Jan. 26, 1943. R. A. ANDREWS 2,309,156

ELECTRIC CONTROLLING APPARATUS

Filed Dec. 14, 1940 2 Sheets-Sheet 1

Fig. 1.

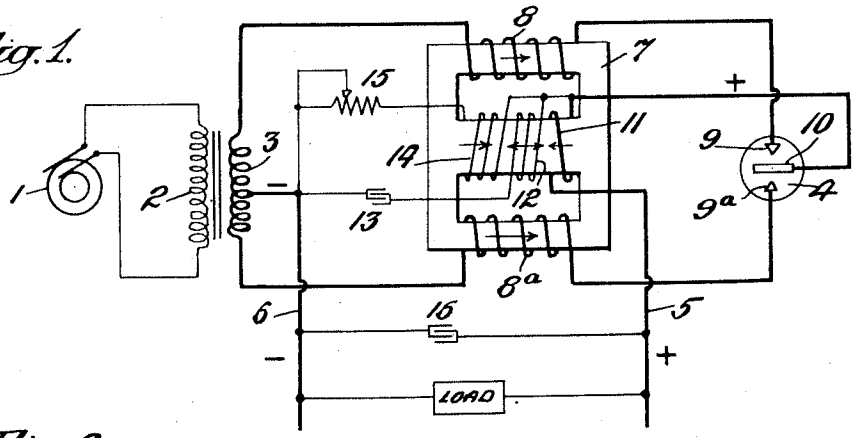


Fig. 2.

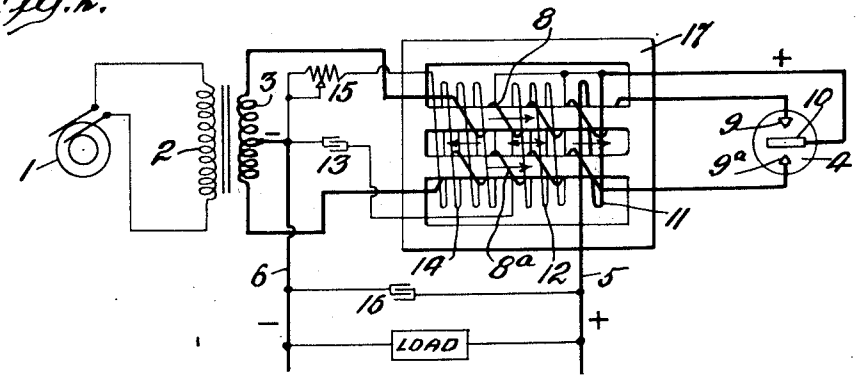
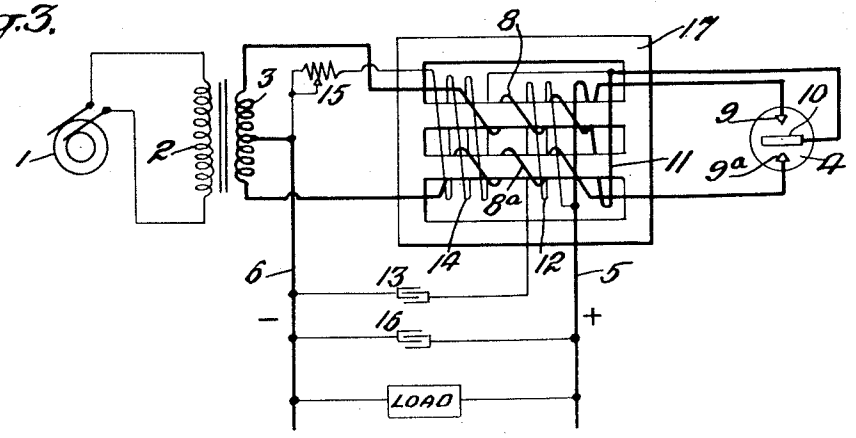


Fig. 3.



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Fig. 4.

