June 7, 1949. C. A. BODDIE 2,472,088

OSCILLATOR TUBE

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FIG.1.

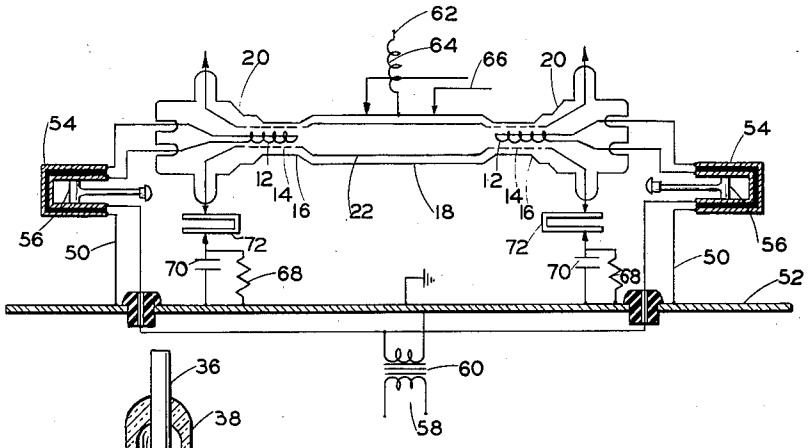


FIG.2.

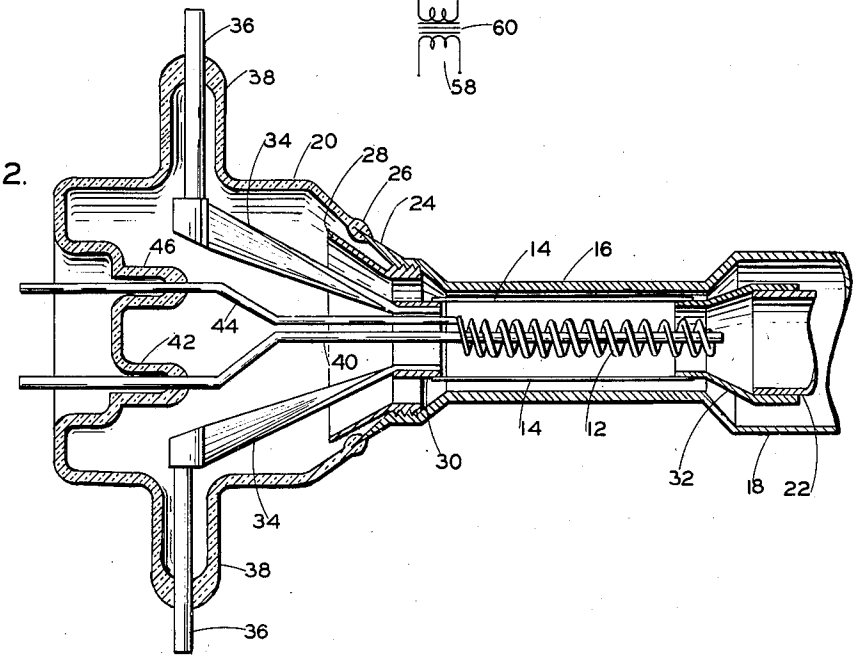
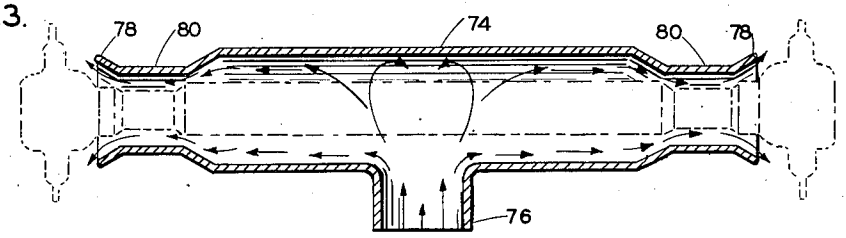


FIG.3.



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FIG.4.

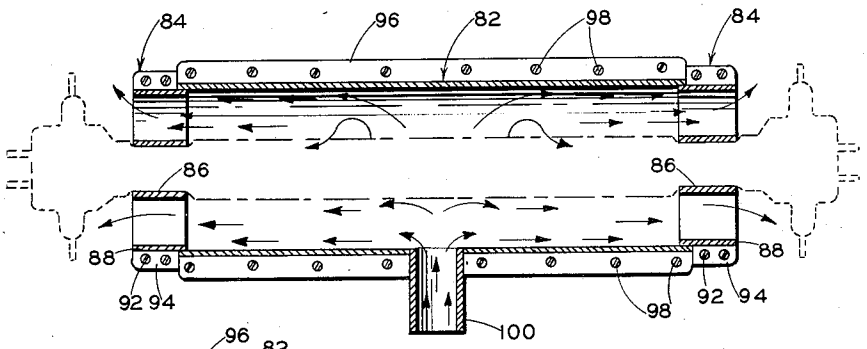


FIG.5.

