

July 1, 1930.

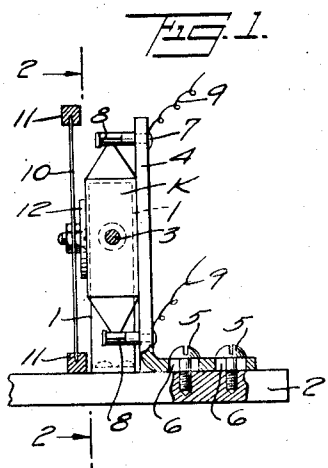
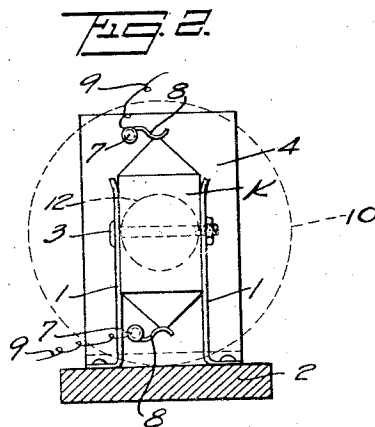
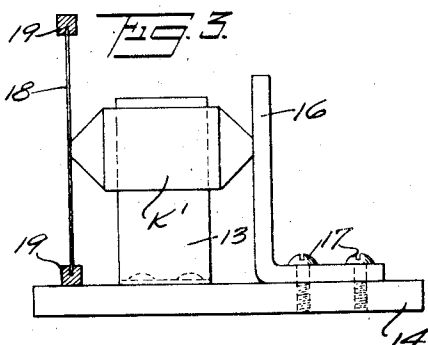
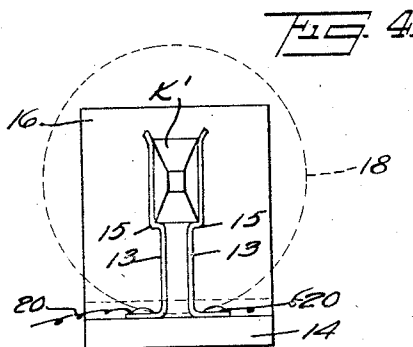
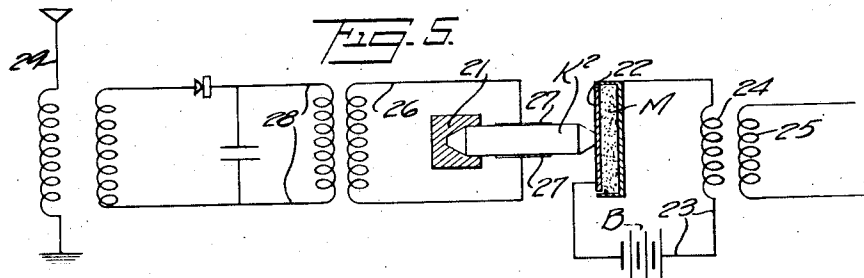
A. A. THOMAS

1,769,360

PIEZOELECTRIC TRANSLATING DEVICE

Original Filed March 24, 1925

2 Sheets-Sheet 1



INVENTOR

Adolph A. Thomas

July 1, 1930.

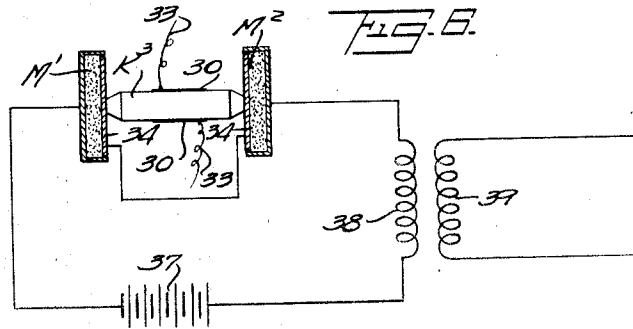
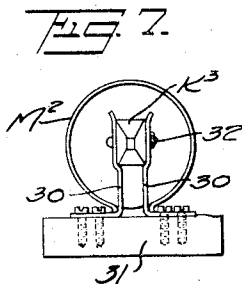
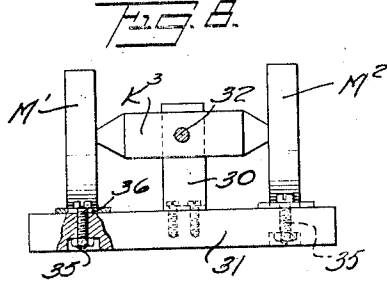
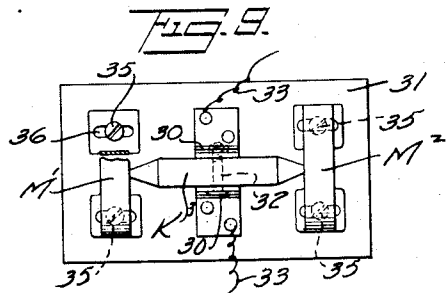
A. A. THOMAS

