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ELECTRIC CONTROLLING APPARATUS

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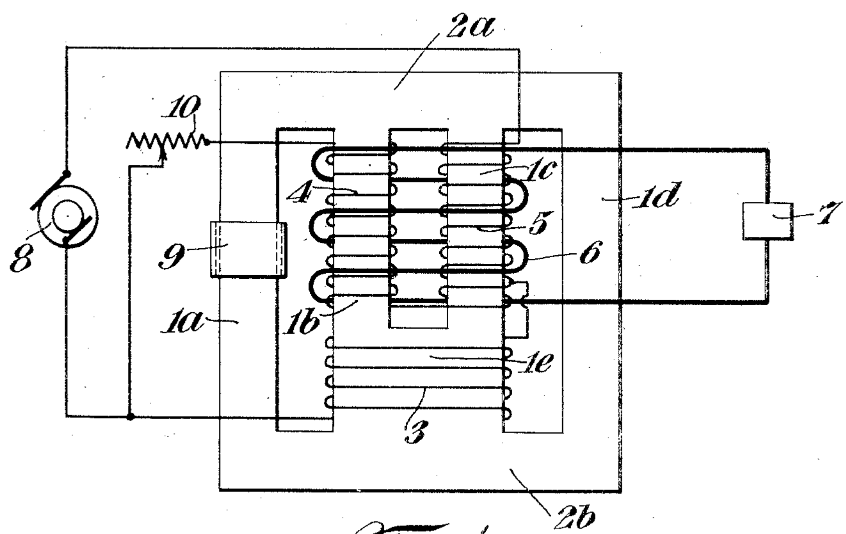


Fig. 1.

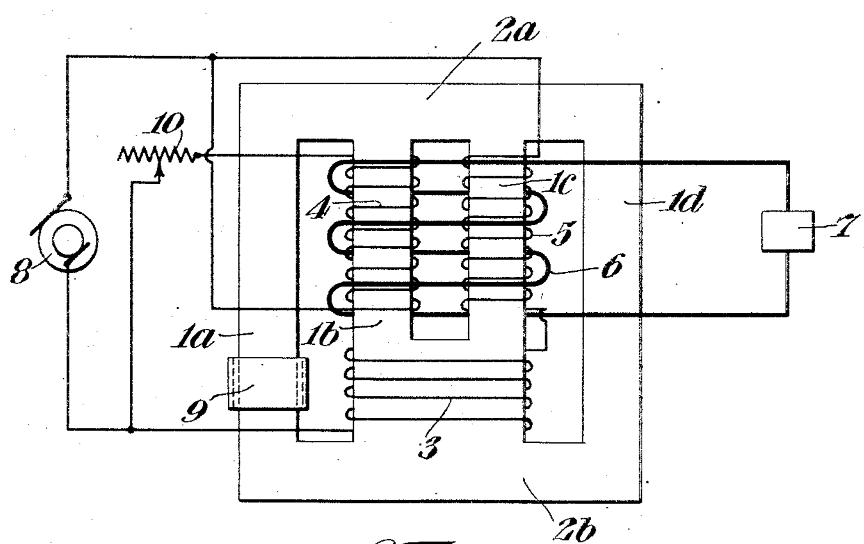


Fig. 2.

INVENTOR
Haroutium K. Kouyoumjian
BY
Lawrence K. Sager
ATTORNEY

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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 particularly to alternating current voltage regulators and transformers wherein the output voltage is maintained substantially constant regardless of variations of voltage in the supply line. The invention also relates to maintaining the output voltage approximately constant, even under changes in load in the consumption circuit.

The present invention is an improvement over the inventions disclosed in my prior pending applications Serial Number 306,259, filed September 15, 1928 and Serial Number 344,333, filed March 5, 1929.

The main object of this invention is to obtain refinement in control of the voltage under very wide variations in the supply voltage and also under pronounced changes in load; and furthermore to accomplish these results by simple and inexpensive means. Another object is to provide means whereby the output voltage which is to be maintained constant may be readily changed to any desired value by adjustments of a simple and convenient character. Other objects and advantages of this invention will be understood by those skilled in the art from the following description and accompanying drawings.

Fig. 1 is a diagram showing one preferred embodiment of the invention; and Fig. 2 is a similar diagram in which the connections of the windings are different from those of Fig. 1.

