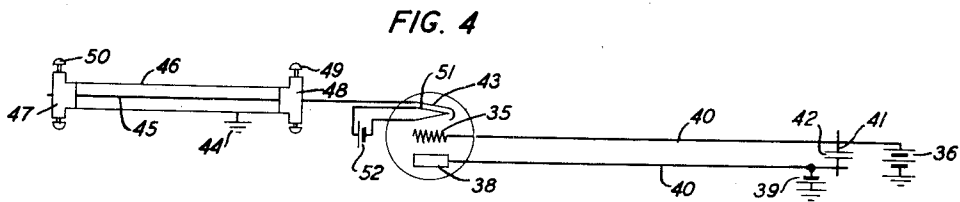
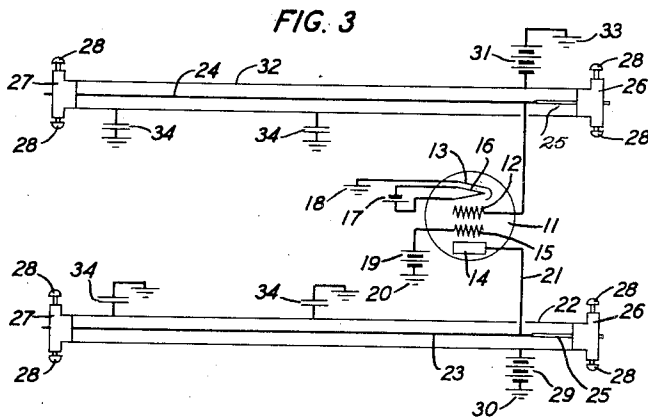
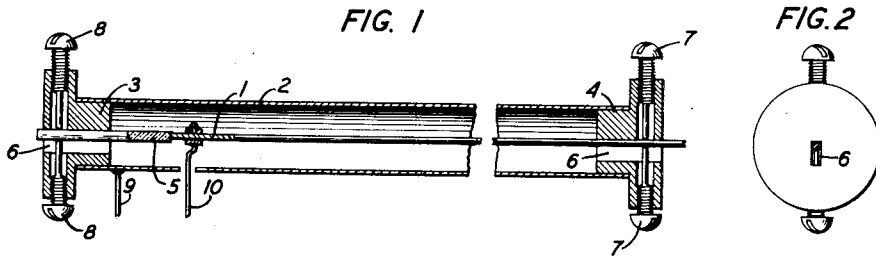


May 10, 1938.

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VARIABLE TUNED CIRCUIT
Filed May 17, 1935

2,116,996



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2,116,996

VARIABLE TUNED CIRCUITS

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Application May 17, 1935, Serial No. 22,037

11 Claims. (Cl. 250—36)

This invention relates to variable tuned circuits and in particular to coaxial element conductors employed in tuned circuits for ultra high frequency waves. As is well known, loop resonant or closed tuned circuits may be employed for many different purposes as, for example, in the selective elements of high frequency amplifiers, meshes of filters, the frequency-determining circuits of oscillators and so-called anti-resonant circuits for suppressing oscillations of an undesired frequency. For oscillations in the range of frequencies above 300 megacycles tuned circuits may be conveniently made of coaxial conductors. If it is desirable to be able to vary or adjust the resonance frequency of such coaxial conductor circuits, it has been customary to provide telescoping sections as, for example, in U. S. patent to Southworth, 1,796,486, March 17, 1931. Such telescoping conductors are, however, subject to certain difficulties in that they tend to complicate the character of mechanical supports required and also to introduce reflection points at the ends of the sliding sections in consequence of the abrupt change in effective diameters of the inner and outer conductors with an accompanying change of ratio of the two diameters. Moreover, precise adjustment in the tuning of such circuits is difficult to make and entails relatively cumbersome adjusting apparatus.

An object of the invention is to provide relatively simple apparatus that will enable precise adjustment of tuned circuits comprising coaxial conductors at ultra high frequencies.

