

March 10, 1964

W. P. STEARNS

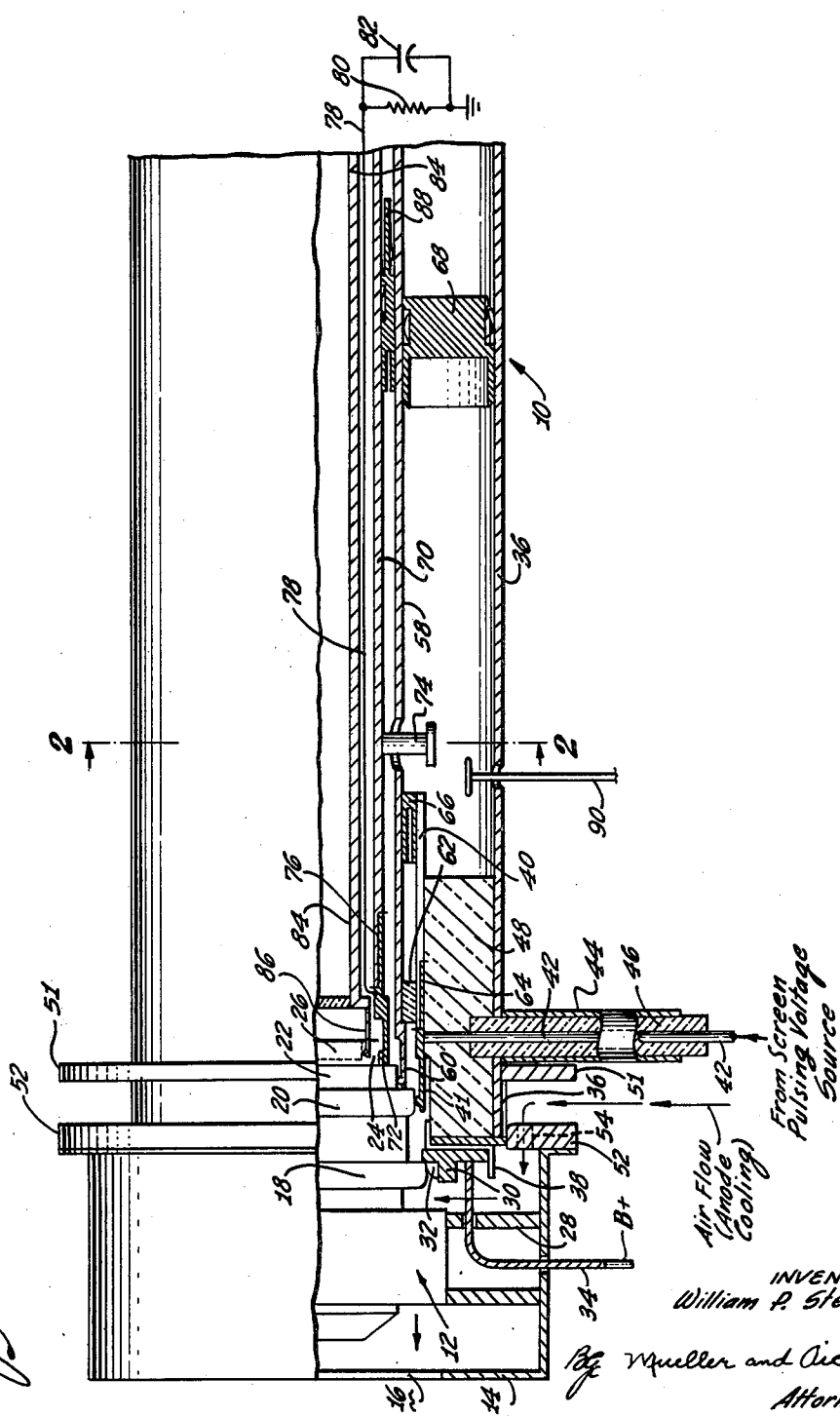
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COAXIAL RESONATOR OSCILLATOR

