

Jan. 21, 1941.

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2,229,205

OSCILLATION GENERATOR CIRCUITS

Filed April 28, 1938

2 Sheets-Sheet 1

Fig. 1

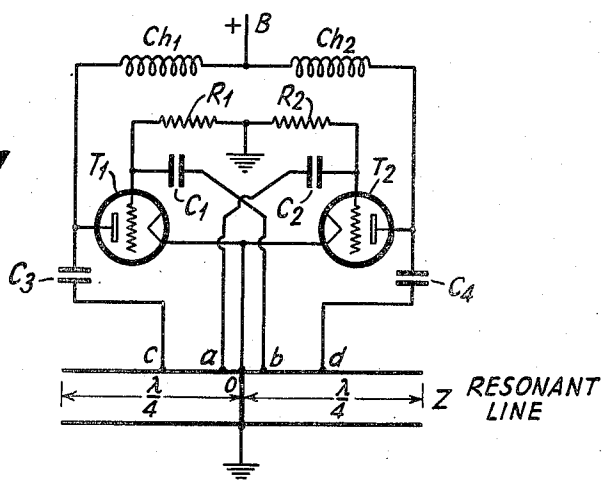


Fig. 2a

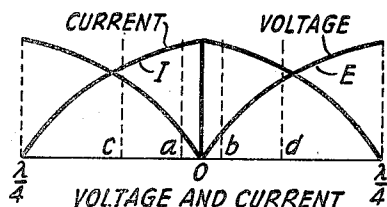


Fig. 2b

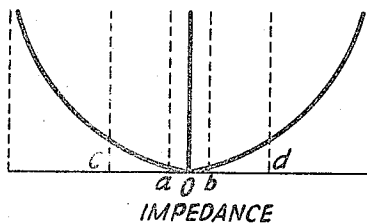
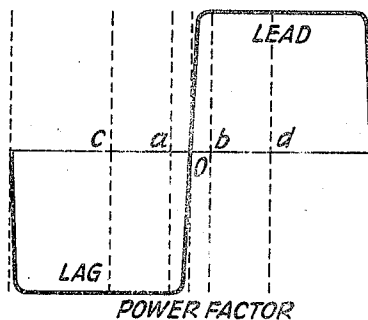


Fig. 2c



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2 Sheets-Sheet 2

Fig. 3

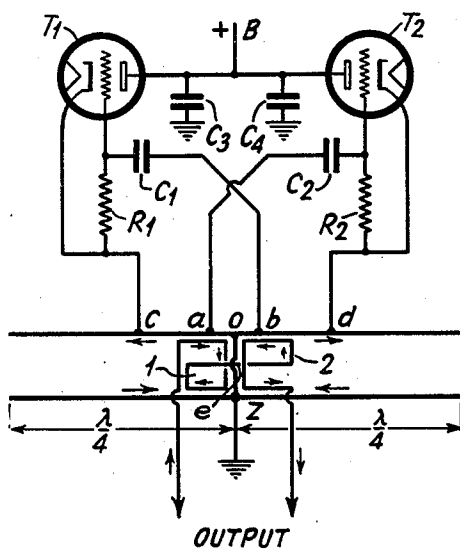


Fig. 4

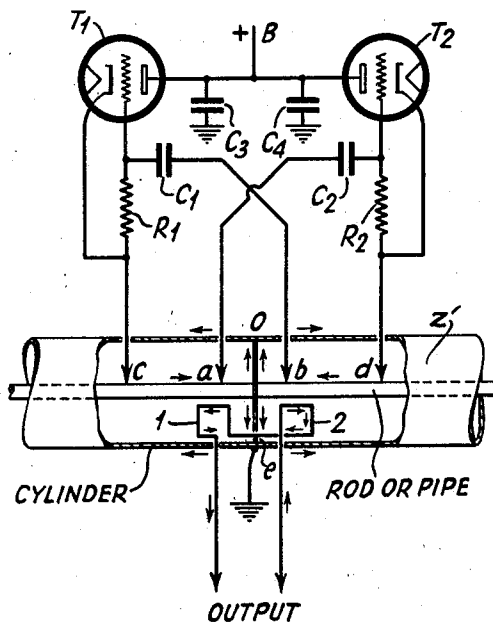
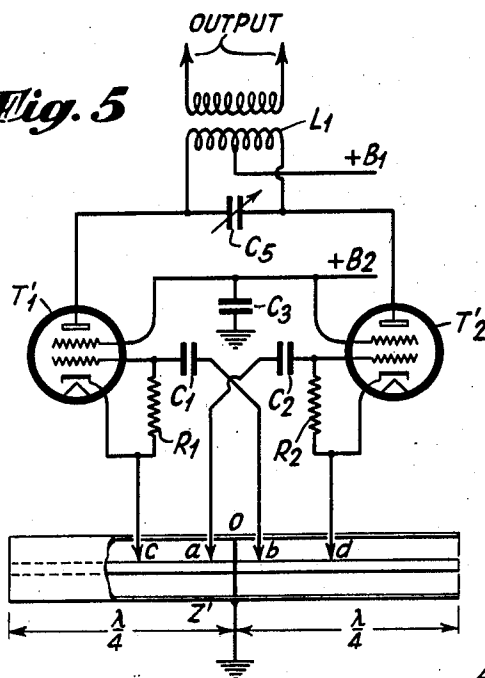