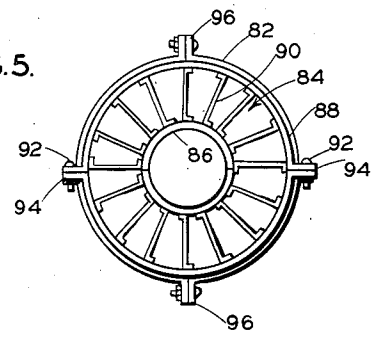
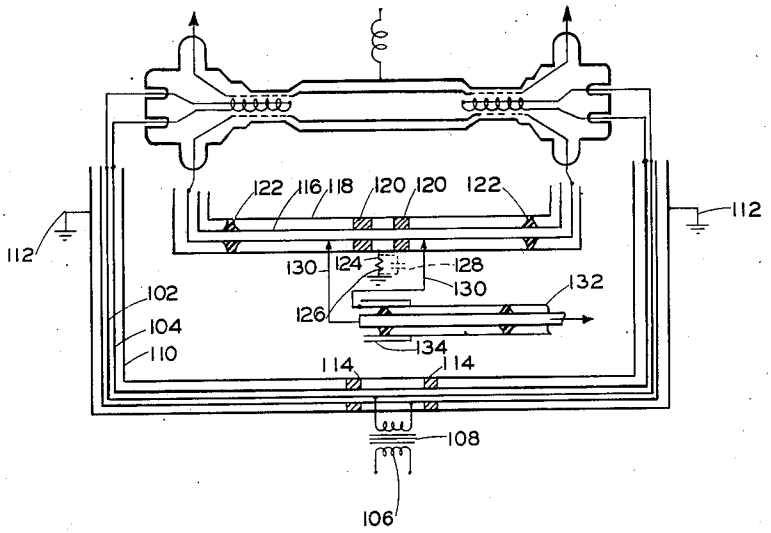


FIG.6.



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OSCILLATOR TUBE

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FIG.7.

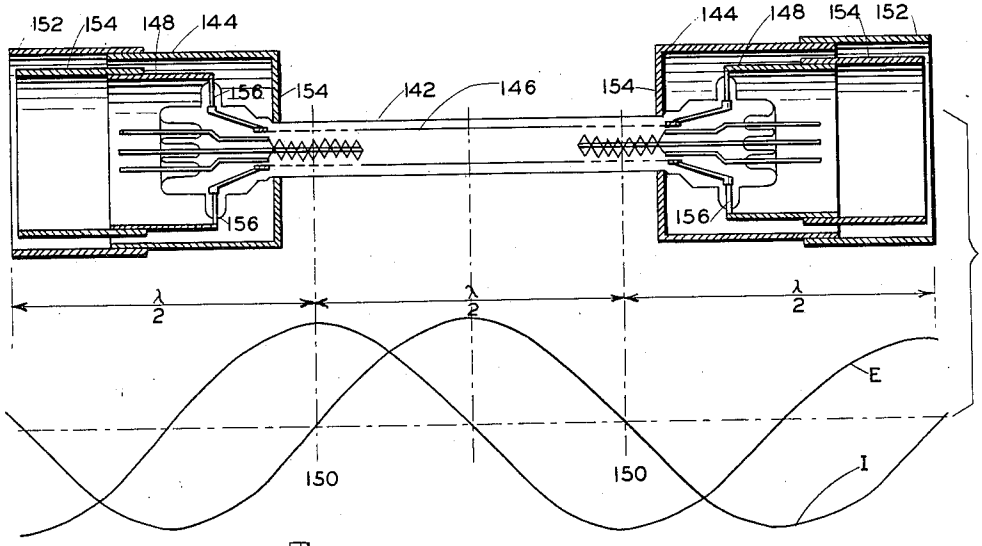
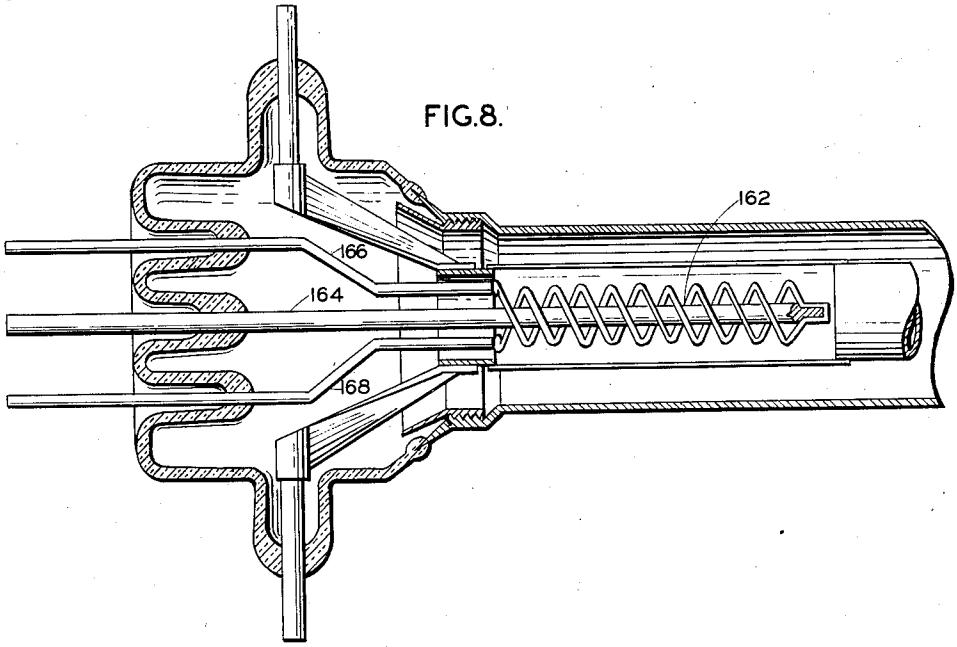


FIG.8.



