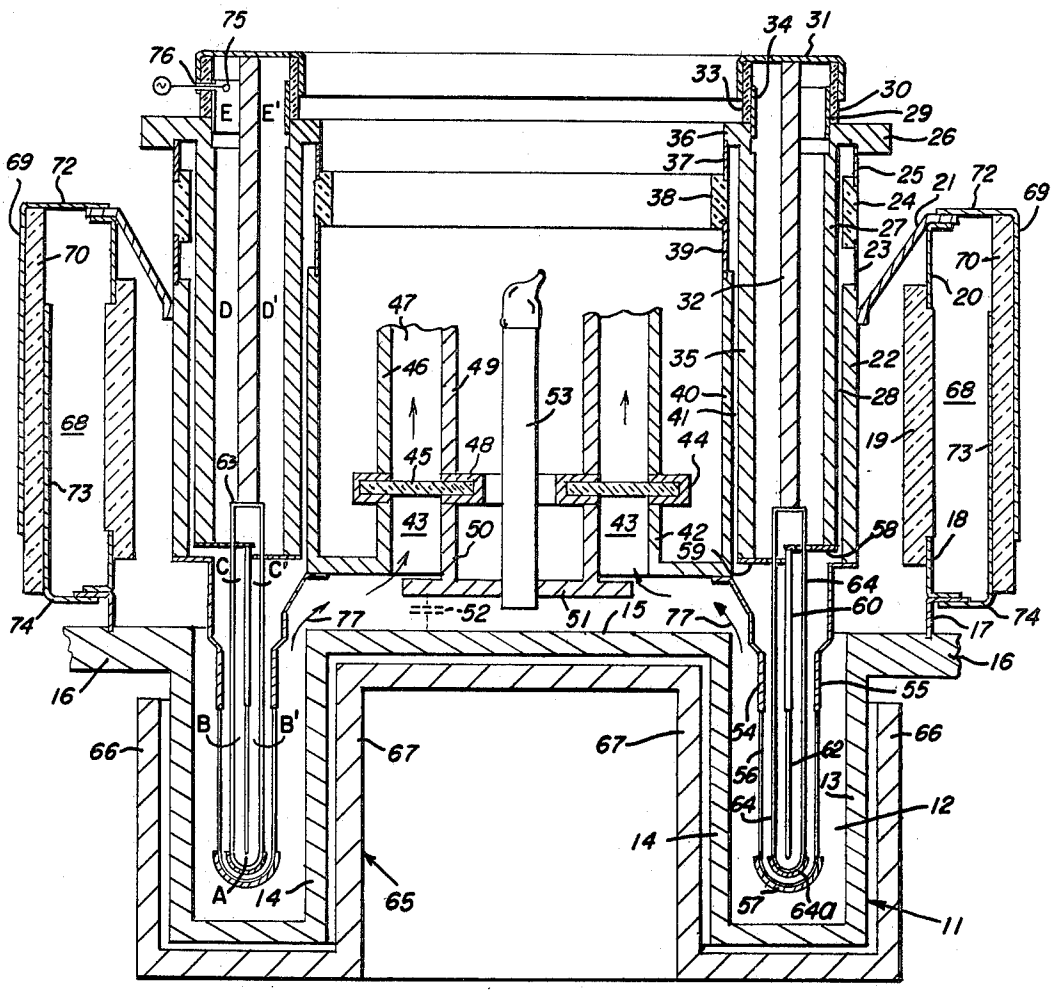
Jan. 27, 1970 H. D. DOOLITTLE ET AL 3,492,528

HIGH FREQUENCY POWER TUBE

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FIG. 1



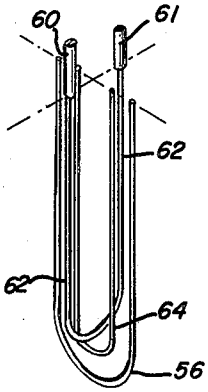


FIG. 3

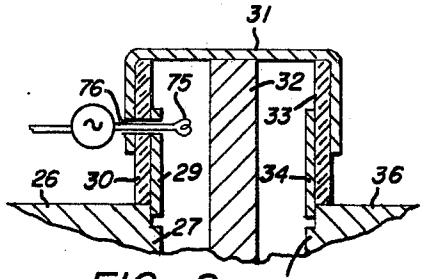


FIG. 2

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HIGH FREQUENCY POWER TUBE

Filed March 4, 1968 2 Sheets-Sheet 2

FIG. 4

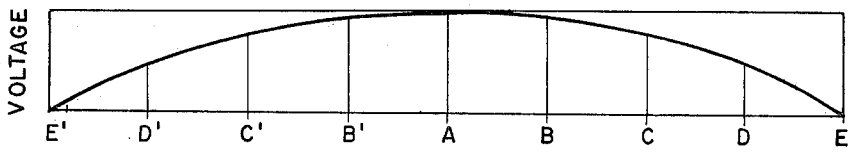
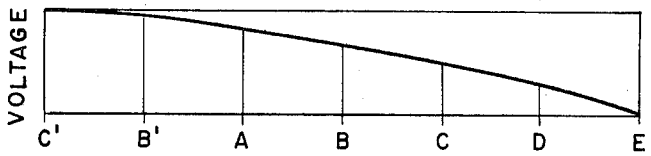