Filed Oct. 4, 1960

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Fig. 1



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Fig. 2

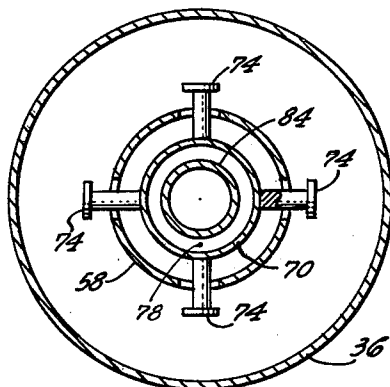
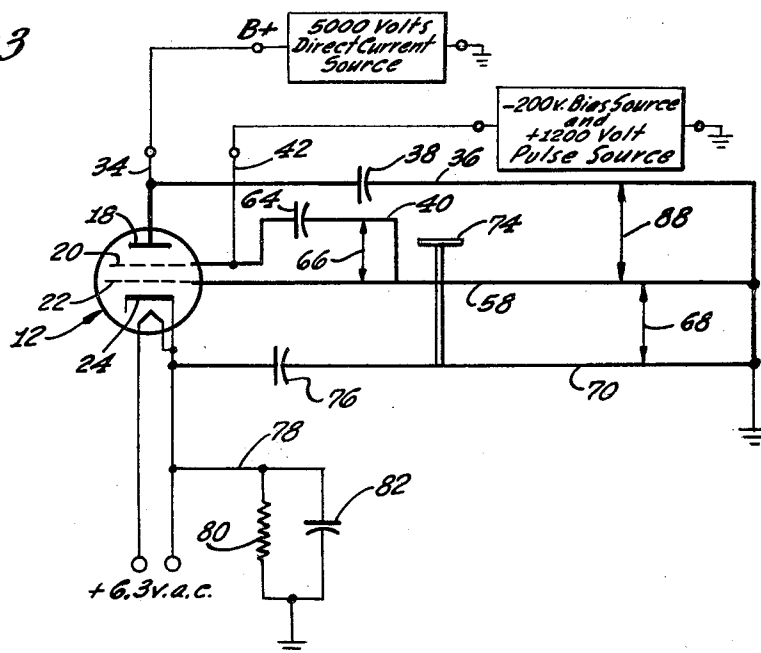


Fig. 3



INVENTOR:
William P. Stearns

By Mueller and Aichele
Attorneys

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COAXIAL RESONATOR OSCILLATOR

William P. Stearns, Scottsdale, Ariz., assignor to Motorola, Inc., Chicago, Ill., a corporation of Illinois

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The present invention relates to ultra high frequency oscillators, and it is more particularly directed to a coaxial resonator structure for use with an ultra high frequency tetrode vacuum tube.

The ultra high frequency tetrode resonator structure of the present invention is of the same general type as disclosed and claimed in copending application Serial No. 657,625 filed May 7, 1957, in the name of Joseph E. Handler, assigned to the present assignee, and entitled "Electron-Coupled Ultra High Frequency Coaxial Transmitter," now Patent No. 2,958,050. However, the oscillator structure of the present invention does not utilize electron coupling as is used in the assembly of the copending application, as will become evident as the description proceeds.

Vacuum tubes have been constructed for microwave applications by designing them so that they can be incorporated into and form a part of a resonant cavity structure. One type of vacuum tube of this general class includes disc-like electrodes spaced from one another along the longitudinal axis of the tube and disposed in parallel relationship with respect to one another. This type of vacuum tube is particularly adapted for use with coaxial resonators. For oscillation purposes, the vacuum tube may be used in conjunction with coaxial cathode-grid and grid-anode resonators, with appropriate feedback means being provided between the resonators.

The coaxial resonator structure of the present invention is conceived for use with a vacuum tube of the ultra high frequency tetrode type. An ultra high frequency tetrode has recently been developed by the Radio Corporation of America and designated by them as Type RCA A2585. The A2585 tetrode is a beam power type with a rating of 64 kilowatts peak power and 600 watts plate dissipation. The resonator structure of the present invention is particularly suited for use with the A2585 tetrode. The resonator structure of the invention, however, is applicable to a wide range of high power ultra high frequency beam tetrodes currently being manufactured or under development by many tube manufacturers. This will become evident as the present description proceeds. The resonator structure to be described is of the folded coaxial type with internal feedback. This construction renders the resulting assembly particularly suited for use as a microwave oscillator.

It is, accordingly, an important object of the present invention to provide an improved, exceptionally compact coaxial resonator structure of the folded coaxial type, having internal feedback, and which is particularly suited for use with an ultra high frequency tetrode to form a microwave oscillator.

A more general object of the invention is to provide such an ultra high frequency, improved, folded coaxial tetrode oscillator resonator structure with internal feedback and which does not require re-entrant resonators.

