Jan. 5, 1943. J. N. WHITAKER 2,307,438

PIEZO-ELECTRIC DEVICE

Filed Sept. 4, 1940

Fig. 1

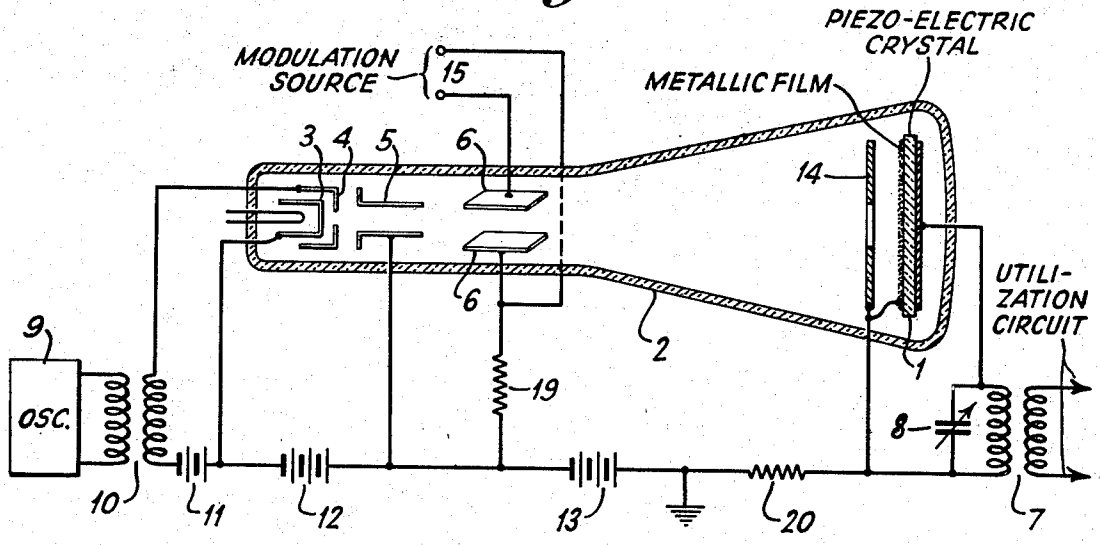
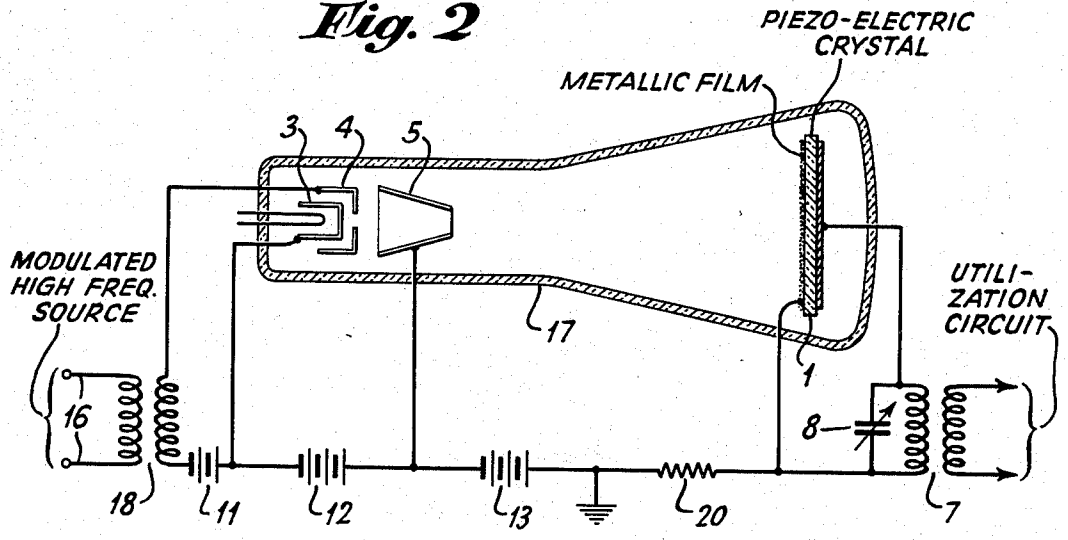


Fig. 2



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PIEZOELECTRIC DEVICE

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12 Claims. (Cl. 178—66)

My invention relates to a piezo-electric device and has particular reference to improved means for exciting such a device, whereby new and useful results are obtained. The invention also relates to the filtering of electric energy by means of a piezo-electrical crystal which is impacted by an electron stream.

It is an object of my invention to provide a piezo-electric device which may be useful in a number of different applications, including for example, a filter which is selective of a relatively narrow band of frequencies.

It is another object of my invention to provide a piezo-electric device which is suitable for filtering purposes, for example, in connection with facsimile transmission and receiving systems.

