March 10, 1942. J. B. GIBBS. 2,276,032

ADJUSTABLE REACTANCE TRANSFORMER

Filed July 31, 1940

Fig. 1.

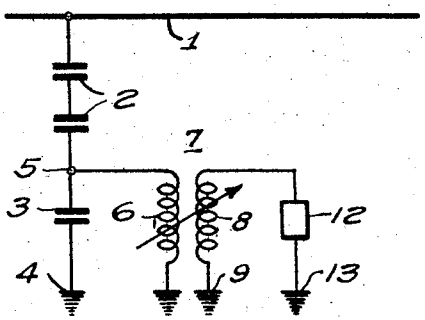


Fig. 2.

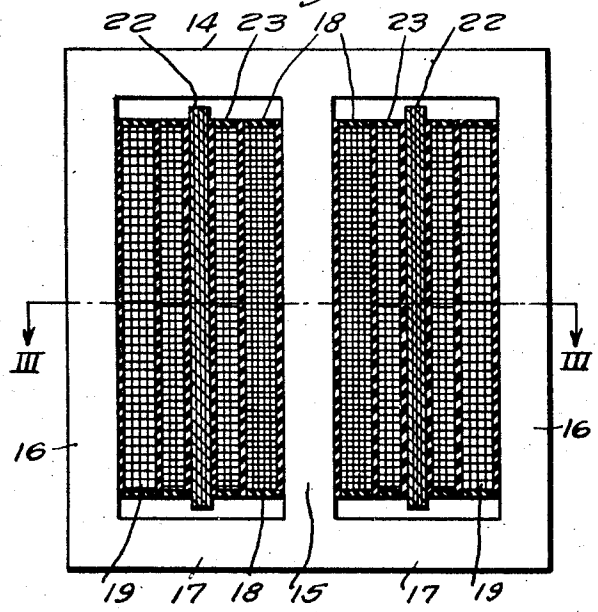


Fig. 4.

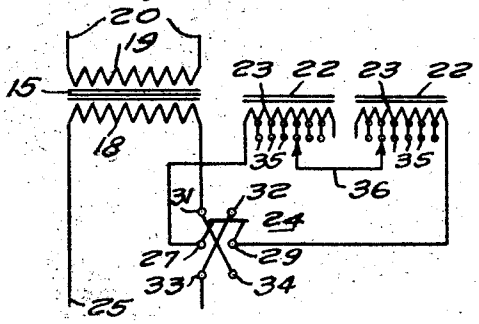


Fig. 3.

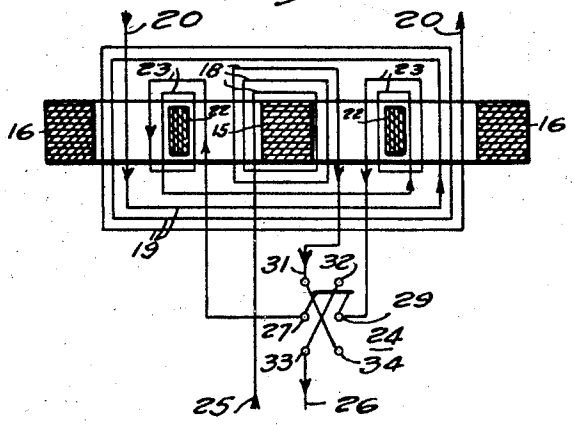
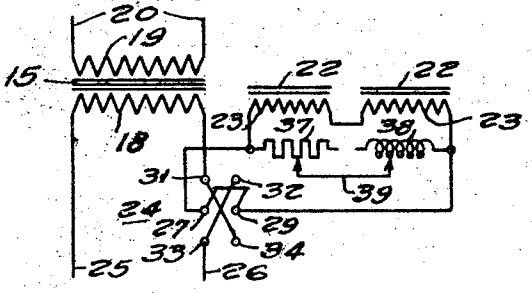


Fig. 5.



WITNESSES:

E. A. McCloskey.

Patented Mar. 10, 1942 2,276,032

UNITED STATES PATENT OFFICE

2,276,032

ADJUSTABLE REACTANCE TRANSFORMER

Jesse B. Gibbs, Sharon, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application July 31, 1940, Serial No. 348,723

8 Claims. (Cl. 171—119)

This invention relates to adjustable reactance transformers and has application whereever adjustable-reactance transformers are required, such as transformers adapted for use in providing the necessary tuning reactance for resonance in a capacitor type potential device of the character employing a coupling capacitor or potentiometer for supplying electromotive force from a high voltage source to voltage-responsive devices, that is proportional to and substantially in phase with the electromotive force of the source. Such a potential device is illustrated and described in application Serial No. 348,774 of P. O. Langguth and E. L. Harder for "Potential device," filed July 31, 1940, and assigned to the same assignee as this application.