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OSCILLATOR TUBE

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FIG.9.

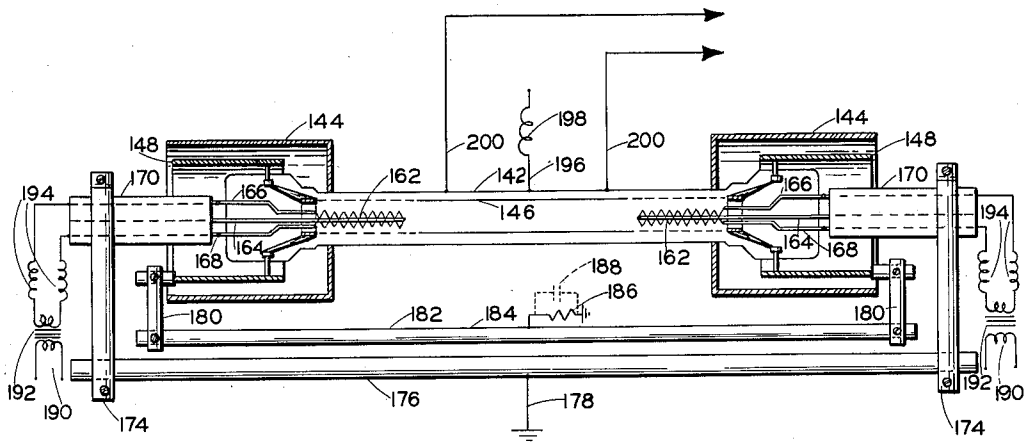


FIG.10.

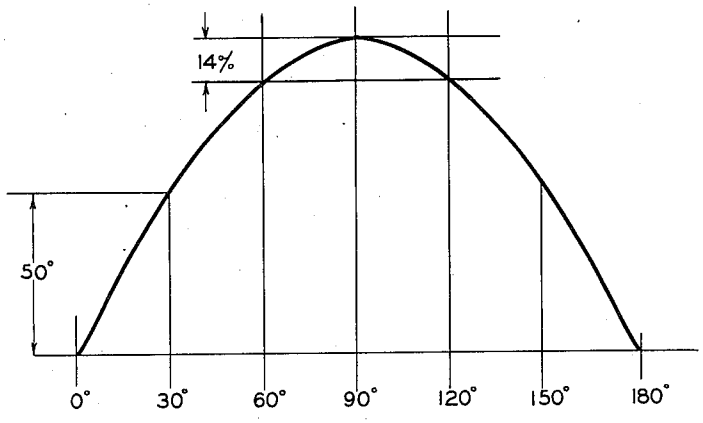


FIG.11.

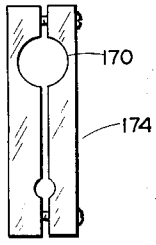
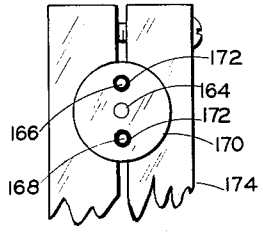


FIG.12.



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Patented June 7, 1949 2,472,088

UNITED STATES PATENT OFFICE

2,472,088

OSCILLATOR TUBE

Clarence A. Boddie, Belmar, N. J.

Application June 18, 1943, Serial No. 491,374

24 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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This 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 very high frequency oscillators.

The primary object of the invention is to generally improve very high frequency oscillators. A more particular object is to improve oscillators in which the anode and grid electrodes are used as a part of a coaxial line of resonant length, such an oscillator being disclosed in my copending application S. N. 491,373, filed June 18, 1943. Still another object is to provide such an oscillator using two sets of tube electrodes operated in push-pull, thereby increasing the power output and providing a symmetrical structure.

Further objects of the invention are to provide a coaxial line which is under vacuum, thereby making possible the use of higher potentials with less spacing between the parts; to provide an oscillator which is compact compared to the use of two separate tubes with external connecting lines; and to provide an oscillator requiring only two glass ends or glass-blowing jobs, instead of four.

To accomplish these objects I connect the two sets of electrodes by means of a coaxial line which forms a major part of the tube envelope, and which is evacuated as a part of the evacuation of the tube.

Other objects of my invention center about the problem of grid-to-cathode capacitance. I have found that in high power tubes operating at very high frequency, the grid-to-cathode capacitance is substantial and requires a relatively heavy charging current which surges back and forth on the coaxial line. Inasmuch as the currents in the coaxial line are anyway heavy and introduce high losses, it is desirable to divert some of this current. With this object in view I provide an external grid circuit which is so tuned as to counteract or series-resonate with the grid-to-cathode capacitance of the electrodes. In another form of my invention, the grid and anode pipes may be extended by means of external grid and anode extensions surrounding the ends of the tube. The length of these may be so proportioned as to locate the potential maximum points at the center of the electrode assemblies. This makes it possible to efficiently use relatively long electrodes, say up to 60° wave length, thereby greatly increasing the power available. Even with such a tube, my invention comprehends the preferable use of an external grid to grid circuit

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which is tunable for maximum efficiency of the oscillator.

Other and more detailed objects of the invention are to hold the cathodes at ground potential; to provide efficient radio frequency coupling to the cathodes for that purpose; and to provide for grid bias supply.

