

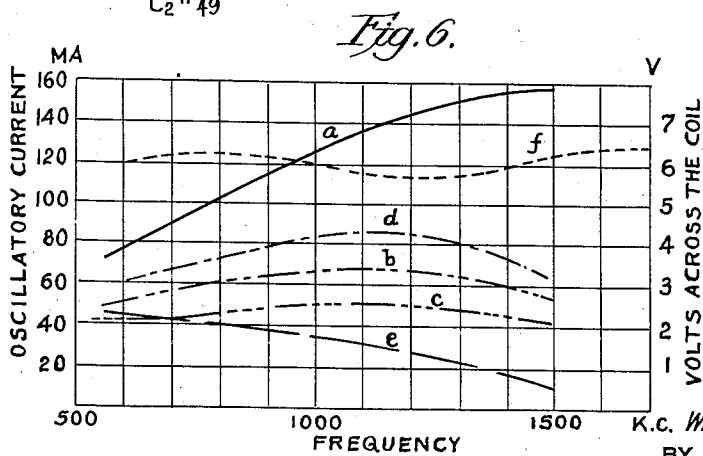
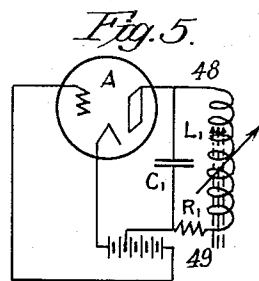
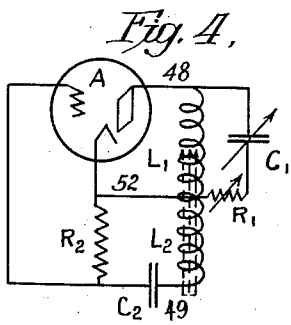
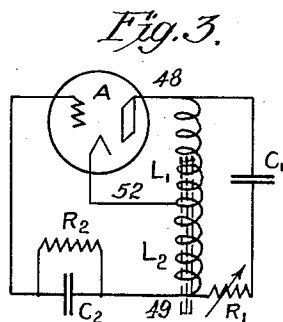
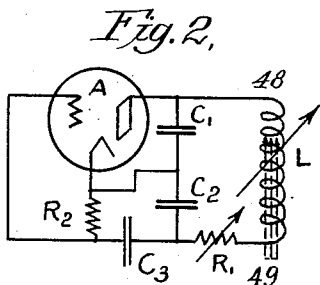
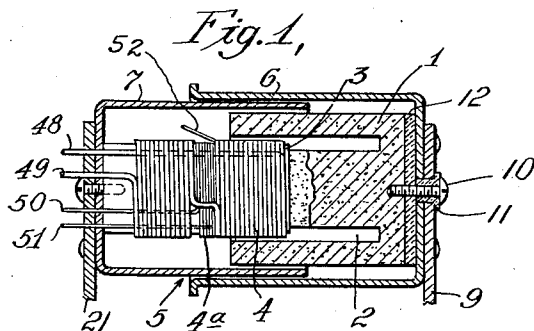
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2,210,303

HIGH FREQUENCY GENERATOR

Original Filed May 7, 1931



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UNITED STATES PATENT OFFICE

2,210,303

HIGH FREQUENCY GENERATOR

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Original application May 7, 1931, Serial No.
535,606, now Patent No. 2,113,603, dated April
12, 1938. Divided and this application June
17, 1937, Serial No. 148,789. Renewed June
3, 1939

12 Claims. (Cl. 250—36)

The invention relates to variable inductance devices, which, among their other advantageous uses, may be employed as parts of radio-frequency generator circuits. The improved variable inductance devices herein disclosed include inductance coils and ferromagnetic cores adjustable relatively thereto, the combination being such that at all high frequencies, maximum permeability of the core consistent with the desired losses involved in any case, may be attained.

One object of the invention is to provide a new and useful tuning device suitable for use in high-frequency circuits, of the variable-inductance rather than the variable-capacitance type, and which will therefore avoid the usual disadvantages encountered with the latter type. Among the disadvantages of systems employing variable-capacitance tuning, which it is one of the objects of the present invention to overcome, is the non-uniformity of the performance of the circuits throughout the tuning range. The present invention provides a tuning device which when employed at radio frequencies, permits tuning a circuit over a desired range of frequencies, while at the same time maintaining the performance of the circuit substantially constant.

