July 6, 1948. A. H. B. WALKER 2,444,715

VOLTAGE REGULATING TRANSFORMER

Filed Sept. 5, 1946

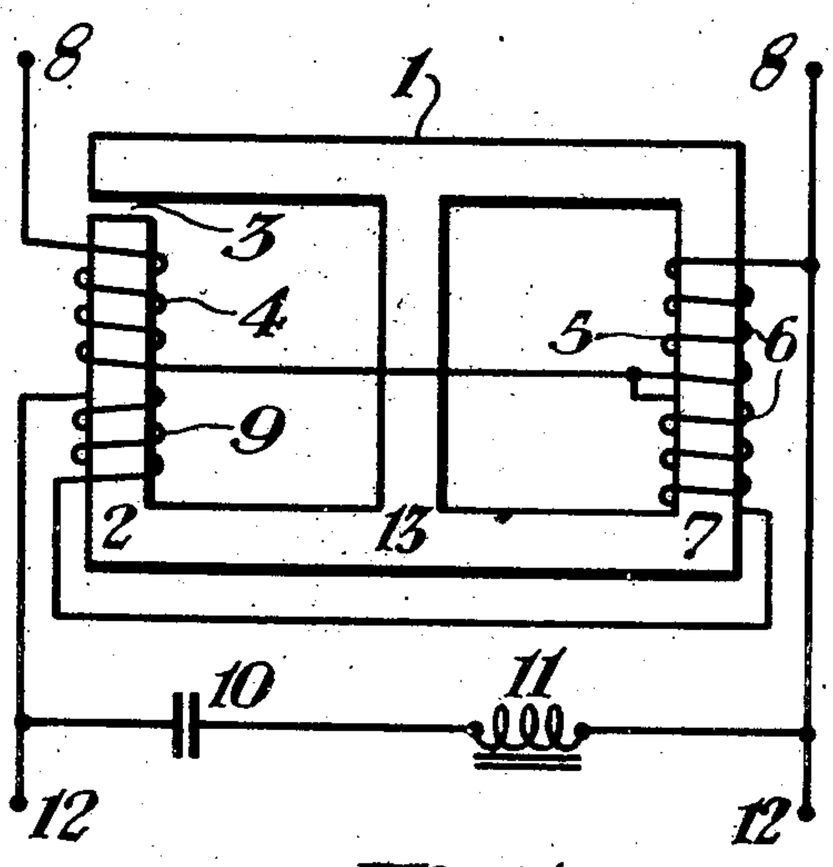

Fig. 1.

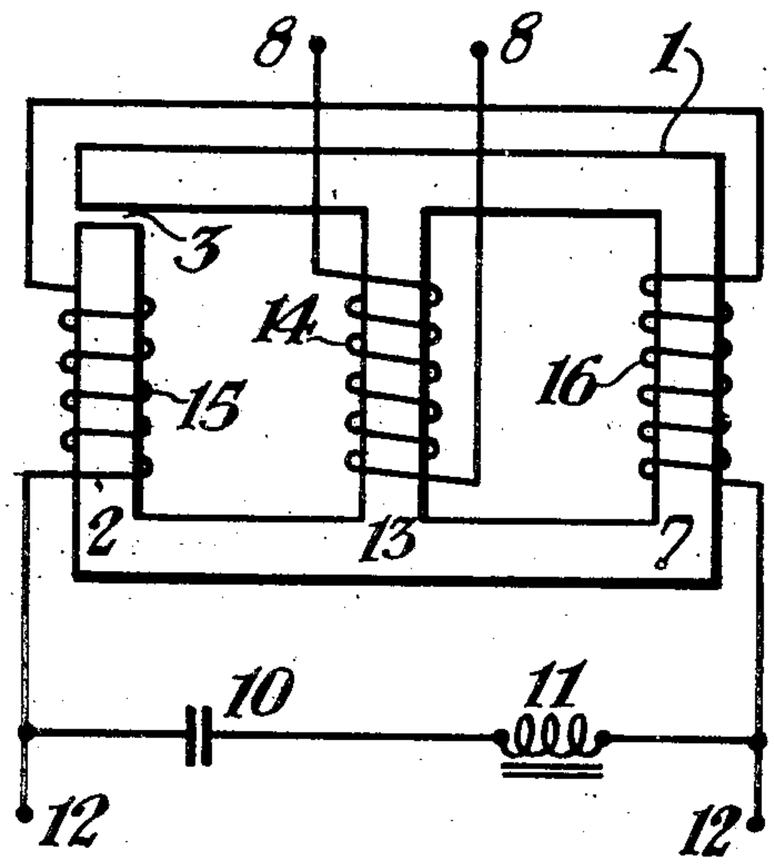

Fig. 2.

