UNITED STATES PATENT OFFICE

2,706,802

CAVITY RESONATOR CIRCUIT

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Application November 30, 1951, Serial No. 259,206

The terminal fifteen years of the term of the patent to be granted has been disclosed

17 Claims. (Cl. 332—64)

This invention relates generally to electron discharge device circuits employing cavity resonators in association therewith, and particularly to such circuits utilizing multigrid electron discharge devices, such as tetrodes.

In electron discharge device circuits employing cavity resonators as tuning input and output circuits, tetrode amplifier devices offer certain advantages. In using tetrodes as power amplifiers in the very high frequency and ultra-high frequency ranges, it is important that both the cathode and screen grid of the tetrode be at the same potential with respect to the radio frequency signal. It is also important that the input cavity resonator be resonant at the radio frequency. These requirements present difficulties which have limited efficient use of such tetrode circuits at frequencies above 100 megacycles.

By maintaining the cathode and screen grid of the tetrode at the same potential with respect to the radio frequency signal, such as radio frequency ground potential, the control grid is shielded from other potentials, especially from the anode, which could cause instability in the amplifier by inducing regeneration or oscillation. If the cathode and screen grid are not maintained at the same instantaneous potential, degeneration can result which increases the amount of driving power required by an amplifier system. However, controlled amounts of regeneration to and beyond the point of oscillation or even a controlled amount of degeneration may be desirable in certain applications. One example of such use would be in the effects of unwanted feedback which may be present either in the electron discharge devices or external to it.

An object of the present invention is to obtain in a simple, convenient and direct manner a control of the amplitude and phase of the relative voltages appearing on the various electrodes of the multigrid electron discharge device.

In accordance with the present invention, the foregoing desirable operation is obtained by the use of a mechanical structure which includes means for tuning and for controlling amplitude and phase of the voltages appearing at the ends of a folded coaxial line cavity resonator in association with a multigrid electron discharge device. One end of this folded line is connected between the screen grid and control grid while the other end is connected between the control grid and cathode. The arrangement and construction of the folded coaxial line resonator is such that it enables an impedance to be presented to the electrodes to which it is connected which effects the same voltage transfer from control grid to cathode that appears between control grid and screen grid. The overall length of the line between these electrodes is effectively one wavelength (or an integral multiple of one wavelength) at the operating frequency when it is desirable to maintain cathode and screen grid at the same potential. A metallic annulus sometimes referred to as a "slug," is inserted in one of the folded sections of the coaxial line resonator and acts as a voltage transformer. This annulus engages one section of the folded line and is slidable over it to provide different voltage transformations at different positions of the annulus. The variation in position of the annulus enables an adjustment or equalization of the instantaneous radio frequency voltages appearing between cathode and control grid and screen grid. In the preferred embodiments of the invention, this annulus is located in that section of the folded coaxial line which is connected at one end to the control grid and cathode.

In one embodiment of the invention the annulus is a slug whose length is short compared to a wavelength at the operating frequency and must be of the order of $\frac{1}{4}$ to $\frac{1}{2}$ of a wavelength. This short annulus cooperates with the portion of the line which is connected at one end to the cathode. The operating position for the annulus in this embodiment is in the first eighth wavelength from the point where the line is folded.

In another embodiment of the invention, the annular structure is a sleeve of appreciable length which engages and is slidable over the portion of the conductor of the folded line which is connected at one end to the cathode.

The structural arrangement of the annular sleeve is such that it can be varied in length, and the end of the annular sleeve is made adjustable about a point $\frac{1}{4}$ wavelength distant from the fold in the coaxial line cavity resonator. By restricting the variation to the region about the first eighth wavelength point, the movement of the annular sleeve has virtually no detuning effect on the input resonant cavity.

Another object of the present invention is to provide a mechanically convenient system for obtaining proper and efficient operation of a multigrid electron discharge device circuit employing cavity resonators as tuned circuits thereof.

It is another object of this invention to facilitate the tuning and balancing of the radio frequency voltages in the cavity resonator portion of a multigrid amplifier adapted for operation in the very high and ultra-high frequency ranges.

A further object of this invention is to provide a means for adjusting the voltage balance between control grid-to-cathode and control grid-to-screen grid of a multigrid electron amplifier operating in a range above 100 megacycles without substantially changing the resonant frequency of the input circuit.

