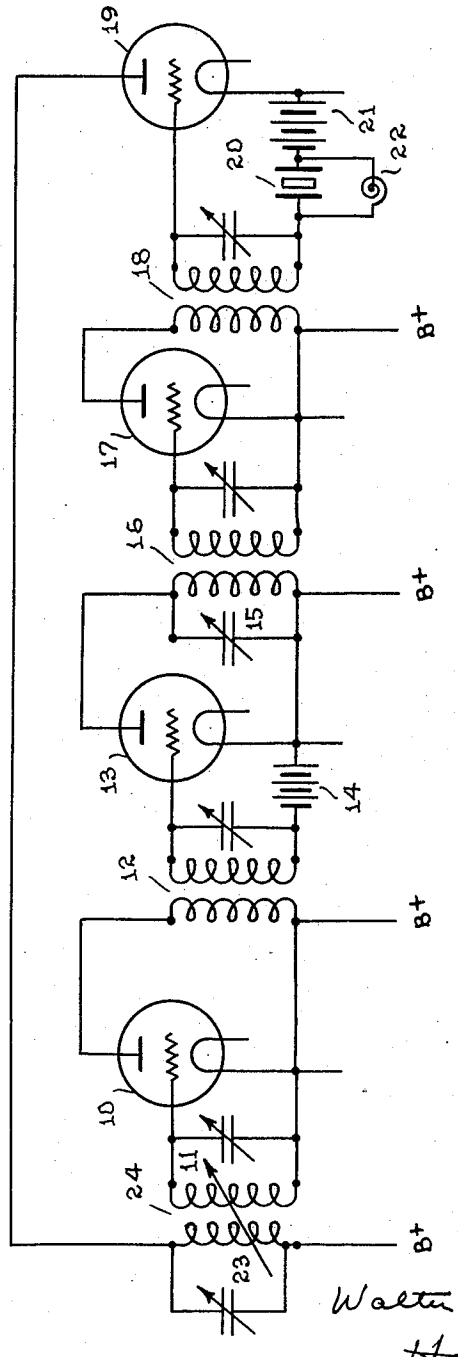
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CRYSTAL SUBHARMONIC GENERATOR

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CRYSTAL SUBHARMONIC GENERATOR

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This invention relates to the piezo-electric art and deals more specifically with a method and apparatus for producing oscillations at constant frequencies, which are lower than the fundamental frequencies of crystals of present day commercial sizes.

It is well known that the fundamental frequency of a piezo-electric crystal is an inverse function of the physical dimensions of that crystal, and therefore, when it is desired to utilize crystal control at frequencies below the order of 100,000 cycles per second, the crystal necessary to maintain control at these relatively lower frequencies has such large dimensions that it cannot be procured without prohibitive cost and difficulty.

There is a great demand at the present time for means of exactly controlling frequencies below the order of 100,000 cycles per second. Frequencies of this order of magnitude find use in time standards, telephotographic and television apparatus as well as other devices requiring mechanical synchronization. Also, the use of frequencies within this range is extremely important in the field of carrier communication with a suppressed fundamental frequency.

It is, therefore, an object of this invention to provide a method and apparatus for generating relatively low frequency oscillations under control of a piezo-electric resonator having commercially practical dimensions.

It is a further object of this invention to generate oscillations of a constant frequency, which frequency is a subharmonic of the fundamental frequency of the piezo-electric resonator used.

Further, it is an object of this invention to provide for the generation of oscillations at different constant frequencies, under control of a single piezo-electric device.

It is a further object of this invention to generate constant frequency oscillations and to vary the value of the particular frequency produced, without necessitating the use of different crystals.

Finally, it is an object of this invention generally to improve the piezo-electric art as applied to its use in connection with maintaining frequency of an oscillation generator constant, and more particularly as applied to crystal control at frequencies lower than the frequencies at which crystal control has heretofore been commercially practical.