A two-conductor line of a type which has very low loss and which is one-quarter wave-length long has an input impedance equal to the square of the characteristic impedance divided by the terminating impedance connected to the output terminals. If the terminating impedance is made very low as, for example, by directly connecting the output terminals of the two conductors to each other, the input impedance may be made very great and the circuit may simulate a loop resonant or anti-resonant circuit at the frequency at which it is effectively a quarter wave-length. In the case of a coaxial conductor having a substantially zero or short-circuiting impedance connected between the output terminals of the two conductors, it is found that in general the electrical wave-length at which the circuit is anti-resonant is very slightly in excess of four times the physical length of the coaxial conductor. I have discovered that the frequency of resonance of such a quarter wave-length circuit is decreased if the central conductor occupies a position eccentric to that of the surrounding conductor at the input terminal and that conversely the resonance frequency is increased if the conductors are eccentric with respect to each other at the output or short-cir-

cuted terminals. The expression "coaxial type conductor" is used in the following specification and the appended claims in a generic sense to describe structures in which a central conductor is in either concentric or eccentric relationship with respect to a surrounding return conductor at one or more points along the central conductor.

In accordance with the invention a coaxial type conductor of approximately a quarter wave-length having one pair of terminals insulated from each other and the other pair of terminals directly electrically connected is so constructed as to permit the position of either end of the central conductor to be shifted with respect to the outer conductor so as to increase or decrease the tuning of the conductor at will.

The invention is illustrated in the accompanying drawing in which Fig. 1 illustrates a quarter wave-length coaxial type conductor with means for adjusting the relative positions of the two conductors in accordance with the invention; Fig. 2 is an end view of the structure of Fig. 1; Fig. 3 illustrates an application of the invention to tuning of the input and output circuits of a vacuum tube oscillator, and Fig. 4 shows a quarter wave-length coaxial type conductor employed as an anti-resonant circuit in the cathode circuit of a vacuum tube oscillator.

Referring to Fig. 1 there is shown a central conductor 1 and an outer conductor 2 which are held in relatively fixed position by means of the end support or spacing devices 3 and 4. Conductors 1 and 2 may consist of copper or any other suitable conducting material preferably of as low resistance as possible. Spacing devices 3 and 4 which are centrally apertured to accommodate the conductor 1 and which have portions fitting closely within the ends of outer conductor 2 may consist of brass or other low resistance metal so that spacing device 4 which is in direct contact with conductors 1 and 2 serves as a very low impedance connector between the terminals of the conductors with which it is associated. The conductor 1 does not extend through the aperture of spacing device 3 but is supported at that end by a longitudinally aligned rod 5 of glass or other suitable insulating material which extends through the aperture of spacing device 3. The central apertures of devices 3 and 4 comprise slots as indicated at 6 in Fig. 2 so that it is possible for the end of conductor 1 which extends through device 4 to be shifted laterally in the slot 6 to a position eccentric with respect to the outer conductor 2. For the purpose of shifting the position of conductor 1 with respect to the slot 6 adjusting screws 7 are provided which extend through threaded apertures in device 4 and bear against conductor 1 at opposite sides. It is accordingly possible by loosening one of the screws 7

and tightening the opposite screw to shift the end of conductor 1, as desired. Beginning with the normal frequency of the coaxial device 1, 2 when the central conductor 1 is concentric with the outer conductor 2 the frequency will increase 5 as the conductor 1 is shifted laterally from its central position in the slot 6 of device 4. If, however, it be desired to decrease the resonance frequency the position of the end of conductor 1 passing through device 4 will first be adjusted so that the conductor 1 is concentric at that end with conductor 2. Thereupon, screws 3 will be so manipulated as to carry the glass rod 5 laterally from a central position in a slot of the device 3 10 similar to the slot 6 shown in Fig. 2. As the end of conductor 1 carried by glass rod 5 becomes eccentric with respect to conductor 2, the resonance frequency decreases. It is, therefore, readily possible to increase or decrease the resonance frequency of such a coaxial type conductor element without disturbing its principal supports or making awkward adjustments of its linear dimensions. Moreover, the troublesome short-circuited end effects which are present in the usual Lecher circuit are avoided. As one end or the other of the central conductor is moved to vary its axis from a normal position of coincidence with the axis of the outer conductor the central conductor assumes varying angles with the axis of the outer conductor. The adjustment may, therefore, be described as varying the position of the inner or central element angularly with respect to the central axis of the outer element.

Electrical connections to the apparatus of Fig. 1 may be made to leads 9 and 13, the former of which is connected directly to the outer conductor 2 or to ground if the outer conductor 2 is connected to ground and the latter of which extends from conductor 1 out through an aperture in conductor 2. The position of the tap point of lead 10 may be varied along the length of the inner conductor by means of its sleeve and set screw connection so as to obtain any desired value of input impedance.

