June 12, 1928. **1,673,200**

R. B. OWENS

CRYSTAL CONTROLLED CALIBRATOR

Filed June 8, 1927

FIG. 1

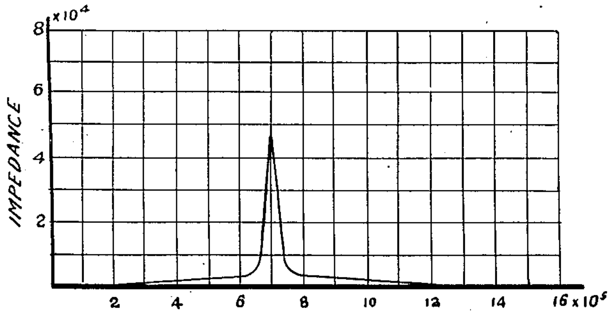


FIG. 2

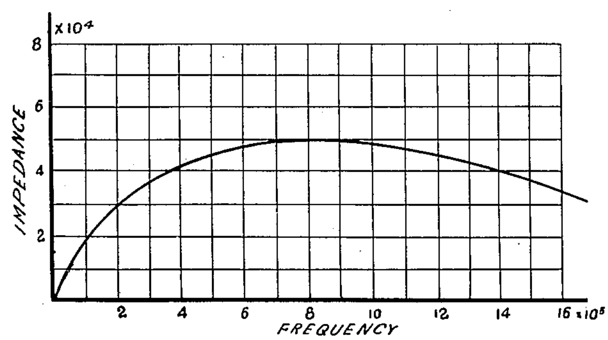


FIG. 3

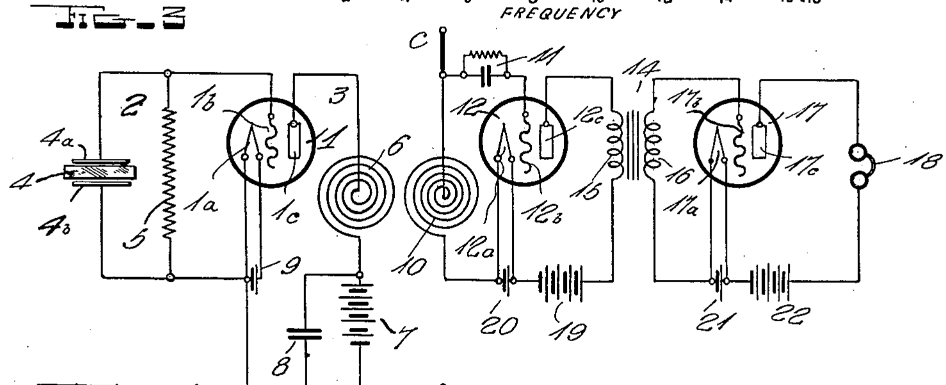
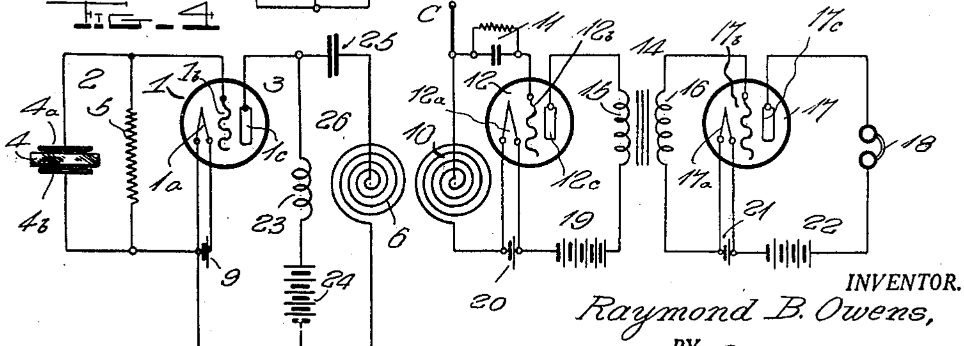


FIG. 4



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UNITED STATES PATENT OFFICE.

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CRYSTAL-CONTROLLED CALIBRATOR.

Application filed June 8, 1927. Serial No. 197,495.

My invention relates broadly to piezo electric crystal control circuits and more particularly to a calibrator apparatus depending for its operation upon the natural frequency characteristics of piezo electric devices.

One of the objects of my invention is to provide a practical circuit arrangement for deriving from a piezo electric device a plurality of harmonic frequencies which, by reason of their constant frequency characteristics, may be employed in accurately calibrating associated electrical circuits.

