Feb. 13, 1934. P. H. BETTS 1,947,182

CONSTANT FREQUENCY APPARATUS

Filed June 7, 1930

FIG. 1

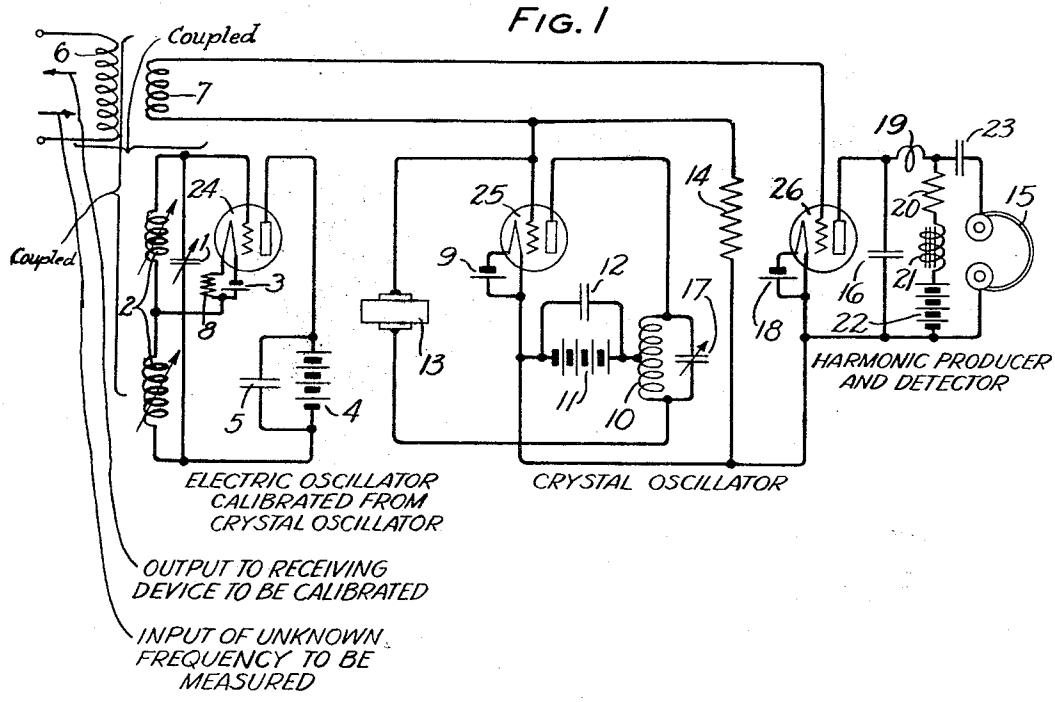
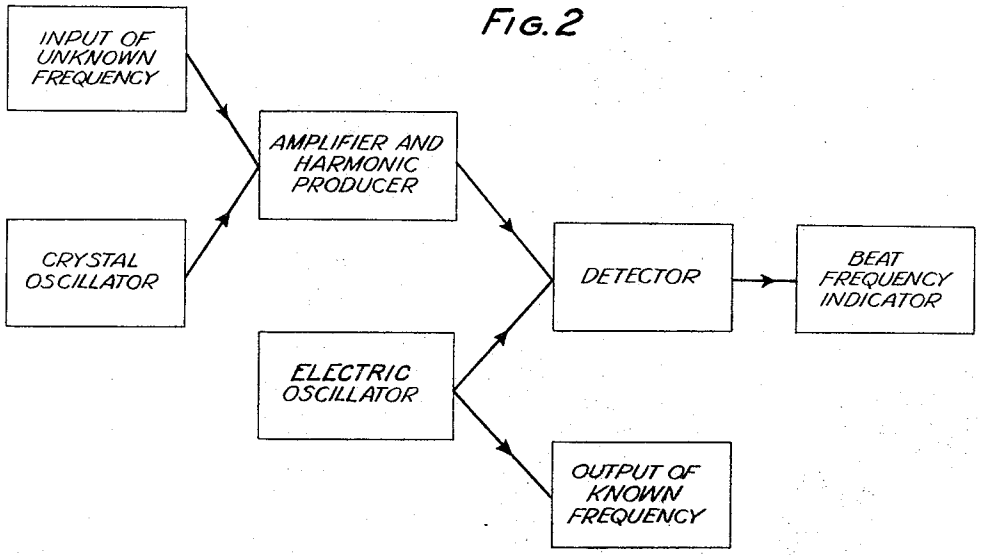


FIG. 2



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CONSTANT FREQUENCY APPARATUS

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3 Claims. (Cl. 250—36)

This invention relates to constant frequency apparatus, and particularly to apparatus which may be assembled into a compact and portable unit, and may be utilized to measure the frequency of an unknown wave, or produce a wave of known frequency, with great accuracy.

A feature of this invention is a piezo-electric crystal controlled oscillation generator, and means for comparing the frequency of an electric oscillation generator with waves produced thereby.

In utilizing the principles of this invention two oscillation generators are provided, one of which may be controlled by electrical reactances, and be capable of generating waves over a wide range of frequencies, and the other of which is mechanically controlled, as by a piezo-electric crystal (which may be of quartz, for example), so as to be capable of generating a wave whose frequency is constant within very narrow limits. There is also provided means for producing harmonics of the waves so generated, and for intermodulating and comparing the waves so produced.

In the operation of one form of the device of the invention a wave of unknown frequency, whose frequency is to be determined, is intermodulated with a wave from the electric oscillation generator, and a zero beat note obtained. The setting of the electrical reactances for this zero beat is noted. The wave of unknown frequency is then replaced by the output of the crystal controlled oscillator, and a zero beat is then obtained between the two nearest settings of the reactances which will give a zero beat with two characteristic frequencies of the crystal controlled oscillator which may comprise the fundamental and a harmonic of the wave from said oscillator or two harmonics thereof. This gives two points of known frequency for the electric oscillator, and by interpolation the frequency of the unknown wave may be determined with great accuracy.

