Aug. 9, 1960 S. A. STAMESON 2,948,858

CAVITY RESONATOR CIRCUIT

Filed July 18, 1958 3 Sheets-Sheet 1

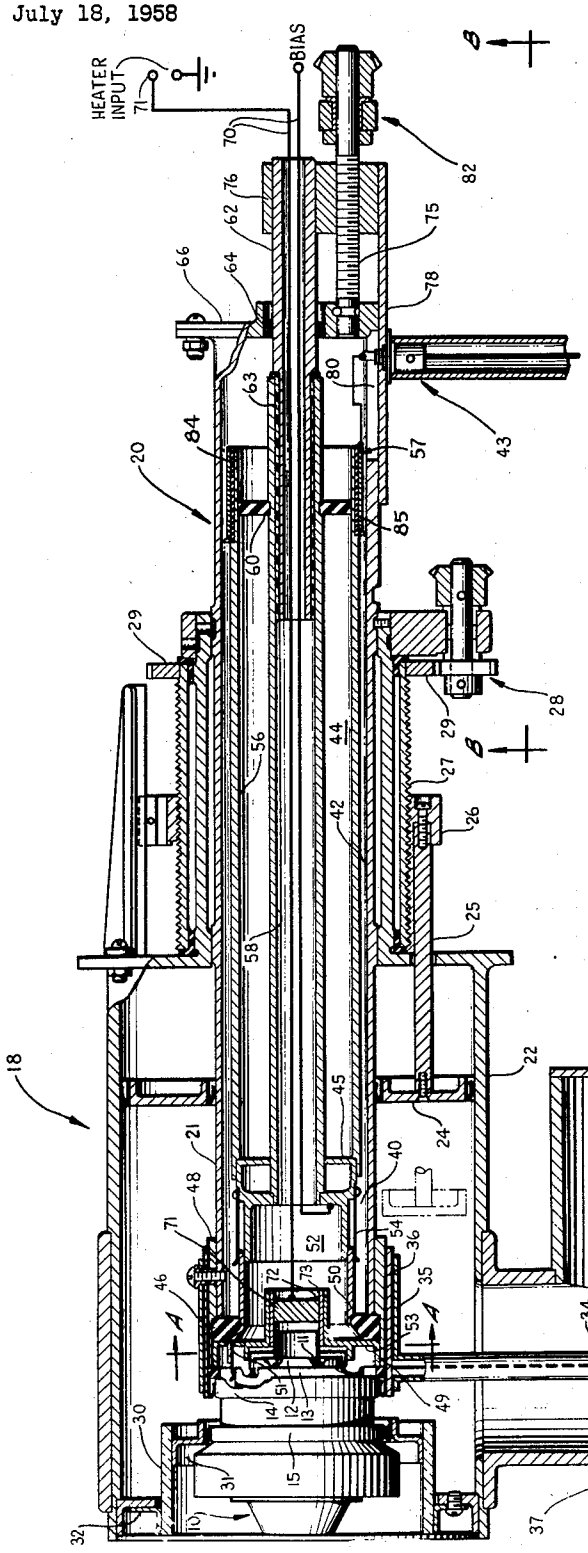


FIG. 1.

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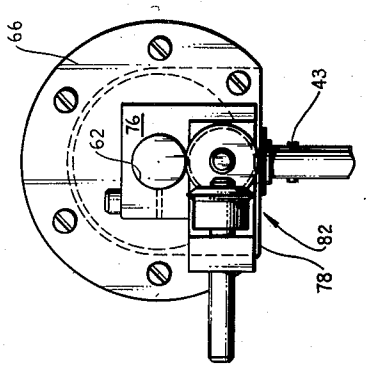


FIG. 4.

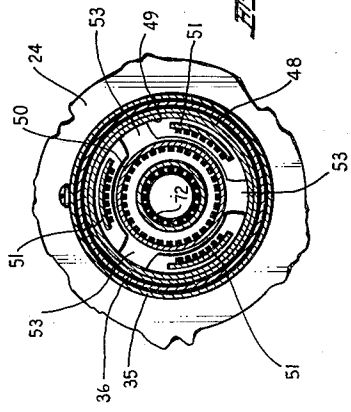


FIG. 2.