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

The specification is accompanied by a drawing in which

Figure 1 is a schematic diagram explanatory of one form of oscillator embodying features of my invention;

Figure 2 is a longitudinal section drawn to enlarged scale through one end of the oscillator tube used in Figure 1;

Figure 3 is a longitudinal section through a jacket which may be used for cooling the tube;

Figure 4 is a similar section through a modified form of cooling jacket;

Figure 5 is an end elevation of the same;

Figure 6 is a schematic wiring diagram showing external circuits of the coaxial line type;

Figure 7 is a partially schematic, longitudinal section through a modified tube provided with anode and grid pipe extensions;

Figure 8 is a longitudinal section through one end of the tube drawn to enlarged scale;

Figure 9 is a partially schematic longitudinal section through the tube of Figure 7 showing external circuits associated therewith;

Figure 10 is a curve explanatory of a feature of the oscillator shown in Figures 7, 8, and 9;

Figure 11 is an end view of a shorting bar used in Figure 9; and

Figure 12 shows the upper end of the same drawn to enlarged scale.

Referring to the drawing, and more particularly to Figure 1, the oscillator there shown employs a tube comprising two sets of electrodes, namely cathodes 12, grids 14, and anodes 16. The anodes 16 are connected by a pipe 18. In the particular case here illustrated, this pipe forms a continuation of the anodes. The anodes 16, together with the connecting pipe 18, form a major part of the evacuated envelope of the tube. In the example here shown the tube envelope is completed by glass walls 20 closing the ends of the anodes. This constitutes an easy way to provide insulation

for the lead-ins of the tube, as will later appear.

The electrodes in each set are preferably coaxially disposed, and the two sets of electrodes are preferably spaced on a common axis approximately a half-wave apart. The grids 14 are connected by a grid pipe 22, which is coaxially disposed within anode pipe 18. The grid and anode pipes, together with the grids and anodes at their ends, form a resonant coaxial line.

For more detailed consideration of the tube structure, reference is made to Figure 2, in which it will be seen that the anode 16 has an outwardly flared feathered edge 24, which is sealed at 26 to the glass wall 20 of the tube. If desired, the seal 26 may be protected by a metallic shield 28. The grid wires 14 are welded on the outside of appropriate rings 30 and 32. Ring 30 is supported by struts 34 running to lead-ins 36 which are sealed in glass stems 38. In the present case two such supporting lead-ins are shown, but if desired a greater number may be used. Ring 32 at the inner end of the grid is secured to the grid pipe 22 previously referred to.

The cathode in the present case is of the filamentary type, it being supported at one end by a lead-in 40 passing through a reentrant glass stem 42. The other end of the filament is connected to a lead-in 44 passing through stem 46. It will be understood that the tube is symmetrical and that the description so far given for one end of the tube is equally applicable to the other end of the tube.

Reverting to Figure 1, the complete oscillator preferably includes external circuits which are next described. The cathodes 12 are maintained at ground potential by means of connections 50 to grounded plate 52, the electrical length of said connections being adjustable by means of trombones or loops 54, having slidable shorting bars 56. The loops may be laminated, with insulation between the laminations as shown, to take care of the filament heating circuit, but the capacitance between the laminations constitutes a short with respect to radio frequency. In the present case, the filaments are heated from a low frequency A.-C. power line 58, through a transformer 60 connected across the cathode lead-ins, preferably at a radio frequency potential node.

The anodes are supplied with D.-C. potential through a lead 62 connected to the midpoint or potential nodal point of the anode pipe 18. A radio frequency choke 64 may be inserted in this lead. Power is taken from the oscillator on transmission line conductors 66 which are tapped to the anode pipe 18 symmetrically on either side of lead 62.

The grids 14 are biased in the present case by means of grid resistors 68. These may be shunted by condensers 70.

In accordance with a feature of the present invention, the external grid circuit is tuned, and for this purpose adjustable trombones or loops 72 are provided between the grids and their connection to the grounded plate 52. I prefer to tune the grid to ground circuits for several reasons. One is that these circuit will then take at least a part of the charging current required for the grid-to-cathode capacitance, thereby reducing the magnitude of current surging on the grid pipe 22 and so reducing the losses on this pipe. Another reason is that the external tuning of the grid circuit may be used to slightly shift the effective terminal point of the coaxial line. This may be thought of as located at the outer ends of the electrode assemblies, but may be shifted somewhat along the electrode assembly, thereby making possible a small range of frequency adjustment for the oscillator, even though the structure of the oscillator tube itself is fixed. From still another viewpoint, and referring to Figure 2, it may be explained that inasmuch as structural necessity requires supports beyond the grids, specifically, the struts 34 and lead-ins 36, this disadvantage may be overcome by tuning the external grid circuit, and making said supports a part of the resulting tuned circuit.

Figure 3 shows a jacket 74 which may be used to improve the cooling of the tube, thus making it possible to drive the same at a higher power level. A suitable blower may be connected at the inlet 76, and the resulting stream of air is blown outwardly along the tube and discharged at the outlets 78. Constrictions at 80 insure cooling at the anodes, and the air discharged from the outlets 78 helps cool the seals through the glass ends of the tube.

