Oct. 13, 1931. H. K. KOUYOUMJIAN 1,826,890

ELECTRIC CONTROLLING APPARATUS

Filed March 5, 1929 2 Sheets-Sheet 1

Fig. 1.

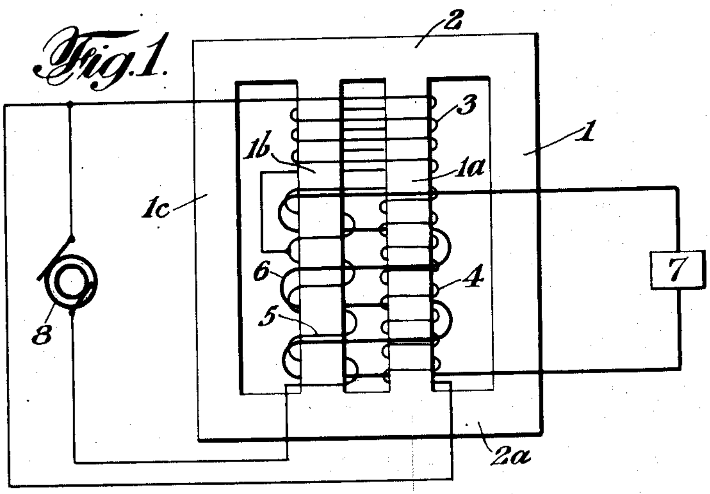

Fig. 2.

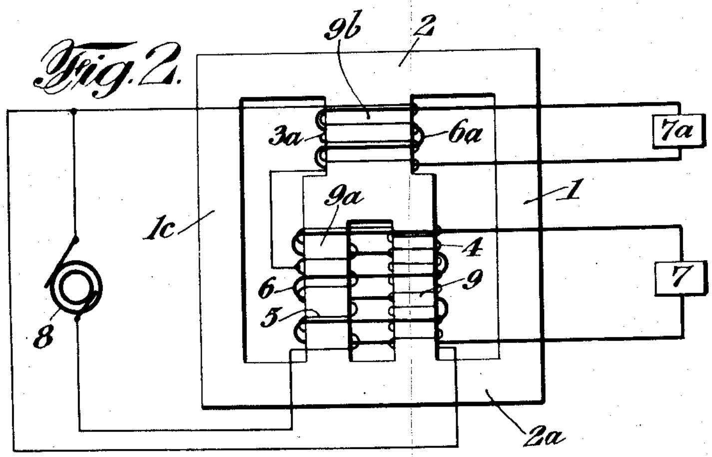

Fig. 3.

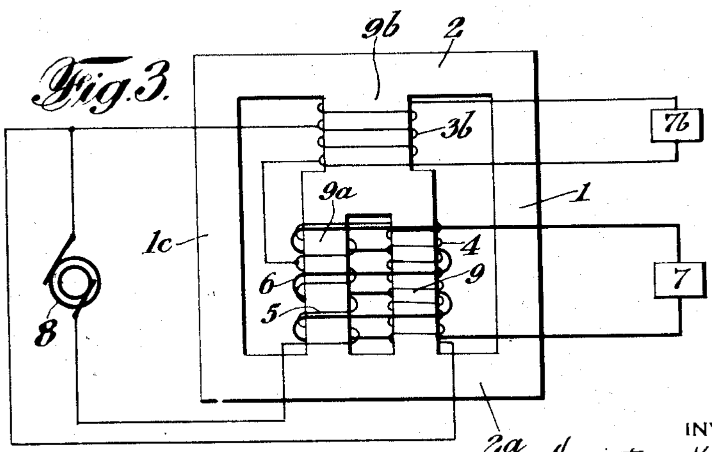

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Fig. 4.