In the drawing, Fig. 1 is a diagram showing one form of circuit for utilizing the principles of this invention; and

Fig. 2 is a schematic diagram illustrating how the various portions of the circuit function.

In Fig. 1 an oscillation generator marked "Electric oscillator" comprises a three-electrode space discharge device 24, a filament battery 3, grid biasing resistance 8, and plate battery 4 which is shunted by by-pass condenser 5. Its frequency is controlled by a tuned circuit consisting of a variable condenser 1 and variable inductances 2, and it may be calibrated in harmonics of the frequency of a piezo-electric crystal to be described. The oscillations generated are impressed on a harmonic producer and detector by means of coupling between inductances 2 and inductance 7. A wave, the frequency of which is to be determined, may be impressed on the detector from another source by means of the coupling between an inductance 6 and inductance 7.

A piezo-electric crystal controlled oscillation generator marked "Crystal oscillator" comprises a three-electrode space discharge device 25, the plate of which is connected to one side of a tuned circuit consisting of an inductance 10 and variable condenser 17. From a point on the inductance a tap leads through a plate battery 11, shunted by a by-pass condenser 12, to the filament. The other side of the tuned circuit is connected through a piezo-electric crystal, 13, to the grid. The filament is heated by battery 9. The grid electrode of the crystal oscillator is biased through resistance 14 connected between its grid and filament. The tuned circuit 10—17 may be adjusted to give a large inductive reactance in the plate circuit of the crystal oscillator, and provide some feed-back into the grid circuit to assist in production of crystal oscillation.

A harmonic producer and detector comprises a three-electrode space discharge device 26 having the inductance 7 and resistance 14 in its input circuit. Its filament is heated by a battery 18. Its plate is connected to its filament through a high frequency by-pass condenser 16. In parallel to the condenser 16 there is provided in series a high frequency choke coil 19 and two parallel circuits which include respectively a resistance 20 for regulating the plate voltage, a low frequency choke coil 21, and plate battery 22, and an audio frequency condenser 23 and telephone receiver 15. The telephone receiver 15 may be replaced by a meter or other suitable device for indicating the frequency of a beat note produced in the output circuit of the detector.

The circuit shown is, of course, simply illustrative of one manner of utilizing the principles of the invention, and may be modified in any desired manner without departing from the scope of the invention. The harmonics of the crystal frequency may be produced in the crystal oscillator and the harmonic producer and detector used for detection only, or the harmonics may be produced and the detection performed each in separate devices.

The operation of the invention may be best described by reference to Fig. 2. Assume that the

crystal oscillator is controlled by a crystal whose fundamental frequency of vibration is exactly 100 kilocycles and that an unknown frequency is to be measured whose frequency is, say, 2,835,000 cycles. The unknown frequency is impressed on the detector through the amplifier together with a wave from the electric oscillator. The electric oscillator is then adjusted to give a zero beat note in the beat frequency indicator, and the condenser setting of the electric oscillator noted. During this operation the crystal oscillator is turned off The unknown frequency is now turned off and the crystal oscillator is turned on. The electric oscillator is now adjusted to give a zero beat with the nearest harmonic from the crystal oscillator. This will be the 28th harmonic which will give a condenser setting of the electric oscillator for 2,800,000 cycles. Another adjustment is then made for zero beat with the nearest harmonic in the other direction. This will give another setting corresponding to 2,900,000 cycles. These two points will be fixed with great precision. The unknown frequency can then be determined by interpolation.

To produce an output of known frequency the process is very similar. If it is desired to produce an output of 2,835,000 cycles, say, the settings of the vacuum tube oscillator for 2,800,000 cycles and 2,900,000 cycles are found by comparison with the corresponding harmonics of the crystal oscillator, and the setting for the desired frequency found by interpolation. The known frequency output is taken off through inductance 6 (Fig. 1). If straight line frequency control is used, the interpolation may be made with greater accuracy and facility.

What I claim is:

1. A crystal calibrated wave meter comprising an electric oscillator, a crystal oscillator, a detector, and means for receiving a wave of unknown frequency, in combination with means for impressing waves from said electric oscillator and said crystal oscillator on said detector, means for impressing the wave from said electric oscillator and said unknown wave on said detector, and means for observing a beat note produced in said detector.

2. The method of measuring the frequency of an unknown wave in a calibrating instrument comprising means for receiving said unknown wave, a variable frequency electric oscillator, a crystal oscillator, a detector and a signal indicator, which comprises impressing said unknown wave and a wave from said electric oscillator on said detector and adjusting the frequency of the wave from the electric oscillator for a zero beat in said signal indicator, impressing waves from said electric oscillator and said crystal oscillator on said detector and again adjusting the frequency of the wave from the electric oscillator for a zero beat in the signal indicator for the two harmonics of the crystal oscillator nearest to the frequency of the unknown wave, and interpolating between said last adjusted frequencies to determine the frequency of the unknown wave corresponding to the first adjusted frequency.

3. The method of producing a wave of known frequency with a device comprising a variable frequency electric oscillator, a crystal oscillator, a detector and a signal indicator, which comprises impressing waves from said electric oscillator and said crystal oscillator on said detector and adjusting the frequency of the wave from the electric oscillator for a zero beat in said signal indicator between the two nearest harmonics of the crystal oscillator to the desired frequency, and setting said electric oscillator, by interpolation between said values, to produce a wave of said known frequency.

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