The objects of this invention briefly are realized as follows:

A relatively high frequency oscillation generator is provided with a crystal control device in a manner well understood in the art at the present time. A separate oscillation generator tuned to a desired relatively low frequency is provided, and with this last mentioned generator is associated a frequency multiplying device, which is constructed and arranged to boost the relatively low frequencies to a value which differs from the value of the frequency of the relatively high frequency generator by an amount equal to the frequency desired to be used. The harmonic or multiplied frequency of the aforesaid relatively low frequency generator together with the relatively high frequency oscillations produced under crystal control are then fed into a modulating tube, in the output circuit of which tube there exists, among other frequencies, a frequency equal to the difference of the relatively high frequency and the harmonic frequency. The output circuit of the modulator tube is tuned to this last mentioned frequency.

The output circuit of the modulator tube is coupled to the input circuit of the low frequency generator whereby oscillations under crystal control are reflexed or fed back thereto. The phase and amplitude of these oscillations produced under frequency control are adjusted to pull the relatively low frequency generator into step and the low frequency generator thereafter operates to produce oscillations of a frequency exactly equal to the reflexed frequencies which, it will be remembered, remain constant due to the action of the crystal on the high frequency oscillation generator.

A specific example will be helpful in understanding the foregoing principles:

Let us assume we wish to produce oscillations of 20,000 cycles per second under crystal control. The relatively low frequency generator is tuned to that frequency. The

harmonic generator is tuned to 80,000 cycles per second. The high frequency generator operating under crystal control is tuned to 100,000 cycles per second. This last mentioned frequency is modulated by the oscillations of 80,000 cycles and the 20,000 cycle oscillations thus produced are selected and reflexed into the said relatively low frequency generator, thus causing it to pull into step and to continue to oscillate at 20,000 cycles with substantially no variation.

The manner in which this invention is carried out will be more readily understood from the following description taken in connection with the accompanying drawing in which the single figure is a schematic diagram of one specific embodiment of the present invention.

Referring in detail to the drawing, a low frequency oscillation generator 10, tuned by means of the resonant circuit 11 to a frequency, for example, of 20,000 cycles per second, has coupled to it at 12 a frequency multiplying vacuum tube 13. The tube 13 is provided with a suitable biasing battery 14 which causes the tube to operate on a knee of its characteristic curve to insure the production of harmonics of the frequencies fed from the tube 10. The output circuit 15 of the tube 13 is tuned, for example, to a frequency four times that of the frequencies produced at 10 or 80,000 cycles per second. Coupled at 16 to the harmonic generator 13 is a suitable amplifying device 17 which is adjusted to bring the amplitude of the harmonics up to the desired value. A second or high frequency oscillation generator tube 19 is coupled to the amplifier 17 at 18. The oscillation generator 19 is provided with a crystal control resonator 20 in a manner well known in the art. The oscillation generator 19 is provided with suitable biasing battery 21 and a choke coil 22. It is to be understood that the structural details of the crystal controlled oscillation generator 19, per se, forms no part of the present invention, but rather any crystal controlled oscillation generator now known in the art may be used. The oscillation generator represented herein may also serve as a mixing tube, or alternatively separate tubes may be utilized, one for the purpose of generating the oscillations and the other as a mixing tube for the oscillations produced from the frequency multiplier 17 and the high frequency generator. In the specific example being described, as already indicated above, the tube 10 produces oscillations of the frequency of 20,000 cycles, the tube 13 oscillations of 80,000 cycles, and the tube 19 is made to oscillate independently at 100,000 cycles, under control of the crystal. The 100,000 cycle frequency is modulated in the tube 19 by the 80,000 cycle frequency produced in 13 and amplified in 17, with the result that, in the output circuit 23 of the tube 19, there flows a frequency of 20,000 cycles, which frequency remains constant due to the action of the crystal 20 on the tube 19. The output circuit 23 of the tube 19 is coupled to the input circuit 11 of the tube 10 at 24, whereby the relatively low frequencies, which are kept constant through the action of the crystal 20, are reflexed into the tube 10. The amplitude and phase of the reflexed oscillations are adjusted to exceed the grid-swing of the tube 10. By virtue of this arrangement the low frequency oscillations produced under crystal control pull the oscillation generator 10 into step and cause it to oscillate exactly at the frequency of the reflexed oscillations, namely, 20,000 cycles per second.

