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I. M. BRUNTIL ET AL

2,453,489

ULTRA HIGH FREQUENCY OSCILLATOR

Filed Aug. 12, 1944

Fig. 1.

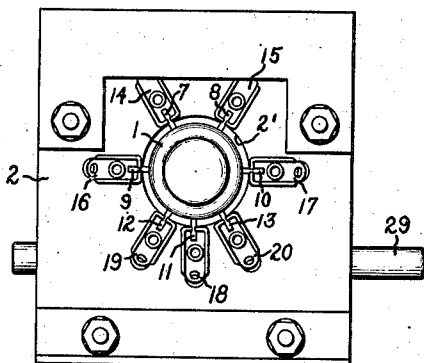


Fig. 2.

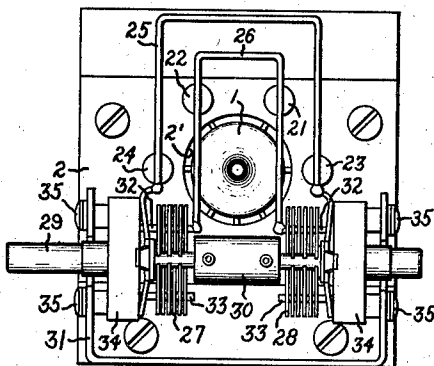


Fig. 3.

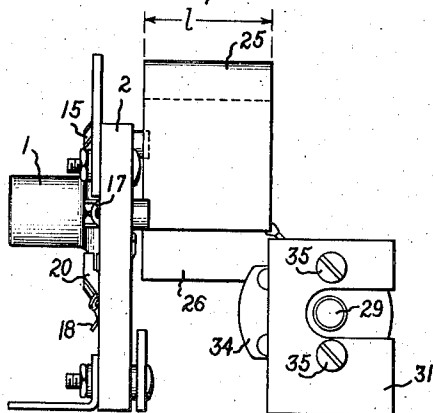


Fig. 4.

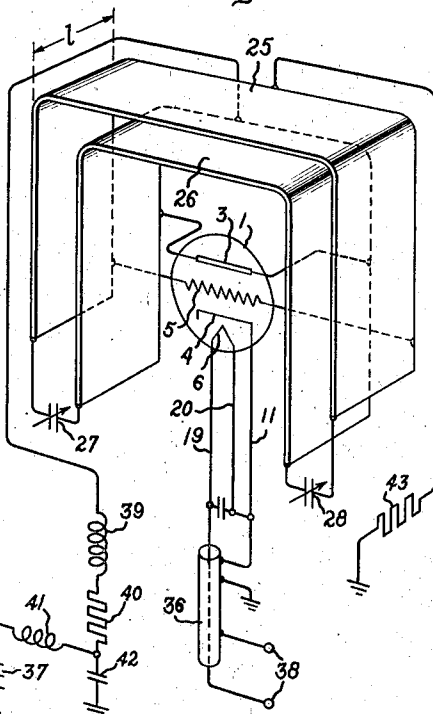
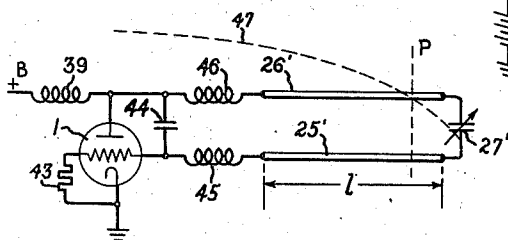


Fig. 5.



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ULTRA HIGH FREQUENCY OSCILLATOR

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Application August 12, 1944, Serial No. 549,262

5 Claims. (Cl. 250-36)

1

Our invention relates to electric wave generators and particularly to high frequency electronic oscillators of the tuned grid-plate transmission line type.

It is a general object of our invention to provide a new and improved high frequency oscillator.

It is a further object of our invention to provide a new and improved oscillator having a tank circuit of the grid-plate transmission line type characterized by unusually low surge impedance and low radiation losses.