Figures 4 and 5 show a modified cooling jacket of somewhat more elaborate construction. This comprises a tubular body portion 82, and finned end portions 84. The end portions comprise an inner ring 86 dimensioned to fit closely about the metallic anode of the tube with a metal-to-metal contact, and an outer ring 88 connected to the inner ring by radial fins 90 (Figure 5). The entire end portion is preferably split diametrically and provided with screws 92 passing through flanges 94, thus making it possible to readily clamp each of the ends 84 about its respective anode with a tight fit. The tubular body portion 82 is also divided diametrically and provided with flanges 96, which may be drawn together by screws 98. The air inlet 100 is employed much as in the case of Figure 3. The flanges 94 and 96 are shown about 90° apart in Figure 5, but have been turned to a common plane in Figure 4 to clarify the construction.

Figure 6 illustrates the use of external circuits of the coaxial type. These have the advantage of being non-radiating. Specifically, the filaments are connected by coaxial lines 102, 104, and heating current is applied from an ordinary low frequency A.-C. power line 106 through transformer 108 to the line 102, 104. The outer conductor 104 is preferably itself housed within a larger pipe 110, so that the pipes 104, 110 form a coaxial line with the respect to radio frequency currents. The outer pipe 110 is grounded, as for example by the ground connections 112. Annular shorting rings 114 are disposed between pipes 104 and 110 on each side of the transformer 108, and are adjustable for tuning the line. By moving these shorting rings, a position may be found such that the reactance from the midpoint of each cathode to ground point 112 is zero, or what is the same thing, the reactance from cathode to cathode by way of the concentric line is zero. This condition is attained when the electrical distance from cathode to cathode is one or more half wave lengths.

The grids are connected by an external circuit consisting of coaxial pipes 116, 118. Annular shorting rings 120 are disposed between these pipes and are adjustable for tuning the coaxial line. The parts 122 are insulation spacers. Grid bias is applied at the connection 124 and, in the present case, is developed across a grid bias resistor 126, the latter preferably being shunted by either distributed or lumped capacitance indicated in broken lines at 128. The shorting rings 120 are adjusted so that the overall reactance

measured from the end of each grid to the midpoint 124 is inductive and approximately equal to one half the capacitive reactance of grid to anode and grid to cathode in parallel. By this adjustment approximately half the grid to anode and grid to cathode charging current is carried in the grid to grid concentric line 118. This greatly reduces the I^2R losses in the grid wires, a matter of importance at very high frequency, and also relieves the grid to grid pipe of a large part of its otherwise heavy current.

Anode potential is applied as before to the midpoint of the anode pipe, preferably through a choke.

The radio frequency power output from the oscillator may be taken from the anode pipe, as in Figure 1, or, as here illustrated, may be taken from the grid to grid line. For this purpose connections 130 are made to the grid to grid line 116, the said connetions being led to an appropriate coaxial transmission line 132, which extends to the antenna or other apparatus using the power output of the oscillator. A Concentric choke 134, of quarter-wave length, may be employed at the input end of the transmission line.

Figure 7 illustrates a modification of the invention in which the coaxial line is extended beyond the electrodes by means of external pipes surrounding the ends of the tube. Specifically, the anode pipe 142 is extended by external pipes 144, and the grid pipe 146 is extended by external pipes 148. With this arrangement the tuning of the coaxial line may be adjusted with reference to the midpoint of the electrodes, as is indicated by the half-wave arrows running to center lines 150. The charging current needed for the inner ends of the electrodes may be taken care of by the main coaxial line 142, 146, while the charging current needed for the outer ends of the electrodes may be taken care of by the pipe extensions 144, 148.

An advantage of this arrangement may be explained with reference to the curve shown in Figure 10, which represents one-half of a sine wave. The 90-degree point corresponds to the potential maximum at the end of the half-wave coaxial line. In moving from the maximum at 90° for a distance of 30° or to the 120° point, the drop in potential is a matter of only 14 percent of the total potential. Thereafter, the drop is much faster; for example, from zero to 30 the change is 50 percent. If the 90° point is established at the center of the electrode, the drop will be distributed on either side of center and a total electrical length of 60° may be employed, with a drop in potential of only 14 percent. The advantage of the arrangement of Figure 7, then, is that in locating the potential maximum at the center of the electrode, substantial electrode length may be used without introducing appreciable inefficiency. This in turn provides substantial electrode area, making possible high power output. In brief, the electrodes may be made twice as long, while operating with the same potential relationship.

In practice, telescopic pipes 152, 154 may be used on the extensions to facilitate adjustment of the length of the extensions. Here again, some shift in the position of the maximum potential lines 150 of the electrodes is permissible, with a view to obtaining a slight range of frequency adjustment despite the fixed structure of the tube. The anode pipe extensions are secured to the ends of the anode pipe by an appropriate flange or step 154. The grid pipe extensions are secured to the ends of the grid lead-ins 156. It will be understood that while two such grid lead-ins are shown at each end of the tube, a greater number, for example four, may be employed, thus strengthening the support of the grid and grid pipe within the tube, and also the attachment of the grid pipe extension on the outside of the tube.

It will be understood that the curves E and I, used to illustrate the potential and current on the anode pipe, may also be referred to as illustrating the potential and current on the grid pipe, except that the standing wave on the grid pipe swings in opposite phase to that on the anode pipe. The curve representing the current is 90° out of phase from the voltage. The electrodes are therefore at current nodes, and at potential loops or maxima.

Considering the structure in greater detail, and referring more particularly to Figure 8, the cathodes 162 have double filaments and are supported at the midpoint by a center lead-in 164, while the outer ends of the two filaments are respectively connected to lead-ins 166 and 168. All three lead-ins pass through appropriate reentrant glass stems, which for clarity are shown disposed in a common plane but which, in practice, may be located 120 degrees apart on a circle, the lead-ins being appropriately bent for this purpose. The greater spacing facilitates the glass blowing job.