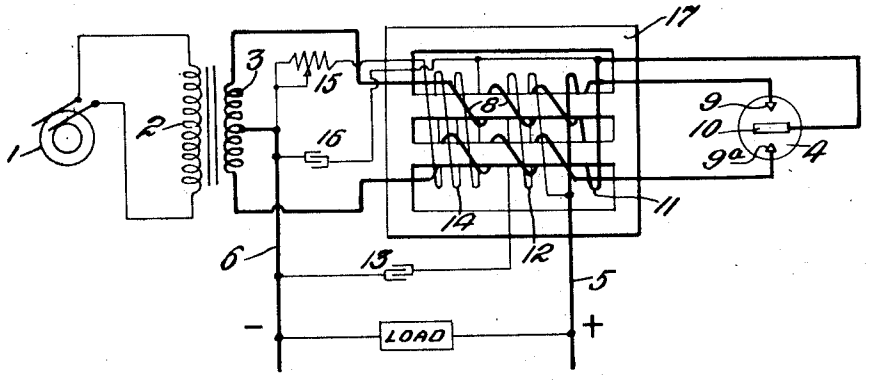
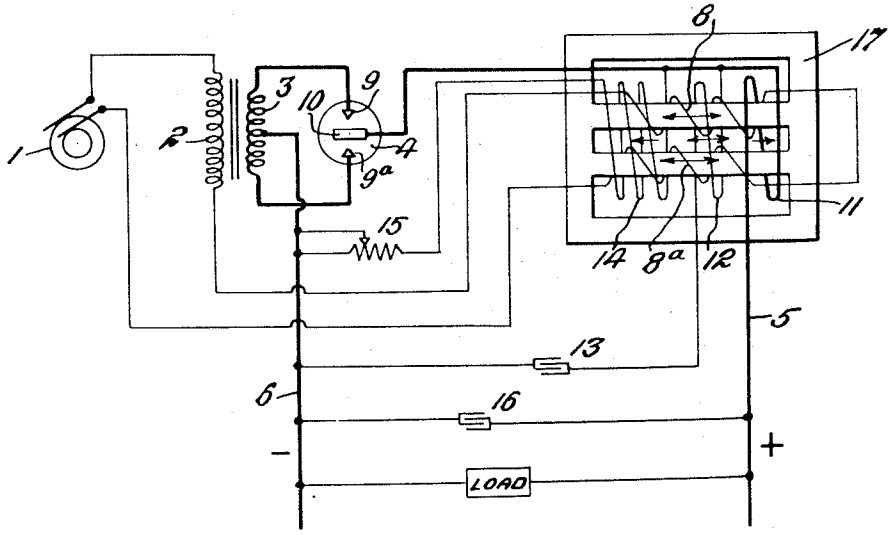


Fig. 5.



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Patented Jan. 26, 1943 2,309,156

UNITED STATES PATENT OFFICE

2,309,156

ELECTRIC CONTROLLING APPARATUS

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Application December 14, 1940, Serial No. 370,112

13 Claims. (Cl. 175—363)

This invention relates to voltage regulating apparatus for a direct current circuit deriving current from an alternating current source and is particularly applicable to circuits which are subjected to abrupt changes in the load current, such as circuits used for telegraphic purposes and for various other uses.

Where the change in load is abrupt and rapid it has been difficult to maintain the voltage of the circuit substantially constant owing to the fact that before the corrective action can become effective a change in voltage has already taken place. For example, when anode reactors are used with a series compensating coil in the load circuit, if the load current changes rapidly, the corrective action is too slow, resulting in fluctuations of the voltage before proper compensation can occur.

The main object of the present invention is to provide a simple form of apparatus without moving parts that will effectively maintain the voltage substantially constant regardless of the rapidity of the change of load, or how frequently such changes may occur. Another object is to provide a compact form of apparatus occupying small space and which will be durable in long continued use. Another object is to avoid the use of sensitive or expensive devices which require care and replacement from time to time. Other objects and advantages will be understood from the following description and accompanying drawings which illustrate preferred embodiments of the invention.

Fig. 1 is a diagram showing one form of the invention; Fig. 2 is a diagram showing the invention applied to a different form of reactor core; and Figs. 3 to 5 are diagrams showing the parts connected in different ways.

