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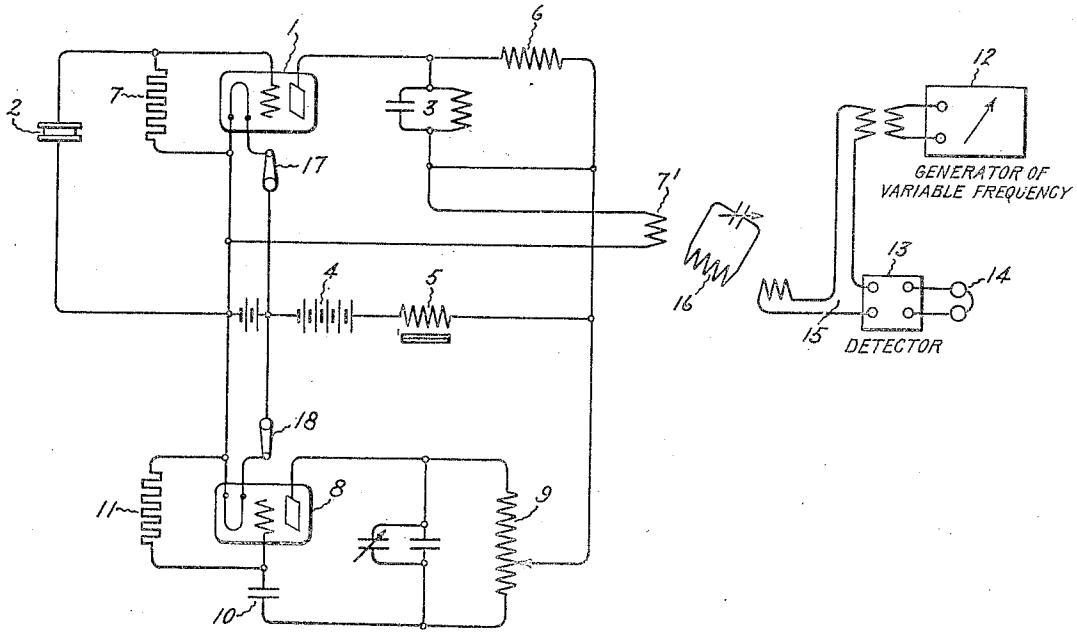
OSCILLATION GENERATOR

Filed May 22, 1930

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# UNITED STATES PATENT OFFICE

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## OSCILLATION GENERATOR

Application filed May 22, 1930. Serial No. 454,778.

My invention relates to oscillation generators and it has for one of its objects to provide an oscillation generator which is capable of producing oscillations of relatively low frequency and also harmonics, or oscillations having integral multiple frequencies thereof, over a very broad range. A further object is to provide such a system in which all of the different frequencies produced are controlled by a single piezo electric device.

Piezo electric crystals, as commonly produced commercially, operate at relatively high frequencies. For laboratory purposes such as calibrating and testing, it is frequently desirable to have means for producing oscillations in the lower range of frequency which have the same degree of constancy which is obtainable in the higher range by means of crystals.

Accordingly, one of the objects of my invention is to provide means whereby the frequency of a low frequency oscillation generator may be governed by means of a crystal, or other frequency determining element, having an inherently fixed natural period, and the natural frequency of which is higher than that at which the oscillation generator operates.

Still a further object of the invention is to provide improved means whereby oscillations having frequencies corresponding to integral multiples of said low frequency over a very broad range may be produced.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself. however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in which the single figure represents an embodiment of my invention.

Referring to the drawing, I have shown at 1 an electron discharge device having a piezo electric crystal 2 connected between the grid and cathode thereof, and an oscillatory circuit 3 connected between the anode and cathode, this circuit being tuned in the usual manner in a crystal controlled oscillator generator that is, at a frequency slightly higher than the natural frequency of the crystal. Electromotive force for energizing the anode of the discharge device is derived from a source 4 through a modulation reactor 5, the purpose of which will presently appear, and a choke coil 6. Also connected between the grid and cathode is a suitable grid leak resistance 7. As thus arranged the device 1 operates to generate high frequency oscillations having the frequency of the crystal 2 and harmonics or integral multiple thereof, these oscillations being supplied to any desired load circuit by means of a suitable output coil 7'.

