May 23, 1933. H. K. KOUYOUMJIAN 1,910,172

ELECTRIC CONTROLLING APPARATUS

Filed Sept. 10, 1930

Fig. 1.

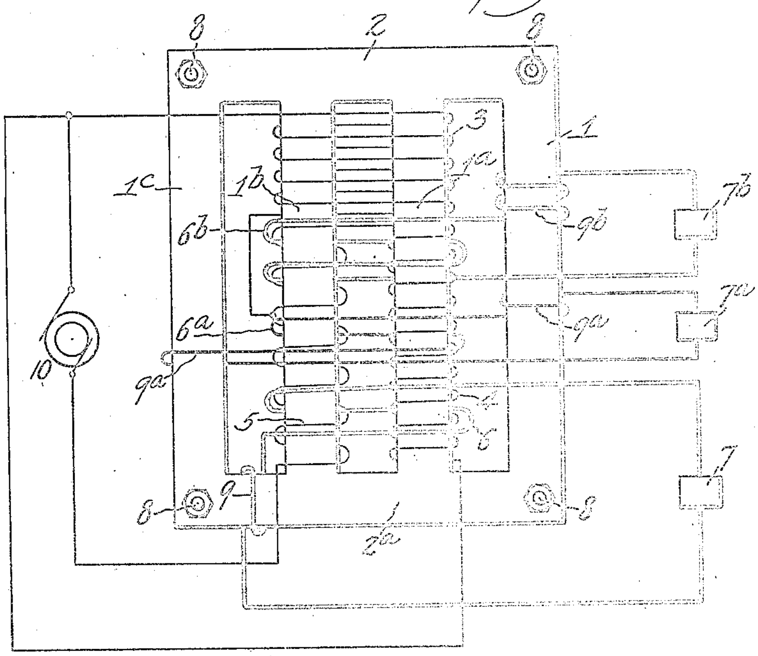


Fig. 2.

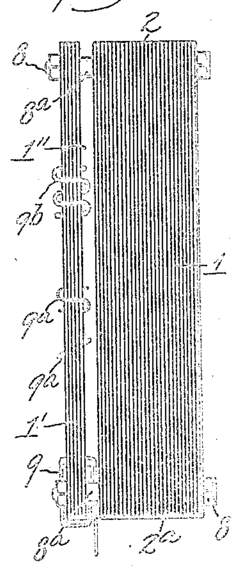
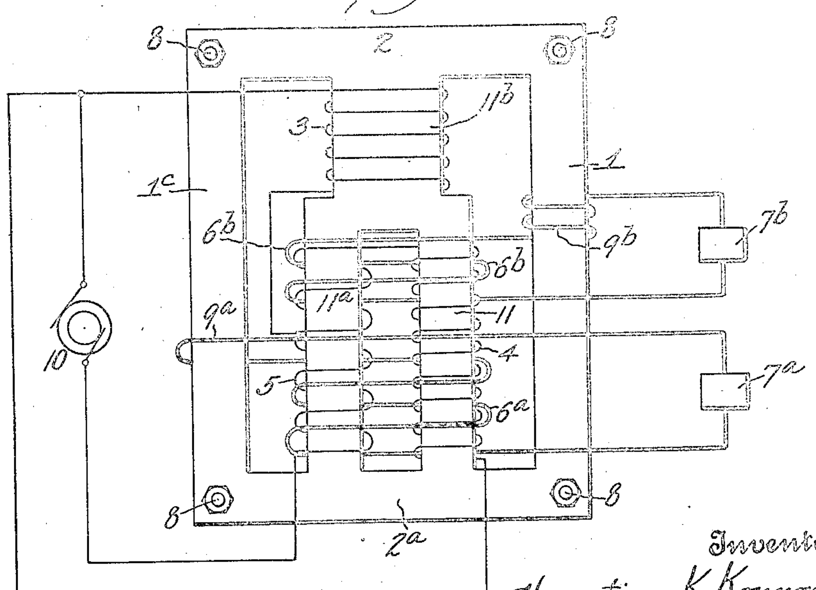


Fig. 3.