Another object of the invention is to provide such an improved, ultra high frequency, compact and lightweight coaxial oscillator resonator structure which is capable of operating at high peak power.

Yet another object of the invention is to provide such an improved ultra high frequency oscillator resonator structure which enables an ultra high frequency oscillator to be constructed which may be controlled and pulsed by a relatively low power modulator driving means

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as compared with the prior art systems, so that the modulator driving means may be relatively small in size and may incorporate a minimum of modulator components.

A still further object of the invention is to provide such an improved oscillator resonator structure which enables an oscillator to be constructed which may be tuned over to a relatively broad tuning range by a relatively simple tuning means.

Another object of the invention is to provide such an improved resonator structure which is conceived and constructed so that the associated vacuum tube may be easily removed for replacement purposes.

A feature of the invention is the provision of a coaxial resonator assembly including a low impedance screen-grid resonator which permits tuning over a broad tuning range by means of a relatively simple tuning system.

Another feature of the invention is the provision of a dielectric transformer exhibiting negligible dielectric losses in the coaxial resonator assembly for causing the assembly to operate in the proper mode for best efficiency.

Another feature of the invention is the additional use of the dielectric transformer to shorten the required length of the screen-anode resonator of the assembly, and also to provide an improved impedance match between the electrodes of the vacuum tube and the corresponding resonator of the resonator assembly.

A still further feature of the invention is the provision of an improved tetrode oscillator resonator structure which provides simplified tuning over a broad tuning range because only the screen-anode and grid-cathode resonators need to be tuned; the screen-grid resonator being constructed with a low impedance, such that it has a low quality factor "Q" so as to exhibit relatively broad band characteristics for tuning purposes.

Yet another feature of the invention is the provision of a structure which results in a straight tetrode oscillator, rather than an electron-coupled type, for higher operating efficiency. The tetrode oscillator of the present invention provides for feedback directly from the screen-anode cavity resonator to the grid-cathode cavity resonator; whereas the electron-coupled oscillator depends upon feedback between the screen-grid resonator and the grid-cathode resonator to provide feedback for the oscillator, and the electron-coupled oscillator depends upon the electron stream between the screen and anode electrodes of the vacuum tube to provide coupling for the high frequency energy from the screen-grid to the screen-anode resonators.

Reference is now made to the accompanying drawings for a detailed explanation of the present invention.

In the drawings:

FIGURE 1 is a longitudinal sectional view of one embodiment of the improved cavity resonator assembly of the invention;

FIGURE 2 is a cross-sectional view of the assembly, taken substantially on the line 2—2 of FIGURE 1; and

FIGURE 3 is a schematic representation of a tetrode oscillator system including the improved coaxial cavity resonator structure of the present invention.

The oscillator including the improved coaxial cavity resonator structure of the present invention may include an ultra high frequency tetrode, as mentioned above, and it may be basically a grounded grid oscillator with a cathode drive. The oscillator may be screen pulsed, as noted above; a bias voltage being applied to the screen electrode of the tetrode to cut off the tetrode between screen pulses. Three-quarter wave mode operation may be realized in the grid-cathode and screen-anode resonators by use of a quarter-wave dielectric transformer, as mentioned above, the transformer

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being positioned in the screen-anode resonator. The screen-grid resonator operates in the half-wave mode in a manner to permit a very low impedance between the control grid and screen electrodes of the tetrode so as to achieve the desired tetrode operation.

As illustrated in FIGURES 1 and 2, the improved cavity resonator 10 of the invention is intended to be used with an ultra high frequency tetrode 12, such as an RCA tetrode of the type presently designated A2585, referred to above. The tetrode 12 is positioned at one end of the resonator structure within a plate cap shield 14, to be readily accessible through an opening 16 in the shield.

The tetrode 12 includes a plurality of parallel electrodes which are spaced along its longitudinal axis, and these electrodes have annular peripheral surfaces for receiving respective external electric connectors. As illustrated, the tetrode 12 includes an anode 18, a screen electrode 20, a control grid 22, a cathode 24 and a heater 26. The tetrode 12 is resiliently supported in the end of the resonator structure, and it can easily be removed for replacement purposes.