FIG. 5



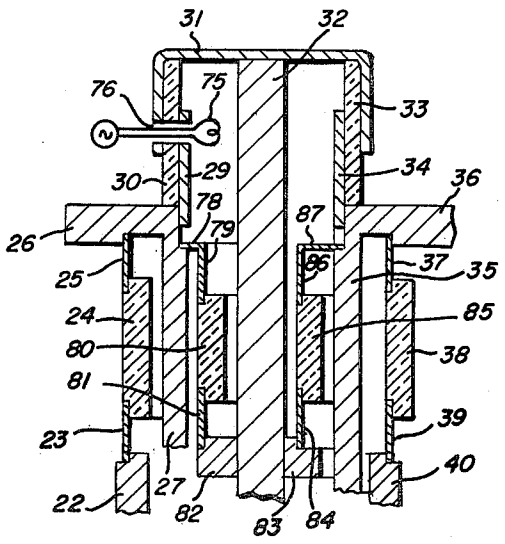


FIG. 6

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United States Patent Office 3,492,528 Patented Jan. 27, 1970

3,492,528

HIGH FREQUENCY POWER TUBE

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Int. Cl. H01j 7/46, 19/80
U.S. Cl. 315—39 11 Claims

ABSTRACT OF THE DISCLOSURE

A high frequency power tube having symmetrically disposed electrodes and support structures for beaming a high frequency input signal into a resonant cavity between the cathode and grid electrodes and obtaining a power amplified output of that signal from said cavity and power tube.

BACKGROUND OF THE INVENTION

This invention relates to electron discharge tubes for high frequency power amplification and is more particularly concerned with an electrode structure that provides a substantially uniform electrostatic field between the cathode and control grid electrodes.

In a conventional triode power tube, electrons are thermionically emitted from a filamentary cathode and flow toward a highly positive anode under the control of an intervening control grid electrode. Usually, a DC voltage is applied to the control grid to bias it negative with respect to the cathode and thereby establish an electrostatic field which retards the flow of electrons to the anode. When an alternating signal voltage is superimposed on the DC bias voltage of the grid, the effective potential of the grid changes in accordance with increasing and decreasing amplitude of the signal voltage and the associated retarding field varies accordingly. Consequently, the density of the electron stream flowing from the cathode to the anode increases and decreases, each variation corresponding to a change in amplitude of the alternating signal voltage. Thus, this modulation of the electron stream flowing through the triode tube represents a power amplification of the alternating signal voltage.

In low frequency operation of the tube, the alternating signal voltage is applied to the control grid through a direct connection of conductive metal. However, lead length becomes important in high-frequency operations; because the associated inductance represents an impedance loading of the input circuit. Consequently, to reduce the inductance and radiation losses associated with the external connecting leads, the high frequency signals are beamed into the interelectrode spacing between the cathode and control grid through a resonant cavity. The high frequency signal establishes an electric field in the inter-electrode space which field interacts with the electron stream passing through this space toward the anode. The density of the electron stream is modulated in the space between the cathode and the control grid and thereby receives a high frequency component which represents a power amplification of the signal voltage. A suitable transmission line is connected between the anode and the control grid to extract the high frequency component of the electron stream as it passes through this region of the tube toward the anode.

If the entrance of the input cavity is provided with a high frequency short circuit, the input cavity will resonate fundamentally at the frequency for which the cavity is a quarter wave-length long. However, this fraction of a wavelength must be distributed along the cavity in a way that will produce a substantially uniform field between the cathode and the grid electrodes. Since the quarter wavelength cavity will have a voltage maximum at the open end and a voltage minimum at the shorted end, the voltage will decrease in value from the open end to the shorted end. The problem is to maintain a fairly constant voltage in the inter-electrode space between the cathode and the grid. Any variation in the field established therein will be transmitted to the electron stream and alter the amplification of the signal.