Referring to Fig. 1 the laminated iron, or steel, core is shown as having four legs 1*a*, 1*b*, 1*c* and 1*d*. The two inner legs 1*b* and 1*c* are merged into a common leg or leg portion 1*e*. The legs are joined together at their upper and lower ends by crosspieces 2*a* and 2*b*. Ordinarily, the cross-sections of the different parts of the core will be the same, except the common leg portion 1*e*, 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 and merged portion of these 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 requirements.

The main, or primary, winding 3 is shown as enveloping the common, or merged, leg portion 1*e*. Another winding 4 is shown enveloping the leg 1*b* and this winding is cumulatively acting with reference to the winding 3 as regards the flux tending to be set up in the legs 1*b* and 1*e*. Another winding 5 is located on the leg 1*c* and is so wound and connected as to act in opposition to the winding 3, as regards the magnetic flux tending to be set up in the leg 1*c* by the main, or primary, winding 3. The secondary, or output, winding 6 is shown enveloping the two legs 1*b* and 1*c*, and also enveloping the windings 4 and 5. The winding 6 supplies a translating device 7 in the consumption circuit and this device may be any form of translating device.

The alternating current source of energy 8 supplies energy 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 also 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. In Fig. 1, the windings 4 and 5 are shown connected in series with each other across the line, whereas in Fig. 2 the cumulatively acting winding 4 is connected across the supply line, and the bucking winding 5 is connected in series with the main winding 3 across the supply line.

The cross-section of leg 1*b* and the ampere turns of the windings enveloping this leg are such that, under normal conditions, this part of the 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 1*c* 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. 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 by assuming a particular instant of the alternating current wave such as to cause the flux to pass upwardly in the leg 1*b*, as caused by the cumulative action of the windings 3 and 4 and an upward passage of flux in the leg 1*c*, 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 1*b*, whether it be small or comparatively large in amount, will be offset by a corresponding increase in the amount of flux in the leg 1*c*, owing to the fact that the bucking winding 5 becomes less effective in its opposition, as this leg is operating on the straight part of the saturation curve. Also, by reason of the fact that the bucking winding is in series with the cumulative winding, a greater decrease of current occurs in the bucking winding than would otherwise take place, because the leg enclosed by the cumulative winding is nearer the saturation point. Thus the change in flux to which the output winding 6 is subjected, is not materially changed with a decrease in the supply voltage, permitting the output voltage to remain substantially constant. Similarly, when the supply voltage increases, the increase in resultant flux in leg 1*b* is offset by a corresponding decrease in the flux in the leg 1*c*, 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, as well as the output voltage. 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 and the output voltage varied, if desired, in a certain predetermined manner with change in the supply voltage.

The foregoing disclosure relates to the inventions described in my said prior pending applications, this disclosure being necessary herein in order to understand the present invention.

I have found that in the making of my improved regulators for various uses and for different operating conditions, it is desirable to provide means for securing particular results and for varying the results attained by convenient adjustment, and by providing auxiliary means which may be conveniently added to the regulator at low cost.

One feature of the present invention is the provision of a device for damping the magnetic flux in the portion of the core which commonly serves as a path for the flux from the leg enclosed by the cumulative winding. In the drawings this is the leg 1*a* and portions thereof adjoining the leg 1*b*. On this leg I have provided a closed metal ring 9, preferably of copper, although it may be of other metals. This ring which envelops the leg 1*a* is preferably of low ohmic resistance and its thickness and size may be made according to the particular damping effects desired. In some cases, it may be made in the form of a coil in closed circuit on itself having a more or less number of turns and size of wire to meet the particular requirements. It is also preferably arranged slidable along the leg 1*a* for securing adjustment to the results desired, or to change of these results, from time to time, as may be desired.

Another feature of the present invention is the provision of ohmic resistance in the circuit of the cumulative winding 4, this being indicated in the drawings by the adjustable resistance 10. It is evident that by increasing the resistance in the circuit of the cumulative winding, this winding is not subjected to as great a proportional change in current under variations of the supply voltage, as are the main winding 3 and bucking winding 5. This has advantageous results for particular conditions.

