March 30, 1948. A. H. TURNER 2,438,832

OSCILLATOR FOR CENTIMETER WAVES

Filed Sept. 16, 1943

Fig. 1.

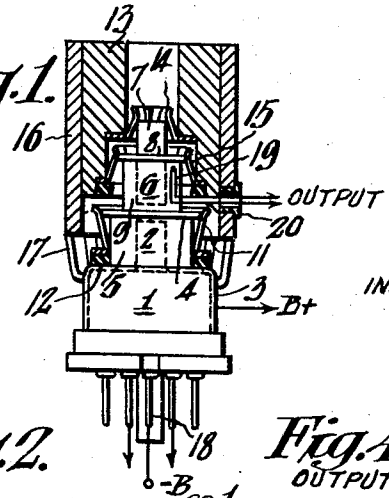


Fig. 2.

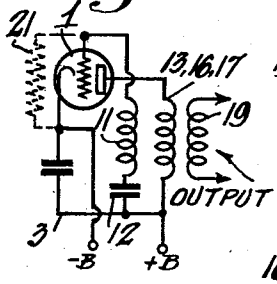


Fig. 4.

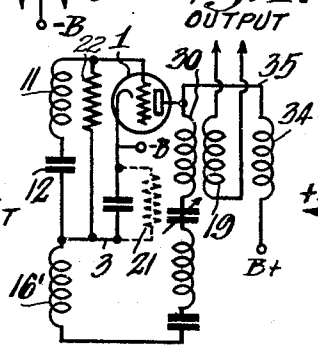


Fig. 3.

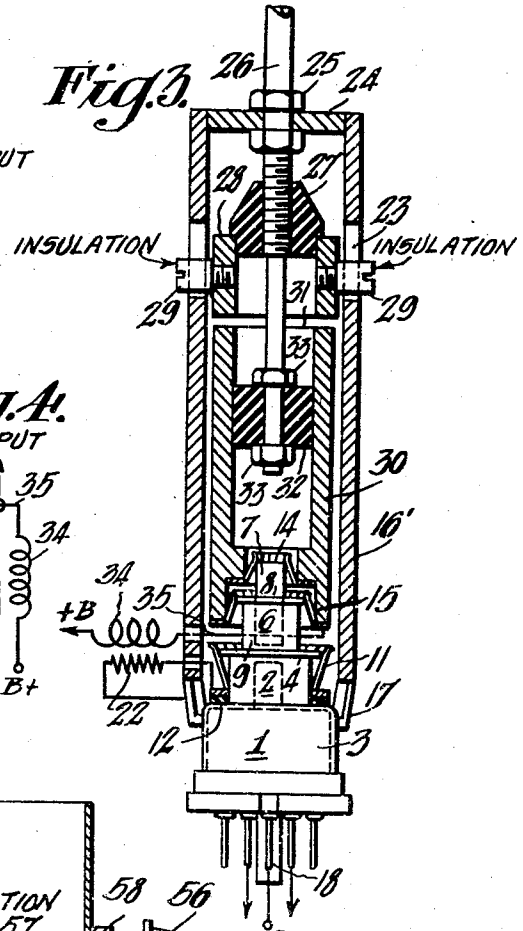


Fig. 5.

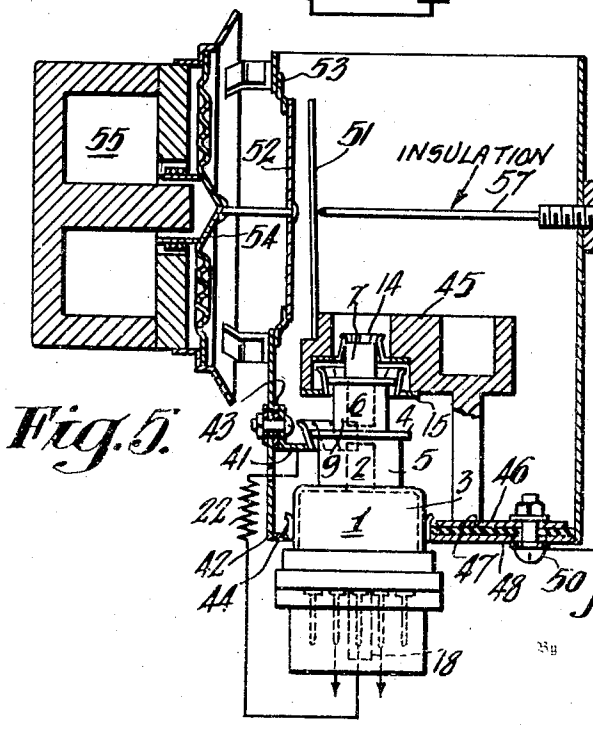
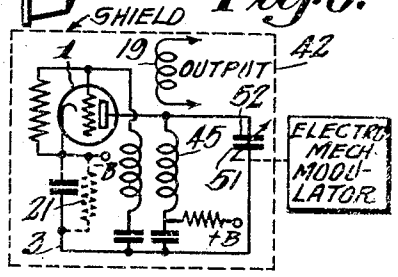


Fig. 6.