SUMMARY OF THE INVENTION

This invention provides a power tube having a symmetrically folded input resonant cavity with RF reflecting ends. A standing half-wave of the fundamental frequency for this resonant cavity is set up therein which has a maximum voltage amplitude located midway between the reflecting ends of the half-wave resonant cavity and a substantially constant voltage distribution in the active interelectrode region. Two portions of the input resonant cavity are provided by the respective spaces between two parallel cathode support members and a control grid support member which is centrally disposed between the respective cathode support members. The portion of the input resonant cavity which communicates between the aforementioned two portions is provided by an array of filament wires axially aligned with and spaced from the control grid support member, each of the respective filament wires having respective ends connected to the respective cathode support members, and an array of control grid wires which encloses the array of filament wires in the active electrode area of the tube, each of the respective control grid wires having respective ends connected to the control grid support member. Reflective ends are provided for the symmetrically folded cavity by nonconductive, RF reflecting members connected between the end of the control grid support member remote from the control grid wires and the adjacent ends of the respective cathode support members.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial sectional view of a tube embodying the invention;

FIG. 2 is an enlarged fragmentary view of one of the nonconductive, RF reflecting ends of the input resonant cavity;

FIG. 3 is a fragmentary view of the cathode, control grid and screen grid wires arranged as in a tetrode structure;

FIG. 4 is a diagrammatic view of the half-wave voltage distribution set up in the input resonant cavity by the fundamental signal frequency; and

FIG. 5 is a diagrammatic view of the quarter-wave voltage distribution set up in the input resonant cavity of a prior art tube by the fundamental resonant frequency.

FIG. 6 is an enlarged axial fragmentary view of the reflective ends of the resonant cavity showing an al-

ternative means of closing the gastight envelope which permits removal of the RF reflecting ends.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, wherein like characters of reference designate like parts throughout the several views, the illustrative tube embodying the invention, as shown in FIG. 1, comprises a gas-tight envelope closed at one end by an annular anode **11** having an annular cavity **12** between axially extending walls **13** and **14** which are concentric with the longitudinal axis of the tube. An external, circular cavity is formed by the annular wall **14** and planar anode surface **15**. The open end of anode **11** is provided with a radially extending flange **16** which functions as the anode terminal of the tube. Kovar sleeve **17** is peripherally attached at one end to annular flange **16** and has an outwardly extending flange at the other end which is hermetically attached to the flanged end of Kovar sleeve **18**. The other end of Kovar sleeve **18** is circumferentially sealed to one end of dielectric cylinder **19** which is similarly sealed at the other end to one end of Kovar sleeve **20**. The opposite end of Kovar sleeve **20** is provided with an outwardly extending annular flange which is hermetically attached to the outer peripheral flange of frustoconical member **21**, the combination functioning as the screen grid terminal of the tube.

Terminal member **21** flares radially inward and is sealed throughout its inner periphery to metallic cylinder **22**, preferably copper. Cylinder **22** provides support for one side of an annular screen grid electrode and is disposed coaxially with the longitudinal axis of the tube. The end of support cylinder **22** adjacent terminal member **21** is hermetically attached to one end of Kovar sleeve **23** which is similarly sealed at the other end to dielectric ring **24**. The opposite end of dielectric ring **24** is circumferentially attached to one end of Kovar sleeve **25** which is similarly secured at the other end to an outwardly extending flange **26** of metallic support cylinder **27**, preferably copper. Cylinder **27** provides support for one side of an annular cathode, and flange **26** functions as one of the cathode terminals of the tube. Cathode support cylinder **27** is concentric with the longitudinal axis of the tube and is in close spaced proximity with the wall of screen grid support cylinder **22**. The annular spacing between the walls of cathode support cylinder **27** and screen grid support cylinder **22** forms a coaxial coupling capacitor **28** which provides a ready means of bypassing the RF current in the screen grid circuit to the cathode. Since it is important in high frequency operations to keep all lead lengths as short as possible, the internal by-pass capacitor **28** provides an advantageous means of RF coupling the screen grid electrode to cathode ground.