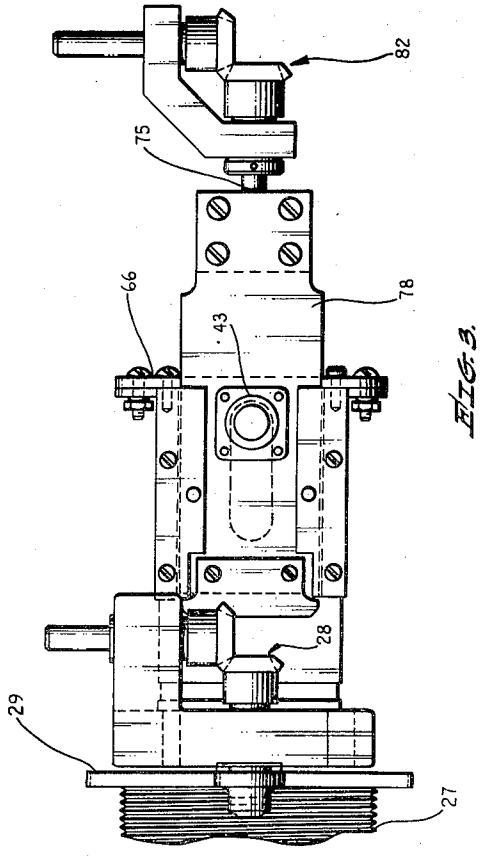


FIG. 3.

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CAVITY RESONATOR CIRCUIT

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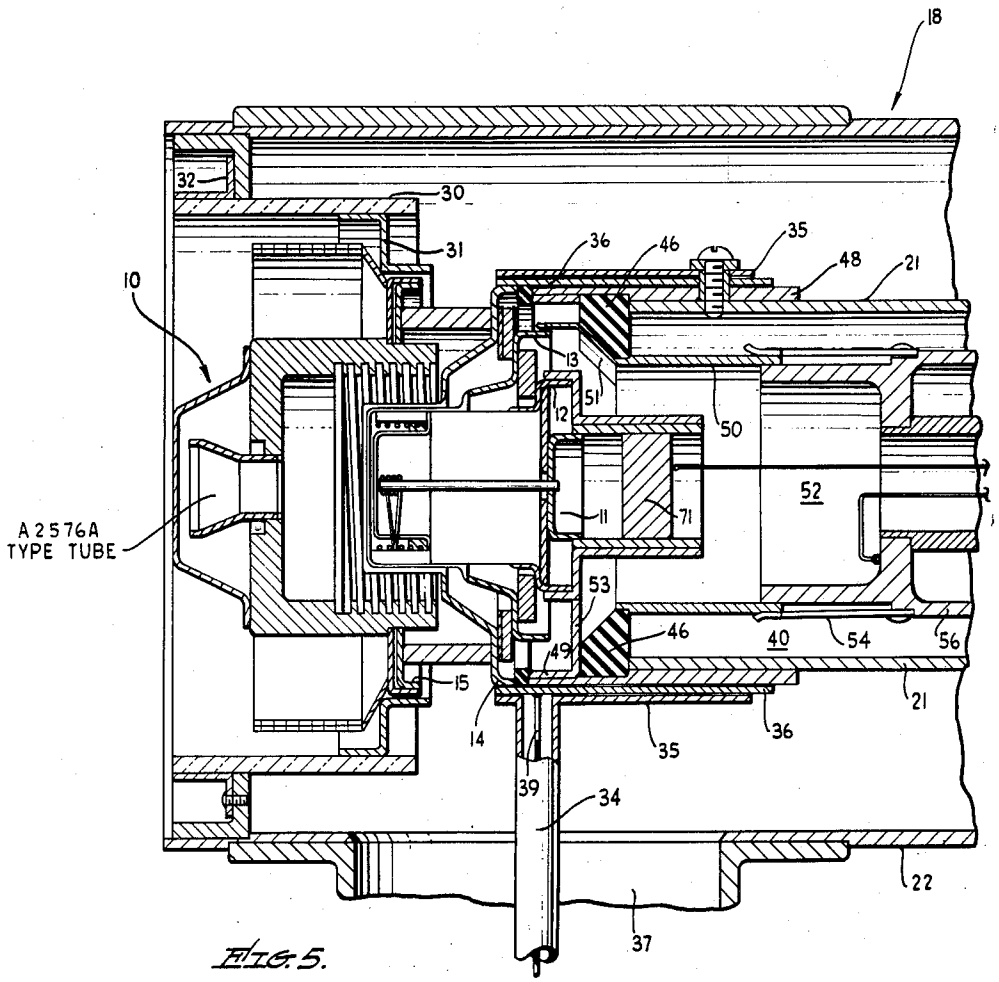


