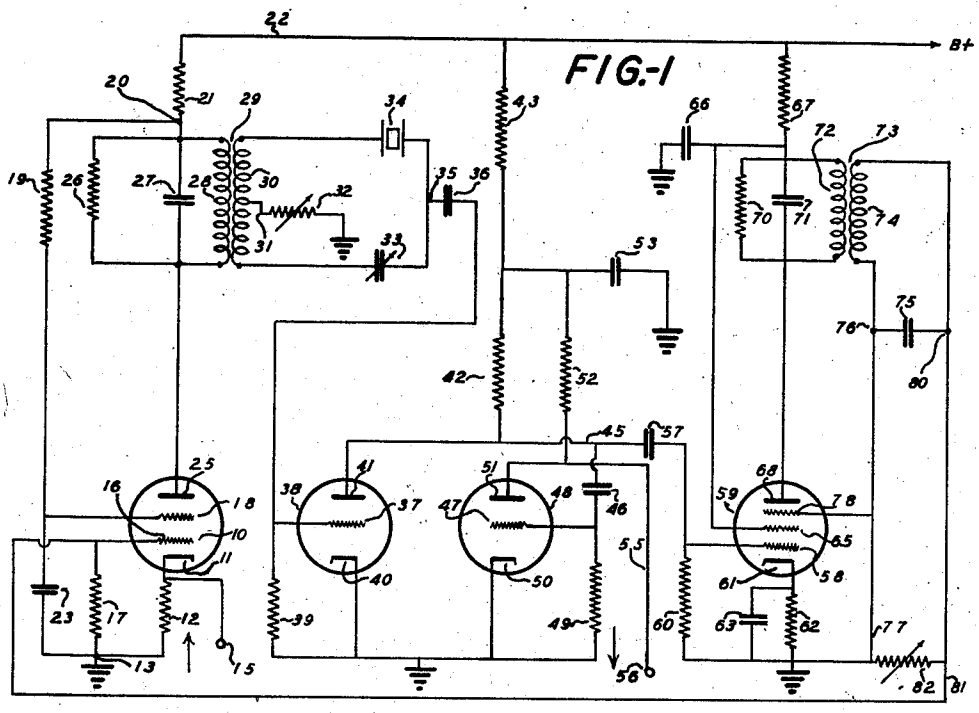
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OSCILLATING SYSTEM

Filed Jan. 11, 1944

FIG-1



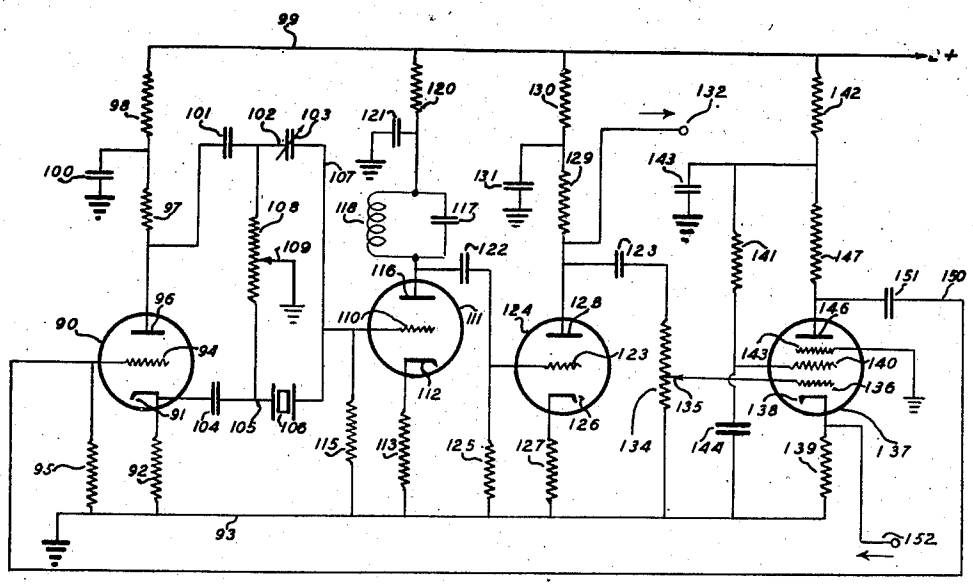


FIG-2

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OSCILLATING SYSTEM

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Application January 11, 1944, Serial No. 517,896

12 Claims. (Cl. 250—36)

1

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to an oscillating system and more particularly to an oscillator for generating a predetermined number of cycles. In the use of certain equipment, it is frequently desirable to generate a predetermined number of cycles and thereafter suppress said oscillations until a new cycle of operation is initiated. Thus in certain types of radio apparatus the pulsing of a transmitter is utilized to initiate a train of waves. In the use of an ordinary oscillator, it is necessary to build up the initial cycles to the final amplitude. When the negative or zero resistance of the oscillating system becomes a positive resistance, then damping sets in to produce a train of waves of decreasing amplitude. However, in certain instances it is necessary to have oscillations begin practically instantaneously at substantially full amplitude, maintain the oscillations at substantially constant amplitude for a predetermined number of cycles and then suppress the oscillations almost instantaneously.

