July 25, 1944. W. D. HERSHBERGER 2,354,636

ELECTRON TUBE OSCILLATOR CIRCUIT

Original Filed Feb. 27, 1942

Fig. 1.

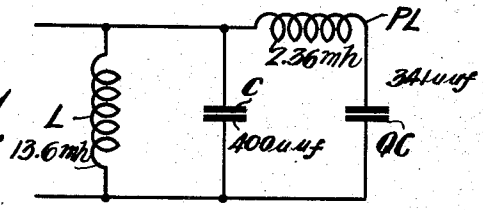


Fig. 2.

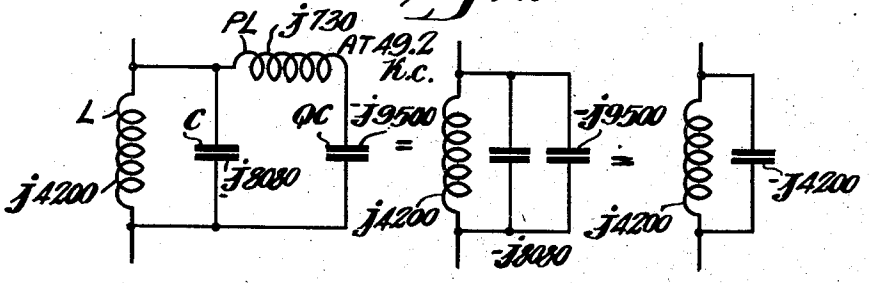


Fig. 3.

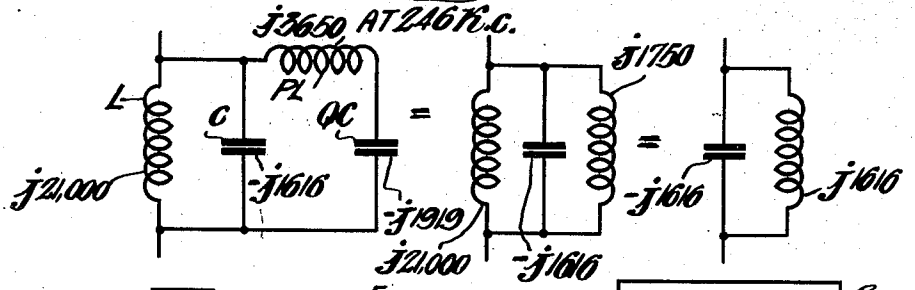


Fig. 4.

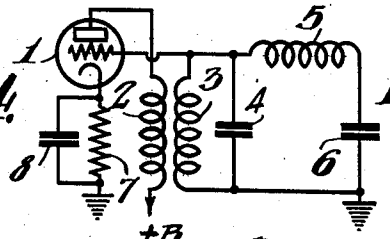


Fig. 6.

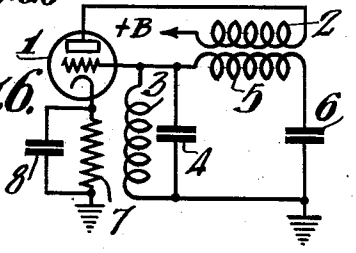
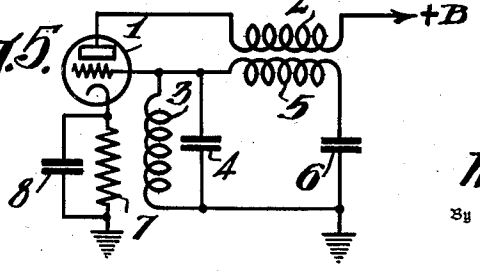


Fig. 5.



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ELECTRON TUBE OSCILLATOR CIRCUIT

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Original application February 27, 1942, Serial No. 432,580. Divided and this application November 25, 1942, Serial No. 466,906

5 Claims. (Cl. 250—36)

This application is a division of my copending application Serial No. 432,580, filed February 27, 1942, entitled "Electron tube oscillator circuit."

This invention relates generally to electron discharge tube oscillation circuits and particularly to oscillator circuits in which a plurality of frequencies can be produced simultaneously or selected harmonics of a fundamental frequency can be accentuated or suppressed.

