

June 21, 1949.

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2,473,504

CONCENTRIC LINE OSCILLATOR

Filed June 18, 1943

2 Sheets-Sheet 1

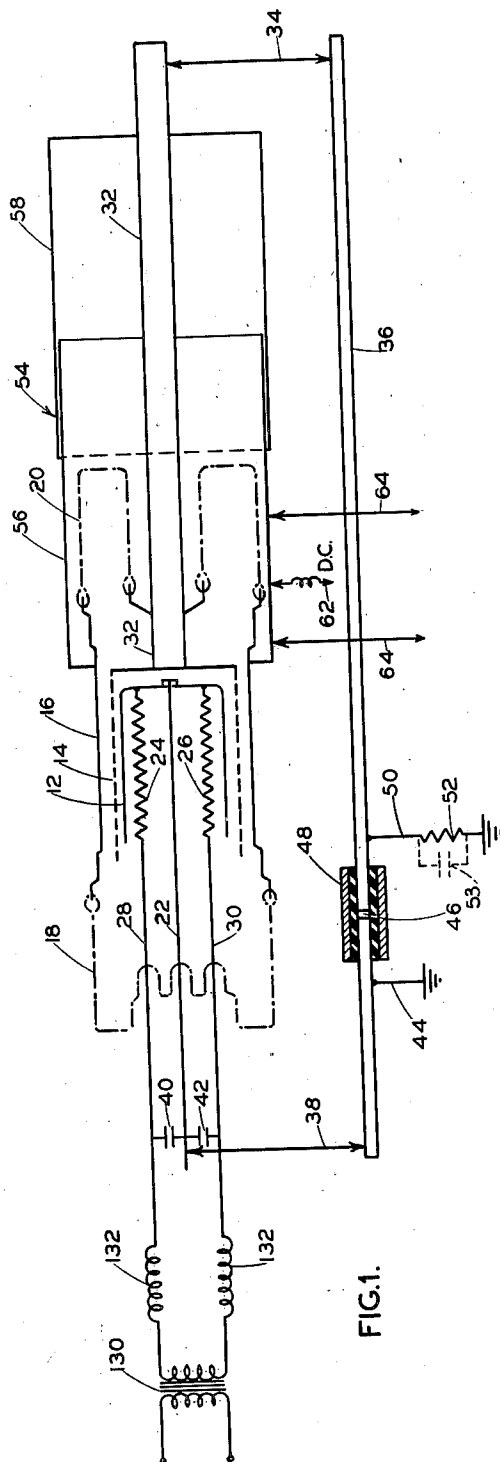


FIG. 1.

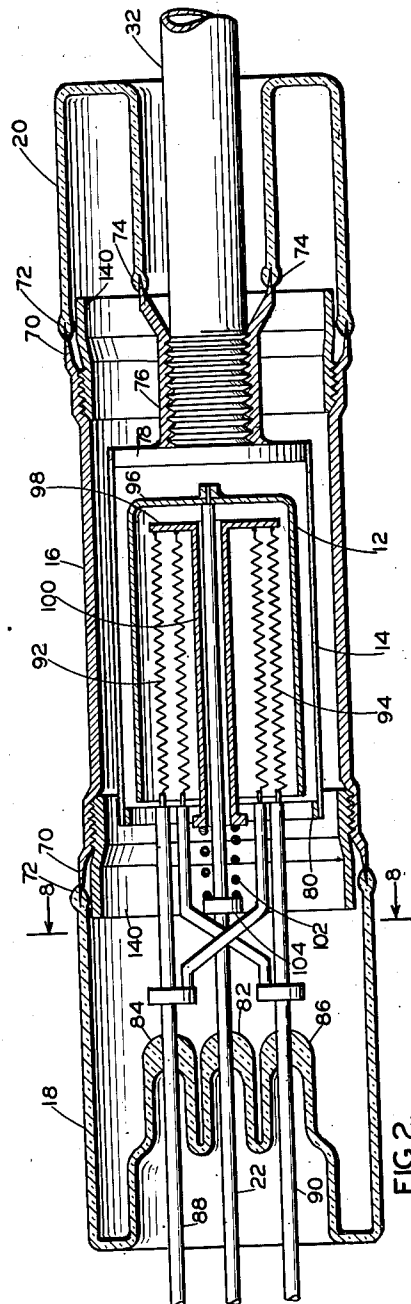


FIG. 2.