Considering the effect of the damping device 9, it is evident that this tends to oppose and to choke flux increase in the leg 1*a*. When the supply voltage increases abnormally, the flux in the leg 1*b* tends to increase by reason of the excitation due to the main winding 3 and the cumulative winding 4, and such increase tends to increase the flux in the leg 1*a*. However, the damping device 9 tends to oppose such increase in the leg 1*a*, which results in a greater proportion of the flux increase being diverted from the leg 1*a* to the legs 1*c* and 1*d*. As the leg 1*d* has already attained a considerable flux density, and as the leg 1*c* is below saturation, the flux diverted from the leg 1*a* by the damping device tends to find its main path through the leg 1*c*. The tendency of the direction of this flux in the leg 1*c* is the same as the direction of the flux tending to be set up by the bucking winding 5, in opposition to the main excitation due to the winding 3. Thus, upon increase of supply voltage, the damping device tends, in effect, to make the opposing action of the flux in the leg 1*c* more effective in offsetting the increase in supply voltage and the increase in magnetization of the leg 1*b*. Similarly, upon decrease in supply voltage the reverse action takes place. Thus the provision of the damping device as described affords means for refinement of control in regulation of the output voltage under changes of the supply voltage. Also, by adjusting the position of the damping device along the leg 1*a*, the output voltage may be raised, or lowered, and thus adjusted to give any particular desired output voltage.

Another advantage of the damping device is its action in tending to maintain the voltage constant with changes in the amount of the load 7.

The resistance 10 in series with the cumulative winding also serves to obtain refinement in control of the output voltage. It is also advantageous in permitting the leg 1*b* to be not carried to a very high degree of saturation when the supply voltage is abnormally high. Ordinarily, without the refinements of control herein disclosed, the regulator upon increase in supply voltage may cause the output voltage to rise slightly, and then upon further increase of the supply voltage to fall slightly, this action being due to the fact that the cumulative leg, when it becomes saturated under high supply voltages, permits the current through the cumulative winding and through the bucking winding, when in series therewith, to increase in greater proportion than the increase in flux in the saturated leg 1*b*. This permits the proportionate increase in current when passing through the bucking winding, however, to become markedly effective in reducing the flux in the leg 1*c*. This, under the circumstances considered, causes a negative control, or reduction in the output voltage under abnormally high supply voltages. It is, of course, desirable for many uses to have the output voltage as normally constant as possible.

Also, the saturation of the cumulatively excited leg 1*b* in order to obtain close regulation without the use of auxiliary means, is objectionable for some purposes, because the high flux density in the leg 1*b* when saturated, causes the presence of higher harmonics and give rise to an undesirable noise or hum. Where the regulator is used for controlling the voltage supplied to radio receiving sets, for example, this noise is an undesirable interference. By use of the resistance in the circuit of the cumulative winding, the output voltage may be given a refined constant value under extreme variations in supply voltage; and the necessity for carrying the cumulatively excited leg of the core to a high degree of saturation with resultant hum, is likewise avoided. Also, by adjusting the value of the resistance 10 in the circuit of the cumulative winding, the output voltage may be given any desired constant value. Instead of using an extraneous resistance 10, this resistance could be incorporated in the cumulative winding itself by use of a small size wire of considerable length in the coil; but this is ordinarily undesirable, owing to the fact that the winding will then heat up considerably and the heating cannot be as readily dissipated as by use of an extraneous resistance. Also, by use of the extraneous resistance, it permits convenient adjustment thereof to give the desired results.

It is apparent that by the conjoint use of the damping device and the resistance as described, very close refinement of control of the output voltage may be obtained to give the particular results desired and that adjustment of these controlling means affords a simple and convenient method for adjustment to the particular results desired, or change of these results as the occasion may arise.

Although I have described a preferred embodiment of this invention, it will be understood that the same may be embodied in various forms of construction of my improved regulator and that various modifications may be made therein without departing from the scope of the invention.

I claim:

1. Alternating current controlling apparatus comprising a core, an alternating current exciting winding embracing a portion of said core, an alternating current exciting winding embracing another portion of said core and acting in opposition to said first-named winding, a damping device embracing another portion of said core and subjected to magnetic flux created by said first-named winding, and an output circuit subjected to resultant magnetic effects.

2. Alternating current controlling apparatus comprising a core, an alternating current exciting winding embracing a portion of said core, an alternating current exciting winding embracing another portion of said core and acting in opposition to said first-named winding, a damping device embracing another portion of said core and subjected to magnetic flux created by said first-named winding, and an output winding em-

bracing portions of said core and subjected to resultant magnetic effects.

3. Alternating current controlling apparatus comprising a core, an alternating current exciting winding embracing a portion of said core, an alternating current exciting winding embracing another portion of said core and acting in opposition to said first-named winding, said last-named portion of the core being below saturation, a damping device on another portion of said core and subjected to magnetic flux created by said first-named winding, and an output circuit subjected to resultant magnetic effects.

