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METHOD OF AND APPARATUS FOR RENDERING VISIBLE OSCILLATIONS OF PIEZO-ELECTRICAL CRYSTALS

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Fig. 1

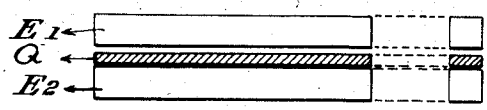
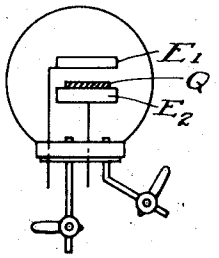


Fig. 2



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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR RENDERING VISIBLE OSCILLATIONS OF PIEZO-ELECTRICAL CRYSTALS.

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This invention relates to a method of and apparatus for rendering visible oscillations of piezo-electrical crystals, and is based upon the known piezo-electrical phenomenon, that under certain circumstances differences of electrical voltage are generated, if a piezo-electrical crystal is subjected to elastical deformations, said differences of voltage taking place at different points of the said crystal. The value of these differences of voltage increases with increasing deformation, and their sign will change, if the crystal, instead of being subjected to a deformation, is subjected to a dilatation, and vice versa. Large deformations and in consequence thereof large piezo-electric voltage differences of changing sign may especially be attained, by subjecting such a piezo-electric crystal, preferably in the form of a rod to elastical oscillations. The means, whereby these oscillations are generated and the nature of these oscillations (whether transverse or longitudinal), may be of any kind, and the nature of this means as far as this invention is concerned is of no importance whatever. An essential feature of this invention is to render these oscillations visible, by utilizing the piezo-electric voltages which are generated thereby, for producing a luminous effect. The manner in which this may be done is shown by way of an example for carrying this invention into effect.

Cady has shown (see Proceedings of the Institute of Radio Engineers, 10, 1922, page 83), that a piezo-electrical crystal rod, which in a crystallographic sense is properly aligned, may be caused to be subject to longitudinal oscillations of high frequency by the effect of an alternating electrical field, if the frequency of the exciting electrical alternating field is in co-incidence with one of the natural elastical frequencies of the crystal thus excited, so that a resonance will be brought about between the electrical and the elastical oscillation.

The elastical oscillations and therewith the occurrence of resonance, now, may for instance be rendered visible according to this invention in the following manner, as illustrated in the accompanying drawing in which:

Figure 1 shows a crystal mounted between two electrodes in open air and,

Figure 2 shows a possible mounting in a vessel adapted to be evacuated or filled with a gas other than air.

In the drawing (see Fig. 1) Q designates a rod of rock-crystal, which is properly aligned in a crystallographic sense, said rod having a length of a few centimeters and a cross-section of a few square millimeters. E_1 and E_2 are two metal electrodes, which are connected with a source of alternating electrical voltages having a frequency n. The rod Q is placed upon the electrode E_2 so as to be freely movable thereon and an intermediate space is provided between the rod Q and the electrode E_1. If this frequency n be equal to the fundamental frequency N_0 of the elastical longitudinal oscillation, the rod Q according to Cady will be subject to stationary oscillations. In the centre of the rod thereby the greatest deformations will take place, while these deformations will decrease towards the ends of the rod until they reach the value zero. The value of the piezo-electric voltage corresponds to the value of the elastical deformation. By properly dimensioning the intermediate space between the rod Q and the electrode E_1 and the alternating voltage impressed upon the electrodes E_1 and E_2, according to this invention a luminous effect may be produced, which renders the oscillations visible between the rod Q and the electrode E_1 over a certain length in the direction of the axis of the rod, said length varying with the amplitude of the elastical oscillations. If the rod instead of being excited by its fundamental frequency N_0, is excited by one of its higher frequencies $2N_0$, $3N_0$ etc., and if the other factors to be considered are properly chosen, there will be a plurality of luminous effects at points of the rod, which are separated by dark intervals. The number of these points at which luminous effects are produced will indicate the ordinal number of the respective higher frequency.

Since in the example above given the rod will only oscillate, if resonance is present between the exciting electrical oscillation and the elastical oscillation which is produced thereby, and since furthermore the luminous effect is caused by the elastical deformation and the consequent piezo-electric voltage, the occurrence of the luminous effect, which is an essential feature of this invention, will indicate this resonance. More particularly the number of points, at which the luminous ef-

fect takes place, will be equal to the ordinal number of the higher elastical oscillation.

