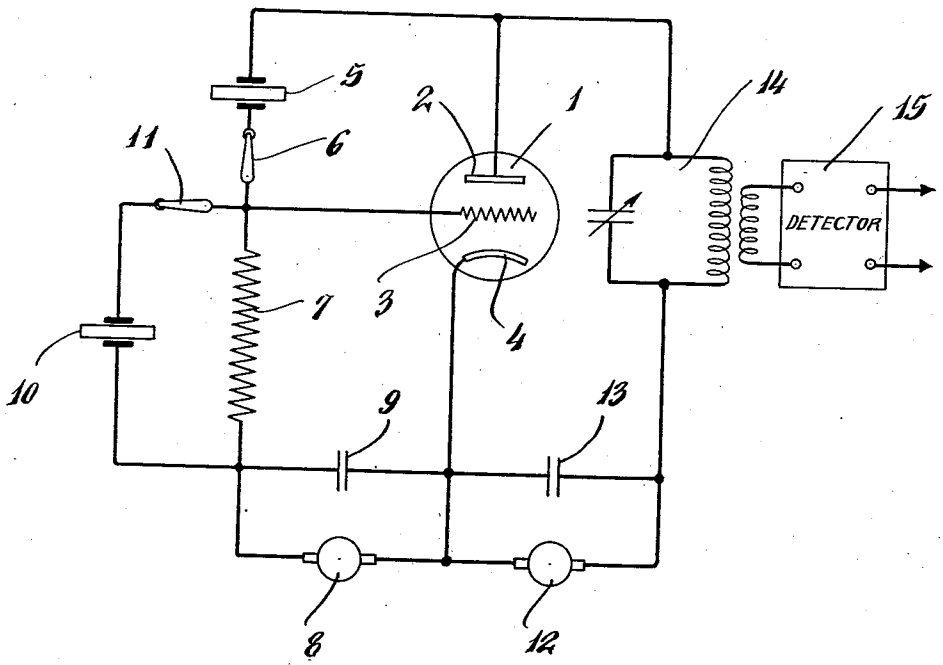
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CRYSTAL BEAT-FREQUENCY OSCILLATOR

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CRYSTAL BEAT-FREQUENCY OSCILLATOR

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The present invention relates to electronic tube oscillators, more particularly to beat-frequency electronic tube oscillators and specifically to piezo-electric crystal controlled beat-frequency electronic tube oscillators.

An object of the invention is to provide a beat-frequency oscillator employing but a single tube and having a high order of beat-frequency stability.

Another object of the invention is to provide a crystal controlled oscillator operating at frequencies, which in the prior art require a costly bar of piezo-electric crystal material, but which, by the employment of the present invention, operate with two very thin and very inexpensive crystals in quantity production.

A further object of the invention is to provide a crystal controlled single tube oscillator for frequencies below the range of practical single-bar crystal-controlled oscillators.

By the employment of the present invention, the lower range of crystal-controlled oscillators is not only extended below the practical range of prior art crystal-controlled oscillators, but further, provides a simple and inexpensive crystal-controlled oscillator within the present low ranges requiring bars of crystals. For instance, by the employment of this invention, primary oscillation frequencies may be obtained simply and inexpensively for oscillators in the audio beat-frequency range. Under prior art structure, a primary frequency oscillator for an audio beat-frequency system would require a bar of quartz crystal of the magnitude of about 3 centimeters long with the accompanying expensive crystal holder and other auxiliary fittings. With the present invention, a beat-frequency oscillator may be constructed employing two crystals of say $\frac{1}{10}$ the thickness of the length of the bar mentioned above and which thin crystals are now in production in large quantities and which may be produced at a very small fraction of the cost of the single bar.

It will be appreciated that exact frequencies are not required in a beat-frequency oscillator, since it is only the difference frequency which needs to be exact; suitable crystals may be selected in pairs from large runs of crystal manufacture without the necessity of grinding any one particular crystal to a high degree of accuracy. In further explanation of this point, it may be said that a single bar of piezo-electric material ground and/or etched to a high degree of accuracy for say 100,000 cycles, is a very expensive procedure. However, if a large number of crystals are ground, say in the vicinity of 3 milli-

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meters without requiring that the frequencies be very exact, the cost of such thin crystals is a very small fraction of that of the single highly accurately made bar. With considerable production, it is practicable to select pairs of approximately ground crystals which have a frequency difference of 100,000 cycles, to a good degree of practical accuracy. In any case, the final grinding or etching of a single unit of a pair of such thin crystals is a comparatively inexpensive procedure.

The lower practical limit of quartz oscillator bars is about 20,000 cycles, and it will be obvious to those skilled in the art that by the employment of the present invention, this lower limit may not only be extended but at a cost greatly under that of a 20,000 cycle bar, which, it will be remembered, requires a very special holder which costs as much as a considerable portion of the cost of the bar itself.

