April 30, 1957 T. M. GLUYAS, JR., ET AL 2,790,857

OUTPUT OR INPUT CIRCUITS FOR VACUUM TUBES

Filed April 1, 1954 3 Sheets-Sheet 1

Fig. 1.

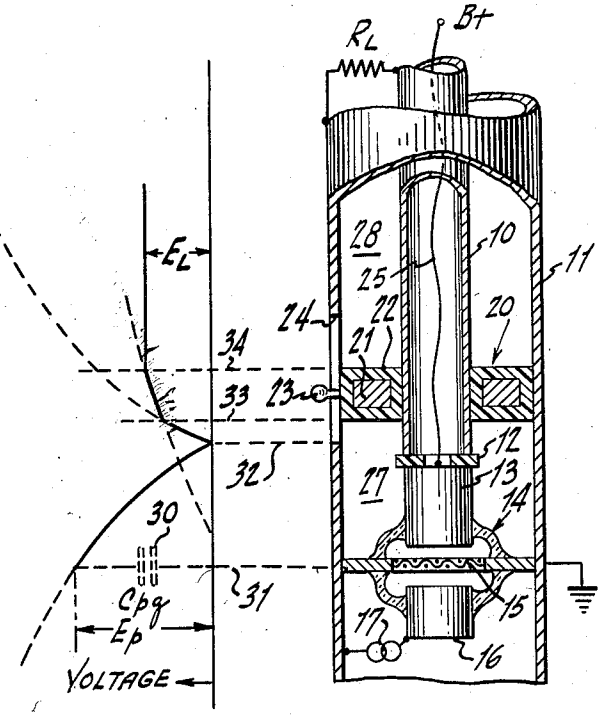
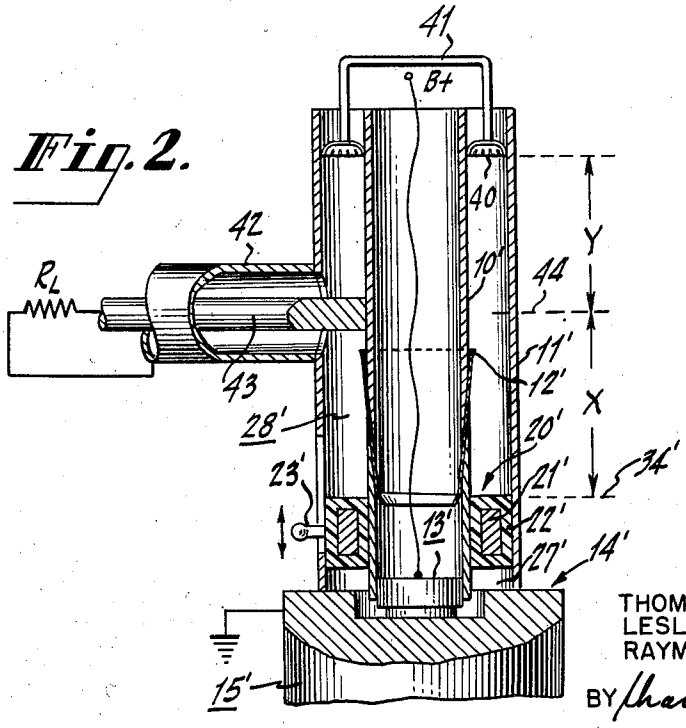


Fig. 2.



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Fig. 3.

