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SEMIREENTRANT LINE OSCILLATOR FOR ULTRA HIGH FREQUENCY COMPRISING AN ELECTRON DISCHARGE DEVICE

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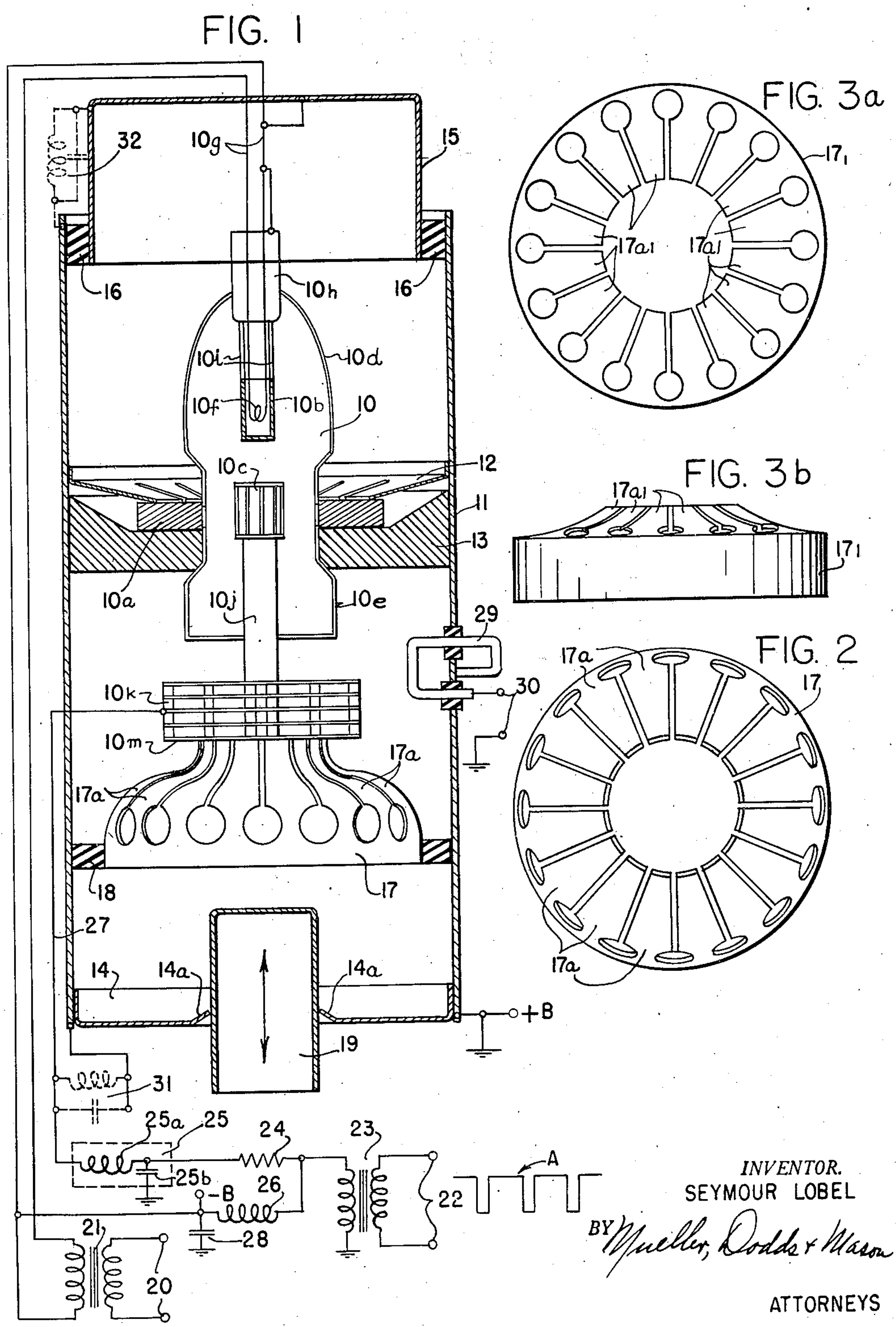

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SEMIREENTRANT LINE OSCILLATOR FOR ULTRA HIGH FREQUENCY, COMPRISING AN ELECTRON DISCHARGE DEVICE

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6 Claims. (Cl. 315—39)

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This invention relates to high-frequency oscillators and particularly to oscillators designed to operate at very high frequencies of the order of 1000 mc.