It is another object of our invention to provide, in a grid-plate transmission line oscillator, new and novel means for varying the effective electrical length of the line to control the oscillator frequency.

It is still another object of our invention to provide a grid-plate transmission line tank circuit for a high frequency oscillator having high capacity per unit length and low inductance and resistance thereby to provide low surge impedance and a narrow band width.

A high frequency oscillator constructed in accordance with our invention comprises a tank circuit formed of a pair of sheets of electrically conducting material disposed in parallel spaced relation and having a width great in proportion to their length in the direction of wave propagation. Between proximate ends of the electrical conducting sheets remote from the grid and plate electrodes we connect a variable condenser arranged to constitute an apparent short circuit at selectable points along the line in the region of its remote end. The conducting sheets are bent transversely of the direction of wave propagation to form a pair of similar surfaces nested one within the other and having an axis of symmetry parallel to the direction of wave propagation. The outer sheet is connected to the grid electrode and the inner sheet to the plate or anode of an electron discharge device, so that the transmission line acts as a resonant circuit to feed back energy from the plate to the grid in regenerative phase, thereby to set up oscillations in the discharge device at a frequency determined by the effective electrical length of the line to the point of apparent short circuit. The total transmission line length to the point of connection of the variable condenser is approximately a quarter wave length or an odd multiple thereof at the desired frequency, the exact effective length being determined by the capacitance of the condenser.

Our invention will be more fully understood

2

and its objects and advantages further appreciated by referring now to the following detailed specification taken in conjunction with the accompanying drawing, in which Figs. 1, 2, and 3 are front, rear, and side elevations, respectively, of an electron discharge device and high frequency tank circuit therefor constructed in accordance with our invention; Fig. 4 is a schematic perspective circuit diagram of a high frequency oscillator embodying our invention; and Fig. 5 is a simplified schematic circuit diagram of the oscillator circuit shown at Fig. 4.

Referring now to the drawing, we have shown an oscillator comprising an electron discharge device 1 of the triode type enclosed in a substantially cylindrical evacuated envelope and mounted upon a panel or base 2 of suitable insulating material. The electron discharge device 1 includes an anode 3, a cathode 4, a grid or control electrode 5, and a cathode heating element 6. The anode 3 is provided at spaced points with a pair of external leads in the form of wires 7 and 8 extending radially outward from the cylindrical envelope. Spaced points on the grid 5 are provided with external leads in the form of a pair of radially extending wires 9 and 10. An external lead wire 11 is connected to the cathode 4 and additional external lead wires 12 and 13 are connected to the cathode heating element 6. The wires 7-13, inclusive, each extend radially from the substantially cylindrical evacuated envelope in substantially the same plane and provide means for mounting the discharge device 1 upon the panel 2. For this purpose the panel 2 is provided with a plurality of clip type terminal connectors 14-20, inclusive, radially spaced about a circular aperture 2' in the panel 2. The grid and anode terminal connectors 14-17 are connected to a plurality of studs 21-24, respectively, which extend through the panel 2 for connection to an external tank circuit on the rear side of the panel.

At the rear side of the panel 2 are disposed a pair of thin sheets 25 and 26 of electrically conducting material disposed in parallel spaced relation and bent into a generally U shape about an axis perpendicular to the plane of the panel 2, so that the sheet 25 partially encloses the sheet 26. The sheets 25 and 26 may be made of copper, or other suitable metal plated with silver, copper or gold. The U-shaped sheets 25 and 26 are mechanically mounted upon and electrically connected to the grid and plate studs 23, 24 and 21, 22, respectively. The connection of the plates 25 and 26 to the studs 23, 24 and 21, 22, respec-

tively, may suitably be made by soldering, welding, brazing, or the like.