A still further object of this invention is to provide in a tetrode amplifier adapted for cavity resonator operation separate control means for adjusting the resonant frequency of the input circuit and for effecting the identical voltage transfer from control grid to screen grid that appears between control grid and cathode of the multigrid electron discharge device.

A particularly advantageous feature of the structure is the arrangement which enables changing of the effective length of the folded coaxial line resonator for tuning the line to resonance without the necessity for shorting bars or tuning stubs.

A more detailed description of the invention follows in connection with the drawings wherein:

Fig. 1 is a cross-section in elevation of a tetrode electron discharge device power amplifier system embodying the invention; and

Fig. 2 is a cross-section in elevation of another tetrode electron discharge device system embodying the invention.

Referring to Fig. 1, there is shown an electron discharge device of vacuum tube 11 having an anode terminal 13, a screen grid terminal 15, a control grid terminal 17 and filamentary cathode terminals 19. A cavity resonator structure includes tuned input and output circuits for the discharge device 11. The input cavity structure consists of an outer metallic cylindrical wall 21 which is mechanically secured to a screen grid terminal contacting ring 23 having a plurality of contact fingers, as shown, an inner metallic cylindrical wall 25 which is mechanically secured to cathode terminals 27 and a cylindrical metallic intermediate wall or "grid bell" 29. The cylindrical grid bell 29 is suspended from the outer wall 21 but is electrically insulated therefrom. The effective length of the grid bell 29 is adjustable by means of an auxiliary cylindrical metallic grid bell 31 which is maintained in electrical and mechanical connection with the grid bell 29 by means of springs 33 on the ends of both the grid bell 29 and the auxiliary bell 31.

Radio frequency energy is supplied to the input cavity through an input coaxial transmission line 35 extending through an opening in the outer cylindrical wall 21 and terminated by an input coupling probe 37 ho-
cated in the interior of the cavity resonator. A hollow metallic ring or annulus 41 (sometimes referred to as a "slug") having an outside diameter somewhat larger than the outside diameter of the inner cylindrical wall 25 surrounds the inner wall 25 and is slidable thereon along the annulus 41 is maintained in electrical contact with the inner wall 25 by means of a ring of springs 42 extending along the inner wall 25. The input cavity is closed at the end remote from the electronic discharge device 11 by a metallic annular disc 43 which makes contact with both the inner cylindrical wall 25 and the outer cylindrical wall 21. The metallic annular closing disc 43 has holes therein through which rods 44 of insulating material extend for the purpose of adjusting the various dimensions of the annulus 41 along the length of the inner wall 25. Also extending through holes in the metallic annular closing disc 43 are tuning rods 46 for adjusting the position of the auxiliary grid bell 31 which determines the total physical length of the grid bell structure 29, 31.

An output cavity resonator is coaxial with and surrounds a portion of the input cavity resonator. The outer wall 31 of the input cavity serves as the inner cylindrical wall of the output cavity, and a cylindrical metallic exterior anode wall 45 serves as the outer conductor. The coaxial output cavity resonator is tuned by means of an adjustable annular shorting bar 47 bridging the walls 21 and 45. The amplified radio frequency energy is extracted from the output cavity by a coupling coil 48 connected to an output transmission line 51 which extends through an opening in the exterior anode cavity wall 45. It should be noted that although the output cavity is shown being coaxial with and surrounding a portion of the input cavity, it may be more convenient for a certain design to make the output cavity in a flat disc shape, or a coaxial or waveguide cavity extending away from the input cavity, or other known configuration. The tuning system of the input cavity resonator arrangement of the present invention is operable with each of these types of output cavity resonators.

The electronic discharge device 11 is supported in the cavity resonator structure by an anode supporting plate 53 which has a retaining shoulder 55 extending downwardly from one end of the plate 53. The anode terminal 13 of the electronic discharge device 11 rests on the retaining shoulder 55 and carries the weight of the entire electronic discharge device 11. The output extracting potential is applied to the anode terminal 13 of the electronic discharge device 11 through an anode supply lead 57 extending to the positive terminal B+ of a source of unidirectional potential, the anode supporting plate 53, and an anode terminal contacting ring 59.