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2 Sheets-Sheet 2

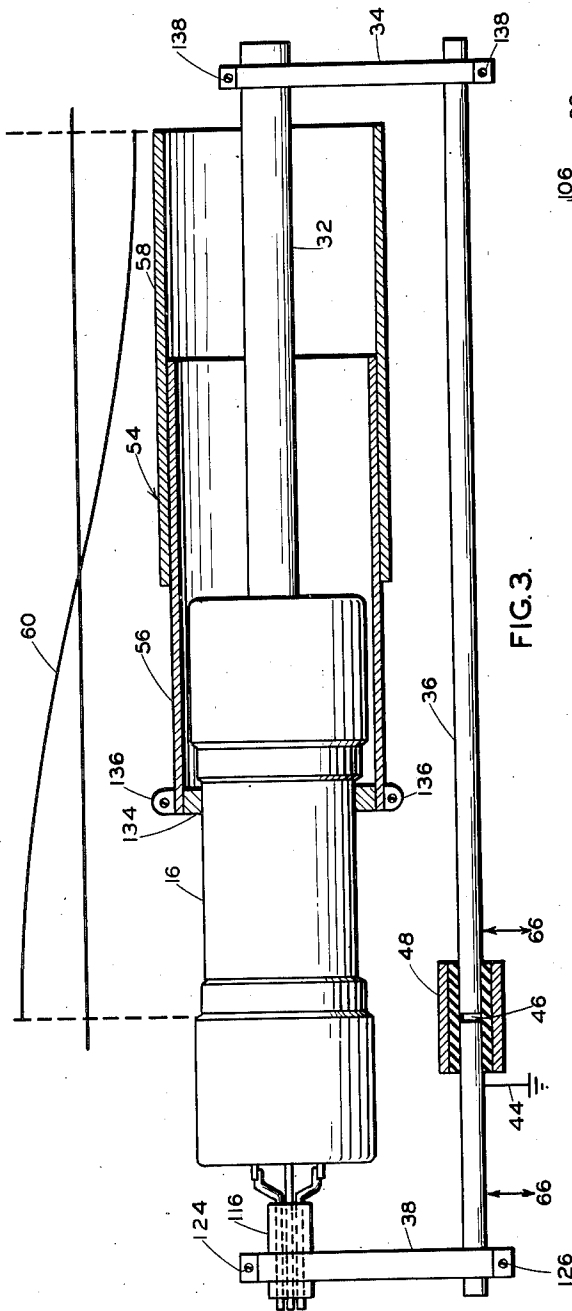


FIG. 3.

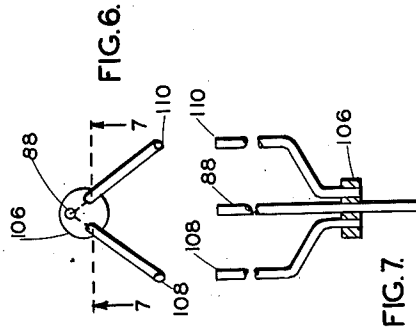


FIG. 6.

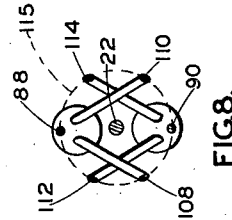


FIG. 7.

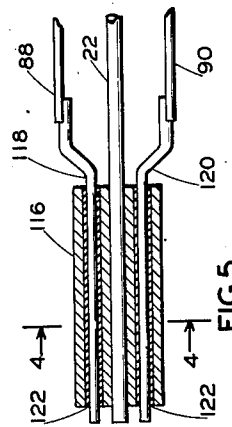


FIG. 8.

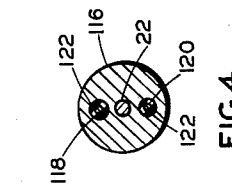


FIG. 4.

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2,473,504

CONCENTRIC LINE OSCILLATOR

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Application June 18, 1943, Serial No. 491,373

15 Claims. (Cl. 250—36)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to oscillators, and more particularly to very high frequency oscillators.

The primary object of my invention is generally to improve very high frequency oscillators.