As clearly shown at Fig. 3, the electric conducting plates 25 and 26 extend rearwardly from the panel 2 for an appreciable distance l and have connected between their proximate ends remote from the electrode connecting studs 21-24 a pair of variable condensers 27 and 28. The condensers 27 and 28 are mounted upon a common shaft 29 having an insulating section 30 and are symmetrically connected between adjacent points of the parallel U-shaped plates 25 and 26 at the ends remote from the panel 2.

The condensers 27 and 28 each comprise a plurality of alternate fixed and movable semicircular plates. The movable plates of both condensers are mounted upon the shaft 29, and the shaft 29 is journaled at its ends in a U-shaped bracket 31. The fixed plates of each condenser are mounted upon a pair of electrical conducting pins 32 and 33 rigidly mounted upon the bracket 31 and extending longitudinally of the shaft 29. Each pair of supporting pins 32, 33 is carried by an insulating member 34 which is connected to the U-shaped bracket 31 at opposite ends of the shaft 29 by bolts 35. As clearly shown at Fig. 2, the electrical conducting pins 32 supporting the stationary plates of the condensers are connected to the extremities of opposite legs of the U-shaped anode conductor 26 and the movable plates of each condenser are connected to the proximate extremities of the legs of the U-shaped grid conductor 25.

The complete oscillator shown at Fig. 4 comprises also a tubular conductor 36 for grounding the cathode 4 at a low potential point and suitable means for connecting the anode 3 to the positive terminal of a source of unidirectional current supply, such as a battery 37. The tubular conductor 36 is of such length that it forms, together with the cathode lead wire 11, a line of approximately one-half wave length at the operating frequency. This arrangement is desirable at the high frequencies herein contemplated in order to ensure that the cathode 4 itself is at ground potential. If a cathode lead of length other than a half wave length or an integral multiple thereof is used at high frequency, the impedance of the cathode lead itself would be sufficient to raise the cathode above ground potential.

The cathode heater leads 19 and 20 are connected to a source 38 of direct current or low frequency alternating current. This connection is conveniently made by connecting the tubular conductor 36 in series with the heater lead 20 and passing the heater lead 19 concentrically through the conductor 36. This also shields the heater lead from the high frequency field, preventing R. F. from appearing on the heater.

The power supply for the oscillator is derived from the positive terminal of the battery 37 through a radio frequency choke coil 39, a resistor 40, and a low pass filter comprising an inductance 41 and a condenser 42. Suitable grid bias is obtained through a grid leak resistor 43 connected between the grid end of the line conductor 25 and ground.

The operation of our high frequency oscillator and the effect of our new and novel tank circuit design may now be understood by referring particularly to Figs. 4 and 5. At Fig. 5, we have illustrated schematically the oscillator shown at Fig. 4. In the latter figure the grid-plate transmission line comprising the electric conducting

sheets 25 and 26 has been shown as a pair of conductors 25' and 26' disposed in parallel spaced relation. The length l of the conductors 25' and 26' corresponds to the length l of the U-shaped grid and plate conducting sheets 25 and 26 between their points of connection to the electrode studs 21-24, inclusive, and their opposite ends connected to the condensers 27 and 28. The condensers 27 and 28 of Fig. 4 are represented by a single variable condenser 27' at Fig. 5. At Fig. 5, we have also shown lumped circuit constants representing certain electrode and lead capacitance and inductance between the grid and plate electrodes of the discharge device 1 and the transmission line plates 25 and 26. Specifically, a capacitor 44 at Fig. 5 represents the interelectrode grid-to-plate capacitance of the discharge device 1 and the capacitance between the external grid and plate lead wires, terminal connectors and studs. The inductances 45 and 46 of Fig. 5 represent the inductance of the internal and external lead wires, terminal connectors, and connecting studs for the grid and plate, respectively. Since the inherent impedances 44, 45 and 46 necessarily form a part of the grid-plate transmission line and are of appreciable value at the frequencies under consideration, they must be taken into account in designing the tank circuit comprising the conducting plates 25 and 26.