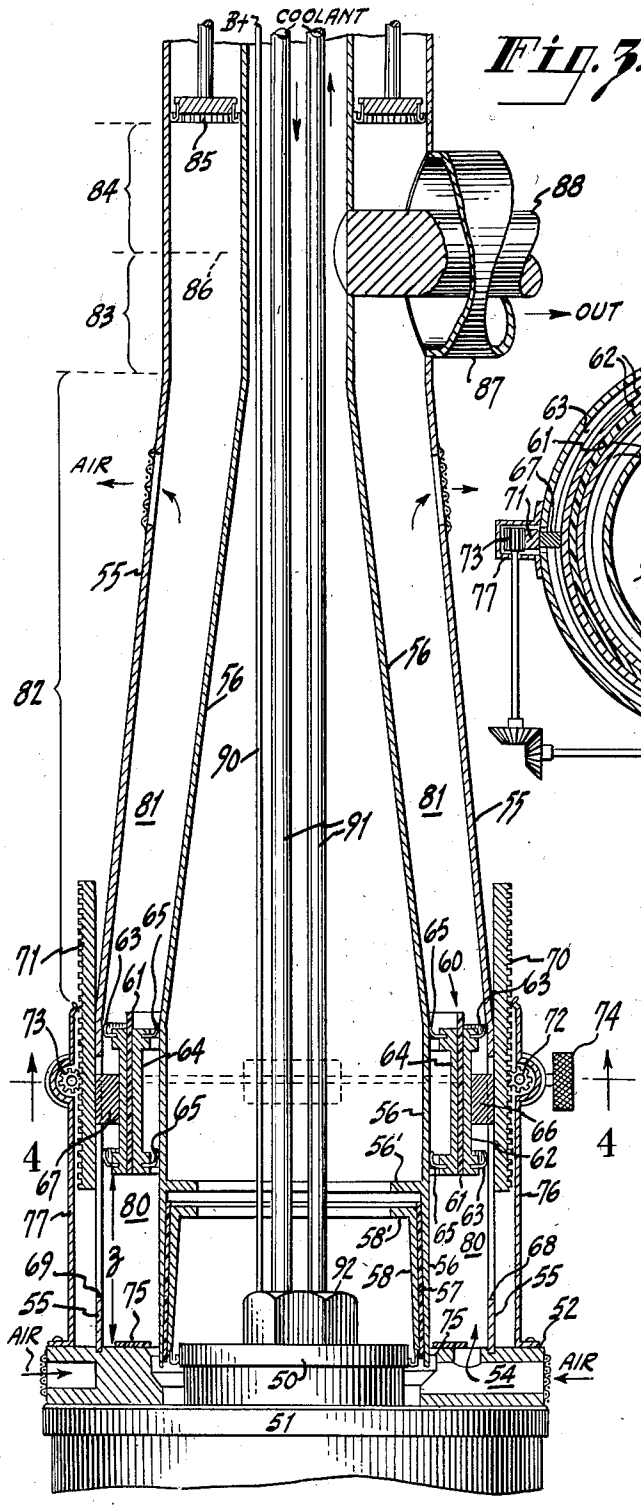
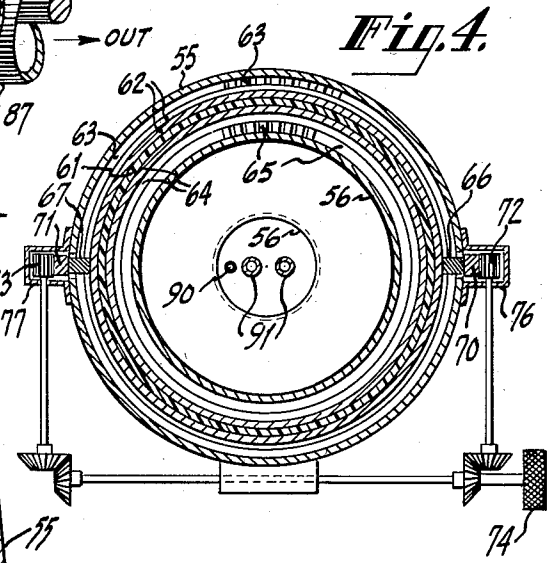


Fig. 4.



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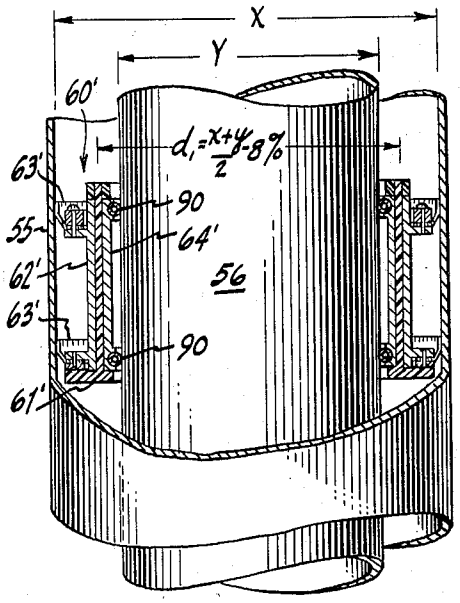


Fig. 5.

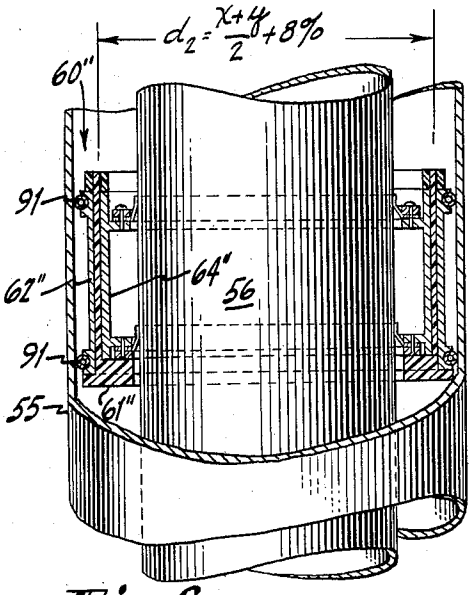


Fig. 6.

Fig. 7.