FIG. 5.

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2,948,858

CAVITY RESONATOR CIRCUIT

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Filed July 18, 1958, Ser. No. 750,550

4 Claims. (Cl. 330—56)

This invention relates generally to cavity resonator circuits which may be employed as the input or output circuit of very high frequency, ultra high frequency or microwave amplifiers and, more particularly, to a tunable three-quarter wave folded cavity resonator circuit which may be employed with a triode, tetrode or pentode electron discharge device in a manner to operate as either a grounded grid or grid driven amplifier.

In conventional cavity resonator circuits where single quarter wave cavities cannot be adapted to operate as either the input or output circuit of an amplifier employing an electron discharge device, it is the present practice to utilize either half-wave cavities or straight three-quarter wave cavities. A straight three-quarter wave cavity is of considerable length and thus its use necessitates a corresponding large amount of space for packaging purposes. Secondly, the straight three-quarter wave cavity requires multiple tuning adjustments which complicates the mechanical construction and makes tuning much harder to implement. The half wave open cavity, on the other hand, has disadvantages in that insulated rods are required for tuning adjustments and, in addition, presents a major problem in routing direct-current connections, filament connections and cooling pipes to and from the tube. Normally these latter connections have to come out through an R.F. portion of the cavity which is undesirable.

It is therefore an object of the present invention to provide an improved electron discharge device amplifier incorporating a folded three-quarter wave resonant cavity.

Another object of the invention is to provide a resonant cavity amplifier circuit wherein the radio-frequency and direct-current paths to and from the tube employed are separated.

Still another object of the invention is to provide a resonant cavity amplifier circuit including a grid bypass capacitor at a high radio frequency voltage point.

A further object of the invention is to provide an electron discharge device amplifier which includes a folded three-quarter wave cavity circuit which possesses a mechanical configuration that permits the use of a single tuning mechanism.

A still further object of my invention is to provide an electron discharge device amplifier which includes a resonant cavity composed of three sections, each of which possesses a characteristic impedance adapted to minimize frequency sensitivity.

In accordance with the present invention, a folded resonant cavity is employed, for example, as the input circuit of a grid driven R.F. amplifier. In particular, a quarter wave cavity is folded back over first and second quarter wave sections which together constitute a half wave open circuit cavity that is coupled across the control grid and cathode of the tube, the first quarter wave section being immediately adjacent thereto. In order to optimize bandwidth, the first quarter wave section must have a characteristic impedance which is no less than the capacitive reactance of the tube input and a length which

is adjustable to permit tuning of the cavity. The second quarter wave cavity, on the other hand, is a section of coaxial line which possesses a characteristic impedance that is less than one-half that of the first quarter wave section. The characteristic impedance of the second quarter wave section is low so as to minimize the reactive stored energy and thus optimize the bandwidth. When tuning the cavity the length of the second quarter wave cavity need not be changed thereby obviating the need of additional adjustment to maintain its length constant.

Lastly, the folded-back quarter wave cavity has at least twice the characteristic impedance of the first quarter wave cavity and is folded back under the second quarter wave cavity whereby the inner conductor of the second quarter wave cavity provides its outer conductor. The impedance of this section is made high to keep frequency sensitivity to a minimum, that is, to optimize bandwidth. Further, the length of this section is not affected by tuning whereby it does not require length compensation.

