Jan. 20, 1931. R. K. POTTER 1,789,416

NEUTRALIZED VACUUM TUBE CIRCUITS

Filed Nov. 3, 1927

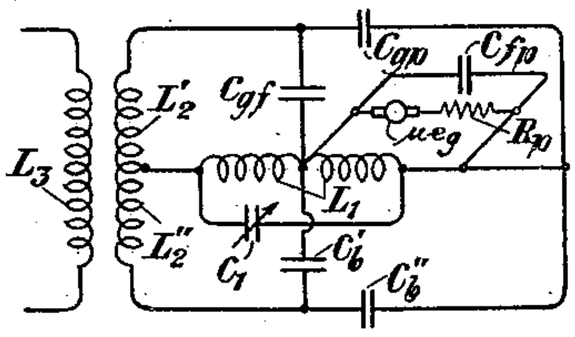

Fig. 1

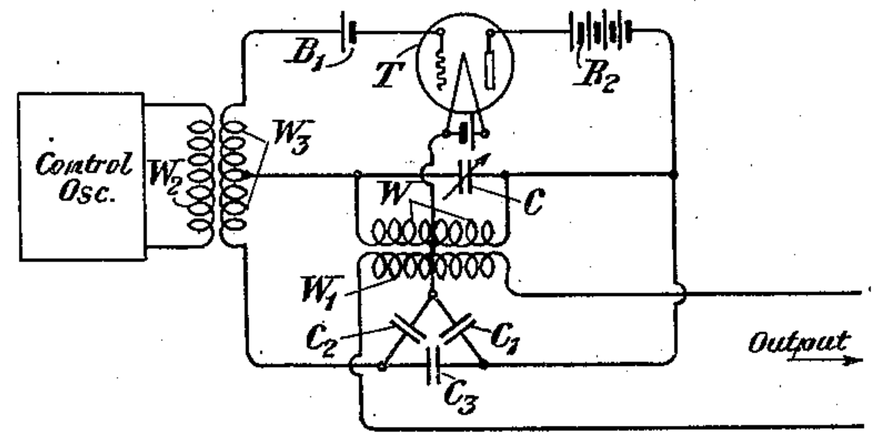

Fig. 2

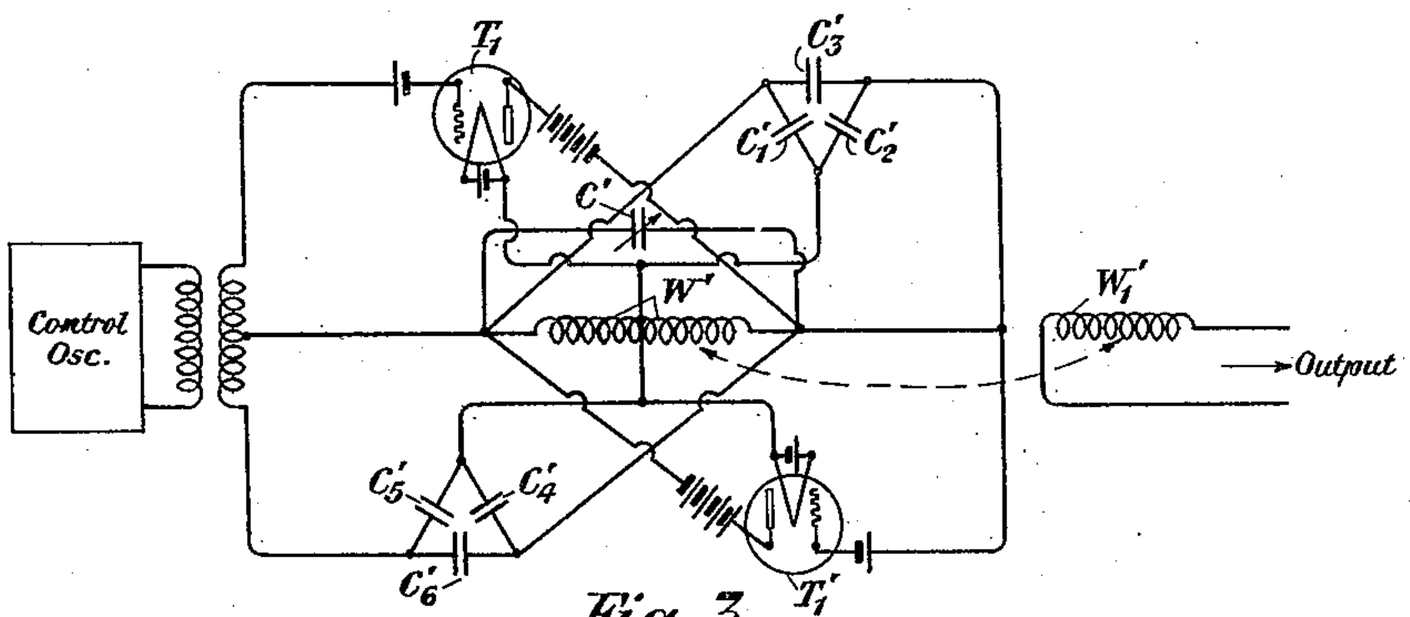

Fig. 3

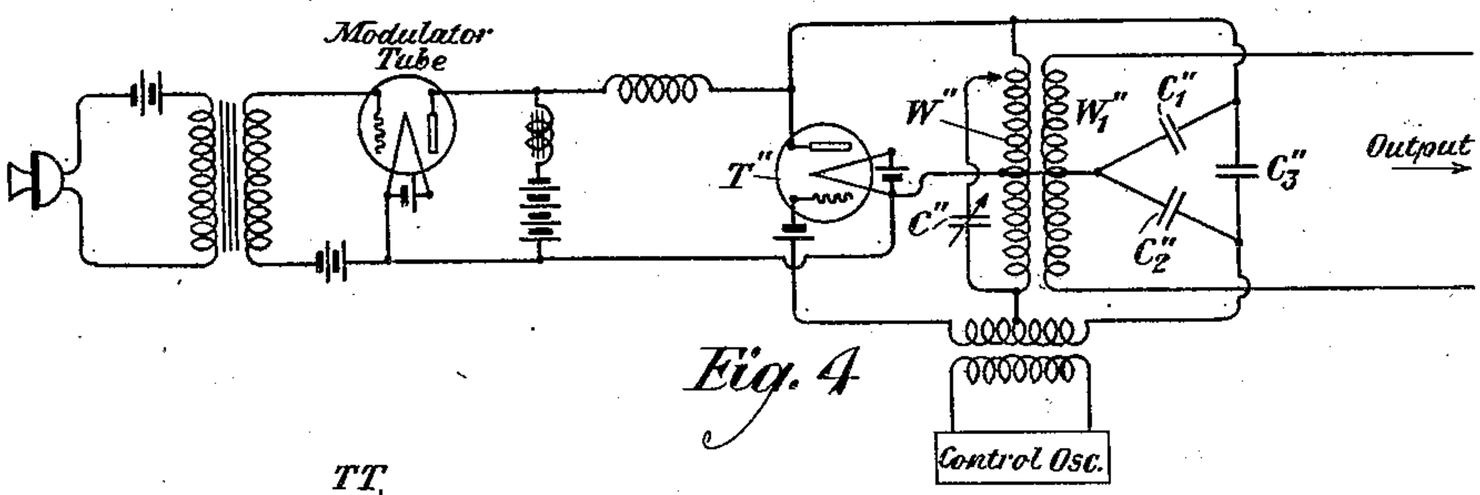

Fig. 4

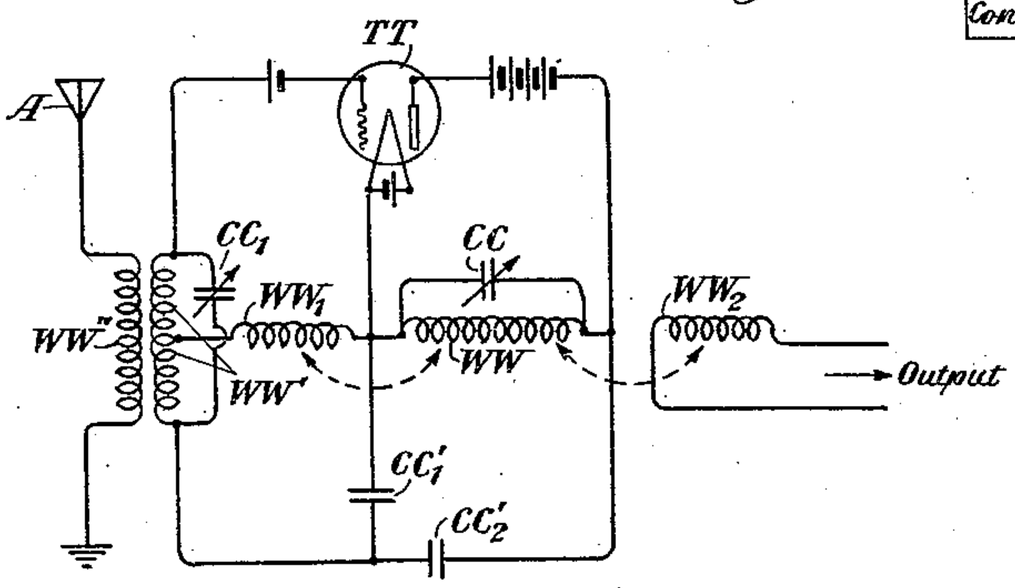

Fig. 5

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UNITED STATES PATENT OFFICE

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NEUTRALIZED VACUUM-TUBE CIRCUITS

Application filed November 3, 1927. Serial No. 230,910.

This invention relates to vacuum tube circuits and more particularly to vacuum tube circuits having a feed-back connection from the output to the input—for instances, oscillator circuits of certain types and regenerative circuits.

The problem solved by the applicant will be better understood from the following discussion relating to oscillator circuits: In the generation of short radio waves it has been found advantageous to make use of so-called "controlled oscillators"—that is, oscillators in which the frequency