

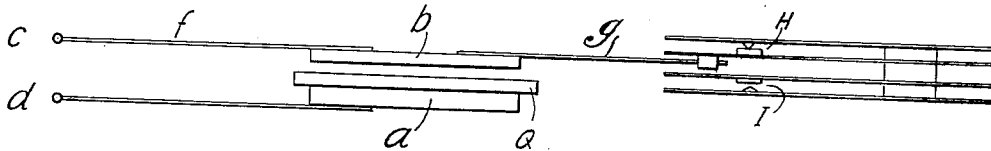
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CRYSTAL RELAY

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CRYSTAL RELAY

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5 Claims. (Cl. 175—320)

This invention relates to a new method and means for producing and utilizing the electrostatic forces of attraction or adhesion which arise on oscillating piezo-electric crystals.

5 An object of this invention is to provide new and novel means to employ the electrostatic forces of piezo-electric crystals effectively. It has been found that a vibrating piezo-electric crystal has a force of attraction which acts similar to a magnet. With this force of attraction there is provided an effective and sensitive device for relay purposes in indicator or control devices, by arranging the piezo-electric crystal with light-weight springs and contact members. Further-
10 more, for the general application of a piezo-electric crystal, I propose to use the force of attraction for the breaking or retarding of any suitable mechanical elements by associating the crystal and the mechanical elements with pressure-measuring devices, microphones, and the like.

20 One of the outstanding merits of this new force of attraction about to be disclosed is its dependence upon the frequency, thereby making the devices sensitive to, and operative only to, a desired or selected frequency. This is predicated upon the natural wavelength or period of the crystal which results in a highly selective arrangement.

25 According to the invention, the control or relay action is released by virtue of the electrostatic force of attraction of one or more oscillating piezo-electric crystals upon a mobile body or several bodies placed opposite thereto, for example, upon a metallic plate.

30 If a non-oscillating piezo-electric crystal supported upon an electrode is on top wholly or partly covered, at a certain distance, by a plate, and if both plates are subjected to a constant or a varying potential difference, the force of attraction upon the upper plate, as long as the crystal does not oscillate, is comparatively slight. But when
40 the crystal is caused to vibrate or swing, the force of attraction upon the electrodes and, in general, upon bodies placed opposite the crystal surfaces, is considerably increased. The cause underlying this condition is thought to reside in that a draft of air caused by the oscillations of the crystal may result in a rarefaction of the air confined inside the space between the crystal and the moving plate. However, this theory does not
50 quite suffice to account for the said phenomenon. As a matter of fact, what plays here a major part are the appreciable charges appearing upon the surface of the crystal upon deformation of the latter, and these charges are capable of setting up
55 considerable dynamic effects owing to their size

and also owing to the comparatively small distance between this surface and the metal plate placed thereover. Now, this effect is a function of the intensity of the crystal vibration, and the same will be particularly large whenever the crystal happens to be excited under conditions when it is in resonance with its natural period inasmuch as in that case the surface charges upon its faces turn out to be particularly large.

What may also be noted is that high dynamic action on the mobile plate arising upon oscillating of the crystal and which is predicated upon the electrostatic force of attraction of the charges incidentally arising on the face of the crystal, will also arise when the crystal is subject to single-pole excitation, in other words, when only the base plate is impressed with alternating potential, but not the movable plate.

In so far as the field distribution of the charges on the surface of the vibrating crystal is concerned, the same, when the longitudinal fundamental wave is excited, is roughly sinuous, in accordance with the mechanical deformation arising with the standing wave. In the center of the crystal surface, the charge reaches a maximum amount seeing that at this point is located the motional node. But at the same point also the attraction is of maximum value. Towards the ends of the crystal, the charges and the forces of attraction diminish.

This invention will be more fully understood by referring to the accompanying drawing, in which

The drawing shows a side elevation of a piezo-electric crystal interposed between two electrodes and spring contacting elements to form an attenuating current relay.

Referring now in detail to the drawing. The drawing illustrates the crystal *Q* upon the base plate or support member *a* which serves also as an electrode. Above the crystal is a movable metallic plate *b* which could serve as the second electrode and is disposed over the crystal in such a way that it will always be able to undergo desired movements. This movement is made possible by a spring *f* which is supported at *c*. Now, as the crystal is caused to experience forced or instantaneous oscillations, for example, by the application of an alternating current, alternating voltage to the terminals *c, d*, of a desired frequency which is a frequency equal to the natural period of the crystal. Then and only then will the crystal be excited and the armature or the electrode *b* of the device of this invention will experience a powerful force of attraction. If the crystal armature is arranged through the intermediary of a trans-

fer link *g* with light-weight springs and electrical contact members, a circuit changing relay or switch is then provided.

