

Jan. 10, 1928.

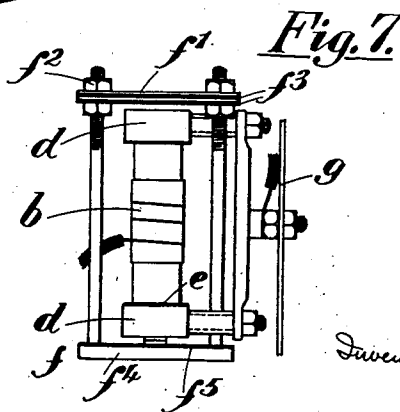
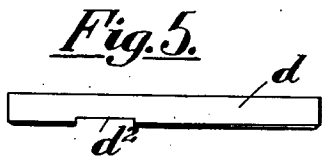
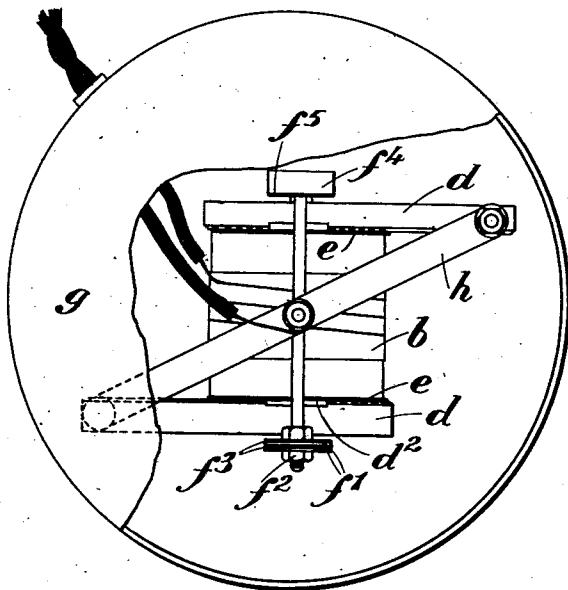
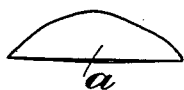
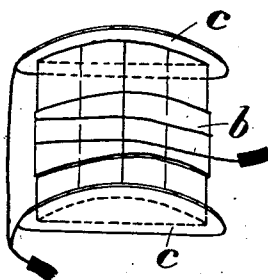
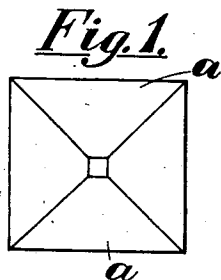
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1,655,974

PIEZO ELECTRIC DEVICE

Filed May 1, 1922

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

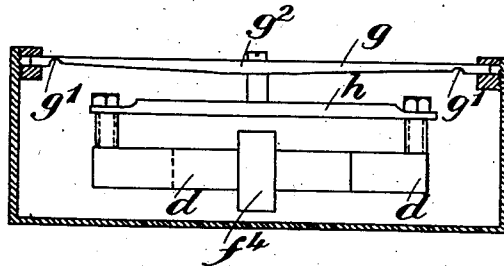
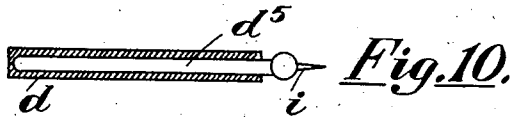
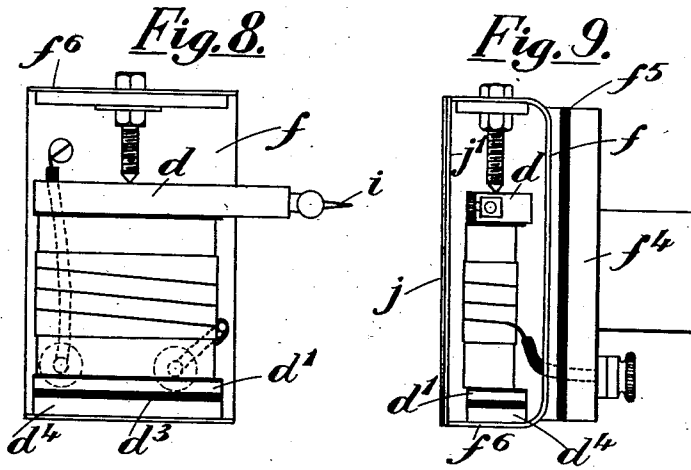
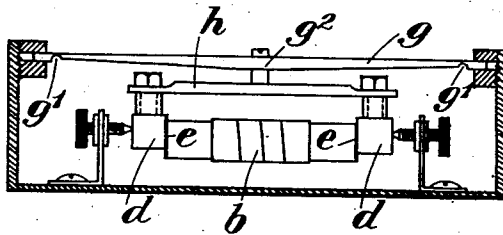