The above-mentioned and other features and objects of this invention and the manner of obtaining them will become more apparent by reference to the following description taken in conjunction with the accompanying drawing, wherein:

Fig. 1 illustrates an axial sectional view of apparatus embodying the improvements of my invention;

Fig. 2 illustrates view A—A of the apparatus of Fig. 1;

Fig. 3 illustrates view B—B of the apparatus of Fig. 1;

Fig. 4 illustrates a view of the left extremity as viewed in the drawing, of the device of Fig. 1; and

Fig. 5 is an enlarged view of a portion of the device of Fig. 1 showing the manner in which electrical connections are made to the tube.

Referring now to the drawings, Fig. 1 illustrates an axial sectional view of a preferred embodiment of the device of the present invention wherein the resonant cavity of the present invention is employed as the grid input cavity of a beam power tetrode tube. Referring also to Fig. 5, the disclosed radio-frequency amplifier includes a beam power tetrode tube **10** which may, for example, be of the type which is designated A2576A. The tube **10** possesses a heater terminal **11**, a heater and cathode terminal **12**, a control grid terminal **13**, a screen grid terminal **14**, and a plate terminal **15**, all of which are circular and which, as shown in Fig. 1, have portions cut away for illustrative purposes. The particular arrangement of the terminals **11** to **15** on the envelope of the tube **10** shown in the drawing is a natural and customary terminal arrangement in beam power tetrode tubes of the type illustrated.

The radio-frequency amplifier of the present invention comprises a conventional type output resonant cavity **18** and an input resonant cavity **20**, the configuration and operation of which is in accordance with the present invention. In general, the output resonant cavity **18** is coaxial with and surrounds a portion of the input resonant cavity **20**. In particular, an outer wall **21** of the input cavity **20** serves as the inner cylindrical boundary wall and a cylindrical metallic exterior anode wall **22** serves as the outer boundary wall for the output cavity **18**. The tube **10** is maintained in a centrally disposed position within the output cavity **18** by means of an annular ceramic member **30** which has both of its lateral surfaces metallized to provide a bypass capacitor to ground and which is fitted with a seating ring **31** which possesses a number of metallic springs adapted to engage the plate terminal **15** of the tetrode tube **10**. Ceramic member **30** is, in turn, held in a centrally disposed position within the output cavity **18** by means of a circular support member **32**. In operation the plate terminal **15** is maintained at a potential of the order of 6,000 volts,

The coaxial output cavity 18 is tuned to resonance by means of a slidable apertured disc 24 which has contacting springs to provide electrical contact with the inner wall 21 and the outer anode wall 22 of the output cavity 18. The position of the slidable apertured disc 24 is controlled by three longitudinal members 25, which members 25 are fastened to a ring 26 which, in turn, is engaged by means of threads with a rotatable annular member 27. A gear arrangement 28 engages a spur gear 29 which is attached to the periphery of the annular member 27 for rotating it and thus position the apertured disc 24 in the output resonant cavity 18 thereby to determine the frequency for which it is tuned. Amplified radio frequency energy is extracted from the output cavity 18 by a hollow conductor 34 which is coupled to the cavity 18 and, in addition, capacitively coupled to the screen grid of tube 10 through annular elements 35, 36, the latter of which is connected to the screen grid terminal 14 of tube 10. Conductor 34 constitutes the extension of the center conductor of a coaxial transmission line 37 which extends through an opening in the exterior anode cavity wall 22. The transmission line 37 has a shorted quarter wave T stub line 38 located near the output from the cavity 18 whereby the conductor 34, which as specified above is hollow, provides a radio frequency space for an insulated lead 39. The lead 39 is connected to the annular element 36 and hence provides means for applying an appropriate potential to the screen grid terminal 14 of the tube 10. In the disclosed device, the operation of the output cavity 18 is considered conventional and hence will not be elaborated upon.

