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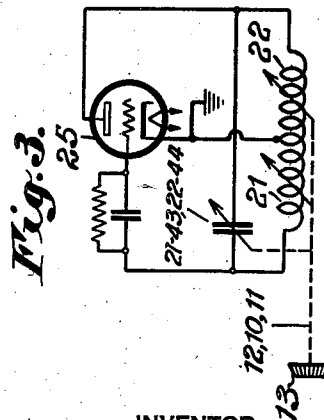
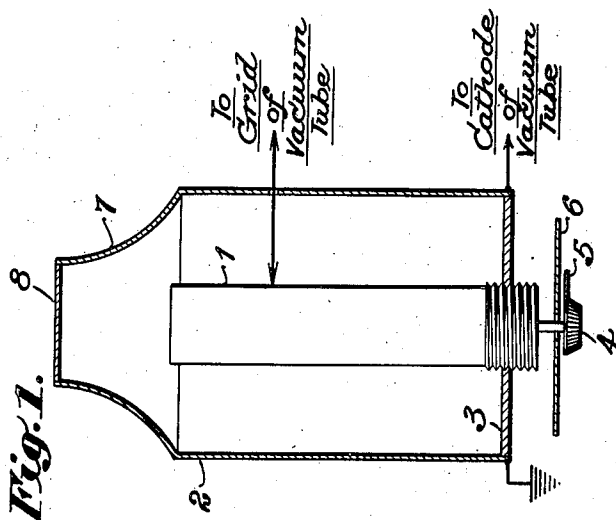
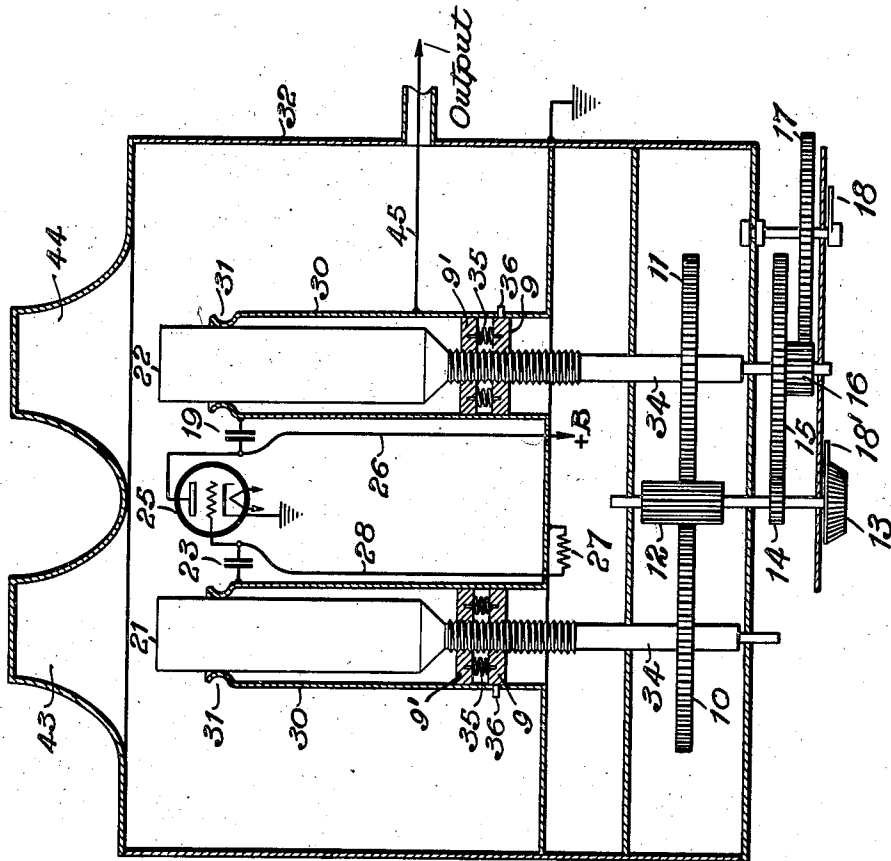
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2,402,443

RESONANT LINE AND ASSOCIATED CIRCUITS

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Fig. 2.



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RESONANT LINE AND ASSOCIATED
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This invention relates to electron discharge device oscillator circuits for use particularly at ultra high frequencies of the order of 100 megacycles and higher, and especially to low loss tuned circuits for use therein.

An object of the present invention is to provide a tuned oscillator circuit having a control member of substantially uniformly distributed inductance and surrounding this member an outer cooperative shield having associated therewith an electrode of such contour that there is obtained a desired relationship between the resonant frequency of the tuned circuit and the mechanical displacement of the controlled member.