Referring to Fig. 1, an alternating current source 1 is shown supplying current to a transformer having a primary winding 2 and a secondary winding 3. The alternating current is rectified by a full wave electronic rectifier 4, the cathode of which is connected to one side 5 of the consumption circuit, the other side 6 being connected to a mid-tap of the secondary winding 3. The rectifier may be of any form or type but is preferably a three element tube as indicated, this being the simplest type for most cases. Instead of using a full wave rectifier, two half-wave rectifiers may be used connected in a similar manner when desirable for capacities different from those available in a three element tube.

An anode reactor is shown having a core 7 of the three-legged type, although this form of core may be modified to assume various forms provided the relationship of the windings is such as to obtain the proper flux reactions. In the simple form of reactor shown, the two outer legs of the core are provided with anode windings 8 and 8a which are connected respectively in series between the outer terminals of the secondary 3 and the anodes 9 and 9a of the rectifier. These anode windings are wound or connected in such direction on their cores as to have a return flux through the middle leg of the core in the same direction. The arrows on the outer legs indicate an assumed direction of flux from left to right which results in the return path in the middle leg of the core being from right to left. The cathode 10 of the rectifier is connected to a series winding 11 on the middle leg of the core from which the circuit continues to the line 5 of the consumption circuit. The direction of the ampere-turns of this winding is such as to act cumulatively with the flux of the anode windings, as indicated by the arrow applied on the winding 11 showing that its flux passes from right to left through the middle leg.

Another winding 12 is applied to the middle leg of the core and is connected across the consumption circuit through a condenser or capacitor 13, the connection shown being made to the tube cathode 10 at one end of the coil and from the other end of the coil through the condenser 13 to the middle tap of the secondary winding 3. The winding 12 is wound or connected in such direction on the core as to secure the compensating effect later described and is shown wound in the reverse direction to that of the series winding 11. The current in the winding 12 is a varying one and is sometimes in one direction and sometimes in the opposite direction as indicated by the double arrow applied to the winding 12. Another winding 14 is applied to the middle leg of the core, being a shunt winding connected at one end to the tube cathode 10 and at the other end through an adjustable resistance 15 to the other side of the consumption circuit. This winding is wound or connected in the reverse direction to that of the series winding and its flux is in such direction that it opposes the flux of the anode windings, as indicated by the arrow applied to the winding 14. This shunt connected winding is for the purpose of adjusting the voltage of the consumption circuit at zero or light load. A filter condenser 16 is connected across the consumption circuit. This condenser may not be used in some instances.

The series winding 11 tends to compensate for changes in the load on the consumption circuit in the usual manner. That is, upon increase in load the flux created by the series winding increases, and being cumulative with the flux of each of the anode windings, increases the total flux of the core which reduces the reactance of the anode windings. This results in less drop in volts in the anode windings and thereby tends to maintain the voltage of the consumption circuit to compensate for the increased load. Upon decrease of the load, the series winding has a decreased cumulative effect which results in increasing the reactance of the anode windings and increasing the drop in volts therein which thus tends to maintain the voltage constant.

However upon abrupt changes of load, the compensating effect of the series winding is not quick enough to prevent the voltage of the consumption circuit from momentarily changing appreciably. The winding 12 overcomes these fluctuations of the voltage of the consumption circuit upon the occurrence of abrupt changes in load. For example, when there is an abrupt increase in load tending to produce a momentary drop in voltage of the consumption circuit, the initiation of such a tendency causes the winding 12 to cooperate with winding 11 to cause a quick change of the flux in the core to reduce the reactive effect and thereby avoid any objectionable momentary drop in the voltage. The series winding 11 acts to maintain the voltage substantially constant, or to increase the voltage by over-compounding if desired. Similarly upon an abrupt decrease in load, the tendency to increase the voltage momentarily is overcome by the winding 12 cooperating with the winding 11 to cause a quick change of the flux to increase the reactive effect and thereby avoid any objectionable momentary increase in the voltage of the consumption circuit. The series winding by its decrease current serves to maintain the voltage at its proper value.