4. Alternating current controlling apparatus comprising a core, an alternating current exciting winding embracing a portion of said core, an alternating current exciting winding embracing another portion of said core and acting in opposition to said first-named winding, said last-named portion of the core being below saturation, a damping device on another portion of said core and subjected to magnetic flux created by said first-named winding, and an output winding embracing portions of said core and subjected to resultant magnetic effects.

5. Alternating current controlling apparatus comprising a core, an alternating current exciting winding on a portion of said core, a second alternating exciting winding on another portion of said core acting cumulatively with said first-named winding, a third alternating current exciting winding on another portion of said core acting in opposition to at least one of said two first-named windings, a damping device on another portion of said core, and an output circuit for delivering energy dependent on the resultant magnetic effect of said three windings and of said damping device.

6. Alternating current controlling apparatus comprising a core, an alternating current exciting winding on a portion of said core, a second alternating exciting winding on another portion of said core acting cumulatively with said first-named winding, a third alternating current exciting winding on another portion of said core acting in opposition to at least one of said two first-named windings, a damping device on another portion of said core, and an output winding subjected to resultant magnetic effects of said three windings and damping device.

7. Alternating current controlling apparatus comprising a core, an alternating current exciting winding on a portion of said core, a second alternating exciting winding on another portion of said core acting cumulatively with said first-named winding, a third alternating current exciting winding on another portion of said core acting in opposition to at least one of said two first-named windings, a damping device on another portion of said core, and an output winding subjected to resultant magnetic effects of said three windings and damping device, the portion of the core having the cumulatively acting winding thereon having a higher normal flux density than that portion of the core carrying the opposing winding.

8. Alternating current controlling apparatus comprising a core, an alternating current exciting winding embracing a portion of said core, an alternating current exciting winding embracing another portion of said core in opposition to said first-named winding, said first-named winding being in series with at least a portion of said opposing winding, a damping device on another portion of said core and subjected to magnetic flux created by said first-named winding, and an output circuit delivering energy dependent upon resultant magnetic effects of said windings and of said device.

9. Alternating current controlling apparatus comprising a core, a main alternating current exciting winding on a portion of said core, a second alternating current exciting winding on a portion of said core acting cumulatively with said main winding, a third alternating current exciting winding on another portion of said core acting in opposition to said winding, said main winding being connected in series with at least a portion of said opposing winding, a damping device on another portion of said core, and an output circuit delivering energy dependent upon resultant magnetic effects of said three windings and of said device.

10. Alternating current controlling apparatus for controlling the output voltage under conditions of variable supply voltage, comprising a core and a plurality of alternating current exciting windings thereon, a damping device on a portion of said core subjected to magnetic flux created by at least one of said windings, and an output winding subjected to resultant magnetic effects of said alternating current windings, and of said damping device.

11. Alternating current controlling apparatus comprising a core, an alternating current exciting winding embracing a portion of said core, an alternating current exciting winding embracing another portion of said core acting in opposition to said first-named winding, the circuit of said first-named winding having a comparatively high resistance and an output circuit subjected to resultant magnetic effects of said windings.

12. Alternating current controlling apparatus comprising a core, an alternating current exciting winding embracing a portion of said core, an alternating current exciting winding embracing another portion of said core acting in opposition to said first-named

winding, the circuit of said first-named winding having a comparatively high resistance, and an output winding embracing both of said portions of the core.

13. Alternating current controlling apparatus comprising a core, an alternating current exciting winding embracing a portion of said core, an alternating current exciting winding embracing another portion of said core acting in opposition to said first-named winding, the circuit of said first-named winding having a comparatively high resistance, and an output circuit subjected to resultant magnetic effects of said windings, the portion of the core embraced by said first-named winding having a higher normal flux density than that embraced by said second-named winding.

14. Alternating current controlling apparatus comprising a core, an alternating current exciting winding on a portion thereof, a second alternating current exciting winding on another portion of said core acting cumulatively with said first-named winding, a third alternating current exciting winding on another portion of said core acting in opposition to at least one of said two first-named windings, a comparatively high resistance in the circuit of one of said two first-named windings, and an output circuit delivering energy dependent upon resultant magnetic effects of said three windings.

15. Alternating current controlling apparatus comprising a core, having at least two leg portions and a common portion, a main alternating current exciting winding on said common portion, a second alternating current exciting winding on one of said leg portions acting cumulatively with said main winding, a third alternating current exciting winding on the other leg portion of said core acting in opposition to said main winding, a resistance in the circuit of said cumulatively acting winding, and an output circuit delivering energy dependent upon combined resultant effects of said three windings.