In the design of oscillators for operation at progressively higher frequencies, it was early proposed to utilize the resonant properties of a concentric-conductor transmission line as the frequency-determining element of the oscillator. In such an arrangement, the frequency of the oscillator is adjusted by varying the effective length of the line either by an adjustable shorting disc or ring, or by relatively telescoping the inner and outer sections of the line. However, even at very high frequencies the physical dimensions of such a line designed for frequencies generally encountered and adjustable over reasonable frequency ranges become unsatisfactorily large, resulting in a number of disadvantages in addition to the bulk of the apparatus itself. In the first place there arises the difficulty in connecting such a line directly with approximate impedance matching to the appropriate electrodes of the oscillator tubes, which are very small when designed for operation at very high frequencies. In the second place, there is the difficulty of adequately shielding the composite structure both with respect to the pickup of stray radio-frequency fields from other sources and with respect to radiation of undesired very high-frequency fields.

In an effort to overcome these limitations of high-frequency oscillators, such concentric transmission lines have been designed as reentrant lines, that is each end of the line has been effectively folded back on itself concentrically or telescoped. Such a configuration has certain of the characteristics of an oscillating cavity and it is not clear whether the resultant oscillations are in the mode of a cavity oscillator or that of a transmission-line tuned oscillator. However, it has been found that in such reentrant-line oscillators if the physical dimensions are such as to provide a desired wide range of tuning at very high frequencies, the low frequency end of the tuning range, corresponding to the fully telescoped reentrant portions of the transmission line, is often below the desired minimum frequency. On the other hand, it would be desirable to provide an oscillator of the type described in which the lower limit on the tuning range is materially raised.

It is an object of the invention, therefore, to provide a new and improved oscillator of the type described which is capable of operating over a relatively wide frequency range in which the lower limit of the range is materially raised while maintaining the maximum physical dimensions of the apparatus within reasonable limits.

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It is another object of the invention to provide a new and improved oscillator of the type described in which the tuning range is spread over a wide range of adjustment of the tuning elements, thus facilitating the tuning operation.

It is another object of the invention to provide a new and improved oscillator of the type described having a maximum frequency stability, that is a minimum frequency drift.

In accordance with the invention, the oscillator is of the semi-reentrant-line type and comprises an electron discharge device having anode, cathode and grid electrodes, a hollow closed transmission-line conductor extending from one of the electrodes and an external terminal member extending from another of the electrodes and disposed coaxially within the conductor. The oscillator also includes a non-reentrant terminal member engaging the electrode terminal and extending substantially across the conductor and having a concave surface disposed toward the remote end thereof and a telescoping plug coaxially mounted in the remote end of the conductor and axially adjustable with respect to said concave surface to tune the oscillator. By the term "semi-reentrant line" as used herein and in the appended claims is meant a line in which only one end of the line has been effectively folded back on itself or made reentrant, as distinguished from the fully reentrant lines described above in which both ends are made reentrant.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, while its scope will be pointed out in the appended claims.

Referring now to the drawings, Fig. 1 is a view, partly in cross-section, of an oscillator construction embodying the invention and showing schematically the associated electrical circuit connections; Fig. 2 is a top view of the grid terminal member embodied in the oscillator of Fig. 1; while Figs. 3*a* and 3*b* are top and side views, respectively, of a modified form of grid terminal member.