The anode supporting plate 53 is mechanically joined to but electrically insulated from a top cover plate 61 which is mechanically and electrically secured to the external anode wall 45. A sheet of dielectric material 63 electrically insulates the anode supporting plate 53 from the top cover plate 61. This structure including the anode supporting plate 53, the top cover plate 61, and the dielectric material 63 forms an anode bypass capacitor between the anode supporting plate 53 and the top cover plate 61.

A screen grid bypass capacitor is also provided between the screen grid terminal contacting ring 23 and the upper end of the outer cylindrical wall 21 of the input cavity. A sheet of insulating material 65 which may be, for example, mica or an insulating plastic such as polyethylene separates the screen grid contacting ring 23 from the outer wall 21 and is dielectric for the screen bypass capacitor.

Such a direct current operating potential may be supplied to the screen grid by a shielded screen line 66 passing up and secured to the outer cylindrical wall 21 and directly connected to the screen grid terminal contacting ring 23.

Filament bypass capacitors may also be included in the structure as shown in the drawing. A sheet of dielectric material 67 between the filamentary cathode contacting springs 27 and the upper end of the inner cylindrical wall 25 to which the contacting springs 27 are secured.

Heating energy is supplied to the filamentary cathode terminals 19 through a pair of filament leads 69 which are directly connected to the filamentary cathode terminals 19. It is convenient to bring the filament leads 69 out of the cavity resonator structure at 25 where they will not interfere with any of the other electrical connections.

A grid biasing and modulating signal potential to be impressed on the control grid terminal 17 may be supplied through a shielded grid cable 71, also conveniently brought in through the interior of the inner cylindrical wall 25 and supplied through the shield cable 71 to the grid bell structure 29. A direct and alternating current path to the control grid terminal 17 is then available through the shielded cable 71, the terminal 73, the grid bell structure 29, 31 and the grid control contacting ring 74.

In operating tetode electronic discharge devices as grid modulated high power amplifiers in the very high frequency and ultrahigh frequency ranges, two conditions must be fulfilled: (1) the input cavity must be resonant at the operating frequency, and (2) the cathode and screen grid of the tetode must be at the same potential with respect to the radio frequency signal.

Considering the input cavity circuit of the present invention, the grid bell structure 29, 31 divides the input line cavity into two parts: a cathode-to-control grid portion and a control grid-to-screen portion. The cathode-to-control grid portion is a section of the input transmission line 51 in which the tubular insulating material 25 is replaced by the cathode terminals 19 is the inner conductor and the inner surface of the grid bell 29 and auxiliary bell 31 is the outer conductor. The control grid-to-screen grid portion is also a section of the input transmission line 51 surrounding the cathode-to-control grid portion, in which the outer surface of the grid bell 29 and auxiliary bell 31 serves as the inner conductor and the outer cylindrical wall 21 couples the screen grid is the outer conductor. The input cavity may be considered as a full wavelength transmission line having one portion folded back on the other so that the grid bell 29 and auxiliary bell 31 serves as the outer conductor of one line and as the inner conductor of the other line. The input circuit is tuned to resonance by adjusting the total effective length of the grid bell 29 and the auxiliary bell 31. The input circuit then operates as a resonant full wavelength line having one end connected between cathode and control grid and the other end connected between control grid and screen grid. It should be borne in mind that in the very high and ultrahigh frequency ranges in which it is contemplated the invention will find its primary application, the portion of the actual electron discharge device elements will be shorter than a full wavelength because of the length of the discharge device appreciable fraction of a wavelength and the interelectrode and other capacities between the line conductors.

In attempting to tune an input coaxial cavity resonator by adjusting the length of the grid bell 29 and auxiliary bell 31, it is found that when resonance of the input circuit is attained, most often the voltages existing between the cathode and control grid and screen grid are not the same. In other words, even though the input line is made resonant at one wavelength, different instantaneous radio frequency voltages appear across the two ends. This means that the screen gridded electronic discharge device will have a radio frequency potential different from the cathode. The presence of a radio frequency potential difference between the screen grid and cathode has a degenerative effect on the plate and the control grid. Regeneration or oscillation can also occur if the instantaneous radio frequency potential difference between the cathode and control grid is of opposite phase to that between the screen grid and cathode.

This voltage difference at the two ends of the input cavity resonant line results from the fact that the interelectrode capacity of the electronic discharge devices is not the same but by positioning the position of the screen grid the capacity between the control grid and screen grid, due to the necessary difference in geometric configuration of the elements of the discharge devices.

