Dec. 19, 1933. C. G. SUITS 1,940,335

ELECTRICAL TIME DELAY APPARATUS

Filed March 25, 1932

Fig. 1.

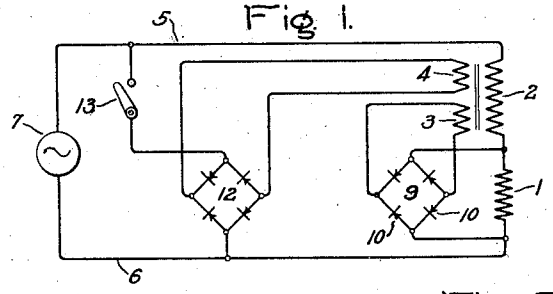


Fig. 2.

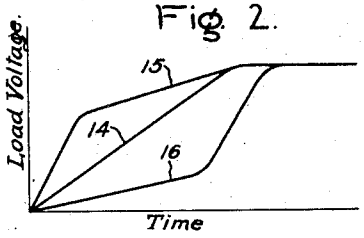


Fig. 3.

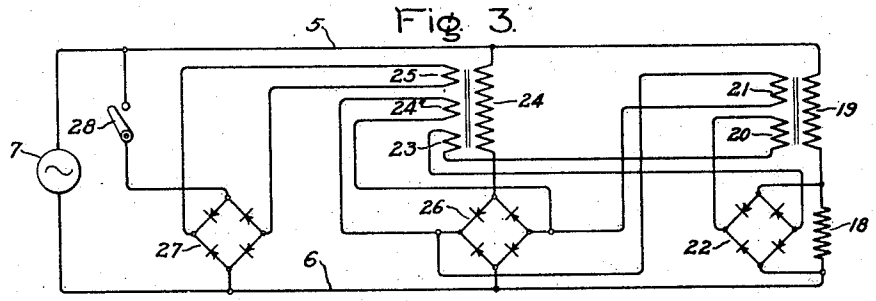


Fig. 4.

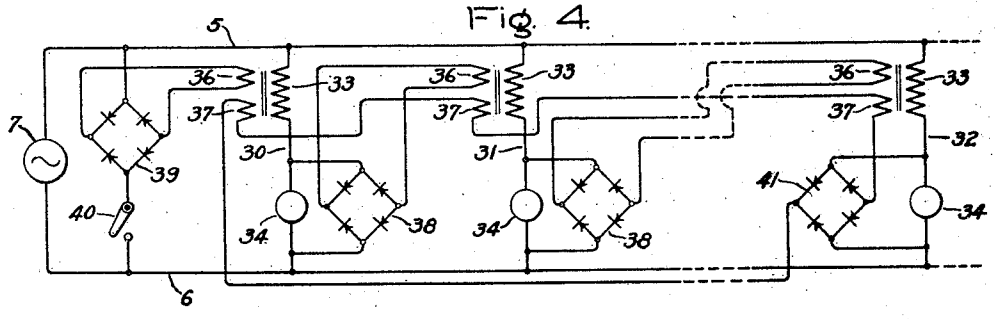


Fig. 5.

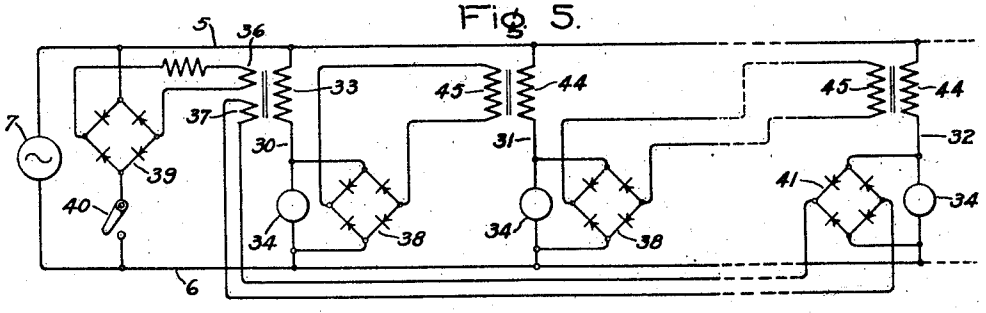


Fig. 6.