For the sake of high power output it has been proposed to make an oscillator tube having large diameter cylindrical cathode, grid, and anode structures, the anode forming a part of the tube envelope and the cathode being a cylindrical can which is indirectly heated by a plurality of filaments disposed therewithin. One object of the present invention is to provide an efficient very high frequency oscillator using a tube of this type.

I have found that such a tube is characterized by a large grid-to-cathode capacitance, this being comparable to the grid-to-anode capacitance when using a cathode can instead of a filamentary cathode. In accordance with a feature and object of the present invention, I provide a radio frequency circuit between the grid and the cathode, said circuit preferably being tunable, and being adjusted to counteract or to series-resonate the grid-to-cathode capacitance of the tube.

Still another object of the invention is to provide resonant anode and grid circuits in the form of a coaxial line in which the anode and grid pipes are effective extensions of the anode and grid electrodes, so that the tube electrodes themselves form a part of the resonant coaxial line. A further object of the invention is to provide an efficient radio frequency coupling to the cathode.

To accomplish the foregoing, and such other objects as will hereinafter appear, my invention resides in the vacuum tube and associated circuit elements and their relation one to the other as are hereinafter more particularly described in the specification and sought to be defined in the claims. The specification is accompanied by drawings in which

Figure 1 is a schematic diagram explanatory of the oscillator;

Figure 2 is a longitudinal section through the tube around which the oscillator is built;

Figure 3 is a partially sectioned elevation of the oscillator structure;

Figure 4 is a section through a bushing used for radio frequency coupling to the cathode, said section being taken approximately in the plane of the line 4—4 of Figure 5;

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Figure 5 is a longitudinal section through the bushing at the lead-ins;

Figure 6 is an end view of one heater-filament supporting structures;

Figure 7 is a section taken approximately in the plane of the bent line 7—7 of Figure 6; and

Figure 8 is a transverse section through the complete heater filament supporting structure, said section being taken approximately in the plane of the line 8—8 of Figure 2.

Referring to the drawing, and more particularly to Figure 1, the transmitter tube comprises a relatively large-diameter cylindrical cathode 12, surrounded by a grid 14 and an anode 16. The metal anode 16 forms a part of the tube envelope, the latter being completed by glass ends 18 and 20 shown in dot-and-dash lines. The cathode 12 is of the oxide-coated, indirectly-heated type, it being supported on a center lead-in 22, and housing heater filaments 24 and 26, supported by heater lead-ins 28 and 30, respectively. The grid 14 is carried by a grid pipe 32, which acts as a lead-in for the grid and also as an electrical extension of the same.

I have found that because of the large-area nature of the cathode 12, the grid-to-cathode capacitance is substantial and comparable to the grid-to-anode capacitance. I have further found that for efficient operation, it is highly desirable to take care of the charging current needed for this substantial capacitance. I have accordingly provided an external circuit from the grid to the cathode to supply this charging current, which circuit is tuned overall to provide an inductive reactance equal to the grid-to-cathode capacitive reactance, or in other words to series-resonate said capacitance. In the present case, the circuit is made up of a grid pipe 32, an adjustable shorting bar 34, an auxiliary grid-to-cathode pipe 36, and a shorting bar 38 leading back to the cathode lead-in. The overall inductive reactance of the resulting grid-to-cathode circuit is made proper to counteract the grid-to-cathode capacitive reactance. I do not mean by this that the overall low frequency inductance cannot be greater, for it can and ordinarily will be greater, for the pipes 32 and 36 constitute a line short-circuited by bar 34 which for structural reasons must exceed the electrical half wave length. The length in excess of the half wave length provides the necessary inductive reactance.

The coupling of shorting bar 38 to the cathode is provided by means which is described later, but for the present it may be pointed out that

there is a conductive connection to the cathode can lead-in 22, and a capacitive coupling to the heater lead-ins 28 and 30, as is indicated by condensers 40 and 42.

The cathode is preferably held at ground potential, this being done most conveniently by means of a ground connection 44, located at a potential nodal point on the auxiliary pipe 36. In this way the ground connection is made one or more half wave lengths electrically distant from the cathode.

In order to permit the application of a desired grid bias to the grid, the auxiliary pipe 36 is preferably broken at 46, the break being bridged with respect to radio frequency by a suitable capacitance indicated at 48. Grid bias may be applied at lead 50, located between the radio frequency condenser 48 and the grid. In the present case, the grid bias is developed across a grid bias resistor 52, shunted by distributed or lumped capacitance 53.