When the tetrode 12 is in place, the annular peripheral connecting surface of its anode engages a shoulder in an electrically conductive annular member 30. This shoulder has a ring-shaped electric contact 32 positioned against it, and this electric contact makes connection with the anode contact surface. The annular member 30 is connected to the positive terminal B+ of a source of direct current exciting potential. The potential of the source may have a value, for example, of 5,000 volts. This latter connection is made by means of a connecting bus 34. The bus 34 extends through a quarter-wave radio frequency choke structure in the shield 14, and it provides a direct current exciting potential to the anode of the tetrode 12.

The annular member 30 is mounted on the end of the outer cylindrical wall 36 of the screen-anode resonator cylinder in the resonator assembly. The cylindrical wall 36 is composed of conductive material, and the annular member 30 is mounted in insulating relationship with the wall 36 by means of a dielectric member 38. The resulting assembly forms a blocking capacitor between the peripheral anode contact of the tetrode 12 and the cylindrical wall.

The screen-grid resonator cylinder of the resonator assembly is positioned coaxially with the screen-anode resonator cylinder, and the screen-grid resonator cylinder has an outer cylindrical wall 40 of conductive material. The forward end of the wall 40 forms an annular contact ring 41 for receiving the annular peripheral contact surface of the screen electrode 20 of the tetrode 12. A connecting bus 42 extends radially through a tube 44 and through the screen-anode resonator cylinder into electric contact with the wall 40 of the screen-grid resonator to connect the screen electrode of the tetrode 12 to a source of screen pulsing signals. An elongated dielectric member 46 surrounds the bus 42 in the tube 44 to form a quarter-wave length screen choke.

A cylinder of dielectric material, such as Teflon, is positioned in the screen-anode resonator cylinder between the wall 36 and 40. This cylinder is a quarter-wave length long at the center of the desired frequency band, and it forms a quarter-wave length dielectric transformer 48. As shown in FIGURE 1, the bus 42 extends through the transformer 48. The dielectric transformer 48 is located contiguous the peripheral electrode contacts of the tetrode 12 to provide a radio frequency impedance match between the screen-anode resonator impedance and the internal screen-anode coaxial line impedance of the tetrode. This provides for efficient power transfer at ultra high frequencies from the tetrode screen-anode coaxial line to the screen-anode resonator.

A disc-like member 51 is mounted on the wall 36 adjacent the tube 44, and a second disc-like member 52 is

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spaced from the member 50. The latter disc-like member supports the cover 14, and it includes a series of openings, such as the opening 54. These openings permit streams of cooling air to pass into the interior of the cover 14 and out through the opening 16 of the cover. These air streams provide for cooling of the anode of the tetrode 12.

The grid-cathode cylinder of the resonator assembly is positioned coaxially within the screen-grid cylinder, and the grid-cathode cylinder has a cylindrical wall 58 of conductive material. The forward end of the wall 58 forms an annular contact 60 for receiving the peripheral contact surface of the control grid 22 of the tetrode 12. An annular insulating member 62 is mounted between the walls 58 and 40.

A screen-blocking capacitor 64 is formed in the wall 40 of the screen-grid resonator, this capacitor having a capacity of, for example, 60 micro-microfarads. A cylindrical-shaped slidable tuning member 66 is positioned in the screen-grid resonator cylinder between the walls 40 and 58. The tuning member 66 is slidable in the screen-grid cylinder to adjust the effective length of the cylinder for tuning purposes. A similar annular slidable tuning member 68 is mounted in the screen-anode resonator between the walls 58 and 36. The latter tuning member is slidable to adjust the effective length of the screen-anode resonator so as to constitute the screen-anode tuner. It will be noted that the wall 40 of the screen-grid cylinder extends only a portion of the length of the assembly.

A cathode cylinder is formed coaxially within the grid-cathode cylinder, and the cathode cylinder has a cylindrical wall 70 of conductive material. The forward end 72 of the cylindrical wall 70 forms an annular contact for engagement with the peripheral contacting surface of the cathode 24 of the tetrode 12.

A group of four radially-extending capacitive feedback probes 74 (FIGURE 2) are mounted on the wall 70 of the cathode cylinder at equi-angular positions, and these probes extend radially from the grid-cathode resonator through corresponding openings in the wall 58 into the screen-anode resonator cylinder. A cathode direct current blocking capacitor 76 is formed in the wall 70 of the cathode resonator, and this capacitor has a capacity, for example, of 70 micro-microfarads.

A lead 78 is connected to the forward end 72 of the wall 70, and this lead extends back through the cathode cylinder. The right hand end of the lead 78 is connected to a grounded resistor 80, this resistor being shunted by a capacitor 82.