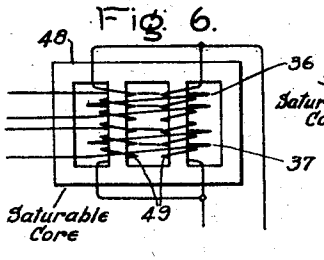
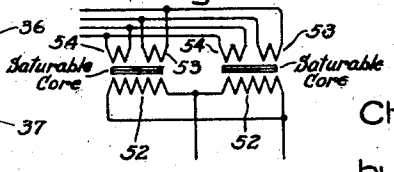


Fig. 7.



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UNITED STATES PATENT OFFICE

1,940,335

ELECTRICAL TIME DELAY APPARATUS

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Application March 25, 1932. Serial No. 601,197

10 Claims. (Cl. 171—97)

My invention relates to electrical apparatus for producing a time delay response. More particularly it relates to such apparatus wherein the time delay is dependent upon the time constant of an inductive circuit. It is the object of my invention to provide improved apparatus of this character by means of which a relatively long time delay may be effected and which is simple, efficient and inexpensive to manufacture.

My invention will be better understood from the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Fig. 1 is a circuit diagram illustrating one embodiment of my invention; Fig. 2 illustrates the effect of successive degrees of saturation of the reactor in Fig. 1; Fig. 3 is a circuit diagram showing an extension of the apparatus illustrated by Fig. 1; Figs. 4 and 5 are modifications showing my invention applied to sequence operating apparatus; and Figs. 6 and 7 illustrate two different forms of saturable core reactor which may be used in this apparatus.

It is well known that upon closing a series circuit containing a resistance, an inductance, and a source of current an appreciable time is required for the current to rise to its full value or any fraction thereof and that the length of time is determined by the ratio of the inductance to the resistance in the circuit. If at the instant at which the current reaches that value the applied voltage should be suddenly increased then a further increase of current occurs, the rate of increase being determined by the same inductance-resistance ratio as before. By continuing this process of successively increasing the applied voltage, it will be seen that the time required for the current to reach a final value may be greatly extended. It is upon this principle that the operation of the apparatus now to be described is based.

Referring to Fig. 1 the resistance 1 which represents any desired load, such for example as a relay winding, an incandescent lamp, etc., is connected in series with the saturable core reactor 2 having a plurality of separate saturating windings represented at 3 and 4. The load resistance and the reactor are shown connected by the conductors 5 and 6 with the source 7 of alternating current which may be any suitable source such as that for 60 cycle, 110 volt commercial lighting. Both the saturating windings 3 and 4 are for supplying a unidirectional saturating current to the reactor. Winding 3 is supplied with rectified current in accordance with the potential drop across the load resistance 1, this winding being connected across the resistance through the full wave rectifier 9 which is represented as comprising a well known bridge arrangement of four contact rectifiers 10. In a similar manner rectified current is supplied to winding 4 through a similar full wave rectifier 12 which in this case connects directly with the conductors 5 and 6 under the control of switch 13.

When the switch is in its open position as illustrated, the inductive reactance of the reactor 2 is so great that insufficient current flows through resistance 1 to operate the device represented thereby. At this small current value the reactor core is not saturated notwithstanding the current supplied to the saturating winding 3, which at this time is small. When switch 13 is closed, saturating current is supplied to winding 4 through the rectifier 12 which current produces a partial saturation in the reactor 2. The resulting decrease in reactance of reactor 2 causes an increase in the current flow through the reactor and the load resistance but this increase is not instantaneous since a time interval is required for it to reach full value determined by the inductance-resistance ratio. The increase in current through the load resistance gives rise to a greater current in winding 3, thus producing a further saturation of reactor 2 which in turn causes a further increase in load current but only after a further time interval determined by the inductance-resistance ratio. This process continues until the degree of saturation reaches a fixed value and the current in the load circuit reaches a maximum value. I have found that the time interval between the instant that the switch is closed and the instant that substantially full voltage appears across the load resistance may be many times the time constant of the reactor without the saturating windings. In certain cases where a single circuit of the type shown by Fig. 1 has a time constant of less than 1 second, by the use of a plurality of saturating windings on the reactor the time constant may be increased to 30 seconds or more.

In Fig. 2 I have shown at 14 a curve plotted between time and load voltage where the windings 3 and 4 produce approximately equal saturation. Curve 15 shows the relation between time and load voltage where the saturation produced by winding 4 is large as compared to that produced by winding 3. Curve 16 represents the relation where the saturation produced by winding 4 is small compared with that produced by

winding 3. In the case of curve 15 it will be seen that the initial increase in current is rapid and the final increase relatively slow while in the case of curve 16 the initial increase is slow and the final increase rapid. Thus the change of load voltage with time is susceptible to control.