Fig. 5



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2,229,205

OSCILLATION GENERATOR CIRCUITS

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Application April 28, 1938, Serial No. 204,764

9 Claims. (Cl. 250—36)

This invention relates to vacuum tube oscillation generators, and more particularly to symmetrical oscillation circuits of extreme frequency stability.

5 The present circuit is an improvement over the ordinary types of oscillators in which lumped oscillatory circuits are used. It is also superior to crystal-controlled oscillators at the higher radio frequencies. The desired extreme frequency stability is attained in accordance with the invention by the use of a resonant line as the oscillatory element in a push-pull vacuum tube oscillator circuit. A balanced inductive coupling arrangement is provided in the invention for deriving output energy from the resonant line.

10 In ordinary oscillatory circuits composed of parallel-tuned elements of lumped inductance and capacitance, the losses are generally so high that it is impossible to build up impedances to values high enough to be useful at the higher radio frequencies. If resonant lines are utilized for tuned circuits, high impedances can be obtained, with low losses and extremely small decrement, at even the highest frequencies. The stabilizing
15 qualities of piezo-electric crystals are due to their very low decrements. Resonant lines can be constructed which are superior to piezo-electric crystals at the higher radio frequencies.

20 In the present invention, because of the symmetrical arrangement of the two vacuum tubes in the oscillator circuit, the circuit is operable at higher frequencies. Very short connections may be used in my improved circuit arrangement in which the inter-electrode capacitances of the two
25 tubes are effectively connected in series, and the tendency to produce parasitic oscillations is minimized. By means of a novel coupling arrangement, balanced output energy may be fed to a symmetrical network. It is therefore an object
30 of this invention to provide oscillators which are at once simpler, more efficient, more reliable, and more flexible than previous high frequency oscillators.

35 According to one feature of the present invention, there is eliminated the necessity for a separate tuned circuit across the anodes of the push-pull oscillator. In the push-pull oscillator of the present invention, a single resonant line serves the dual function of the usual grid and anode
40 tuned circuits, thus obviating possible undesirable reaction of the anode circuit on the grid circuit.

45 In the accompanying drawings, wherein like parts are represented by like reference numerals, Figs. 1, 3, 4 and 5 illustrate, schematically, differ-

ent embodiments of the present invention; Figs. 2a, 2b, and 2c are curves which illustrate graphically the voltage, impedance, phase and power factor distributions over the resonant line of the
5 embodiments.

Fig. 1 shows one specific push-pull oscillator embodiment of the invention employing two three-element vacuum tubes T_1 and T_2 . The cathodes of these tubes are connected to ground, and the grids also connected to ground through
10 the fixed resistors R_1 and R_2 , respectively. A pair of blocking condensers C_1 and C_2 , also connect the grids to suitable points a and b on the half wavelength two-conductor resonant line Z . The anodes, or plates, are connected, respectively,
15 through chokes ch_1 and ch_2 to a source $+B$ of positive potential, and through condensers C_3 and C_4 to suitable points c and d on the resonant line Z . The two conductors of resonant line Z are short-circuited at the center of the lines and
20 connected to ground at this point, thus dividing the line into two quarter-wavelength sections. The filaments of the tubes T_1 and T_2 are energized by the usual battery or alternating current
25 source.

It will be apparent that the circuit of Fig. 1 is a modification of the basic Hartley oscillator. The oscillatory element in this case is the double quarter-wave resonator Z used in such manner
30 that a symmetrical disposition of the circuit elements may be had. It will be seen from the diagram that the element Z is composed of two quarter-wave resonant lines with their short-circuited ends connected together. The impedance and
35 phase relationships in such a resonator are graphically depicted in Figs. 2a, 2b and 2c.

