

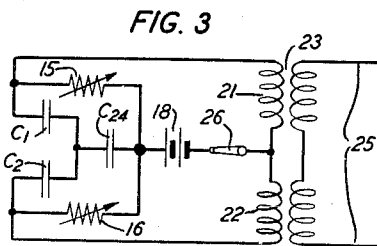
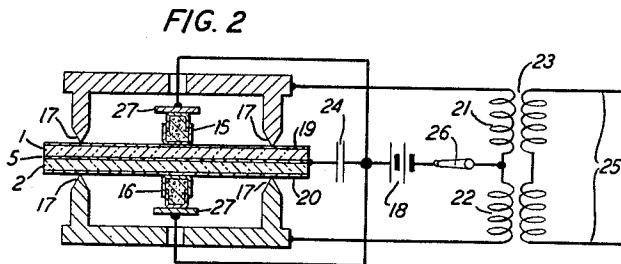
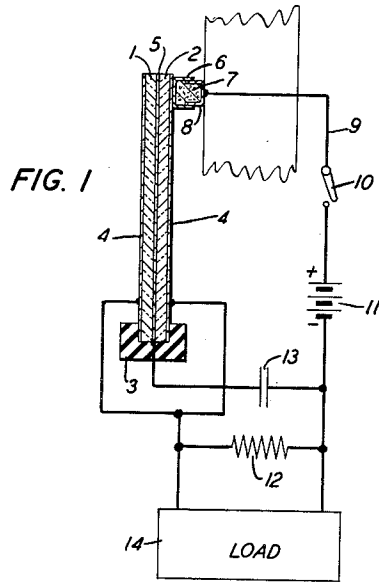
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PIEZOELECTRIC VIBRATOR OSCILLATOR

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PIEZOELECTRIC VIBRATOR OSCILLATOR

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8 Claims. (Cl. 250—36)

This invention relates to sources of electrical oscillations involving piezoelectric vibrators.

An object of the invention is to provide a simple oscillator for producing oscillations of constant frequency.

Another object of the invention is to provide a source of oscillations comprising only elements which have long life and are therefore not subject to the necessity of frequent renewal or replacement.

In accordance with the invention a piezoelectric vibrator is so associated with a variable resistance element such as a carbon microphone and a source of current as to maintain the vibrator in continuous vibration at a frequency determined chiefly by its natural periodicity.

In the drawing Fig. 1 illustrates diagrammatically a simple form of oscillator constructed in accordance with the invention.

Fig. 2 shows a modification of the apparatus of Fig. 1 designed for balanced or symmetrical operation, and

Fig. 3 is an equivalent electrical diagram of the apparatus of Fig. 2.

Referring to Fig. 1 a piezoelectric device comprising two thin strips 1 and 2 of piezoelectric material is shown with the strips held in close juxtaposition throughout their length by cement or some equivalent means and mounted by a clamp 3 of any suitable type. The piezoelectric strips 1 and 2 are provided with conducting electrodes or coatings 4 and 5 respectively on their outer and adjacent faces in the manner of the well-known "bilame" or Curle. The details of this structure, mounting and electrodes may be in accordance with the disclosure of Figs. 1 and 2 in the application of W. P. Mason, Serial No. 131,160, filed March 16, 1937. The strips 1 and 2 are so cut and positioned that an electromotive force applied between their electrodes 4 and 5 causes one strip to contract and the other to simultaneously elongate in such manner as to cause the assemblage as a whole to flex laterally to the right or the left. Strip 2 carries the movable electrode 6 of a microphone 7 having a fixed electrode 8. The electrode 8 is connected by way of conductor 9 and a normally open switch 10 to a source 11 of unidirectional current, the other terminal of which is electrically connected by way of resistance 12 to the electrode 4 of strip 2. The electrodes 4 are electrically connected directly together. The electrodes 5 are connected through a capacity element 13 to the common junction point of resistance 12 and source 11.