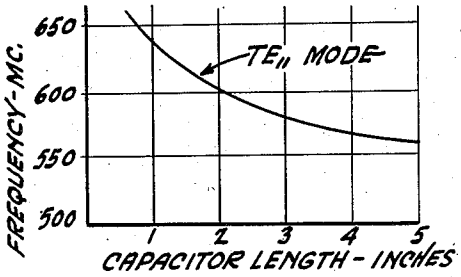
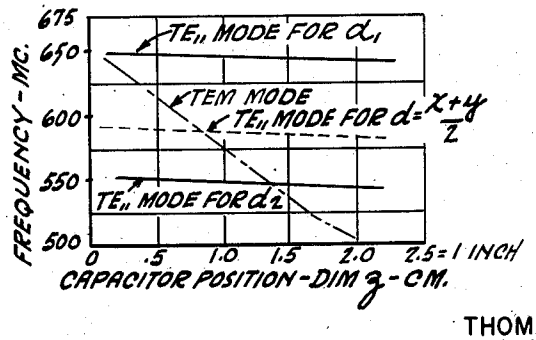


Fig. 8.



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2,790,857

OUTPUT OR INPUT CIRCUITS FOR VACUUM TUBES

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Application April 1, 1954, Serial No. 420,396

8 Claims. (Cl. 179—171)

This invention relates to high power, ultra-high frequency coaxial line output or input circuits for vacuum tubes. More specifically, the invention relates to improvements in coaxial line vacuum tube circuits of the type described in U. S. Patent No. 2,421,784, "Ultra-high Frequency Apparatus," issued to L. W. Haeseler et al. on June 10, 1947. Circuits of this type include a coaxial line coupled at one end to electrodes of a vacuum tube and at the other end to an output or input line. A tuning capacitor is disposed concentrically between the inner and outer conductors of the coaxial line to form a resonant cavity on the vacuum tube side of the capacitor and a transmission line on the other side of the capacitor. The capacitor is arranged to be axially adjustable in position to tune the resonant cavity, and to couple the cavity with the transmission line.

It is a general object of this invention to provide an improved coaxial line circuit of the type described for efficiently handling high power, ultra-high frequency energy.

It is another object to provide an improved coaxial line circuit which is equally effective over a broad range of operating frequencies, and which is capable of handling relatively broad band signals.

It is a further object to provide an improved power amplifier output circuit for an ultra-high frequency television transmitter capable of transmitting either black and white or color signals.

In one aspect, the invention comprises a coaxial line having an inner conductor connected to one electrode of a vacuum tube and an outer conductor connected to another electrode of the vacuum tube so that the space between said electrodes is in communication with the space between said inner and outer conductors. A generally annular capacitor is mounted to be axially reciprocable and electrically effective between the inner and outer conductors of the coaxial line. The capacitor effectively divides the coaxial line into a coaxial resonant cavity in communication with the space between the electrodes in the tube, and a coaxial transmission line. The position of the capacitor determines the size, and therefore the resonant frequency, of the resonant cavity, and the capacitor also serves to couple energy from the resonant cavity to the transmission line.

A feature of the invention is the construction of the annular capacitor in the form of two concentric metallic tubes separated by a tube of dielectric material. The dielectric tube is forced under high pressure between the metallic tubes to preclude the presence of air pockets. The inner and outer metallic tubes electrically engage the inner and outer conductors, respectively, of the coaxial line thru stiff contact fingers. Destructive, unwanted oscillations in the circular or TE_{11} mode are avoided by a construction whereby the diameter of the dielectric tube bears a predetermined relationship with the mean of the diameters of the inner and outer conductors of the coaxial line.

These and other objects and aspects of the invention

will appear from the following more detailed description taken in conjunction with the appended drawings, wherein:

Figure 1 is a sectional view of a vacuum tube output circuit, together with a chart of relative voltages existing at corresponding points therein, which will be used in explaining the operation of the circuit;

Figure 2 is a vacuum tube output circuit according to the invention;

Figure 3 is a longitudinal sectional view of a presently preferred form of vacuum tube output circuit according to the invention;

Figure 4 is a transverse sectional view taken on the line 4—4 of Figure 3;

Figure 5 is a sectional view showing a capacitor construction suitable for use over a given range of frequencies;

Figure 6 is a sectional view showing a capacitor construction suitable for use over a different overlapping range of frequencies;

Figure 7 is a chart illustrating frequencies at which destructive TE_{11} mode oscillations occur, as a function of capacitor axial length; and

Figure 8 is a chart illustrating the operating characteristics of the two capacitors shown in Figures 5 and 6.