is stabilized by impressing upon the grid, for instance, a wave of the desired frequency from a constant source. When the natural frequency of the controlled oscillator differs slightly from that of the controlling wave from the associated source, the reaction in an unneutralized circuit arrangement tends to produce a change in the frequency of the stabilizing source. For a given vacuum tube oscillation circuit the current fed back through the capacity from plate to grid increases with the frequency. Accordingly, it will readily be understood that the reaction due to the feeding back of energy comes to have a particular importance in the generation of short radio waves. Furthermore, there are, of course, many cases in which it is desirable to impress upon the grid of a vacuum tube oscillator waves quite different in frequency from the natural period of the oscillator. In the absence of neutralization there will be a tendency for the modulated oscillator to react upon the associated circuit, changing the frequency if the frequency separation is small, or modulating back upon the plates of the associated vacuum tube apparatus.

The object of this invention is to prevent the above-discussed reaction upon the associated "modulation" circuit due to the feeding back of energy in the oscillator or similar "feed-back" circuit.

This object the applicant accomplishes by balancing the inter-electrode impedances of the oscillator circuit and so arranging the circuits that in the element of the oscillator through which the coupling to the associated circuit is effected the feed-back currents are neutralized and so have no effect on the associated circuit.

The invention will be more clearly understood from a reading of the following description. It is proposed to show in some detail the application of the invention to three controlled oscillator arrangements differing somewhat and to a regenerative radio receiving circuit. The principles of the invention which underlie the arrangements of these illustrative circuits will be clarified by a schematic disclosure of the inter-relation of impedances in a vacuum tube circuit of the type herein considered.