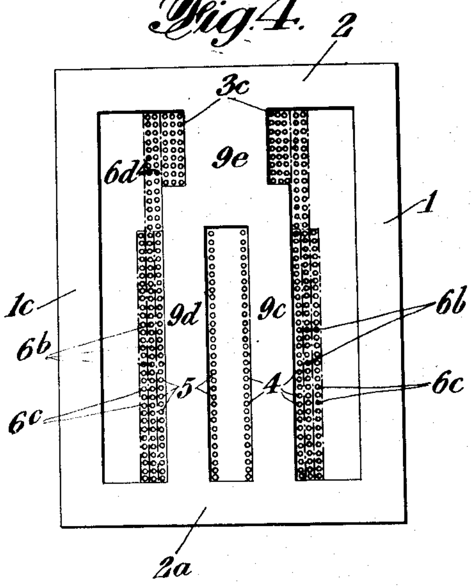


Fig. 5.

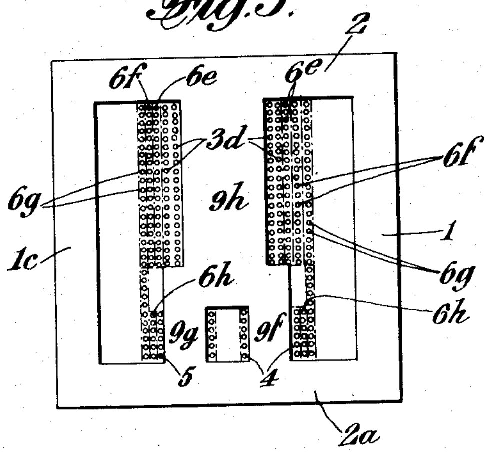
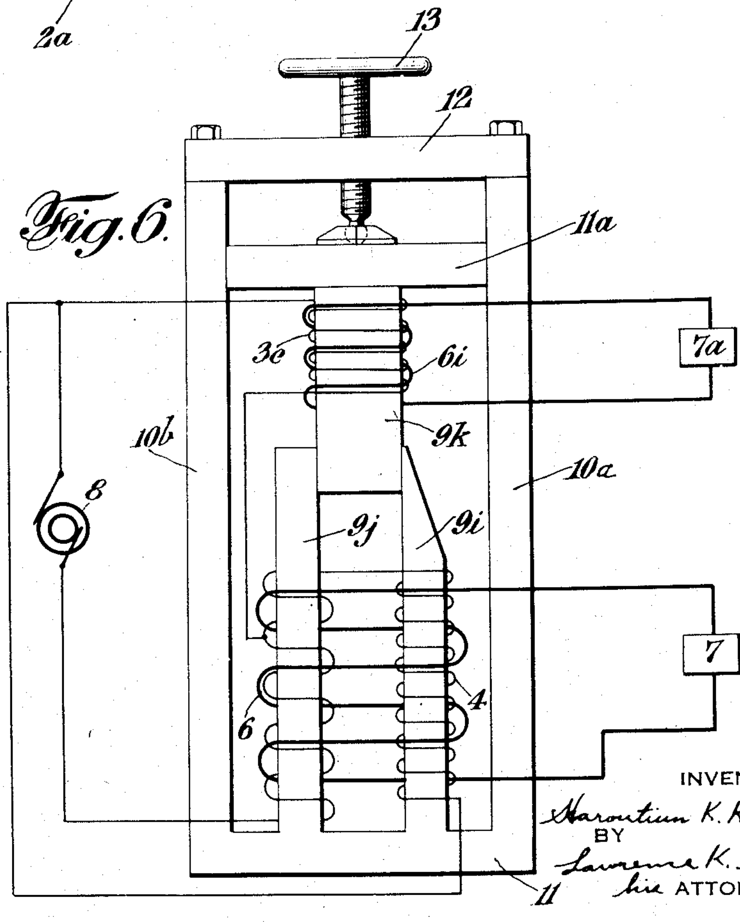


Fig. 6.



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UNITED STATES PATENT OFFICE

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ELECTRIC CONTROLLING APPARATUS

Application filed March 5, 1929. Serial No. 344,333.