As shown more clearly in FIG. 2, one end of Kovar sleeve **29** is hermetically attached to the inner periphery of cylinder **27** adjacent the flanged end thereof and is circumferentially sealed to the inner peripheral surface of dielectric ring **30**. The outer peripheral surface of dielectric ring **30** is hermetically sealed to one side of the U-shaped channel in annular Kovar collar **31**. Metallic support cylinder **32**, preferably copper, has one end peripherally attached to Kovar collar **31** along the annular center line of the U-shaped channel therein and is disposed concentric with the longitudinal axis of the tube. Cylinder **32** provides support for an annular control grid electrode, and Kovar collar **31** functions as the control grid terminal of the tube. Kovar sleeve **29**, dielectric ring **30** and Kovar collar **31** combine to form a nonconductive, RF reflecting barrier across the annular space between control grid support cylinder **32** and cathode support cylinder **27**. Since direct current is not conducted through the thickness of the dielectric ring **30** between Kovar sleeve **29** and grid terminal collar **31**, the DC potential on the control grid electrode will not be short-circuited to the cathode. Although the dielectric ring **30** will not stop an RF energy from passing through, the metallic surfaces of Kovar sleeve **29** and Kovar collar **31** will be strong reflecting surfaces for the RF energy. Since an end portion of sleeves **29** on one side of dielectric ring **30** overlaps, when viewed radially, an end portion of collar **31** on the other side of dielectric ring **30**, an RF wave in the space between support cylinder **32** and support cylinder **27** will "see" a continuous reflecting surface across the barrier. Hence, the RF energy of the wave, disregarding negligible losses, will be reflected back into the annular space between support cylinder **27** and **32**.

The other side of the U-shaped channel in Kovar collar **31** is hermetically sealed to the inner peripheral surface of dielectric ring **33**. The outer peripheral surface of dielectric ring **33** is circumferentially sealed to a Kovar sleeve **34** which is hermetically attached at one end to metallic support cylinder **35**, preferably copper. Cylinder **35** provides support for the other side of the annular cathode and is concentric with the longitudinal axis of the tube. Kovar sleeve **34**, dielectric ring **33** and Kovar collar **31** combine to form a nonconductive, RF reflecting barrier across the annular space between the control grid support cylinder **32** and the cathode support cylinder **35**. An annular flange **36**, which extends radially from support cylinder **35** adjacent the attached end of Kovar sleeve **34**, functions as the other cathode terminal of the tube. Kovar sleeve **37** is attached throughout one end to flange **36** and is sealed throughout the other end to dielectric ring **38**. The opposite end of dielectric ring **38** is circumferentially sealed to one end of Kovar sleeve **39** which is peripherally attached at its opposite end to one end of metallic cylinder **40**, preferable copper. Cylinder **40** provides support for the other side of the annular screen grid and is coaxially aligned with the longitudinal axis of the tube. Cylinder **40** is in close spaced proximity with the wall of cathode support cylinder **35** and forms therewith coaxial capacitor **41** which is in parallel with and has the same function as RF coupling capacitor **28**. An annular flange at the other end of support cylinder **40** extends radially inward and is hermetically attached adjacent the inner periphery thereof to one end of a metallic cylinder **42**, preferably copper. Cylinder **42** is disposed coaxially with the longitudinal axis of the tube and functions as one side of an annular output line **43**. The other end of cylinder **42** is peripherally attached to one side of an annular duct **44**, preferably Kovar. The inner surface area of duct **44** is hermetically sealed to the outer perimeter of an annular dielectric ring **45**. The other external side of duct **44** is circumferentially attached to one end of metallic cylinder **46**, preferably copper. Cylinder **46** serves as one side of an external-connecting output line **47**. The inner perimeter of annular dielectric ring **45** is hermetically sealed to the internal surface area of annular duct **48**, preferably Kovar. One end of metallic cylinder **49** is peripherally attached to one of the external sides of duct **48** and serves as the other side of the external-connecting output line **47**. Annular dielectric ring **45** is an impedance matching device across the annular output line **43** and provides the line with a desired characteristic impedance, such as 50 ohms, for example. The other external side of annular duct **48** is circumferentially attached to one end of metallic cylinder **50**, preferably copper. Cylinder **50** is concentric with the longitudinal axis of the tube and serves as the other side of the output line **43**. The other end of cylinder **50** is peripherally attached to a metallic disc **51**, preferably copper. Metallic disc **51** is in parallel, spaced relationship with planar anode surface **15** whereby the combination forms a capacitor, indicated by **52**, which couples the RF current in anode **11** to the output line **43**. A central aperture in disc **51** is circumferentially sealed to an exhaust tubulation **53**, adjacent one end thereof. The other end of exhaust tubulation **53** is pinched off after processing of the tube is completed.