Previous circuits have been devised which provided for simultaneous generation of a plurality of frequencies in an oscillator circuit. However, this invention utilizes new and improved methods of generating and controlling such oscillations in an extremely simple electrical circuit. The invention also provides means for accentuating or suppressing any selected harmonic of the fundamental oscillator frequency, by utilizing a multi-resonant oscillation circuit tuned to the fundamental and selected harmonic frequencies.

An object of the invention is to provide a new and simple method and circuit for simultaneously producing a plurality of frequencies in a single oscillation circuit. Another object is to provide means for accentuating selected harmonics of the fundamental frequency in an oscillation circuit. Still another object is to provide means for suppressing selected harmonics of the fundamental frequency in an oscillation circuit.

The invention will best be understood by reference to the drawing, of which Fig. 1 is a schematic diagram of a typical bi-resonant circuit, Fig. 2 is a schematic diagram of the same circuit showing equivalent reactance values for one selected frequency, Fig. 3 is a schematic diagram of the same circuit showing equivalent reactance values for another selected frequency, Fig. 4 is a schematic diagram of an oscillator circuit, and Figs. 5 and 6 are schematic circuit diagrams of modifications of the circuit of Fig. 4. Similar reference characters are applied to similar circuit elements in Figs. 4, 5 and 6.

Referring to Fig. 1 of the drawing, a typical bi-resonant or multi-resonant circuit, of the type useful for the invention, is provided. A first inductance L is connected in parallel relation with a first capacity C. A second inductance PL is connected in series relation with a second capacity QC. The parallel-resonant circuit L, C is connected in parallel relation with the series-resonant circuit PL, QC. Arbitrary values of inductance and capacity have been chosen for inductances L and PL and capacitors C and QC to provide resonant peaks at 49.2 kc. and at 246 kc. It should be understood that any other frequencies could be selected and that they need not necessarily be of harmonic relation.

The connections of the left hand portion of Figure 2 correspond to the circuit of Fig. 1 and the numbers indicate the reactances in the various branches of the circuit of Fig. 1 at 49.2 kc. Inductive reactance is shown as positive quantities and capacitive reactance as negative quantities. The center portion of Fig. 2 is the equivalent circuit at 49.2 kc. wherein the series circuit PL, QC becomes a capacitive reactance of 8770 ohms. The right hand portion of Fig. 2 is a further equivalent circuit wherein the capacitances combine to provide a resultant parallel circuit which resonates at 49.2 kc.

The connections of the left hand portion of Fig. 3 also correspond to the circuit of Fig. 1 and the numbers indicate the reactance relations in the same circuit at 246 kc. Inductive reactance is shown as positive quantities and capacitive reactance as negative quantities. The center portion of Fig. 3 is the equivalent circuit at 246 kc. wherein the parallel circuit L, C becomes an inductive reactance of 21,000 ohms. The right hand portion of Fig. 3 is a further equivalent circuit wherein the inductances combine to provide a resultant parallel circuit which resonates at 246 kc.

Fig. 4 is a diagram of an electron discharge tube oscillation circuit utilizing the bi-resonant circuit of Fig. 1 as a part of the control electrode circuit. The control electrode of tube 1 is connected to one end of the parallel-resonant circuit consisting of a first inductor 3 and a first capacitor 4, and to one end of the series-resonant circuit comprised of a second inductor 5 and a second capacitor 6. The other terminal of the bi-resonant circuit is connected to ground. The anode of tube 1 is connected to one terminal of a third inductor 2 which is coupled to the first inductor 3. The remaining terminal of the coupling coil 2 is connected to the anode voltage source. Suitable grid bias is obtained by a conventional cathode resistor 7 and bypass condenser 8. This circuit will oscillate at 49.2 kc. and provide a strong fifth harmonic at 246 kc. It will be seen that the currents at both frequencies in the first coil 3 are in phase, and the amplitude of oscillations at the two frequencies depends on the values of P and Q as hereinafter explained.