Another object of the invention is to provide a tuned oscillatory circuit having a rod-like inductance member and surrounding this member an outer shield a portion of which is so shaped as to provide capacity to the rod which increases with effective increase in the length of the rod-like member at such a rate that the oscillation frequency varies linearly with mechanical displacement of the member.

A further object is to provide a concentric line resonator having an adjustable length inner conductor and a trumpet-shaped electrode connected to the outer conductor and cooperating with the free end of the inner conductor, whereby a desired frequency calibration is obtained over a range of movement of the inner conductor.

Another object is to provide an oscillator having such correlation between mechanical design and resulting frequency that the operating frequency will be directly proportional to a linear function of the mechanical displacement of the control member.

A still further object is to provide an oscillator having a frequency control circuit of substantially uniformly distributed constants with means for precisely adjusting the frequency over a relatively large variable range.

Other objects and features will appear from a reading of the following description which is accompanied by a drawing wherein:

Fig. 1 illustrates a concentric line resonator in accordance with the present invention;

Fig. 2 illustrates an ultra high frequency oscillator embodying the principles of the present invention, particularly applicable to a superheterodyne receiver; and

Fig. 3 shows an equivalent electrical circuit of the oscillator shown in Fig. 2.

Referring to Fig. 1 in more detail, there is shown a concentric line resonator comprising an inner conductor 1 and an outer conductor 2 con-

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ductively coupled to the inner conductor by means of end plate 3. Inner conductor 1 is provided with screw threads at the end which is connected to, and passes through the end plate 3 for enabling adjustment of the effective length of the inner conductor within the resonator. A control member in the form of a dial 4 serves to vary the length of the inner conductor with a consequent variation of resonant frequency of the resonator. Dial 4 is provided with a suitable pointer 5 cooperating with index markings on disc 6. The resonator as so far described is of a type well known in the art, reference being made to the article by Clarence W. Hansell entitled "Resonant lines for frequency control," published in "Electrical Engineering," August, 1935, pages 852 to 857.

In accordance with the invention, there is provided a trumpet-shaped electrode 7 which is connected to the end of the outer conductor 2 remote from the end plate 3 and which cooperates in capacitive manner with the free end of conductor 1 to provide a capacity to the inner conductor which increases as the inner conductor is lengthened at such a rate that the oscillation or resonant frequency of the resonator varies linearly with the rotation of the dial 4. The contour of trumpet-shaped electrode 7 can be calculated mathematically, and refinements made by trimming the electrode after it has been constructed. In this way I am able to obtain an operating frequency which is directly proportional to a linear function of mechanical displacement of the inner conductor 1.

Trumpet-shaped electrode 7 converges gradually from the end which directly connects with the outer conductor. If desired, the converging sides of the trumpet-shaped electrode 7 can terminate in an end plate 8 or may continue to meet at a point more removed from end plate 8. Under certain circumstances, end plate 8 may be eliminated entirely, although its use is preferred not only for the reason that it may increase the capacity coupling to the free end of the inner conductor 1, but also because it prevents dust from entering the interior of the resonator.

It is contemplated that the concentric line resonator of Fig. 1 will be employed in connection with an electron discharge device oscillator system wherein the grid is coupled to the inner conductor of a vacuum tube and the outer conductor of the resonator is grounded and connected to the cathode of the vacuum tube, as indicated in the drawing.

One advantage of providing the trumpet-

shaped termination at the end of the outer conductor of a coaxial resonator is that the frequency calibration of an oscillator system employing the resonator as a frequency determining circuit is thus made more uniform; that is, over a range of movement for the inner conductor the relationship between the resonant frequency of the resonator and the dial reading is more uniform than if there were employed either the customary end plate construction for the outer conductor or an outer conductor of uniform cross section.

Fig. 2 illustrates another embodiment of the present invention wherein an ultra high frequency oscillator system employs a low loss tuned oscillatory circuit having a pair of trumpet-shaped electrodes in accordance with the principles of the invention. In Fig. 2 the oscillator comprises an electron discharge device 25 which has its anode connected to a point at or near the high potential end of rod-like inductance element 22 by means of a by-pass condenser 19, which is of low impedance to the oscillator frequency, while the grid of the oscillator 25 is firmly connected to a point at or near the high potential end of rod-like inductance element 21 by means of a by-pass condenser 23. The potential for the anode of the oscillator is supplied through a lead 26. The grid of the oscillator has connected thereto a grid leak 27 directly connected across the grid input condenser 23 through lead 28. Leads 26 and 28 may, if desired, be shielded by means of surrounding outer conductors (not shown), or where rod-like inductors 21 and 22 are made hollow, the leads 26 and 28 may extend, respectively, through the interiors of the inductance elements 22 and 21. The cathode of the oscillator 25 is connected to ground.

