Feb. 1, 1938. H. TUNICK 2,106,821

PIEZOELECTRIC CRYSTAL CONTROLLED OSCILLATOR CIRCUITS

Original Filed Feb. 6, 1932

Fig. 1

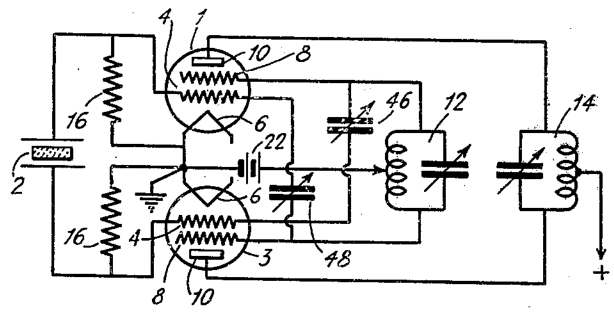


Fig. 1a

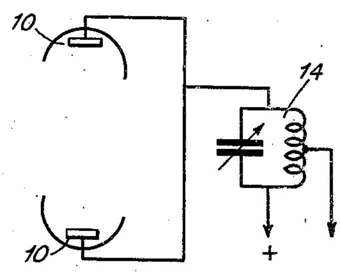


Fig. 2

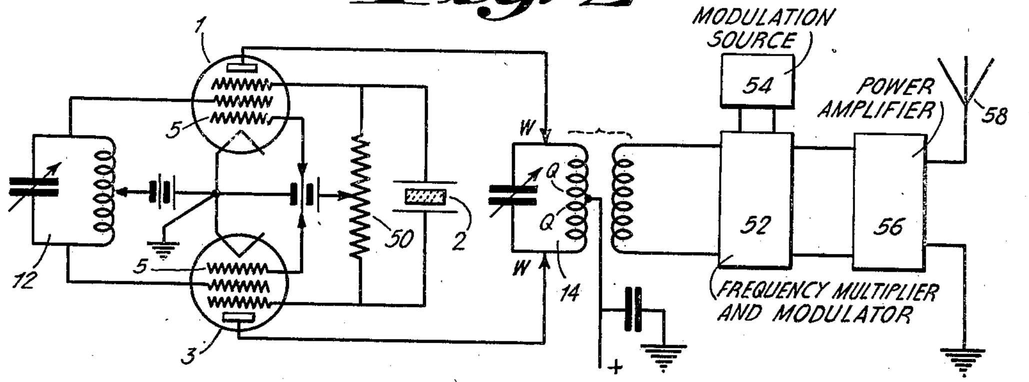
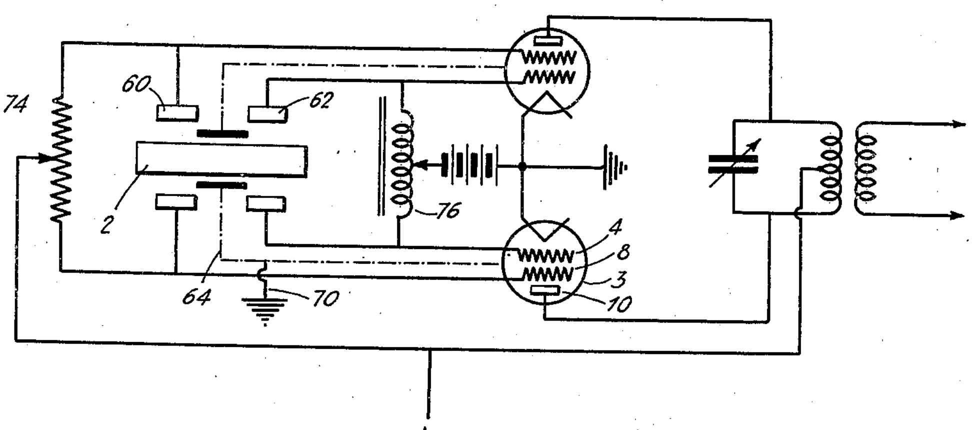


Fig. 3



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PIEZOELECTRIC CRYSTAL CONTROLLED OSCILLATOR CIRCUITS

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Original application February 6, 1932, Serial No. 591,365. Patent No. 2,044,137, dated June 16, 1936. Divided and this application October 19, 1933, Serial No. 694,229. In Great Britain February 6, 1933

4 Claims. (Cl. 250—36)

My present invention is a division of my copending application, Serial Number 591,365, filed February 6, 1932, Patent No. 2,044,137, granted June 16, 1936.