The applicant appreciates that the operative results of his invention may be accomplished by a combination of two separate and complete oscillators employing two tubes and two plate circuit oscillatory systems and the nature of the present invention resides in the novel structure disclosed, which employs but a single tube and a single plate circuit oscillatory system which, it is believed, is a distinct improvement in the art.

The spirit of the present invention does not reside in the employment of any particular type of tube and is independent of the number of electrodes contained in the tube and independent of which electrodes are employed for what purpose, provided of course, that the structure in question is within the meaning of the recitation of the claims hereunder.

The nature of the invention resides in a structure which employs two piezo-electric crystal oscillatory systems connected to a single electronic space discharge tube having a single capacitive-inductive oscillatory output circuit in such a structural form that both of the frequencies of the two crystal oscillatory systems are simultaneously present in the single output capacitive-inductive oscillatory system.

A very large number of structures may be made, employing the spirit of this invention, by the use of multi-electrode tubes employing more than one grid for control purposes, structural differences in feed-back arrangements and various other modifications, extensions and changes, but it is believed that the invention can be best taught to those skilled in the art by the disclosure of one of the very simplest embodiments of the invention

since the use of multi-electrode tubes, beam power tubes, internal and external feed-back circuits and the like are well known to those skilled in the art. The specific nature of the invention will be understood by reference to the description hereunder, particularly when taken in connection with the drawing.

In the figure, 1 is a triode having an anode 2, a grid 3 and a cathode 4. A piezo-electric crystal 5 is connected between the anode 2 and the grid 3 and which crystal may be thrown out of circuit by opening switch 6.

The grid cathode circuit is shunted by a resistor 7 which is provided with a bias generator 8 which may be shunted by a condenser 9. The cathode grid circuit is further shunted by a second piezo-electric crystal 10 which may be thrown out of circuit by opening switch 11.

Tube 1 is provided with a source of anode energy 12 which may be shunted by condenser 13 and energy is fed from source 12 through the capacitive-inductive oscillatory system 14 to anode 2. The oscillatory system 14 is coupled to a detector 15, if and when desired.

The operation of the invention will now be disclosed.

By opening switch 6, it will be observed by those skilled in the art that in the absence of any operation on the part of crystal 5, that the circuit is that of a common type of crystal-controlled oscillator in which the feed-back from the anode circuit is provided by the capacitive coupling between anode 2 and the grid 3.

It is well known in the art that such a circuit, that is, as illustrated by the figure with switch 6 open, requires that the feed-back to the crystal 10 be from an anode circuit system such as 14 which is inductive to the frequency of the natural period of crystal 10, that is, the oscillatory circuit 14 must be tuned to a natural frequency slightly higher than that of the natural period of crystal 10.

Further, if switch 6 be closed and switch 11 be opened, it is obvious to those skilled in the art, that the diagram under these conditions discloses a common type of crystal-controlled oscillator in which the control crystal is operated by direct feed-back from the anode circuit, and further, it is well known in the art that such a crystal-controlled oscillator requires that the feed-back energy for crystal 5 be supplied from an oscillatory circuit 14 which is capacitive to the natural frequency of the crystal 5, or in other words, circuit 14 must be tuned to a slightly lower frequency than that of the control crystal 5.

The applicant has discovered that by closing both switches 6 and 11 and by properly choosing the frequency difference between crystals 5 and 10, he can adjust circuit 14 so that the circuit 14 is simultaneously inductive to the frequency of crystal 10 and capacitive to the frequency of crystal 5 and thus is able to provide with a single tube and a single anode oscillatory system the complete requirements for excitation of both crystals 5 and 10, simultaneously.

The Q of the circuit 14 must be considerably lower than that of crystals 5 and 10, so that circuit 14 is capable of oscillation with considerable amplitudes at both the frequencies of crystals 5 and 10.

With the simultaneous operation of crystals 5 and 10, both frequencies thereof are produced in the oscillatory system 14 simultaneously and therefore the beat-frequency of crystals 5 and 10 appears in the output circuit 14.

The present invention is distinguished from oscillating detectors and regenerative detectors by the fact that these detectors feed back only one frequency to the input circuit thereof, that the beat-frequency is generated in a single capacitive-inductive input circuit, and not in the output circuit, and further, that if crystal control is resorted to in oscillating detectors, only one crystal may be employed locally and obviously no feed-back can be said to exist between an oscillating detector and a crystal control in a remote transmitter. Many other structural differences exist which are obvious to those skilled in the art.

What is claimed is:

1. A beat-frequency oscillator employing a single space discharge electronic tube having a cathode, a grid and an anode; comprising a tube having a piezo-electric oscillatory crystal circuit coupled between the cathode and grid thereof, a second piezo-electric oscillatory crystal circuit coupled between the anode and grid of said tube, a single capacitive-inductive oscillatory circuit and a source of anode energy connected between the anode and cathode of said tube, and means to feed back energy from the single capacitance-inductance oscillatory circuit to both said crystal circuits.