The inductor elements 21 and 22 are each surrounded by hollow tubular sleeves 30, 30 which are provided at the ends directly contacting the inductor elements with spring contacts 31, 31. These spring contacts firmly grip the inductor elements and provide excellent electrical connection therewith as the inductors move relative to the sleeves in a manner described hereinafter. The inductor elements 21 and 22, it should be noted, are provided with screw threads at their lower ends in order to enable adjustment of their lengths. Surrounding the inductors 21 and 22 and the oscillator 25 is a grounded shield 32 which is connected to both inductor elements. It will thus be seen that, in effect, both inductor elements 21 and 22 are connected together and grounded at one of their adjacent ends and that the cathode is connected to these same ends. In order to simultaneously control the length of inductor elements 21 and 22, there are provided gears 10 and 11 which are controlled by a central gear 12 for rotating the shafts 34, 34 forming an integral part of the inductor elements. Both gears 10 and 11 are driven in unicontrol fashion by the longer gear 12 which, in turn, may be rotated by the operator by means of dial 13. Thus, movement of dial 13 will cause rotation of both inductor elements 21 and 22 axially in the same direction. In order to remove back lash in the threads of the inductor elements 21 and 22, there are provided floating nuts 9, 9 which are located in the interior of the sleeves 30, 30 between the sleeves and the threaded portion of the inductor elements. These floating nuts 9, 9 operate in conjunction with spring pressure produced by springs 35 located between them and stationary nuts 9', 9'. A suitable pin

36 serves to prevent floating nut 9 from rotating while slots in the sleeves accommodating the pins 36 give a desired degree of freedom to the nuts 9. It is preferred that means be provided to take up the back lash in the gears 10 and 11 by making each of these gears in two sections and provided with springs to apply a constant torque between the two sections of each gear. An arrangement of this kind for taking up the back lash in the gears is known in the art and described in Trevor Patent 2,247,212, granted June 24, 1941.

For determining the frequency of the oscillator there is geared to the shaft of the dial 13 a gear train 14, 15, 16, 17 and an indicating card with a reference element 18, so that by reading reference element 18 and reference element 18' associated with the dial 13 the frequency of the oscillator is indicated. The face of gear 17 is fitted with graduated dial readings for cooperation with index marker 18. Gears 15, 16 and 17 are held in position between suitable thrust bearings, not shown. Gears 15 and 16 are connected and driven together at the same speed but these two gears are loosely mounted on shaft 34.

In order to provide capacity between the inductor elements 21 and 22 and the ground shield 32, of a desired relationship, there are provided trumpet-shaped electrodes 43 and 44 of a contour which is similar to the shape of the electrode 7 of Fig. 1. As the conductor elements 21 and 22 advance in a direction along their axes so as to enter the interior of trumpet-shaped electrodes 43 and 44, there is obtained a desired relationship between frequency of operation of the oscillator system and angular rotation of the control dial 13; or putting it another way, a desired relationship between frequency and axial movement of inductor elements 21 and 22. Because of the contour of electrodes 43 and 44, the capacity between the electrode 43 and the rod-like inductor 21, and also the capacity between the electrode 44 and the rod-like inductor 22 will increase as the rod-like inductors approach the trumpet-shaped electrodes, as a consequence of which the frequency will decrease. This increase in capacity with its consequent decrease in frequency as the inductor elements approach and enter into their trumpet-shaped electrodes is greater than would be the case if there were employed the customary flat-end plate for the outer conductor shield, as known in the art.

As previously mentioned in connection with Fig. 1, the approximate shape of these trumpet-shaped electrodes 43 and 44 can be calculated mathematically, although for extremely accurate calibration these electrodes can be trimmed to the desired contour after first being roughly formed to the approximate shape.

The oscillator system shown in Fig. 2 is suitable for use as a local oscillator in a superheterodyne receiver, the output of this oscillator being obtained in any well known fashion, as for example by means of a lead 45 connected to one of the inductor elements, for example 22 as shown.

The oscillator of Fig. 2 has the advantage of being completely enclosed in a metallic structure which affords excellent electrical shielding and good mechanical stability. If desired, the metallic parts of the tuned circuit may be so chosen as to tend to minimize changes in frequency caused by variations in temperature. Obviously, the entire oscillator may be operated

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in a temperature controlled enclosure as known in the art.

Fig. 3 illustrates the equivalent electrical circuit for the heterodyne oscillator of Fig. 2. It will be noted that this circuit is generally of the Hartley three-point type, the grid being connected to one end of the frequency control circuit, the anode being connected to the other end thereof, while the cathode is connected to an intermediate point such as the center of the inductance. The same reference numbers have been used in Fig. 3 as in Fig. 2 to indicate the same parts. The capacity and the inductance of the tuned circuit of Fig. 3 is uncontrolled by dial 13. It is not believed necessary to go into the operation of Fig. 3, since it is believed to be apparent from an inspection thereof.