Figure 1 shows a vacuum tube output circuit including coaxial inner and outer conductors **10** and **11**, respectively. The inner conductor **10** is coupled for radio frequencies thru an annular insulator **12** to the anode **13** of a vacuum tube generally designated **14**. The grid **15** of the vacuum tube is connected to the outer conductor **11**. The vacuum tube **14** also includes a cathode **16**. A source of input radio frequency energy connected between the outer conductor **11** and the cathode **16** is represented schematically at **17**. An annular capacitor generally designated **20** is mounted to be axially reciprocable and electrically effective between the inner and outer conductors **10** and **11**, respectively. The capacitor **20** consists of a conductive annnular core **21** surrounded by an insulating sheath **22**. A handle **23** is connected to the capacitor **20** and extends thru a longitudinal slot **24** in the outer conductor **11**. The handle **23** permits the capacitor **20** to be moved axially in the coaxial line for tuning purposes.

The inner conductor **10** is hollow to permit the connection of direct current potential from a B+ terminal thru a conductor **25** to the anode **13** of vacuum tube **14**. Insulator **12** serves as a B+ isolating capacitor. An output load is schematically represented by a resistor R_L connected between the inner conductor **10** and the outer conductor **11**.

The operation of the vacuum tube output circuit shown in Figure 1 will be described in connection with the chart of voltages appearing at various points therein. The chart is plotted on the assumption that the vacuum tube **14** is one having a capacitive output reactance. The capacitor **30** represents the capacitance between the anode **13** and the grid **15** of the vacuum tube **14**. The voltage E_p represents the magnitude of the radio frequency voltage existing between the anode **13** and the wall of the outer conductor **11** at the point where it connects with the grid **15**. The standing wave voltage at points intermediate plane **31** and plane **32** is shown by the solid curve to gradually decrease in sine wave fashion to substantially zero potential at the plane **32**. The standing wave potential then increases continuously to the plane **33** at the lower edge of capacitor **20** where there is a discontinuity in the potential curve. The voltage increases at a lower rate in the distance between the plane **33** and the plane **34** between which the capacitor **20** is located. At the plane **34** the potential is substantially equal to the

constant potential existing throughout the transmission line 28 to the load R_L.

The distance between plane 31 and plane 34 constitutes an electrical half-wavelength at the operating frequency for the reason that the voltages in these planes differ in phase by 180 degrees. The axial position of the capacitor 20 may be varied to tune the resonant cavity 27 to an electrical half-wavelength at any desired frequency within a relatively broad range. It is thus apparent that the axial position of the capacitor 20 serves to properly tune the resonant cavity 27 at the desired operating frequency.

The slope of the voltage curve between planes 33 and 34 is determined by the capacitance per unit of axial length of the capacitor 20. The capacitance of capacitor 20 is in turn determined by the relative dimensions of the conductor 21 and the insulating sheath 22, and the dielectric constant of the material in sheath 22. The axial length of the capacitor 20 determines the amount of voltage change between planes 33 and 34 with a given capacitance per unit of axial length. The solid line in the curve of voltage between plane 33 and 34 is extended at both ends by dash line to suggest the manner in which various capacitors 20 of different axial length may be utilized to produce a desired voltage E_L within the coaxial transmission line 28 and at the load resistor R_L. It is thus far apparent that the capacitor 20 serves to tune the resonant cavity 27 to the desired operating frequency, and also serves to provide the desired voltage transformation in coupling energy from the resonant cavity 27 to the coaxial transmission line 28.

The capacitor 20 may also be considered as a section of coaxial line coupling the coaxial resonator 27 to the coaxial transmission line 28. The surge impedance of the coaxial line between planes 33 and 34 is given by the formula:

$$Z_s = \frac{33.3}{C} \text{ ohms}$$

where Z_S is the surge impedance of the line between planes 33 and 34, and C is the capacitance in micro-microfarads between the inner conductor 10 and the outer conductor 11 per centimeter of axial length. Various useful combinations of surge impedance in the coaxial line 10, 11 and in the section between the planes 33 and 34 may be selected. As a typical example, the coaxial line 10, 11 may be constructed to have a surge impedance in the range between 10 and 60 ohms, and the surge impedance of the capacitor section between planes 33 and 34 may then have a surge impedance of between 1 and 4 ohms. It may be proper to consider the capacitor 20 as a section of transmission line when its axial length is in the order of a quarter-wavelength, or more. When the axial length of the capacitor 20 is much less than a quarter-wavelength, it may be more appropriate to consider it as a lumped capacitance.

Figure 2 shows a modified form of the invention in which corresponding elements have the same numerals as are used in Figure 1 except that prime designations are added. A fragment of the vacuum tube 14' is illustrated, including a grid electrode contact ring 15' partially broken away to reveal an anode electrode 13'. The construction shown in Figure 2 differs from that shown in Figure 1 in that the B+ isolating capacitor formed by insulator 12' is located in the coaxial transmission line 28' above the capacitor 20' rather than in the coaxial resonator 27'. By this construction, the B+ blocking capacitor carries much less radio frequency current and this sometimes constitutes an advantage in preventing stray radio frequency radiation when water cooling pipes, etc., are carried down the center of the hollow inner conductor 10'.