2. In a beat-frequency oscillator, a space discharge electronic tube having input electrodes including a cathode and a control grid and output electrodes including said cathode and an anode, a source of electrical energy connected to last said electrodes, a capacitance-inductance oscillatory circuit coupled to said output electrodes, two oscillatory systems connected to said grid, each of said systems having a natural period of oscillation different from that of the other of said systems, each of said systems being fed back with energy from the oscillatory circuit coupled to said output electrodes under reactively different couplings, and the combined frequencies of both said systems being generated in said oscillatory circuit.

3. In a beat-frequency oscillator, a space discharge electronic tube having input electrodes including a cathode and a control grid and output electrodes including said cathode and an anode, a source of electrical energy connected to last said electrodes, a single capacitance-inductance oscillatory circuit coupled to said output electrodes, two oscillatory systems connected to said grid, each of said systems having a natural period of oscillation different from that of the other of said systems, each of said systems being fed back with energy from the single oscillatory circuit coupled to said output electrodes under reactively different couplings, and the combined frequencies of both said systems being generated in said single oscillatory circuit.

4. In a beat-frequency oscillator, a space discharge electronic tube having input electrodes including a cathode and a control grid and output electrodes including said cathode and an anode, a capacitance-inductance oscillatory circuit coupled to said output electrodes, a crystal oscillatory system having a predetermined natural period and connected to said grid, said oscillatory system having a feed-back from said oscillatory circuit reactively inductive to said natural period, a second crystal oscillatory system having a natural period different from that of first said crystal oscillatory system and connected to said grid, second said oscillatory system having a feed-back from said oscillatory cir-

cuit reactively capacitive to said different natural period, and a source of electrical power connected to said oscillatory circuit providing energy to said feed-backs.

5. In a beat-frequency oscillator, a space discharge electronic tube having input electrodes including a cathode and a control grid and output electrodes including said cathode and an anode, a single capacitance-inductance oscillatory circuit coupled to said output electrodes, a crystal oscillatory system having a predetermined natural period and connected to said grid, said oscillatory system having a feed-back from said single oscillatory circuit reactively inductive to said natural period, a second crystal oscillatory system having a natural period different from that of first said crystal oscillatory system and connected to said grid, second said oscillatory system having a feed-back from said single oscillatory circuit reactively capacitive to said different natural period, and a source of electrical power connected to said single oscillatory circuit providing energy to said feed-backs.

6. In a beat-frequency oscillator, a space discharge electronic tube having input electrodes including a cathode and a control grid and output electrodes including said cathode and an anode, a source of electrical energy connected to said output electrodes, two crystal oscillatory systems having a predetermined beat-frequency coupled to said grid, a capacitance-inductance oscillatory circuit coupled to said output electrodes and feeding back energy through different coupling paths individually to said two crystal oscillatory systems, said oscillatory circuit having said beat-frequency generated therein by reaction of said tube, and a detector means coupled to said oscillatory circuit providing an alternating current of said beat-frequency.

7. A beat-frequency oscillator comprising, a single space discharge electronic tube having input electrodes including a cathode and a control grid and output electrodes including said grid and an anode, two piezo-electric oscillatory crystals electrically connected in series and electrically coupled at the intermediary connection to said grid, said two crystals having different natural periods of oscillation, a capacitive-inductive oscillatory circuit coupled to said output electrodes and having a natural period of oscillation in between the periods of oscillations of said two

crystals, a source of electrical energy coupled to said output electrodes, and means to a part of said energy back to both said crystals.

8. A beat-frequency oscillator comprising, a single space discharge electronic tube having input circuit electrodes including a cathode and a control grid and output circuit electrodes including said cathode and an anode, two piezo-electric oscillatory crystals electrically coupled to said grid and having two different oscillatory frequencies, a single capacitive-inductive oscillatory circuit coupled to said output electrodes and oscillating at both the frequencies of said crystals under reaction thereof with said tube, a source of electrical energy connected to said output electrodes, and means to feed a part of said energy through different coupling paths back to both said crystals providing independent driving energy for each crystal.

9. A beat-frequency oscillator comprising a single space discharge electronic tube having electrodes including a cathode, a grid and an anode, in combination a piezo-electric oscillatory crystal circuit coupled to two of said electrodes requiring feed back reactively inductive to the frequency thereof to maintain oscillation therein under operation, a second piezo-electric oscillatory crystal circuit coupled to two of said electrodes requiring feed back reactively capacitive to the frequency thereof to maintain oscillation therein under operation, a single capacitive-inductive oscillatory circuit coupled to two of said electrodes and providing reactively inductive feed back to first said crystal circuit and reactively capacitive feed back to second said crystal circuit, and a source of electrical energy connected to said capacitive-inductive oscillatory circuit providing feed back energy to said crystal circuits.

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