What is claimed is:

1. In a concentric line resonator wherein the inner conductor is movable relative to the outer conductor by means of a control member for varying the resonant frequency of the resonator, a trumpet-shaped electrode electrically connected and affixed at its widest part to that end of the outer conductor which is adjacent the free end of the inner conductor, said electrode by virtue of its shape providing a capacity to the inner conductor which increases as the effective length of the inner conductor is increased at such a rate that the resonant frequency of the resonator varies substantially linearly with displacement of the control member.

2. An oscillation generator comprising an electron discharge device having an anode, a cathode, and a control electrode; a pair of rod-like inductance elements adjustable in length and arranged parallel to each other and connected to each other at one end and having a frequency determining element at the other ends of said inductance elements; a shield surrounding said device and said inductance elements; a connection from said cathode to said shield; and connections from said last ends of said inductance elements to said anode and control electrode respectively; said frequency determining element including at least one trumpet-shaped electrode electrically connected and fastened at its widest part to said shield and forming a capacity with the adjacent end of one of said inductance elements, said trumpet shaped electrode being so formed that the frequency of said oscillation generator varies linearly with displacement of said rod-like inductance elements.

3. An oscillation generator comprising an electron discharge device having an anode, a cathode, and a control electrode; a pair of rod-like inductance elements arranged parallel to each other and connected to each other at one end and having a frequency determining element at the other ends of said inductance elements; a shield surrounding said device and said inductance elements; a connection from said cathode to said shield; and connections from said last ends of said inductance elements to said anode and control electrode respectively; a dial arrangement for changing the effective lengths of said rod-like elements; said frequency determining element comprising a cap for said shield which is spaced from the adjacent ends of the rod-like elements and so shaped as to provide capacity to the rod-like inductance elements which increases with increase in effective length of said elements at such a rate that the oscillation frequency varies linearly with dial displacement.

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4. An oscillation generator system comprising an electron discharge device having an anode, a cathode, and a grid; a pair of straight parallel inductance elements; a shield surrounding said device and said elements; said elements being electrically connected to said shield and to each other at one end; a connection from said cathode to said shield; connections from points at or near the other ends of said inductance elements to said anode and grid respectively; unicontrol means for simultaneously changing the effective lengths of said inductance elements within said shield; and an electrode for said shield which is spaced from the last ends of inductance elements and so shaped as to provide capacity to the inductance elements which increases with increase in effective length of said elements at such a rate that the oscillation frequency varies substantially linearly with movement of said inductance elements, said electrode comprising a pair of trumpet-shaped elements whose mouths are in the same straight line as said inductance elements and of larger size than the adjacent ends of said inductance elements.

5. A system in accordance with claim 4, characterized in this that said unicontrol means includes a gear assemblage linked to said pair of inductance elements and a dial arrangement for driving said assemblage.

6. An oscillation generator comprising an electron discharge device having an anode; a cathode, and a control electrode; a pair of rod-like inductance elements adjustable in length and arranged parallel to each other and connected to each other at one end and having a frequency determining element at the other ends of said inductance elements; means near said last ends of said inductance elements for supporting said electron discharge device; a shield surrounding said device and said inductance elements; a connection from said cathode to said shield; and connections from said last ends of said inductance elements to said anode and control electrode respectively; said frequency determining element including at least one trumpet-shaped electrode electrically connected and fastened at its widest part to said shield and forming a capacity with the adjacent end of one of said inductance elements which varies in such a manner as to adjust the frequency of said oscillation generator linearly with adjustment in length of said rod-like inductance elements.

7. In a concentric line resonator having an inner conductor of substantially the same cross-sectional dimension throughout its entire length, wherein the inner conductor is movable relative to the outer conductor by means of a control member for varying the resonant frequency of the resonator, a trumpet-shaped electrode electrically connected and affixed at its widest part to that end of the outer conductor which is adjacent the free end of the inner conductor, said electrode by virtue of its shape providing a capacity to the inner conductor which increases as the effective length of the inner conductor is increased at such a rate that the resonant frequency of the resonator varies substantially linearly with displacement of the control member.

8. A tuned circuit comprising a rod-like inductor element of substantially the same cross-sectional dimension throughout its entire length, and a shield surrounding said element, a connection from one end of said rod-like inductor element to an adjacent portion of said shield, a trumpet-shaped electrode having sides which

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curve inwardly terminating said shield and having its widest part adjacent the other end of said rod-like inductor element, and means for moving said inductor element on a line with the axis of said trumpet-shaped electrode for varying the capacity therebetween with a consequent variation in tuning of said tuned circuit, said elec-

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trode by virtue of its shape providing a capacity to the inner conductor which increases as the effective length of said inductor element is increased at such rate that the resonant frequency of the tuned circuit varies substantially linearly with displacement of said means.

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