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Patented Mar. 30, 1948

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UNITED STATES PATENT OFFICE

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OSCILLATOR FOR CENTIMETER WAVES

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Application September 16, 1943, Serial No. 502,702

10 Claims. (Cl. 315—39)

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This invention relates generally to centimeter wave oscillators and more particularly to centimeter wave thermionic tube oscillators employing inductive feedback.

Because of the low values of inductance permissible in centimeter wave oscillators, it is usually difficult with standard thermionic tubes to tap the cathode circuit effectively to the main tuning inductance at a suitable point intermediate the grid and anode connections. However, with tubes of the "lighthouse" type such as the General Electric models GL-446 and ZP-464, having extremely low internal inductances and capacitances, more freedom is permissible in shaping the external inductive circuit elements. With tubes of the type described, it has been found practicable to provide a capacity tuned-inductive feedback circuit for wavelengths as short as 11 centimeters at fundamental resonance and for shorter wavelengths when employing parasitic resonances.

The inductive feedback type of oscillator circuit has been found to be superior to the capacity feedback (Colpitts) circuit when relatively wide frequency tuning range is required, since the tuning affects the feedback less in the inductive feedback circuit. This condition is especially true when a variable capacitor is provided for tuning the resonant circuit.

The inductive feedback type of oscillator circuit has also been found to be superior to the grounded grid type of oscillator since the latter requires two tuned circuits for effective frequency adjustment over any considerable operating wave band.

Among the objects of the invention are to provide an improved method of and means for generating oscillations at centimeter waves. Another object of the invention is to provide an improved centimeter wave thermionic tube oscillator employing inductive feedback. A further object of the invention is to provide an improved centimeter wave oscillator having inductive feedback and unitary frequency adjusting means.

Further objects of the invention include an improved centimeter wave inductive element. Another object of the invention includes an improved centimeter wave reactive circuit component. A further object of the invention includes an improved centimeter wave oscillator having means for adjusting the frequency over a relatively wide frequency band. An additional object is to provide an improved centimeter wave adjustable frequency oscillator including means

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for modulating electromechanically the output frequency of said oscillator.

The invention will be further described by reference to the accompanying drawing of which Figure 1 is an elevational cross-sectional view of one embodiment of the invention; Figure 2 is a schematic circuit diagram of the equivalent electrical circuit of Figure 1; Figure 3 is a cross-sectional elevational view of a second embodiment of the invention; Figure 4 is a schematic circuit diagram of the equivalent electrical circuit of Figure 3; Figure 5 is a cross-sectional elevational view of a third embodiment of the invention, and Figure 6 is a schematic circuit diagram of the equivalent electrical circuit of Figure 5. Similar reference characters are applied to similar elements throughout the drawing.

Referring to Figure 1, a thermionic tube 1 of the "lighthouse" type such as, for example, the General Electric types GL-446 or ZP-464, includes a cathode element 2 which is coupled capacitively, as indicated by the dash lines, to an external cathode shell 3. A transverse grid element, disposed parallel to the electron emissive surface of the cathode 2 is terminated in a conductive grid contact ring 4 which is separated from the cathode shell 3 by means of an insulating sleeve 5. An anode electrode 6 is cylindrical in shape, and is terminated in a conductive anode cap 7 and a conductive anode sleeve 8. The anode sleeve 8 is separated from the grid sleeve 4 by means of a second insulating sleeve 9. The operative faces of the cathode 2 and anode 6 are disposed parallel to and on opposite sides of the grid element which is terminated in the grid sleeve 4. Direct connections to the cathode, and to the heater element disposed adjacent thereto, are brought out through the base of the tube and terminated in conventional tube contact pins.