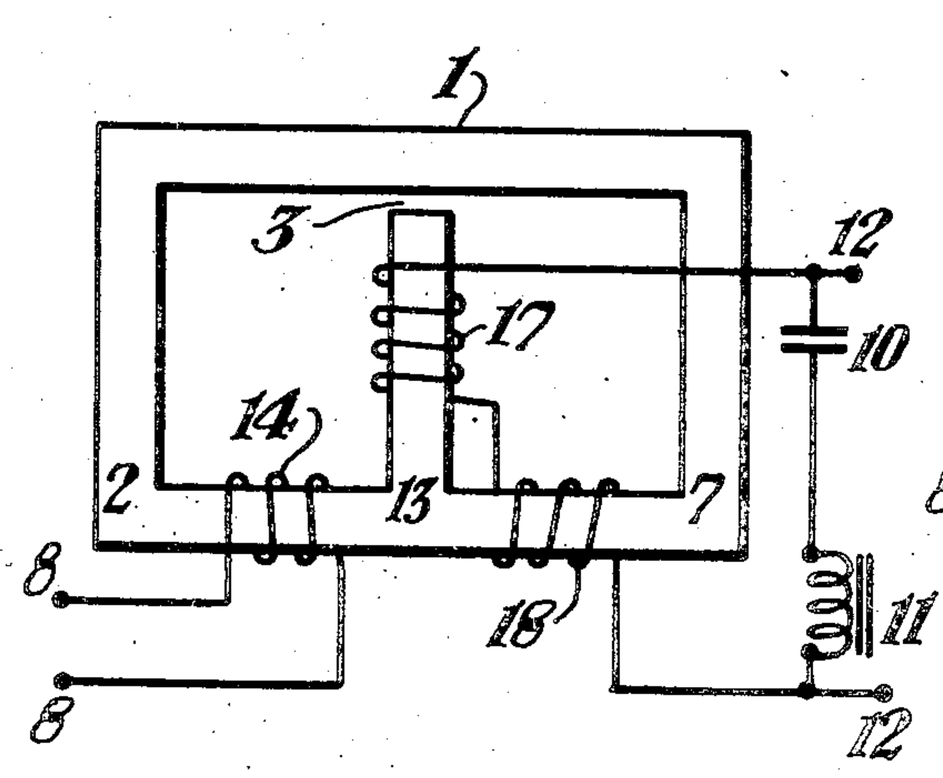

Fig. 3.

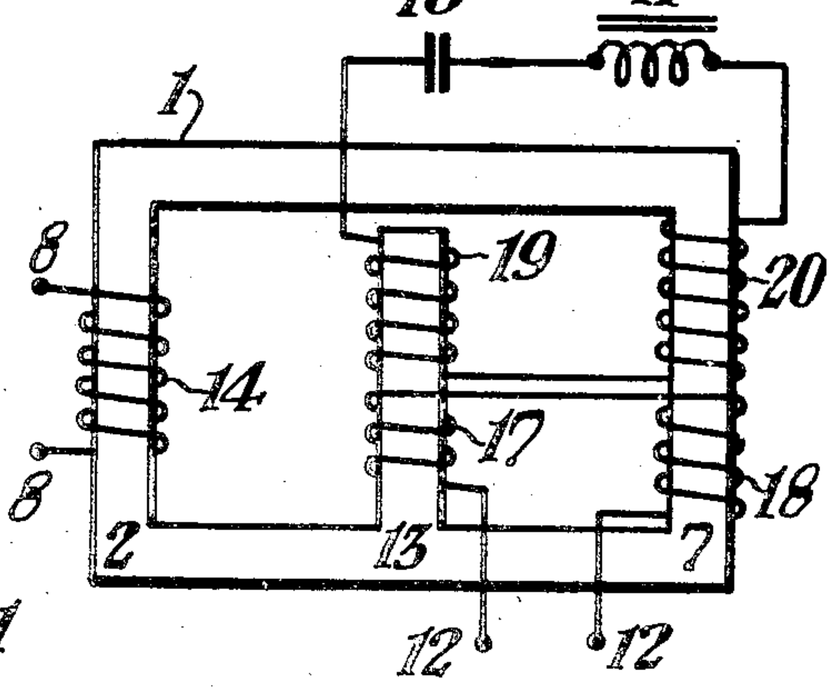

Fig. 4.