The anode is extended by means of an anode pipe 54. This is preferably made of telescopically-related sections 56 and 58, thus affording adjustment of the overall length of the anode and anode pipe to be an equivalent half wave of the oscillation frequency. This is most clearly shown in Figure 3, in which it will be seen that there is a standing wave on the anode and anode pipe, indicated at 50. The grid and grid pipe are also excited with a standing wave, but this is opposite in phase to the standing wave on the anode pipe.

Direct anode potential may be supplied in any desired fashion, but preferably by means of a direct current supply lead 62 (Fig. 1), connected at the potential nodal point of anode pipe 54. Power may be taken from the oscillator by means of leads spaced symmetrically about a nodal point in one of the circuits. In Figure 1 the transmission line leads 84 are tapped onto the anode pipe on opposite sides of the D. C. supply lead 62. In Figure 3, the power takeoff leads 66 are disposed on opposite sides of the ground 44.

The structure of the vacuum tube is shown in greater detail in Figure 2, and referring to that figure it will be seen that both ends of the anode 16 are stepped outwardly at 70, and tapered to a feathered edge. This is sealed at 72 to glass ends 18 and 20. The end 20 is sealed at 74 to a socket 76 forming a part of a disk 78 on which the grid 14 is built. More specifically, the grid consists of a cage of axially-directed wires which are welded at one end to disk 78, and at the other end to a ring 80. Socket 76 is internally threaded to receive the threaded end of grid pipe 32.

The opposite glass end 18 has a reentrant stem 82 sealed to a center lead-in 22 which supports the cathode can 12. There are also reentrant stems 84 and 86 sealed to heater lead-ins 88 and 90, respectively. Lead-in 88 is connected to the end of a heater filament 92, while lead-in 90 is connected to the end of a heater filament 94. The ends of the heater filaments 92 and 94 may be connected directly to the closed end 96 of the cathode can. However, it is desirable to prevent sagging of the filaments caused by expansion when heated, for otherwise the filaments may touch the cathode can, and when, as later described, a considerable number of heater filaments are employed, they may touch one another. To overcome this difficulty I connect the inner ends of the filaments 92 and 94 to the flanged end 98 of a sleeve 100, slidably carried on

center lead-in 22. A relatively light compression spring 102 is disposed between the opposite end of sleeve 100 and a collar 104, fixed on lead-in 22. Spring 102 is so designed as to take up any slack caused by expansion of the filaments when heated, and sufficient clearance is provided between flange 98 and the closed end 96 of the cathode can to accommodate the necessary movement.

In the particular structure here illustrated there are six heater filaments, three of which are connected to each of the lead-ins 88 and 90. The method of accomplishing this may be described with reference to Figures 6, 7, and 8. Figures 6 and 7 show how lead-in 88 is provided with an eccentric collar 106, which in turn carries two additional supports 108 and 110. These are appropriately bent to provide three support points spaced 120° apart.

It will be understood that the other lead-in 90 is similarly provided with an eccentric collar and two additional supports. The parts then fit together in the manner shown in Figure 8, in which lead-in 88, with added supports 108 and 110, is shown nested with lead-in 90 and its added supports 112 and 114. In all there are six supports, disposed 60° apart, on an imaginary circle 115, said circle being concentric with the center lead-in 22, and therefore with the cathode can. All of the filaments are connected at their outer ends to the filament supports, and are connected at their inner ends to the flange 98 (Figure 2) of the spring pressed sleeve 100.

The coupling of the cathode to the shorting bar 38 has been schematically indicated in Figure 1, and is shown in structural form in Figures 4 and 5. The center lead-in 22 is received in a metallic bushing 116 with a metal-to-metal contact. The heater lead-ins 88 and 90 are either made long enough, or, as is here illustrated, are welded to extensions 118 and 120, which also pass through the bushing 116. However, these lead-ins are surrounded by insulation tubes 122. Referring to Figure 3, the shorting bar 38 is a split bar, which is clamped about the bushing 116 by means of a screw 124, while its opposite end is clamped about the auxiliary pipe 36 by means of a screw 126. It will be evident that there is a radio frequency coupling between the cathode and the shorting bar 38, this being provided by the conductive connection to center lead-in 22, and by the capacitive coupling to the heater lead-ins. It will also be understood that shorting bar 38 is adjustable along bushing 116 and auxiliary pipe 36 for appropriate tuning of the cathode to ground connection 44.

