

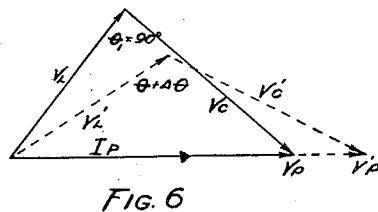
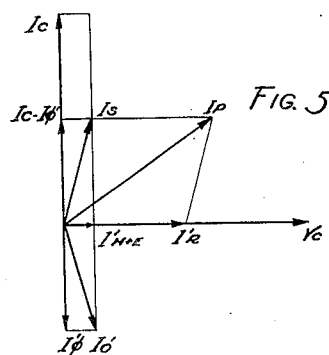
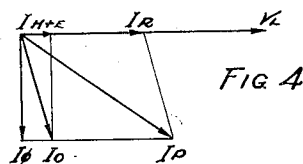
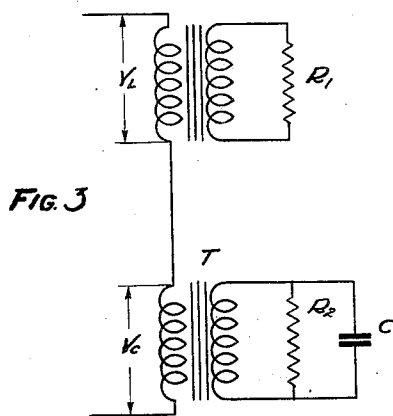
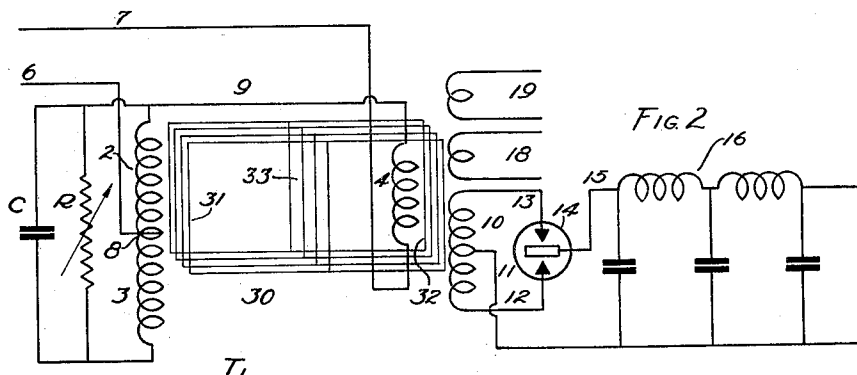
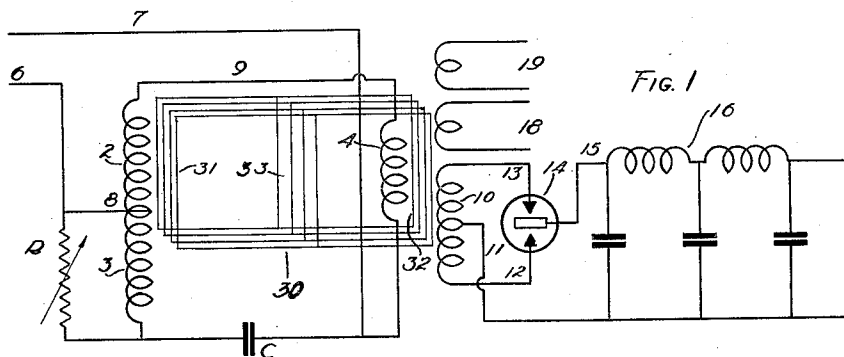
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REGULATING SYSTEM

Original Filed April 28, 1928



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UNITED STATES PATENT OFFICE

1,985,635

REGULATING SYSTEM

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8 Claims. (Cl. 171-119)

My invention relates to an electrical regulating system and more specifically to a power transformation system whereby variations of input voltage over a wide range of limits do not affect the voltage output in any substantial degree.

The recent developments of radio receiving systems have resulted in a demand for means for supplying the filament and plate circuits of vacuum tubes from the ordinary house current mains. As is well known, the thermionic tubes used in such sets require that the power delivered to them be of substantially constant and invariable voltage. Under the present methods of distribution of alternating current for domestic purposes, it is practically impossible for the voltage of the house circuit to be constant throughout the day or to be equal to the voltage of the circuit in another house. The load variations through the day result in line variations. The position of the particular house circuit with respect to the supply transformer, as well as the position of the supply transformer with respect to the high tension mains, results in a voltage variation which not only occurs through the day in one particular spot, but which also occurs among a number of spots at one particular time.