The impedance of the two ends of the full wavelength coaxial line forming the input cavity may be made to match the interelectrode impedance of the vacuum tube elements to which each end of the line is connected by a
The relative diameter ratio of the inner and outer conductors of one portion of the resonant input coaxial line cavity is changed according to this invention, by employing the sliding annulus or slug 41, to the inner cylindrical wall 25. Since the annulus 41 has an outer diameter larger than that of the inner cylindrical wall 25, the portion between the annulus 41 and the grid wall 29 or auxiliary bell 31 has a different ratio of inner and outer diameters than the remaining length of that portion between the inner cylindrical wall 25 and the auxiliary bell 31. This section of line in the input cavity adjacent to the annulus 41 therefore has a different impedance from the remaining length of that portion of the folded line.

The instantaneous radio frequency voltage appearing across the side of the auxiliary bell 31 and the adjacent conductors of the two sections of the line (the outer wall of the annulus 41) is transformed in the inserted section of line of different dimensions as constructed by the slug-like annulus 41 and the grid bell structure 29, 31. The amount of voltage transformation is adjustable to the position of the sliding annulus 41 along the inner cylindrical wall 25. At one position of the annulus on the inner cylindrical wall 25, for a certain predetermined operating condition of resonance, the same radio frequency voltages which appears across the control grid and screen grid of the discharge device 11 will be applied between the control grid and cathode of the electron discharge device. This biasing or equalizing adjustment of the instantaneous radio frequency voltages of the input circuit enables the multigrid electron discharge device to be operated as a power amplifier at maximum efficiency and enables cavity resonant circuits at different frequencies, as well as with electron discharge devices having different internal impedance characteristics.

The length of the annulus 41 along the inner cylindrical wall 25 for a particular amount of voltage transformation necessary to equalize the instantaneous radio frequency voltage between the control grid and the screen grid of the grid, 11 will depend upon the change in the ratio of the diameters of the inner and outer conductors. It is found that an annular slug 41 which reduces the ratio of the outer to inner diameter from a value of about 1.6 to a value of about 1.2 produces an impedance change such that the total length of the annulus 41 may be between ¼ and ¾ of a wavelength at the operating frequency. Only a small portion of this length may be included between the two conductors of the input line whose diameter ratio is being altered, of course. An annular slug 41 having a length of ¼ of a wavelength at the operating frequency of the particular cavity resonator for which it is designed has been found to be satisfactory.

The annulus 41 will accomplish the same electrical function if it is placed on the inside of the grid bell structure 29, 31 facing wall 25. In such a position it will alter the ratio of inner and outer diameters of that portion of the line section which is coupled across the cathode terminals 19 and control grid terminals 17. Also, of course, the annulus may be inserted on the other side of the line, cooperating with the inside surface of the outer cylindrical wall 21 or the outside surface of the cylindrical grid bell structure 29, 31. It has been found more convenient to position the annulus as shown in the figures on the inner cylindrical wall 25, since with this structure it does not interfere with the input line 35 and input coupling probe 37 nor hamper the adjustment of the grid bell structure 29, 31.

It is found that with the structure described above utilizing the annulus 41 as a voltage transforming section of coaxial line in cooperation with the grid bell structure 29, 31 that an adjustable amount of grid bias is added in adjusting the length of the input cavity to resonance becomes unnecessary. Actually, with the structure described which includes the inserted section of line having different dimensions in the cathode-to-control grid pass wall thick resonant input line, the presence of a shorting bar (like the annular shorting bar 47 for the output cavity) for the purpose of tuning between the inner cylindrical wall 25 and the outer cylindrical wall 21 has a negligible effect. By dispensing with such an arrangement entirely, the tuning operation is simplified and facilitated, and the mechanical structure of the device is made much less intricate.

Air for cooling both the cavity resonator structure and the electron discharge device 11 may be conveniently supplied through two inlets 45, the tubular interior of the inner cylindrical wall 25 is utilized for one air passage, the course of the air flow through the structure being shown by arrows on the drawing. The first air path is through the inner cylindrical wall 25, through openings in the control grid terminal contacting ring 74, and out through the control grid-to-screen grid portion of the input cavity and exhaust ports 77 in the outer cylindrical wall 21.