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VOLTAGE REGULATING TRANSFORMER

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4 Claims. (Cl. 323—56)

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This invention relates to voltage regulating apparatus for alternating electric current circuits adapted to ensure the maintenance of a substantially constant voltage at the terminals of a load circuit supplied with current from an alternating current supply circuit regardless of variations in the load and in the supply circuit voltage.

A form of regulating apparatus of this character devised by me is shown and described in British Patent No. 548,526, and comprises two transformers one of which is a two-coil transformer, the other having a magnetic core arranged to be operated at a relatively high flux density above the knee of the B-H curve of the core material, the primary windings of the transformers being connected in series with one another across the alternating current supply circuit while the secondary windings are connected in series opposition with one another and in parallel with a series connected condenser and inductances across the load circuit.

The present invention has for its object to provide novel and improved voltage regulating apparatus of the same general character in which the two transformers are combined into a single transformer comprising a core having partially separate magnetic flux paths, one of which is operated at the relatively high degree of saturation.

One advantage of this combined arrangement is that the portion of the core operated at the lower degree of magnetic saturation is available for dissipating the heat developed in other portions of the core, another advantage being that the windings may be so arranged and connected that the output voltage applied to the load circuit can be arranged to have any desired value relative to the supply circuit voltage in a simple and convenient manner.

The invention is illustrated by way of example in the accompanying drawings, Figures 1, 2, 3 and 4 of which are diagrammatic views of different forms of regulating apparatus embodying the invention.

Referring first to Figure 1 it will be seen that this form of apparatus comprises a single three-legged magnetic core 1, an outer leg 2 of which is provided with a suitable air-gap 3. The leg 2 of the core is provided with a winding 4 connected in series with a portion 5 of a winding 6 on the other outer leg 7 across the supply circuit terminals 8. A winding 9 on the outer leg 2 is connected in series opposition with the whole of the winding 6 on the outer leg 7 of the core and in parallel with a series connected condenser 10 and inductance 11 across the load circuit terminals 12. The central leg 13 of the core 1 is not provided with any winding and serves to complete the path for the magnetic fluxes traversing the outer legs 2, 7 of the core.

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The leg 2 of the core is operated at a normal flux density, while the leg 7 is arranged to be operated at a relatively high flux density which is above the knee of the B—H curve of the core material. The output voltage is due principally to winding 6, and this is reduced by winding 9 sufficiently to stabilize the voltage across the output terminals 12. The condenser 10 draws a leading current in opposition to the magnetizing current in winding 6 to provide the stabilizing action. The winding of inductance 11, which is in series with condenser 10, is preferably mounted on a magnetic core having an air gap and arranged to operate at a relatively low flux density.

The condenser 10 and the coil 11, being connected in series across the output terminals, constitute a filter circuit having a double action. In the first place, coil 11 and condenser 10 are so chosen that at the supply frequency the filter circuit behaves as a condenser and draws a leading current in opposition to the magnetizing current in winding 6 to provide the stabilizing action, while at the frequency of the third harmonic of the supply frequency, which is the principal component of the wave form distortion, coil 11 and condenser 10 are in series resonance and appear as a low resistance, therefore providing a virtual short circuit to the third harmonic magnetizing current in winding 6. Owing to the purity of wave form which results from this filter, the circuit may be analyzed by vector diagrams as explained in the British patent hereinbefore referred to, wherein it is shown that a substantially constant output voltage is attained with varying load and varying input voltage.

It will be evident that the form of apparatus shown in Fig. 1 of the present application is electrically and magnetically equivalent to that of the earlier form of apparatus above referred to.

Referring now to Figure 2 in this form of apparatus a single primary winding 14 on the central leg 13 of the core 1 is connected to the supply circuit terminals 8, and secondary windings 15, 16 on the outer legs 2, 7 respectively are connected in series opposition to the load circuit terminals 12 in parallel with the series connected condenser 10 and inductance 11. The outer leg 2 of the core 1 is provided with a suitable air-gap 3 and the operation of this form of apparatus is substantially the same as that of the previously known apparatus above referred to. It will be appreciated, however, that the primary winding 14 is electrically separated from the secondary windings 15, 16 which is of advantage in certain applications of my invention.