Inventor

Harootiun K. Kouyoumjian

By his Attorney

Lawrence K. Sager.

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UNITED STATES PATENT OFFICE

HAROUTIUN K. KOUYOUMJIAN, OF PROVIDENCE, RHODE ISLAND, ASSIGNOR TO WARD LEONARD ELECTRIC COMPANY, A CORPORATION OF NEW YORK

ELECTRIC CONTROLLING APPARATUS

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This invention relates to an improved form of construction and method of obtaining a refinement in adjustment of the windings in electric controlling apparatus, and particularly to my improved alternating current regulator wherein the output voltage is maintained constant, or approximately constant, regardless of variations in voltage of the supply circuit, such as disclosed in my pending applications Serial Number 306,259, filed September 15, 1928, and Serial Number 344,-333, filed March 5, 1929, and also in later pending applications covering improvements thereon.

In such type of apparatus where accurate results as to the value of the output voltage is required, it may frequently occur, even in duplications of prior apparatus, that the output voltage will be somewhat higher, or lower, than that desired. In such a case where a core type of apparatus is used, the secondary, or output, winding can be changed by the amount of about one turn, and in the shell type by the amount of one-half turn. Such changes may make too great a change in the desired output voltage. Where only one output winding is used, the required refined adjustment can be obtained by changing the turns of the primary, or exciting, winding in cases where the voltage is stepped down, because the change of one turn or one-half turn in the primary winding would have less effect upon the output voltage than would the change of one turn or half a turn in the output winding. But where there are two or more output windings, refined adjustment of the primary exciting winding may take care of the desired output voltage for one winding, but not for the others. Therefore, some means in such cases, must be provided for individual refined adjustment of the different output windings.

The main object of this invention is to provide an improved method and means for refined adjustment of individual windings without materially affecting the others, and to do this in a simple manner which may be conveniently and economically accomplished in practice. Other objects and advantages of this invention will be understood by the following description and accompanying drawing.

Fig. 1 is a diagram of apparatus embodying this invention and showing one form of core in front elevation; Fig. 2 is a side view of the core, although for simplicity, the windings are not indicated thereon, except the auxiliary turns for refined adjustment; and Fig. 3 is a diagram of another embodiment of my invention showing in front elevation a different form of core from that of Fig. 1.

Referring to Fig. 1, the laminated iron or steel core is shown having four legs 1, 1*a*, 1*b* and 1*c*, which are joined at their upper and lower ends by cross-pieces 2, 2*a*. Ordinarily, the cross-sections of the different parts of the core will be the same, although in some cases, for particular purposes the cross-sections of the different parts may be modified relatively to each other. The two inner legs carry a number of windings which are indicated diagrammatically, but it will be understood that the number of turns of the different windings will be made such as the particular conditions require, and it will also be understood that the location of the windings may be modified from that indicated, and that some of the windings instead of being superimposed with reference to each other, may be located side by side, or may be more or less distributed or sandwiched with each other to meet particular conditions as regards requirements, cost of manufacture, convenience of assembling, and the like.

The main, or primary, winding 3 is shown as enveloping both of the inner legs at their upper portions. Another winding 4 is shown enveloping the lower portion of the leg 1*a* and is cumulatively acting with reference to the winding 3 as regards the flux tending to be set up in the leg 1*a*. Another winding 5 is located on the lower portion of the leg 1*b* and is so wound and connected as to act in opposition to the winding 3, as regards magnetic flux tending to be set up in the leg 1*b*. A secondary, or output, winding 6 is shown enveloping the lower portions of the legs 1*a* and 1*b*, and also enveloping the windings 4 and 5. The winding 6 is shown as supplying a translating device 7 which may be any form of translating device. Similarly, secondary or output windings 6a, 6b are shown enveloping the lower portions of the legs 1a and 1b, and respectively supply translating devices 7a and 7b.