Fig. 2a shows the distribution of voltage and current; Fig. 2b shows the impedance curve; and Fig. 2c the power factor curve. The phase angle
40 changes by 180° as the center of the line is crossed; that is, corresponding points on opposite sides of 0 are substantially 180° out of phase. Because of inherent losses in any line, the voltage and current minima never actually reach zero.
45 It is for this reason that adjacent maxima of voltage and current are shown on the same side of the base line. If voltage and current were drawn as sine waves, adjacent maxima would fall on opposite sides of the base line and the curves
50 would have to be shown as passing through zero. This would give an accurate representation of conditions all along the line, except in the immediate vicinity of minima points. If the resonant line had no losses, the voltage and current min-
55

ima would go to zero, and the phase reversals would be instantaneous. Actually, the reversals take place somewhat gradually.

It is seen that points *a* and *d* are of opposite phase, as are points *b* and *c*. This puts on the grids and plates of the two tubes potentials having the proper phase relations to produce oscillations in the circuit. The frequency of oscillation of the system is of course determined by the length of the resonant line *Z*. Since this is easily adjustable, the device possesses stability and flexibility characteristics not to be found in other oscillatory elements.

In Fig. 3 is shown a modification of the system in which the plates (anodes) of the vacuum tubes *T*₁ and *T*₂ are maintained at zero radio frequency potential by means of the by-passing condensers *C*₃ and *C*₄. The cathodes in this case must necessarily be at radio-frequency potentials above ground, and to simplify this the use of heater type cathodes is resorted to. This figure also shows in detail my novel method of obtaining a balanced output from the resonant line, by means of a pair of coupling loops 1, 2 symmetrically positioned with respect to the center of the line and coupled to the line in opposite senses. The line shown here is of the two-wire type. The arrows represent the directions of the currents in various parts of the line and in the pick-up loops. These loops or coils 1, 2 are connected so that the currents induced in them by the two parts of the line additively combine in the output. The pick-up coils may be completely insulated from the line, or they may be grounded to the line at their center tap *e*. By means of these loops, balanced voltages may be fed to other symmetrical networks, such as frequency doublers, push-pull power amplifiers, antenna transmission lines, etc.

For ultra-high frequency work, resonant lines of the concentric type possess certain advantages over those of the two-wire type. Foremost among these advantages is the shielding provided by the outer cylinder of the concentric line, when it is grounded. In Fig. 4 I have shown how my novel coupling arrangement may be used in connection with a resonant line *Z'* of the concentric type. The wires from the pick-up coils may pass, in insulated manner, through holes in the outer cylinder provided therefor. Here again the center tap of the pick-up coils may be connected to ground at *e*.

In Fig. 5 there is shown a push-pull oscillation generator in accordance with another embodiment of the invention, in which the electron coupling principle is used. *T*₁' and *T*₂' are four-element tubes having indirectly heated cathodes. The screen grids are used as the plates (anodes) for the generator portion of the circuit and are maintained at ground radio-frequency potential by the condenser *C*₃. The anodes of the tubes are used for the output portion of the circuit, which is energized through electron coupling. The circuit *L*₁*C*₅, from which output energy may be derived, may be tuned to the fundamental frequency of oscillation or to a harmonic thereof. Fig. 5 shows the use of a concentric resonant line *Z'* as the frequency control element of the oscillator. The phase relations are the same as those graphically shown in Figs. 2*a* to 2*c*. The leads which tap onto the inner conductor of the resonant line *Z'* at *a*, *b*, *c*, and *d* insulatingly pass through openings in the outer cylinder. The physical construction may be made so that the

positions of the taps can easily be adjusted to any desired points on the inner conductor.

It should be understood that the invention is not limited to the circuits shown. Only a few specific embodiments have been given. For instance, in Fig. 1, tubes with indirectly heated cathodes could be used. Again, in the circuit of Fig. 3, vacuum tubes with directly heated cathodes can be utilized, if means such as chokes are provided to isolate the cathode from ground radio frequency potential. The term "cathode" as used herein is taken to mean any type of electrode which is the source of electrons necessary for operation of the device, regardless of its form, composition, disposition, temperature, or method of heating. Although only two general types of output coupling circuits have been shown, it is to be understood that the scope of the invention is not limited to these. Any satisfactory method of coupling to an external circuit may be employed, as, for example, by means of direct connections to the resonant line. In this regard it should be understood that vacuum tubes having additional elements to the ones shown in the drawings may be used. Also, the resonant line may be any odd multiple of a half wavelength, provided the tapping points to the vacuum tube elements are chosen to give the proper phase relations. Hence the term "odd multiple" used in the appended claims is intended to include any odd multiple including unity.