The heater cylinder of the resonator assembly is positioned coaxially with the cathode cylinder, and the heater cylinder has a wall 84 of conductive material. The forward end 86 of the wall 84 forms a ring contact for engagement with the annular peripheral contact surface of the heater electrode 26 of the tetrode 12.

A slidable tuning member 88 is positioned in the grid-cathode resonator cylinder between the walls 58 and 70, and this slidable member serves to change the effective length of the grid-cathode resonator. A capacitive output probe 90 may extend into the screen-anode resonator assembly.

The schematic diagram of the oscillator formed by the resonator assembly of the invention is shown in FIGURE 3. As shown in FIGURE 3, the lead 34 connects the anode of the tetrode 12 to the positive terminal B+ of a 5,000 volt direct voltage source, the negative terminal of the source being grounded. The lead 42 connects the screen electrode of the tetrode 12 to a 12,000 volt pulsing source, the source exhibiting a -200 volt bias between successive pulses. As also shown in FIGURE 3, the screen-anode resonator is capacitively coupled to the grid-cathode resonator by the probe 74. The direct current blocking capacitors 38, 64 and 76 are interposed in the respective anode, screen and cathode circuits. The right hand end of the resonator assembly is grounded. The

heater electrodes of the tetrode are energized by a 6.3 volt alternating current source.

The resonator assembly of FIGURES 1, 2 and 3 is intended to operate with the screen-anode and grid-cathode resonators functioning in the three-quarter wave coaxial mode, and with the screen-grid resonator operating in the half-wave coaxial mode. As noted above, the oscillator of FIGURE 3 is basically a grounded grid oscillator, with cathode drive feedback.

The resonator structure of the invention provides three coaxial resonators, namely: a screen-anode resonator, a grid-screen resonator, a grid-cathode resonator. As noted, the screen-anode and grid-cathode resonators operate in the three-quarter wave coaxial mode, and the grid-screen resonator operates in the half-wave mode. The outer wall 58 of the grid-cathode resonator forms the inner wall of the screen-anode resonator for a portion of its length. This permits the feedback probes 74 from the screen-anode resonator to the grid-cathode resonator to provide electric field feedback through the common wall between the screen-anode and grid-cathode resonators.

The capacitive probes 74 provide a completely internal feedback structure within the resonator assembly. The capacitive feedback probes 74 provide feedback between the screen-anode coaxial resonator and the grid-cathode coaxial resonator. The feedback assembly does not interfere in any way with the electrical operation of the screen-grid resonator. This results in straight tetrode oscillator characteristics of high efficiency and constant power output under varying anode potentials. The disclosed feedback assembly provides an exceptionally compact resonator structure for oscillator purposes.

The coaxial line quarter-wave mode dielectric transformer 48 in the screen-anode resonator suppresses the quarter-wave, or fundamental, coaxial mode. This enables the screen-anode resonator to operate in the three-quarter wave coaxial mode. This results in sufficient resonator line length being provided with practical dimensions to operate the oscillator with the desired high quality factor "Q." The screen-grid resonator structure is constructed to operate in the half-wave coaxial mode, as noted, this resonator has low characteristic impedance, and it is sufficiently short physically to enable the feedback probes 74 to provide feedback between the screen-anode and grid-cathode resonators around the screen-grid resonator and completely within the resonator structure.

It should be noted that for amplifying, rather than oscillation, purposes the feedback probes 74 can be removed and replaced by a proper grid-cathode input signal. This provides a tetrode amplifier having a compact structure and a high quality factor "Q" screen-anode output resonator by virtue of a short grid-screen resonator. The result is a high performance, ultra high frequency amplifier structure.

The compact oscillator assembly described above, therefore, is a screen pulse-modulated oscillator, and it utilizes a beam power tetrode. The resonators are of the folded coaxial type, they all extend in the same direction, and they incorporate a completely internal probe type feedback structure including the probes 74. The oscillator operates, as noted, in the half-wave and three-quarter wave mode. It has peak power capabilities of the order of 20-25 kilowatts, for example, and it permits a 98 percent reduction in normal modulator power requirements as compared with the prior art systems of this general type.

The use of the quarter-wave transformer 48 has the effect of injecting a resonator mismatch in the screen-anode resonator at the undesired frequency mode. This transformer causes the screen-anode resonator to operate at the three-quarter frequency mode. The quarter-wave transformer also serves, as noted, for impedance matching the inter-electrode tube impedances with the resonator

impedances. The transformer additionally serves to shorten the required length of the screen-anode resonator.