In its more general aspect, the invention provides a shock-excited oscillating circuit having a minimum of damping during the time that oscillations are desired. When the number of waves generated has reached the required value, means are provided for introducing high damping. Unless the shock duration is small compared to the periodicity of the wave train, there will be a masking effect on the initial cycles and this will effectively result in the train beginning several cycles after the desired time. A small shock duration requires a high shock intensity compared to the energy in a wave train of a naturally resonating system. But high shock intensity involves forced oscillations and transient effects which will have a deleterious effect on the wave shape of the train. This invention provides means for impressing a comparatively high intensity shock on a resonant circuit and provides means for eliminating shock effects in the circuit so that substantially pure natural resonance effects result.

Referring now to the drawings, Figure 1 shows one circuit wherein a combination of inductance and capacitance are used in connection with a crystal. Figure 2 shows a modification wherein resistance and capacitance are used in combination with a crystal.

Referring now to Figure 1, a vacuum tube 10 is provided having a cathode 11 connected

2

through a bias resistor 12 to ground 13. An input terminal 15 is connected to cathode 11 and together with ground 13 forms an input circuit. Control grid 16 of tube 10 is connected by a grid resistor 17 to ground 13. An accelerating grid 18 is connected through a resistor 19 to junction point 20 and thence through a dropping resistor 21 to lead 22 connected to a source of B+ potential. Accelerating grid 18 is effectively grounded as far as alternating current is concerned by condenser 23.

Vacuum tube 10 has its anode 25 connected through a load resistor 26 to junction point 20. Shunted across resistor 26 are condenser 27 and winding 28, forming the primary of a transformer 29. Transformer 29 has a secondary 30 having a center connection 31 connected to ground through a variable resistor 32. The terminals of secondary 30 are connected to variable condenser 33 and crystal 34 respectively, these latter going to a junction point 35. Load resistor 26 preferably has a resistance high compared to the impedance of the resonant circuit 27—28 for the operating frequency.

The entire secondary circuit forms a bridge system in which excessive shock energy tending to cause forced oscillations is dissipated. The energy left for normal resonance operation remains in the circuit, which, after the initial shock, behaves as a normal resonant circuit. The crystal with its high Q results in the overall circuit Q being high enough so that a wave train of substantially constant amplitude is generated. The response of a crystal to a shock is highly desirable in this instance. The crystal appears to follow the shock wave and then continues on with oscillations upon the disappearance of the shock. The inherent sharp frequency response of this type of circuit is desirable since transients are suppressed.

Junction point 35 is connected through a coupling condenser 36 to grid 37 of vacuum tube 38. Grid 37 is connected to ground through a grid resistor 39, while cathode 40 is directly connected to ground. Anode 41 of vacuum tube 38 is connected through a load resistor 42 and dropping resistor 43 to lead 22.

Anode 41 of tube 38 is connected by lead 45 and coupling condenser 46 to control grid 47 of vacuum tube amplifier 48. Control grid 47 has a grid resistor 49 connected between it and ground. Cathode 50 is also grounded. Vacuum tube 48 has its anode 51 connected through a load resistor 52 to the junction of resistors 42 and 43 and is by-passed by grounded condenser 53.

From anode 51 a lead 55 is taken, terminating in an output terminal 56 which together with ground constitute an output circuit.

From anode 41 of vacuum tube 38 lead 45 is extended to a coupling condenser 57, and the other terminal of this coupling condenser is connected to control grid 58 of vacuum tube amplifier 59. Control grid 58 is connected to ground by means of grid resistor 60, while cathode 61 is automatically biased by bias resistor 62 connected between it and ground. By-pass condenser 63 is shunted across bias resistor 62. Accelerating grid 65 is by-passed to ground by condenser 66 and is maintained at a suitable potential by connection to lead 22 through dropping resistor 67. Vacuum tube 59 has its anode 68 connected through a load resistor 70 to dropping resistor 67 and thence to lead 22. Load resistor 70 is shunted by condenser 71 and the primary 72 of transformer 73. Transformer 73 has its secondary 74 shunted by a condenser 75. One terminal 76 of condenser 75 is connected to ground by lead 77, this lead also being connected to suppressor grid 78 of the vacuum tube. The other terminal 80 of condenser 75 is connected to lead 81 going back to control grid 16 of the first vacuum tube. A feed-back control resistor 82 is connected between lead 81 and ground.