Another object of my invention is to provide a circuit system for a crystal calibrator comprising an electron tube oscillator circuit, a detector and an amplification system by which harmonic frequencies may be selected from a piezo electric device and sustained by said oscillator circuit.

Still another object of my invention is to provide a piezo electric crystal controlled electron tube oscillator system in which the output circuit of the oscillator has a large ratio of inductance to capacity for the development of harmonic frequencies from said piezo electric crystal.

My invention will be more fully understood from the specification hereinafter following by reference to the accompanying drawings wherein:

Figures 1 and 2 show curves illustrating opposite conditions that may exist in the relation of impedance and frequency in an electrical circuit upon which phenomena my invention is based; Fig. 3 illustrates one embodiment of the crystal calibrator circuit arrangement of my invention; and Fig. 4 illustrates a modified wiring arrangement for the crystal calibrator in which a parallel feed circuit is applied to the crystal controlled oscillator system.

The crystal calibrator of my invention is a crystal controlled oscillating circuit which is so designed as to reenforce the strength of the harmonic frequencies of the fundamental of the crystal that are developed in the plate circuit of this oscillator. My experience with crystal oscillating circuits has shown that when the ratio of the inductance to the capacity used for tuning the plate circuit to produce the oscillating condition is small, the harmonic frequency currents in this circuit are very weak, and it is very hard to observe any harmonic frequency greater than the fifth. If, however, the ratio of the inductance to capacity is increased, the harmonic frequency currents will also increase in strength, and if the capacity can be dispensed with and only a coil having large inductance and very small distributed capacity is employed, then it is possible, with the proper value of grid potential, as controlled by the grid leak, to observe as high as the 200th harmonic of the fundamental frequency.

This condition can be better explained by the fact that a circuit having a small inductance to capacity ratio has a maximum impedance at one definite frequency and a rapidly diminishing impedance above or below this frequency, while if the ratio is increased, the resonance is less pronounced and if the ratio is made large enough, the impedance curve will be fairly uniform over a large range of frequencies. Now it is known that the maximum transfer of power from one circuit to another is obtained when the impedances of the circuits are identical, and for this reason and by the use of the large inductance and very small capacity for the plate load, a condition arises where the tube impedance may be matched with the plate load impedance for a wide range of frequencies.

Figs. 1 and 2 show the values of impedance that can be had with the two extreme cases that have been previously discussed. Fig. 1 is a curve showing relation of impedance to frequency for a circuit having a small inductance and a large capacity; while Fig. 2 represents the condition obtained with a pancake or universal coil that has a large inductance and a very small distributed capacity.

If such a circuit is arranged for generating frequencies equal to the fundamental and its harmonics and it is desired to use this circuit as a frequency standard, it is necessary to provide a detector and amplifier system that will respond to all frequencies without resort to the use of a number of tuned circuits. To accomplish this result I employ a coupling coil that is similar in impedance characteristics to that of the plate coil system of the oscillator and connect this coil through a grid leak and condenser to the grid and filament of the detector tube as shown in Fig. 3.

To use this calibrator as a frequency

standard, it is necessary to employ a coupling wire, shown as C in Fig. 3, and place this close to the radio frequency generator whose frequency is to be measured. This wire will pick up a weak signal from the transmitter that will combine with one of the harmonic frequencies of the calibrator and produce a beat note in the plate circuit of the detector tube. This beat note is amplified by use of one or two stages of amplification as shown in Fig. 3.

Referring to the drawings in more detail, reference character 1 designates an electron tube arranged as an oscillator. The electron tube 1 includes filament electrode 1^a, grid electrode 1^b and plate electrode 1^c. The filament electrode 1^a is heated from battery system 9. An input circuit 2 is provided for the electron tube 1 to which is also connected the output circuit 3. The input circuit 2 includes piezo electric crystal element 4 that is positioned between electrodes 4^a and 4^b which connect respectively with grid electrode 1^b and filament electrode 1^a. A proper biasing potential is supplied to the grid electrode 1^b by the arrangement of resistor 5 across the electrodes 1^a and 1^b. The output circuit 3 includes a large inductance 6 having a small distributed capacity and providing a low impedance matched with respect to the tube impedance. The inductance 6 is arranged in circuit with battery 7 that is shunted by means of by-pass condenser 8. Inductance 6 is designed to have a large inductance to capacity ratio. This inductance is coupled to a corresponding inductance 10 disposed in the input circuit of a detector tube 12. The detector tube 12 includes filament electrode 12^a, grid electrode 12^b and plate electrode 12^c. The pick-up wire C connects to the grid circuit of the detector tube. The grid leak and grid condenser 11 is shown disposed in the grid circuit of tub tube 12. Filament electrode 12^a is heated from battery 20. The output circuit of tube 12 includes the primary winding 15 of an audio frequency transformer system 14 and the battery system 19. The secondary winding 16 of the transformer 14 connects to the input circuit of the audio frequency amplifier tube 17. The amplifier tube 17 includes filament electrode 17^a, grid electrode 17^b and plate electrode 17^c. Battery 21 is arranged to supply the high potential to the output circuit of amplifier tube 17. Telephone receivers 18 are arranged in the output circuit of the amplifier 17. While only a single stage of audio frequency amplification has been illustrated, it will be understood that additional stages of amplification may be employed.