This invention relates to improved controlling apparatus and method of control for regulating the voltage, where energy is derived from an alternating current source subject to variations in the voltage supplied or in the frequency, or both and wherein the derived voltage may be maintained substantially constant irrespective of the variations in the supply; or, where desired, the output voltage may be caused to increase or decrease in any predetermined amount according to whether the supply voltage decreases or increases, or vice versa, permitting any desired results to be obtained.

This invention is an improvement upon that disclosed in my pending application filed September 15, 1928, Serial Number 306,259.

The main object of the present invention is to produce an improved form of apparatus of the above character which will permit the size of the apparatus to be reduced and permit the amount and cost of the windings and of the iron core to be reduced. Another important object is to produce a form of construction which is well adapted for variation in the relative proportions and form of the core, and to permit a wide range and flexibility as regards the relative location of the windings with reference to each other and to the core in order to fulfill particular required conditions as to the control of the output voltages, as may be desired, in supplying a plurality of circuits. Another object is to produce an improved form of construction adapted for adjustment to satisfy particular conditions and to permit convenient adjustment for obtaining desired results for adaptation to change in conditions, or change in the requirements of the output voltage. Other objects and advantages of this improvement will be understood from the following description and accompanying drawings.

Fig. 1 is a diagram showing one form of this invention; Fig. 2 is a diagram showing an improved form of core and a plurality of output windings; Fig. 3 is a similar diagram of the auto transformer type; Figs. 4 and 5 are diagrams showing the core and indicating the location of various windings and illustrating how the core and location of the windings may be modified for adaptation to particular requirements; and Fig. 6 is a diagram showing another form of construction where portions of the core may be adjusted with reference to other parts thereof for obtaining desired results, or change in results, or for obtaining the same result under changed conditions of use.

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-section 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 of any form of translating device.

The alternating current source of energy 8 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 windings 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 effecting the primary winding requires a correspondingly less amount of regulation in giving the desired results.

The cross-section of the leg 1*a* 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 1*b* 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 1*a*, as caused by the cumulative action of the windings 3 and 4, and a downward passage of flux in the leg 1*b*, 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*a*, 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*b*, 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 substantially 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.

Fig. 2 illustrates another improved form of my invention, wherein portions of the two inner legs are merged into one leg. This forked form of my improvement results in a considerable reduction in 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 the parts of the core to suit particular requirements

In Fig. 2, the two inner legs 9, 9*a* correspond to portions of the legs 1*a* and 1*b* of Fig. 1, but these portions are merged into a common leg 9*b*, which in turn is joined to one of the end cross-pieces of the core.

The primary winding 3*a* is wound around the leg portion 9*b* and obviously may be of much smaller diameter than the primary winding 3, thus making a considerable saving in the size and cost of this winding. The cumulative winding 4 and the bucking winding 5 are similar to the same windings of Fig. 1 and are wound upon the leg portions 9 and 9*a* respectively. The connections of these windings are shown the same as in Fig. 1; and likewise the secondary winding 6 is shown as superimposed over the cumulative and bucking windings and as supplying the translating device 7. But this form of construction also permits the convenient application of another secondary winding 6*a* over the primary winding 3*a* for supplying any desired translating device 7*a*. This form of construction obviously permits the size of the additional secondary winding 6*a* to be smaller in diameter than that of the secondary winding 6 with the advantage of reduced size and cost. However, the same degree of regulation of the output voltage from the coil 6*a* will not be obtained as that from the coil 6, owing to the fact that it does not envelop or is not sandwiched with the cumulative and bucking windings; but in many instances the same degree of regulation is not as important for certain uses as for others. In such a case the winding 6, or a similarly located winding, may be used for supplying the output voltage where close regulation is required, and the winding 6*a* may be used at the same time for delivering an output voltage where the degree of regulation is not so important. For example, the winding 6 may be utilized for supplying energy to the filaments of the tubes of radio sets where constant voltage is important, and the winding 6*a* may be utilized for supplying energy to the plate circuits where constant voltage is less important. It will, of course, be understood that the number of turns in the different secondary windings will be such as to deliver the voltage required and that as many separate secondary windings may be used as necessary for supplying the required voltages. Also, taps may be provided on the secondary windings for supplying different voltages from the same winding; but where the consumption current is quite materially different for the required purposes, it will be desirable to provide separate secondary windings and locate them on the core, according to the degree of regulation that may be needed.