1,769,360

PIEZOELECTRIC TRANSLATING DEVICE

Original Filed March 24, 1925

2 Sheets-Sheet 2



INVENTOR

Adolph A. Thomas

UNITED STATES PATENT OFFICE

ADOLPH A. THOMAS, OF NEW YORK, N. Y.

PIEZO-ELECTRIC TRANSLATING DEVICE

Application filed March 24, 1925, Serial No. 17,900. Renewed April 10, 1930.

My invention relates to means and methods for receiving and transmitting variable electric impulses by the use of so-called piezo-electric crystals. The piezo-electric devices and systems of my invention are particularly useful for translating feeble electric impulses into audible sound. For this reason my invention finds special application in radio circuits, although not limited to this field of utility.

It has been known for many years—since about 1880—that certain crystals, when subjected to pressure in certain directions, become electrified; that is to say, they become a source of electric potential and produce a flow of current when properly connected in circuit. The reverse of this phenomenon has also been observed: namely, when such a crystal is subjected to an electric strain, a change in the dimensions of the crystal takes place. In other words, it undergoes a slight expansion or contraction. Among substances exhibiting these peculiar properties are crystals of tourmaline, quartz, Rochelle salts, boracite, fluor-spar, and perhaps others. These crystals are known as piezo-electric crystals, and the electricity they produce is called piezo-electricity, which means electricity caused by pressure.

In the present invention, I make use of the foregoing properties of piezo-electric crystals to produce novel devices and systems for transmitting and receiving feeble electric currents or impulses of variable character and amplifying them sufficiently for acoustic reproduction. In carrying out my invention, I employ suitable piezo-electric crystals in the construction of telephone transmitters and receivers, radio loudspeakers, and generally in electric circuits in which a piezo-electric crystal is subjected to mechanical stresses to produce electric oscillations, or is subjected to electric stresses to control a working circuit of relatively heavier currents, which may operate any suitable device.

In the accompanying drawings, which form part of this specification, I have shown various devices and circuits to explain the principles of my invention, so that those

skilled in the art may fully understand the same. In these drawings—

Fig. 1 is a side view, partly in section, of a telephone transmitter embodying my invention;

Fig. 2 is a front view of Fig. 1, approximately on section line 2—2;

Fig. 3 is a side view of a modified form of telephone transmitter or receiver having a piezo-electric crystal along an axis at right angles to the plane of the diaphragm;

Fig. 4 is a front view of Fig. 3, with the diaphragm omitted, for clearness;

Fig. 5 shows diagrammatically a radio-receiving circuit containing a piezo-electric crystal for operating a microphone or other resistance device in the output circuit;

Fig. 6 illustrates a circuit in which a pair of resistance devices, such as microphones, are simultaneously controlled by a piezo-electric crystal arranged between them;

Fig. 7 shows an end view of a form of mounting for the crystal of Fig. 6;

Fig. 8 is a side view of Fig. 7; and

Fig. 9 is a plan view of the arrangement shown in Figs. 7 and 8.

Before proceeding with a detailed description of the various embodiments illustrated in the drawings, I want it understood that the figures are for the most part merely diagrammatic, and have been made as simple and clear as possible. This is particularly true as regards the representation of a piezo-electric crystal, which I have shown in a conventional form to indicate any kind or form of piezo-electric crystal suitable for use in this invention.

Referring to Figs. 1 and 2, a piezo-electric crystal K is firmly supported in any practical way, as between a pair of spring plates 1 mounted on a base 2. If desired, a bolt 3 or similar fastening member may be used to hold the crystal rigidly clamped between the plates. The member 3, if metal, should be insulated from the metal plates 1. The crystal is so supported that at the back it rests or bears against an upstanding rigid wall 4 firmly mounted on the base 2 by screws 5 or otherwise. The wall or abutment 4 is preferably adjustable on the base by means

of elongated slots 6, through which the bolts 5 pass. On the wall 4 are mounted pins 7 which carry suitable conducting springs 8 in contact with the opposite ends of the crystal. The pins 7 also act as binding posts for connecting wires 9, by which the crystal is connected in the desired circuit.