Referring now to Figure 3 in this form of apparatus the air-gap 3 is provided in the central leg 13 of the magnetic core 1, the primary winding 14 connected to the supply circuit terminals 8 being arranged on the portion of the core circuit

including the outer leg 2. A secondary winding 17 on the central leg 13 and a secondary winding 18 arranged as shown are connected in series opposition across the load circuit terminals 12 in parallel with the series-connected condenser 10 and inductance 11.

Referring now to Figure 4 a modified form of the apparatus of Figure 3 is shown in which the series-connected condenser 10 and inductance 11 instead of being directly connected across the load circuit terminals are connected to separate windings 19, 20 on the same legs 13, 7 of the core as the secondary windings 17, 18 this arrangement having the advantage that since the secondary windings 17, 18 are entirely electrically separate from the primary winding 14 and from the condenser and inductance circuit, the voltage applied to the load circuit terminals 12 can be readily adapted to any particular requirements without interfering with the design of the rest of the apparatus.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. Voltage regulating apparatus for an alternating current circuit of the kind described, in which a single transformer is provided comprising a primary winding on a magnetic core having partially separate magnetic flux paths one of which is operated at a relatively high flux density sufficient to cause wave form distortion and the other is operated at a low flux density, said apparatus comprising a main secondary winding on that portion of the magnetic core operated at a high flux density, a compensating winding connected in series opposition to said main winding on that portion of the magnetic core operated at a low flux density, and a filter comprising an inductance and a condenser tuned to series resonance at the third harmonic frequency of said alternating current effectively connected across said windings, the proportions of said filter being such that at the fundamental frequency of said alternating current said filter acts as a tuning condenser for said main winding of such a value that the current through said filter cooperating with the magnetizing current in said main winding serves to stabilize the voltage delivered by said apparatus.

2. Voltage regulating apparatus adapted to be interposed between the input and output terminals of an alternating current circuit comprising a transformer having a primary winding on a magnetic core with partially separate magnetic flux paths, a main secondary winding on a portion of said magnetic core operated at a high flux density sufficient to cause wave form distortion, a compensating winding on another portion of said magnetic core operated at a low flux density, said primary winding being connected in series with a portion at least of said main winding across said input terminals and said compensating winding being connected in series opposition with said main winding across said output terminals, and a filter comprising an inductance and a condenser tuned to series resonance at the principal harmonic frequency due to said wave form distortion connected across said output terminals, the proportions of said filter being such that it acts as a tuning condenser at the fundamental frequency of said current and supplies magnetizing current to said main winding of a value sufficient to stabilize the voltage delivered to said output terminals.

3. Voltage regulating apparatus adapted to be interposed between the input and output terminals of an alternating current circuit comprising a transformer having a magnetic core with partially separate flux paths, a main secondary winding on a portion of its magnetic core operated at a high flux density sufficient to cause wave form distortion, and a compensating winding on another portion of its magnetic core operated at a low flux density, said compensating winding being connected in series opposition with said main winding across said output terminals, a primary winding on said magnetic core for supplying flux to both said portions, said primary winding being connected across said input terminals, a filter comprising an inductance and a condenser connected in series across said output terminals and tuned to resonance at the principal harmonic frequency of said wave form distortion, said filter acting primarily as a tuning condenser at the fundamental frequency of said alternating current to supply magnetizing current to said windings for stabilizing the resultant voltage across said output terminals.

4. Voltage regulating apparatus adapted to be interposed in an alternating current circuit supplied with a varying primary voltage comprising a primary winding on a magnetic core having two portions one of which includes an air gap for increasing its reluctance the other being of relatively low reluctance, a main winding on the low reluctance portion of said core for delivering induced secondary voltage, a condenser effectively connected in parallel with said main winding for tuning it to at least partial resonance whereby said low reluctance path is normally operated at a flux density approaching saturation thereby limiting the variation in the secondary voltage as the primary voltage varies and also causing distortion of the wave form, a compensating winding connected in series opposition to said main winding but mounted on the high reluctance portion of said core, said compensating winding supplying an opposing undistorted voltage which varies with the primary voltage so as to stabilize the fundamental component of the secondary voltage, an inductance comprising an additional winding on a separate core connected in series with said condenser across said main and compensating windings, said additional winding serving to tune said condenser to series resonance to provide an effective short circuit for the principal harmonic component of said distorted wave form, whereby said secondary voltage is caused to have not only a substantially constant value but also a substantially undistorted wave form.

ALEC HERVEY BENNETT WALKER.

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