Piezo-electric crystal controlled oscillation generators are usually coupled to some load circuit as a result of which variations in load, reacting back upon the crystal controlled oscillator, cause undesired variations in frequency. The principal object of my present invention is to provide crystal controlled multi-electrode tube oscillator circuits wherein the crystal is loaded lightly and wherein variations in load cannot cause appreciable reaction, with the concomitant evil of frequency drift, upon the crystal. In fulfilling this object, I associate the crystal with an electron discharge device such that certain electrodes within the device together with the crystal, form a complete oscillating circuit. Then, I couple another electrode to the oscillating system, this coupling taking place only through the electron stream within the electron discharge device. This coupling is of such a nature that despite variations in load, there is very little effect or reaction upon the crystal whereby the system oscillates at a frequency widely independent of load variations and of a constancy heretofore unobtainable with known systems.

A further object of my present invention is to provide a symmetrical, balanced, or pushpull oscillator arrangement utilizing the features outlined above.

Turning to the accompanying drawing, which are given solely by way of illustration and in no way are limitative of my present invention,

Figures 1, 1*a*, 2 and 3 are preferred embodiments of my present invention.

In Figure 1 I have shown the crystal **2** connected between the control grids **4** of a pair of electron discharge device oscillators **1**, **3**. Grid bias is accomplished by means of resistors **16** which, however, may be replaced by other biasing means. The oscillatory system of Figure 1 is formed by the screen grid **8**, control grids **4**, cathodes **6** and crystal **2**. The anodes **10** are coupled through the electron streams within the tubes to the oscillatory system. Also, in Figure 1 impedances, preferably in the form of tunable circuits **12**, **14**, are connected between the screen grids and anodes respectively. To prevent spurious oscillation generation due to, for example, the inherent capacity between the crystal electrodes, neutralizing condensers **46**, **48** are provided. These are suitably adjusted so that without the crystal in circuit the system fails to oscillate. However, it will be found that when the crystal is placed into circuit the circuit will go into oscillation at a frequency corresponding to that of a natural frequency of the crystal.

Circuit **14** is tuned to the fundamental frequency of the crystal, or, should odd harmonics be desired it should be tuned to some odd harmonic of the crystal **2** because of its pushpull relation with respect to the anodes of the devices. Should it be desired to obtain even harmonics the anodes **10** as shown in Figure 1*a* should be connected in parallel and the tunable circuit **14** connected in series with the parallel connection, the circuit **14** being tuned to some even harmonic. Thus, as indicated, either odd harmonic or even harmonic energy may be built up in the output circuit **14** which, of course, is only coupled by virtue of the electron streams within the tubes to the crystal oscillating system.

As shown in Figure 2 the tuned circuit **12** and crystal **2** may be reversed in position, the circuit **12** being preferably tuned to a natural oscillating frequency. The circuit **12** as shown in Figure 2, may of course be replaced by a resistance or inductance. The crystal **2** is shunted in the arrangement shown in Figure 2 by a resistor **50** allowing polarizing potentials to pass unidirectionally to the screen grids of the electron discharge devices **1**, **3**. By way of example, the output circuit **14** is coupled inductively to the input of a frequency multiplier modulator circuit diagrammatically indicated at **52** supplied with modulating potentials from a suitable source **54**. Modulated output from the arrangement **52** is fed to some power amplifying device indicated at **56** and in turn transmitted either by wire line or preferably through the air by electromagnetic waves by the action of antenna **58**.