Fig. 5 is a modification of the circuit of Fig. 4 in which the anode is connected to the third inductor 2 which is coupled to the second inductor 5 of the series-resonant circuit. The remaining

terminal of the coupling coil **2** is connected to the anode voltage source. This circuit will provide oscillations at the high frequency resonant point only, in this case 246 kc. The currents at the two resonant frequencies are opposing in the second coil **5** and regeneration occurs only at the higher frequency with the connection shown to the third coil **2**.

Fig. 6 is a modification of the circuit of Fig. 5 in which the direction of the winding of the coupling coil **2** is reversed with respect to the winding of the series-resonant coil **5**. This circuit will produce oscillations at the lower resonant frequency of the circuit and suppress the fifth harmonic determined by the high resonant frequency of the circuit. The currents at the two resonant frequencies are in opposition in the second coil **5** and regeneration occurs only at the lower frequency with the connection shown to the third coil **2**.

It will be understood that the method of coupling the control electrode and anode circuit may be varied in accordance with recognized engineering practice. Although the bi-resonant circuit has in each case been shown in the control electrode circuit of the oscillator tube, it may be used in the anode circuit if desired. In this case the coupling means would be provided in the control electrode circuit for reaction with the anode circuit. Also, the invention is not limited to magnetic coupling between the control electrode and the anode circuits, but can be accomplished by other coupling methods providing suitable reaction.

The following formulae may be used for calculating the values of P and Q in Fig. 1 for any combination of frequencies in a bi-resonant circuit:

When, $f_2=nf_1$, and n is any value, integral or non-integral

$$\omega_1=\frac{1}{nLC\sqrt{PQ}}$$

$$\omega_2^2=\frac{n}{LC\sqrt{PQ}}$$

$$n+\frac{1}{n}=\frac{1+PQ+Q}{\sqrt{PQ}}$$

The series-resonant circuit determines a zero impedance point at a frequency between the two resonant frequencies of the complete circuit. At frequencies below the point of zero impedance, the series-resonant circuit exhibits a capacitative reactance, while at frequencies above this point it exhibits an inductive reactance.

By varying the product PQ, the frequency of the zero impedance point can be varied, and the relative impedances of both resonant peaks can be varied. By proper selection of the values of P and Q, the degree of accentuation or suppression of both resonant frequencies can be determined for the circuit of Fig. 4, since all currents are in phase in the coil **3**. However, since the currents of the two frequencies are in phase opposition in the coil **5**, the circuits of Figs. 5 and 6 are capable of producing oscillations at only one of the resonant frequencies, depending on the reaction with the coupling coil **2**.

It will be understood that a plurality of series resonant circuits can be connected in parallel with the parallel resonant circuit to provide three or more resonant responses.

I claim as my invention:

1. An electron discharge tube oscillator circuit including control electrode and anode circuits, a multi-resonant network including a parallel resonant circuit and a series resonant circuit connected across said parallel resonant circuit, said network being connected in said control electrode circuit and aperiodic means for coupling said anode circuit to said multi-resonant network to provide oscillations at all resonant frequencies of said multi-resonant network.

2. An electron discharge tube oscillator circuit including control electrode and anode circuits, a multi-resonant network including a parallel resonant circuit and a series resonant circuit connected across said parallel resonant circuit, said network being connected in said control electrode circuit and aperiodic means for coupling said anode circuit to said multi-resonant network to provide oscillations at some resonant frequencies and suppress oscillations at other resonant frequencies of said multi-resonant network.

3. An oscillator having an electron tube including cathode, anode and control electrode circuits, a network in the control electrode circuit of said tube including a parallel resonant circuit and a series resonant circuit connected across said parallel resonant circuit, and aperiodic means for coupling said anode circuit to said network.

4. An oscillator circuit having an electron tube including cathode, anode and control electrode circuits, a network in the control electrode circuit of said tube including a parallel resonant circuit and a series resonant circuit connected across said parallel resonant circuit, and aperiodic means for coupling said anode circuit to said parallel resonant circuit.

5. An oscillator circuit having an electron tube including cathode, anode and control electrode circuits, a network in the control electrode circuit of said tube including a parallel resonant circuit and a series resonant circuit connected across said parallel resonant circuit, and aperiodic means for coupling said anode circuit to said series resonant circuit.

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