It is common practice when a high reactance transformer is desired to provide a magnetic shunt in the space between the high voltage and low voltage windings of the transformer to increase the leakage flux. The reactance of such a transformer cannot ordinarily be varied.

The reactance of such a transformer may, however, be made adjustable if an auxiliary winding is provided about the magnetic shunt and controlled to vary the flux density of the shunt so as to vary the relation between the leakage flux which passes through the shunt to the total flux of the transformer.

It is an object of this invention to provide a transformer having means controlled by the current flowing in the transformer windings for determining the leakage reactance of the transformer and to provide for varying this leakage reactance.

It is a more specific object of the invention to provide an adjustable reactance transformer provided with magnetic shunts between the primary and secondary windings having auxiliary windings positioned thereabout and in which the current in the auxiliary windings is the primary winding current or the secondary winding current or a portion thereof.

Other objects and advantages of the invention will be apparent from the following description of a preferred embodiment thereof, reference being had to the accompanying drawing, in which:

Figure 1 is a diagrammatic view of apparatus and circuits illustrating one application of a variable reactance transformer to a capacitor potential device;

Fig. 2 is an elevational view partly in section through a transformer constructed in accordance with the invention;

Fig. 3 is a sectional view taken on the lines III—III of Fig. 2, in which the winding conductors are shown diagrammatically; and

Figs. 4 and 5 are diagrammatic views showing modifications of the circuit connections shown in Fig. 3.

Referring to Fig. 1, the numeral 1 indicates a conductor of an alternating current high voltage circuit which may be one conductor of a polyphase circuit. A coupling capacitor or capacitance potentiometer comprising a series of condensers, indicated as 2 and 3, is connected between the conductor 1 and ground at 4. A tap 5 is provided between the upper section 2 and the lower section 3 of the potentiometer providing one terminal for the primary winding 6 of a variable reactance transformer 7 connected between point 5 and ground, the secondary winding 8 of which is connected to a burden 12, the secondary circuit being completed through the grounded terminal 9 of the winding 8 and the grounded terminal 13 of the burden 12.

Referring to Fig. 2, a variable reactance transformer is illustrated comprising a core 14 having a winding leg 15 and two outer legs 16 connected together at their corresponding ends by yoke portions 17. A primary winding 19 and a secondary winding 18 are provided and positioned about the winding leg 15, and are spaced sufficiently from each other to provide space for magnetic shunts 22 and windings 23 thereabout extending parallel to the winding leg 15, between the yoke portions of the core.

Referring to Fig. 3, the turns of the high voltage winding 19 extend about the winding leg 15 and both of the magnetic shunts 22. The auxiliary windings 23 comprising winding turns about the magnetic shunts 22 are shown connected through a switch 24 in series with the secondary winding 18 between terminal conductors 25 and 26. When the switch 24 is closed in the upper of its two circuit closing positions, connecting terminals 27 and 29 to the terminals 31 and 32 respectively, the instantaneous direction of current through several circuits will correspond to that indicated by the arrows. It will thus be noted that the current through the primary winding 19 and the current through the auxiliary windings 23 are in a counterclockwise direction as viewed in Fig. 3, so that the effect of the two currents in producing flux in the magnetic shunt 22 is added, thus increasing the flux in the magnetic shunts 23, thus increasing the leakage flux

of the transformer and the transformer reactance.

Similarly, when the switch 24 is in the lower of its two circuit closing positions, connecting the terminals 27 and 29 to terminals 33 and 34, respectively, the current through the circuit of the windings 23 will be in the opposite direction with respect to the current in windings 18 and 19, thus reducing the magnetic flux in the shunts 22 causing a reduction in the leakage flux and a decrease in the transformer reactance.

Referring to Fig. 4, in addition to the circuit arrangements shown in Fig. 3, a plurality of taps 35 are provided on the auxiliary windings 23 between selected ones of which the conductor 36 may be connected to vary the number of turns in the windings 23 that are included in series with the secondary winding 18 to correspondingly vary the control of the leakage flux effected by the windings 23. Thus any desired number of steps between the maximum and minimum reactance required may be effected by changing the connections to the tap points 35 to vary the number of effective turns in the auxiliary windings 23 and by changing the direction of current through these turns as controlled by the switch 24 to cause an increase or a decrease in the leakage flux that would exist if no auxiliary windings were provided about the magnetic shunts.