Accordingly, Figure 1 of the accompanying drawing shows schematically the impedance relations involved in the arrangements disclosed in the other figures of the drawing. Fig. 2 shows diagrammatically a simple controlled oscillator circuit neutralized in accordance with the invention. Fig. 3 shows a controlled oscillator of the push-pull type similarly neutralized. Fig. 4 shows a circuit arrangement combining a neutralized oscillator and a modulation circuit (the term "modulation circuit" being used in its more generally accepted sense). Fig. 5 shows diagrammatically a simple regenerative radio receiving circuit neutralized in accordance with the invention.

With reference, first, to Fig. 1 of the drawing, the inductances and the capacity of the oscillatory circuit are represented by L_1 and C_1, respectively. In accordance with convention, the plate output of the vacuum tube which generates the oscillations is represented by a small generator μe_g connected in series with the filament-plate resistance of the vacuum tube (R_p). The filament-plate capacity C_{fp} is connected in parallel with the generator and the filament-plate resistance, and both elements are bridged across a part of the oscillatory circuit inductance L_1. It is assumed that the grid of the vacuum tube generator is made sufficiently negative to prevent the flow of conductive current. The remaining inter-electrode impedances may now be represented by the capacities C_{gf} and C_{gp}, the grid-filament and the grid-plate impedances, respectively. In accordance with

the invention, the balancing or neutralizing capacities C'_b and C''_b are added to the circuit, and the circuit connections are made such that the inductances L'_2 and L''_2 are balanced. It will now be seen that the output of the generator (μe_g) will have no effect upon the input circuit L_3, the currents flowing through L'_2 and L''_2 being made equal in amplitude and opposite in phase by the proper selection of the neutralizing impedance values. It will be understood, of course, that the inductive coupling here shown is for the purpose of illustration. Other couplings, capacitive or through resistance, may be employed.

Turning attention now to Fig. 2 of the drawing, but bearing in mind the schematic disclosure of Fig. 1, the reader will understand the practical application of the ideas of the invention. Fig. 2 shows an oscillator circuit arrangement having a generator tube T. The battery B_1 serves to bias the grid of the tube T, and the battery B_2 provides the positive potential which is maintained on the plate. The resonant circuit of the oscillator comprises the condenser C and the coil winding W. Through this winding W and the associated winding W_1 the oscillator circuit is coupled to the output circuit. The winding W_3 in the grid circuit is associated with a winding W_2, and by this coupling means the stabilizing frequency from the control oscillator is impressed upon the controlled oscillator circuits. This control oscillator should be preferably a shielded vacuum tube generator of the crystal controlled type or an ordinary oscillator which is carefully shielded to prevent any exposure except that through its balanced output. It will be noted that the oscillator circuits are divided, and in particular there is a connection to an intermediate point of the winding W_3. The capacities to balance the inter-electrode capacities are here shown in the form of the condensers C_1, C_2 and C_3. It is to be understood that these elements represent balancing impedances, which might, in accordance with the requirements of an individual case, take the form of a capacity with a resistance and an inductance added, or some other form of impedance to suit the case. Again, a dummy vacuum tube arrangement may be used in a symmetrical circuit to form the balancing impedance. What is essential is that impedances are added to balance the inter-electrode impedances so that the current flows through the two parts of the coil W_3 will be equal in amplitude and opposite in phase.

In Fig. 3 of the drawing there is shown the application of the invention to a well-known type of push-pull oscillator, including the tubes T_1 and T'_1 associated, as shown, with a control oscillator which furnishes the stabilizing frequency. The resonant circuit is formed by the capacity C' and the inductance W', and the inter-electrode impedances of the tubes T_1 and T'_1 are balanced by the auxiliary impedances (here shown as capacities) C'_1, C'_2, C'_3 and C'_4, C'_5, C'_6, respectively. The element of the oscillator circuit through which this circuit is coupled to the control oscillator is, of course, divided as was the case is Fig. 2. The winding W' is associated with the winding W'_1 to form the output coupling of the system.