Merely by way of illustration of the possible uses of my invention, it is worthy of mention that in facsimile systems it is required that the useful modulations comprising elemental area representations in a train of signals be superimposed upon a carrier wave of relatively high frequency, thereby causing the carrier wave itself to be keyed on and off or to be amplitude modulated. The relatively low frequency at which marking and spacing signals succeed one another (as in transmitting the elemental areas of a picture) amounts to a modulation of the carrier wave such that during marking signals a sum frequency or a difference frequency exists, while during spacing elements the carrier wave continues unmodulated or else it is suppressed.

If it is desired that the carrier wave be keyed on and off as by means of signals representing black and white areas of a picture, then it is common practice to employ a tone frequency at which successively scanned elemental areas are translated into impulses in a train of signals.

If, however, a facsimile system is to be provided which reproduces the relative shading between black and white areas of the picture, then it is customary to amplitude modulate the carrier wave between such limits as will represent the blackest and the whitest portions of the picture area. In this case the carrier wave is transmitted continuously. Even by this mode of transmission it is common practice to superimpose a tone frequency on the carrier wave for the purpose of distinctly differentiating successive elemental areas of the picture.

In carrying out my invention I have found that various forms of filter systems essential to the faithful reproduction of pictures are quite useful. Those known in the art, however, are subject to certain drawbacks which it is among the objects of my invention to overcome.

My invention will now be described in more detail, reference being made to the accompanying drawing in which

Figure 1 shows diagrammatically one form in which the invention may be embodied; and

Fig. 2 shows a different embodiment of the invention.

Referring first to Fig. 1, I show therein a piezo-electric crystal 1 enclosed in an envelope 2 which may be in the form of a cathode ray tube. This envelope also contains the usual electrodes of a cathode ray tube, including a cathode 3, a control electrode 4, a focussing electrode 5 and beam deflecting means such as electrostatic deflecting plates 6. The piezo-electric crystal 1 is preferably coated with a thin but continuous deposit of metal on each of its two faces. This coating may take the form of a silver deposit which is affixed to the faces of the crystal in any well known manner. The metallic coating on the face of the crystal surface which faces the electron gun is preferably grounded through a resistor 20 so that a negative charge which would otherwise be produced by impact of the electrons may be dissipated. The back face of the crystal 1 is provided with a metallic coating or plate such as to constitute an output electrode in circuit with the first mentioned metallic coating which represents a target for the electron stream.

I have found that electro-mechanical vibrations may be set up in a piezo-electric crystal if it is impacted by a variable electron stream having substantially the same periodicity as the natural frequency of the crystal. As shown in Fig. 1 the crystal electrodes are interconnected by an output circuit which includes the primary of a transformer 7, this primary being shunted by a suitable capacitor 8. The combination of inductance and capacitance may be tuned to the frequency of the crystal, thereby offering a high impedance to currents of the working frequency. The primary of the transformer 7 induces a useful current in the associated secondary leading to any desired utilization device. The applications of the invention have been discussed in the preamble of this specification and need not be further dwelt upon since they constitute no part of the present invention.

In order to deliver a useful current in the utilization circuit I may, if desired, deflect the electron beam by means of modulation energy impressed upon the deflecting electrodes 6. The electron beam itself is of a form which delivers

periodically a succession of clouds of electrons in accordance with the frequency at which the input circuit of the cathode ray tube is controlled by an oscillator 9. This oscillator has an output circuit which is coupled by means of an input transformer 10 to the input circuit of the cathode ray tube 2. This input circuit is preferably biased by means of a direct current source 11. The electron gun operates in the usual manner by virtue of the different potentials applied to the cathode 3, the focussing electrode 5 and the target electrode of the crystal 1. These several electrodes are interconnected by direct current sources 12 and 13. A resistor 19 interconnects one of the deflector plates 6 with the junction between sources 12 and 13. If desired, both deflector plates 6 may be similarly self-biased by means of separate resistors.

Between the piezo-electrical crystal 1 and the electrodes of the tube 2 which constitute the electron gun I preferably employ a mask electrode 14, having an orifice therein through which electrons may be permitted to pass for impact upon the front face of the crystal. The electron beam will pass unimpeded through this orifice when not deflected by potentials applied to the deflecting plates 6. When, however, modulations are impressed upon these deflecting plates from any suitable source the wobbling of the electron beam will cause the electrons to strike the metal-coated surface of the crystal intermittently. Deflection of the beam to one side or the other of the orifice will interrupt the vibrations of the crystal, since the crystal itself will not operate without external excitation.

It will be seen that, in accordance with the arrangement shown in Fig. 1, I can utilize the electron gun in combination with the mask 14 and the piezo-electric crystal to key the oscillations from the source 9 by means of modulations applied to the deflecting circuit terminals 15. However, since each half-cycle of the modulation frequency causes the electron beam to be deflected away from the orifice in the mask 14, the output delivered to the transformer 7 will be keyed at twice the frequency of the input modulations. If frequency multiplication is not desired, then the deflection of the electron beam may be biased so that the mask 14 will only intercept modulation peaks of one polarity.

