Dec. 27, 1949 A. G. KANDOIAN 2,492,155

TUNING SYSTEM

Filed Aug. 11, 1945 2 Sheets-Sheet 1

Fig. 1.

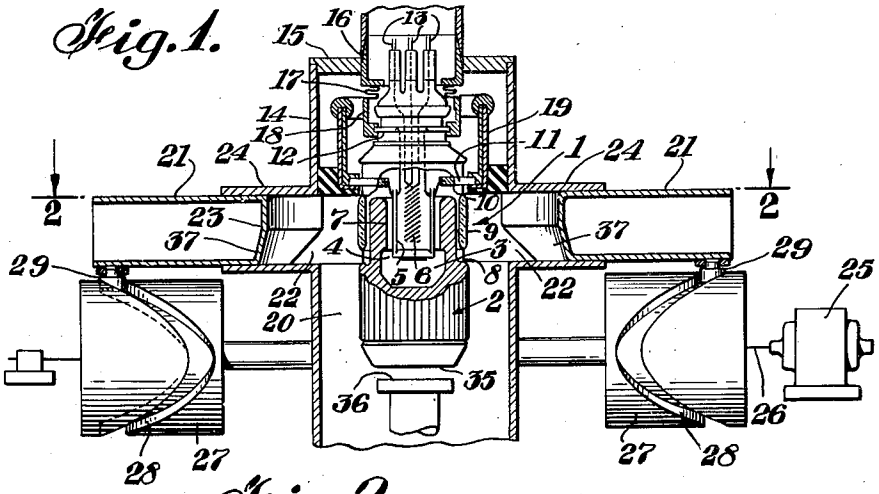


Fig. 2.

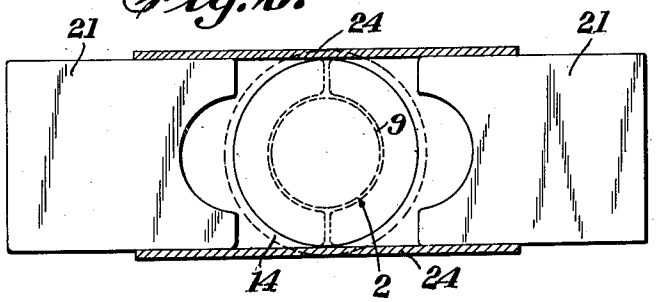


Fig. 3.

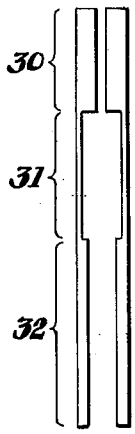
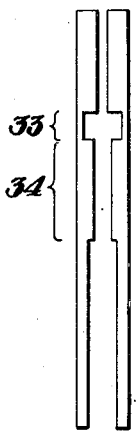


Fig. 4.



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Filed Aug. 11, 1945 2 Sheets-Sheet 2