The method of energizing the filaments is illustrated in Figure 1, in which it will be seen that a low frequency alternating current power supply is fed through a transformer 130 to the filament lead-ins 28 and 30. Radio frequency chokes 132 may be inserted. It will be evident that filament 24 is heated in series with filament 26, and that with six filaments arranged as previously described, three of them are heated in parallel, and the two parallel groups are connected in series.

Referring to Figure 3, the anode pipe 56 is connected to the anode 16 by means of a collar 134. This is preferably a split collar, the halves of which may be placed about the anode and clamped in position, as by means of ears 136 receiving appropriate screws. The pipe 56 is necessarily slightly larger in diameter than the vacuum tube with which it is used, but the in-

crease in diameter is preferably minimized in order not to exaggerate the discontinuity with respect to radio frequency caused by the step at ring 134. The use of slidably-related pipes 56 and 58 is not essential, but is convenient. The shorting bar 34 is a split shorting bar, much like the shorting bar 38 previously referred to. When screws 130 are loosened, the shorting bar may be slid along grid pipe 32 and auxiliary pipe 36. This tunes the grid to cathode or grid to ground circuit.

Referring to Figure 2, the annular metal members 140 are electrostatic shields which protect the seals 72 against excessive field concentration at the sharp metallic edges, which otherwise would produce heat endangering the seals.

It is believed that the construction and operation of my improved very high frequency oscillator, as well as the many advantages thereof, will be apparent from the foregoing description thereof. It will also be apparent that while I have shown and described my invention in a preferred form, many changes and modifications may be made in the structure disclosed, without departing from the spirit of the invention, as sought to be defined in the following claims.

I claim:

1. A very high frequency oscillator comprising an oscillator tube and associated circuits, said tube having a concentric cylindrical anode, grid and cathode having appreciable cathode-to-grid capacitance, an anode pipe connected to the anode, the anode and anode pipe approximating a half-wave-length of the desired frequency, a grid pipe within the anode pipe connected to the grid said associated circuits including a grid-to-cathode circuit having an adjustable shorting bar and tuned to carry the grid-to-cathode portion of the total grid charging current, said grid-to-cathode circuit including a radio condenser permitting the application of grid bias potential without interrupting the radio frequency.

2. A very high frequency oscillator comprising an oscillator tube and associated circuits, said tube including an indirectly-heated cathode of large area, whereby the cathode-to-grid capacitance becomes appreciable and comparable to the anode-to-grid capacitance, an anode pipe connected to the anode, the anode and anode pipe approximating a half-wave-length of the desired frequency, a grid pipe within the anode pipe and connected to the grid, said associated circuits including a grid-to-cathode circuit having a reactor therein adjusted to carry the grid-to-cathode portion of the total grid charging current, said grid-to-cathode circuit being grounded at a radio frequency potential node with respect to the cathode, and said grid-to-cathode circuit including a break with respect to direct current, thereby permitting the application of grid bias potential to the grid, said break being bridged with respect to radio frequency by a condenser.

3. A high power very high frequency oscillator comprising a cathode in the form of a relatively large diameter cylindrical can, a plurality of heater filaments within the can, and means to prevent sagging of said filaments when heated, said means including a movable member to which one end of the heater filaments are connected, and a spring urging said member in a direction tending to take up any slack caused by expansion of the filaments when heated.

4. A high power very high frequency oscillator comprising a cathode in the form of a relatively large diameter cylindrical can, a center rod sup-

porting said can, a plurality of heater filaments disposed about the center rod within the can, and means to prevent sagging of said filaments when heated, said means including a sleeve slidable on the center rod and having a flange at one end to which the heater filaments are connected, and a spring surrounding said center rod and bearing against one end of the sleeve in a direction tending to take up any slack caused by expansion of the filaments when heated.

5. A very high frequency oscillator comprising an oscillator tube, said tube including an indirectly-heated cathode having a can and heater filaments therein, said can being supported by a lead-in and said heater filaments being supported by two additional lead-ins, a cathode-to-ground circuit, and means efficiently coupling the cathode to said circuit with respect to radio frequency, said means including a metal bushing receiving the aforesaid can lead-in with a conductive connection, and receiving the heater lead-ins with tubes of insulation therearound, whereby all three of the cathode lead-ins are coupled to the aforesaid circuit with respect to radio frequency.