The operation of the system is as follows. A positive gate input consisting of a rectangular voltage wave of suitable amplitude and duration is impressed between ground and input terminal 15 and serves to raise the potential of cathode 11. As shown, vacuum tube 10 is normally conducting but is rendered non-conducting at the instant that the cathode potential is raised by the control gate. The cutting off of space current in vacuum tube 10 results in a rise in potential at anode 25, and this generates a surge across condenser 27 and primary 28. The surge in primary 28 induces a surge in secondary 30, and this results in shock exciting the crystal bridge circuit. During the duration of the positive gate, vacuum tube 10 is non-conducting so that the crystal circuit may oscillate with a minimum of damping. This is due to the high resistance of 26. The shock itself is eliminated by the bridge circuit. The sine waves generated in the crystal bridge circuit are impressed through coupling condenser 36 on control grid 37 of vacuum tube 38, amplified and impressed on control grid 47 of amplifier 48. The resulting potential variations at anode 51 of vacuum tube 48 are impressed upon output terminal 56.

At the same time, waves from anode 41 are also impressed upon control grid 58 of amplifier 59 and result in oscillations being generated in circuit 71 and 72. These amplified waves appear in secondary 74 and are fed back to control grid 16 of first vacuum tube 10. The amplitude of feed-back may be controlled by variable resister 82.

As long as vacuum tube 10 is non-conducting—and this occurs during the duration of the positive gate—feed-back to control grid 16 is ineffective. By careful design of the various circuits, a substantially uniform calibrated series of waves may be taken off at output terminal 56. At the end of the positive gate when cathode 11 drops, vacuum tube 10 becomes conducting. This provides substantial damping for the crystal bridge circuit while the feed-back, which is 180° out of phase, adds further damping. The 180° phase angle of feed-back is a composite of the phase angles in circuit 27—28, tube circuits and other elements. Thus phase shift due to initial crystal response and other unavoidable circuit elements are compensated for. The net result is that when the positive gate is ended, oscillations in the crystal bridge circuit are quickly suppressed. Thus the inverse feed-back potential applied to the bridge circuit functions to accelerate the damping.

In the system shown in Figure 1, the resonant circuit formed by condenser 27 and primary 28 does not introduce much damping resistance into the secondary crystal circuit. This will be true as long as load resistor 26 is high and vacuum tube 10 is non-conducting. As soon as vacuum tube 10 becomes conducting, then a comparatively low resistance is effectively connected across primary 28 and results in a highly damped primary circuit. This high damping is coupled into the crystal circuit.

Referring now to Figure 2, a circuit is disclosed having a different operation. In this circuit, a vacuum tube 90 has its cathode 91 connected through a high bias resistor 92 to a ground lead 93. Control grid 94 is connected through a grid resistor 95 to ground. Vacuum tube 90 has its anode 96 connected through a load resistor 97 and a dropping resistor 98 to a lead 99 connected to a suitable source of B+ potential. The junction of resistors 97 and 98 is connected to a grounded by-pass condensor 100.

From anode 96 of vacuum tube 90 connection is made to a condenser 101 and thence by lead 102 to a variable tuning condenser 103. From cathode 91 a connection is taken through a condenser 104 and lead 105 to crystal 106. A lead 107 connects crystal 106 and variable condenser 103. Between leads 102 and 105 a high resistance 108 is connected and cooperating with this resistance is a grounded movable contact 109. Condensers 101 and 104 may have substantially equal capacitances, while variable condenser 103 may preferably have a capacitance range somewhat larger than but of the order of the capacitance of crystal 106.

From lead 107 a connection is made to control grid 110 of a vacuum tube amplifier 111 having a cathode 112 connected through a comparatively low bias resistor 113 to ground. Control grid 110 is connected to ground by a high grid resistor 115. Anode 116 is connected to a parallel resonant circuit consisting of condenser 117 and inductance 118, and thence the anode circuit continues on through a dropping resistor 120 to lead 99. A by-pass condenser 121 is connected between ground and the low end of dropping resistor 120.