The screen-grid resonator was constructed to operate in the half-wave coaxial mode for the purpose of providing a low radio frequency impedance between the screen and control grids of the tetrode 12. Since the screen-anode and grid-cathode resonators are both three-quarter wave mode resonators, the quarter-wave dielectric transformer 48 is used, as mentioned above, for mode suppression and also to shorten the required screen-anode resonator length. Space considerations made it necessary to limit the maximum frequency mode to the three-quarter wave mode. High inter-electrode capacitances of the tetrode 12 made operation in the fundamental, or quarter-wave mode, impractical. The resonator requirements were such that the three-quarter wave mode operation is satisfactory for the screen-anode and for the grid-cathode resonators.

As noted above, in the illustrated oscillator circuit, cathode bias and cathode drive are used in conjunction with a grounded-grid basic oscillator circuit. Since the oscillator is basically a grounded-grid type with cathode drive, a phase reversal of 180° is required between the screen-anode resonator and the grid-cathode resonator. This is accomplished by the capacitive probes 74 of FIGURE 2. These capacitive probes provide the necessary 180° phase reversal between the screen-anode and grid-cathode resonators. The probes 74 are placed at the approximate position of voltage maximum, or maximum standing wave electric field, within the resonators to provide for optimum amplitude of feedback. For this particular oscillator, only voltage, or probe type feedback is practical due to the physical interference of the screen-grid resonator.

The output probe 90 is provided in the screen-anode resonator, or a loop can be used if so desired. If a probe is used, it is located at the approximate maximum amplitude position of a voltage standing wave. On the other hand, if a loop is used, it is located at the approximate position of minimum amplitude of a voltage standing wave and current maximum. The depth of penetration of the probe, or the area and orientation of the loop, will determine the degree of coupling and hence the impedance match between the resonator and the output line.

The screen of the tetrode 12 is used to bias the tetrode beyond cut-off by use of a -200 volt bias on the screen between pulses. As noted, screen pulsing of the oscillator tetrode results in a considerable saving in modulated power. Input power to the screen is about 1.5 kilowatts peak with about .3 kilowatt peak dissipated in the anode of the modulator tube. A comparable hard tube plate modulator would require 70 kilowatts of input power to the oscillator, with approximately 20 kilowatts dissipated in the modulator. This low level screen modulation also results in excellent pulse shape characteristics from the oscillator of FIGURE 3. Rise times of the order of .06-.08 microsecond can be realized, and fall times of the order of .10-.15 microsecond for .5 microsecond pulses can also be realized.

Oscillators and amplifiers utilizing the techniques and concepts of the present invention are exceptionally compact and light weight, and such instrumentalities have a wide range of utility, especially where minimum weight is important and where space is at a premium. The oscillator and amplifier embodying the concepts of the invention are especially suited for high speed digital data transmitting systems, and for many other applications.

In a constructed embodiment of the invention, the resulting package was exceedingly compact. The total length of the oscillator was 12½ inches, including the tuning members and mounting structure. The outer diameter of the screen-anode resonator was 3 inches, with tuning components and the mounting structure increasing the maximum to about 4 inches.

The three-quarter wave mode operation of the screen-

anode and grid-cathode resonators has enabled satisfactory operation to be achieved, for the particular embodiment of the invention illustrated and described herein, from 980-1225 megacycles. By modifications in the screen-grid resonator length, in the length of the dielectric transformer 48, and in the position of the feedback probes 74, lower or higher oscillating frequencies may be realized.

The invention provides, therefore, an ultra high frequency resonator structure which is compatible with ultra high frequency beam power tetrodes having a relatively large interelectrode capacitances. The improved ultra high frequency resonator assembly of the invention is tunable over a relatively broad band width. The oscillator described herein has high peak power capabilities of the order of 15 kilowatts, for example, and greater. The oscillator also may have a relatively long duty cycle for a relatively high average power output. Moreover, the oscillator operates in other than the fundamental mode of operation; such as in the three-quarter wave mode, thereby overcoming the low quality factors (Q) and insufficient resonator lengths normally associated with coaxial resonators for beam power tubes having high inter-electrode capacitances.