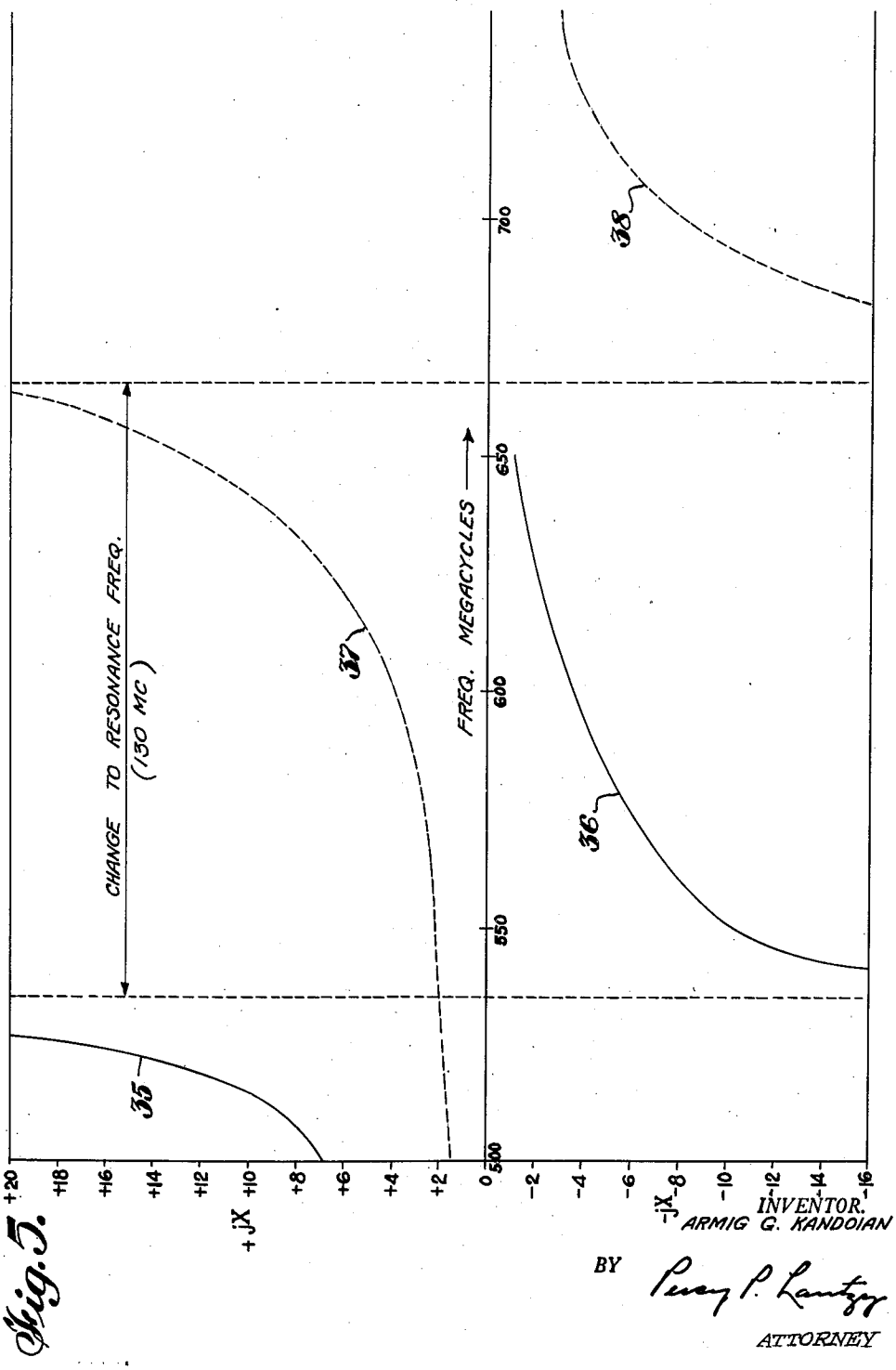


Fig. 5.

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2,492,155

TUNING SYSTEM

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Application August 11, 1945, Serial No. 610,366

3 Claims. (Cl. 250—36)

1

The present invention relates to tuning systems for coaxial line oscillators which present essentially the problem of tuning transmission line circuits.

In tuning certain transmission line circuits, particularly where variation of the length of the transmission line is not convenient, a variable capacity placed near the maximum voltage point of said line, is used for tuning. Where, however, relatively high voltages are encountered, this type of tuning has the disadvantage that arcing is likely to occur across the capacity.

For certain purposes, a pulse transmitter oscillator is required capable of operation at frequencies of the order of 500 megacycles over a frequency band of approximately 100 megacycles. The frequency of such is required to be varied over the entire band of frequencies covered thereby at a rate of roughly a hundred cycles per minute while not varying more than, roughly, plus or minus 15% in peak power output where the peak power output is in the order of several hundred kilowatts. Ordinarily tuning of a coaxial line oscillator involves a plurality of adjustments, such as tuning the grid-anode line, tuning the grid-cathode line, tuning the output coupling and tuning the feedback means, which feed-back tuning theoretically involves two separate adjustments, one for phase and the other for amplitude. Where the operating frequency of an oscillator must be continuously and cyclically varied over a wide frequency range, it is difficult to provide means for simultaneously and correspondingly tuning these lines, output coupling and feed-back means.

I have found that under the conditions hereinabove specified, tuning of the oscillator can be accomplished by tuning the grid-anode line alone. These specified conditions are, roughly, that the frequency range is limited to approximately ±8% of the maximum operating frequency and that approximately a ±15% variation in power output be tolerated over this frequency range.

In varying the frequency of such oscillators, it has been found that the use of a variable capacity at the high voltage end of the grid-anode line is not practicable because of the voltage breakdown problem. In accordance with a feature of my invention, I tune a transmission line, particularly the grid-anode line, by varying the inductance near the current maximum point. At the current maximum point, the voltage is at a minimum and therefore the danger of breakdown is greatly reduced. Furthermore,

2

the voltage minimum point remains substantially stationary as the inductance and hence the frequency is changed.

Another object of the present invention is the provision of an improved oscillator of the coaxial line type.

Still another object of the present invention is the provision of an improved oscillator having improved tuning means and particularly tuning means that are adapted for continuous and cyclical operation, and which tuning means are not likely to break down under very high voltages.