Another pushpull modification is illustrated in Figure 3 wherein the crystal **2** is provided with two pairs of electrodes **60**, **62**. These electrodes are connected to the control grids **4** and screen grids **8** as indicated, of electron discharge devices **1**, **3**. To prevent capacitive coupling between the leads to the crystal electrodes, shielding **64** grounded at point **70** or several points is provided. Polarizing potential is applied to the screen grids through shunting resistor **74**, and, biasing potential is applied to the control grids to the shunting choke **76**. In this arrangement, the screen grids act as plates in the crystal controlled oscillating system, and the plates or anodes **10** of the electron discharge devices **1**, **3** are coupled to the frequency control oscillating system formed by the crystal, screen grids, cathodes and control grids only by virtue of the electron streams within the tubes. Oscillations are set up by virtue of the fact that variations in screen grid voltages at a natural frequency of the crystal are fed to the crystal 2 which in turn generates voltages which are applied to the electrodes 62 in such phase that the electron streams are varied to cause continuous oscillation generation at a very constant frequency.

Various modifications of my present invention may of course be made as will be apparent from even a casual reading of the specification. Accordingly, I do not intend to be limited by the exact modifications illustrated and described, but my invention should be given the full scope indicated by the breadth of the appended claims.

Having thus described my invention, what I claim is:

1. An oscillation generator comprising a pair of electron discharge devices each having an anode, a cathode, a control grid adjacent the cathode, and a screen grid adjacent the anode, a piezo-electric crystal having only two electrodes connected to like grids of said devices, said crystal electrodes being electrically isolated from said anodes, a resonant circuit having inductance and capacity connected between other like grids of said devices whereby oscillations corresponding to a predetermined frequency of said crystal are set up between said cathodes, crystal and grids, means including a circuit having inductance and capacity connected between the anodes of said devices, the electrical constants of the last said circuit being such as to render said circuit resonant at an even harmonic frequency with respect to the vibrational frequency of said crystal and means including a source of direct current potential applied negatively to said cathode and positively to said anodes for sustaining useful oscillations in said discharge devices at said harmonically related frequency, the oscillations being produced by virtue of electron coupling of said anodes to said grids and cathodes.

2. In an oscillation generator, a push-pull network comprising two electron discharge tubes, each tube having a cathode, an anode and at least two intermediate electrodes, including a control grid and a screen grid, a piezo-electric device having at most two electrodes and circuit connections therefrom to said control grids, a resonant circuit tuned to a natural frequency of said piezo-electric device and symmetrically disposed in conductive association with said screen grids, a resonant output circuit tuned to an even harmonic of the vibrational frequency of said piezo-electric device and symmetrically connected to said anodes, and means for deriving oscillations of said even harmonic frequency from said output circuit while preventing the feed-back of energy thereof into the circuit connections to said piezo-electric device, the last said means including a system of cross-connected capacitors between each control grid of one tube and the screen grid of a different tube.

3. In an oscillation generator having a push-pull network including two multi-electrode electron discharge tubes and a piezo-electric device having at most two electrodes and circuit connections therefrom to similarly disposed electrodes in said tubes, the method of deriving oscillatory energy in a utilization circuit connected thereto, which comprises the steps of resonating said push-pull network at a natural frequency of said piezo-electric device, neutralizing the interelectrode capacitive feed-back of energy in said tubes by mutual interchange of electrostatic charges externally of said tubes, and as between unlike electrodes of said tubes, causing pulsations of electronic flow to take place contraphasally in one of said tubes with respect to the other, resonating said utilization circuit at an even harmonic of the natural frequency of said piezo-electric device, and utilizing said pulsations as the sole and entire control of the output energy in said utilization circuit.

4. An oscillation generator having two electron discharge tubes, each tube having a cathode, an anode, a control grid and at least one grid intervening between the control grid and the anode, a piezo-electric device having two electrodes at most, said electrodes being connected respectively to corresponding grids of the respective tubes, a resonant circuit interconnecting two other corresponding grids of the respective tubes, another resonant circuit having parallel-connected capacitive and inductive elements interconnecting the anodes, a source of direct current anode potential connected between a mid-tap on the inductive element of the last said resonant circuit and ground, said cathodes being grounded, an adjustable capacitor connected from the control grid of a first tube to a different grid of a second tube, another adjustable capacitor connected between the control grid of said second tube and a different grid of said first tube, a grid leak resistor connected between the control grid and the cathode of each tube, and means for so adjusting the electrical constants of said generator that it is caused to deliver oscillatory energy of a frequency having an even harmonic relation to the frequency at which said piezo-electric device vibrates.

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