The other parts are similar to those described in connection with Figure 2, including the grid supporting struts, grid lead-ins, and the metallic shields for the metal-to-glass seal of the anode.

Figure 9 illustrates an oscillator using the tube of Figure 7 with appropriate external circuits. All three of the aforementioned lead-ins 164, 166, and 168 pass through metallic bushings 170, but the heater lead-ins 166, 168 are insulated, as indicated at 172 in Figure 12, while center lead-in 164 is in metal-to-metal contact with the bushing.

The filament-to-filament circuit is completed by shorting bars 174 and an auxiliary filament line 176, this being grounded at its midpoint 178. The end portions with the shorting bar may be considered to be trombones. The coupling to the cathodes with respect to radio frequency is efficient, and includes not only the conductive connection to center lead-in 164, but also the capacitive coupling through the heater lead-ins 166, 168.

Another auxiliary circuit is preferably provided for externally tuning the grids. This is done by means of shorting bars 180 and an auxiliary grid line 182, the end portions being in effect trombones. Grid bias is supplied to the grids by means of a midpoint connection 184 in auxiliary grid line 182. In the present case, the grid bias is developed across a grid resistor 186, preferably shunted by distributed or lumped capacitance shown in dotted lines at 188. It will be understood that the shorting bars 180, as well as the shorting bars 174, are all of the adjustable type, as by the use of split bars which may be clamped in position by appropriate clamping screws, or fixed by set screws.

The filaments are heated by using either D.-C. or low frequency A.-C. power, the latter being here indicated by an ordinary power line 190 coupled through transformers 192 to the filament leads. Radio frequency chokes 194 are preferably introduced.

Anode potential is supplied through a lead 196 connected to the midpoint of the anode pipe 142. A radio frequency choke 198 is preferably inserted. Power may be delivered from the oscillator by leads properly spaced on either side of a potential node in one of the circuits. In the present case, leads 200 are shown at opposite sides of anode po-

tential supply lead 196, but it should be understood that power may be taken from the auxiliary cathode line 176, or the auxiliary grid line 182.

It is believed that the construction, and method of use of my improved oscillator, as well as the advantages thereof, will be apparent from the foregoing detailed description. It may be mentioned that although different forms of external circuit have been shown in Figures 1, 6, and 9, these external circuits are not unique to the particular tube. Specifically, the external grid circuit of either Figure 1 or 6 may be used with the tube of Figures 7 and 9, and the external grid circuit of Figure 9 may be used with the tube of Figure 1. Similar remark applies to the external cathode circuits, except for such changes as may be needed to take care of the fact that in the one case there are only two filament lead-ins, and in the other there are three. The coaxial line circuits of Figure 6 have the advantage of being non-radiating.

It will be apparent therefore, that while I have shown and described my invention in several preferred forms, changes and modifications may be made in the structures 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 tube comprising two sets of cathode, grid, and anode electrodes, and a pipe connecting said anodes together, said anodes and pipe forming a part of the evacuated envelope of the tube, hollow glass enclosures respectively sealed to said anodes, a conducting pipe connecting said grids together to form the central member of a coaxial line, and conducting means including glass stems sealed through said enclosures and connected respectively to the grid ends of said coaxial line member to form a support therefor.

2. A very high frequency oscillator tube comprising two sets of cathode, grid and anode electrodes, said sets being spaced approximately a half wave length apart on a common axis, a pipe connecting said anodes together, said anodes and pipe forming a part of the evacuated envelope of the tube, hollow glass enclosures sealed to said anodes, a conducting pipe connecting said grids together to form the central member of a coaxial line, conducting means sealed through each enclosure and connected respectively to the grid ends of said coaxial line member to form a support therefor, and circuit reactance means connecting said grid ends together external to the tube.

3. A very high frequency oscillator tube comprising two sets of cathode, grid and cylindrical anode electrodes, a pipe connecting said grids together, another pipe surrounding said first pipe and connecting said anodes together, said anode pipes forming a resonant coaxial line with the two sets of electrodes, the anode part of said coaxial line forming a part of the envelope of the tube and being evacuated therewith, hollow glass enclosures sealed throughout the periphery of and covering the opposite open ends of said anodes respectively, and grid supporting members including glass stems sealed through the envelope and connected to the end of each grid.

4. A very high frequency oscillator comprising two sets of cathode, anode and grid electrodes, a pipe connecting said grids, another pipe surrounding said first pipe and connecting said anodes, said pipes including the two sets of electrodes and forming a resonant coaxial line, the anode part of said coaxial line forming a part of the envelope of the tube and being evacuated therewith, grid supporting members sealed through the envelope, and external circuits including a grid-to-grid circuit having adjustable trombones tuned to supply the charging current required by the grid supporting members.

5. A very high frequency oscillator tube comprising two sets of cathode, grid, and anode electrodes, said sets being spaced approximately a half wave length apart on a common axis, a pipe connecting said grids together, another pipe surrounding said first pipe and connecting said anodes together, said pipes including the two sets of electrodes forming a resonant coaxial line, said anode pipe forming part of the envelope of the tube and being evacuated therewith, hollow glass cylinders sealed to said anodes, conducting means sealed through said glass cylinders and connected to the grid ends of said coaxial line to form a support therefor, and circuit reactance means connecting said grid ends together external to the tube.