In the form shown in Fig. 3, the shape of the core is the same as that shown in Fig. 2, and the windings are the same with the same connections, except that Fig. 3 shows an auto-transformer type wherein the primary winding 3*b* is also utilized as a secondary winding for supplying the translating device 7*b*. Here the primary winding 3*b* is provided with additional turns beyond the tap to which the alternating current source is connected for the purpose of obtaining the required voltage for the translating device 7*b*. Of course, in some cases, the connection from this primary winding to the translating device may be made within the connection of this winding to the alternating current source, depending upon the voltage required. The voltage delivered to the translating device 7*b* will not usually be as well regulated as that supplied to the translating device 7 from the secondary winding 6, owing to the latter's more favorable location.

Figs. 4 and 5 illustrate how the relative proportions of the cores may be changed and likewise how the output windings may be variously located, as determined by the particular requirements.

Fig. 4 shows a case where the legs 9*c* and 9*d* carrying the cumulative and bucking windings are of considerable length, and the leg 9*e* carrying the primary winding 3*c* is comparatively short. Here two secondary windings 6*b* and 6*c* are shown one enveloping the other and adapted to supply separate translating devices under close regulation, the delivered voltage being according to the number of turns in the secondary windings. The secondary winding 6*d* is shown enveloping leg $9e$ and a portion of the core beyond the leg $9e$, this secondary winding having such number of turns as to give the required voltage, but its regulation would not be as close as that obtained from the secondary windings $6b$ and $6c$.

In Fig. 5 the legs $9f$ and $9g$ are shown comparatively short and the leg $9h$ comparatively long, permitting ample room for the location of a primary winding $3d$ with a considerable number of turns and of secondary windings $6e$ and $6f$ having a less refined regulation than that of the secondary winding $6g$ which envelops the other secondary windings and also extends the full length of the core to envelop the cumulative and bucking windings. Another secondary winding $6h$ is shown enveloping the cumulative and bucking windings and not extending beyond their lengths, but being within the outer secondary winding $6g$. The secondary winding $6h$ will give refined regulation of the voltage as compared with that obtained from the other secondary windings of this figure.

Thus it is evident that the form and relationship of the parts may be readily made such as to suit the particular requirements with economy in size and cost of material.

In some cases, where it is inconvenient to change the number of turns of the windings, or to provide taps from the various windings to suit particular conditions, the apparatus may be constructed so as to permit convenient adjustment for different conditions, or change in conditions, as they may arise.

Fig. 6 is an embodiment of my invention wherein the core, or a portion thereof, is made adjustable for changing the range of control, or for other purposes. In Fig. 6, the core is provided with the outer legs $10a$ and $10b$ and a lower cross-piece 11. The upper cross-piece $11a$ is slidable between the outer legs of the core and carries therewith the leg $9k$ which extends downwardly and is adapted to slide between the legs $9i$ and $9j$. A non-magnetic cross-piece 12 is secured to the upper ends of the legs $10a$ and $10b$; and an adjustable screw 13 has a threaded engagement with the cross-piece 12 and a swivel connection with the magnetic cross-piece $11a$ of the core in order to adjust the cross-piece $11a$ and leg $9k$ to any position desired.

The cumulative winding 4 and bucking winding 5 are respectively located upon the legs $9i$ and $9j$; and the primary winding $3e$ envelops the leg $9k$. The secondary winding 6 is shown as enveloping the legs $9i$ and $9j$ and another secondary winding $6i$ is shown enveloping the primary winding on the leg $9k$ and supplying a translating device $7c$. The leg $9i$ is shown tapered at its upper end to cause it to have increased reluctance as compared with leg $9j$ and to correspondingly affect its saturation under different conditions.