Referring now to Fig. 1 of the drawing, there is shown a semi-reentrant-line oscillator embodying the invention. This oscillator comprises an electron discharge device or vacuum tube 10 having an anode electrode 10*a*, a cathode electrode 10b and a grid electrode 10c. While the vacuum tube 10 may be of any suitable type, there is illustrated a construction corresponding to the type 3C37 in which the anode 10a is in the form of an annular external conductive member which divides the envelope into two portions 10d and 10e and is sealed to such portions at the junction. The cathode 10b is in the conventional form of a hollow sleeve coated with electron-emissive material and provided with an internal heater 10f brought out to conductors 10g through a seal 10h. The cathode 10b is supported from the seal 10h by rods or posts 10i, the seal 10h and cathode 10b being electrically connected to one of the heater leads 10g, as indicated. The grid 10c is in the form of a cylindrical cage mounted on a post 10j extending through the lower envelope portion 10e and including an external cylindrical heat-radiating terminal 10k comprising a series of circular radiating discs or fins surrounding the post 10j and having a terminal face 10m normal to its axis.

The oscillator also includes a hollow closed transmission-line conductor extending from the anode annular member 10a. This conductor may be in the form of a cylindrical sleeve 11 surrounding and coaxial with the vacuum tube 10 and electrically connected to the anode member 10a by means of a connection plate 12 having a plurality of resilient radially inwardly extending fingers contacting the member 10a and soldered or otherwise electrically bonded to the cylinder 11 about its periphery. The vacuum tube 10 may be supported by means of its annular anode member 10a on a disc 13 of heat radiating material, such as copper, soldered, brazed or otherwise secured in the cylinder 11. The lower end of the cylinder 11 is closed in any suitable fashion as by a conductive cup-shaped member 14 soldered or otherwise electrically bonded about its periphery to the cylinder 11. In the upper end of the cylinder 11 is disposed a telescopically sliding cup-shaped conductive cathode-tuning member 15 spaced from the cylinder 11 by means of a plurality of spacers 16 of insulation material and electrically connected to the cathode 10b, as indicated. With the construction described, the heat-radiating grid terminal 10k is disposed coaxially within the transmission-line conductor 11.

The oscillator also includes a non-reentrant terminal member 17 engaging the grid terminal 10k and extending substantially across the cylindrical conductor 11 and having a concave surface disposed toward the remote end thereof. The member 17, shown in plan view in Fig. 2, may be in the form of a cup-shaped member of resilient conductive material, such as a beryllium-copper alloy, and includes a plurality of radially inwardly extending resilient fingers 17a, preferably curved slightly upwardly and engaging the terminal face 10m of the grid terminal 10k. An annular spacer 18 of insulation material is interposed between the rim of the terminal member 17 and the cylindrical conductor 11 and serves to support the member 17 within the conductor 11 and to form therewith one end of an anode-grid oscillation cavity.

In order to tune the oscillator over a desired range of frequencies, there is provided a telescoping plug 19, preferably in the form of a hollow-cup-shaped member coaxially mounted in the end plate 14 of the conductor 11 and axially adjustable to tune the oscillator. The telescoping plug 19 may be supported mechanically in any suitable manner, not shown. Electrical connection is maintained between the cylindrical conductor 11 and the plug 19 by a plurality of resilient radially inwardly extending fingers 14a upset from the terminal cup 15 and resiliently engaging the periphery of the telescoping plug 19.

One circuit arrangement for making external electrical connections to the oscillator of the invention is illustrated schematically in Fig. 1 of the drawings. The transmission-line conductor 11 is connected directly to ground and to a suitable source +B of space current. The negative terminal of the space current source —B is connected by way of one of the heater conductors 10g, to the cathode seal 10h and cathode 10b. The cathode heater 10f is energized from any suitable source of alternating current by way of supply circuit terminals 20 and an isolating transformer 21. The oscillator described is particularly suitable for operation at peak power outputs by pulsing control. To this end, there are provided pulse-circuit supply terminals 22 connected to the grid 10c by way of an isolating transformer 23, a grid resistor 24, a filter 25 comprising a series inductance element 25a and a shunt condenser 25b, a conductor 27, and the grid heat-radiating terminal 10k. A suitable bias potential on the grid is established by connecting the cathode 10b to the grid through a radio-frequency choke coil 26 and a grid resistor 24, the cathode, and thus the source —B, being by-passed to ground for radio frequencies by a condenser 28. High-frequency output oscillations may be derived by means of a single-turn pick-up coil 29 extending through and insulated from the cylindrical conductor 11 and extending into the grid-anode oscillation cavity. The pick-up coil 29 is connected to one of the output terminals 30, the other one of which is grounded. As indicated by the dotted-line resonant circuit 31, the grid-anode cavities formed between the grid terminal 10k, the member 17 and the transmission-line conductor 11 is the equivalent of a frequency-determining resonant circuit 31. Similarly, the upper end of the cylinder 11 between the anode member 10a and the cathode-tuning cup 15 forms an anode-cathode oscillation cavity which is the equivalent of and represented by the dotted-line resonant circuit 32.