Figure 2 also shows a construction for taking off the output power from the coaxial transmission line 28', and at the same time providing access to the anode 13' for a B+ lead and water cooling pipes. The top end of the coaxial transmission line 10', 11' is shorted by an annular shorting ring 40 which is axially adjustable in position by means of a handle 41. A coaxial output line includes an outer conductor 42 connected to the outer conductor 11', and an inner conductor 43 connected to the inner conductor 10', at a junction plane 44. A load resistance R_L is schematically represented as a resistor connected from the outer conductor 42 to the inner conductor 43. By way of example, it was found that with the dimension X having a value of 0.165 wavelength or 0.165 wavelength plus an even number of quarter-wavelengths, the shorting ring 40 could be varied in position so that the dimension Y varied from one-eighth to one-fourth wavelength to provide a load impedance variation thru a range of 2.61 times, the load impedance at plane 34' being substantially a pure resistance throughout this range.

It will be understood that the shorted stub between the junction plane 44 and the shorting ring 40 can be transposed with the coaxial output line 42, 43 and the output taken axially out from the top of the coaxial line 10', 11'. The arrangement shown in Figure 2 is preferred for the practical reason that the entire assembly including coaxial line 10', 11' may be moved upward to facilitate the removal of the vacuum tube 14' without complications due to the presence of water cooling pipes within the hollow inner conductor 10'.

Figures 3 and 4 show a form of the invention constructed and employed to amplify television radio frequency picture-modulated signals from 1 kilowatt to 20 kilowatts at frequencies in the ultra-high frequency range between 470 and 940 megacycles. Figures 3 and 4 show the output circuit used with an RCA tetrode tube type 6448. The tube is one having an inner anode and an outer concentric cathode. The tube is shown in part as including an anode contact ring 50 and a cathode contact ring 51. The base ring 52 is mounted in electrical contact with the cathode ring 51 to limit the size of the cavity effectively between the cathode 51 and the anode 50. The base ring 52 is provided with conduits 54 for the circulation of cooling fluid such as air thru the output circuit.

A coaxial line includes an outer conductor 55 connected thru the base ring 52 to the cathode 51, and an inner conductor 56 coupled to the anode 50. The coupling from the inner conductor 56 to the anode 50 is thru a B+ blocking capacitor formed by the insulating cylinder 57 and an anode contacting cylinder 58. The parts 56, 57 and 58 are tapered, and flanges 56' and 58' are provided which may be forced toward each other to positively exclude air pockets from the blocking capacitor.

An annular capacitor 60 is mounted concentrically between the outer conductor 55 and the inner conductor 56 in such a way that it can be moved axially for tuning purposes. Capacitor 60 consists of cylindrical metallic capacitor plates 62 and 64 which are substantially coextensive in the axial direction. A cylindrical or tubular insulator employed as a dielectric separates plates 62 and 64. The capacitor 60 is substantially formed where plates 62 and 64 and insulator 61 abut. Non-abutting extensions and attachments to these component parts do not materially alter the electrical properties of the capacitor. As illustrated in Fig. 3 the dielectric member 61 may be slightly longer than plates 62 and 64. Capacitor plate 62 is connected by upper and lower sets of spring fingers 63 (one set being at each respective axial end of member 62) to the outer conductor 55. Capacitor plate 64 is connected by upper and lower sets of spring fingers 65 (one set being at each respective axial end of member 64) to the inner conductor 56. As clearly illustrated in Fig. 4, each set of spring fingers 63 and 65 comprises a plurality of separated fingers, the spaces between adjacent fingers allowing a fluid coolant (air) to flow in the coaxial line 55, 56 in an axial direction past the capacitor 60. Guiding blocks 66 and 67 are secured to the capacitor plate 62 and extend out thru slots 68 and 69 in the outer con-

ductor 55. Blocks 66 and 67 are fastened to racks 70 and 71 which have teeth engaged by the teeth of pinions 72 and 73. The pinions and the racks are manually operated in synchronism by means of a knob 74, as shown in Figure 4. By turning the knob 74, the caapcitor 60 may be positioned at any desired distance z from the base ring 52. Insulator 75 provides an insulating stop for the capacitor 60 at its lowest position. Metallic covers 76 and 77 prevent radio frequency leakage thru slots 68 and 69, respectively.

The capacitor 60 divides the coaxial line 55, 56 into a coaxial resonant cavity 80 and a coaxial transmission line having a space 81 between the inner and outer conductor thru which energy is propagated outward to the load. The transmission line includes a tapered section 82 providing a smooth impedance transition to the impedance of a standard coaxial line section 83.