The ordinary means for translating the alternating current of the mains into substantially direct current for use in a radio receiving set, comprises a transformer, a rectifier in secondary circuit, and means for filtering out and smoothing out the ripples in the rectified current. It will readily be seen that as the line voltage varies, the final rectified voltage will vary and unless compensating means at the radio receiving set are used, the tubes will be operated more or less haphazardly. Such haphazard tube operation is very bad on the life of the tube. If the filaments of the tubes are operated in such a manner, they will be burned out or stripped of their coating depending upon whether the filament is overloaded or underloaded. If the plate circuit varies too much, a great plate voltage overload will strip the filament or paralyze the tube.

My invention aims at overcoming the variations in secondary voltage, irrespective of how the primary line voltage may vary within reasonably wide limits. Although I have described my invention with reference to a vacuum tube supply system, it is to be clearly understood that my invention is independent of this and may be used wherever a constant voltage which is to be obtained from a variable voltage is required. Although the variations may be fast, it will readily be understood that the variations might just as well be over a period of days or even weeks and in fact, the supply voltage need not necessarily vary at all and can very well be different from what is ordinarily taken as the average.

In the broader aspects of the invention, the voltage supply is divided up into two vector quantities. The magnitude of one of these vector quantities is kept substantially constant and this quantity is the one that is actually used. The other vector quantity is allowed to vary although its magnitude, too, may be kept constant. In either case, this second vector quantity, whether variable or constant, may be used or discarded. The angle between the two vectors is allowed to vary. In this way, the supply voltage which, of course, represents the resultant vector is broken up into the above two vectors. The variable resultant has as its counterpart in the components, the variable phase angle and perhaps one variable vector, the other remaining substantially constant.

My invention is an improvement on the invention which is the subject of my application entitled "Regulating system", Serial No. 267,402, filed April 4, 1923, and assigned to the same assignee as this case.

In the application mentioned, the invention broadly comprises a system for accomplishing substantially the same results as my invention does. The means for accomplishing this comprises in general a transformer, the primary of which is in series with a reactance which is either predominantly capacitative or inductive. If the reactance is capacitative, then there is also an inductance as a choke or transformer used in connection therewith. This choke or transformer has a large capacity used with it so that the combination is capacitative. The substantial constancy of voltage may be obtained either at the terminals of the inductive or capacitative part of the system. In any event, the inductance which may be either a choke or a transformer, which is part of the capacitative portion of the system, is operated preferably at the upper bend of the magnetization curve. This is done in order to take advantage of the very large variation of inductance with small variation of impressed voltage.

The capacity may be assumed to be constant for all practical purposes. The result is, therefore, that in the capacitative portion of the system a small change in voltage across the terminals of that portion of the system will result in a current change which will result in a great change of the value of inductance and hence the effective reactance of the capacitative portion of the system is materially changed, thus resulting in a phase displacement between current and voltage.

Of course it is to be understood that the choke might be used in the inductive portion of the system and the transformer be part of the capacitative portion of the system.

By actual measurement the voltage across each portion of the system has been measured and since the actual numerical values do not

differ very much with the variation in line voltage, the only logical conclusion is that the phase angle is changed. The inductance of the capacitative portion of the system need not of necessity be operated at that portion of the curve and may actually be operated on any non-linear part of the magnetization curve, but best results are obtained by operating as stated. The inductive portion of the system may or may not be operated at the same portion of magnetization curve.

To make a device embodying a regulating system as above described, commercially practical, it must be compact, must have as little material therein as possible and be efficient. In general, my improvement consists in winding all the necessary coils on one core. I also make use of an auto transformer, rather than a transformer with two separate windings to save materials and space. In this way, the wire of the autotransformer carries both primary and secondary currents, which of course, are in opposition and thus less copper is required than would ordinarily be the case. Since the core is operated at a high magnetic intensity by at least one of the inductive elements of the system, it can readily be seen that there will be considerable heat losses in the core from that fact alone. By combining all inductance elements on one core, I have applied the same heat losses to a greater mass—that is, a greater core in this instance—with the result that the entire core will run much cooler, especially at high loads.