Another object of the present invention is the provision of a coaxial line oscillator which is adapted to be continuously and cyclically varied over a relatively wide frequency range.

Other and further objects of the present invention will become apparent and the invention will be understood from the following description of an embodiment thereof, reference being had to the accompanying drawings, in which:

Fig. 1 is a schematic sectional view of a coaxial line oscillator including a tuning system embodying my invention;

Fig. 2 is a plan view taken along the line 2—2 of Fig. 1;

Figs. 3 and 4 are equivalent transmission line circuits used in describing the operation of the oscillator illustrated in Fig. 1; and

Fig. 5 is a set of curves likewise used in explaining the operation of the oscillator illustrated in Fig. 1.

Referring now to Fig. 1, the oscillator there illustrated includes an electron discharge device, generally designated by the numeral 1, having an anode 2 of the reentrant type such as, for example, that described in the copending application of P. G. Chevigny, for "Vacuum tube structure," Serial No. 441,105, filed April 30, 1942, now Patent Number 2,402,602. The anode 2 is in the form of a block having a portion of the interior hollowed out to form a cylindrical opening 3 within which are concentrically arranged, a grid 4 and a cathode 5 of the indirectly heated type which is heated by a heater 6, the heater, cathode and the active surface 7 of the anode (the portion facing the cathode and grid) being all coaxially arranged. A feather edge 8 is provided on the outside of the anode block, which edge is sealed within a cylinder of glass 9, the other end of the glass 9 being sealed to the feather edge 10 of a conductive ring 11 which is the grid support and terminal, or grid-connecting ring. The cathode is likewise supported by, and connected to, a conductive ring 12 while the leads

13 to the heater project through the upper end of the tube 1.

The tube 1 is arranged coaxially within an outer hollow cylindrical conductor 14. Conductor 14 is connected through a conductive end plate 15, conductor 16, bellows 17 (which allows for expansion and contraction) and cylindrical conductor 18 to the cathode ring 12 and thus to the cathode. The conductor 14 serves as the ground line of the system and forms, with various other conductors, coaxial line circuits as will be seen from the following. A cylindrical conductor 19, referred to hereinafter as the "grid bell," is connected at one end to the grid ring 11 and extends longitudinally intermediate the outer conductor 14 and conductor 18 connected to the cathode ring. The grid bell 19 forms with conductors 14—18 a folded grid-cathode, open transmission line having an electrical length equivalent to approximately a half wavelength at the mean operating frequency of the oscillator. The grid-anode line 20, which is tuned in accordance with a feature of my invention to vary the frequency of the oscillator, includes the active surface 7 of the anode and the portion of said grid facing said surface, and the outer surface of the anode and the portion of outer conductor 14 facing said outer surface. Of the radio frequency energy appearing in the cavity of the grid-anode line 20 only a small proportion thereof, sufficient to sustain strong continuous oscillations, is fed back through the grid-cathode line to the cathode, while most of the R. F. energy is applied across the grid-anode region of the tube 1, the reactance across the space from the grid bell 19 to the outer conductor 14 being made sufficiently small for this purpose.

The anode-grid line 20 is tuned by varying the inductance and therefore the surge impedance of said line at a minimum voltage region thereof. In the embodiment illustrated in Fig. 1, this region appears at a portion of said line adjacent the glass cylinder 9. Accordingly, the tuning is accomplished by varying the inductance at said region. For this purpose I provide a pair of movable conductive members 21 extending through opposite openings 22 in the outer conductor 14 and having their forward ends 23 curved to fit closely around the glass 9 when said members are in their inner position. The members 21 are adapted to be moved synchronously radially inwardly and outwardly relative to the tube 1 on diametrically opposite sides thereof and are guided in their movement by flanges 24 extending from the outside conductor 14, the members 21 being electrically connected to said outer conductor 14. Means are provided for moving said conductive members inwardly and outwardly, continuously and cyclically to correspondingly vary the tuning. Said means includes a motor 25 whose shaft 26 may be used to drive two drums 27 having oppositely cut cam channels 28 therein within which rollers 29 connected to the members 21 are adapted to ride. Rotation of motor 25 rotates the drums 27 and moves the members 21 back and forth. It will be recognized that if the members 21 are moved linearly, the frequency will be varied roughly exponentially. In order to provide for a more linear variation of frequency with respect to time, the cam channels 28 are curved to produce a non-linear movement approaching a harmonic movement so that the frequency will be varied relatively linearly.

