in my copending application Serial No. 463,019, filed on even date herewith, for Electrical translating apparatus.

It should be pointed out that while I have illustrated the apparatus embodying my invention as supplying current to an electric lamp 12, this particular load is not essential. The output circuit may supply energy to any suitable form of current consuming device or may supply the input circuit of a second stage amplifier of any suitable type.

Although I have herein shown and described only two forms of electrical translating apparatus embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, a secondary winding, a magnetizable core linking said secondary winding, a primary winding supplied with periodic current and inductively related with said secondary winding, means for varying the coupling between said primary and secondary windings, a load, and means for connecting said load with said secondary winding in such manner that the current through the load assumes a comparatively high value in response to increases above a definite value in the electromotive force induced in said secondary winding and returns to a comparatively low value only when the electromotive force induced in said secondary winding is decreased to an amount substantially below said definite value.

2. In combination, a secondary winding, a magnetizable core linking said secondary winding, a primary winding supplied with periodic current and inductively related with said secondary winding, means for varying the coupling between said primary and secondary windings, a load, a condenser, and means for connecting said secondary winding, said load and said condenser in series to form an output circuit having a discontinuous potential-current characteristic.

3. In combination, a secondary winding, a magnetizable core linking said secondary winding, a primary winding supplied with periodic current and inductively related with said secondary winding, means for varying the coupling between said primary and secondary windings, a load, and a condenser connected in series with said load and said secondary winding and having a constant capacity too large to balance the reactive impedance of said secondary winding at comparatively low values of the current supplied to the load but sufficient to balance said impedance at comparatively high values of such current.

4. A transformer comprising a first winding supplied with periodic current, two magnetic paths both linking said first winding, a second winding linking both said paths, means for at times varying the permeability of one of said paths to vary the distribution of flux from said first winding between said two paths, a condenser, and a load connected across said second winding and said condenser in series.

5. A transformer comprising two magnetic paths, a source of substantially constant periodic magnetomotive force for creating flux which divides between said paths, a winding linking both said paths in such manner that the fluxes in such paths induce opposing electromotive forces in said winding, means for controlling the distribution of flux from said source between said two paths, a condenser, and a load connected across said winding and said condenser in series.

6. In combination, two windings, means for supplying periodic current to one said winding, two magnetizable cores each linking both said windings in such manner that the fluxes produced in said cores by current in such one winding flow in opposite directions at an instant through the other winding, means for varying the permeability of one said core to vary the electromotive force induced in said other winding, a condenser, and a load connected across said condenser and said other winding in series.

7. A transformer comprising two magnetic paths, a source of substantially constant periodic magnetomotive force for creating flux which divides between said paths, a winding linking both said paths in such manner that the fluxes in such paths induce opposing electromotive forces in said winding, means for controlling the distribution of flux from said source between said two paths, a third magnetic path linking only said winding, a load connected with said winding, and means for effectively tuning the circuit including said load to resonance for at least one value of the current in said circuit.

8. A transformer comprising two magnetic paths, a source of substantially constant periodic magnetomotive force for creating

flux which divides between said paths, a winding linking both said paths in such manner that the fluxes in such paths induce opposing electromotive forces in said winding, means for controlling the distribution of flux from said source between said two paths, a closed magnetic path linking said winding to increase the effective reactance of such winding, a load connected with said winding, and means for effectively tuning the circuit including said load to resonance for at least one value of the current in said circuit.

9. A transformer comprising two magnetic paths, a source of substantially constant periodic magnetomotive force for creating flux which divides between said paths, a winding linking both said paths in such manner that the fluxes in such paths induce opposing electromotive forces in said winding, means for controlling the distribution of flux from said source between said two paths, a closed magnetic path linking said winding to increase the effective reactance of such winding, a load connected with said winding, and a condenser included in series with said winding and said load and having sufficient capacity to balance the effective reactance of said winding for at least one value of current supplied by the winding to said load.

10. In combination, two windings, means for supplying periodic current to one said winding, two magnetizable cores each linking both said windings in such manner that the fluxes produced in said cores by current in such one winding flow in opposite directions at an instant through the other winding, means for varying the permeability of one said core to vary the electromotive force induced in said other winding, a third magnetizable core linking said other winding but not said one winding, and a circuit including the other said winding and effectively tuned to resonance for at least one value of the current in said circuit.

11. In combination, two windings, means for supplying periodic current to one said winding, two magnetizable cores each linking both said windings in such manner that the fluxes produced in said cores by current in such one winding flow in opposite directions at an instant through the other winding, means for varying the permeability of one said core to vary the electromotive force induced in said other winding, a third magnetizable core linking said other winding but not said one winding, a condenser, and a load connected across said condenser and said other winding in series.

12. In combination, a primary winding supplied with periodic current, a reactive secondary winding inductively related with said primary winding, an input winding operating when supplied with current to vary the electromotive force induced in said secondary winding by flux from said primary winding, a load connected with said secondary winding in an output circuit, and a condenser interposed in series with said load and said secondary winding to cause the current in said output circuit to vary discontinuously with the current supplied to said input winding.

13. In combination, a transformer comprising a primary winding and a secondary winding, means for supplying periodic current to said primary winding, means for varying the electromotive force induced in said secondary winding by such current in said primary winding, a load, a circuit for said load including said secondary winding, and means for tuning said circuit to resonance at the frequency of said current for at least one value of current in such circuit to impart a discontinuous potential-current characteristic to said circuit.

14. In combination, a primary winding, means for supplying periodic current to said primary winding, a secondary winding in inductive relation with said primary winding, means for varying the coupling between said primary and secondary windings, a magnetizable core linking said secondary winding, a load, a circuit for said load including said secondary winding, and means for tuning said circuit to resonance at the frequency of said current to impart a discontinuous potential-current characteristic to said circuit.

15. In combination, a secondary winding, a magnetizable core linking said secondary winding, a primary winding supplied with periodic current and inductively related with said secondary winding, means for varying the coupling between said primary and secondary windings, a load connected with said secondary winding, an additional winding located on said core, and a condenser connected across said additional winding for effectively tuning said secondary winding to resonance at the frequency of said current for at least one value of the current in the secondary winding.

16. In combination, two magnetic paths, a source of magnetomotive force for creating flux which divides between said two paths, a secondary winding linking both said paths in such manner that the fluxes in such paths induce opposing electromotive forces in said secondary winding, means for controlling the distribution of flux from said source between said two paths, a third magnetic path linking said secondary winding, another winding on said third path, a condenser connected across said other winding, and a load connected with said secondary winding.

In testimony whereof I affix my signature.

PHILIP H. DOWLING.