The core as indicated in Fig. 2, has a spaced portion 1′ which is separated from the main portion thereof, in a plane parallel to the plane of the laminæ by the gap 1″ and spaced from the main portion in a direction at right angles to the plane of the laminæ. The portion 1′ so spaced is built up of laminæ and of the same form as the main portion of the core, but is ordinarily made comparatively thin with respect to the thickness of the main portion of the core. Through bolts 8 are indicated at the corners of the core for holding the laminæ together, and spacing tubes 8a may be provided on these bolts 8 for spacing the portion 1′ of the core from the main portion. Of course, any other suitable means for holding the core together and for spacing a portion of the same therefrom may be used. The output winding 6 is indicated in Figs. 1 and 2 as including in series therewith one or more turns 9 which are passed around the lower spaced portion of the core 1′, being shown, for example, as enveloping a cross end portion. Similarly, the output winding 6a is shown as having one or more turns 9a enveloping a side portion of the part 1′ of the core, and also as having in series one or more similar turns 9a around the opposite side of the portion 1′ of the core. Likewise, the output winding 6b is shown as having a few turns 9b around the right hand side portion of the spaced part of the core.

The alternating current source of energy 10 supplies current to the windings described, the windings 4 and 5 being connected in series with each other across the supply lines, and the primary winding 3 being shown connected in parallel with the winding 4 and in series with the winding 5 across the supply lines, or, more strictly stated, in series with a portion of the winding 5. The particular point in the winding 5 to which one terminal of the winding 3 is connected may be varied in order to obtain the desired results. In some cases, the primary winding may be connected in series with all of the bucking winding 5, or it may be connected in series with it and in series with more or less of the winding 4. In some cases the primary winding may be connected directly across the line, and in parallel with the other two windings which may be in series with each other, or in some cases in parallel with each other.

The particular form of connection shown, however, is desirable in most cases, as it gives better operating results and permits the use of fewer turns in the bucking winding, than would otherwise be necessary. One particular advantage of this form of connection is that, upon increase in the supply voltage above normal, the tendency is to reduce the watt-less current in the main winding. This, of course, results in improving the regulation, because less watt-less current means less primary ampere turns and less flux which the bucking winding must overcome. A further advantage results in permitting the bucking winding to be made with fewer turns. Another advantage results from the fact that by reason of the core of the bucking winding being less saturated than the core of the primary winding, an increase in the input voltage will produce a greater proportionate reactance drop on the bucking winding than on the primary winding. Thus, an increase in the input voltage produces a lesser increase on the primary winding than would be the case if the primary reactance increased proportionately to the bucking coil reactance. This lesser proportionate change of supply voltage in affecting the primary winding requires a correspondingly less amount of regulation in giving the desired results.

The cross-section of the leg 1a and number of ampere turns of the windings enveloping this leg are such that under normal conditions, this core is worked near or just below the knee of the saturation curve, although in some cases, for particular requirements, this core may be normally worked at a different part of the saturation curve. The cross-section of the leg 1b and the net ampere turns of the windings enveloping this leg are such that this leg is normally worked on the so-called straight part of the saturation curve below the knee of the curve, although for particular purposes, the normal condition of this leg of the core may be such as to be normally worked at a higher or lower portion of the straight part of the saturation curve, according to the results desired.

The operation in a general way may be understood by first assuming the supply voltage and output voltage to be at normal amounts and assuming a particular instant of the alternating current waves such as to cause the flux to pass downwardly in the leg 1a, as caused by the cumulative action of the windings 3 and 4, and a downward passage of flux in the leg 1b, as caused by the predominating action of the winding 3 over the bucking action due to the winding 5. It will, of course, be understood that the outer legs and the upper and lower cross-portions of the core serve as return paths for the flux.