An air manifold may surround the output cavity and supply a second stream of air through inlets 79 in the external anode wall 45 of the output cavity. Part of this cooling air, also indicated by arrows on the drawing, passes downwardly through the output cavity and out through a ring of exhaust ports 81. The other portion flows upwardly through the anode radiator cooling fins of the electron discharge device 11.

One embodiment of the invention successfully tried out in practice which was designed to be operable over a range of frequencies from 180 to 300 megacycles had the following dimensions: The electron discharge device 11 was an air-cooled tetrode RCA type experimental model A2505A. The inner cylindrical wall 25 was 0.06 inch outside diameter of 3⅛" and was constructed of 9⅝" wall copper tubing. Obviously, other suitable metals such as aluminum can also be employed. The outer wall 21 had the same thickness and had an inside diameter of 8⅝". The grid bell structure 29, 31 had a mean diameter of 6⅘", the cylindrical grid bell being made of 5⅝" wall tubing, and the auxiliary bell 31 being made of 6⅛" tubing, with the same thickness. The grid bell 29 had a length of 8⅝" and the auxiliary bell 31 had a length of 6". The total grid bell structure could be varied from 9⅛" to 15⅛" in length below the control grid terminal contacting ring 74.

The annulus 41 had an outside diameter of 5" and a length of 4", and could travel over a distance of 9¼" along the tubular inner wall 25. The screen grid terminal contacting ring 23, the cathode terminal contacting springs 27, the control grid terminal contacting ring 74 and the anode terminal contacting ring 59 were all made of phosphor bronze, silver plated to increase the electrical conductivity.

The anode bypass capacitor was formed by spacing the anode support plate 55, which was ⅝" copper from the top cover plate 61, which was ⅝" thick, with an inside diameter of 8¼" and an outside diameter of 13". The anode bypass capacitor dielectric spacer 63 was of polyethylene sheet material 0.050" in thickness. A screen grid bypass capacitor was made by covering the screen grid terminal contacting ring 23 and the upper end of the outer cylindrical wall 21 of the input cavity by inserting a sheet of mica 0.010" thick. Filament bypass capacitors were provided by inserting a sheet of mica sheet material 67 between the cathode contacting springs 27 and the upper end of the inner cylindrical wall 25.

The exterior anode wall had an inside diameter of 10¼" and a thickness of ⅛". The output coupling loop 49 had a height of 2' and extended into the cavity 1¾'.
from the exterior anode wall 45 and was made of a flat copper strip 8/sixteenths" x 1/2". The outer conductor of the output line 51 had an inside diameter of 3" while the inner conductor had an outside diameter of 1/sixteenths" while the inner conductor was 1/2" in diameter and the input coupling probe 37 was a disc 1/sixteenths" in diameter.

An excitation frequency of 216 megacycles was coupled to the line through the input line 38. The input circuit was tuned to resonance by adjusting the length of the grid bell structure 29, 31. The position of the annulus 41 was then moved a small amount along the inner wall 25 to approach the proper condition of voltage balance and a vernier adjustment of the length of the grid bell structure 29, 31 was made to restore the resonance condition. Alternate fine tuning adjustments of the position of the annulus 41 and the length of the grid bell structure 29, 31 were then made until the instantaneous radio frequency voltage difference between the cathode and screen grid was eliminated, as reflected in the output power of the system. These alternate fine tuning adjustments of the position of the annulus 41 and the length of the grid bell structure 29, 31 are advisable since too great a movement of the annular ring 41 causes a slight detuning of the input circuit and the power output to drop off and perhaps mask the position of exact voltage balance and input cavity resonance.

The action of the annulus is caused by operating in the first eighth wavelength from the end of the grid bell structure 29, 31. The movement of the added capacitance of this portion of the folded line appearing between the grid bell structure 29, 31 and the annulus 41 has the undesired effect of changing the electrical length of the line to detune the input circuit.