It is believed that the operation of the oscillator of the invention will be apparent to those skilled in the art from the foregoing description. Essentially, the oscillator is a conventional one in which the frequency-determining element represented by the equivalent tuned circuit 31 is connected between the grid and anode of the oscillator and serves both as the frequency-determining element and the regenerative feedback coupling from the anode circuit to the grid circuit. The frequency of the oscillator is determined by the dimensions of the grid-anode cavities. There are two of these cavities, one bounded by the anode member 10a, the cylinder 11 and the grid terminal member 17 and the other formed by the grid terminal member 17, the anode cylindrical conductor 11, and the re-entrant plug 19. The first of these cavities is fixed and is analogous to a fixed-tuned circuit in parallel with the conventional adjustably tuned circuit of an oscillator, while the second is adjustable by adjustment of the tuning plug 19. This latter cavity may be termed a semi-reentrant line since the end formed by the grid terminal member 17 is non-reentrant while that formed by the cap 14 and tuning plug 19 is reentrant.

The exact nature of the oscillation phenomenon within this cavity is not precisely understood, since the construction is somewhat of a hybrid between a concentric transmission-line tuner, composed of the outer cylindrical conductor 11 and the inner cylindrical conductor made up of the grid post 10j, the grid terminal 10k and the terminal member 17 and having a reentrant portion formed by the plug 19 at one end, and that of the more conventional simple cavity oscillator formed by the cavity between the grid terminal member 17 and the end plate 14 of the cylindrical conductor 11 as modified by the position of the tuning plug 19. In any event, these elements together constitute an oscillation or frequency-determining assembly, the frequency of which may be adjusted over a relatively wide range by axial adjustment of the plug 19.

As indicated, the cathode tuning cup 15 with the upper portion of the cylinder 11 forms an oscillation cavity equivalent of the parallel resonant circuit 32. The natural frequency of this cathode cavity has a broad effect on the oscillator frequency and its power output. The adjustment of the tuning cup 15 is preferably preselected to favor the oscillator efficiency at the higher frequencies of the tuning range, at which it otherwise tends to fall off, and the cup is then fixed in this position.

The cavity between the grid terminal 17 and the anode member 10a also constitutes a fixed-frequency oscillation cavity. If the end cup 14, the tuning plug 19 and the lower end of the sleeve 11 were removed, the frequency of the oscillator would be determined by this cavity. The effect of the addition of the adjustable cavity including the tuning plug 19 is to lower the mean frequency of the oscillator. In other words, the oscillation frequency of the cavity above the grid terminal member 17 is the limiting factor on the highest frequency of the tuning range.

As stated above, the oscillator described is one particularly suitable for pulse control. To this end, a pulse signal, such as represented by curve A adjacent to terminals 22, is applied to these terminals, thence through the transformer 23, the grid resistor 24 and the filter circuit 25 to the grid terminal 10k. With this arrangement, the apparatus is effective to develop oscillations only during the negative pulses of curve A. During intervening periods, the bias on the grid 10c is such as to prevent oscillation. There is thus derived from the output terminals 30 a series of pulses or trains of very-high-frequency oscillations having a modulation envelope represented by curve A.

In Figs. 3a and 3b are represented a modified construction of grid terminal element 17_1 having a plurality of resilient radially inwardly extending contact fingers $17a_1$. It has been found that this construction operates in a manner substantially similar to that of the grid terminal member 17 of Fig. 1 but, due to its slightly different configuration, the tuning range of the oscillator embodying this element is somewhat less than that of Fig. 1.