Metallic sleeves **54** and **55** have respective radially extending flanges at one end which are attached to the ends of screen grid support cylinders **22** and **40** respectively. Supporting sleeves **54** and **55** extend longitudinally within the annular anode cavity **12** in spaced relationship therewith. The other ends of supporting sleeves **54** and **55** are in parallel spaced relationship with one another and are attached to respective ends of parallel, U-shaped grid wires **56**. Screen grid wires **56** form an annular array of equally spaced members centrally disposed around the annular cavity **12**. The arcuate ends of screen grid wires **56** are attached to the concave surface of annular ring **57** whereby spaced relationship is maintained between the respective members of the annular array. The respective ends of cathode support cylinders **27** and **35** adjacent the open end of anode cavity **12** are circumferentially attached to the outer peripheries of respective annular flanges **58** and **59**. Since cathode support cylinder **27** is slightly shorter than cathode support cylinder **35**, flange **59** is slightly closer to the open end of anode cavity **12** than flange **58**. Supporting flanges **58** and **59** extend radially inward toward the annular centerline between cathode support cylinders **27** and **35** and have respective portions adjacent the inner peripheries thereof which overlap slightly in axial spaced relationship. Respective support rods **61** (FIG. 3) have respective ends attached to annular flange **59** and extend longitudinally into anode cavity **12**. Respective alternate support rods **60** have respective ends attached to annular flange **58**, pass insulatingly through respective apertures in annular flange **59** and extend longitudinally into anode cavity **12** in annular alignment with support rods **61**. Thus, support rods **60** and **61** form an annular array centrally disposed within the U-shaped screen grid. U-shaped filament wires **62** have respective ends attached to respective support rods **60** and **61**, as shown in FIG. 3, and are equally spaced apart around the anode cavity along the annular centerline thereof. Each screen grid wire **56** is perpendicularly disposed to an enclosed filament wire **62** and is located in a plane that bisects the enclosed filament wire. Each filament wire **62** is uniformly spaced from the encircling screen grid wire **56**. The end of control grid support cylinder **32** adjacent the open end of anode cavity **12** is peripherally attached to one side of a radial flange **63** along the annular centerline thereof. U-shaped control grid wires **64** have respective ends attached to flange **63** adjacent the respective inner and outer peripheries thereof and have respective sides which extend through openings in the respective radial flanges **58** and **59** in spaced relationship therewith. Control grid wires **64** form an annular array disposed longitudinally within the anode cavity between the filament array and the screen grid array and uniformly spaced therewith. The arcuate portions of control grid wires **64** may be interconnected by a support ring **64***a*, similar to support ring **57** on screen grid wires **56**. Referring again to FIG. 3, each of the U-shaped wires **64** in the control grid array is co-planar with one of the respective screen grid wires **56** and is uniformly spaced therefrom. Each of the U-shaped filament wires **62** is perpendicularly disposed to one of the respective control grid wires **64** and is uniformly spaced therefrom.

A permanent magnet **65** having the same general configuration as the annular anode **11** encloses the external surfaces of the anode and has opposing pole pieces **66** and **67** which produce a transverse magnetic field through anode cavity **12**. The magnetic field does not affect electrons moving radially toward the anode because these electrons are travelling in paths parallel to the flux lines of the magnetic field. However, electrons tending to travel in paths that cross the flux lines of the magnetic field will be acted on by the field and will be directed toward the anode **11**.

If it is desirable to change the resonant output frequency of anode cavity **12**, an RF inductance cavity may be connected between the screen grid terminal and the anode terminal. The inductance cavity may take the form of the annular cavity **68** which is shown in FIG. 1 connected across screen grid terminal **21** and anode terminal **16**. This type of cavity is made up of a sleeve **69**, preferably copper, which is bonded to one side of a dielectric ring **70** and has a radially extending flange **72**. The other side of dielectric ring **70** is bonded to a similar sleeve **73**, preferably copper, which has a radially extending flange **74**. This type of construction is similar to the nonconductive, RF reflecting barriers connected between one end of grid support cylinder **32** and the adjacent ends of cathode support cylinders **27** and **35**. The dielectric ring **70** prevents a DC short-circuit between the anode and the screen grid and the radially overlapping Kovar sleeves **69** and **73** represent a continuous metallic surface and, consequently, an RF short circuit to the resonant frequency.