What is claimed is:

1. A resonator structure for use with an ultra high frequency vacuum tube which has annular cathode, grid, screen and anode contact surfaces all spaced along an axis thereof, said resonator structure including in combination: a plurality of hollow cylindrical conductive members coaxially positioned with respect to one another and positioned to receive the vacuum tube at a first end thereof in coaxial relationship therewith and to establish respective electrical contacts with said annular contact surfaces thereof; said hollow cylindrical members respectively forming a screen-anode resonator, a screen-grid resonator and a grid-cathode resonator; the one of said hollow cylindrical conductive members forming said screen-grid resonator extending from said first end of said plurality of conductive members along a part only of the length of the others of said conductive members; and a plurality of angularly positioned feedback probes mounted on a second of said cylindrical members and axially spaced from said first end of said plurality beyond the second end of said one of said cylindrical members and extending radially from said grid-cathode resonator into said screen-anode resonator to provide feedback between said screen-anode resonator and said grid-cathode resonator.

2. A resonator structure for use with the ultra high frequency vacuum tube which has cathode, grid, screen and anode contact surfaces all spaced along an axis thereof, said resonator structure including in combination: a plurality of hollow cylindrical conductive members coaxially positioned with respect to one another and positioned to receive the vacuum tube at a first end thereof in coaxial relationship with said axis of the tube and to establish respective electrical contacts with said contact surfaces thereof; said hollow cylindrical members respectively forming a screen-anode resonator to operate in the three-quarter wave coaxial mode, a screen-grid resonator to operate in the half-wave coaxial mode and a grid-cathode resonator to operate in the three-quarter wave coaxial mode; and dielectric means positioned in at least one of said resonators for causing such resonator to operate in a mode other than its fundamental quarter-wave mode.

3. A resonator structure for use with an ultra high frequency vacuum tube which has annular cathode, grid, screen and anode contact surfaces all spaced along an axis thereof, said resonator structure including in combination: a plurality of hollow cylindrical conductive members coaxially positioned with respect to one another and positioned to receive the vacuum tube at a first end thereof in coaxial relationship with said axis of the tube and to establish respective electrical contacts with said

annular contact surfaces thereof; said hollow cylindrical members respectively forming a screen-anode resonator adapted to resonate at odd multiples of the quarter-wave coaxial mode, a screen-grid resonator adapted to resonate at even multiples of the quarter-wave coaxial mode and a grid-cathode resonator adapted to resonate at odd multiples of the quarter-wave coaxial mode; feedback means positioned internally to said hollow cylindrical conductor members for providing feedback between said screen-anode resonator and said grid-cathode resonator, and means positioned in said screen-anode resonator for causing said screen-anode resonator to operate in the three-quarter wave coaxial mode.

4. A resonator structure for use with an ultra high frequency vacuum tube which has annular cathode, grid, screen and anode contact surfaces all spaced along an axis thereof, said resonator structure including in combination: a plurality of hollow cylindrical conductive members coaxially positioned with respect to one another and positioned to receive the vacuum tube at a first end thereof in coaxial relationship with said axis of the tube and to establish respective electrical contacts with said contacting surfaces thereof; said hollow cylindrical members respectively forming a screen-anode resonator, a screen-grid resonator and a grid-cathode resonator; internal feedback means for providing feedback between said screen-anode resonator and said grid-cathode resonator, and a quarter-wave dielectric transformer positioned in said screen-anode resonator for the suppression of the quarter-wave coaxial mode and for providing proper relationship between said screen-anode and said grid-cathode resonators to enable the screen-anode resonator to operate in the three-quarter wave coaxial mode.

5. The combination defined in claim 4 in which said dielectric transformer is positioned in said screen-anode resonator adjacent said first end of said plurality of cylindrical members additionally to provide impedance matching between the inter-electrode impedances of the vacuum tube and the impedances of the resonator structure.

6. A resonator structure for use with an ultra high frequency vacuum tube of the tetrode type; which tube has annular cathode, grid, screen and anode terminals all spaced along an axis thereof, said resonator structure including in combination: a plurality of hollow cylindrical conductive members coaxially positioned with respect to one another and positioned to receive the vacuum tube at a first end thereof in coaxial relationship with said axis of the tube and to establish respective electrical contacts with said annular terminals thereof; said hollow cylindrical members respectively forming a screen-anode resonator, a screen-grid resonator and a grid-cathode resonator; said screen-grid resonator being constructed to operate in the half-wave coaxial mode, and said screen-grid resonator extending from said first end of said plurality of conductive members a distance less than said screen-anode and grid-cathode resonators, and capacitive feedback means extending between said screen-anode and grid-cathode resonators at a position axially displaced beyond the second end of said screen-grid resonator.