At an operating frequency of 216 megacycles, it was found that when the voltage between the control grid and the screen grid held constant, a change in position of the annulus 41 of 1/sixth produced a variation of approximately 20% in the ratio of screen grid-cathode voltage to the control grid-screen grid voltage. It was found also that if the annulus 41 was closer to the cathode, the cathode voltage swing was greater with respect to the screen grid while if it was further from the cathode than the zero voltage position the cathode had an instantaneous radio frequency potential swing lower than the screen compared to a point of reference potential, such as structure 29, 31 had the effect of changing the electrical length of the line to detune the input circuit. By extending the annular sleeve structure 41', 48 from the region around a point 1/sixth wavelength from the end of the grid bell structure 29, 31, this capacitance is made uniform near the end of the grid bell structure 29, 31 where its effect is most critical on the tuning of the input cavity.

The end of the annular sleeve structure 41', 48 is made variable from about 1/sixth to the fold in the input line, or end of the grid bell structure 29, 31, to accomplish a direct control of the amplitude and phase of the relative voltages appearing between the control grid and cathode and grid and screen grid of the tetrod electron discharge device 11.

An advantage of the construction of Fig. 2 which uses the annular sleeve structure 41', 48 is that it renders unnecessary the many alternate fine tuning adjustments of the length of the grid bell structure 29, 31 and the position of the annulus which is required when the structure of Fig. 1 is used. This difference in the tuning procedure arises from several factors, one of which is that the variation in the position of the annular sleeve 41 around the 1/sixth wavelength point from the end of the grid bell structure 29, 31 can be accomplished with negligible effect on the electrical length of the resonant circuit. As distributed capacitance due to the change in diameter ratio between the two sides of the line starting from the end of the grid bell structure 29, 31, a large increment of foreshortening of the line occurs for a finite quantity of added capacitance in proximity of the end of the grid bell structure 29, 31; but as the length of the section over which the diameter ratios are changed is made longer, the amount of foreshortening and line length per incremental step becomes less. In the region around the 1/sixth wavelength point there is no incremental change in line length for the introduction of the same finite additional quantity of distributed capacitance between the two conductors of the line. On the other side of this eighth wavelength point from the end of the grid bell structure 29, 31, the insertion of additional distributed capacitance resulting from a change in the diameter ratios of the inner and outer conductors acts to lengthen the line to approach the condition of a 1/sixth wave transformer.

The principles and structure of the invention are applicable to types of operation wherein multigrind electron discharge devices employ cavity resonators as tuned elements other than the portion of the elements described. For example, the system may be tuned to act as a high power oscillator generator by making the total length of the input cavity one half wavelength for the desired operating frequency of the annular slug 41 of Fig. 1 or the annular sleeve 41' of Fig. 2 serves in this case as an adjustment on the amount of regenerative feedback necessary to sustain oscillation.

The system is also operable as an oscillator by coupling a portion of the output into the input cavity either through the input line 35 and input coupling probe 37 or by utilizing other known principles. In the latter case the annulus 41 of Fig. 1 or the annular sleeve 41' of Fig. 2 provides an adjustment on the amount and relative phase of the feedback applied between the two sections of the input cavity.

The structure is further utilized as a frequency multiplication stage, in which case the input circuit would be adjusted to 1/sixth wavelength to be multiplied, and the output circuit tuned to resonance at the desired output frequency in the usual manner.

The system of the invention is particularly useful for obtaining efficient operation of high-power electron discharge devices in the range of frequencies from 100 megacycles to 1000 megacycles. The principles of the invention are applicable to all power levels.

We claim:

1. An electron discharge device system for a multigrind electron discharge device having at least one cathode, a control grid, and a screen grid which extends through the entire body of the device, said grid extending including a coaxial line, one end of said line having one conductor coupled to said screen grid and the other conductor coupled to said control grid and
the other end of said line having said one conductor coupled to said cathode and said other conductor coupled to said control grid, means for changing the length of said line, and an adjustable annulus inserted between two said conductors but engaging only one of said conductors to alter the ratio of inner and outer diameters in the portion of said line into which it is inserted.

2. An electron discharge device system for a multi-grid electron discharge device having at least a cathode, a control grid and a screen grid, comprising a tunable coaxial cavity resonator input circuit, said input circuit including a coaxial line, one end of said line having one conductor coupled to said screen grid and the other conductor coupled to said control grid and at the other end of said line having said one conductor coupled to said cathode and said other conductor coupled to said control grid, means for changing the length of said line, and a variable length section of coaxial line in the portion of said line nearer the end coupled to said cathode, said variable length section having a different ratio of inner and outer diameters from the portion of said input line in which said variable length section is interposed.