6. A very high frequency oscillator comprising an oscillator tube and associated circuits, said tube including an indirectly-heated cathode having a can and heater filaments therein, said can being supported on a center lead-in and said heater filaments being provided with two additional lead-ins, a cathode-to-ground circuit including a split, adjustable shorting bar for tuning purposes, and means for efficiently coupling the cathode to the shorting bar with respect to radio frequency, said means including a metal bushing receiving the aforesaid center lead-in with a conductive connection, and receiving the heater lead-ins with tubes of insulation therearound, the adjustable, split shorting bar being clamped directly around the metallic bushing, whereby all three of the cathode lead-ins are coupled to the shorting bar with respect to radio frequency.

7. A very high frequency oscillator comprising an oscillator tube and associated circuits, said tube including cathode, grid, and anode structures, the anode forming a part of the tube envelope, said associated circuits including an anode pipe connected to one end of the anode and surrounding the adjacent end of the tube, said anode and anode pipe having a length approximately a half wave length of the desired oscillation frequency, the grid having a pipe running concentrically through the anode pipe and projecting from one end thereof, the cathode having lead-ins projecting from the opposite end of the tube, an auxiliary grid-to-cathode circuit having a ground connection including an adjustable reactor between the cathode lead-ins and ground tuned to hold the cathode at substantially ground potential, another adjustable reactor between the grid pipe and ground, a condenser between the ground connection and the grid, a grid bias connection between said condenser and the grid, the resulting grid-to-cathode circuit being adjusted to divert the grid-to-cathode portion of the total grid charging current to the grid-to-cathode circuit.

8. A very high frequency oscillator comprising an oscillator tube and associated circuits, said tube including relatively large-diameter cylindrical cathode, grid, and anode structures, the anode forming a part of the tube envelope, said associated circuits including an anode pipe connected to one end of the anode and surrounding the adjacent end of the tube,

said pipe including telescopically-related sections which are slightly larger in diameter than the tube and which afford tuning of the overall length of the anode and anode pipe to approximately a half wave length of the desired oscillation frequency, the grid having a pipe running concentrically through the anode pipe and projecting from one end thereof, the cathode having lead-ins projecting from the opposite end of the tube, an auxiliary grid-to-cathode circuit having a ground connection, an adjustable shorting bar between the cathode lead-ins and ground, another adjustable shorting bar between the grid pipe and ground, a condenser between the grid and said ground, a grid bias connection between said condenser and the grid, the resulting grid-to-cathode circuit being adjusted to divert the grid-to-cathode portion of the total grid charging current to the grid-to-cathode circuit, a direct current anode connection to the anode circuit, and power take-off connections symmetrically disposed with respect to a potential nodal point on the aforesaid grid-to-cathode circuit.

9. A very high frequency oscillator comprising, an oscillator tube having a concentric cylindrical anode, cathode and grid, and associated circuits, said tube having an appreciable cathode-to-grid capacitance, an anode pipe connected to the anode, the anode and anode pipe approximating a half wave length of the desired frequency, a grid pipe within the anode pipe connected to the grid and extending appreciably beyond the end of the anode pipe, said associated circuits including a grid-to-cathode circuit adapted to carry the grid-to-cathode charging current, said circuit including a longitudinal conductor external to the tube, a radio frequency connection from the cathode to a point near one end of said longitudinal conductor and a radio frequency connection from the aforesaid grid pipe to a point near the opposite end of said longitudinal conductor.

10. A very high frequency oscillator comprising an oscillator tube and associated circuits, said tube including an indirectly-heated cathode of large area, whereby the cathode-to-grid capacitance becomes comparable to the anode-to-grid capacitance, an anode pipe connected to the anode, said anode and anode pipe approximating a half wave length of the desired frequency, a grid pipe within the anode pipe connected to the grid and extending appreciably beyond the end of the anode pipe, said associated circuits including a cathode-to-grid circuit adapted to carry the cathode-to-grid charging current, said circuit including a longitudinal conductor external to the tube, a radio frequency connection from the cathode to said longitudinal conductor adjacent to the cathode, and a radio frequency connection from a point on the aforesaid grid pipe to an adjacent point on the longitudinal conductor.