Fig. 11.

Fig. 12.



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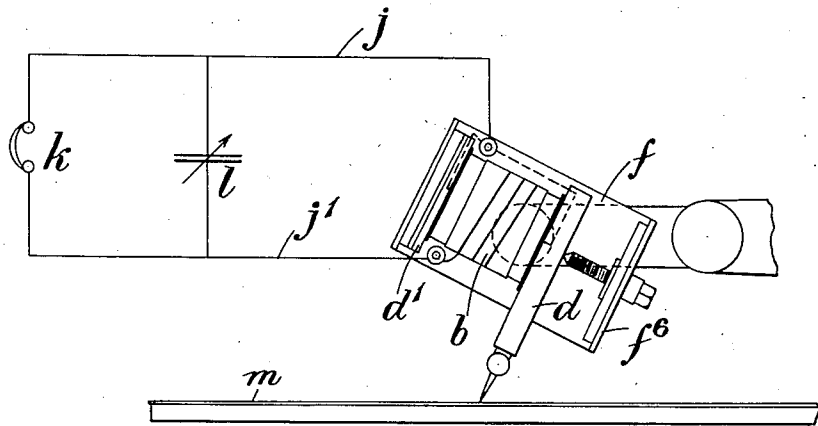
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Fig. 13.



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UNITED STATES PATENT OFFICE.

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PIEZO-ELECTRIC DEVICE.

Application filed May 1, 1922, Serial No. 557,641, and in Great Britain June 9, 1921.

This invention relates to piezo-electric devices and consists in an improved arrangement for the use of the active crystal, for example of Rochelle salt, more especially for the reception or reproduction of sound or pressure waves which may be collected in any suitable manner.

According to the present invention, the crystal is subjected to pressure at each end of an axis, which may or may not be one of its axes of symmetry, and at one or both ends of the said axis it is connected to a conducting member, the conduction or transmission of waves down which is produced by or transmitted to a receiving surface. By the expression "conducting member" we mean to imply a member adapted to the reasonably efficient conduction of mechanical pressure waves through the material of the said member.

A convenient form of conducting member for applying vibrations or pressure waves to the basal planes of the piezo-electrically active crystal is found to be a bar or plate kept in contact with a basal plane of the crystal by constant pressure, suitably applied.

The crystal may be mounted between two conducting members, which extend preferably in diametrically opposite directions, their operation being produced by or serving to operate the receiving or transmitting surface through a suitable conductor of waves, such as a cross bar arranged diagonally to connect the extremities of the arms.

We have discovered that the piezo-electric effect is independent of mechanical movement of the members which connect the receiver of vibrations to the basal planes of the crystal, and may be as efficiently obtained by the passage of pressure waves through the crystal structure. From this it will be obvious that absolute rigidity of construction makes for efficiency and sensitivity, and is of considerable use in the prevention of resonance of the extraneous vibrations in that sound and musical reproduction for which the apparatus is intended.

We have also found that substances which are insulators to sound are still capable of a reasonably efficient conductivity of pressure waves. For example, compressed cellulose acetate not only has this property to

a marked degree, but its peculiar elasticity is also employed by us to assist in the conversion of mechanical vibrations into pressure waves.