In operation when switch 10 is closed, an elec-

tromotive force is applied between the electrodes 4 and 5 of the piezoelectric strips 1 and 2 in series with the capacity element 13. The polarity of the source 11 is so arranged in conjunction with the orientation and position of the strips 1 and 2 that strip 2 tends to contract in its lengthwise direction and strip 1 to expand thus causing the outer end of the assemblage of elements to move toward the right carrying with it the movable electrode 6 of the microphone 7. As the resistance of the microphone 7 decreases the unidirectional current in the series circuit including the resistance element 12 increases thus increasing the potential drop occurring across the resistance 12. Since the resistance 12 is effectively in shunt to the series combination of the capacitance 13 and the capacitance between electrodes 4 and 5 of the strip 2, the potential across the combination of capacitances will also change. This change of potential is such as to augment the potential initially applied to the piezoelectric device upon closure of the switch 10 and consequently motion of the electrode 6 tends to increase the force impelling the piezoelectric device to flex toward the right. The movement of the piezoelectric device continues until a normal displacement has occurred which is determined by the piezoelectric driving force and the dimensions and stiffness of the element 2. Because of the mass and inertia of the element 2 and the rapidity with which the device operates there is a tendency for the element 2 to slightly overthrow beyond its normal stable position and thereafter to settle back to that position under the force exerted by the flexed strip 2. When, however, the strip 2 thus reverses its direction of motion, it impels the movable electrode 6 toward the left and causes the resistance of the microphone to increase thus decreasing the current through resistance element 12 and the potential drop thereacross. This action results in a reduction of the effective potential between the electrodes 4 and 5 thus augmenting the tendency of the element 2 to restore to the original unflexed position. This action continues until under the influence of its own inertia the element returns to a position beyond that which it would tend normally to assume with the switch 10 closed and a steady charge between the electrodes 4 and 5. In the same manner that the stiffness of the element 2 caused it to recede from the extreme position to the right it will now tend to recede from its extreme position to the left. Accordingly, motion to the right is again initiated. In this manner the device undergoes flexural vibrations

with synchronous variation in the resistance of the microphone 7 and of the polarizing electromotive force applied between the electrodes 4 and 5. It will therefore continue to vibrate at a frequency determined primarily by the resonance characteristics of the piezoelectric strips 1 and 2.

The piezoelectric strips 1 and 2 may consist of Rochelle salts cut from sheets perpendicular to the A or X axis and with the lengths of the strips extending at an angle of 45 degrees to each of the other two axes of the virgin material. However, quartz or other piezoelectric substances may be employed and other modes of vibration may also be used if the design be such as to afford a sufficient displacement of the microphone electrode 6 to substantially vary the current through the microphone. The length dimension of the strips 1 and 2 may be made such as to enable the desired oscillation frequency to be attained. For ordinary sizes of crystal elements the natural period will be in the supersonic region of frequencies. However, it is obvious that with larger elements such oscillators may be made to function in the audible range and even below that. Some limitation is produced at high frequencies by the ordinary type of granular carbon button if such an element is employed in the microphone 7. This limitation may be overcome, however, by the utilization of single contact microphonic elements. Where the impedance of the crystal is low a number of these single contact microphonic elements may be utilized, the individual contacts being connected in parallel.

The rising and falling current through the resistance 12 sets up an undulating potential between the terminals of that resistance. A load element 14 to which alternating potential may be applied may therefore be connected directly across the resistance 12.

In one example of the invention the microphone 7 may have a normal position resistance of 200 ohms and the resistance element 12 similarly may have a resistance of 200 ohms. The capacity element 13 may have a capacitance of the order of 1 microfarad but this may be varied within wide limitations. The capacity 13 may even be omitted and the electrodes 5 connected directly to the terminal of source 11.

In Fig. 2 similar elements are designated in the same manner as in Fig. 1. Two microphones 15 and 16 are provided and are associated respectively with the strips 1 and 2 in such manner that strip 1 carries the movable electrode of microphone 15 and strip 2 the movable electrode of microphone 16. Knife edge supports 17 clamp the strips in such manner as to permit lateral, i. e., flexural vibration of the assemblage. A source 18 of unidirectional current is connected to the upper and lower electrodes 19 and 20, respectively, of the piezoelectric strips 1 and 2 through primary windings 21 and 22 of an output transformer 23 and the supports 17. The other terminal of the source 18 is connected by parallel paths extending through microphones 15 and 16, respectively, back to the electrodes 19 and 20. The same terminal of source 18 is also connected directly to the common electrode 5 of the two piezoelectric strips 1 and 2 through capacity element 24 which corresponds to the capacity 13 of Fig. 1. The secondary winding of the transformer 23 is included in a load circuit 25. A switch 26 may also be included in series with source 18.