It is evident that by varying the position of the leg $9k$ with reference to the legs $9i$ and $9j$, the density of flux in the latter legs will be varied and correspondingly affect the operation. One important result is to change the range of regulation. For example, with one position of adjustment, the output voltage may be maintained at a substantially constant value with a variation of 90 to 140 volts in the supply line, whereas with another adjustment substantially constant voltage will be maintained within a range of from 100 to 150 volts variation in the supply line. Other means for varying and adjusting the relations of the core may be utilized for securing particular results.

One important advantage of my invention results from the fact that the phase of the secondary current, in the usual forms of construction, corresponds with the phase of the bucking winding, and therefore when a short-circuit occurs in the secondary circuit, or circuits, the action is such as to tend to protect the apparatus and translating devices from serious damage. Likewise, in first supplying energy to certain types of lamps, or to certain tubes for radio use, or to parts thereof, in prior uses thereof, an abnormally high initial current flows, which is undesirable and tends to damage or shorten the life of such lamps or tubes. With my invention, the reactive effect of the secondary in assisting the bucking coil, tends to oppose increase in the secondary current and by holding it down within safe limits, protects the lamps, tubes or similar devices from injury.

Where the load on the secondary winding, or windings, changes materially in normal use and it is desired to maintain substantially constant voltage with change of secondary load, then the effect of the bucking coil should be made comparatively great as regards the effect of the secondary winding, or windings. With such a condition, moderate changes in load on the secondary circuit, or circuits, have comparatively little effect on the regulation and the output voltage is not materially affected.

It is evident that my invention may be embodied in various forms of apparatus and various modifications made without departing from the scope thereof.

I claim:

1. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, and a plurality of alternating current exciting windings on said inner legs, at least one of said windings tending to create a flux in opposition to that of other of said windings.

2. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, a plurality of alternating current exciting windings on said inner legs, at least one of said

windings tending to create a flux in opposition to that of other of said windings, and an output winding on said core subjected to resultant flux.

3. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, a primary winding supplied with alternating current enveloping at least one of the inner legs and energizing the inner legs, a bucking winding supplied with alternating current enveloping one of said inner legs, and an output circuit supplied with energy derived from a winding subjected to resultant flux.

4. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, a primary winding supplied with alternating current enveloping at least one of the inner legs and energizing the inner legs, a bucking winding supplied with alternating current enveloping one of said inner legs and axially displaced from said primary winding, and an output circuit supplied with energy derived from a winding subjected to resultant flux.

5. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, a primary winding supplied with alternating current enveloping at least one of the inner legs and energizing the inner legs, a bucking winding supplied with alternating current enveloping one of said inner legs, a cumulatively acting winding supplied with alternating current enveloping another of said inner legs, and an output circuit supplied with energy derived from a winding subjected to resultant flux.

6. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, a primary winding supplied with alternating current enveloping at least one of the inner legs and energizing the inner legs, a bucking winding supplied with alternating current enveloping one of said inner legs and axially displaced from said primary winding, a cumulatively acting winding supplied with alternating current enveloping another of said inner legs, and an output circuit supplied with energy derived from a winding subjected to resultant flux.

7. Alternating current controlling apparatus comprising a core having legs forming a fork, a primary alternating current winding on the leg forming the common portion of the fork, a bucking winding supplied with alternating current on a leg forming one of the prongs of the fork, a cumulatively acting winding supplied with alternating current on a leg forming another prong of the fork, and an output winding on said core subjected to resultant flux.

8. Alternating current controlling apparatus comprising a core having legs forming a fork, a primary alternating current winding on the leg forming the common portion of the fork, a bucking winding supplied with alternating current on a leg forming one of the prongs of the fork, a cumulatively acting winding supplied with alternating current on a leg forming another prong of the fork, and an output winding enveloping at least one of said legs of the fork.