This feature forms the basis for the several modes of the technical applications according to this invention. Since the above-mentioned longitudinal oscillations, which are produced according to the cited article by Cady, are within the range of the frequencies employed in wireless electrical signalling, in this branch of engineering especially important possibilities of a practical application of this invention will result. For instance, for a great number of transmitting stations there is a necessity, that every station is always working with the same operating frequency or wave length. By means of a piezo-electric crystal rod, which is tuned, as above described, to such an operating frequency or wave length, the transmitter, may easily be tuned or adjusted, without carrying on any measurement with wave meters or the like, in such a manner, that a luminous effect takes place at the crystal rod according to this invention. By this luminous effect it may therefore be indicated that the transmitting station has the proper operating frequency.

In addition to the indication of frequency, according to this invention, the device may also be used for measuring frequencies or wave lengths. If a number of crystal rods as above described are united into one apparatus and are once graduated according to their fundamental and their higher frequencies, a high-frequency, wave-meter may be obtained, which may be compared with the frequency meters operating on the principle of vibrating blades or tongues, such as are used for measuring or indicating low frequencies. In the case of a high-frequency wave-meter or frequency-meter, according to this invention the occurrence of the luminous effect at one of the crystal rods will immediately permit to read off the value of the frequency or wave length to be measured or indicated.

If several crystal rods are employed, and the natural frequencies of the same are properly tuned, for instance, the variations in the speed of high-frequency generators may immediately be indicated by the variation of the luminescence of the several crystal rods.

The specific arrangement of the device according to this invention, as represented in the drawing, is intended to serve only as an example for utilizing this invention for the purpose of measuring or indicating frequencies or wave lengths. The arrangement as shown in the drawing may be changed or modified in various ways. Thus, for instance, instead of two electrodes a greater number of electrodes may be employed, which may be paralleled in various combinations and connected to the source of alternating voltages, in order to emphasize a certain higher frequency of the crystal rod, and render the same visible. Besides the voltage-carrying electrodes there may also be employed electrodes which are not connected to the source of alternating voltages, but which merely serve for the production of the luminous effects. Also the form and size of the electrodes and of the crystal as shown in the drawing are of no importance for the purpose of this invention. In order to render the luminous effect more intense, the entire device may be enclosed within a more or less evacuated container or in a tube or vessel which is filled with proper gases. Likewise, for the purpose of intensifying the luminous effect, for instance, pointed electrodes or chemically prepared electrodes may be employed. Furthermore, for instance, only one half of the rod may be arranged between the electrodes, while no electrodes are present on both ends of the other half of the rod. In this case on the free half of the rod the oscillations may also be made visible in an evacuated space by luminous effects.

This invention is by no means confined to the examples described herein or that shown in the drawing. Thus, for instance instead of longitudinal also transverse oscillation of the crystal or crystals may be made visible by a luminous effect, so that this invention may also be used in connection with frequencies which are far lower than those employed in the wireless art.

We claim:

1. The method of rendering visible elastical oscillations of a piezo-electric crystal, which consists in producing a luminous effect by the piezo-electric voltages, which are caused by the deformations of said crystal, when subjected to said elastical oscillations.

2. An apparatus for indicating and measuring the frequency of electrical oscillations, comprising a piezo-electric crystal, means for producing an alternating electrical field passing through said crystal, whereby the latter will be subjected to elastical oscillations, and means for rendering visible said elastical oscillations by a luminous effect caused by the piezo-electric voltages in said crystal, which are set up by said elastical oscillations.

3. An apparatus for indicating electrical oscillations, comprising a piezo-electric crystal, a pair of electrodes adapted to be coupled to a source of electrical oscillations, one of said electrodes contacting with said crystal and the other of said electrodes being at a distance therefrom, whereby the resonance between said electrical oscillations and the elastical oscillations of said crystal is indicated by a luminous effect between said crystal and said other of said electrodes.

4. In an apparatus for visibly indicating electrical oscillations, an electrode, a crystal resting on said electrode, a second electrode

above and spaced from said crystal so that the surface of said crystal adjacent the second mentioned electrode is discernible, and a transparent evacuated envelope surrounding said electrodes and crystal.

5. In an apparatus for visibly indicating electrical oscillations, an electrode, a crystal resting on said electrode, a second electrode above and spaced from said crystal at such a distance that by impressing an alternating voltage upon the electrodes luminous effects upon the upper surface of the crystal may be discerned.

In testimony whereof we have affixed our signatures.

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ADOLF SCHEIBE.