3. An electron discharge device system for a multi-grid electron discharge device having at least a cathode, a control grid and a screen grid, comprising a tunable coaxial cavity resonator input circuit, said input circuit including a coaxial line, one end of said line having one conductor coupled to said screen grid and the other conductor coupled to said control grid and the other end of said line having said one conductor coupled to said cathode and said other conductor coupled to said control grid, means for changing the length of said line, and a variable length section of coaxial line interposed in the portion of said input coaxial line nearer the end coupled to said cathode.

4. In an electron discharge device system for a multi-grid electron discharge device having at least a cathode, an anode, a control grid, and a screen grid, the combination comprising a tunable coaxial cavity resonator, said tunable input cavity including a coaxial line, one end of said input coaxial line being coupled to said control grid and said screen grid, and the other end of said input coaxial line being coupled to said cathode and said anode, and a transmission line section having a different ratio of inner and outer conductor diameters from the portion of said input line in which said inserted section is interposed.

5. In an electron discharge device system for a multi-grid electron discharge device having at least a cathode, a control grid, and a screen grid, the combination comprising a tunable coaxial cavity resonator, said tunable input cavity including a coaxial line, one end of said input coaxial line being coupled to said control grid and said screen grid, and the other end of said line being coupled to said control grid and said cathode, and a section in one portion of said input coaxial line having a different ratio of inner and outer conductor diameters from the portion of said input line in which said inserted section is interposed.

6. In an electron discharge device system for a multi-grid electron discharge device having at least a cathode, a control grid, and a screen grid, the combination comprising a tunable coaxial cavity resonator, said tunable input cavity including a coaxial line, one end of said input coaxial line being coupled to said control grid and said screen grid, and the other end of said line being coupled to said control grid and said cathode, and a variable length section of coaxial line in one portion of said input coaxial line having a different ratio of inner and outer conductor diameters from the portion of said input line in which said inserted section is interposed.

7. In an electron discharge device system for a multi-grid electron discharge device having at least a cathode, a control grid, and a screen grid, the combination comprising a tunable coaxial cavity resonator, said tunable input cavity including a coaxial line, one end of said input coaxial line being coupled to said control grid and said screen grid, and the other end of said line being coupled to said control grid and said cathode, and a section in the portion of said input coaxial line nearer the end coupled to said control grid and said cathode, having a different diameter ratio of inner and outer conductors from the remaining portion of said input line in which said inserted section is interposed.

8. An electron discharge device system comprising an electron discharge device having at least a cathode, a control grid, and a screen grid, a tunable coaxial cavity resonator circuit, said resonator circuit including an intermediate wall of metallic tubing coupled to said cathode, an intermediate wall of metallic tubing spaced from said cathode and coupled to a transmission line section, an outer wall of metallic tubing coupled to said control grid and said cathode, and said screen grid, means for changing the effective length of said intermediate wall, and an annular conductive member in the space between said inner wall and said intermediate wall and slidably engaging only one of said walls and having distributed capacitance and inductance to constitute, in conjunction with one of said adjacent walls, a transmission line section to thereby alter the impedance of one section of the resonator relative to that of another section.

9. An electron discharge device system comprising an electron discharge device having at least a cathode, a control grid, and a screen grid, a tunable coaxial cavity resonator circuit, said resonator circuit including an intermediate wall of metallic tubing coupled to said cathode, an intermediate wall of metallic tubing spaced from said cathode and coupled to said control grid, an outer wall of metallic tubing coupled to said control grid and said cathode, and said screen grid, means for changing the effective length of said intermediate wall, and an annular conductive member in the space between said inner wall and said intermediate wall and slidably engaging only one of said walls and having distributed capacitance and inductance to constitute, in conjunction with one of said adjacent walls, a transmission line section to thereby alter the impedance of one section of the resonator relative to that of another section.

10. An electron discharge device system comprising an electron discharge device having at least a cathode, a control grid, and a screen grid, a tunable coaxial cavity resonator circuit, said resonator circuit including an intermediate wall of metallic tubing coupled to said cathode, an intermediate wall of metallic tubing spaced from said cathode and coupled to said control grid, an outer wall of metallic tubing coupled to said control grid and said cathode, and said screen grid, means for changing the effective length of said intermediate wall, and an annular conductive member in the space between said inner wall and said intermediate wall and slidably engaging only one of said walls and having distributed capacitance and inductance to constitute, in conjunction with one of said adjacent walls, a transmission line section to thereby alter the impedance of one section of the resonator relative to that of another section.