Additional objects and advantages of the present invention will be apparent from what is to follow. Among these may be mentioned the provision of tuning devices which are not subject to detuning or other difficulties due to mechanical vibrations, and which are inherently incapable of the microphonic action by which sustained audio-frequency oscillations frequently arise in capacitance-tuned systems. Also to be noted are the advantages of extreme compactness, ease of assembly, and the ease and effectiveness of shielding to avoid the effects of extraneous electromagnetic and/or electrostatic fields.

The application is a division of my application, original Serial No. 535,606, filed May 7, 1931, now Patent No. 2,113,603, issued April 12, 1938, in which are disclosed various advantageous embodiments of my invention.

In the present application, the specific object is to provide high-frequency generating apparatus tuned by a ferromagnetic core having unique advantages over the capacitance-tuned high-frequency generating apparatus of the prior art.

The core embodied in the present device may be one of the compressed powdered-iron type which is fully described in my United States Patent No. 1,982,689 issued December 4, 1934, and which may have varying ferromagnetic density along its axis as disclosed therein.

The invention will be best understood if reference be made to the accompanying drawing in which:

Figure 1 is a sectional view showing a tuning device which may be employed for the purpose of the invention;

Figures 2 to 5 inclusive are schematic diagrams of high-frequency generators, constructed in accordance with the invention; and

Figure 6 is a graph indicating results attained by the use of the circuits of Figures 2 to 5 inclusive.

Specifically, the present invention involves a radio-frequency inductance device having a core, such as is described in my aforesaid patent, and so arranged in any one of various radio-frequency generator circuits, that tuning of that circuit may be effected by adjustments of the core with the attainment of the several advantages hereinafter indicated.

Referring to Figure 1, 1 is a compressed ferromagnetic core preferably having an annular cavity 2 that is adapted to receive a tube 3 carrying an inductance coil 4, and, if desired, an additional winding 4a.

As shown, the core 1 is movable, while the tube 3 carrying either the coil 4 or the coils 4 and 4a, is fixed, to thereby effectuate variations of inductance in the device 5, which, as herein revealed, may be employed for tuning radio-frequency generator circuits of different types.

Telescoping open-ended shields 6, 7 of any suitable material may be employed in order at all times to exclude external inductive influences. Such shields 6, disposed around the cores, are optional and are desirable only when thorough shielding is required.

In order to produce an effective permeability of 7.5 by a given core, the coil used with the core should have a ratio of length to diameter of substantially 1.5 to 1. If greater permeability is required, the core may be lengthened, to correspond with a coil of increased ratio of length to diameter, for example, 2 to 1, in which case the coil, being longer, will have less inductance relative to resistance. On the other hand, if ferromagnetic material having greater permeability is used for the core, the length of the coil relative to its diameter may be reduced. By the term "effective permeability" (μ_1), I mean the ratio of the inductance of a coil having a ferromagnetic core to the inductance of the same coil with an air core, without regard to whether the core is closed, or whether or not the core encloses all of the flux lines through the coil.

It may be advantageous to keep the electrical properties of the circuit at certain optimum conditions, which are satisfied when the ratio of inductance to resistance, or L/R , of that circuit is kept constant at all frequencies to which the circuit may be tuned.

At a frequency f_0 , where the core is withdrawn, the corresponding ratio L_0/R_0 of the coil alone is responsible for the successful operation of the circuit. When the core is partly moved in, certain losses are introduced and the inductance is increased to $L_{0\mu 1}$. The core is so constructed that, for each new value of inductance $L_{0\mu 1}$, a new value of effective resistance $R_{0\alpha 1}$ is obtained in such manner that the value of $L_{0\mu 1}/R_{0\alpha 1}$ at any new frequency f_1 , is substantially equal to the original value L_0/R_0 of the coil at frequency f_0 . By the resistance-increase factor α_1 , I mean the ratio of the effective resistance of a coil having a ferromagnetic core measured at frequency f_1 to the effective resistance of the same coil with an air core measured at frequency f_0 . Thus the factor α_1 includes both the change in effective resistance of the air-core coil itself with frequency and the increase in effective resistance of the coil due to the core at the new frequency f_1 .