In Fig. 3 I have shown the load resistance 18, the saturable core reactor 19 having saturating windings 20 and 21 and the full wave rectifier 22 all as shown in Fig. 1. In this case, however, a second saturable core reactor 24 is connected to be supplied by the same source 7, this latter reactor being shown provided with three separate saturating windings 23, 24', and 25. Reactor 24 connects through the full wave rectifier 26 with the supply leads 5 and 6. This rectifier supplies saturating current to windings 21 and 24'. Likewise rectifier 22 supplies current to windings 20 and 23 and rectifier 27, similar to rectifier 12 of Fig. 1, supplies winding 25 under the control of switch 28. In this form of my invention the time delay of the load current in reaching its final value is the combined delay brought about by the two saturable core reactors 19 and 24. The effect of the two reactors and the separate saturating windings of each is cumulative for the reasons already explained above in connection with Fig. 1 and requires for completion an interval which is large compared to the time constants of the reactors alone or the sum of these time constants.

In the modified form of my invention illustrated by Fig. 4 I have shown a series of similar branch circuits 30, 31, 32 each containing a saturable core reactor 33 and a load resistance such as lamp 34 connected across the supply circuit 5, 6. This arrangement is for producing a sequence operation of the lamps of the series by which a wave of illumination is caused to travel along the series. To this extent the arrangement is similar to that disclosed in my copending application, Serial No. 582,801, filed December 23, 1931, assigned to the same assignee as the present application. In the arrangement disclosed in my aforesaid application the saturable core reactor in each of the branch circuits has a single saturating winding which is energized by current received from a full wave rectifier connected across a lamp in the preceding branch. In my present invention the reactor in each branch circuit has a plurality of saturating windings designated at 36 and 37. Each winding 36 with the exception of the reactor in the first branch circuit is connected through the full wave rectifier 38 with the lamp 34 of the preceding branch of the series, winding 36 of the reactor of the first branch being connected through rectifier 39 directly with the supply circuit 5, 6 through switch 40. The other saturating windings 37 are connected together in a series circuit with the rectifier 41 which connects across the load in the last branch circuit.

With this arrangement, the switch 40 being assumed to be open as illustrated, the several reactors 33 of the series offer too great a reactance for the illumination of the lamps 34 in circuit therewith. When the switch 40 is closed saturating current is supplied to winding 36 of the first reactor, reducing its impedance and allowing the lamp 34 in circuit therewith to become partly illuminated. The resulting increase in potential drop across this lamp operates through the rectifier 38 connected therewith to supply saturating current to winding 36 of the reactor in the next branch circuit. Hence the lamp in this branch circuit becomes partly illuminated as in the first branch and this operation continues on down the whole series of branch circuits until all of the lamps become partly illuminated. When the last lamp of the series becomes illuminated the increased potential drop across the same operates through rectifier 41 to supply an increased saturating current to each of the saturating windings 37. Hence the degree of saturation of each of the reactors is thereby increased decreasing the impedance of each reactor and causing the illumination of each lamp of the series simultaneously to increase. Coincident with the increased illumination of each lamp the potential drop therethrough increases and an increase in saturating current is thereby supplied to windings 36 of the subsequent reactors of the series. Hence additional waves of increased brightness travel down the series of lamps.

The modified form illustrated by Fig. 5 is similar to that disclosed in Fig. 4 with the exception that reactors 44 in all of the branch circuits after the first branch have but a single saturating winding 45 which is connected in the same manner as windings 36 of the form shown in Fig. 4. The reactor 33 of the first branch circuit 30 has saturating winding 36 connected through the rectifier 39 with the supply circuit 5, 6 through switch 40 as in Fig. 4 but saturating windng 37 alone connects with the rectifier 41 supplied from the lamp of the last branch circuit.

In accordance with this arrangement before the switch 40 is closed the several lamps of the series are not illuminated but when switch 40 is closed a wave of illumination travels down the series and when the last lamp is illuminated additional saturation is produced in the reactor of the first branch circuit. Hence another wave of greater illumination travels down the series, this being repeated until all of the lamps will burn with a uniform illumination. In both Figs. 4 and 5 it will be understood that when switch 40 is opened successive waves of decreased illumination progress down the series until a condition of equilbrium is reached at which all of the lamps are not illuminated.