Fig. 3 illustrates an application of the invention to a vacuum tube oscillator circuit in which a screen grid tube of well-known type provided with the usual energizing and polarizing sources has a tuned input circuit and a tuned output circuit each comprising a coaxial type conductor element of the type disclosed in Figs. 1 and 2. The screen grid tube 11 comprises the usual grid 12, cathode 13, anode 14 and shield electrode 15, together with a heating element 16. Source 17 supplies energy to the heating element. The cathode 13 is connected to ground at 18. The shield 15 is connected through a polarizing source 19 to earth at 20. Anode 14 is connected by lead 21 extending through an aperture in the outer conductor 22 to the inner conductor 23. Inner conductor 23 and outer conductor 24 are similarly supported at one end by longitudinally aligned glass tubes 25 extending through slots in spacing devices 26 and at their opposite ends passing through slots in spacing devices 27. Adjusting screws 28 serve to position the ends of conductors 23 and 24 in the manner described in connection with the adjustment of conductor 1, Fig. 1. Source 29, the positive terminal of which is connected to outer conductor 22 and the negative terminal of which is connected to ground at 30, supplies space current to the oscillator. Source 31, the negative terminal of which is connected to outer conductor 32 and the positive terminal of which is connected to earth at 33 impresses suit-

able grid bias potential upon the grid 12. Capacity elements 34 of relatively large capacity are connected between various points of outer conductors 22 and 32 to divert therefrom any currents which might set up undesirable potentials. 5

The tuning of the input circuit and the output circuit of the oscillator of Fig. 3 is accordingly susceptible to variation in such manner as to make either circuit resonant to a higher or a lower frequency than that corresponding to its normal concentric conductor position. It is accordingly possible to tune the oscillator very exactly to a desired frequency. 10

Fig. 4 discloses an oscillator circuit of the well-known Barkhausen type in which the grid 35 is polarized at a relatively high positive potential by means of source 36, the negative terminal of which is grounded. The anode 38 is polarized by a source 39 to a potential approximately that of the cathode and which may be either slightly negative with respect to the cathode as indicated, or somewhat positive with respect thereto. Two Lecher conductors 40 connected directly at their inner ends respectively to the grid and anode and connected together at their outer ends by a sliding bridge 41 including a large series blocking capacity 42 in well-known fashion, constitute the frequency-determining oscillation circuit of the oscillator. Cathode 43 is connected to earth at 44 through a path including in series the inner conductor 45 of a coaxial type element and the outer cylindrical conductor 46. Conductors 45 and 46 are electrically connected at their outer ends by the conducting spacing device 47. At their inner ends, conductors 45 and 46 are separated by the spacing device 48 consisting of any suitable insulating material. The adjusting screws 49 associated with spacing device 48 are, likewise, preferably of insulating material or may be provided with tips of insulating material to prevent any possible conducting path between the outer conductor 46 and the inner conductor 45 at that point. The coaxial element is provided with adjusting screws 50 similar to those described in connection with Figs. 1 and 3. The coaxial element 45, 46 is tuned to one-quarter wave-length of any oscillation which it is desired to exclude from the cathode to ground path. It accordingly serves effectively as a radio frequency choke at the frequency at which it is resonant. 30

A heater element 51 for heating the cathode is supplied with energy from the source 52.

Although the specific means for adjusting the position of the central conductor with respect to the outer conductor has been illustrated as a slot with adjusting screws, it will be understood that any mechanically and electrically equivalent expedient may be employed for this purpose. Moreover, the principle of the invention may be applied to any type of circuit in which it is desired to make use of the frequency selective properties of a quarter wave-length coaxial type conductor element. 45

What is claimed is:

1. An electric circuit for selective transmission of oscillations of a given frequency comprising a section consisting of coaxial-type conductors of a length substantially equal to an integral number of quarter wave-lengths at the given oscillation frequency, and means for adjustably varying the distance between the centers of the conductors at one point in their length while maintaining it substantially constant at another point whereby the anti-resonance frequency of the section for 75

electrical waves impressed upon its conductors at one end of the section may be varied at will.

2. An electric circuit for selective transmission of oscillations of a given frequency comprising
 5 a central conductor, a cylindrical conductor enclosing and concentric with the central conductor, both conductors having a length substantially equal to an integral number of quarter wave-lengths at the given oscillation frequency, means
 10 for holding the two conductors in relatively fixed position with respect to each other at one point in their length, and means for adjusting the central conductor relative to the center of the cylindrical conductor at another point in their
 15 length whereby the anti-resonance frequency of the circuit for oscillations applied to the two conductors at one pair of corresponding ends may be varied.