The oscillator grid circuit comprises a slotted cylindraceous inductive element 11 which is inserted over the grid sleeve 4 and capacitively coupled to the shoulder of the cathode sleeve 3 through a relatively thin ring of mica or other dielectric material 12. When in position, the slotted portions of the inductive element 11 are maintained in contact with the grid sleeve 4 by the inherent resilience of the conductive element. Feedback is adjusted by varying mechanically the number of fingers of the slotted portions of the inductive element 11 which contact the grid ring 4.

A second fixed inductive element, comprising the anode circuit, includes a cylindrical conduct-

ing member 13 to which is secured a pair of slotted cylindraceous contact portions 14, 15 which contact respectively the anode cap 7 and the anode ring member 8. A second cylindrical anode circuit portion 16 surrounds the first cylindrical portion 13 and includes slotted resilient end portions 17 which engage the cathode sleeve 3. If desired, the anode circuit portions 13, 16, 17 may be of unitary construction.

It will be seen that the anode circuit portions 13, 16 provide an inductive circuit between the tube anode 6 and the cathode shell 3 which in turn is coupled capacitively to the cathode 2. Similarly, the anode circuit inductive elements 13, 16 are coupled inductively to the grid circuit element 11 since both anode and grid circuit elements are coaxial with the thermionic tube 1. Actually, in effect, the cathode is coupled to an intermediate point on the main tuned circuit connected between the anode and the grid, and the anode-cathode and grid cathode portions of the circuit are directly coupled and carry nearly the same radio frequency currents.

A source of positive anode potential is connected to the cathode shell 3 and hence to the anode through the inductive elements 17, 16, 13, 14 and 15. The negative terminal of the anode voltage supply is connected to the tube cathode terminal 18.

Output power at the resonant frequency of the oscillator circuit is derived by means of a coupling loop 19 disposed within the anode inductive elements 16, 13. Output leads from the coupling coil 19 are brought out through the wall of the anode element 16 through an insulating grommet 20.

Referring to Figure 2 the equivalent electrical circuit of the device described in Figure 1 includes the tube 1 having its grid terminal connected through the inductive element 11 and the capacitive element 12 to the external cathode sleeve 3 which is capacitively coupled to the tube cathode element. The anode inductive element 13, 16, 17 is connected intermediate the tube anode and the external cathode shell 3. The negative terminal of the anode voltage supply is connected directly to the tube cathode while the positive terminal is connected to the cathode sleeve 3. Output to any desired external load circuit, not shown, is provided by inductive coupling between the anode circuit 13, 16, 17 and the output coupling coil 19. Suitable grid bias is provided by the leakage between the cathode and the external cathode sleeve as indicated by the resistor 21 shown in dash lines.

The oscillator thus described will be resonant at a particular frequency in the centimeter wave region determined by the physical proportions of the anode circuit elements 13, 16, 17. The feedback will be determined by the number of finger portions of the conductive grid element 11 which are in contact with the grid sleeve 4. Extremely high power output may be derived from the circuit due to the relatively heavy anode circuit components. The inherently compact proportions provided by the coaxially disposed tube and circuit elements greatly facilitates design of the circuit for extremely short centimeter wavelengths.

Referring to Figure 3, the tube and grid circuit arrangements are similar to that described in Figures 1 and 2 with the exception that an external grid leak 22 is connected between the grid inductive element 11 and the resilient fingers 17 of the anode inductance 16' which are in contact with the external cathode sleeve 3. Alternatively, the grid bias resistor 22 may be connected directly between the grid 4 and the cathode terminal 18. The grid circuit feedback is adjusted, as described heretofore in Figure 1, by varying the number of contact fingers of the inductive element 11 which are permitted to contact the grid sleeve 4.

The anode circuit comprises means for adjusting the oscillator over a selected frequency band without affecting substantially the inductive feedback required to provide sustained oscillations. The anode circuit includes an external cylindrical conductive shell 16' which includes longitudinal slots 23, and which is terminated at its end remote from the thermionic tube in an apertured plug portion 24. The apertured plug portion 24 includes a bushing 25 having a bearing arranged to receive a tuning shaft 26 which extends therethrough. The shaft 26 carries an insulating bushing 27 which is threaded thereto. The bushing 27 supports a longitudinally movable internal conductive shell 28 coaxially disposed with respect to the outer conductive shell 16'. Insulating studs 29, extending through the apertures 23 of the outer conductor shell 16', provide guides to prevent rotation of the inner conductive shell 28 as the inner shell is moved longitudinally with respect to the outer shell. The spacing between the outer surface of the inner shell 28 and the inside surface of the external shell 16' should be relatively small to provide substantial capacitive coupling therebetween.