Referring now to Fig. 2, I show how my invention may be carried out without the use of deflecting plates in the region of the electron stream. In this case it is presumed that a high frequency source is already modulated by useful signals when applied to the input terminals 16.

In the circuit diagram of Fig. 2 I show an evacuated envelope 17 containing a piezo-electric crystal 1, a cathode 3, a control electrode 4 and a focussing electrode 5. Suitable potentials are applied to these electrodes by circuit connections through the direct current sources 11, 12 and 13.

The piezo-electric crystal 1 is mounted in the tube 17 in the same manner as the same crystal is shown mounted in the tube 2 of Fig. 1. However, in the case of the embodiment shown in Fig. 2 I have no need for the masking electrode 14 since the energy applied to the transformer 18 is already modulated.

The arrangement shown in Fig. 2 includes an output circuit connected from one electrode of the crystal 1 through the primary of the transformer 7, shunted by the capacitor 8, and thence to the metallic coating which constitutes the target electrode on the crystal. This target electrode is preferably grounded so that it may not accumulate a negative charge from the impacting electrons.

The crystal 1 as shown in Fig. 2 should be made resonant to the sum frequency or the difference frequency derived from mixing the high frequency of the carrier wave and the frequency of the modulations. Due to the periodic impacts of electron clouds at the sum frequency or difference frequency of the modulated energy, the piezo-electric crystal will vary in its amplitude of oscillations and will deliver a modulated electrical output as induced by its mechanical vibration in response to the periodic impacts of the electrons. Should the carrier wave frequency deviate from the assigned frequency, then the modulated energy will differ from that of the resonant frequency of the crystal; hence the response in the output circuit will either cease or will be materially diminished. The crystal, therefore, serves for filtering the wanted frequencies and for rejecting unwanted frequencies. In a sense the crystal becomes a single side band selector, since it will oscillate only when the modulated high frequency is adjusted to the natural frequency of the crystal. Furthermore, any departure of the modulation frequency from an assigned value will cause the sum frequency (if it is used), or the difference frequency, to depart from that to which the crystal is resonant, and consequently the utilization circuit will be protected against control by these undesired frequencies. The filtering action of the crystal is, therefore, apparent.

Various modifications of my invention may be made by those skilled in the art without departing from the spirit of the invention itself. The scope of the invention is, therefore, defined by the claims.

I claim:

1. A piezo-electric crystal having a metallic coating on at least one of its faces, said crystal being disposed in an electron discharge tube, an electron gun in said tube, means for causing impacts of electrons against said metallic coating to excite the crystal, and means for periodically varying the intensity of the impacts at the natural frequency of the crystal.

2. A device according to claim 1 in which the last said means includes a control electrode in the electron gun and a high frequency voltage source applied between the cathode and control electrode of said electron gun.

3. A device according to claim 1 in which the last said means includes beam deflecting means and a mask for shading the coated surface of said crystal when the electron beam is deflected.

4. In combination, a cathode ray tube having electron emitting and focussing electrodes and a pair of beam deflecting electrodes, a piezo-electric crystal having one face presented to the electron beam, a metallic coating on said crystal face, an electrode for the opposite crystal face, an output circuit interconnecting said crystal faces, a high frequency source for controlling the emission in said tube, a mask for intercepting the deflected electron beam, and means connected to said deflecting electrodes for controlling the periods of interception of said beam by said mask, thereby to modulate the excitation of said crystal.

5. A device according to claim 4 and having a ground connection for said mask and for the

metallic coating on the crystal face which is presented to the electron beam.

6. Apparatus for intermittently exciting a metallically coated piezo-electric crystal and for deriving keyed high frequency energy therefrom, comprising a cathode ray tube, means including an energy source having a frequency equal to the natural frequency of said crystal for causing the metallic coating of said crystal to be impacted by successive clouds of electrons, and a keying source under control of which the electron beam in said tube is rendered intermittently effective.

7. Apparatus according to claim 6 and including electron beam deflecting means in combination with an orificed mask in association with said keying source.

8. Apparatus according to claim 6 in which said crystal frequency source is modulated by said keying source.

9. The method of exciting a metallically coated piezo-electric crystal, thereby to derive usefully keyed energy of the crystal frequency, which comprises causing the metallic coating of said crystal to be intermittently impacted by trains of electron clouds, controlling the pulsative frequency of impacts of said clouds in accordance with the natural frequency of the crystal, and resistively dissipating to ground the resultant negative charge which accumulates on said metallic coating.

10. Apparatus for setting up oscillations in a piezo-electric crystal comprising an envelope enclosing said crystal, an electron gun within the envelope, metallic electrodes adjacent certain faces of the crystal, and means for causing an electron beam to be variably directed by said gun against one of said metallic electrodes.

11. Apparatus according to claim 10 wherein the last said means includes a modulated energy source applied to a control electrode associated with the electron gun.

12. Apparatus according to claim 10 wherein the last said means includes a beam deflector to which is applied a source of alternating potentials.

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