July 25, 1933. W. A. MARRISON 1,919,796

MECHANICAL VIBRATING ELEMENT

Filed April 29, 1930

FIG. 1

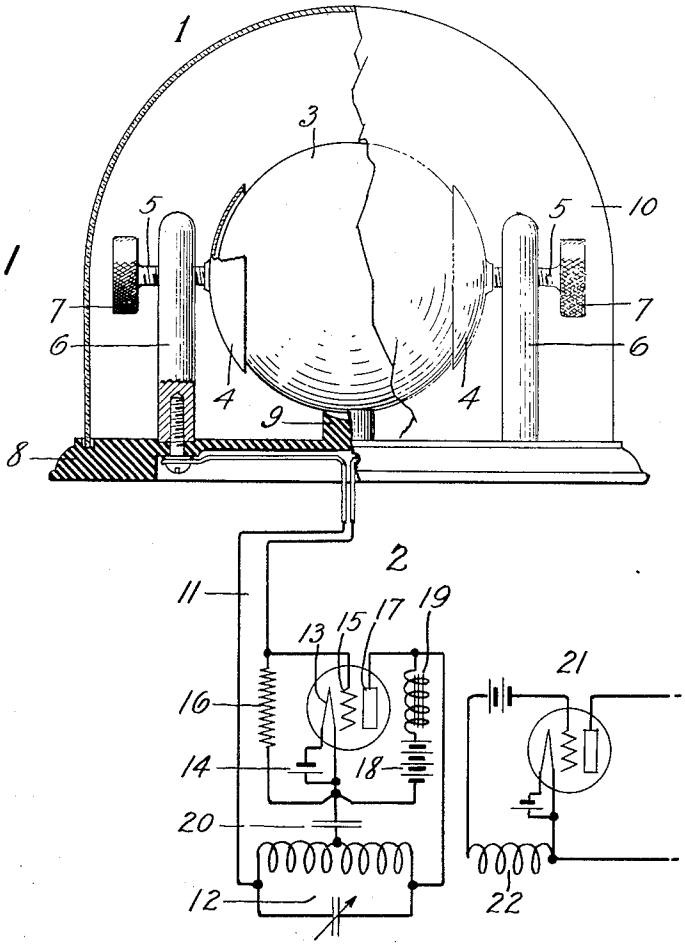
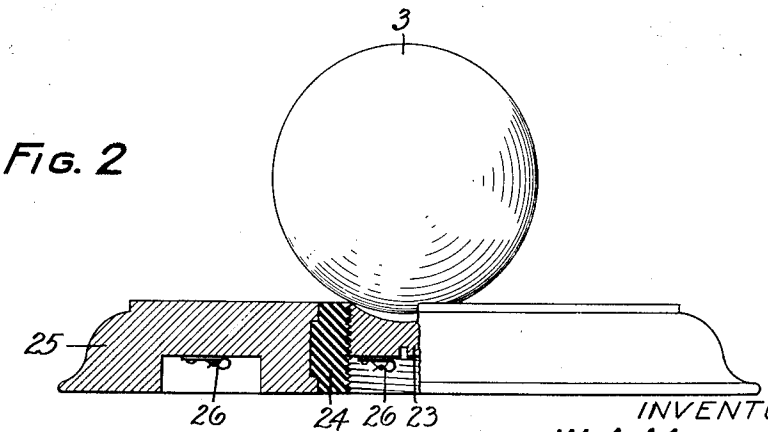



FIG. 2




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# UNITED STATES PATENT OFFICE

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## MECHANICAL VIBRATING ELEMENT

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This invention relates to a mechanical vibrating element of a particular form and to a method of relating it with associated circuits or structure so as to constitute an effective frequency control means for the system as a whole.

In the prior art there are many examples of mechanical vibrating elements adapted as to material and form to vibrate, when impulsed by an outside force, with comparative constancy of frequency as affected principally by damping conditions, changes in their physical environments and (where used in electrical circuits) by changes in their electrical environments. Familiar examples of such elements are tuning forks and piezo electric crystal devices. In these examples and in others that might be mentioned, there is a common dependency for their frequencies and damping coefficients on the materials which compose them, more specifically, on their specific densities and elasticities.