An RF coupling loop **75** (FIG. 2) is sealed insulatingly in aperture **76** which extends through the RF reflecting barrier between one end of grid support cylinder **32** and the adjacent end of cathode support cylinder **27**. A high frequency current in coupling loop **75** feeds RF energy into the annular space between support cylinders **27** and **32**, which energy has an associated wavelength comparable with the longitudinal dimensions of the tube. Since the adjacent RF reflecting barrier represents a short-circuit and, therefore, low impedance to the RF energy, the associated RF current has a maximum amplitude and the associated RF voltage has a minimum amplitude at the RF reflecting barriers. The high frequency energy is transmitted through the spaces designated as E and D in FIG. 1. The openings in annular flange **58** adjacent the respective legs of control grid wires **64** are dimensioned for the transmission of the desired frequency. These openings may have any contour, such as cutouts, radial slots, etc., or may have any configuration, such as circular, elliptical, etc. The RF energy is transmitted through the spaces designated as C and B to the arcuate space A between the ends of the filament wires **62** and the control grid wires **64**. The RF energy passes through the arcuate region A and through the spaces designated as B′ and C′. The openings in annular flange **59** adjacent the other respective legs of control grid wires **64** are also dimensioned for transmission of the preselected frequency. The RF energy passes through these openings in annular flange **59** and through the spaces designated as D′ and E′ to the RF reflecting barrier between the end of grid support cylinder **32** and cathode support cylinder **35**. At the barrier, the RF energy is reflected back to the region A. Since the RF reflecting barrier represents a short-circuit, and, therefore, low impedance to the RF energy, the associated RF current amplitude has a maximum value and the associated RF voltage amplitude has a minimum value at the RF reflecting barrier. Thus, the RF cavity formed by the spaces E′, D′, C′, B′, A, B, C, D and E with RF reflecting ends is a half-wave cavity for the fundamental resonant frequency and a standing half wavelength of this frequency is set up in the symmetrically folded resonant cavity. Since a voltage node occurs at the RF reflecting ends of the folded cavity, the fundamental frequency has an RF associated voltage of maximum amplitude midway between the reflecting ends, that is in the arcuate region A. The voltage distribution associated with the fundamental frequency of the resonant cavity is shown in FIG. 4. Note that in the active interelectrode spaces B′ A B the voltage distribution is substantially constant. Thus, the fundamental resonant frequency will provide a uniform electrostatic field in the spaces B′, A and B between the filament wires **62** and the control grid wires **64**.

The electron stream flowing from the filament wires **62** to the anode **11** passes through the electrostatic field established in the space between the annular array of filament wires **62** and the annular array of control grid wires **64**. The electron stream is density modulated by

the uniform electrostatic field and, therefore, is a power amplified representation of the RF signal introduced into the resonant cavity by the RF coupling loop **75**. The density modulated electron stream passes through the region between the isolating screen grid wires **56** and the annular anode **11**. The DC component of the electron stream passes out of the tube through the annular flange **16** while the RF component passes out of the tube through output line **43**, as indicated by arrows **77**, after passing through coupling capacitor **52**. As pointed out above, RF components in the screen grid structure are bypassed to cathode ground through RF coupling capacitors **28** and **41**. Generally, in tubes of the prior art, the RF output energy is extracted from the anode cavity by a coupling loop which is insulatingly inserted into the annular inductance cavity **68** through the RF reflecting wall, similar to the method shown for inserting RF coupling loop **75** into the input resonant cavity. The disadvantages with such a method of coupling out the RF energy is that it limits reduction of the radial distance between the RF reflecting wall of the cavity **68** and the external wall of dielectric cylinder **19** whereby the output resonant frequency of the anode cavity **12** is varied. With the annular output line **43** of the illustrative tube, this radial distance can be reduced until the RF reflecting wall of inductance cavity **68** butts up against the external wall of dielectric cylinder **19**.

High frequency tubes of the prior art do not have a symmetrically folded, input resonant cavity; because the two cathode supporting cylinders are usually disposed coaxially within the control grid supporting cylinder, uniformly spaced therefrom and from one another. The described prior art structure is a convenient one to use because the filament wires, connected to the cathode supporting cylinders, are centrally disposed within the outline of the control grid wires. In high frequency operation of this tube, a nonconductive, RF reflecting member is connected across the space between one end of the control grid support cylinder and one end of the adjacent coaxial cathode support cylinder, and an RF coupling loop is insulatingly inserted therein. The input resonant cavity provided by this type of construction extends between the control grid support cylinder and the cathode support cylinder, through the interelectrode spaces designated as C, B, A and B′ in FIG. 1 and terminates at an opening between the filament electrode and the control grid electrode at point C′. Thus, a quarter wavelength input resonant cavity is provided by this type of tube which has a reflecting end adjacent the coupling loop and an open end at point C′ in FIG. 1. The fundamental frequency resonating in this type of cavity has an associated RF voltage of maximum amplitude at the open end, that is C′ in FIG. 1, which drops off in value through the active interelectrode spaces B′ A and B′ to have a minimum amplitude at the RF reflecting end adjacent the coupling loop. As shown in FIG. 5, the amplitude of the RF voltage drops off sharply in the active electrode spaces B, A and B′ and results in a nonuniform electrostatic field between the filament wires and the control grid wires. Thus, the density modulation of the electron stream passing through the nonuniform electrostatic field will not be a true representation of the high frequency signal introduced into the input resonant cavity by the RF coupling loop.