In front of crystal K is mounted an acoustic diaphragm 10 held in a frame diagrammatically indicated by 11. To the center of the diaphragm is secured a pressure plate or disk 12 arranged to bear against the adjacent face of the crystal.

The operation of the device shown in Figs. 1 and 2 will be clearly understood without further description. It is only necessary to say that the vibrations of the diaphragm 10, due to sound waves impinging upon it, produce varying pressures in the crystal K and these pressures cause the crystal to generate electric currents, in accordance with the degree of pressure exerted at any particular moment. The ends of the crystal K, which are in contact with the springs 8, may be covered with tin foil or other conducting material, in order to secure a good electrical contact between the crystal and the springs. It will be understood that the rear abutment 4 is sufficiently strong and rigid to remain immovable (or practically so) under the pressures exerted on the crystal by the disk 12 of the vibrating diaphragm. By making the abutment 4 adjustable toward and from the diaphragm 10, it is easy to secure the correct initial or normal contact pressure between the diaphragm and the crystal.

Figs. 3 and 4 illustrate, more or less diagrammatically, an arrangement in which the crystal is mounted in a position at right angles to that shown in Figs. 1 and 2. The crystal K' of Figs. 3 and 4 is firmly clamped between a pair of spring plates 13 mounted on a base 14. The supporting plates 13 are preferably offset at 15 to provide shoulders for receiving the bottom face of the crystal. The rear end of crystal K' rests against an upstanding wall 16 mounted on the base 14 by screws 17 or in any other practical way. The wall 16 forms an immovable abutment for the crystal. The forward end of crystal K is in contact with the center of an acoustic diaphragm 18, which is properly mounted in a frame diagrammatically indicated at 19. The crystal K' is included in circuit by means of conductors 20, which are attached to the conducting plates 13 in any convenient way. The abutment 16, like the abutment 4 of Figs. 1 and 2, may be adjustable with respect to the diaphragm 18, so as to secure the correct normal position of the crystal K' with respect to the diaphragm 18 and the abutment 16.

As the operation of the device as shown in Figs. 3 and 4 is similar to that of Figs. 1 and 2, nothing further need be said on

this point. The device of Figs. 3 and 4 may be used as a receiver or as a transmitter.

In Fig. 5 I have diagrammatically shown a crystal K² rigidly mounted at one end in a suitable support 21, which is held rigid. The opposite end of crystal K² is in contact with the movable disk or diaphragm 22 of a microphone M, which may be of any approved form or structure, such as a carbon button or carbon granules whose contact area or pressure is varied. It will be understood that the microphone M is illustrated in a purely diagrammatic way and is intended to represent any suitable resistance device adapted to be varied by varying pressures of the crystal K² against the movable diaphragm 22. The microphone M is connected in a circuit 23, which has a battery B and a primary coil 24. The secondary coil 25 is intended to represent a part of whatever mechanism is operated or controlled by variable currents in circuit 23. This will be understood by those skilled in the art without further description. The crystal K² is included in a circuit 26. For this purpose I may use a pair of conducting plates 27 held in intimate electric contact with opposite faces of the crystal, as diagrammatically indicated in Fig. 5. The circuit wires are attached to the conducting plates 27 in any practical way. The circuit 26 is inductively or otherwise connected with a detector circuit 28, which receives electric oscillations from an antenna 29.

As the operation of radio-receiving circuits is generally well understood by radio engineers, I need only say, in speaking of the operation of Fig. 5, that the variable voltages induced in circuit 26 by the received oscillations in circuit 28 subject crystal K² to variable electric strains or pressures, and consequently the crystal undergoes slight expansion and contraction in the direction of its longitudinal axis. That is to say, the crystal moves toward and from the diaphragm 22 of the microphone in a vibratory manner, according to the electric oscillations of the circuit 26. These mechanical movements of the crystal 22 vary the resistance of the microphone M and thereby produce current variations in the circuit 23, which is normally supplied with substantially constant potential from the battery B. The current variations in coil 24 induce corresponding variations in the secondary coil 25, which may operate a loudspeaker or any other electrical device. The vibrations of crystal K² produce variations in the resistance of the microphone M in such a way that the electrical effect of the crystal movements is amplified in the circuit 23, and therefore in the coil 25.