Applicant has perceived new and unexpected advantages, as a frequency control means, of a mechanical vibrating element, and especially a piezo electric crystal element, having a substantially spherical form. More particularly, he has found that such an element is more effective than priorly used alternatives as a frequency control means in an electric circuit, especially as adapted to control the frequency in the generation of self-sustained electrical waves.

It is an object of the invention to improve, as by the above means, the effectiveness of mechanical vibrating elements as frequency control means.

More specific objects of the invention, also realized by the structure above described, are to achieve frequency control by mechanical vibrating means which are relatively independent of changes of physical and electrical environment and by means which may be produced and duplicated with a minimum of labor expense and uncertainty of result.

A feature of the invention is a mounting of the crystal element which is characterized by simplicity, economy and facility of assembling.

These and other objects and features of the invention may be more fully understood from a reading of the following detailed description when read in connection with the accompanying drawing in which:

Fig. 1 illustrates a spherical crystal element of the invention and a preferred mounting therefor in a typical oscillator circuit in which the invention is adapted to be used, and

Fig. 2 illustrates a spherical crystal of the invention and an alternative mounting.

In Fig. 1, which illustrates the crystal element of the invention and its mounting as well as a novel circuit with which it is associated, the reference numeral 1 indicates generally the crystal element mounting assembly and reference numeral 2 indicates generally the associated circuits.

The spherical crystal 3 (which will also be variously denominated elsewhere in the specification and in the claims as "crystal element" and "crystal body"), which constitutes perhaps the most outstanding feature of the invention, is positioned and relatively fixed in space by members 4 which are adapted to function also as electrodes whereby the crystal is related to its immediately associated circuits. These members are integral with screw threaded members 5 which are threaded through fixed supporting brackets 6 through which, by means of knurled heads 7 the positions of the electrodes may be adjusted relatively to the crystal element.

These brackets are supported on an insulating base 8 of bakelite or like material. The brackets themselves may be of similar material or may be metallic. The crystal element receives gravity support from a salient portion 9 of the base 8. For most effective engagement between the sphere and said element 8, it is preferable to dish its upper surface in such a manner as to provide a bearing with respect to the sphere at its edge or rim portion only.

As actually used the mounting of the crystal element has been loose with respect to its electrodes so as to impose no restraint on its

vibrations. It has been found that the element vibrates energetically, quietly, and with a minimum of rotation, when so mounted. The whole assembly as above is conveniently enclosed by a cover member 10 which is preferably of transparent material such as glass. This cover member functions to protect the crystal element and mounting from dust and violence and from sudden changes in air pressure or other changes in environmental conditions.

The crystal, mounted as above, is connected by leads 11 to the circuits, whatever they may be, which it is the function of the crystal element to control. In the specific embodiment illustrated, the crystal element controls the frequency of sustained oscillations generated in the electric discharge circuit. This circuit, illustrated generally by reference numeral 2, comprises essentially a Hartley type electric discharge oscillator otherwise disclosed in detail in his U. S. Patent 1,356,763, granted October 26, 1920. The characteristic feature of such an oscillator is a resonant circuit, like circuit 12, coupling the input and output circuits of a three-element electric discharge repeating device and providing a regenerative feedback therebetween so as to perpetuate oscillations initially impressed on the input circuit, the frequency of such oscillations being the natural frequency of the resonant circuit.

It is characteristic of a piezo electric crystal body that when vibrating at a resonant frequency it interposes a very small reactance in the circuit in which it is contained. Accordingly when the circuit 2 is adjusted, as by coincidence of the resonant frequency of circuit 12 with a resonant frequency of the crystal body 3, so as to generate oscillations at one of the resonant frequencies of the crystal body, the circuit has all the attributes of a conventional Hartley oscillator circuit, the impedance control element of the electric discharge device being effectively directly connected to the end of the inductance of the resonant circuit.

The particular circuit relations here illustrated are similar to those disclosed in applicant's U. S. Patent No. 1,847,124 granted March 1, 1932, differing therefrom in that the crystal body is interposed between the resonant circuit and the controlling element instead of between the resonant circuit and the anode or plate. The present arrangement has certain specific advantages respecting, for example, ease of control and which are perhaps best exemplified where the crystal body is such as is adapted to vibrate less energetically than in the circuit of the above patent. It should be understood that the circuit 2 is adaptable to be used with other types of crystals and mountings than that illustrated in this application, the converse being equally true.