In FIG. 6, there is shown an alternative embodiment comprising a radial flange **78** on one end of annual sleeve **79**, preferably copper plated Kovar, hermetically attached to the inner periphery of cathode support cylinder **27** adjacent annular sleeve **29**. The other end of sleeve **79** is circumferentially sealed to one end of dielectric ring **80**, preferably ceramic, which is similarly sealed at the other end to one end of annular sleeve **81**, preferably copper plated Kovar. The opposite end of sleeve **81** is hermetically attached to the outer periphery of annular ring **82**, preferably copper, which is similarly attached around the entire inner periphery thereof to one side of grid support cylinder **32**. The opposite side of grid support cylinder **32** is circumferentially attached to the outer periphery of annular ring **83**, preferably copper, which is similarly secured throughout its inner periphery to one end of annular sleeve **84**, preferably copper plated Kovar. The opposite end of sleeve **84** is peripherally sealed to one end of dielectric ring **85**, preferably ceramic, which is similarly sealed at the other end to one end of annular sleeve **86**, preferably copper plated Kovar. A radial flange **87** at the opposite end of sleeve **86** is hermetically attached to cathode support cylinder **35** around the entire annular periphery thereof adjacent one end of sleeve **34**. This structure seals that portion of the gastight envelope between the end of grid support cylinder **32** remote from the electrodes and the adjacent ends of the respective cathode support cylinders **27** and **35**. The RF energy transmitted from RF coupling loop **75** passes through the dielectric "window" **80**, around the region A shown in FIG. 1, and through the other dielectric "window" **85** to the adjacent RF reflecting end of the folded resonant cavity. This alternative embodiment permits the removal of the nonconductive, RF reflecting ends from the tube without breaking the gastight seal of the tube envelope. Thus, nonconductive RF reflecting ends having other configurations and lengths can be interchanged with the RF reflecting ends shown in FIGS. 1 and 2. Hence the sides of the folded resonant cavity can be made longer and thereby change the fundamental resonant frequency of the input resonant cavity. Furthermore, this alternative embodiment eliminates the necessity of hermetically sealing the RF coupling loop **75** to the gastight envelope of the tube. Therefore, the RF coupling loop **75** can be inserted into and removed from the input resonant cavity through aperture **76** at any time that it proves convenient to do so.

Thus, there has been disclosed herein a novel input resonant cavity for high frequency operation of power tubes. Portions of the symmetrical folded resonant cavity are provided by the respective spaces between parallel cathode support cylinders and a grid support cylinder centrally disposed between the respective cathode support cylinders. The remaining portion of the resonant cavity is provided by the spaces between the filament wires connected to the cathode support cylinders and the enclosing control grid wires which are connected to the grid support cylinder. The resonant cavity is provided with reflecting ends by nonconductive, RF reflecting members connected between one end of the grid support cylinder and each of the adjacent ends of the cathode support cylinders. It will be obvious to those skilled in the art that the resonant cavity provided by this invention is applicable to triode tubes as well as tetrodes, and to planar tubes as well as annular tubes. It will also be obvious to those skilled in the art that the half-wavelength resonant cavity of this invention can be fed with an RF energy signal from either of the reflective ends or from both ends at the same time. These and other modifications which may occur to those skilled in the art are not intended to limit the spirt and scope of this invention but are intended to be included in the claims appended thereto.

We claim:

1. An electron discharge device comprising:

an elongated first electrode having spaced parallel sides connected at one end by a spanning portion;

an elongated second electrode axially and centrally disposed between said sides of the first electrode and spaced from said spanning portion thereby defining a symmetrically folded cavity between the first and second electrodes;

a first support member axially aligned with the second electrode and spaced therefrom having one end connected to the adjacent ends of said first electrode;

second and third support members disposed on oppo-

site sides of the first support member spaced parallel thereto and having one end connected to an adjacent end of the second electrode thereby defining extended portions of said symmetrical folded cavity;

nonconductive, RF reflecting means for connecting the other end of said first support member to adjacent ends of said second and third support members whereby reflective ends are provided for the symmetrically folder cavity;

and means for introducing RF signal energy into said cavity whereby the maximum voltage associated with said RF signal energy is substantially constant in the cavity region between said first and second electrodes.

2. An electron discharge device as set forth in claim 1 wherein nonconductive, RF transmitting means for hermetically sealing said first support member to said second and third support members is disposed between said ends thereof.

3. An electron discharge device comprising.

an anode electrode having an open-ended cavity therein;

a second electrode axially disposed in said anode cavity in spaced relationship with said anode and having a U-shaped contour opened toward the open end of the anode cavity;

a filamentary electrode axially and centrally disposed within the U-shaped second electrode and having its ends disposed adjacent said open end thereof, the space between said second and third electrodes forming a symmetrically folded cavity;

an elongated first support member axially aligned with the filamentary electrode and spaced therefrom and connected at one end to the ends of the second electrode;

second and third elongated support members disposed one on either side of said first support member spaced parallel therewith, each having an end adjacent the filamentary electrode connected to one end thereof whereby the symmetrically folded cavity between said first and second electrodes is extended to the spaces between the first support member and said second and third support members;

nonconductive, RF reflecting members connected between said first support member and said second and third support members adjacent the ends of the support members remote from the electrodes;

and means for introducing RF signal energy into the space between the support members.