While the physical and electrical dimensions and constants of the oscillator of the invention obviously will vary within wide limits in accordance with the tuning range, the mean frequency of the range, and other performance characteristics desired, there follow, by way of example, the more important dimensions and constants of a particular oscillator embodying the invention, the physical dimensions being expressed in terms of the wave length of the generated oscillations:

Tube 10	Type 3C37
Cylindrical conductor 11:	
Diameter	0.237
Length	0.700
Grid terminal member 17:	
Diameter	0.162
Length	0.056
Tuning plug 19:	
Diameter	0.106
Length	0.200
Range of penetration into cavity oscillator	0.050–0.112
Cathode tuning cup 15:	
Diameter	0.187
Length	0.250

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

I claim:

1. A semi-reentrant-line oscillator comprising, an electron discharge device having anode, cathode and grid electrodes, a hollow closed transmission-line conductor extending from a first of said electrodes, an external terminal extending from a second of said electrodes and disposed coaxially within said conductor, a non-reentrant terminal member engaging said terminal and extending substantially across said conductor and having a concave surface disposed toward the end thereof remote from said first of said electrodes, and a telescoping plug coaxially mounted in said remote end of said conductor and axially adjustable with respect to said concave surface to tune said oscillator.

2. A semi-reentrant-line oscillator comprising, an electron discharge device having cathode and grid electrodes and an anode including an annular external conductive member, a hollow closed transmission-line conductor extending from said anode annular member, an external terminal extending from said grid electrode and disposed coaxially within said conductor, a non-reentrant terminal member engaging said terminal and extending substantially across said conductor and having a concave surface disposed toward the end thereof remote from said first of said electrodes, and a telescoping plug coaxially mounted in said remote end of said conductor and axially adjustable with respect to said concave surface to tune said oscillator.

3. A semi-reentrant-line oscillator comprising, an electron discharge device having anode, cathode and grid electrodes, a hollow closed transmission-line conductor extending from a first of said electrodes, a cylindrical heat-radiating terminal extending from a second of said electrodes externally of said device and disposed coaxially within said conductor, a non-reentrant terminal member engaging said terminal and extending substantially across said conductor and having a concave surface disposed toward the end thereof remote from said first of said electrodes, and a telescoping plug coaxially mounted in said remote end of said conductor and axially adjustable to tune said oscillator.

4. A semi-reentrant-line oscillator comprising, an electron discharge device having anode, cathode and grid electrodes, a hollow closed transmission-line conductor extending from a first of said electrodes, a cylindrical heat-radiating terminal extending from a second of said electrodes

externally of said device and disposed coaxially within said conductor and having a terminal face normal to its axis, a non-reentrant terminal member including a plurality of resilient fingers engaging said terminal face and extending substantially across said conductor and having a concave surface disposed toward the end thereof remote from said first of said electrodes, and a telescoping plug coaxially mounted in said remote end of said conductor and axially adjustable to tune said oscillator.

5. A semi-reentrant-line oscillator comprising, an electron discharge device having anode, cathode and grid electrodes, a hollow closed transmission-line conductor extending from a first of said electrodes, a cylindrical heat-radiating terminal extending from a second of said electrodes externally of said device and disposed coaxially within said conductor and having a face normal to its axis, a non-reentrant terminal member comprising a cup-shaped member of resilient conductive material including a plurality of radially inwardly extending resilient fingers engaging said terminal face and extending substantially across said conductor and having its concave surface disposed toward the end thereof remote from said first of said electrodes, and a telescoping plug coaxially mounted in said remote end of said conductor and axially adjustable to tune said oscillator.

6. A semi-reentrant-line oscillator comprising, an electron discharge device having anode, cathode and grid electrodes, a hollow closed transmission-line conductor extending from a first of said electrodes, a terminal extending from a second of said electrodes externally of said device and disposed coaxially within said conductor, a non-reentrant terminal member engaging said terminal and extending substantially across said conductor and having a concave surface disposed toward the end thereof remote from said first of said electrodes, insulation spacing means interposed between the periphery of said member and said conductor and forming therewith one closure of said hollow closed conductor, and a telescoping plug coaxially mounted in said remote end of said conductor and axially adjustable to tune said oscillator.

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