In Fig. 4, I have shown the oscillator circuit provided with a parallel feed system in the output thereof. The output circuit 3 includes a choke 23 and a battery system 24. A high frequency branch circuit 26 is connected around the power supply circuit and includes condenser 25 and the inductance 6 having a large value of inductance and small distributed capacity as heretofore explained in connection with Fig. 3. The high frequency oscillations, occurring in the circuit whose frequency is to be measured, are picked up by means of the coupling wire C. The oscillations of unknown frequency combine with one of the harmonic frequencies produced by the oscillator system including piezo electric crystal element 4 and inductance 6 for deriving a beat note in the plate circuit of the detector tube 12. The beat note may be amplified to any suitable number of stages of amplification for operating the telephones 18.

The inductances 6 and 10 are preferably of the pancake or universal type which, by their inherent construction, enable a high $\frac{L}{C}$ ratio to be obtained. A wide variety of harmonics may be derived in this manner enabling a reading to be secured with respect to the frequency of the circuit under observation.

While I have described my invention in one of its preferred embodiments, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

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

1. A crystal calibrator circuit comprising an electron tube oscillator including input and output circuits, a piezo electric crystal element connected in said input circuit and means in said output circuit having a large inductance to capacity ratio for the derivation of harmonic frequencies from said piezo electric crystal element, and means for detecting the individual harmonic frequencies derived from said piezo electric crystal element.

2. A crystal calibrator circuit comprising an electron tube oscillator having input and output circuits, a piezo electric crystal element connected in said input circuit and a coil connected to said output circuit, said coil having a relatively large value of inductance and a relatively small distributed capacity for the derivation of harmonic frequencies from said piezo electric crystal element.

3. A piezo electric crystal controlled calibrator including an oscillator, a detector, and a signal observing circuit, a piezo electric crystal element, connections between said piezo electric crystal element and said oscillator, and means interposed between said oscillator and said detector for deriving a plurality of harmonic frequencies from said

piezo electric crystal element and for transferring the effects thereof to said signal observing circuit.

4. In a piezo electric crystal controlled calibrator system, the combination of an oscillator circuit, a detector, and a signal observing circuit, a piezo electric crystal element connected with said oscillator, an inductively coupled circuit interposed between said oscillator and said detector, said inductively coupled circuit being constituted by coils having large inductance and relatively small distributed capacity for the development of harmonic frequencies from said piezo electric crystal element and the impression of such harmonic frequencies upon said signal observing circuit.

5. A piezo electric crystal calibrator system comprising an electron tube oscillator including input and output circuits, a piezo electric crystal element disposed in said input circuit, a coil having a relatively large value of inductance and a relatively small distributed capacity arranged in said output circuit, a detector, a coil connected in circuit with said detector and coupled with said aforementioned coil, a coupling wire extending from said detector for collecting and transferring to said detector high frequency oscillations, and a signal observing circuit connected to said detector for rendering apparent a beat frequency formed by the combination of harmonic frequencies derived from said piezo electric crystal element and the high frequency oscillations collected by said coupling wire.

6. A crystal controlled calibrator system, an electron tube oscillator including input and output circuits, an electron tube detector including input and output circuits, a signal observing circuit connected to the output circuit of said detector, a coupling wire connected to the input circuit of said detector, a piezo electric crystal element connected to the input circuit of said electron tube oscillator, and means coupling the output circuit of said oscillator with the input circuit of said detector for transferring to said detector a plurality of harmonic frequencies derived from said piezo electric crystal element and means for impressing high frequency oscillations collected by said coupling wire upon said electron tube detector, whereby the combined effects of harmonic frequencies derived from said piezo electric crystal element and the high frequency oscillations collected by said coupling wire may be impressed upon said signal observing circuit.

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