The entire system may be supported by the receiving or transmitting surface. It will be obvious that the means for obtaining the constant pressure may in this case take the form of a cradle surrounding the crystal and embracing the conducting members. It may alternatively be found advantageous to attach the apparatus to a solid base or sides in which event it would probably be more convenient to apply the pressure from uprights extending from the base or sides.

Pressure waves when received are conveyed either directly, or through the cross-bar, to the conducting members. We have found that the greater the cross sectional area of these members the greater is their conductivity, up to the saturation point, which is a factor of the crystal constant. This law has also been found to apply to the cross bar surface and any intermediate conductors.

The invention is hereafter described with reference to the accompanying drawings, in which:—

Figure 1 represents a crystal of the shape which has been found most suitable for the present invention.

Figure 2 is a plan of the same.

Figure 3 is a perspective view of the mounted crystal.

Figure 4 shows a device for converting vibrations or pressure waves into electricity or vice versa.

Figures 5 and 6 are details of one of the conducting members seen in Figure 4.

Figure 7 is an end view of the device showing the cradle mounting.

Figures 8 and 9 represent the application of the invention to a transmitter intended to replace the sound box of a gramophone.

Figure 10 represents a reinforced conducting member for musical sounds.

Figures 11 and 12 illustrate alternative methods of mounting the device.

Figure 13 is a diagram showing the electrical connections when using a condenser for removing needle-scratch and similar noises of gramophone records when producing electrical currents by means of a crystal

transmitter such as shown in Figures 8 and 9.

Crystals of Rochelle salt may be encouraged in a particular habit of growth to assume the shape illustrated in Figures 1 and 2, in which the surfaces a are those referred to as the basal planes. Figure 3 shows the crystal provided with the usual contact plates or bands, for example one circumferential band b and one plate c at each of the selected bases.

In one manner of carrying the invention into practice, see Figures 4, 5, 6 and 7, a crystal of this kind is mounted between two parallel conducting members d which project in diametrically opposite directions; these conducting members are arranged at the basal planes and they may be made of metal, in which case the separate contact plates c may be suppressed.

The mounted crystal is supported upon an axis perpendicular to the basal planes and to the members d , so that by means of the latter the crystal may be subjected to pressure waves or its converse effects may be manifested. It has not been found necessary to provide delicate pivotal mounting, any suitable bearing surface being applicable.

The conducting members, made in this case of metal and cross-cut or chequered on their adjacent faces, are bedded against the basal planes of the crystal by means of contact pads e of tinfoil or the like interleaved with cellulose acetate or similar material capable of being softened before assembly so that it will take up the shape of the basal plane of the crystal.

To ensure adequate bearing of the contact surfaces upon the sensitive regions of the basal planes of the crystal, viz the corners or angles of the basal planes, the conducting members d are recessed as indicated at d^2 in Figures 5 and 6.

Pressure is applied to the crystal through the conducting members and contact pads by means of the cradle f , the open end of which carries spring plates f' which can be adjusted by nuts f^2 to regulate the pressure. These spring plates may be of metal with an intermediate layer f^3 of cellulose acetate or other damping material, and at the opposite closed end of the cradle, a bearing plate f^4 may be supported likewise upon a cushion f^5 of cellulose acetate.

The oppositely extending ends of the conducting members d are connected to the receiving or transmitting surface g directly or by means of a cross bar h which is fixed rigidly to the members d in any suitable manner and also connected to the receiving or transmitting surface.

The vibration or pressure waves of the diaphragm g will thus be translated into an alternating effect upon the crystal, produc-

ing an electro-motive force between the contact plates or bands b , c , which may be utilized for the transmission of current possessing the characteristics of the impressed vibration or pressure waves. Conversely, if an alternating or fluctuating current be applied to the contact plates b , c , the resulting effect upon the crystal will produce vibration at the surface g in equivalent mechanical reproduction of the applied current.