In the arrangement shown diagrammatically in Fig. 4 of the drawing, the control oscillator, the coupling to the controlled oscillator circuit, the tube T'', the elements C'' and W'' forming the resonant circuit, the coupling winding W''_1 of the output circuit and the balancing impedances C''_1, C''_2 and C''_3 all correspond to elements of the arrangement shown in Fig. 2. In place of the plate battery B_2 of Fig. 2, however, there is here substituted a modulator circuit as shown. Here again the inter-electrode impedances are balanced, and there is neutralization of the feed-back current flow in that portion of the oscillator circuit which is coupled to the control oscillator, reaction upon the control oscillator being thus prevented.

In Fig. 5 of the drawing the invention is applied to a regenerative radio receiving circuit. The vacuum tube TT has associated with it the usual grid and plate batteries. The receiving antenna circuit, including the antenna A and the winding WW'', is coupled to the vacuum tube circuit through the winding WW', which, with the variable condenser CC_1, forms a tuned circuit. The plate circuit is tuned to parallel resonance by adjustment of the resonant arrangement including the winding WW and the variable condenser CC. The winding WW is coupled to the winding WW_1 in the grid circuit to feed energy back into that circuit in a manner well understood in the art. The coil WW_2 also is coupled to the winding WW to form the output of the system. If, now, there are added the balancing impedances CC'_1 and CC'_2, there is a balance of the impedances of the two circuits having the winding WW_1 in common and each a part of the winding WW'. Accordingly, the feed-back currents in the two parts of the winding WW' will be equal in amplitude and opposite in phase, no voltage being induced in the winding WW''. Thus, there is no reaction upon the input or modulation circuit due to the feed-back currents of the vacuum tube circuit.

While the invention has been disclosed for the purpose of illustration in certain specific embodiments which are deemed desirable, it is to be understood that such disclosure in no way limits the scope of the invention, which is defined in the appended claims.

What is claimed is:

1. In a vacuum tube circuit having a feed-

back connection from the output portion to the input portion thereof and a control circuit associated therewith, the method of preventing the feed-back of energy into the control circuit, which consists in balancing the inter-electrode impedances of the vacuum tube circuit, and neutralizing the flow of feed-back currents in the input portion thereof.

2. In a vacuum tube circuit having a feed-back connection from the output portion to the input portion thereof and a control circuit associated therewith, the method of preventing the feed-back of energy into the control circuit, which consists in dividing the vacuum tube circuit, and balancing the inter-electrode impedances thereof so as to neutralize the flow of feed-back currents in the input portion of the vacuum tube circuit.

3. In a vacuum tube circuit having a feed-back connection from the output portion to the input portion thereof and a control circuit coupled to said input portion, the method of preventing the feed-back of energy into the control circuit, which consists in dividing the vacuum tube circuit, balancing the inter-electrode impedances thereof, and neutralizing the effect of the feed-back currents in the two parts of the input portion thereof.

4. In an electrical system including a vacuum tube arrangement having an input circuit, an output circuit, and a feed-back connection from said output circuit to said input circuit, a circuit associated with said input circuit for supplying a modulating potential thereto, auxiliary impedances for balancing the vacuum tube inter-electrode impedances, and means for neutralizing the flow of feed-back currents in the vacuum tube input circuit.

5. In an electrical system including a vacuum tube arrangement having an input circuit, an output circuit, and a feed-back connection from said output circuit to said input circuit, a circuit coupled to said input circuit for supplying a modulating potential thereto, auxiliary impedances for balancing the vacuum tube inter-electrode impedances, and circuit connections whereby feed-back currents in the coupling element of the input circuit are neutralized.

6. In an electrical system, a vacuum tube oscillator, a control oscillator associated with the input circuit thereof, means for balancing the vacuum tube inter-electrode impedances, and means for neutralizing the feed-back currents in the input circuit of the oscillator to prevent reaction of said currents on the control oscillator.

7. In an electrical system, a vacuum tube oscillator, a control oscillator coupled to the input circuit thereof, auxiliary impedances in the oscilator circuit for balancing the inter-electrode impedances thereof, and circuit connections to the coupling element of said input circuit to neutralize the flow of feed-back currents therein.

In testimony whereof, I have signed my name to this specification this 18th day of October, 1927.

RALPH K. POTTER.