Additionally, maintaining the capacitance C of the circuit constant and L/R of the inductance device constant, causes the dynamic resistance of the circuit ($R_d = L/RC$) to remain constant at any frequency to which the circuit is tuned.

Figures 2, 3, 4 and 5 show the application of the iron-core variable inductance device to various types of frequency-generating apparatus known in the art as thermionic relay oscillators. Figure 2 shows an oscillator including a thermionic relay A, its grid and plate being connected to the opposite ends of coil L, the inductance of which is varied by relative movement of a ferromagnetic core to produce oscillations of various frequencies. Capacitors C_1 and C_2 , preferably of equal values, serve as voltage-dividing means with respect to the cathode of the thermionic relay A. Regulating resistor R_1 may be employed to further control the current in the circuit L, C_1 , C_2 , its value being initially so chosen as to equalize the current output at different frequencies.

Figure 3 represents apparatus wherein a center tap of the inductance device L_1 , L_2 is provided for the cathode of thermionic relay A. A variation of Figure 3 is represented in Figure 4 where the plate inductance L_1 only is tuned to generate the desired frequencies, the inductance L_2 not being included in the tuned plate circuit.

Figure 5 represents another form of oscillator, wherein a circuit L_1 , C_1 , R_1 is tuned by an inductance device L_1 having a ferromagnetic core, the circuit operating on the principle known as a dynatron oscillator.

Figures 3 and 4 show a tapped inductance coil, parts of which are respectively in the grid and plate circuits of the thermionic relay A. The tap may be placed in such a position that one part of the coil will be more affected than the other by the core movement, thus producing variable excitation of the oscillator to equalize the output current at different frequencies.

Figure 6 graphically represents operating conditions of the described oscillators. Curve a shows the variation of current output of the oscillator of Figure 2 when resistor R_1 is short-circuited, and curve b shows the variations of current of the same oscillator when resistor R_1

is included in the circuit so as to obtain substantially uniform output of current at different frequencies. Curves c , d and e correspondingly show variations of current with frequency in the oscillators of Figure 3, Figure 4 and Figure 5 with resistor R_1 in the circuit, and curve f , read from the scale on the right of Figure 6, shows the output voltage obtainable from the inductance device L_1 of Figure 5, when the oscillator is operating at different frequencies as a dynatron oscillator with constant dynamic resistance.

Having thus described my invention, what I claim is:

1. A high-frequency variable inductance device, including an inductance coil and a core of comminuted ferromagnetic material insulated from and movable relatively to said coil, combined with a resistance of the order of the high-frequency resistance of the device at its maximum inductance, whereby the total effective impedance of said combination may be adapted for use in a tunable oscillator circuit.

2. A thermionic oscillation generator for use at high frequencies, including an inductance coil, a movable core of comminuted ferromagnetic material for varying the inductance of said coil, and fixed capacitances of predetermined values, said core being such that the L/R ratio of said coil is maintained substantially constant at different frequencies generated by said generator, and that the oscillatory current increases with frequency increases.

3. A thermionic oscillation generator for use at high frequencies, including an inductance coil, a movable core of comminuted ferromagnetic material for varying the inductance of said coil, fixed capacitances, and a resistor of such value that the current in said oscillator is maintained substantially constant while the resistance of the inductance coil is varied proportionally to the variations of the inductance.

4. A thermionic oscillation generator for use at high frequencies, including fixed capacitances, a tapped inductance coil, and a movable core of comminuted ferromagnetic material for varying the inductance of said coil, the adjustability of said core and the position of said tap being so related that one portion of said coil is magnetically more affected than the other by said core and a substantially constant oscillatory current at different frequencies is maintained.

5. A variable high-frequency oscillation generator, including a thermionic vacuum tube having a grid, a cathode and a plate; a resonant circuit having first and second capacitors connected in series and an inductance coil in shunt with said capacitors; and means for varying the frequency and simultaneously controlling the amplitude of the output of said generator including a ferromagnetic core movable relatively to said inductance coil, said resonant circuit including a resistance of the order of the high-frequency resistance of the coil and core combination at the maximum inductance of said coil, a connection from the high-potential terminal of said circuit to said plate, a connection from the low-potential terminal of said series-connected capacitors through a third capacitor to said grid and through said third capacitor and a resistor to said cathode, and a connection from the junction of said first and second capacitors to said cathode.