9. Alternating current controlling apparatus comprising a core having legs forming a fork, a primary alternating current winding on the leg forming the common portion of the fork, a bucking winding supplied with alternating current on a leg forming one of the prongs of the fork, a cumulatively acting winding supplied with alternating current on a leg forming another prong of the fork, and an output winding enveloping at least two of the said legs of the fork.

10. Alternating current controlling apparatus comprising a core having legs forming a fork, a primary alternating current winding on the leg forming the common portion of the fork, a bucking winding supplied with alternating current on a leg forming one of the prongs of the fork, a cumulatively acting winding supplied with alternating current on a leg forming another prong of the fork, and an output winding enveloping said legs forming the prongs of the fork.

11. Alternating current controlling apparatus comprising a core, a plurality of alternating current windings on said core, at least one of said windings tending to create a flux in opposition to that created by another of said windings, and adjustable means for affecting the flux in said core.

12. Alternating current controlling apparatus comprising a core, a plurality of alternating current windings on said core, at least one of said windings tending to create a flux in opposition to that created by another of said windings, and means for adjusting a portion of the core.

13. Alternating current controlling apparatus comprising a core having a plurality of legs, a plurality of alternating current windings on at least two of said legs, at least one of said windings tending to create a flux in opposition to that of another of said windings, and means for adjusting one of the legs of the core with reference to other portions of the core.

14. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, a primary winding supplying alternating current enveloping at least one of the inner legs and energizing the inner legs, a bucking winding supplied with alternating current enveloping one of said inner legs, said primary winding being in series with at least a

portion of said bucking winding, and an output circuit supplied with energy derived from a winding subjected to resultant flux.

15. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, a primary winding supplied with alternating current enveloping at least one of the inner legs and energizing the inner legs, a bucking winding supplied with alternating current enveloping one of said inner legs and axially displaced from said primary winding, said primary winding being in series with at least a porton of said bucking winding, and an output circuit supplied with energy derived from a winding subjected to resultant flux.

16. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, a primary winding supplied with alternating current enveloping at least one of the inner legs and energizing the inner legs, a bucking winding supplied with alternating current enveloping one of said inner legs, a cumulatively acting winding supplied with alternating current enveloping another of said inner legs, said bucking winding and cumulatively acting winding being connected in series with each other, and an output circuit supplied with energy derived from a winding subjected to resultant flux.

17. Alternating current controlling apparatus comprising a core having a plurality of outer legs and a plurality of inner legs, a primary winding supplied with alternating current enveloping at least one of the inner legs and energizing the inner legs, a bucking winding supplied with alternating current enveloping one of said inner legs and axially displaced from said primary winding, a cumulatively acting winding supplied with alternating current enveloping another of said inner legs, said primary winding being in series with at least a portion of said bucking winding and said bucking winding being connected in series with said cumulatively acting winding, and an output circuit supplied with energy derived from a winding subjected to resultant flux.

18. Alternating current controlling apparatus comprising a core having legs forming a fork, a primary alternating current winding on the leg forming the common portion of the fork, a bucking winding supplied with alternating current on a leg forming one of the prongs of the fork, a cumulatively acting winding supplied with alternating current on a leg forming another prong of the fork, said bucking winding being connected in series with said cumulatively acting winding, and an output winding on said core subjected to resultant flux.

19. Alternating current controlling apparatus comprising a core having legs forming a fork, a primary alternating current winding on the leg forming the common portion of the fork, a bucking winding supplied with alternating current on a leg forming one of the prongs of the fork, a cumulatively acting winding supplied with alternating current on a leg forming another prong of the fork, said primary winding being in series with at least a portion of said bucking winding, and an output winding enveloping at least one of said legs of the fork.

20. Alternating current controlling apparatus comprising a core having legs forming a fork, a primary alternating current winding on the leg forming the common portion of the fork, a bucking winding supplied with alternating current on a leg forming one of the prongs of the fork, a cumulatively acting winding supplied with alternating current on a leg forming another prong of the fork, said primary winding being in series with at least a portion of said bucking winding and said bucking winding being in series with said cumulatively acting winding, and an output winding enveloping said legs forming the prongs of the fork.

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