6. A very high frequency oscillator comprising two sets of cathode, anode and grid electrodes, said sets being spaced approximately a half wave length apart on a common axis, a pipe connecting said grids, another pipe surrounding said first pipe connecting said anodes, said pipes including the two sets of electrodes and forming a resonant coaxial line, said anode pipe forming part of the tube envelope and being evacuated therewith, grid supporting members sealed through the envelope, and external circuits including cathode-to-ground circuits having adjustable trombones for tuning purposes, and a grid-to-grid circuit having adjustable trombones, the latter circuit functioning to supply the charging current required by the grid supporting members and also to provide a small range of frequency adjustment.

7. A very high frequency oscillator tube comprising two sets of cathode, grid, and anode electrodes, a pipe connecting the grids together, a coaxially-arranged pipe connecting the anodes together, said anode pipe forming a part of the envelope of the tube and being structurally a continuation of the anodes, glass walls sealing the outer ends of the tube and grid lead-ins including glass stems sealed through the glass side walls and connected to the outer ends of the grids to support the grid-to-grid structure.

8. A very high frequency oscillator comprising two sets of cathode and grid electrodes, a pipe connecting the grids, a coaxially arranged anode pipe including anodes at opposite ends thereof, an envelope completely surrounding the cathode and grid electrodes, said anode pipe forming a part of the envelope, cathode and grid lead-ins for supporting the cathode and grid electrodes respectively, and an external circuit including a grid-to-grid circuit having tuning means adjacent one of said grid lead-ins and tuned to supply the charging current required by such grid lead-in.

9. A very high frequency oscillator tube comprising two sets of cathode, grid, and anode electrodes disposed end to end and spaced approximately a half wave length apart, a pipe connecting the grids together, a coaxially arranged pipe connecting the anodes together, said anode pipe forming part of the envelope of the tube and being structurally a continuation of the anodes, glass walls sealing the outer ends of the tube, grid supporting means connected to the outer

ends of the grid-to-grid structure and sealed through the glass walls at the ends of the tube respectively.

10. A very high frequency oscillator comprising two sets of cathode and grid electrodes disposed end to end and spaced approximately a half wave length apart, a grid pipe connecting the grids, a half wave length pipe coaxial with the grid pipe and including portions at opposite ends thereof constituting anodes, said anode pipe forming a part of the envelope of the tube, glass walls sealing the opposite open ends of the anode pipe, each of said glass walls having stems for cathode and grid lead-ins to support the cathodes and grids, and external circuits including cathode-to-ground circuit having adjustable tuning means and means including a grid-to-grid circuit to supply the charging current required by the grid lead-ins and at least part of the charging current required by the tube electrodes and also to provide a small range of frequency adjustment, said grid-to-grid circuit including adjustable tuning means therein to effect said frequency adjustment.

11. A very high frequency oscillator tube comprising two sets of cathode, grid, and anode electrodes of substantial length, a grid-to-grid pipe connecting said grids together, an anode-to-anode pipe connecting said anodes together, glass walls closing the outer ends of the anodes, cathode lead-ins and grid lead-ins including glass stems sealed through said glass walls, grid pipe extensions carried by the grid lead-ins, and anode pipe extensions coaxial with said grid pipe extensions and connected to the outer ends of the anodes, said grid and anode extensions forming a continuation outside the tube of the coaxial line within the tube.

12. A very high frequency oscillator tube comprising two sets of cathode, grid, and anode electrodes of substantial length, a grid-to-grid pipe connecting said grids together, an anode-to-anode pipe connecting said anodes together and forming an apparent continuation thereof, the distance along the pipes between the midpoints of the electrode assemblies being approximately a half wave of the desired oscillation frequency, glass walls closing the outer ends of the anodes cathode lead-ins and grid lead-ins including glass stems sealed through said glass walls, grid pipe extensions carried by the grid lead-ins, and anode pipe extensions coaxial with said grid pipe extensions and connected to the outer ends of the anodes, the electrical distance from the midpoint of the electrode structures to the outer ends of the extensions being approximately a half wave length of the desired oscillation frequency.

13. A very high frequency oscillator tube comprising two sets of cathode, grid, and anode electrodes of substantial length disposed end-to-end, said sets being spaced approximately a half wave apart, on a common axis, a grid-to-grid pipe connecting said grids together, an anode-to-anode pipe connecting said anodes together and forming an apparent continuation thereof, glass walls closing the outer ends of the anodes, cathode lead-ins and grid lead-ins including glass stems sealed through said glass walls, grid pipe extensions carried by the grid lead-ins, and anode pipe extensions coaxial with said grid pipe extensions and connected to the outer ends of the anodes, said grid and anode extensions forming a continuation outside the tube of the coaxial line within the tube.

14. A very high frequency oscillator comprising two sets of cathode, anode and grid electrodes of substantial length disposed end to end, said sets being spaced approximately a half wave length apart on a common axis, a grid-to-grid pipe connecting said grids, an anode-to-anode pipe connecting said anodes and forming a continuation thereof, glass walls closing the opposite open ends of the anodes and including stems for cathode and grid lead-ins, grid pipe extensions carried by the grid lead-ins, and anode pipe extensions coaxial with said grid pipe extensions and connected to the outer ends of the anodes, and external circuits, said circuits including cathode-to-ground connections, and a grid-to-grid circuit having adjustable tuning means for tuning the same.