16. Alternating current controlling apparatus comprising a core, having at least two leg portions and a common portion, a main alternating current exciting winding on said common portion, a second alternating current exciting winding on one of said leg portions acting cumulatively with said main winding, a third alternating current exciting winding on the other leg portion of said core acting in opposition to said main winding, a resistance in the circuit of said cumulatively acting winding, and an output circuit delivering energy dependent upon combined resultant effects of said three windings, said main winding being connected in series with at least a portion of said opposing winding.

17. Alternating current controlling apparatus comprising a core, a main alternating current exciting winding embracing one portion of said core, a second alternating current exciting winding embracing another portion of said core and acting cumulatively with said main winding, a third alternating current exciting winding embracing another portion of said core and acting in opposition to said main winding, a damping device on another portion of said core, a resistance in series with said cumulatively acting winding, and an output circuit subjected to combined resultant effects of said windings and said device.

18. Alternating current controlling apparatus comprising a core having a plurality of inner and outer leg portions, a main alternating current exciting winding embracing an inner leg portion, a second alternating current exciting winding embracing another inner leg portion and acting in opposition to said main winding, a damping device on one of the outer leg portions, and an output winding embracing an inner leg portion.

19. Alternating current controlling apparatus comprising a core having a plurality of inner and outer leg portions, a main alternating current exciting winding embracing an inner leg portion, a second alternating current exciting winding embracing another inner leg portion and acting in opposition to said main winding, a damping device on one of the outer leg portions, and an output winding embracing two inner leg portions.

20. Alternating current controlling apparatus comprising a core having inner leg portions and outer leg portions, a main alternating current exciting winding embracing an inner leg portion, a second alternating current exciting winding embracing another inner leg portion and acting cumulatively with said main winding, a third alternating current exciting winding embracing another inner leg portion and acting in opposition to said main winding, a damping device on one of the outer leg portions, and an output winding embracing two inner leg portions.

21. Alternating current controlling apparatus comprising a core having inner leg portions and outer leg portions, a main alternating current exciting winding embracing an inner leg portion, a second alternating current exciting winding embracing another inner leg portion and acting cumulatively with said main winding, a third alternating current exciting winding embracing another inner leg portion and acting in opposition to said main winding, a damping device on one of the outer leg portions, a resistance in series with said cumulatively acting winding, and an output winding embracing two inner leg portions.

22. Alternating current controlling apparatus comprising a core having two inner leg portions and an inner leg portion common to said two inner leg portions, and also having outer leg portions, a main alternating current

exciting winding embracing said common inner portion, a second alternating current exciting winding embracing one of said two inner leg portions and acting cumulatively with said main winding, a third alternating current exciting winding embracing the other of said two inner leg portions and acting in opposition to said main winding, a resistance in the circuit of said cumulatively acting winding, and an output winding embracing said two inner leg portions.

23. Alternating current controlling apparatus comprising a core having two inner leg portions and an inner leg portion common to said two inner leg portions, and also having outer leg portions, a main alternating current exciting winding embracing said common inner portion, a second alternating current exciting winding embracing one of said two inner leg portions and acting cumulatively with said main winding, a third alternating current exciting winding embracing the other of said two inner leg portions and acting in opposition to said main winding, a damping device on one of the outer leg portions, and an output winding embracing said two inner leg portions.

24. Alternating current controlling apparatus comprising a core having two inner leg portions and an inner leg portion common to said two inner leg portions, and also having outer leg portions, a main alternating current exciting winding embracing said common inner portion, a second alternating current exciting winding embracing one of said two inner leg portions and acting cumulatively with said main winding, a third alternating current exciting winding embracing the other of said two inner leg portions and acting in opposition to said main winding, said main winding being in series with at least a portion of said opposing winding, a damping device on one of the outer leg portions, and an output winding embracing said two inner leg portions.

25. Alternating current controlling apparatus comprising a core having two inner leg portions and an inner leg portion common to said two inner leg portions, and also having outer leg portions, a main alternating current exciting winding embracing said common inner portion, a second alternating current exciting winding embracing one of said two inner leg portions and acting cumulatively with said main winding, a third alternating current exciting winding embracing the other of said two inner leg portions and acting in opposition to said main winding, a resistance in the circuit of said cumulatively acting winding, a damping device on one of the outer leg portions, and an output winding embracing said two inner leg portions.

HAROUTIUN K. KOUYOUMJIAN.