The flux in the magnetic shunts may be decreased, but not increased by short-circuiting the shunt coils through suitable resistance or reactance, or both. This serves to more or less completely choke the flux out of the iron shunts and thus decrease the reactance of the transformer. In Fig. 5, a circuit arrangement is shown in which, instead of the tap points 35 provided on the auxiliary windings 23 as in Fig. 4, a circuit in shunt to the windings 23 is provided including a resistor 37 and reactor 38 between selected points of which a conductor 39 is provided to vary the current flowing in the circuit of resistor 35 and reactor 36 in shunt to the windings 23. Thus the effective ampere turns of the windings 23 are varied by varying the proportion of the secondary current from the winding 18 that passes through the auxiliary windings 23.

Modifications in the apparatus and circuits illustrated and described within the spirit of my invention will occur to those skilled in the art, and I do not wish to be limited otherwise than by the scope of the appended claims.

I claim as my invention:

1. A variable reactance transformer comprising a core of magnetic material having a winding leg, primary and secondary windings positioned about said winding leg, one of said windings being positioned about the other, a shunt of magnetic material positioned between the primary and secondary windings and means for adjusting the flux density of said shunt comprising a winding thereon and means for including said winding in circuit with one of said above-named windings.

2. In combination, a transformer comprising a core of magnetic material including a winding leg, primary and secondary windings thereon positioned the one about the other about a common axis, and means for varying the reactance of said transformer comprising a magnetic shunt between the primary and secondary windings of the transformer extending along the outside of the inner one of the two windings and within the outer one of the two windings, an auxiliary winding about the magnetic shunt included in circuit with one of the aforenamed windings, and means comprising a plurality of tap connections for varying the effective number of turns of said auxiliary winding.

3. In combination, a transformer comprising a core of magnetic material including a winding leg, primary and secondary windings thereon about a common axis thereon, means for varying the reactance of said transformer comprising a magnetic shunt between the primary and secondary windings of the transformer extending along the outside of the inner of the two windings and within the outer of the two windings, an auxiliary winding about the magnetic shunt included in circuit with one of the aforenamed windings, means comprising a plurality of tap connections for varying the effective number of turns of said auxiliary winding, and means for reversing the direction of current flow in said auxiliary winding with respect to the primary and secondary windings.

4. In combination, a transformer comprising a core of magnetic material having a winding leg, primary and secondary windings thereon one of said windings being positioned about the other, and means for varying the reactance of said transformer comprising a plurality of magnetic shunts between the primary and secondary windings extending along the outside of the inner one of the two windings and within the inner of the outer one of the two windings, individual auxiliary windings about the several magnetic shunts connected in series with the secondary winding for effecting changes in the leakage reactance of the transformer, and means comprising a plurality of tap connections for varying the effective number of turns of said auxiliary windings.

5. In combination, a transformer comprising a core of magnetic material having a winding leg and two outer legs parallel thereto and connected by yoke portions between their outer ends, primary and secondary windings about the winding leg, and means for varying the reactance of said transformer comprising magnetic shunts extending between the yoke portions and between the primary and secondary windings parallel to the axis thereof, auxiliary windings about the magnetic shunts connected in series with the secondary winding for effecting changes in the leakage reactance of the transformer, said auxiliary windings having a plurality of tap connections for varying the effective number of turns thereof in circuit with the secondary winding.

6. In combination, a transformer comprising a core of magnetic material having a winding leg, primary and secondary windings thereon, and means for varying the reactance of said transformer comprising a plurality of magnetic shunts between the primary and secondary windings, auxiliary windings about the magnetic shunts connected in series with the secondary winding for effecting changes in the leakage reactance of the transformer, and a circuit in shunt to said auxiliary windings including a variable impedance for varying the current flow through the auxiliary windings.

7. In combination, a transformer comprising a core of magnetic material having three leg portions connected at their ends by two yoke portions, primary and secondary windings on the middle one of the three leg portions, and means

for varying the reactance of said transformer comprising a plurality of magnetic shunts extending between the yoke portions of the core parallel to the leg portions and positioned between the primary and secondary windings, auxiliary windings about the magnetic shunts connected in series with the secondary winding for effecting changes in the leakage reactance of the transformer, said auxiliary windings having a plurality of tap connections for varying the number of turns thereof in circuit with the secondary winding, and means for reversing the direction of current flow in said auxiliary winding with respect to the primary and secondary windings.

8. In combination, a transformer comprising a core of magnetic material having a winding leg and two outer legs connected by yoke portions, primary and secondary windings on the winding leg, and means for varying the reactance of said transformer comprising magnetic shunts extending between the primary and secondary windings parallel to the winding leg, auxiliary windings about the magnetic shunts connected in series with the secondary winding for effecting changes in the leakage reactance of the transformer, a circuit in shunt to said auxiliary windings including a variable impedance for varying the current flow through the auxiliary windings, and means for reversing the direction of current flow in said auxiliary winding with respect to the primary and secondary windings.

JESSE B. GIBBS.