The specific elements of the circuit 2 are conventional. The cathode or filament 13 is excited by direct current source 14. Alternating current may equally well be used. The requisite negative bias for the grid or controlling element 15 is provided by the leakage impedance 16. The anode or plate 17 has impressed on it the usual direct current potential from direct current source 18 through a choke coil 19 which tends to restrict the flow of current in its path to direct current. The condenser 20 has low impedance at the characteristic frequency of the oscillator and it is designed to prevent a substantial short circuit of the battery 18 through the inductance of the resonant circuit.

The circuit represented generally by the reference numeral 21 is a work circuit, the energy therefor being derived from the oscillator through a coupling, which is preferably loose, between coupling coil 22 and the coil of the resonant circuit 12 of the oscillator. This circuit 21 is representative of any type of load circuit adapted to be used with an alternating current source such as is constituted by the oscillator of the invention and obviously it may take any one of a great many forms and may be associated with the oscillator in any one of many alternative ways beside that specifically illustrated.

The circuits and structure above described have been found to function very effectively in a stable frequency oscillator and especially in a crystal clock organization. It is characteristic of this type of crystal body that it has a lower temperature coefficient of frequency than crystal bodies of more conventional shapes. In fact it has been found well adapted for use in a crystal clock without temperature regulation, such as has been customarily found to be necessary with similar circuits, and without undue sacrifice of frequency stability. The mounting provides a very simple means for physically positioning the crystal body and associating it with its related circuit, a mounting which is inexpensive, relatively uncritical in its adjustment, and easily assembled and disassembled. The physical conditions governing the resonant frequency of vibration of such a sphere are necessarily complicated and of a somewhat different character than those governing the corresponding frequencies of crystal elements cut according to the conventional modes. In one instance of a practical use of the invention the sphere was about 3⅜ inches in diameter and vibrated resonantly at a frequency of about 33000 cycles per second. The necessary geometrical relations of the crystal axes and the direction of electrostatic

stress on account of the electrodes is fairly critical, but an optimum adjustment may easily be achieved by empirical trials, as has been done in the practice of the invention.

The alternative mounting illustrated in Fig. 2 perhaps excels that of Fig. 1 in simplicity and in pleasing appearance, although it does not afford as complete physical independence from environmental conditions. In this form, the crystal body, having the same numbering as in Fig. 1, is supported wholly by gravity on electrode 23 screw threaded in an insulating bushing member 24 fixed in a metallic base member 25. The bushing member 24 may conveniently be of plastic composition molded to the base. The elements 23 and 25 constitute the usual electrodes for the crystal body, means being illustrated, by reference numerals 26, for attaching leads to the elements 23 and 25. The upper surface of element 23 may be dished similarly as the element 9 of Fig. 1, and for appearance, the upper surfaces of the members 24 and 25 and the edge of element 23 may be flush with each other although the spacial relation of the crystal body and outer electrode 25 may be varied somewhat by threadedly adjusting the position of the electrode 23. There is sufficient electrostatic coupling between the crystal body and the outer electrode 25, combining the direct neutral capacity of such elements and the capacity between them through ground, to insure resonant vibration of the crystal body. This crystal ensemble may be used in place of the corresponding structure in Fig. 1 or in association with any other type of associated circuit.

What is claimed is:

1. A piezo electric frequency controlling element having a substantially spherical form.

2. In combination, a substantially spherical piezo electric body, a plurality of electrodes therefor, the surfaces of said electrodes opposed to said body being adapted to conform substantially with the surface of said body, said body being loosely disposed between said electrodes.

3. The combination recited in claim 2 including additionally a basal gravity supporting means for said body.

4. In combination, a substantially spherical piezo electric body and a basal mounting plate therefor comprising an electrode portion immediately adjacent to the body and adapted to provide gravity support thereto, another electrode portion surrounding said first mentioned portion but insulated from it, and means for connecting said electrodes in an electric circuit.

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