The tuning of the anode-grid line 20 may be

better understood from the equivalent transmission line circuits of Fig. 3 and Fig. 4. Referring to Fig. 3 which approximately represents the anode-grid line 20, when the conductive members 21 are in their retracted position, (farthest from the anode), the portion 30 represents the anode-grid region, that is, the region where the anode and grid face each other within the tube 1. The portion 31 of the transmission line of Fig. 3 represents the glass region, that is the region where the anode and the outside conductor 14 face each other through the glass cylinder 9. The portion 32 of the line represents the portion of the line 20 beginning from the feather edge 8 down to the lower end of the anode and also includes a slight additional length to compensate for end effects, which, latter may be experimentaly determined. The entire transmission line of Fig. 3 and the line 20 which it represents, is the equivalent of a half wavelength line at the mean operating frequency of the band of frequencies covered by the oscillator. Referring further to Fig. 3, with a one megawatt input, the radio frequency voltage distribution (with a 12.5 kilovolt pulse voltage applied to the anode) is as shown (plus, of course, the 12.5 kilovolt pulse voltage). It will be seen that the voltage minimum occurs at portion 31 which is the portion at which the glass cylinder is located. It is therefore at this portion that the inductance is varied to vary the tuning of line 20 and therefore of the oscillator.

Referring to Fig. 4, in the equivalent transmission line circuit there illustrated, the region 31 becomes broken up into two regions 33 and 34 when the conductive members 21 are in their inner position surrounding tube 2, portion 34 representing the transmission line section produced between the anode and the inner faces 23 of members 21. It will be seen that the voltage minimum remains substantially at the same point (as in Fig. 3). However the inductance of the line at said point, its surge impedance and the D/d ratio, is varied.

Fig. 5 shows the change in the resonant frequency produced by moving the members 21 inwardly and outwardly, the solid curves 35, 36 representing the retracted position of members 21 and the dotted curves 37, 38 representing the position of members 21 immediately surrounding the tube.

Referring back to Figs. 3 and 4, the lengths of the portions of line 20 in one actual embodiment and the corresponding surge impedances were as follows:

Portion	Length	Surge Impedance
	Inches	
30	2	11Ω
31	2.5	55Ω
32	3.75	42Ω
33	0.5	55Ω
34	2	17Ω

The output energy from the oscillator may be taken off by any suitable means. In the embodiment of Fig. 1, the bottom 35 of the anode 2 is capacitively coupled to an adjacent member 36 whose surface is sufficiently close to said bottom 35 to provide a substantial capacity therebetween. The member 36 is connected outside the oscillator to the load by means not shown. To lessen the tendency for arcing to occur between the forward ends 23 of the movable tuning members 21 and

the portions of the anode about the feather edge 6, the forward ends 23 may each be curved backwards, as indicated at 37, so that when the movable members 21 are in the inner position substantially surrounding the anode, there is still sufficient spacing between the curved-back portions 37 and the portions of the anode about feather edge 8 to prevent arcing therebetween.

While I have described a specific embodiment of my invention and various details thereof, it will be apparent to those versed in the art that numerous changes may be made in the details of said embodiment without departing from the teachings of my invention. For example, various different ways of moving the conductive members 21 will readily occur to those versed in the art. Different forms of such conductive members may also be employed. Accordingly, while I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of my invention as defined in the accompanying claims.

I claim:

1. In a coaxial line oscillator including an electron discharge device of the type having a reentrant anode and a cathode and grid, a hollow cylindrical conductor surrounding said anode coaxially and forming an open coaxial grid-anode line therewith, adjustable means for tuning said line comprising movable conductive means extending through approximately at right angles to and slidably connected with said cylindrical conductor, and tuning control means connected to said conductive means and adapted to move said conductive means toward and away from said anode at substantially an exponential rate to thereby change the frequency of said line linearly with respect to time.

2. In a coaxial line oscillator including an electron discharge device of the type having a re-

entrant anode and a cathode and grid, a hollow cylindrical conductor coaxially surrounding said anode and forming an open coaxial grid-anode line therewith, line-tuning control means comprising a pair of conductive elements located substantially at a minimum voltage point of said line and extending through openings in said cylindrical conductor toward each other, said elements being slidably connected with said cylindrical conductor, means connected to said conductive elements to synchronously move said elements toward and away from said anode, and means for continuously and cyclically reciprocating said elements toward and away from said anode at approximately an exponential rate so as to produce a linear change of frequency with respect to time.

3. In a coaxial line oscillator according to claim 2 in which the surfaces of said elements facing said anode are curved to substantially surround said anode when said elements are in their innermost position.

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