The coaxial line section 83 is connected to a quarter-wave shorted coaxial line stub section 84 having an annular metallic shorting ring 85 which may be adjustably positioned with reference to the junction plane 86. An output coaxial transmission line includes an outer conductor 87 connected to the outer conductor 55, and an inner conductor 88 connected to the inner conductor 56.

The shorted stub 84 is necessary to provide access thru the center of hollow inner conductor 56 to the anode 50 of the vacuum tube for the application of B+ potential and a liquid coolant. The B+ potential is applied over lead 90 and the coolant is applied thru pipes 91 and flows in the directions of the arrows. A nut 92 provides a removable water-tight connection to the cooling chamber within the anode 50. Of course, the shorted quarter-wave stub could be arranged at right angles to the longitudinal axis of the output circuit, and the output energy taken out along the longitudinal axis. The arrangement shown is preferred for the practical reason that the entire output circuit assembly may be raised axially for the removal of the vacuum tube with the least complication in connection with the coolant pipes 91 and the B+ lead 90. There is no B+ potential on the coaxial line 55, 56 because of the presence of the B+ blocking capacitor including the cylindrical insulator 57.

The capacitor 60 shown in Figures 3 and 4 differs from the capacitors 20 and 20' shown in Figures 1 and 2 in that a single cylindrical dielectric member 61 is located between the outer capacitor plate 62 and the inner capacitor plate 64. The construction shown in Figures 3 and 4 is preferred for the reason that the spring contacts 63 and 65 engaging the outer and inner conductor permit the manufacturing tolerances of the capacitor assembly 60 to be very much relaxed compared with the tolerances required for the construction shown in Figures 1 and 2. With the construction shown in Figures 1 and 2, the insulating sheath 22 and 22' must be very accurately dimensioned to provide a sliding fit between the inner and outer conductors and at the same time precluding the presence of air which would cause arcing and deterioration of the insulating material.

The most favorable axial length for the capacitor 60 is an electrical quarter-wavelength at the operating frequency. However, the capacitor 60 may have an axial length of one-eighth wavelength or even shorter. The output circuit shown in Figures 3 and 4 is designed for operation at frequencies in the ultra-high frequencies television band between 470 and 890 megacycles. The equipment is designed to handle signals having a bandwidth in the order of 12 megacycles, and is suitable for color television signals as well as monochrome signals. A single capacitor 60 of a given axial length is not suitable for coupling energy at all frequencies between 470 megacycles and 890 megacycles. Therefore, a number of capacitors 60 of different axial length are alternatively utilized, one for each region of the frequency range from 470 megacycles to 890 megacycles. The axial length of the capacitor 60 effects the efficiency of energy transfer from the resonant cavity 80 to the transmission line 81.

In operation, the capacitor 60 is axially positioned to cause the volume of the coaxial resonator cavity 80 to have a value such that it resonates in the TEM or coaxial line mode at the desired operating frequency. Under this condition, the top edge of the capacitor 60 is electrically a half-wavelength from the electrodes of the tube, as has been described in connection with Figure 1. The capacitor 60 is dimensioned to provide a voltage immediately above the capacitor so that the desired power output is obtained according to the formula: Powel equals voltage squared divided by the characteristic impedance of the line. This voltage is transformed by the tapered section 82 to a higher voltage in the coaxial line section 83. The voltage transformation is proportional to the square root of the ratio of the characteristic impedance of section 83 compared with the characteristic impedance of the coaxial line section including cavity 80. The cavity 80 may have a characteristic impedance of 20 ohms, and the coaxial line section 83 may have a characteristic impedance of 50 ohms. The tapered section 82 therefore serves to decrease the ratio of circulating volt amperes to watts in the resonant cavity 80.

The length of the tapered section 82 should be at least 0.35 wavelength at the lowest desired frequency of operation of the equipment. The voltage standing wave ratio is then kept to a value of 1.5 or less. Since the voltage standing wave ratio is kept at a low value, the plunger 85 may be positioned at any distance from the capacitor 60 without appreciably disturbing the operation of the resonant cavity. The plunger 85 may therefore be positioned so as to optimize the transfer of energy to the output coaxial line 87, 88, without regard to its effect on the resonant cavity 80.

This invention utilizes coaxial line sections which support the TEM or coaxial line mode of oscillations therein. Other modes of oscillation must be avoided because if they are allowed to exist they detract from the efficiency of the system and result in circulating currents which generate destructive amounts of heat. One such undesired mode of oscillations is known as the TE_{11} or circular mode. This mode can exist in a coaxial line. It has been generally believed in the art that the TE_{11} mode can exist only if the coaxial line section has an axial length of at least a half-wavelength. The capacitor 60 constitutes a section of a coaxial line having a length in the order of from one-eighth to one-fourth wavelength. Therefore, according to the teachings of the prior art, the TE_{11} mode should not exist in the capacitor 60. However, it was found that the TE_{11} mode can exist in the capacitor 60 to such an extent that if the output circuits are operated at full output, the capacitor 60 will be quickly destroyed by the heat generated.