In some applications, two collecting surfaces may be used in connection with a single crystal. For example the conducting members d may be connected to opposite collecting surfaces directly by means of cross bars or other suitable connections in conjunction with two collecting surfaces parallel to each other.

Figures 8, 9 and 10 illustrate a form of the apparatus, suitable for converting the musical sounds or speech represented by the grooves of the known type of gramophone or like records, into their electrical equivalents.

The apparatus is conveniently arranged upon a base f comprising a frame-work or casing of channel or flat U-section composed of some springy metal such as duralumin, having attached to the web of the channel f a sheet f^5 of sound insulating material, clamped to the web by a plate f^4 of ebonite or the like. The crystal is held between the flanges f^6 of the channel, and is pressed at one end upon a chequered plate d' of steel or other suitable material sound-insulated from the base, for example by a layer of cellulose acetate d^3 with an outer plate of lead d^4 , the latter resting against the inner side of the flange. The crystal is clamped between the chequered base d' at the one end, and a conducting member d at the other, constant pressure being applied on the conducting member by any suitable means, between two springy flanges f^6 of the U-shaped frame-work.

The conducting member d is preferably made of compressed cellulose acetate or other semi-yielding material, which may be reinforced by a suitable proportion of metal d^5 (see Figure 10): this arrangement serves to convert mechanical vibrations, if any, into pressure waves, to act as an efficient conductor if already formed pressure waves are impressed, and to produce the modulating and regulating effect described above. A gramophone needle i or its equivalent is placed in one end of the member.

Figure 13 shows the crystal having its circumferential contact band b and basal contacts d d' connected by leads j j' respectively to the receiving or amplifying apparatus, represented by head phones k . The leads j j' are connected through a variable condenser l , the function of which is to eliminate scratching and surface noises of the gramophone record m from reproduction in

the receiver k ; these noises are due to the roughness of the surface of the record, due to wear, etc., the sounds caused thereby being of a far higher frequency than the normal acoustic tones of the record. The piezo-electric device acts to convert these noises into electrical oscillations of equivalent frequency, which are readily shunted by the condenser, while the relatively lower frequencies equivalent to the normal acoustic tones pass on through the head-phones or amplifier.

The condenser 1 may be adjusted to suit the crystal used and the condition of the surface of the gramophone record; convenient values range between .001 microfarad and .01 microfarad, depending on the state of the record surface, the power of the crystal and the ratio of amplification, but different degrees of surface roughness produce electrical oscillations of different frequencies, for which reason the range of capacity provided will with advantage be wide, to enable the same apparatus to function with any record, whatever its condition.

The device is preferably enclosed for protection from external influences; it has been found that stiff paper or thin cardboard j , lined on the inside with soft india rubber sheet j' makes an extremely satisfactory cover as in itself it is non-resonant.

Figures 11 and 12 illustrate modifications of the device, the former showing a cradled mounting, the system being supported from the receiving or transmitting diaphragm, and the latter figure showing the mounted crystal as being supported from the base or side of the container.

To obtain the most efficient results the collecting surface or diaphragm must be calculated so as to be proportional to the capacity of the conducting members, whose volume is a factor of the crystal constant.

It is a known fact that pressure waves will travel through any substance to its extremities as in the case of ripples on the surface of a pond caused by an impact on its surface, provided the pressure waves are of sufficient amplitude to overcome the natural resistance of the conductor.

In cases where the collecting surface or diaphragm g has to be gripped by its outer edge the pressure waves will tend to pass from the diaphragm to the main frame.

This results in loss of efficiency, and may be prevented by making the centre more solid, and reducing the thickness, and hence the conductivity of the outer edge. We have effected this most simply by making a groove g' all round the active area between the latter and the gripped edges, as shown in Figures 11 and 12. Increased efficiency may be obtained by shaping the diaphragm like a magnifying lens, the centre portion g^2 being of increased thickness.

The usual contact plates and connections to the basal planes and centre of the crystal may be arranged in any suitable manner.