In order to describe more clearly the input cavity 20 together with its manner of operation, reference is made to Figs. 1 to 4 wherein Figs. 2 and 3 illustrate views A—A and B—B of the axial sectional view of the apparatus shown in Fig. 1, respectively, and Fig. 4 is an end view thereof. Referring to these figures wherein like reference numerals designate like parts or elements, the input resonant cavity 20, in general, comprises a first quarter wave section 40 which has an extremity coupled across the control grid terminal 13 and the cathode and heater terminal 12 of tube 10, a second quarter wave section 42 which extends from the remaining extremity of the first section 40 to a coaxial input 43 and a folded back quarter wave section 44 which is folded back under the second quarter wave section 42 and extends from the coaxial input 43 to a shorting termination 45.

More particularly, the inner boundary cylindrical wall 21 of the output cavity 18 is extended to provide the outer boundary wall for the first and second quarter wave sections 40, 42 of the input cavity 20. The cylindrical wall 21 butts up against a dielectric ring 46 and is expanded as well as extended at this point by means of an annular metallic element 48. The dielectric ring 46 serves as a support for an annular metallic member 50 which constitutes a portion of the length of the inner boundary wall of the quarter wave section 40. The left extremity of the annular metallic member 50, as viewed in the drawing, which constitutes the inner boundary wall of the quarter wave section 40, is expanded and extended over three arcuate portions 51 (see Fig. 2) which have a number of finger contacts that are adapted to electrically engage the control grid terminal 13 of the tube 10. The outer boundary wall of quarter wave section 40, on the other hand, is extended by the annular metallic element 48 which, in turn, is attached to the periphery of rim-shaped member 49 which has three spokes 53 that extend radially inwards between the arcuate portions 51 to electrically engage the heater and cathode terminal 12. The right extremity of the annular member 50, as viewed in the drawing, is adapted to receive a metallic "cup-shaped" member 52 which has a central aperture and which is surrounded by axially disposed finger contact strips 54 that are adapted to make a slidable electrical contact with the annular member 50. As will hereinafter be explained in more detail, the electrical length of the first quarter wave section 40 is determined by the extent to which the metallic "cup-shaped" member 52 is inserted into the annular metallic member 50.

The inner boundary wall of the second quarter wave section 42 is provided by a metallic cylindrical member 56 which is supported by and extends from the outer periphery of the "cup-shaped" member 52 to a point short of the coaxial input 43. At this point the cylindrical member 56 is connected through a capacitor 57 to the center conductor of coaxial input 43. Capacitor 57 is provided by undercutting the outer surface of the right extremity of the tube 56, as viewed in the drawing, sliding on a "Teflon" sleeve 84 which has a small flange portion which juts up against the under-cut and sweating an annular metallic band 85 about the outer surface of the sleeve 84. This metallic band 85 is connected to the center conductor of coaxial input 43. Capacitor 57 may, for example, have a capacitance of the order of 200 micromicrofarads. Also extending from the "cup-shaped" member 52 is a metallic tube 58 which commences from the centrally disposed aperture thereof and extends the length of the cylindrical member 56 and is centrally supported therein by means of a dielectric disc 60. Further, the right portion of the tube 58 is capacitively coupled and physically attached to a metallic tube 62 through a dielectric layer 63, the latter tube 62 being supported by finger-contacting springs 64 which are disposed around the circumference of a circular aperture in an appendage 66 which, in turn, is attached as viewed in the drawings to the right extremity of the metal cylinder 21. Thus, the contacting springs 64 provide a slidable support for the tube 62 thereby maintaining the tube 58 and the cylindrical member 56 centered within the cylindrical wall of input resonant cavity 20.

In addition to providing the inner boundary wall of the folded back quarter wave section 44, the metallic tube 58 together with tube 62 provides an R.F. free entry for heater and bias leads 70 that provide R.F. free connections to the heater and control grid terminals 11, 12, respectively. More particularly, the heater lead connects to a plug 71 that is received by an annular element 72 which, in turn, has a finger contact ring that is adapted to engage the heater terminal 11 of tube 10. The heater terminal 11 is by-passed to ground through a capacitance provided by a metallic annular element 73 that is disposed coaxially about the annular element 72 and is insulated therefrom by a thin layer of dielectric material. The left extremity of the annular element 73, as viewed in the drawing, extends radially outwards to electrically engage the heater and cathode terminal 12 of the tube 10 and to connect through the spokes 53 to the rim-shaped member 49 which is maintained at ground potential. The bias lead 70, on the other hand, is connected to the "cup-shaped" member 52 thereby to provide a means of applying bias potential to the control grid terminal 13 of tube 10.