A second internal conductive shell 30 includes cylindraceous contact means 14, 15 which engage respectively the anode contact stud 7 and anode sleeve 8 of the thermionic tube 1. The second internal conductive shell 30 is disposed coaxially with respect to the outer conductive shell 16' and is terminated in a substantially flat end portion 31 which is in variable capacitive relation with the adjacent end of the first internal conductive shell 28. The control shaft 26 is journaled into an apertured insulating plug 32 which is fixed to the inner surface of the second inner conductive shell 30. Stop nuts 33 prevent axial movement of the control shaft 26 within the insulating plug 32. It will be seen that rotation of the control shaft 26 will provide longitudinal adjustment of the first inner conductive shell 28, and hence provide variable capacitive coupling between the adjacent surfaces of the inner conductive shells 28, 30.

The anode circuit may be operated at its fundamental resonance or at a predetermined parasitic frequency, determined by the desired operating frequency.

Anode voltage is applied through a radio frequency choke coil 34 and a quarter wave line 35 to the end of the spring contact member 15 where it is attached to the adjacent end of the second inner conductive shell 30.

Figure 4 illustrates schematically the equivalent circuit of the device described in Figure 3. It will be seen that the tube 1 includes a fixed grid inductance 11 which is capacitively coupled through the capacitor 12 to the external cathode shell 3. The leakage path between the cathode and the external cathode shell 3 is indicated by the resistor 21 shown in dash lines. The grid resistor 22 may be connected as shown between the grid and the cathode shell 3 or it may be connected directly between the grid and cathode tube electrodes. The anode circuit includes the in-

ductive element comprising the second inner conductive shell 30 which is in inductive relation to the outer cylindrical conductive shell 16'. The inductor 30 is capacitively coupled to the inductor 28 through the variable capacitor described heretofore. The remaining terminal of the inductor 28 is capacitively coupled to the conductor 16' through the fixed capacity provided between the surfaces of the two inductive elements. The remaining terminal of the outer inductor 16' is connected to the cathode sleeve 3. Anode potential is supplied through the radio frequency choke coil 34 and the quarter wave conductor 35. Centimeter wave output energy may be derived from a coupling coil 19 inductively coupled to any desired point in the anode circuit. The output winding 19 has been omitted in the device described in Figure 3 to simplify the illustration thereof. It should be understood that output energy may be derived in any other manner known in the art.

Referring to Figure 5, the tube 1 includes a fixed inductive grid element 41 having a plurality of conductive fingers disposed in contact with the grid sleeve 4. The grid inductive element 41 is coupled capacitively to a cylindrical shield 42 which substantially surrounds the tube and all high frequency circuit portions thereof. The capacitive coupling between the grid inductive element 41 and the cylindrical shield 42 is provided by an enlarged base bracket portion of the inductive element 41 which is closely spaced with respect to the cylindrical shield 42. Insulated bushings 43 or insulated washers, separate these elements from the mounting screws which support the inductive element 41. The outer cylindrical shield 42 includes spring contact members 44 which engage the cathode shell 3 of the tube 1. A grid resistor 22 is connected between the grid inductive element 41 and the tube cathode terminal 18.

The anode circuit comprises a relatively heavy buss bar 45, having contact portions 14, 15 connected thereto in contact respectively with the anode cap 7 and anode sleeve 8 of the thermionic tube 1. The end of the anode buss bar 45 remote from the anode terminals is terminated in a flat plate 46 which is separated by a layer of mica or other insulating material 47 from the closed end portion 48 of the external cylindrical shield 42 adjacent the contact fingers 44 which engage the cathode sleeve 3. The capacity between the conductive elements 46, 48 provides ample capacitive coupling between the anode and cathode circuit elements. The positive anode potential source is connected, through a suitable isolating resistor 49, to a terminal 50 which is connected to the capacitive plate 46 and hence to the anode buss bar 45.

The anode circuit also includes a variable capacitive element comprising a resilient first capacitive plate 51 supported by the anode buss bar 45 at a point adjacent the anode contact 14. A second capacitive plate 52 is resiliently supported by a spider 53 to the edges of an aperture in the wall of the cylindrical shield 42. The second capacitive plate 52 is coupled mechanically to the diaphragm 54 of a vibrating element such as, for example, a dynamic loudspeaker unit 55.