By means of the shunt winding 14 and adjustment of the resistance device 15, the flux in the core of the reactor may be increased or decreased for securing the proper drop in volts in the anode windings and thereby obtain the desired no load voltage on the consumption circuit. Adjustment to increase the current in the winding 14 will increase the reactance and drop in volts in the anode windings to decrease the voltage of the consumption circuit to the desired amount, while adjustment to decrease the current in the winding 14 will decrease the reactance and drop in volts of the anode windings and thereby enable the no load voltage to be raised to the desired amount. In some cases the direction of turns of the shunt winding may be reversed from that above considered in which case adjustment to increase the current in the winding 14 will increase the voltage of the consumption circuit while adjustment to decrease the current in the winding 14 will then increase the voltage of the consumption circuit to the desired amount.

Although the windings 11 and 12 and 14 are indicated side by side on the center leg of the core, this is merely for clearness and understanding the relationship of the windings and their connections; and in practice these may be superimposed one over the other and may extend along the length of the middle leg of the core. In some cases the winding 14 may not be used and although the series winding 11 and the compensating winding 12 are both desirable in their cooperative effects for securing the best results, there may be conditions which do not require the presence of the series winding in which case the winding 12 would serve to avoid abrupt changes in the voltage of the consumption circuit.

In Fig. 2 the same reference characters indicate the parts already described in connection with Fig. 1 but here a different form of core is provided. In Fig. 2 the core 16 is a four-legged core and the anode windings 8 and 8a are wound or connected on the two inner legs of the core respectively and in such direction as to have a common direction of flux, that is, for example, the flux of these anode windings is indicated by the arrows on the two middle legs as passing from left to right. The series winding 11 envelops the two middle legs of the core and the windings 8 and 8a are wound or connected in a direction to act cumulatively with the flux of the anode windings, as indicated by the arrow applied to the winding 11. The compensating winding 12 also envelops both of the inner two legs of the core and is wound or connected in an opposite direction to that of the series winding and creates a flux which is sometimes aiding and sometimes opposing the flux of the anode windings 8 and 8a, as indicated by the double arrow applied to the winding 12. The shunt winding 14 also envelops both of the inner legs of the core and is shown wound in a direction to oppose the flux of the anode windings, as indicated by the arrow applied to the winding 14. Although these windings are shown displaced from each other, they may in practice be superimposed one over the other and may extend over the whole length of the two inner legs.

The mode of operation of the apparatus in Fig. 2 is similar to that already described with reference to Fig. 1, the form of core and relationship of windings in Fig. 2 giving a closer coupling between the anode windings and the control windings and also has the advantage of reducing the leakage flux of the anode windings.

Fig. 3 is similar to Fig. 2 except the winding 12 with its condenser 13 is shown connected directly across the output lines 5 and 6. Fig. 4 is the same as Fig. 3 except the condenser 16 is shown connected between the line 6 and the cathode 10. Fig. 5 is similar to Fig. 2 except that the windings 8, 8a instead of being connected in the circuit of the secondary winding 3 and with the respective anodes of the rectifier, are connected in series with each other and in series with the primary winding 2 of the transformer, the anodes of the rectifier being connected directly to the terminals of the secondary winding 3. In this form the windings 8 and 8a are subjected to an alternating current and are so wound or connected as to cause the flux created by these windings to pass in opposite directions at any one instant through their cores, that is, say from left to right within the winding 8 and from right to left within the winding 8a when the current is passing in one direction and from right to left within the winding 8 and from left to right within the winding 8a when the current is passing in the opposite direction. The windings 11, 12 and 14 function in general in the manner already described, serving to control the voltage at the terminals of the primary winding 2. This in turn affects the voltage of the secondary winding and thereby controls the voltage applied to the anodes 9 and 9a.

Although certain embodiments of the invention have been described it will be understood that

various modifications and various applications of this invention may be made without departing from the scope thereof.

I claim:

1. Controlling apparatus comprising rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having windings respectively connected in series in each supply line connected to said rectifying means, and also having a winding for affecting the flux of said first named windings and connected across the consumption circuit and having a capacitor connected in series therewith.

2. Controlling apparatus comprising rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having windings respectively connected in series in each supply line connected to said rectifying means, the core also having a series winding connected between the rectifying means and one side of the consumption circuit, said series winding acting cumulatively with said first named windings, and also having a winding for affecting the flux of said first named windings and connected across the consumption circuit and having a capacitor connected in series therewith.