What is claimed is:

1. A push-pull oscillation generator comprising a pair of space discharge paths each having a grid, a cathode, and an anode, a two-conductor resonant line an odd multiple of a half wave long grounded at its center, a connection from ground to said cathodes, connections from said grids to points on one conductor of said line symmetrically and oppositely disposed with respect to said center for producing opposite instantaneous polarities on said grids relative to each other, and connections from said anodes to different points on the same conductor of said line symmetrically and oppositely disposed with respect to said center, whereby the instantaneous polarity of the alternating voltage applied to each anode is opposite in phase to the instantaneous polarity on the grid of the same space discharge tube.

2. A push-pull oscillation generator comprising a pair of vacuum tubes each having a grid, a cathode, and an anode, a resonant line an odd multiple of a half wave long grounded at its center, connections from said grids to points on said line symmetrically and oppositely disposed with respect to said center for producing opposite instantaneous polarities on said grids relative to each other, a capacitive connection from each anode to ground for the radio frequency currents, and connections from said cathodes to points on said line symmetrically and oppositely disposed with respect to said center, each of said last points being on the opposite side of the center of said line with respect to the point of connection to the grid of the same vacuum tube.

3. A push-pull oscillation generator in accordance with claim 2, characterized in this that said resonant line is a section of concentric transmission line to whose inner conductor said connections from the grid and cathodes extend.

4. A push-pull oscillation generator comprising a pair of vacuum tubes each having a grid, a cathode, and an anode, a resonant line an odd multiple of a half wave long grounded at its

center, connections from said grids to points on said line symmetrically and oppositely disposed with respect to said center for producing opposite instantaneous polarities on said grids relative to each other, a capacitive connection from each anode to ground for the radio frequency currents, and connections from said cathodes to points on said line symmetrically and oppositely disposed with respect to said center, each of said last points being on the opposite side of the center of said line with respect to the point of connection to the grid of the same vacuum tube, said anodes having apertures therein for enabling electrons to flow therethrough, and an outer electrode for each tube for collecting said electrons, and a resonant circuit coupled between said outer electrodes of said tubes, each of said anodes being so constructed and arranged as to isolate the oscillation portion of the tube comprising the cathode, grid and anode, from the outer electrode.

5. A push-pull oscillation generator comprising a pair of vacuum tubes each having a grid, a cathode, and an anode, a resonant line an odd multiple of a half wave long grounded at its center, connections from said grids to points on said line symmetrically and oppositely disposed with respect to said center for producing opposite instantaneous polarities on said grids relative to each other, a capacitive connection from each anode to ground for the radio frequency currents, and connections from said cathodes to points on said line symmetrically and oppositely disposed with respect to said center, each of said last points being on the opposite side of the center of said line with respect to the point of connection to the grid of the same vacuum tube, and means symmetrically disposed on opposite sides of the center of said resonant lines and coupled thereto for deriving output energy from said line.

6. A push-pull oscillation generator comprising a pair of vacuum tubes having their input and output electrodes coupled to a resonant concentric transmission line whose overall length is an odd multiple of a half wave, such that the voltages applied to the input electrodes of the tubes are at opposite instantaneous polarities with respect to each other and at opposite instantaneous polarities relative to their respective associated output electrodes, and a pair of loops symmetrically disposed on opposite sides of the cen-

ter of said resonant concentric line and coupled thereto for deriving output energy from said line.

7. A push-pull oscillation generator comprising a pair of space discharge paths each having a grid, a cathode, and an anode, a resonant line an odd multiple of a half wave long grounded at its center, connections from said grids to points on said line symmetrically and oppositely disposed with respect to said center for producing opposite instantaneous polarities on said grids relative to each other, a capacitive connection from each anode to ground for radio frequency currents, and connections from said cathodes to points on said line symmetrically and oppositely disposed with respect to said center, each of said last points being on the opposite side of the center of said line with respect to the point of connection to the grid of the same space discharge path.

8. A push-pull oscillation generator comprising a pair of space discharge paths each having within an evacuated envelope an input electrode and an output electrode, a two-conductor resonant line whose overall length is an odd multiple of a half wavelength located externally of said envelopes and comprising a pair of parallel conductors, and connections from the input and output electrodes of said devices to the same conductor of said resonant line such that the voltages applied to the input electrodes of the devices are at opposite instantaneous polarities with respect to each other and at opposite instantaneous polarities relative to their respective associated output electrodes.

9. A push-pull oscillation generator comprising a pair of space discharge paths each having an input electrode and an output electrode, a resonant line whose overall length is an odd multiple of a half wavelength comprising a pair of parallel conductors, a connection of low impedance to radio frequency energy from a point of fixed radio frequency potential to the centers of the conductors of said resonant line, and connections from the input and output electrodes of said devices to solely one conductor of said resonant line such that the voltages applied to the input electrodes of the devices are at opposite instantaneous polarities with respect to each other and at opposite instantaneous polarities relative to their respective associated output electrodes.

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