15. A very high frequency oscillator comprising an oscillator tube as defined in claim 13, and external circuits, said circuits including an auxiliary cathode to cathode line having a ground connection, with adjustable shorting bars between the cathode lead-in and said auxiliary cathode line for tuning the cathode-to-ground connections, an auxiliary grid line with adjustable shorting bars between the grid pipe extensions and said auxiliary grid line for tuning the external grid-to-grid circuit, a grid bias connection to said auxiliary grid line, and an anode potential connection to the anode pipe.

16. A very high frequency oscillator tube comprising two sets of cathode, grid, and anode electrodes of substantial length disposed end-to-end on a common axis, a grid-to-grid pipe connecting said grids together, an anode-to-anode pipe connecting said anodes together, the distance between the midpoints of the electrode assemblies being approximately a half wave of the desired oscillation frequency, glass walls closing the outer ends of the anodes cathode lead-ins and grid lead-ins including glass stems sealed through said glass walls, grid pipe extensions carried by the grid lead-ins, and anode pipe extensions coaxial with said grid pipe extensions and connected to the outer ends of the anodes, the electrical distance from the midpoint of the electrode structures to the outer ends of the extensions being approximately a half wave length of the desired oscillation frequency.

17. A very high frequency oscillator comprising an oscillator tube as defined in claim 16, and external circuits, said circuits including an auxiliary cathode to cathode line having its midpoint grounded, with adjustable shorting bars between the cathode lead-ins and said auxiliary cathode line for tuning the cathode-to-ground connections, an auxiliary grid to grid line with adjustable shorting bars between the grid pipe extensions and said auxiliary grid line for tuning the external grid-to-grid circuit, a grid bias resistor between said auxiliary grid line and ground, and an anode potential connection to a nodal point on the anode pipe.

18. A very high frequency oscillator comprising an oscillator tube as defined in claim 3, and external circuits including a coaxial line connected from grid lead-in to grid lead-in and provided with shorting bars for tuning the same, and a grid bias connection to said coaxial line between said shorting bars.

19. A very high frequency oscillator comprising an oscillator tube as defined in claim 5, and external circuits including a coaxial line connected from grid lead-in to grid lead-in and provided with shorting bars for tuning the same, a grid bias connection to said coaxial line between

said shorting bars, and a three-pipe coaxial line connected between the cathode lead-ins, the outermost pipe being grounded, shorting bars between the outermost pipe and the intermediate pipe, the intermediate pipe and the center conductor being used for heating current for the cathodes, said heating current being supplied thereto at a point between said shorting bars.

20. A very high frequency oscillator comprising an oscillator tube as defined in claim 7, and external circuits including a coaxial line connected from grid lead-in to grid lead-in and provided with shorting bars for tuning the same, and a grid bias connection to said coaxial line between said shorting bars.

21. A very high frequency oscillator comprising an oscillator tube as defined in claim 9, and external circuits including a coaxial line connected from grid lead-in to grid lead-in and provided with shorting bars for tuning the same, a grid bias connection to said coaxial line between said shorting bars, and a three-pipe coaxial line connected between the cathode lead-ins, the outermost pipe being grounded, shorting bars between the outermost pipe and the intermediate pipe, the intermediate pipe and the center conductor being used for heating current for the cathodes, said heating current being supplied thereto at a point between said shorting bars.

22. A very high frequency oscillator comprising first and second parallel closely spaced conductors, opposite ends of the first conductors including means constituting grids, opposite ends of the second conductors including means constituting anodes, two cathodes respectively positioned near said grids and on the opposite ends thereof from the anodes, enclosure means for maintaining the cathode-anode electron paths evacuated and air tight, supporting means for the first conductor comprising third and fourth conductors passing through said enclosure means and connected to and supporting opposite ends respectively of the first conductor, a grid-to-grid current path external to the enclosure including tuning means therein for varying the frequency of the oscillator, said grid-to-grid current path being connected between the outer ends of the third and fourth conductors, a conductor for connecting the cathodes together, and a source of high potential direct current impressed between the cathodes and said second conductor.

23. A very high frequency oscillator comprising first and second closely spaced parallel conductors, opposite ends of the first conductor including means constituting grids, opposite ends of the second conductor including means constituting anodes, two cathodes respectively positioned near said grids and on the opposite sides thereof from the anodes, enclosure means for maintaining the cathode-anode electron paths evacuated and air tight, supporting means for the first conductor comprising third and fourth conductors passing through said enclosure means and respectively supporting opposite ends of the first conductor, a grid-to-grid current path external to the enclosure and connected between outer ends of the third and fourth conductors and including a reactor therein for supplying the charging current required by said supporting means, and a source of high voltage direct current impressed between the cathode and said second conductor.

24. A very high frequency oscillator comprising first and second closely spaced parallel conductors, opposite ends of the first conductor including means constituting grids, opposite ends of the second conductor including means constituting anodes, two cathodes respectively positioned near said grids and on opposite sides thereof from the anodes, enclosure means for maintaining the cathode-anode electron paths evacuated and air tight, supporting means for the first conductor comprising an extension at each end of said first conductor passing through the enclosure means, variable length conductors external to the enclosure and connected respectively to the outer ends of said extensions for tuning the oscillator, a grid-to-grid current path connected between the grids, and a source of high potential direct current impressed between the cathode circuit and the anodes.

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