Variations in potential of the anode 116 are impressed upon a coupling condenser 122 and continue on to control grid 123 of vacuum tube amplifier 124. The grid circuit is completed by a grounded grid resistor 125, while cathode 126 is connected to ground by a low bias resistor 127. Anode 128 is connected through a load resistor 129 and dropping resistor 130 to B+ lead 99. A by-pass condenser 131 is connected between dropping resistor 130 and ground. An output terminal 132 is taken from anode 128 and together with ground constitutes an output circuit.

From anode 128 connection is made to a coupling condenser 123 and thence to a grounded resistor 134. Cooperating with resistor 134 is a potentiometer tap 135 connected to control grid 136 of an amplifier 137. Cathode 138 is connected to ground by a low bias resistor 139. An accelerating grid 140 is connected through a suitable resistor 141 to a dropping resistor 142 and thence to B+ lead 99. Grounded by-pass condensers 143 and 144 are provided on opposite sides of resistor

141. A suppressor grid 145 may be grounded, while anode 146 is connected through a load resistor 147 to dropping resistor 142. From anode 146 a feed-back lead 150 is taken through a coupling condenser 151, lead 150 going back to control grid 94 of vacuum tube 90. Input terminal 152 is connected to cathode 138 and together with ground forms an input circuit.

Pentode 137 is biased by potentiometer tap 135 to be normally conducting. When a positive voltage gate is impressed on input terminal 152 and ground, the potential of cathode 138 is raised with respect to control grid 136 and results in space current being cut off. This results in a sudden rise in potential at anode 146, which rise is communicated to control grid 94 of vacuum tube 90. This tube has a high bias resistor 92 in the cathode circuit which results in little space current under normal conditions. However, the high positive voltage gate impressed upon control grid 94 reduces the resistance of vacuum tube 90 to a low value. The sudden decrease in tube resistance and increase in space current cause the potential at anode 96 to drop sharply and thus shocks the bridge circuit 101, 103, 106 and 104.

As long as the positive gate is impressed upon control grid 94, vacuum tube 90 forms a comparatively low resistance connection between condensers 104 and 101 and completes the crystal circuit. Resistance 103 is so high in comparison to the series reactances of condensers 101 and 104 for the frequency used and resistance of tube 90 as to have substantially no effect. The shock impressed upon crystal 106 results in the generation of a series of sine waves having a comparatively low decrement. These sine waves are impressed upon amplifier 111 and result in oscillations in parallel resonant circuit 117 and 118. This circuit is tuned to the same frequency as generated in the shock-excited crystal circuit. From vacuum tube 111 the sine waves are further amplified at vacuum tube 124 from which the output may be taken.

In order to provide feed-back for suppressing oscillation after the gate disappears, the output from vacuum tube 124 has a predetermined portion thereof applied to the control grid of pentode 137. As long as the pentode is cut off by the gate there is no feed-back. At the end of the positive gate at input terminal 152, pentode 137 reverts to its normal conducting condition. Then feed-back in opposite phase is applied to tube 90. At the same time that pentode 137 resumes its normal condition of conductivity, a negative pulse is impressed upon control grid 94 of vacuum tube 90 and causes that tube to be near cut-off. When this happens, there is a high resistance between condensers 101 and 104 by way of vacuum tube 90. Also feed-back effectively increases this resistance. This leaves the crystal circuit highly damped by resistance 108.

Vacuum tube amplifier 111 in the absence of signals on its control grid 110 tends to be normally conducting by virtue of a comparatively low value of bias resistor 113. Hence the comparatively low resistance of vacuum tube 111 becomes shunted across the parallel oscillating circuit normally consisting of condenser 117 and 118. This results in a high damping of oscillations in this circuit.

It is understood that in both Figures 1 and 2 the time constants of the various circuits through which the gates are impressed must be so chosen as to maintain the potentials of the various electrodes at substantially constant values for the duration of the gate.

The frequency at which the various circuits resonate may be chosen at will. The actual design of the circuits will depend on such factors as the number of cycles for each gate cycle, permissible decrement, variation of circuit constants with tube life and other details. If a large number of cycles per shock excitation are required then high Q crystal circuits will be required, care will have to be exercised in coupling through transformers or condensers and the entire system will have to be designed to have a low decrement. In addition, when damping is introduced, it will have to be heavy to dissipate the oscillating energy. However, such details are well known to one skilled in this art.