7. A coaxial resonator structure for use with an ultra high frequency vacuum tube of the tetrode type, and which has an annular cathode terminal, an annular grid terminal, an annular screen terminal and an annular anode terminal all spaced along an axis of the tube, said resonator structure including in combination: a first hollow cylindrical conductive member having a first end for receiving the annular anode terminal of the tube in coaxial relationship with said axis thereof and for reestablishing electrical contact with said annular anode terminal; a second hollow cylindrical conductive member positioned coaxially within said first cylindrical member and having a first end for receiving the annular screen terminal of the tube and for establishing electrical contact therewith; a third hollow cylindrical conductive member

positioned coaxially within said second cylindrical member and having a first end for receiving the annular grid terminal of the tube and for establishing electrical contact therewith; a fourth hollow cylindrical conductive member positioned coaxially within said third cylindrical member and having a first end for receiving the annular cathode terminal of the tube for establishing electrical contact therewith; said cylindrical members respectively forming screen-anode, screen-grid and grid-cathode resonators; said screen-anode and grid-cathode resonators being constructed to operate in the three-quarter wave coaxial mode, and said screen-grid resonator being constructed to operate in the half-wave coaxial mode; and a plurality of angularly positioned probes mounted on said fourth cylindrical member and axially spaced from said first end of said cylindrical members beyond the second end of said second cylindrical member, and extending radially from said fourth member to provide feedback coupling between said screen-anode resonator and said grid-cathode resonator.

8. A coaxial resonator structure for use with an ultra high frequency vacuum tube of the tetrode type, and which has an annular cathode terminal, an annular grid terminal, an annular screen terminal and an annular anode terminal all spaced along an axis of the tube, said resonator structure including in combination: a first hollow cylindrical conductive member having a first end for receiving the annular anode terminal of the tube in coaxial relationship with said axis thereof and for establishing electrical contact with said annular anode terminal; a second hollow cylindrical conductive member positioned coaxially within said first cylindrical member and having a first end for receiving the annular screen terminal of the tube and for establishing electrical contact therewith; a third hollow cylindrical conductive member positioned coaxially within said second cylindrical member and having a first end for receiving the annular grid terminal of the tube and for establishing electrical contact therewith; a fourth hollow cylindrical conductive member positioned coaxially within said third cylindrical member and having a first end for receiving the annular cathode terminal of the tube for establishing electrical contact therewith; said cylindrical members respectively forming screen-anode, screen-grid and grid-cathode resonators,

said screen-grid resonator constructed to resonate in the half-wave coaxial mode; a quarter-wave dielectric transformer means positioned in said screen-anode resonator for causing said screen-anode resonator to operate in the three-quarter wave coaxial mode; and a plurality of angularly positioned coupling probes mounted on said fourth cylindrical member and axially spaced from said first end of said cylindrical members beyond the second end of said second cylindrical member, with said probes insulated from and extending through said third cylindrical member to provide feedback between said screen-anode resonator and said grid-cathode resonator.

9. The combination defined in claim 8 and in which said quarter-wave dielectric transformer is positioned in said screen-anode resonator contiguous said first ends of said cylindrical members to provide a radio frequency impedance matching network to match the impedance of said screen-anode resonator and the coaxial line impedance of the screen-anode electrodes of said vacuum tube.

10. A coaxial resonator structure adapted to receive a vacuum tube having cathode, grid, screen and anode electrodes all spaced along the axis thereof, said resonator structure including in combination; a plurality of hollow cylindrical conductive members coaxially positioned with respect to one another and positioned to receive the vacuum tube at a first end thereof in coaxial relationship therewith and to establish respective electrical contacts with said electrodes; said cylindrical members respectively forming a screen-anode resonator to operate in the three-quarter wave coaxial mode, a screen-grid resonator to operate in the half-wave coaxial mode and a grid-cathode resonator to operate in the three-quarter wave coaxial mode; means disposed in said screen-anode resonator to suppress oscillations in the quarter wave coaxial mode; and a plurality of angularly positioned feedback probes axially spaced beyond the second end of said screen grid resonator and contained within said cylindrical members to provide feedback coupling between said screen anode resonator and said grid cathode resonator.

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