As previously stated, for many purposes it is desirable to produce oscillations which have the constancy of frequency which is characteristic of oscillation generators which are controlled by means of piezo electric crystals but which operate at a frequency much lower than the natural period of crystals which may be economically produced. It is further desirable to produce oscillations having a plurality of fixed frequencies spaced apart in the frequency range at uniform intervals which are closer together than the frequencies of oscillations produced by operation of a single crystal of the nature commonly employed.

Accordingly, to produce oscillations which are of lower frequency than the frequency at which the crystal controlled oscillation generator 1 operates, I provide a second oscillation generator comprising an electron discharge device 8. This discharge device has an oscillatory circuit 9 comprising parallel connected inductance and capacity connected between the anode and grid thereof through a suitable blocking condenser 10. The anode of this discharge device is energized from a source of electromotive force 4 through the modulation reactor 5 and a portion of the inductance of the oscillatory circuit 9. Connected between the grid and cathode of the discharge device 8 is the usual grid leak resistance 11.

In the operation of the system oscillatory circuit 9 of the generator 8 is so adjusted that it operates at a frequency, of which the

frequency of generator 1 is an integral multiple. Thus, for example, if the frequency of the oscillation generator 1 is 100,000 cycles per second, that of the generator 8 may be 10,000 cycles per second. With the circuit as thus constructed and arranged, I have found that the frequency of the oscillator 8 is very definitely maintained by means of the crystal 2. Thus, for example, the condenser of the oscillatory circuit of the generator 8 may be varied through a considerable range without affecting the frequency at which the generator operates, thereby showing that the frequency is being controlled by the crystal 2.

As thus constructed both of the oscillation generators produce harmonics of their fundamental frequencies. The amplitude of these harmonics is of course dependent to a certain extent upon the adjustment of the anode source of potential. By proper adjustment of this source of potential and other parts of the circuit such, for example, as the grid leaks 7 and 11, as well understood in the art these harmonics may be made of considerable amplitude. I have found that as thus constructed, the fundamental and each of the harmonics of the high frequency generator 1, are modulated by the fundamental and each of the harmonics of the low frequency generator 8. The modulation reactor 5 is included in the circuit as described to improve this modulating operation of the system. Its operation in the circuit will not be described since it is well understood in the art.

Thus, for example, since the high frequency generator operates at a frequency corresponding to an integral multiple of the frequency of the low frequency generator, integral multiples of the fundamental frequency of the low frequency generator throughout a very broad range will be present in the circuit. Thus if we assume the frequencies previously mentioned, it will be found that oscillations having frequencies corresponding to integral multiples of 10,000 cycles will be present in the circuit throughout a range extending from the fundamental of the oscillation generator 8 to the frequency of the higher harmonics of the generator 1.

Thus, for example, if we assume that the 100,000 cycle frequency is modulated by the fundamental and second to ninth harmonic of the 10,000 cycle frequency, the lower and upper side band frequencies will be seen to supply integral multiples of the 10,000 cycle frequency up to 190,000 cycles. The lower side bands will, of course, be of the same frequency as the harmonics of the source 8 produced in its own circuits and these frequencies will tend to maintain the frequency of the generator at the predetermined value governed by the crystal. Similarly, if we now assume the second harmonic produced by the generator 1 to be modulated by the same frequencies, it will be seen that the lower side bands will be of the same frequency as the upper side bands produced by the first modulation and these frequencies will combine in the circuit. The upper side band frequencies will supply integral multiple frequencies of the 10,000 cycle fundamental up to 290,000. The modulation of the higher harmonics may similarly be explained. Of course, the tenth and higher harmonics of the source 8 correspond in frequency respectively with the fundamental of source 1, and certain frequencies produced by modulation and hence additionally tend to maintain the frequency of the source 8.

While in the above explanation I mention the modulation of oscillations produced by generator 1 with the second to ninth harmonic of the oscillations produced by generator 8, it will be readily understood that because of the presence of both the upper and lower side band frequencies in the output circuit, the operation of the system in producing multiple frequencies would be the same were the harmonics above the fifth of negligible intensity.