In the embodiment of the invention as illustrated in Figs. 6-9, a piezo-electric crystal K³ is operatively supported in any prac-

tical way between a pair of microphones M' and M'' . These microphones may be of any suitable construction, and are indicated merely in a diagrammatic way. The crystal K^2 is firmly held between a pair of conducting plates 30 rigidly mounted on a base 31 of suitable insulating material. If desired, a nonmetallic or insulated fastening member 32 may be used to hold the crystal securely clamped between the supporting plates 30. These plates are in intimate electrical contact with the crystal, and for that purpose the faces of the crystal may be provided with tin foil, or other conductive coating. The plates 30 may also serve as terminals for attaching conductors 33, by means of which the crystal is included in an electric circuit of variable potential.

In order to adjust the initial or normal contact between the ends of the crystal and the movable diaphragms 34 of the microphones M' and M'' , the microphones (one or both) are adjustably mounted on the base 31 by means of bolts 35 passing through slots 36 in the outer frame of the microphone.

In the circuit arrangement of Fig. 6, the microphones M' and M'' are connected in series, whereby the longitudinal vibrations of the crystal K^2 , due to the electric oscillations to which it is subjected, will simultaneously increase or decrease the resistance values of the microphones, so that the mechanical movements of the crystal produce amplified electrical effects in the circuit of the microphones. This is evident from the fact that, when the crystal expands longitudinally, the diaphragms 34 are pushed in to reduce the resistance of each microphone. Conversely, when the crystal contracts, the resistance of both microphones is increased. The battery 37 is supposed to supply a practically constant current in the circuit, and the variations of current due to variations in the microphone resistances cause the coils 38 and 39 to operate as a transformer. The current variations thus induced in coil 39 may be applied to any practical purpose.

When I speak of a piezo-electric crystal, both in the description and in the claims, I do not necessarily mean a complete crystal, but I include any part or section of a crystal that may be found to be operative. For instance, a plate, rod or bar may be cut from a crystal and used in constructing my invention. The dimensions of such a crystal section will depend upon the kind and size of crystal used. Furthermore, the direction of the most effective mechanical and electrical strain in the crystal will vary with different kinds of crystals, so that the best way of mounting the crystal is often a matter of experimentation, which may readily be carried out by those skilled in the art. When I, therefore, in certain claims refer to opposite

ends of the crystal being in contact with movable members, I mean any two contact faces or points of the crystal between which physical movements of the crystal will take place.

In some of the claims I speak of a resistance element controlled by the movements of the piezo-electric crystal. This does not mean a resistance consisting only of one element or part, but I mean broadly any practical form of electrical resistance device, irrespective of the number of parts comprised therein. In other words, I make no distinction between a resistance element and a resistance device.

Although I have explained my invention by means of certain constructions and arrangements, I wish to be understood that I have done so merely by way of illustration, and not as a restriction or limitation of my invention. It is obvious that the various novel features of my invention may be mechanically embodied in other ways and by other means than herein set forth.

What I claim as my invention is:

1. The combination with a piezo-electric crystal, of a separate electric resistance element mechanically controlled by the movements of said crystal, said resistance element being adapted to operate at any frequency within practical limits.

2. The combination of a circuit including a piezo-electric crystal, and a resistance element connected in a separate circuit and arranged to be mechanically controlled by the movements of said crystal, said resistance element being separate from said crystal and adapted to operate at any frequency within practical limits.

3. The combination of a piezo-electric crystal suitably supported, and a resistance device at each end of said crystal and adapted to be controlled by the movements of said crystal.

4. The combination of a piezo-electric crystal suitably supported, a resistance device at each end of said crystal and adapted to be controlled by the movements of said crystal, and means for connecting said resistance devices in series in a circuit.

5. In an electric amplifying system, the combination of a pair of resistance devices including each a movable member for controlling the resistance, and a piezo-electric crystal supported between said devices and at its opposite ends in contact with said movable members, whereby the movements of said crystal produce operation of said members for simultaneously varying said resistances.