As is well known, the primary and secondary currents in an autotransformer are approximately 180° out of phase with each other. The result will be that that portion of the wire which carries both secondary and primary currents will only have the difference between the currents. This means that with less current flowing through a considerable portion of the transformer, the resistance losses which are transformed into heat will be much less than would be the case were there two separate coils. Hence, by my improvement in combining all the inductance elements on one core, I have reduced the current losses and the heating effect therefrom and have distributed the heat losses in the magnetic core over a much greater mass of material.

In addition to the above—what might be termed technical advantages—the device as a whole becomes much more compact, requires less material and is considerably cheaper than the system of the application above. Referring to the above in general, I carry out my invention by providing a three legged core, the central leg having a cross section approximately equal to the sum of the cross sections of the other two legs. The outside legs may be of substantially equal cross section but need not be so if not desirable. On one leg, I wind a coil which is tapped at an intermediate portion thereof. The entire coil represents the secondary of the autotransformer while a smaller portion thereof comprises the primary of the autotransformer. On the other leg of the core, I provide primary and secondary coils of a transformer. The first coil and primary of the transformer are connected in series and have the line current flowing through them. By suitably connecting a capacity in the circuit, I make one of the inductance elements part of a capacitative load in which the inductance changes greatly with a comparatively small change of applied potential.

Referring to the drawing:

Figure 1 shows one form of my invention,

Figure 2 is a modification,
Figure 3 is a diagrammatic showing of the invention,

Figures 4 and 5 are vector diagrams referring to Figure 3,

Figure 6 is a vector diagram of the resultants obtained from Figures 4 and 5.

Referring to Figure 1, there is shown the three legged core 30 having the end legs 31 and 32 preferably of substantially equal cross section and the central leg 33 equal to the cross sections of the other two. On leg 31 is wound a coil which is tapped at 8, forming coils 2 and 3. On the other leg are wound primary 4 and secondary 10 of a transformer. Conductor 9 connects outer end of coil 2 to the primary 4. The other end of primary 4 is connected through a condenser C to the outer end of coil 3. The position of tap 8 on coil 1 is more or less related to the capacity of condenser C and in general, the greater the capacity of condenser C, the nearer to the condenser tap 8 approaches. Across tap 8 and outer end of coil 3 is connected a variable resistance R. The line supply 6 and 7 is connected to tap 8 and end of the primary 4. The secondary 10 of the transformer, as is usual, has a center lead 11 and two end leads 12 and 13 for rectification purposes. The two end leads are connected to any suitable rectifying device 14 and finally go out to lead 15. The central lead 11 is the other lead of the rectified current circuit. If desired, a filter 16 shown here as comprising a plurality of shunt condensers and series inductances, may be connected to smooth out the current impulses.

The resistance R is made variable so that the amount of current flowing through coil 3 may be regulated and thereby insure the proper operation of the device.

The line current goes from lead 6 to tap 8 through coil 2 which forms primary 2 of the autotransformer and then to the primary 4 of the transformer and then to the other side 7 of the line. The secondary of the autotransformer comprises coils 2 and 3. The condenser C combined with the coil 3 of the autotransformer makes the autotransformer load capacitative with respect to the coil 3 and hence aids in regulating the system.

If desired, other secondaries 18 and 19 may be added on core 32 to provide filament supply for tubes or other purposes.

Referring to Figure 2, we have substantially the same elements and connections except that condenser C and resistance R are connected across the entire secondary 2 and 3 of the autotransformer.

Referring to Figure 3 two transformers T and T_1 are shown. T has capacitance C across its secondary which operates in such a way that the entire transformer load becomes capacitative rather than inductive. R_1 and R_2 represent the loads. V_c and V_L each represent the capacitative and inductive load voltages in series across the line.

In the vector diagrams, Figures 4 and 5, Figure 4 represents the inductive portion of the system, namely T_1 and its circuits while Figure 5 represents the capacitative portion of the entire load—that is, transformer T and its circuits. I_p represents the line current. Along vector V_L may be laid off vectors I_R and I_{H+E} . I_R represents the load current while I_{H+E} represents the current losses due to hysteresis and eddy currents.

At right angles to the current vector, is vector

I_L which represents the magnetizing component of the current at right angles to the primary voltage. The resultant I_o of the two vectors I_{H+E} and I_L represents the no load operating current. The vector I_p , which is the resultant of I_R and I_o , represents the current going through the primary of T_1 . In case T_1 were a choke this current would, of course, be the current going through the choke. As can be seen, the angle between V_L and I_p represents the lagging current in T_1 .