11. A very high frequency oscillator comprising an oscillator tube and associated circuits, said tube having appreciable cathode-to-grid capacitance and having an anode and anode pipe approximating a half wave length of the desired frequency, a grid pipe within the anode pipe connected to the grid and extending appreciably beyond the end of the anode pipe, said associated circuits including a grid-to-cathode circuit adapted to carry the grid-to-cathode charging current, said circuit including a conductor external to the tube and extending substantially parallel to the tube axis, a series resonant connection from the cathode to a point on the external conductor adjacent to the cathode, and a ra-

dio frequency connection from a point on the aforesaid grid pipe to an adjacent point on the external conductor.

12. A very high frequency oscillator comprising, an oscillator tube having a relatively large-diameter cylindrical anode, the anode forming a part of the envelope of the tube, an anode pipe connected to one end of the anode and surrounding the adjacent end of the tube, said pipe being slightly larger in diameter than the tube, the length of the anode and anode pipe approximating a half wave length of the desired frequency, a grid pipe running through the anode pipe and extending beyond the end thereof connected to the grid, and a cathode-to-grid circuit adapted to carry the cathode-to-grid portion of the grid charging current, said circuit including, a conductor external to the tube and extending substantially parallel to the axis of the tube, a connection to ground at a point on said external conductor near the cathode, a radio frequency connection from the cathode to the external conductor substantially series resonant between the cathode and said ground, and a radio frequency connection from a point on the aforesaid grid pipe to an adjacent point on the external conductor adapted to draw the cathode-to-grid portion of the grid charging current.

13. A very high frequency oscillator comprising, an oscillator tube having a relatively large diameter cylindrical anode, the anode forming a part of the envelope of the tube, an anode pipe connected to one end of the anode and surrounding the adjacent end of the tube, said pipe being slightly larger in diameter than the tube and including a telescopically-related section affording tuning of the anode and anode pipe to a resonant length approximating a half wave length of the desired frequency, and a cathode-to-grid circuit adapted to carry the cathode-to-grid portion of the grid charging current, said circuit including, a conductor external to the tube and extending substantially parallel to the axis thereof, a ground connection for said external conductor at an intermediate point along its length, a radio frequency connection from the cathode to the external conductor substantially series resonant between the cathode and said ground point, and a radio frequency connection from a point on the aforesaid grid pipe to an adjacent point on the external conductor adapted to draw the cathode-to-grid portion of the total grid charging current.

14. A very high frequency oscillator comprising, an oscillator tube and associated circuits, said tube including cathode, grid and anode structures, the anode forming a part of the tube envelope, said associated circuits including an anode pipe connected to one end of the anode and surrounding the adjacent end of the tube, said anode and anode pipe having a length approximately a half wave length of the desired frequency, the grid having a pipe running through the anode pipe and projecting from one end thereof, the cathode having lead-ins projecting from the opposite end of the tube and an auxiliary grid-to-cathode circuit adapted to carry the grid-to-cathode portion of the grid charging current, said auxiliary circuit including a conductor external to the tube and extending substantially parallel to the axis thereof, a radio frequency connection between the cathode lead-ins and said external conductor, and a radio frequency connection from a point on the aforesaid grid pipe to a point on the external conductor adapted to

draw the grid-to-cathode portion of the total grid charging current.

15. A very high frequency oscillator comprising, an oscillator tube and associated circuits, said tube including cathode, grid, and anode structures, the anode forming part of the tube envelope, said associated circuits including an anode pipe connected to one end of the anode and surrounding the adjacent end of the tube, said anode and anode pipe having a length approximately a half wave length of the desired frequency, the grid having a pipe running through the anode pipe and projecting from one end thereof, the cathode having lead-ins projecting from the opposite end of the tube, and an auxiliary radio frequency grid-to-cathode circuit adapted to carry an appreciable part of the grid charging current, said auxiliary circuit including a conductor external to the tube and extending substantially parallel to the axis thereof, a radio frequency connection from the cathode lead-ins to said external conductor, a radio frequency connection from a point on the aforesaid grid pipe

to an adjacent point on the external conductor; a direct current connection to the anode for supplying power, and power take-off connections symmetrically disposed with respect to a potential nodal point on the anode-to-anode-pipe structure.

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