6. A variable high-frequency oscillation generator, including a thermionic vacuum tube having a grid, a cathode and a plate; a resonant

circuit having a first capacitor and an inductance coil having a tap connected to said cathode, a first terminal connected to said plate and a second terminal connected through a second capacitor shunted by a resistor to said grid; and means for varying the frequency and simultaneously controlling the amplitude of the output of said generator including a ferromagnetic core movable relatively to said inductance coil, which varies the coupling between the grid and plate portions thereof, said resonant circuit including a resistance of the order of the high-frequency resistance of the coil and core combination at the maximum inductance of said coil.

7. A variable high-frequency oscillation generator, including a thermionic vacuum tube having a grid, a cathode and a plate; a resonant circuit having a first capacitor and an inductance coil having a tap connected to said cathode, a first terminal connected to said plate and a second terminal connected through a second capacitor shunted by a resistor to said grid; and means for varying the frequency and simultaneously controlling the amplitude of the output of said generator including a ferro-magnetic core constructed to maintain the ratio of inductance to resistance in said resonant circuit substantially constant and movable relatively to said inductance coil, which varies the coupling between the grid and plate portions thereof.

8. A variable high-frequency oscillation generator, including a thermionic vacuum tube having a grid, a cathode and a plate; a resonant circuit having a first capacitor and an inductance coil having a tap connected to said cathode, a first terminal connected to said plate and a second terminal connected to said grid; and means for varying the frequency and simultaneously controlling the amplitude of the output of said generator including a ferro-magnetic core movable relatively to said inductance coil, which varies the coupling between the grid and plate portions thereof; said resonant circuit including a resistance of the order of the high-frequency resistance of the coil and core combination at the maximum inductance of said coil.

9. A variable high-frequency oscillation generator, including a thermionic vacuum tube of the dynatron type and having a grid, a plate and a cathode; a resonant circuit having a capacitor and an inductance coil having a first terminal connected to said plate and a second terminal connected through a resistor and a source of direct-current potential to said cathode; a connection through a second source of direct-current potential from said cathode to said grid; and means for varying the frequency and simultaneously controlling the amplitude of the output of said generator including a ferromagnetic core movable relatively to said inductance coil, said

resonant circuit including a resistance of the order of the high-frequency resistance of the coil and core combination at the maximum inductance of said coil.

10. A variable high-frequency oscillation generator, including a thermionic vacuum tube of the dynatron type and having a grid, a plate and a cathode; a resonant circuit having a capacitor and an inductance coil having a first terminal connected to said plate and a second terminal connected through a resistor and a source of direct-current potential to said cathode; a connection through a second source of direct-current potential from said cathode to said grid; and means for varying the frequency and simultaneously controlling the amplitude of the output of said generator including a ferromagnetic core constructed to maintain the ratio of inductance to resistance in said resonant circuit substantially constant and movable relatively to said inductance coil.

11. A variable high-frequency oscillation generator, including a thermionic vacuum tube having a grid, a cathode and a plate; a resonant circuit having first and second capacitors connected in series and an inductance coil in shunt with said capacitors; and means for varying the frequency and simultaneously controlling the amplitude of the output of said generator including a ferromagnetic core constructed to maintain the ratio of inductance to resistance in said resonant circuit substantially constant and movable relatively to said inductance coil, a first resistor in series in the low-potential side of said resonant circuit, a connection from the high-potential terminal of said circuit to said plate, a connection from the low-potential terminal of said series-connected capacitors through a third capacitor to said grid and through said third capacitor and a second resistor to said cathode, and a connection from the junction of said first and second capacitors to said cathode.

12. A variable high-frequency oscillation generator, including a thermionic vacuum tube having a grid, a cathode and a plate; a resonant circuit having a first capacitor and an inductance coil having a tap connected to said cathode, a first terminal connected to said plate and a second terminal connected through a second capacitor shunted by a first resistor to said grid; means for varying the frequency and simultaneously controlling the amplitude of the output of said generator including a ferromagnetic core constructed to maintain the ratio of inductance to resistance in said resonant circuit substantially constant and movable relatively to said inductance coil, which varies the coupling between the grid and plate portions thereof; and a second resistor in series in said resonant circuit.

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