In accordance with one object of the present invention, the input resonant cavity 20 is tunable by making only one adjustment which adjustment tunes the length of the first quarter wave section 40 without affecting the second and folded back resonant sections 42, 44, respectively. To accomplish the tuning, a threaded longitudinal element 75 is rotatably mounted in the appendage 66 and extends therefrom to the right, as viewed in the drawing parallel to the metallic tube 62. The threaded longitudinal element 75 is engaged by means of threads to a member 76 which is affixed to the end portion of the metallic tube 62 and to a slidable member 78. The coaxial input 43 is attached to the slidable member 78 whereupon it moves axially along the input cavity 20 along with the metallic tubes 58, 62, the cylinder 56 and "cup-shaped" member 52. The outer boundary wall 21 of the input cavity 20 has an aperture to accommodate the longitudinal

movement of the coaxial input 43. A gear arrangement 82 is attached to the end portion of the threaded rotatable longitudinal element 75 to enable it to be turned by an appropriate amount to tune the input cavity 20.

In operation, radio frequency energy is fed through the center conductor of the coaxial input 43 and through the capacitor 57 to the right extremity of the metal cylinder 56, as viewed in the drawing. This excites both the folded back resonant quarter wave section 44 together with the second quarter wave section 42. In that the folded back quarter wave section 44 has a shorting termination 45, it presents a very high impedance at its input which is at the output side of the capacitor 57. The input energy is also fed to the second quarter wave section 42 which has an inner boundary provided by the metal cylinder 56 and an outer boundary provided by the cylindrical wall 21. The second quarter wave section 42 is terminated by the first quarter wave section 40 and, as specified above, has a characteristic impedance that is less than one-half the characteristic impedance of the first quarter wave section 40. Also, in order to optimize bandwidth, as specified above, the characteristic impedance of the folded back quarter wave section is made equal to or greater than twice the characteristic impedance of the first quarter wave section 40. It is to be noted that the turning of the threaded longitudinal member 75 to effect tuning of the first quarter wave section 40 does not affect the length of the second quarter wave section 42 or the folded back quarter wave section 44, nor the relative spacing of the coaxial input 43 with respect thereto.

Lastly, the first quarter wave section 40 receives a signal from the second quarter wave section 42 and applies it across the heater and cathode terminal 12 and control grid terminal 13 of the tube 10. As specified above, the characteristic impedance of the first quarter wave 40, to achieve optimum bandwidth, is made greater than the capacitance reactance of the tube input.

What is claimed is:

1. A radio-frequency amplifier comprising an electron discharge device having at least a cathode terminal, a control grid terminal and a heater terminal, an input resonant cavity including a first tunable one-quarter wave section having an extremity coupled across said control grid terminal and said cathode terminal, said first section having a first cylindrical outer conductor and a first substantially cylindrical inner conductor disposed concentrically within said outer conductor, said first inner conductor being of adjustable length thereby to enable said first quarter wave section to be tuned; a second quarter wave section of fixed length having an extremity coupled to the remaining extremity of said first quarter wave section, said second quarter wave section having a second substantially cylindrical outer conductor attached and electrically connected to said first outer conductor and a second hollow cylindrical inner conductor disposed concentrically within said second outer conductor and attached and electrically connected to said first inner conductor; a third quarter wave section folded back from said second quarter wave section, said third quarter wave section being provided by a third cylindrical inner conductor disposed concentrically within said second inner conductor and being attached thereto with a shorting termination one-quarter wavelength from the extremity thereof that is common with the remaining extremity of said second section; means coupled to said second inner conductor for simultaneously exciting said second and third quarter wave sections with an input signal; and means attached to said third inner conductor for slidably moving one extremity of said first inner conductor thereby to tune said input resonant cavity.