4. An electron discharge device as set forth in claim 3 wherein nonconductive, RF transmitting members are hermetically attached to said first member and said second and third support members and are disposed between said ends thereof.

5. An electron discharge device comprising:

an elongated first electrode;

an anode electrode enclosing said first electrode;

a third electrode having opposing members disposed within said anode electrode on opposite sides of and parallel with said first electrode and in spaced relation therewith thereby defining between said first and third electrodes two portions of a symmetrical resonant cavity

means connecting members on one side of said first electrode with respective opposing members on the opposite side whereby said two cavity portions are in communication with one another;

a support for said third electrode axially aligned with said first electrode and spaced therefrom;

a pair of parallel spaced supports which are connected to said first electrode and disposed on opposite sides of said supporting member thereby defining between said supports and supporting member extended portions of said symmetrical resonant cavity;

nonconductive, RF reflecting members connected between said supports adjacent the ends remote from the electrodes;

and means for introducing RF signal energy into said cavity whereby the associated RF signal voltage maximum is substantially constant in the area of said first portions of the cavity.

6. An electron device as set forth in claim 5 wherein said first electrode is an array of parallel filament wires.

7. An electron discharge device as set forth in claim 5 wherein an elongated fourth electrode having opposing members disposed between said anode and third electrode on opposite sides and parallel with said third electrode and in spaced relation therewith, a second pair of parallel spaced supports which are connected to said fourth electrode, one disposed on one side of said first parallel spaced supports and one disposed on the opposite side thereof, and nonconductive members connected between said first and second pairs of parallel spaced supports adjacent the ends thereof remote from the electrodes.

8. An electron discharge tube comprising:

a gas-tight envelope;

an anode connected at one end to the envelope and having an open-ended cavity therein;

first and second arrays of parallel grid wires longitudinally disposed within said anode cavity in spaced relationship with said anode, the respective grid wires of said first grid array in opposing spaced relationship with the respective grid wires of said second grid array, said opposing grid wires having inter-connected ends within the anode cavity and respective opposite ends disposed adjacent the open end of said cavity;

first and second arrays of alternate parallel filament wires longitudinally disposed between said first and second arrays of grid wires and in spaced relationship therewith, said respective filament wires having interconnected ends within the anode cavity and respective opposite ends disposed adjacent the open end of said cavity;

a grid support member axially aligned with said first and second filament arrays and having a first end spaced from said opposite ends of the respective filament wires and connected to said opposite ends of the respective grid wires, said grid support member having an opposite end;

a first cathode support member disposed parallel with said grid support member and having a first end adjacent said first end of the grid support member and an opposite end;

a first interconnecting member having a portion thereof connected to said opposite ends of the first filament array and a portion thereof connected to said first end of the first cathode support member;

a second cathode support member disposed parallel with said grid support member on the side opposite the first cathode support member and having an end adjacent said first end of the grid support member and an opposite end;

a second interconnecting member having portions thereof connected to said opposite ends of the second filament array and portions thereof connected to said first end of said second cathode support member;

a first nonconductive, RF reflecting member having portions thereof connected to said opposite end of the first cathode support member and portions thereof connected to the grid support member adjacent said opposite end thereof in gas-tight relationship;

a second nonconductive, RF reflecting member having portions thereof connected to said opposite end of the second cathode support member and portions thereof connected to said grid support member adjacent said opposite end thereof in gas-tight relationship; and

means for introducing RF energy into the spaces be-

tween said cathode support members and said grid support member.

9. An electron discharge tube as set forth in claim **8** wherein said interconnected ends of said opposing grid wires are arcuate and said respective opposing wires of the first and second grid arrays are opposing sides of U-shaped grid wires, and said interconnected ends of said filament wires are arcuate and said filament wires of the first and second filament arrays are opposing sides of U-shaped filament wires.

10. An electron discharge tube as set forth in claim **8** wherein said first and second interconnecting members have respective openings therein, said openings having respective peripheries in spaced relationship with an adjacent grid wire.

11. An electron discharge tube as set forth in claim **8** wherein said tube is a magnetically beamed tube having a magnet of conforming configuration with the anode and

enclosing the external surfaces of the anode and having a magnetic field across the anode cavity whereby said magnetic field coacts with stray electrons and redirects said electrons to the anode.

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