Figures 5 and 6 show modified capacitors 60' and 60'' which are used for different overlapping frequency ranges. The chart of Figure 7 illustrates the reason why the different capacitors of Figures 5 and 6 are necesary in order for the output circuit to be operated over a wide range of frequencies. Of course, only one capacitor is employed at a time for operation over a pre-determined limited range of frequencies.

Figure 7 shows how the length of the capacitor 60 or 60' or 60'' affects the frequency at which the destructive TE_{11} mode is encountered. A capacitor length of 3½ inches corresponds with a quarter-wavelength at 600 megacycles. It is apparent from the chart of Figure 7 that a capacitor having a length of quarter-wavelength or less, as is preferred, cannot be utilized in the frequency range between 550 and 650 megacycles without encountering the TE_{11} mode.

The chart of Figure 8 is based on a capacitor having an axial length of 3½ inches. The chart shows the frequencies at which desired TEM mode (the dot-dash curve) occurs as a function of the distance z of the

capacitor from the tube. This distance z is represented on Figure 3 of the drawings. The undesired TE_{11} mode is represented by a dashed line which indicates the frequencies at which the mode is encountered if the diameter of the dielectric tube **61** or **61'** or **61''** in the capacitor is halfway between the diameters of the inner and outer conductors of the cavity **80**. It is apparent from Figure 8 that a single capacitor cannot be used for all frequencies between 500 and 675 megacycles without encountering the destructive TE_{11} mode.

The upper solid curve in Figure 8 represents the frequencies at which the destructive TE_{11} mode occurs when the diameter d_1 of the dielectric tube in the capacitor **60'** has a value as shown in Figure 5 to be 8% less than the mean diameters of the inner and outer conductors **56** and **55** respectively. The lower solid line curve in Figure 8 represents the frequencies at which the destructive TE_{11} mode occurs when the diameter d_2 of the dielectric tube in the capacitor has a value, as shown in Figure 6, of 8% more than the mean diameters of the inner and outer conductors. It is apparent from the chart of Figure 8 that the capacitor construction according to Figure 5 may be employed for frequencies between 500 and 625 megacycles without encountering the destructive TE_{11} mode; and a capacitor constructed according to Figure 6 may be employed at frequencies between, say, 575 megacycles to 650 megacycles or more without encountering the destructive TE_{11} mode.

Referring to Figure 5, the capacitor **60'** is constructed of two rigid metallic tubes **62'** and **64'**. The dielectric cylinder **61'** may be made of a dielectric material such as tetrafluoroethylene. The dimensions of the three parts are made so that very high pressure is required to force the dielectric cylinder **61'** between the metallic cylinders **62'** and **64'**. By this construction, air pockets are positively excluded from the space between the capacitor plates. Due to the high power of the output circuit, the presence of air pockets would result in arcing and destructive generation of heat.

Spring fingers **63'** are used to make sliding contact from the capacitor plate **62'** to the outer conductor **55**. Electrical contact from the capacitor plate **64'** to the inner conductor **56** is provided by means of coil springs **90** which are confined by semicircular sockets or grooves in the capacitor plates **64'**.

In the form of the invention shown in Figure 6, the coil spring type contacts **91** are employed between the capacitor plate **62''** and the outer conductor **55**. In both cases, the coil spring type contacts are used on the side of the capacitor having the least clearance. This results in important mechanical advantages.

The invention has been described as an output circuit for a vaccum tube. However, the invention is equally useful as an input circuit for a vaccum tube, in which case the coaxial line **55**, **56** is connected to the cathode and grid electrodes of the vacuum tube, and input energy is inserted via the coaxial line **88**, **87**. The flow of energy is in the reverse direction when the invention is used as an input circuit, but the tuning procedure and fundamental manner of operation remains the same.

It is apparent that according to this invention there is provided an output circuit or an input circuit for a vacuum tube, the circuit being simple, effective and efficient in handling high power ultra-high frequency energy.

What is claimed is:

1. A vacuum tube output circuit comprising a vacuum tube having an inner anode contact ring and an outer concentric grounded electrode ring; an outer conductor connected at one end to said grounded electrode ring, a coaxial inner conductor, a cylindrical contact member of smaller diameter than said inner conductor and connected to said anode contact ring, a cylindrical dielectric member between said inner conductor and said cylindrical contact member to constitute therewith a direct current blocking capacitor, two branch coaxial lines extending from a junction point, a tapered coaxial line section connected from said inner and outer conductors to said junction point, means to short circuit one of said branch lines at a point substantially one-quarter wavelength from said junction point, a capacitor mounted between said inner and outer conductors, said last-named capacitor including inner and outer metallic cylindrical members and a cylindrical dielectric member therebetween; sliding contact means between said inner member and said inner conductor and between said outer member and said outer conductor, and means to axially move said last-named capacitor.