A control knob 56, secured to a control shaft 57 of insulating material, is threaded through a bushing 58 in the side wall of the cylindrical shield 42 diametrically opposite from the loudspeaker unit 55. Rotation of the control knob 56 provides manual adjustment of the relative

spacing of the capacitive plates 51, 52 for controlling the shunt capacitance in the anode circuit. Actuation of the loudspeaker unit 55 by any suitable source of modulating currents thereby provides frequency modulation of the oscillator output at the mean carrier frequency selected by the preliminary adjustment of the control knob 56.

Figure 6 illustrates schematically the equivalent electrical circuit of the device described in Figure 5. It will be seen that all high potential radio frequency circuits are enclosed substantially within the shield 42 and that tuning is provided by the shunt capacitance 51, 52 connected between the anode of the tube 1 and the cathode sleeve 3. Output may be derived from an output coupling coil 19 coupled in any known manner to the anode buss bar 45. It should be understood that the embodiment of the invention illustrated in Figures 5 and 6 may be operated at substantially lower radio frequencies than could be readily provided in the devices previously described in Figures 1 and 3. Adjustment of the grid circuit may be provided in the same general manner as described heretofore in the other embodiments of the invention.

The frequency-modulated oscillator thus described may be employed in any manner known in the art such as, for example, the generation of distinctive radio beacon signals, the jamming of other radio signal transmission, the generation of signals for the purpose of distance determination or object location, or as a sweep oscillator for receiver selectivity observation.

Thus the invention described comprises three embodiments of a centimeter wave oscillator employing fixed inductive coupling between anode and grid portions of the circuit to sustain oscillations at predetermined super-high frequencies.

I claim as my invention:

1. An ultra-high-frequency oscillator including a thermionic tube having at least an anode, a cathode and a control electrode, means including first inductive means and first capacitive means connected between said control electrode and said cathode, means including second inductive means and said capacitive means connected between said anode and said cathode, said first and said second inductive means being mutually coupled and portions thereof being disposed substantially coaxially with said tube to provide regenerative feedback to sustain oscillations in said circuit.

2. An ultra-high-frequency oscillator including a thermionic tube having at least an anode, a cathode and a control electrode, means comprising a first cylindraceous inductive element having a plurality of longitudinal slots in one end thereof, said slotted end being slidably connected to said control electrode and another portion of said element being capacitively coupled to said cathode, and means comprising a second inductive element inductively coupled to said cylindraceous element and concentric therewith to provide inductive feedback and having separate portions thereof slidably connected to said anode and capacitively coupled to said cathode, respectively.

3. Apparatus as claimed in claim 1 including variable capacitive means coupled between said anode and said cathode for adjusting the frequency of said oscillator.

4. Apparatus as claimed in claim 1 including motor driven variable capacitive means coupled

between said anode and said cathode for adjusting the frequency of said oscillator.

5. Apparatus as claimed in claim 1 including separate motor driven and manually operable variable capacitive means coupled between said anode and said cathode for adjusting the frequency of said oscillator.

6. Apparatus as claimed in claim 2 characterized in that said second inductive element comprises three coaxially disposed capacitively coupled conductive means, and means coupled to one of said conductive means for adjusting the position of said one of said conductive means to vary substantially the capacitive coupling between only two of said three conductive means.

7. Apparatus as claimed in claim 2 including cylindrical conductive shielding means substantially surrounding said tube and said inductive and capacitive elements, said shielding means being open at one end for access to said oscillator and being capacitively coupled at the remaining end to said cathode and said second inductive element.

8. An ultra-high-frequency oscillator including a thermionic tube having at least an anode, a cathode and a control electrode, means comprising a first cylindraceous inductive element having a plurality of longitudinal slots in one end thereof, said slotted end being slidably connected to said control electrode and another portion of said element being coupled capacitively to said cathode, and means comprising a second cylindraceous inductive element substantially surrounding and coaxial with said tube and concentric with said first element providing feedback coupling to said first inductive element and having separate portions thereof slidably connected

to said anode and capacitively coupled to said cathode, respectively.

9. In combination, an ultra-high-frequency thermionic discharge tube having a plurality of tube electrode terminals and an inductor comprising a cylindraceous conductive element having one end capacitively coupled to one of said tube electrode terminals and said element being longitudinally slotted for a substantial portion of its length from its other end to provide a plurality of longitudinally extending portions effectively comprising a plurality of parallel connected inductances engaging another of said tube electrode terminals, said inductor being disposed coaxially with said tube.

10. Apparatus as claimed in claim 9 wherein predetermined ones of said extending portions of said inductor are spaced from said last-mentioned tube electrode terminal.

ALFRED H. TURNER.

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