2. The radio-frequency amplifier as defined in claim 1 which additionally includes an electrical conductor connected to said heater terminal and extending through said third cylindrical inner conductor to a direct-current input terminal thereby to provide a radio frequency free direct-current connection to said electron discharge device.

3. A radio-frequency amplifier having an electron discharge device with a circular heater terminal and concentric cathode and grid terminals, said terminals being disposed in the order named in proceeding outwards from the axis of the evacuated envelope of said discharge device; an input resonant cavity comprising a first tunable one-quarter wave section having an extremity coupled across said grid and cathode terminals, said first section having a first cylindrical outer conductor connected to said cathode terminal and a first substantially cylindrical inner conductor disposed concentrically within said outer conductor and which crosses over said outer conductor to connect to said grid terminal, said first inner conductor being of adjustable length thereby to enable said first quarter wave section to be tuned; a second quarter wave section of fixed length having an extremity coupled to the remaining extremity of said first quarter wave section, said second quarter wave section having a second substantially cylindrical outer conductor attached and electrically connected to said first outer conductor and a second hollow cylindrical inner conductor disposed concentrically within said second outer conductor and attached and electrically connected to said first inner conductor; a third quarter wave section folded back from said second quarter wave section, said third quarter wave section being provided by a third cylindrical inner conductor disposed concentrically within said second inner conductor and being attached thereto with a shorting termination one-quarter wavelength from the extremity thereof that is common with the remaining extremity of said second section; means coupled to said second inner conductor for simultaneously exciting said second and third quarter wave sections with an input signal; and means attached to said third inner conductor for slidably moving one extremity of said first inner conductor thereby to tune said input resonant cavity, said last-named means being rigidly attached to said means coupled to said second inner conductor for simultaneously exciting said second and third quarter wave sections with an input signal whereby tuning said first quarter wave section does not affect tuning of said second and third quarter wave sections.

4. In a radio-frequency amplifier including an electron discharge device having concentric cathode and grid terminals with a predetermined input reactance, an input resonant cavity comprising a first tunable one-quarter wave section with a characteristic impedance that is no less than said predetermined input reactance, one extremity of said first section being coupled across said grid and cathode terminals, said first section having a first cylindrical outer conductor and a first substantially cylindrical inner conductor disposed concentrically within said outer conductor and being of adjustable length thereby to enable said first quarter wave section to be tuned; a second quarter wave section of fixed length with a characteristic impedance that is no more than one-half said predetermined input reactance, one extremity of said second section being coupled to the remaining extremity of said first quarter wave section, said second quarter wave section having a second substantially cylindrical outer conductor attached and electrically connected to said first outer conductor and a second hollow cylindrical inner conductor disposed concentrically within said second outer conductor and attached and electrically connected to said first inner conductor; a third quarter wave section with a characteristic impedance that is no less than twice said predetermined input reactance, said third section being folded back from said second quarter wave section and provided by a third cylindrical inner conductor disposed concentrically within said second inner conductor and being attached thereto with a shorting termination one-quarter wavelength from the extremity thereof that is common with the remaining extremity of

said second section; means coupled to said second inner conductor for simultaneously exciting said second and third quarter wave sections with an input signal; and means attached to said third inner conductor for slidably moving one extremity of said first inner conductor thereby to tune said input resonant cavity, said last-named means being rigidly attached to said means coupled to said second inner conductor for simultaneously exciting

said second and third quarter wave sections with an input signal whereby tuning said first quarter wave section does not affect tuning of said second and third quarter wave sections.

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UNITED STATES PATENTS

2,706,802 Meisenheimer ---------- Apr. 19, 1959

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,948,858 August 9, 1960

Spiro A. Stameson

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 25, after "frequency" insert -- free --.

Signed and sealed this 4th day of April 1961.

(SEAL)
Attest: ERNEST W. SWIDER

XXXXXXXXXXX
Attesting Officer

ARTHUR W. CROCKER
Acting Commissioner of Patents