2. An output circuit as defined in claim 1, wherein said first-mentioned cylindrical dielectric member is tubular with a uniform wall thickness and a taper along its length, and wherein said inner conductor and said cylindrical contact member are provided with complementary tapers, whereby very tight mechanical contact is made with said first-mentioned dielectric member by forcing said inner conductor and said cylindrical contact member axially toward each other.

3. An output circuit as defined in claim 2, wherein said means to axially move the last-named capacitor comprises a rack connected to such capacitor thru a slot in said outer conductor, and a pinion having teeth engaging the teeth of said rack, whereby rotation of said pinion causes an axial movement of such capacitor, and in addition, a conductive shield covering said slot and said rack to prevent leakage of radio frequency energy thru said slot.

4. In a television transmitter for transmitting a wide range of frequencies, a vacuum tube output circuit comprising a vacuum tube having an inner anode contact ring and an outer concentric grounded electrode ring; an outer conductor connected at one end to said grounded electrode ring, a coaxial inner conductor, a cylindrical contact member of smaller diameter than said inner conductor and connected to said anode contact ring, a cylindrical dielectric member between said inner conductor and said cylindrical contact member to constitute therewith a direct current blocking capacitor, two branch coaxial lines extending from a junction point, a tapered coaxial line section connected from said inner and outer conductors to said junction point, means to short circuit one of said branch lines at a point substantially one quarter-wavelength from said junction point, a capacitor mounted between said inner and outer conductors, said last-named capacitor including inner and outer metallic cylindrical members and a cylindrical dielectric member therebetween; sliding contact means between said inner member and said inner conductor and between said outer member and said outer conductor, and means to axially move said last-named capacitor.

5. An output or input circuit for a vacuum tube having concentric electrode contact rings, comprising an outer conductor adapted at one end for connection with one of said contact rings, a coaxial inner conductor, a cylindrical contact member of smaller diameter than said inner conductor and adapted at one end for connection to said other contact ring, a cylindrical dielectric member between said inner conductor and said cylindrical contact member to constitute therewith a direct current blocking capacitor, an annular concentric capacitor mounted between said inner and outer conductors to form a resonant cavity on the tube side of said capacitor and a transmission line on the other side of said capacitor, said last-named capacitor including inner and outer metallic cylindrical members and a cylindrical dielectric member therebetween; contact means between said inner member and said inner conductor and between said outer member and said outer conductor, a coaxial line junction at one end of said coaxial conductors from which two coaxial branches extend, and means to short-circuit one of said coaxial line branches at a distance of substantially a quarter wavelength from said junction, said inner conductor and the inner conductor of said

shorted branch being hollow to provide access to said tube thru said hollow inner conductors.

6. An output or input circuit for a vacuum tube, comprising coaxial inner and outer conductors adapted to be coupled respectively to electrodes of said tube, an annular concentric capacitor mounted between said inner and outer conductors to form a resonant cavity on the tube side of said capacitor and a transmission line on the other side of said capacitor, said capacitor including inner and outer metallic substantially cylindrical and substantially coextensive members and a substantially cylindrical dielectric member therebetween, said dielectric member extending over at least the length of said substantially coextensive members and said capacitor having an axial length of between one-eighth wavelength and one-fourth wavelength at the operating frequency to form a coupling capacitor between said resonant cavity and said transmission line; contact means between said inner member and said inner conductor and between said outer member and said outer conductor, and means to axially move said capacitor.

7. An output or input circuit for a vacuum tube, comprising coaxial inner and outer conductors adapted to be coupled respectively to electrodes of said tube, an annular concentric capacitor mounted between said inner and outer conductors to form a resonant cavity on the tube side of said capacitor and a transmission line on the other side of said capacitor, said capacitor including inner and outer metallic substantially cylindrical and substantially coextensive members and a substantially cylindrical dielectric member therebetween, said dielectric member extending over at least the length of said substantially coextensive members and said capacitor having an axial length of between one-eighth wavelength and one-fourth wavelength at the operating frequency to form a coupling capacitor between said resonant cavity and said transmission line; a coaxial line junction in said transmission line from which two coaxial branches extend, a load terminating one of said coaxial branches, contact means between said inner member and said inner conductor and between said outer member and said outer conductor, and means to axially move said capacitor.

8. An output circuit as defined in claim 1, wherein at least one of said branch lines is concentric with said outer and inner conductors, and wherein all of the cylindrical members forming the last-named capacitor are concentric with said outer and inner conductors.

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