Operation of the apparatus of Fig. 2 may be readily understood from consideration of the

equivalent electrical diagram of Fig. 3 in which C1 and C2 represent the capacitances between the electrodes of piezoelectric strips 1 and 2, respectively, and C24, the capacitance of element 24. The microphones 15 and 16 are represented in Fig. 3 by variable resistances. With the switch 26 open the piezoelectric element is in a normal undeflected position. On closing the switch, if perfect electrical balance were maintained, the deflecting impulse would be equal and opposite in the two piezoelectric elements. However, with the switch closed, i. e., current on, the piezoelectric element is in a state of unstable equilibrium and the slightest impulse one way or the other starts it oscillating. The mechanism by which it oscillates is essentially the same as described for Fig. 1 with the addition that the carbon buttons act in such a way as to aid one another. In any practical set-up perfect electrical balance is not maintained so that the closing of the switch in the battery circuit results in slightly unequal forces on the two piezoelectric elements and the device thus starts to oscillate. During the cycle of operations the contraction or shortening of strip 1 is attended by a simultaneous elongation of strip 2 and the decrease of resistance in one microphone is attended with an increase of resistance in the other microphone. Accordingly, the device as a whole operates in a symmetrically balanced, or as it is sometimes termed, push-pull relation. As is well known such circuits have an inherent tendency to neutralize or balance out certain types of distortion. The apparatus of Fig. 2 may, therefore, be expected to develop a more symmetrical wave form than that of Fig. 1 other circumstances being the same.

What is claimed is:

1. An oscillator comprising a piezoelectric vibrator consisting of a Rochelle salt bilame device having electrodes and arranged to warp in response to an electromotive force applied to the electrodes, a local source of current, a microphone in circuit with the source for controlling the current in the circuit, means for transferring warping vibrations of the piezoelectric vibrator to the microphone to vary its resistance, and means for deriving a vibrating sustaining electromotive force from the microphone circuit and for applying it to the electrodes of the piezoelectric vibrator to maintain its warping vibrations.

2. An oscillator comprising a piezoelectric vibrator consisting of a Rochelle salt bilame device having electrodes and mounted to warp in response to an electromotive force applied to the electrodes, a microphone driven thereby, a source of current in series with the microphone, and means electrically connected to the microphone and to the electrodes for actuating the vibrator to execute warping vibrations.

3. In combination, a piezoelectric vibrator including a Rochelle salt bilame device having electrodes, the device being arranged to warp in response to an electromotive force applied to the electrodes, a source of current, a microphone driven by the vibrator and connected in series with the source of current to vary the magnitude of the current delivered by the source, and means including the electrodes responsive to the varying current delivered from the source to maintain the vibrator in warping vibration.

4. An oscillator comprising a piezoelectric device including a Rochelle salt bilame element having electrodes, the element being mounted to permit it to warp in response to an electro-

motive force applied to the electrodes, and means for causing the actuation of the device including a local source of current, a capacity element electrically connected to said source and to the device and a microphone connected in series with the source and mechanically connected with the device to be driven thereby.

5 5. An oscillator comprising a source of current, a microphone in circuit therewith, a piezoelectric
10 element consisting of a Rochelle salt bilame mounted in such manner as to permit warping vibration of the element, means for deriving an electromotive force from the microphone circuit
15 which varies with the current in the circuit for driving the piezoelectric element to tend to cause it to vibrate, and means for transmitting motion of the piezoelectric element to the microphone
20 to maintain vibrations at a frequency corresponding substantially to the natural resonance frequency of the piezoelectric element.

6. In combination, two piezoelectric devices each having electrodes, a microphone individual to each device and having a movable electrode carried thereby, a source of current, means in
25 circuit with the source and with the microphone whereby the variable current which results from motion of the movable electrode of the microphone is utilized to impress a driving electromotive force across the electrodes of the respective device, means holding the device together
30 as a unit in such manner that when the unit vibrates compression of one microphone is accompanied by relaxation of the other and a load

circuit coupled to the circuits of both microphones to derive aiding electromotive forces therefrom.

7. A circuit including a source of current, a load coupling element and a microphone in series, a path in shunt to the microphone and including a piezoelectric element and a capacity element
5 connected in series, the piezoelectric element consisting of a Rochelle salt bilame having electrodes to which an actuating electromotive force
10 may be applied and mounted for warping action whereby variations in the potential difference across the terminals of the microphone affect the terminal potentials of the piezoelectric element, and means whereby motion of the piezo-
15 electric element in response to variations in its electrode potentials is transmitted to the microphone to vary its resistance.

8. A circuit including a source of current, a microphone and a load coupling element in series, a piezoelectric element consisting of a Rochelle
20 salt bilame having electrodes electrically connected in a path in shunt to the coupling element and mounted to undergo warping vibrations in response to an alternating electromotive
25 force applied to its electrodes, and means whereby motional response of the piezoelectric element to varying potentials derived thereby from the coupling element is transmitted to the microphone to vary the current in the circuit of the
30 coupling element.

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