Referring to Figure 5, V_o , I_R and I_{H+E} are laid off in similar manner. The resultant I_o' is obtained in the same manner as in Figure 4. At right angles to V_o and opposite in direction to I_o' , is laid off I_c which is the capacitive leading current. Subtracting I_o' from I_c and then combining I_{H+E} with this difference vector, we obtain vector I_s . Combining this vector with the load current I_R , we finally obtain the resultant I_p which, as above, represents the current through the primary of the load—in this case—of transformer T . It should be noted that since T and T_1 have their primaries in series, I_p will be the same in both instances and, therefore, vectors I_p in Figures 4 and 5 are equal to each other. Figure 6 is a composite of both resultants of Figures 4 and 5. Taking vector V_p and laying I_p along in the same direction, we may obtain components V_L and V_c from the original V_p . It should be noted that the supply line is assumed to have substantially unity power factor since I_p and V_p are in the same direction. V_c has been transposed about V_p so as to close the triangle.

Assume that V_p varies. It is readily seen that this variation may be taken up in any one of three ways. The sides of the triangle V_L and V_c may both remain substantially constant while their angles with respect to each other and to the base V_p may change. This, of course, is only true within certain limits. In addition, the lengths of the two sides V_L and V_c , as well as their angles, may change to meet the changing length of V_p . A third way is for the angles to remain the same as V_p changes, while the lengths of V_L and V_c change. It is also possible to have only one side of V_L or V_c change as well as the angles when base V_p changes. The dotted lines V_L' and V_c' show a variation of base V_p . V_L remains substantially constant while θ varies as well as V_c . Thus it can be seen that though base V_p varies considerably, still V_L and V_c do not vary much, V_L swinging and describing an arc of a circle. In my system, I keep at least one of the sides, preferably V_L , constant and allow V_c and the corresponding angles to vary as V_p changes. I can, of course, keep both V_L and V_c constant and merely allow the angles to vary, but this method is not as desirable from a commercial point of view as only keeping one side constant.

Thus it will be seen that I have devised a system which will regulate to within close limits for variations of or departures from standard voltages. Furthermore, the system may be embodied in an apparatus which is cheap, and requires a minimum of parts and material and operates with a minimum of losses.

I claim:

1. A regulating system comprising a transformer having a primary and secondary, an impedance in series with the primary, said impedance having inductance, and a condenser associated with the impedance, the system thereby

providing means for operating the inductance of one of the elements with which the condenser is associated so that a small change of voltage results in a great change in the value of the inductance, all the magnetic elements having a common core.

2. A regulating system comprising a plurality of inductances in series, and a condenser in parallel with one of said inductances, the system thereby providing means for operating at least one of said inductances so that its value changes greatly compared to voltage changes, said inductances having a common core.

3. A regulating system comprising a plurality of inductances in series, at least one of said inductances being a transformer, and a condenser in parallel with at least one of said inductances, the system thereby providing means for operating at least one of said inductances so that its value changes greatly compared to voltage changes, one of said inductances being an autotransformer.

4. A constant current supply system comprising a transformer having a primary and secondary, an inductance in series with the primary, said transformer and inductance having a common core, and a condenser associated with at least one of the series connected elements, the system thereby providing means for operating the element with which said condenser is associated so that small voltage variations result in large inductance variations.

5. An alternating current regulating system adapted to supply a substantially constant alternating voltage from a line in which voltage fluctuations occur comprising means for breaking up the line voltage into a plurality of portions, means for causing a phase displacement of said voltages and for causing a variation of said phase displacement as the line voltage varies, and means for causing any further line voltage variations to be restricted to one of the voltage portions, all of said means comprising a plurality of inductances on a common core.

6. A regulating system, comprising a plurality of inductances in series and a condenser associated with one of said inductances, at least one of said inductances being so operated that its value changes greatly compared to voltage changes, all of said inductances having a common magnetic core.

7. A regulating system, comprising a network consisting of a plurality of inductive and reactive impedances in series, all of said inductive impedances having a common magnetic core, a source of alternating potential connected to two spaced points in said network, at least one of said reactive impedances being so operated that its value changes greatly compared to voltage changes impressed thereon.

8. An alternating current regulating system adapted to supply a substantially constant alternating voltage from a line in which voltage fluctuations occur, comprising means for breaking up the line voltage into a plurality of components, means for causing a phase displacement between said components, and means for causing a variation of said phase displacement as the line voltage varies, said means being so designed that said variations in line voltage produce variations in magnitude of but one of said components, each of said means including an inductance and all of said inductances being provided with a common magnetic core.

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