6. In an electric amplifying system, the combination of a pair of resistance devices including each a movable member for controlling the resistance, a piezo-electric crystal supported between said devices and at

its opposite ends in contact with said members, so that the movements of said crystal produce operation of said members for simultaneously varying said resistances, a circuit including said resistances in series, a source of substantially constant potential for said circuit, and an operating coil in said circuit, whereby the current variations in said coil are controlled by the movements of said crystal.

7. In an electric amplifying system, a circuit containing a variable resistance, a coil in said circuit, a source of practically constant potential for said circuit, a piezo-electric crystal so mounted that its movements control said resistance, and means for subjecting said crystal to variable voltage, whereby current variations are produced in said coil in accordance with the variable voltage impressed upon the crystal.

8. The combination with a piezo-electric crystal, of a microphone mechanically operated by the movements of said crystal.

9. The combination with a piezo-electric crystal, of a pair of microphones mounted in contact with the opposite ends of said crystal and simultaneously operated by the movements of the crystal.

10. The combination of an electric circuit containing two resistance elements in series, and a piezo-electric member for simultaneously decreasing or increasing said resistances by the movements of said member when subjected to variable voltage.

11. In an electric system, the combination of a variable controlling circuit including a piezo-electric element, an output circuit connected with a source of substantially constant potential, and a resistance device separate from said crystal and having means in mechanical contact with said element and controlled thereby for producing current variations in said output circuit by varying the resistance of this circuit in accordance with potential variations in said controlling circuit.

12. In a telephone instrument, a base, a pair of spring metal plates mounted on said base and electrically insulated from each other, and a piezo-electric crystal held between said plates and in electric contact therewith.

13. In a telephone instrument, a base, a pair of resilient conducting plates mounted on said base and provided with off-set portions which form retaining shoulders, and a piezo-electric crystal clamped between said plates and in electric contact therewith, said shoulders retaining the crystal in predetermined position between said off-set portions which firmly grip the crystal without interfering with its movements.

14. In an electric instrument, the combination of a piezo-electric element suitably supported, and a vibratory member mounted in-

dependently of said element, said parts being relatively so arranged that mechanical movements of said element produce corresponding vibrations of said member.

15. The combination of a base, a pair of relatively adjustable members mounted on said base, and a piezo-electric crystal held between said members, which are supported independently of said crystal.

16. In a piezo-electric device, the combination of a base, a pair of members mounted on said base in spaced parallel relation, a piezo-electric crystal held between said members, which are supported independently of said crystal, and means for adjusting at least one of said members to regulate the normal distance between them.

17. The combination of a carbon transmitter and piezo-electric means for operating the same.

18. The combination of a piezo-electric element and a microphonic resistance device mechanically controlled by the movements of said element.

19. The combination of a piezo-electric element and carbon contacts mechanically connected with said element, whereby the movements of said element vary the resistance of said contacts.

20. In an electric translating device, the combination of a plurality of transmitters, and a single piezo-electric means for simultaneously actuating said transmitters.

21. In an electric translating device, the combination of a pair of transmitters, and a piezo-electric element mounted between said transmitters for simultaneously actuating the same.

22. In an electric translating device, the combination of a pair of carbon transmitters, and a piezo-electric element mounted between said transmitters for simultaneously actuating the same.

23. A piezo-electric crystal having a spring-pressed electrode in pressure contact therewith, and a second electrode engaging said crystal, said electrodes constituting a support for the crystal.

24. A piezo-electric crystal supported by and between a pair of electrodes in contact therewith, at least one of said electrodes exerting a spring pressure against the crystal.

25. A piezo-electric crystal supported by and between a pair of metal plates in contact therewith to form electrodes, at least one of said plates being spring-pressed.

26. In a piezo-electric device, the combination of a base, a pair of spaced metal plates mounted on said base and electrically insulated from each other, and a piezo-electric crystal held between said plates in electric contact therewith and projecting at its ends beyond said plates.

27. In a piezo-electric device, the combination of a base, a pair of members mounted on said base in spaced parallel relation, a piezo-electric crystal held between said members, which are supported independently of said crystal, and means for adjusting at least one of said members to regulate the normal distance between them.

nation of an insulating base, a pair of metal plates mounted in spaced parallel relation on said base, and a piezo-electric crystal held flatwise between said plates in electric contact therewith, said plates engaging opposite faces of said crystal which extends at its ends beyond said plates.

ADOLPH A. THOMAS.

10

15

20

25

30

35

40

45

50

55

60

65