While there is disclosed herein a specific embodiment of the invention it is to be understood that many changes in the system and method disclosed will readily suggest themselves to those skilled in the art. For example, any suitable number of stages of amplification may be utilized at any point in the system without departing from the spirit of this invention. Also, any one or several of the tubes shown may be used to perform a single or dual function, such as, for example, the tube 19 which serves as both an oscillation generator and a modulating tube. It is to be strictly understood that the present disclosure is merely used for the purpose of illustrating the principles of this invention, and that the scope thereof is not to be limited except as outlined in the appended claims

Having thus described my invention, I claim:

1. The method of producing electrical oscillations of substantially constant frequency which comprises, producing relatively high frequency oscillations under control of an electro-mechanical vibrator, independently producing relatively low frequency oscillations, multiplying the frequency of said last mentioned oscillations, modulating said first mentioned oscillations by means of said oscillations of multiplied frequency, and reflexing said modulated oscillations through said relatively low frequency oscillation producing apparatus.

2. The method of producing electrical oscillations of substantially constant frequency which comprises, producing relatively high frequency oscillations under control of an electro-mechanical vibrator, independently producing relatively low frequency oscillations, multiplying the frequency of said last mentioned oscillations to a value which differs from said first mentioned oscillations approximately by an amount equal to the desired frequency of oscillation, and combining said multiplied oscillations with said first mentioned oscillations to produce oscillations having the desired frequency.

3. The method of producing electrical oscillations of substantially constant frequency which comprises, producing relatively high frequency oscillations under control of an electro-mechanical vibrator, independently producing relatively low frequency oscillations, multiplying the frequency of said last mentioned oscillations to a value which differs from said first mentioned oscillations approximately by an amount equal to the desired frequency of oscillation, combining said multiplied oscillations with said first mentioned oscillations to produce oscillations having the desired frequency, and reflexing the oscillations thus produced through said relatively low frequency producing apparatus.

4. The method of producing electrical oscillations of substantially constant frequency which comprises, producing relatively high frequency oscillations under control of a piezo-electric resonator, independently producing relatively low frequency oscillations, multiplying the frequency of said last mentioned oscillations, modulating said first mentioned oscillations by means of said oscillations of multiplied frequency, and reflexing said modulated oscillations through said relatively low frequency oscillation producing apparatus.

5. The method of producing electrical oscillations of substantially constant frequency which comprises, producing relatively high frequency oscillations under control of a piezo-electric resonator, independently producing relatively low frequency oscillations, multiplying the frequency of said last mentioned oscillations to a value which differs from said first mentioned oscillations approximately by an amount equal to the desired frequency of oscillation, combining said multiplied oscillations with said first mentioned oscillations to produce oscillations having the desired frequency, and reflexing the oscillations thus produced through said relatively low frequency producing apparatus.

6. The method of producing electrical oscillations of substantially constant frequency which comprises, producing relatively high frequency oscillations under control of an electro-mechanical vibrator, independently producing relatively low frequency oscillations, multiplying the frequency of said last mentioned oscillations to a value different in frequency from the high frequency oscillations generated, modulating said first mentioned oscillations by means of said oscillations of multiplied frequency, utilizing said modulated oscillations to control the production of said relatively low frequency oscillations.

7. The method of producing electrical oscillations of substantially constant frequency which comprises, producing relatively high frequency oscillations under control of an electro-mechanical vibrator, independently producing relatively low frequency oscillations, multiplying the frequency of said last mentioned oscillations to a value which differs from said first mentioned oscillations approximately by an amount equal to the desired frequency of oscillation, and combining said multiplied oscillations with said first mentioned oscillations to produce oscillations having the desired frequency, utilizing said oscillations having the desired frequency to pull the relatively low frequency producing apparatus into step therewith.