3. Controlling apparatus comprising rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having windings respectively connected in series in each supply line connected to said rectifying means, the core also having a series winding connected between the rectifying means and one side of the consumption circuit, said series winding acting cumulatively with said first named windings, also having a winding for affecting the flux of said first named windings and connected across the consumption circuit and having a capacitor connected in series therewith, and also having a shunt winding affecting the flux of said first named windings and connected across the consumption circuit.

4. Controlling apparatus comprising full wave electronic rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having windings respectively connected in series in the supply lines from the source to the anodes of the rectifying means, and also having a winding for affecting the flux of said windings and connected across the consumption circuit and having a capacitor connected in series therewith.

5. Controlling apparatus comprising full wave electronic rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having windings respectively connected in series in the supply lines from the source to the anodes of the rectifying means, the core also having a series winding connected between the rectifying means and one side of the consumption circuit, said series winding acting cumulatively with the flux of said windings, and also having a winding for affecting the flux of said first named windings and connected across the consumption circuit and having a capacitor connected in series therewith.

6. Controlling apparatus comprising full wave electronic rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having windings respectively connected in series in the supply lines from the source to the anodes of the rectifying means, the core also having a series winding connected between the rectifying means and one side of the consumption circuit, said series winding acting cumulatively with the flux of said windings, also having a winding for affecting the flux of said first named windings and connected across the consumption circuit and having a capacitor connected in series therewith, and also having a shunt winding cooperating with said first named windings and connected across the consumption circuit.

7. Controlling apparatus comprising full wave rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having windings respectively connected in series in each supply line connected to said rectifying means, a common portion of the core being subjected to the flux of said windings in one direction only, and also having a winding on said portion of the core for affecting the flux of said windings and connected across the consumption circuit and having a capacitor connected in series therewith.

8. Controlling apparatus comprising full wave rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having windings respectively connected in series in each supply line connected to said rectifying means, a common portion of the core being subjected to the flux of said windings in one direction only, the core also having a series winding on said portion of the core connected between the rectifying means and one side of the consumption circuit, said series winding acting cumulatively with the flux of said windings, and also having a winding on said portion of the core for affecting the flux of said first named windings and connected across the consumption circuit and having a capacitor connected in series therewith.

9. Controlling apparatus comprising full wave rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having two inner portions, windings on said portions respectively and connected in series respectively with each supply line connected to said rectifying means, and said core also having a winding connected across the consumption circuit and having a capacitor connected in series therewith and enveloping both of said inner portions.

10. Controlling apparatus comprising full wave rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, and a reactor, the core of said reactor having two inner portions, windings on said portions respectively and connected in series respectively with each supply line connected to said rectifying means, said core also having a series winding connected between the rectifying means and one side of the consumption circuit and enveloping both of said inner portions, and said core also having a winding connected across the consumption circuit and having a capacitor connected in series therewith and enveloping both of said inner portions.

11. Controlling apparatus comprising rectifying means for converting current from an alternating source and for supplying a direct current

consumption circuit, a transformer having its primary winding connected to said source and its secondary winding connected to said rectifying means, and a reactor, the core of said reactor having a winding connected in series with the primary of said transformer, and also having a winding for affecting the flux of said first named reactor winding and connected across the consumption circuit and having a capacitor connected in series therewith.

12. Controlling apparatus comprising rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, a transformer having its primary winding connected to said source and its secondary winding connected to said rectifying means, and a reactor, the core of said reactor having a winding connected in series with a winding of said transformer, and also having a winding for affecting the flux of said first named reactor winding and connected across the consumption circuit and having a capacitor connected in series therewith.

13. Controlling apparatus comprising rectifying means for converting current from an alternating source and for supplying a direct current consumption circuit, a transformer having its primary winding connected to said source and its secondary winding connected to said rectifying means, and a reactor, the core of said reactor having a winding connected in series with a winding of said transformer, also having a series winding connected between said rectifying means and one side of said consumption circuit for affecting the flux of said first named reactor winding, and also having a winding connected across the consumption circuit and having a capacitor connected in series therewith for affecting the flux of said first named reactor winding.

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