The several saturable core reactors described above and shown diagrammatically in the several circuit diagrams may be constructed in the manner illustrated by Fig. 6 where the four-legged core 48 is shown having its main winding comprisng the coils 49 wound in opposite directions on the two inner legs and as having a plurality of saturating windings, two in the present case, shown at 36 and 37 each wound in the same direction on both of said legs. A reactor of this type is disclosed in the Alexanderson Patent No. 1,328,610, dated January 20, 1920. If desired the saturable core reactors may be constructed each as two separate transformers as illustrated for example by Fig. 7 where the main winding of the reactor is represented by the coils 52 and the saturating windings represented by the coils 53 and 54. With this arrangement by reversing the coils 52 any induced alternating electromotive force of fundamental frequency may be prevented from reaching the rectifiers.

I have chosen the particular embodiments described above as illustrative of my invention and it will be apparent that various other modifications may be made without departing from the spirit and scope of my invention which modifications I aim to cover by the appended claims.

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

1. Apparatus adapted to be connected with a

source of alternating current for producing a delay in the time required for a current taken from said source to reach a predetermined value comprising a saturable core reactor for controlling said current having a plurality of saturating windings, control means for one of said windings and means responsive to the reactor current for controlling another of said windings.

2. Apparatus for producing a time delay response in the operation of an alternating current actuated device comprising a saturable core reactor for controlling the current taken by the device, the reactor being provided with a plurality of saturating windings, means for controlling the energization of one of said windings and means responsive to the current in the reactor for controlling the energization of another of said windings.

3. Apparatus for producing a time delay response in the operation of an alternating current actuated load device comprising a saturable core reactor for controlling the curent in the load device, the reactor being provided with a plurality of saturating windings, means for controlling the energization of one of said windings and means responsive to the load current for controlling the energization of another of said windings.

4. Apparatus for producing a time delay response in the operation of an alternating current actuated load device comprising a saturable core reactor in circuit with the load device having a plurality of saturating windings, means for controlling the energization of one of said windings and a rectifier connected with the load device for supplying saturating current to another of said windings.

5. Apparatus for producing successive time delay responses in a plurality of load devices when connected with the same alternating current supply circuit comprising a saturable core reactor arranged to be connected with each device, one of said reactors having a plurality of saturating windings, means for controlling the energization of one of said windings and means responsive to the load current in the device associated with another reactor for controlling the energization of the other of said windings and for controlling the saturation of said other reactor.

6. In combination, an alternating current supply circuit, a plurality of load devices connected to be supplied therefrom, a saturable core reactor in circuit with each device, one of said reactors having a plurality of saturating windings, means for controlling one of said windings, means responsive to the load current in the device associated with another of said reactors for controlling the other winding and means responsive to the load current in the device associated with said one reactor for controlling the saturation of said other reactor.

7. In combination, an alternating current supply circuit, a series of load devices connected to be supplied therefrom each having a saturable core reactor in circuit therewith, the reactor of the first device of the series having a plurality of saturating windings, means for controlling the energization of one of said windings, means for controlling the energization of each of the other reactors in response to the load current taken by the device which precedes it in the series and means responsive to the load current in the last device for controlling the energization of another of said windings.

8. In combination, an alternating current supply circuit, a series of load devices connected to be supplied therefrom each having a saturable core reactor in circuit therewith and each reactor having a plurality of saturating windings, manual means for controlling the energization of one winding of the first reactor of the series, means for controlling the energization of one winding of each of the other reactors in response to the current taken by the preceding load device and means responsive to the load current taken by last device for controlling the energization of another saturating winding of each of the reactors.

9. In combination, a source of alternating current, a load connected to be supplied therefrom and means for producing a time delay change in the voltage applied to said load comprising a saturable core reactor in circuit with the load, means for changing the degree of saturation of the reactor in one sense and means responsive to the resulting change in voltage applied to the load for producing a further change in saturation of the reactor in the same sense.

10. In combination, a source of alternating current, a load connected to be supplied therefrom and means for producing a time delay change in the voltage applied to said load comprising a saturable core reactor in circuit with the load having a plurality of saturating windings, means connected therewith for producing a change in the degree of saturation of the reactor in one sense and means responsive to the resulting change in load current for producing a further change in saturation of the reactor in the same sense.

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