What is claimed is:

1. An oscillating system comprising a resonant circuit having inductance and capacitance, said circuit having some resistance inherent therein, means for shock exciting said circuit so that oscillations are induced therein, an output circuit from which said oscillations may be taken for utilization, and means operative after a predetermined number of shock-excited oscillations for damping said oscillations, said oscillating circuit having negligible damping during its normal operation and having such high damping upon the operation of said last named means as to suppress oscillations completely almost instantly, an amplifier for said shock-excited oscillations, means for feeding said amplified oscillations back into said shock-excited circuit in opposite phase, and means for rendering said feed-back means inoperative during the time that oscillations are desired.

2. An oscillating system comprising a parallel resonant circuit having inductance and capacitance, and including a crystal, said circuit normally having a low decrement, a vacuum tube amplifier, said amplifier having cathode, grid and anode circuits, means for connecting said resonant circuit in said anode circuit, said anode circuit forming a low resistance across said resonant circuit when said tube is conducting, means for normally maintaining said vacuum tube amplifier in a conducting condition, means for changing said vacuum tube from a conducting condition to a non-conducting condition rapidly enough to shock excite said resonant circuit, means for maintaining said vacuum tube in a non-conducting condition for the time during which oscillations are desired, and means for returning said tube to its normal conducting condition whereupon said oscillating circuit becomes highly damped to suppress oscillations.

3. The system of claim 2 wherein oscillations from said parallel resonant circuit are fed back to the grid of said amplifier, said feed-back being ineffective while said tube is non-conducting and being out of phase so that when said tube becomes conducting amplifier action in the tube aids in damping.

4. An oscillating system comprising a three element vacuum tube, three condensers and a crystal all connected in series to form a bridge with a crystal in one arm a condenser in a second arm the third and fourth arms having condensers with the cathode-anode tube space forming a switch connection between the third and fourth arms, a high damping resistance connected across the first and second arms, said bridge being resonant to a certain frequency when said tube is conducting, said damping resistance being high enough to have little effect on the bridge under normal conditions, means for biasing the tube grid so that said tube is normally near cut-off,

means for sharply changing said grid bias to render said tube highly conducting and shock excite said bridge circuit, means for maintaining said tube in said highly conducting condition while oscillations are desired and means for restoring said tube to its normal non-conducting condition to suppress oscillations.

5. The system of claim 4 wherein oscillations from said crystal circuit are fed back to the control grid of said amplifier, said feed-back being out of phase to suppress oscillations.

6. An oscillating system for generating spaced wave trains comprising a crystal bridge circuit, means for intermittently shock exciting said bridge circuit, means for dissipating the initial shock in said bridge while leaving energy therein for resonant oscillations, and means for amplifying said resonant oscillations without imposing a substantial load on said resonant circuit.

7. The system of claim 6 wherein the amplified oscillations are fed to said resonant circuit 180° out of phase and means for rendering said feedback inoperative only during the time that oscillations are desired.

8. An oscillating system comprising a symmetrical bridge, only one of the arms of said bridge comprising a circuit resonant to a predetermined frequency and having a relatively low decrement at said frequency, the other arms of said bridge, being so constructed that said bridge is substantially balanced at all frequencies except those near said predetermined frequency, means for applying intermittent, shock-exciting pulses to the input of said bridge, the repetition rate of said pulses being considerably lower than the resonant frequency of said circuit, whereby the initial shock of each pulse is substantially balanced out, while the resonant circuit continues to oscillate at its own frequency after said initial shock.

9. An oscillating system comprising a symmetrical bridge, only one of the arms of said bridge comprising a circuit resonant to a predetermined frequency and having a relatively low decrement at said frequency, the other arms of said bridge, being so constructed that said bridge is substantially balanced at all frequencies except those near said predetermined frequency, means for applying intermittent, shock-exciting pulses to the input of said bridge, the repetition rate of said pulses being considerably lower than, and independent of, the resonant frequency of said circuit, whereby the initial shock of each pulse is substantially balanced out while the circuit continues to oscillate at its own frequency after said initial shock, and means to damp said oscillations a predetermined interval after each shock.

10. A system as set forth in claim 9, wherein said last named means applies an inverse feedback potential to said circuit.

11. The method of generating spaced wave trains which comprises intermittently shock exciting a resonant circuit, alternately shunting said circuit with a low impedance to damp the waves therein, and accelerating said damping by applying inverse feed-back to said circuit during the shunting periods.

12. The method of generating spaced wave trains comprising shock exciting at spaced intervals a resonant means to cause it to generate oscillations to be utilized, alternately damping said resonant means reversing the phase of said oscillations, and applying the oscillations of reversed phase to said resonant means during each damping period.

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