Now assume that the supply voltage falls to an abnormally low amount. The decreased amount of excitation of the leg 1a, whether it be small or comparatively large in amount, will be offset by a corresponding increase in the amount of flux in the leg 1b, owing to the fact that the bucking winding 5 becomes less effective in its opposition and, as this leg is operating on the straight part of the saturation curve, there will be a resulting increase in the flux in this leg. It will be appreciated, furthermore, that the bucking winding is in series with the cumulatively acting winding, and that upon change of voltage, owing to the fact that the leg enclosed by the cumulative winding is near saturation, a larger proportionate change in the value of the current takes place in the cumulative and bucking windings than in the main winding. Thus, upon decrease of supply voltage, there is a proportionately greater decrease in value of the current in the bucking winding than in the main winding. Thus the change in flux to which the output winding 6 is subjected, is not materially changed with a decrease in the supply voltage and permits the output voltage to remain substanially unchanged. Similarly, when the supply voltage increases, the increase in resultant flux in the leg 1*a* is offset by a corresponding decrease in the flux in the leg 1*b*, because the bucking winding then exerts increased bucking action. This results in the flux to which the output winding 6 is subjected remaining substantially the same and in not materially affecting the output voltage.

It will be understood that by properly proportioning the legs of the core and the number of turns of the different windings and variation of the point at which the primary winding is connected to the bucking winding, any desired result may be obtained. For example, an increase in supply voltage may be caused to deliver a decreased output voltage in greater or lesser amount, as desired, or the output voltage may be caused to increase with the increase of supply voltage to a small amount, or to a considerable amount, as desired, or the output voltage may be caused to remain constant over a considerable range of variation in supply voltage, and then at a certain limit cause the output voltage to decrease. Thus any desired change in the output voltage may be caused to occur with change of the supply voltage by properly proportioning and relating the parts, although for most purposes, it will be desirable to obtain a substantially constant output voltage regardless of variations in the supply voltage. The action of the controller is also such that it will maintain the voltage substantially constant, even when change in the frequency of the supply occurs; or, by suitably proportioning the parts, may cause the output voltage to change as desired upon change of frequency.

Now, as regards the auxiliary turns of the output windings which envelope portions of the part of the core spaced from the main part, it may, for example, in the case of Fig. 1 be required that the output voltage of the winding 6 is to be 1.5 volts, that of the winding 6*a* 1.9 volts, and that of the winding 6*b* 1.7 volts. A full turn, or a half turn of these output windings, added or subtracted, may be too much, or too little, to give these particular output voltages; and, obviously, adjustment of the primary winding would affect all of the output windings alike, or substantially so. Thus, for the particular results desired, individual refined adjustment of the output windings becomes necessary. This is accomplished by adding a suitable number of turns 9, 9*a* and 9*b*, as may be necessary in the different windings to secure the required output voltages. Obviously, by making these turns around a small portion of the core, as already described, the effect of each of these auxiliary turns is comparatively slight on the output voltage, so that a very refined adjustment thereof may be made. Also, instead of winding these auxiliary turns in a direction to be additive to the voltage of the main output winding, they may be wound in the opposite direction so as to give a slightly reduced voltage, where such a compensation is required.

Fig. 2 illustrates another improved form of my regulator, or controller, wherein portions of the two inner legs are merged into one leg. This forked form of core results in a considerable reduction in the size and cost of the primary winding by reason of permitting it to be of a much smaller diameter than in the form shown in Fig. 1. It also is highly desirable in that it permits a large range of flexibility in location of the secondary windings in an economical manner and in changing the relative proportions of parts of the core to suit particular requirements. In Fig. 2, the two inner legs 11 and 11*a* correspond to the portion of the legs 1*a* and 1*b* of Fig. 1, but these portions are merged into a common leg or portion 11*b*, which in turn is joined to one of the end pieces of the core. As regards other portions of Fig. 3, they correspond with and are given reference characters like those of Fig. 1, although only two output windings 6*a* and 6*b* are indicated in Fig. 3.

The particular form of the core and the relationship of the windings may obviously be modified as described in my said prior applications and various other modifications may be made without departing from the scope of my invention.

I claim:

1. Alternating current controlling apparatus comprising a laminated core, an alternating current exciting winding on said core, a second alternating current exciting winding on another portion of said core acting in opposition to said first-named winding, a plurality of output windings on said core subjected to resultant magnetic effects, said core having a portion thereof spaced from the remaining portion in a direction at right angles to the plane of the laminæ of the core, and at least one auxiliary winding embrac-

ing said spaced portion of the core only and in series with at least one of said output windings.