In the way of indicating one application of utility of an oscillation generator of the type described, I have shown at 12 an oscillation generator of variable frequency which is to be calibrated, and at 13, a detector, of any well known type having in its output circuit a suitable indicating device 14. Oscillations from the output coil 7′ of the system described, and from the generator 12 may be supplied to the detector 13 by means of an input circuit 15 coupled both to the coil 7′ and the generator 12. Oscillations having the frequency of the source 8 and of any desired integral multiple thereof may be selected from the output coil 7′ by means of a tuned selective circuit 16 and supplied to the input circuit of the detector 13. Thus in operation, the operator will adjust the condenser of the tuned circuit 16 to a frequency corresponding to a certain multiple frequency of the source 8. He will then adjust the frequency of the oscillator 12 until a zero beat is indicated by the device 14. This indication may be produced by a pair of headphones, or by a galvanometer mounted in the output circuit of the detector. He may then adjust the circuit 16 to each of the different multiples and repeat the process, thereby calibrating the generator 12 through its entire range.

Switches 17 and 18 are included in the cathode circuits of generators 1 and 8 to enable either generator to be operated independently of the other. Frequently it is desirable in calibrating, first, with the switch 18 open, to determine the points corresponding to the fundamental and harmonics of generator 1. The intermediate points may then be very rapidly determined by closing switch 18 and counting the points of zero beat as the adjustment of selecting circuit 16

and the calibrated device 12 is progressively varied from one of the previously determined points to another.

While I have particularly mentioned the use of a piezo electric crystal for controlling the frequency of the system described, it will be understood that other frequency determining elements such as a magnetostrictive bar, may be employed, as taught for example, by Patent No. 1,750,124 to G. W. Pierce.

While I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since many modifications both in the circuit arrangement and the instrumentalities employed may be made, and I therefore contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, an electron discharge oscillation generator including a piezo electric device arranged to govern the frequency thereof, said generator being arranged to produce oscillations having a fundamental frequency and harmonics thereof, said fundamental frequency being substantially equal to a natural frequency of said piezo electric device, a second oscillation generator arranged to produce a fundamental frequency and harmonics thereof, a certain harmonic of the fundamental frequency of said second oscillation generator being equal to said natural frequency of said piezo electric device, and means including a coupling between said generators whereby oscillations are produced having frequencies controlled by the piezo electric device, said frequencies occuring in the frequency range both above and below the natural frequency of the piezo electric device and spaced apart in the frequency range by an amount equal to the fundamental frequency of said second oscillation generator.

2. In combination, an electron discharge oscillation generator arranged to operate at a certain fundamental frequency, a second electron discharge oscillation generator arranged to operate at a different fundamental frequency, said different frequency being an integral multiple of the frequency at which said first generator operates and both of said generators being adapted to produce harmonics of said fundamental frequency at which the respective generator operates, and means whereby the fundamental and certain of the harmonics of said second oscillation generator are each modulated by the fundamental and certain of the harmonics of said first oscillation generator whereby oscillations having frequencies corresponding to a broad range of multiples of the frequency of said first generator are produced.

3. In combination, a pair of electron discharge oscillation generators, one of said generators being arranged to oscillate at a frequency which is an integral multiple of the frequency at which said other generator operates, and each of said generators having an anode circuit, a coupling between said anode circuits whereby the fundamental and certain of the harmonics of the higher frequency generator are modulated by the fundamental and certain of the harmonics of the lower frequency generator, and means for selecting from the circuit of one of said generators the fundamental and each harmonic of the lower frequency generator through a range broader than the difference in frequency between the fundamentals of the two generators.

4. In combination, an electron discharge oscillation generator including a piezo electric device arranged to govern the frequency thereof, said generator being arranged to produce oscillations having a fundamental frequency and harmonics thereof, said fundamental frequency being substantially equal to a natural frequency of said piezo electric device, an output circuit for said generator and means to produce in said output circuit additional frequencies evenly spaced in the frequency range between the different harmonics of said generator, said means comprising a second oscillation generator coupled to said first oscillation generator, and arranged to produce a fundamental frequency and harmonics thereof, said fundamental frequency of said second generator being equal to the difference between adjacent desired frequencies in said range.

In witness whereof, I have hereunto set my hand this 16th day of May, 1930.

FRANK J. MOLES.