It will be understood that various modifications may be introduced in the arrangement described without affecting the principle involved.

Having thus described our invention, what we claim is:—

1. A piezo-electric device, comprising an active crystal, electrical contacts upon said crystal, means for subjecting said crystal to pressure along an axis, a conducting member clamped to one of the basal planes of said crystal by said pressure means, and means for exerting an opposite torsional effect at the other basal plane of said crystal, said conducting member being constructed of semi-yielding material to conform to the contour of the basal plane of the crystal, said semi-yielding material being reinforced with metal and adapted to conduct pressure waves through said basal plane.

2. A piezo-electric device, comprising an active crystal, a contact band around the periphery of said crystal, contact pads at opposite basal planes of said crystal, said contact pads composed of metal foil interleaved with cellulose acetate, electrical connections to said contact band and pads respectively, a conducting member, and means for clamping said conducting member against one of said contact pads.

3. A piezo-electric device, comprising an active crystal, electrical contacts upon said crystal, means for subjecting said crystal to pressure along an axis, conducting members clamped to said crystal by said pressure at opposite ends of said axis, said conducting members extending in diametrically opposite directions relatively to said axis, said conducting members connected to transmitting surfaces, and semi-yielding means for conducting pressure waves between the crystal and said conducting members, said semi-yielding means being in direct contact with the end of the crystal.

4. A piezo-electric device, comprising an active crystal, electrical contacts upon said crystal, a rigid support for said crystal, means for subjecting said crystal to axial pressure, means for subjecting said crystal to pressure, waves at opposite ends of the axis of pressure, and a transmitting surface, said surface being of lenticular section having a circumferential groove.

5. A piezo-electric device, comprising an active crystal, electrical contacts upon said crystal, a support for said crystal, means for subjecting said crystal to pressure at its basal planes, conducting members clamped against said crystal at its basal planes, said members being recessed to insure adequate bearing of said members upon the sensitive regions of the basal planes, a transmitting surface, and

means for conveying pressure waves between said surface and said conducting members.

6. A piezo-electrical device, comprising an active crystal, electrical contacts upon said
5 crystal, means for subjecting said crystal to pressure along an axis, and a conducting member clamped to the basal plane of said crystal at one end of said axis, said member
10 conducting pressure waves through said basal plane and consisting of compressed cellulose acetate reinforced with metal proportioned to the absorptive capacity of the crystal used.

7. A piezo-electric device comprising an
15 active crystal, a contact band around the periphery of said crystal, torsional arms at opposite basal planes of said crystal extending outwardly in opposed directions, contact pads arranged to conform closely with said
20 basal planes disposed intermediate said planes and said outwardly extending arms, electrical connections to said contact band and plates respectively, adjustable means for exerting pressure axially of said crystal, and
25 means connected to the outer ends of said arms whereby to exert opposite torsional effects simultaneously upon said basal planes.

8. In a piezo-electric device, in combination, an active crystal, conducting members
30 contacting closely with opposite basal planes

of said crystal, means for exerting a torsional effect upon said crystal through said members, means for exerting desired constant pressure axially of said crystal, electrical
35 connections to said members, and a condenser connected across the terminals of said crystal, whereby high frequency electrical impulses may be shunted.

9. A piezo-electric device, comprising an active crystal, electrical contacts upon said
40 crystal, a cradle, said cradle supporting said crystal, and means for subjecting said crystal to pressure at opposite planes of the crystal, said means including a conducting member of semi-yielding material reinforced with
45 metal and directly contacting with a portion of the crystal.

10. In a piezo-electric device, in combination, an active crystal, conducting members
50 contacting closely with opposite planes of said crystal, means for causing pressure to be exerted upon the crystal, electrical connections to said conducting members, and a condenser connected across the electrical terminals of the crystal, whereby high frequency
55 electrical impulses may be shunted.

In testimony whereof we hereunto affix our signatures.

EDWARD W. RUSSELL.

ARTHUR FREDERICK RICHMOND COTTON.