2. Alternating current controlling apparatus comprising a laminated core, an alternating current exciting winding on said core, a second alternating current exciting winding on another portion of said core acting in opposition to said first-named winding, a plurality of output windings on said core subjected to resultant magnetic effects, said core having a portion thereof spaced from the remaining portion in a direction at right angles to the plane of the laminæ of the core, and at least one auxiliary winding embracing said spaced portion of the core only and in series with at least one of said output windings, said portion of the core enveloped by said second-named winding being below saturation.

3. Alternating current controlling apparatus comprising a laminated core, an alternating current exciting winding on said core, a second alternating current exciting winding on another portion of said core acting in opposition to said first-named winding, a plurality of output windings on said core subjected to resultant magnetic effects, said core having a portion thereof spaced from the remaining portion in a direction at right angles to the plane of the laminæ of the core, and at least one auxiliary winding embracing said spaced portion of the core only and in series with at least one of said output windings, said first-named winding being in series with at least a portion of said second-named winding.

4. Alternating current controlling apparatus comprising a laminated core, an alternating current exciting winding on said core, a second alternating current exciting winding on another portion of said core acting in opposition to said first-named winding, a third alternating current exciting winding on another portion of said core acting cumulatively with said first-named winding, a plurality of output windings on said core subjected to resultant magnetic effects, said core having a portion thereof spaced from the remaining portion in a direction at right angles to the plane of the laminæ of the core, and at least one auxiliary winding embracing said spaced portion of the core only and in series with at least one of said output windings.

5. Alternating current controlling apparatus comprising a laminated core, an alternating current exciting winding on said core, a second alternating current exciting winding on another portion of said core acting in opposition to said first-named winding, a third alternating current exciting winding on another portion of said core acting cumulatively with said first-named winding, a plurality of output windings on said core subjected to resultant magnetic effects, said core having a portion thereof spaced from the remaining portion in a direction at right angles to the plane of the laminæ of the core, and at least one auxiliary winding embracing said spaced portion of the core only and in series with at least one of said output windings, said portion of the core enveloped by said second-named winding being below saturation.

6. Alternating current controlling apparatus comprising laminated core, an alternating current exciting winding on said core, a second alternating current exciting winding on another portion of said core acting in opposition to said first-named winding, a third alternating current exciting winding on another portion of said core acting cumulatively with said first-named winding, a plurality of output windings on said core subjected to resultant magnetic effects, said core having a portion thereof spaced from the remaining portion in a direction at right angles to the plane of the laminæ of the core, and at least one auxiliary winding embracing said spaced portion of the core only and in series with at least one of said output windings, said first-named winding being in series with at least a portion of said second-named winding.

7. Electrical controlling apparatus comprising a laminated core, said core having a main portion and an auxiliary portion, said auxiliary portion being of reduced size compared to the main portion and spaced from the main portion in a direction at right angles to the plane of the laminæ of the core, input and output windings on said core, the turns of both said input and output windings embracing in single loops both the main and auxiliary portions of said core, and an auxiliary winding embracing said auxiliary portion only and in series with at least one of said windings.

8. Electrical controlling apparatus comprising a laminated core, said core having a main portion and an auxiliary portion, said auxiliary portion being of reduced size compared to the main portion and spaced from the main portion in a direction at right angles to the plane of the laminæ of the core and extending parallel to the plane of the laminæ of the core, input and output windings on said core, the turns of both said input and output windings embracing in single loops both the main and auxiliary portions of said core, and at least one auxiliary winding enveloping said spaced portion of the core only and in series with one of said first named windings.

9. Alternating current controlling apparatus comprising a laminated core, said core having a main portion and an auxiliary portion, said auxiliary portion being of reduced size compared to the main portion and spaced from the main portion in a direction at right angles to the plane of the laminæ of the core and extending parallel to the plane of the

laminæ of the core, a primary winding on said core, a plurality of secondary windings on said core, the turns of each of said primary and secondary windings embracing in single loops both the main and auxiliary portions of said core, and at least one auxiliary winding embracing said spaced portion of the core only and in series with at least one of said secondary windings.

HAROUTIUN K. KOUYOUMJIAN.