3. An electric circuit for selective transmission
 20 of oscillations of a given frequency comprising a central conductor, a tubular conductor insulated from and surrounding said central conductor, the conductors each having a length substantially equal to an integral number of quarter wave-lengths at the given oscillation frequency, means
 25 for insulating said conductors from each other throughout most of their length and holding them in relatively fixed relationship with respect to each other, means for electrically connecting the conductors at one end, and means for varying
 30 the distance between their centers at the other end to enable the anti-resonance frequency of the circuit for electromotive forces applied at said other end to be varied at will.

35 4. An electric circuit for selective transmission of oscillations of a given frequency comprising a central conductor having a length substantially equal to an integral number of quarter wave-lengths at the given oscillation frequency,
 40 a tubular conductor of approximately the same length insulated from and surrounding the central conductor, means for insulating said conductors from each other throughout most of their length and holding them in relatively fixed relationship with respect to each other, means for
 45 electrically connecting the conductors at one end, and means for varying the distance between their effective centers at the end at which they are electrically connected to enable the anti-resonance
 50 frequency of the circuit viewed from the end at which the conductors are held in relatively fixed relationship to be varied at will.

5. An electric circuit for selective transmission of oscillations of a given frequency comprising a
 55 central conductor having a length substantially equal to an integral number of quarter wave-lengths at the given oscillation frequency, a tubular conductor of substantially the same length surrounding the central conductor and spacers
 60 holding said conductors in relatively fixed positions, one of said spacers comprising means for varying the relative position of said conductors to enable an eccentric relation to be established between the conductors at said spacer whereby
 65 the anti-resonance frequency of said electric circuit may be varied at will.

6. In an electric circuit for selective transmission of oscillations of a given frequency, a central
 70 conductor, an outer conductor surrounding the central conductor, the conductors each having a length substantially equal to an integral number of quarter wave-lengths at the given oscillation frequency, a washer separating said conductors at one end and having a slot, means for
 75 supporting the central conductor in a position in

which it passes through said slot, and means for adjusting the supporting means to cause the central conductor to assume an eccentric position thereat with respect to the outer conductor whereby the natural electrical resonance frequency of the outer and central conductors operating as a unit may be varied at will.

7. In combination, an oscillator comprising a vacuum tube having a cathode, an anode and a grid element, a tuned circuit connected to said
 10 cathode and grid, a second tuned circuit connected to said cathode and anode, one of said tuned circuits comprising a quarter wave-length coaxial type conductor section, the conductor section having a central conductor and a surrounding
 15 conductor and means for adjusting the position of the central conductor with respect to the surrounding conductor to tune the quarter wave-length circuit to an optimum condition with respect to the tuning of the other tuned circuit.

8. A vacuum tube oscillator comprising a cathode, an anode and a grid, a tuned circuit connected to said grid and anode, means for supplying said anode and grid with suitable polarizing potentials with respect to said cathode to enable
 25 the oscillator to produce oscillations and a path extending from the cathode to the tuned circuit, said path including an anti-resonant circuit comprising a quarter wave-length coaxial type conductor section, and means for adjusting the relative
 30 positions of the centers of the conductors of the coaxial conductors to tune the anti-resonant circuit to a desired frequency.

9. A circuit tuned for oscillations of a given wave-length comprising two coaxial type conductors each of a length substantially equal to an
 35 integral number of quarter wave-lengths of the given wave-length and means for adjustably varying the distance between the centers of the conductors at one point in their length while maintaining it substantially constant at another point.

10. A circuit tuned for oscillations of a given frequency comprising a pair of coaxial type elements each of a length substantially equal to an
 45 integral number of quarter wave-lengths at the given oscillation frequency, means for varying the position of the inner element angularly with respect to the central axis of the outer element and means for electrically connecting the elements together at one end whereby the anti-resonance frequency of the circuit for electromotive forces applied at the other end may be varied at will.

11. A vacuum tube oscillator comprising an electron discharge device having a cathode, an
 55 anode and an impedance control element, a space current circuit including a space current source connecting the cathode and anode, a pair of circuits tuned for oscillations of a given wave-length
 60 and each comprising two coaxial type conductors each of a length substantially equal to an integral number of quarter wave-lengths of the given wave-length and means for adjustably varying the distance between the centers of the conductors at one point in their length while maintaining it substantially constant at another point, means for connecting said anode to the inner conductor of one tuned circuit, means for connecting the impedance control element to the inner conductor of the second tuned circuit, and means for connecting the cathode to the outer conductors of both tuned circuits.