It will also be understood that armatures may be mounted upon two or more sides or faces or points of the crystal. Similarly, one and the same armature or keeper may be acted upon by a plurality of crystals, or inversely, several keepers on one and the same crystal.

The armature or plate *b* could also be arranged to act as an indicator element or could be used for the purpose of moving or releasing a visual signal or pointer. In order to insure electrical and mechanical impedance adaptation recourse may be had to methods known in the prior art. For instance, supplying a potential causative of the oscillations by way of an amplifier, transformer or the like.

It will be evident that "armatures" could be disposed upon two or more sides or places of the crystal, and similarly one and the same armature could be acted upon by a plurality of crystals, or, inversely, several armatures by one crystal.

Furthermore, according to this invention, an increase in sensitiveness of the arrangement is insured by ways and means well known in the prior art. For instance, a differential action by the use of two or more crystals by suitable arrangement of the moving parts or a biasing excitation of the crystal.

In cases where the dependence upon the frequency is to be used for a practical relay purpose, the crystal of the relay may be associated with an oscillator whose amplitude and frequency regulation are selected according to the desired requirements. For instance, the crystal may be affected by the agency of a switching arrangement, or optionally the oscillator, and the switching arrangement may be associated so that both effects may be applied simultaneously.

One outstanding advantage of the use of electrostatic forces of attraction of oscillating crystals may, when desired, be the frequency dependence thereof which, in turn, is predicated upon the natural wave of the crystal. Inasmuch as the crystal damping, as known, is only very small and since therefore its resonance curve is very sharp, this means that arrangements insuring high selectivity may be obtained therefrom. For some purposes it may be recommendable to confine the crystal and part or the whole of the device in a vacuum.

The present invention is not to be confused with the compressive force on a vibrating piezo-electric crystal fundamentally due to the current of air which arises on an oscillating crystal.

While I have described only several forms in which this electrostatic attraction of a piezo-electric crystal is utilized, it will be distinctly understood, however, that the forces may be utilized in many other forms by securing to the upper electrode of the crystal suitable well-known mechanical elements such as an annunciator drop, a visual indicator, and many forms of gauging devices.

I claim:

1. A piezo-electric crystal device comprising a

fixed electrode for said device, a movable electrode located above and spaced apart from said fixed electrode, a piezo-electric crystal interposed between said fixed and movable electrodes and supported upon said fixed electrode, means for applying a desired frequency to the electrodes of said crystal, a plurality of electrical contact elements, a link member secured to said movable electrode, said link member engaging said electrical contact elements, said contact elements being actuated by the electrostatic attraction of said crystal when the desired frequency is applied to said electrodes.

2. An electrostatic actuating relay device comprising fixed and movable electrodes, a piezo-electric crystal interposed between said electrodes and supported upon said fixed electrode, means for applying a desired frequency to the electrodes of said crystal, a plurality of electrical contact elements, a link member secured directly to the movable electrode, said link member engaging said electrical contact elements, said contact elements being actuated by the electrostatic attraction of said piezo-electric crystal when the desired frequency is applied to said electrodes.

3. An electrostatic actuating relay device comprising fixed and movable electrodes, a piezo-electric crystal interposed between said electrodes and supported upon said fixed electrode, a spring like member supporting said electrodes and said crystal, means for applying a desired frequency to the electrodes of said crystal, a plurality of electrical contact elements, a link member secured directly to the movable electrode, said link member engaging said contact elements, said contact elements being actuated by the electrostatic attraction of said piezo-electric crystal when the desired frequency is applied to said electrodes.

4. A piezo-electric crystal relay comprising a fixed electrode for said relay, a movable electrode located above and spaced apart from said fixed electrode, a suspension member for each electrode, a piezo-electric crystal interposed between said fixed and movable electrodes and supported upon said fixed electrode, a plurality of electrical contact elements, a link member secured to said movable electrode, said link member engaging said electrical contact elements, said contact elements being actuated by the electrostatic attraction of said crystal when the desired frequency is applied to said electrodes.

5. A piezo-electric crystal relay comprising a fixed electrode for said relay, a movable electrode located above and spaced apart from said fixed electrode, a spring like suspension member for each electrode, a piezo-electric crystal interposed between said fixed and movable electrodes and secured to said fixed electrode, a link member secured to said movable electrode, a plurality of electrical contact elements, said link member engaging said electrical contact elements, said contact elements being actuated by the electrostatic attraction of said crystal when the desired frequency is applied to said electrodes.

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