11. A high power grid modulated amplifier comprising an electron discharge device having at least a cathode, an anode, a control grid and a screen grid, a tunable coaxial cavity resonator output circuit coupled to said anode, a tunable coaxial cavity resonator input circuit including a resonant coaxial line, one end of said line having one conductor coupled to said grid and the other end of said line being coupled to said cathode and said control grid and said screen grid, and the other end of said line being coupled to said control grid and said cathode, and a section in one portion of said input coaxial line having a different ratio of inner and outer conductor diameters from the portion of said input line in which said inserted section is interposed.

12. A high power grid modulated amplifier comprising an electron discharge device having at least a cathode, an anode, a control grid and a screen grid, a tunable coaxial cavity resonator circuit, a tunable resonator input circuit, a tunable resonator output circuit coupled to said anode, said input circuit including
a resonant coaxial line, one end of said line having one conductor coupled to said screen grid and the other conductor coupled to said control grid and the other end of said line having said conductors coupled to said cathode and said other conductor coupled to said control grid, coupling means for impressing a radio frequency signal across a point in said input line nearer the end coupled to said screen grid, means for changing the length of said input line, transmission line means also coupled to said control grid for impressing a modulating signal thereon, an annular slug positioned between two of said conductors but contacting only one of said conductors of said input coaxial line to alter the ratio of inner and outer diameters in one portion of said input line, and output coupling means cooperating with said output resonator circuit for extracting an output signal from said amplifier.

13. A high power grid modulated amplifier comprising an electron discharge device having at least a cathode, an anode, a control grid and a screen grid, a tunable resonator input circuit, a tunable resonator output circuit coupled to said anode, said input circuit including a resonant coaxial line, one end of said line having one conductor coupled to said screen grid and the other conductor coupled to said control grid and the other end of said line having said conductor coupled to said cathode and said other conductor coupled to said control grid, coupling means for impressing a radio frequency signal across a point in said input line nearer the end coupled to said screen grid, means for changing the length of said input line, transmission line means also coupled to said control grid for impressing a modulating signal thereon, an annular slug positioned on and contacting said conductor of said input coaxial line coupled to said cathode to alter the ratio of inner and outer diameters in the portion of said input line nearer the end coupled to said cathode, and output coupling means cooperating with said resonator output circuit for extracting an output signal from said amplifier.

14. A radio frequency system comprising a multigrid electron discharge device having a cathode, and first and second grids, a folded coaxial line resonator having three coaxially arranged sections of metallic tubing, means respectively coupling said sections of tubing to said cathode and first and second grids, the axis of said coaxial line resonator being coincident with the axis of said discharge device, the outer two sections of said tubing of said resonator being longer than the intermediate section, said outer two sections of tubing being electrically connected together at their ends nearest to said discharge device, and a metallic ring-like insert positioned between two of said sections of tubing but directly engaging only one of said last two sections, said insert being adjustable in position over a portion of the length of said one section for altering the impedance of one portion of the resonator relative to another portion.

15. A radio frequency system comprising a multigrid electron discharge device having a cathode, and first and second grids, a folded coaxial line resonator having three coaxially arranged sections of metallic tubing, means respectively coupling said sections of tubing to said cathode and first and second grids, the axis of said coaxial line resonator being coincident with the axis of said discharge device, the inner section and outer section of said tubing of said resonator being longer than the intermediate section, said inner and outer two sections of said tubing being electrically connected together at their ends nearest removed from said discharge device, and an additional two sections of tubing telescoping one within the other positioned between said inner section of tubing and said intermediate section but directly contacting only said inner section, said additional sections being adjustable in length for altering the impedance of one portion of the resonator relative to another portion.

16. A system as defined in claim 14, wherein said metallic ring-like insert is an annulus which extends from a point at least one-sixteenth wavelength from the free end of said intermediate section of tubing to a point where said outer two sections of tubing are connected together.

17. A system as defined in claim 14, wherein said metallic ring-like insert is an annulus which extends from a point within the first eighth wavelength from the free end of the intermediate section of tubing to a point below said free end but above the location where said outer two sections of tubing are connected together.

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