The total electrical length of the transmission line between the electrodes 3 and 5 of the discharge device 1 and the remote ends of the conducting sheets 25 and 26 is determined by the lumped circuit constants 44, 45, and 46 and the distributed inductance and capacitance for the length l of the conductors 25 and 26 themselves. This length is approximately an odd multiple of a quarter wave length at the frequency of the desired oscillations. By an odd multiple of a quarter wave length we intend to include a single quarter wave length, and in the drawing we have illustrated a line of such length. The variable capacitor 27' of Fig. 5 is sufficiently large so that at its maximum value it offers substantially no impedance to currents of the desired high frequency and therefore constitutes substantially a short circuit across the remote ends of the transmission line. When adjusted to lesser values of capacitance, the condenser 27' no longer constitutes a short circuit but offers an appreciable impedance less than the characteristic impedance of the transmission line.

It is understood by those skilled in the art that a short-circuited transmission line of the type described above possesses a characteristic or resonant frequency determined by its effective electrical length. At this frequency standing waves will appear on the line in such phase relation that the line possesses the characteristics of a parallel resonant circuit. The effective electrical length of the line is that length between the anode and grid electrodes 3 and 5 and the point of short-circuiting at the remote end of the line. We have found that the point of apparent short circuit between the conductors 25' and 26' of Fig. 5 may be varied by variation of the capacitance of the condenser 27'. Similarly the point of apparent short circuit between the sheets 25 and 26 of Figs. 1-4 may be varied by the condensers 27 and 28. This is illustrated graphically at Fig. 5 where the dotted line 47 represents a standing wave of voltage having a maximum value at the open end of the line between the anode and grid electrodes 3 and 5 and a zero value at a point P located between the ends of

5

the transmission line conductors 25' and 26'. The location of the point P and, therefore, the length and frequency of the generated waves may be varied by varying the capacitance of the condenser 27' and thus changing the impedance between the conductors 25' and 26' at the points of connection of the condenser 27'. When the condenser 27' has its maximum capacitance, its impedance, as previously stated, is substantially zero, so that the node of the voltage wave 47 is located approximately at the remote end of the conductors 25' and 26'. By decreasing the capacitance and therefore increasing the impedance of the condenser 27', the voltage node at the point P may be caused to move inwardly toward the electron discharge device 1 in order to establish between the remote ends of the conductors 25' and 26' and across the condenser 27' a voltage determined by the impedance of the condenser 27'.

In a practical embodiment of our invention designed to generate oscillations having a wave length of the order of 40 centimeters, it was found that the major portion of the quarter wave length transmission line was constituted by the inherent lumped circuit constants 44, 45, and 46; so that the length 1 of the external line constituted by the parallel conducting plates 25 and 26 was approximately only two and one-half centimeters.

From the foregoing detailed explanation of the construction, arrangement, and operation of our invention, it will be observed that we have incorporated into a simple, compact, and inexpensive structure a number of new and novel features which add greatly to the efficiency of operation of a high frequency electric wave generator of the type herein described. Heretofore, it has been proposed to vary the effective length of an oscillator tank circuit formed of parallel conducting sheets by providing the sheets with inter-fitting sliding sections arranged to change the actual physical length of the sheets. This arrangement is awkward, mechanically complicated, and extremely susceptible to maladjustment. In accordance with our invention, we have found that by forming the external transmission line of conducting sheets having a width great relative to their length, it is possible to so decrease the line surge impedance by increase in line capacity that the effective electrical length of the line may be varied by connecting across its remote ends a variable condenser of practical size. Further advantage is derived from our arrangement of the parallel conducting sheets in U or equivalent symmetrical shapes with the plate conductor substantially enclosed by the grid conductor. By this arrangement the plate conductor is shielded, so that power loss by plate radiation is appreciably diminished and the percentage band width of the line decreased. Also, by shaping the transmission line conductors symmetrically in a plane transverse to the direction of wave propagation along the line and utilizing an electron discharge device having a pair of external leads from each of the grid and plate electrodes symmetrically connected to opposite sides of the transmission line conductors, the potential distribution upon the plate and grid of the tube is rendered more uniform. In this way unbalance within the tube is largely avoided and the effect of inductance and capacitance in the electrode leads is minimized.