8. Apparatus for producing oscillations of substantially constant frequency comprising in combination, means to produce relatively high frequency oscillations, electro-mechanical means to control said means, means to generate relatively low frequency oscillations, means to produce a harmonic of said last mentioned oscillations, means to combine said relatively high frequency oscillations with said harmonic, and means to reflex said combined frequency into said means for generating low frequency oscillations.

9. Apparatus for producing oscillations of substantially constant frequency comprising in combination, means to produce relatively high frequency oscillations, piezo-electric means to control said means, means to generate relatively low frequency oscillations, means to produce a harmonic of said last mentioned oscillations, means to combine said relatively high frequency oscillations with said harmonic, and means to reflex said combined frequency into said means for generating low frequency oscillations.

10. Apparatus for producing oscillations of substantially constant frequency comprising in combination, a crystal controlled oscillating vacuum tube tuned to a relatively high frequency, means to generate oscillations of a desired relatively low frequency, means coupled to said last mentioned means to produce a harmonic of said last mentioned oscillations, means to impress said harmonic upon said vacuum tube whereby to modulate the oscillations produced thereby, and means to impress said modulated oscillations upon said first mentioned means.

11. Apparatus for producing oscillations of substantially constant frequency comprising in combination, a crystal controlled oscillating vacuum tube tuned to a relatively high frequency, vacuum tube means to generate oscillations of a desired relatively low frequency, means coupled to said last mentioned means to produce a harmonic of said last mentioned oscillations, means to impress said harmonic upon said vacuum tube whereby to modulate the oscillations produced thereby, and means to impress said modulated oscillations upon said first mentioned means, the amplitude of said modulated

oscillations being adjusted to exceed the grid-swing of said second mentioned vacuum tube.

12. Apparatus for producing oscillations of substantially constant frequency comprising in combination, a vacuum tube oscillation generator tuned to a relatively high frequency, piezo-electric means to maintain said frequency substantially constant, a second vacuum tube oscillation generator tuned to a relatively low frequency, vacuum tube means to produce a harmonic of said last mentioned oscillations coupled to said last mentioned generator, a modulating tube fed by said first mentioned vacuum tube and said harmonic generator constructed and arranged to combine said relatively high frequency oscillations with said harmonics, and means to reflex said combined frequencies into said means for generating low frequency oscillations.

13. The method of producing electrical oscillations of substantial constant frequency which comprises generating substantially constant frequency high frequency oscillations, generating independently relatively low frequency oscillations, multiplying the frequency of the low frequency oscillations to a value different from that of the high frequency oscillations generated, combining the oscillations of the multiplied frequency with the high frequency oscillations, and utilizing the resultant oscillations to control the frequency of the relatively low frequency oscillations generated.

14. Apparatus for producing relatively low frequency oscillations of substantially constant frequency comprising a high frequency oscillator generating oscillations of substantially constant frequency, a low frequency oscillator, generating oscillations at the desired low frequency, means for multiplying the frequency of said low frequency oscillations to a value such that when beaten with oscillations of said high frequency oscillator the resulting beat oscillations have a frequency corresponding to the frequency of oscillation of said low frequency oscillation generator, and, means for applying oscillations of beat frequency to said low frequency oscillation generator whereby said low frequency oscillation generator is pulled into step with the beat frequency oscillations applied thereto.

15. Apparatus for generating oscillations of constant frequency comprising an oscillation generator whose frequency is to be controlled, an oscillation generator generating oscillations of substantially constant frequency, means for frequency multiplying oscillations from the oscillator whose frequency is to be controlled, means for beating the frequency multiplied oscillations with oscillations from said constant frequency generator whereby to obtain oscillations of a frequency corresponding to the frequency of the oscillator whose frequency is to be controlled, and, means for applying beat frequency oscillations so obtained to the oscillator whose frequency is to be controlled whereby said controlled oscillator is pulled into step with the applied beat frequency oscillations.

In testimony whereof I have affixed my signature.

WALTER ALBERSHEIM.