While we have described only a preferred embodiment of our invention by way of illustration, many modifications will occur to those skilled in

6

the art and therefore we wish to have it understood that we intend in the appended claims to cover all such modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. A high frequency wave generator including an electron discharge device having an anode, a cathode and a control electrode, a tank circuit including a transmission line formed of a pair of sheets of electrically conducting material disposed in parallel spaced relation, one end of one of said sheets being connected to said anode and one end of the other of said sheets being connected to said control electrode, said sheets having a width great relative to their length and being curved in a plane transverse to the direction of wave propagation, said length being measured in said direction from one of said ends of one of said sheets to the respectively opposite end thereof, the sheet connected to said control electrode surrounding and shielding the sheet connected to said anode.

2. A high frequency wave generator including an electron discharge device having an anode, a cathode and a control electrode disposed in an evacuated envelope, said discharge device including external anode and control electrode conductors in substantially the same plane, a tank circuit including a pair of similarly curved metal sheets nested one within the other and having a plane of symmetry substantially perpendicular to the plane of said conductors, the length of said sheets in a direction perpendicular to said plane of said conductors being sufficient to provide an odd multiple of a quarter wave transmission line between opposite ends of said line at the frequency of said waves, said anode being connected to said one sheet at one end of said line and said control electrode being connected to said other sheet at said one end.

3. A high frequency wave generator comprising an electron discharge device having an anode, a cathode and a control electrode, a transmission line tank circuit comprising a pair of metallic sheets disposed in parallel spaced relation and connected at proximate near ends to said anode and control electrode respectively, said sheets being curved transversely of the length as determined by the direction of wave propagation so that the sheet connected to said control electrode at least partially surrounds the sheet connected to said anode, the length of said transmission line between opposite ends of said sheets being approximately an odd multiple of a quarter wave length at the frequency of said waves, and a variable condenser connected between the proximate far ends of said sheets remote from said anode and control electrode, said length being measured from said near ends to said far ends.

4. A high frequency wave generator comprising a substantially planar supporting base, an electron discharge device having an anode, a cathode and a control electrode disposed in a substantially cylindrical evacuated envelope, said anode and control electrode being each provided with a pair of external lead wires extending radially from said discharge device in substantially the plane of said base, a plurality of terminal connectors mounted upon said base for supporting engagement with said external lead wires, a tank circuit comprising a pair of nested substantially U-shaped metal sheets mounted upon said base and directly connected to said

7

terminal connectors, said U-shaped sheets having an axis of symmetry substantially perpendicular to the plane of said base, the outer sheet being connected at the edge adjacent said base to said pair of control electrode leads at symmetrical points on opposite sides of said axis of symmetry and the inner sheet being similarly connected to said pair of anode leads, said sheets being of such length in the direction of said axis of symmetry that the total electrical length of said transmission line is approximately a quarter wave length at the frequency of said waves, and a pair of variable condensers connected between said metal sheets at symmetrical points on opposite sides of said axis of symmetry and at the edge remote from said base.

5. A high frequency wave generator including an electron discharge device having an anode, a cathode and a control electrode, a transmission line tank circuit comprising a pair of similar nested metallic sheets connected at one end of said line to said anode and control electrode respectively and having an axis of symmetry in the direction of wave propagation, said direction being from said one end to the opposite end of said line, the outer sheet having symmetrically disposed points on opposite side of said axis of symmetry connected to said control electrode,

8

and the inner sheet having similar points connected to said anode, and a pair of variable condensers connected between said sheets at symmetrical points on opposite sides of said axis of symmetry and at the opposite end of said line.

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Certificate of Correction

Patent No. 2,453,489.

November 9, 1948.

IRWIN M. BRUNTIL ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 7, line 27, claim 5, for the word "side" read *sides*;
and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of March, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.