Nov. 26, 1929. A. A. LINSELL 1,737,253

MEANS FOR RECORDING AND REPRODUCING SOUND

Filed Sept. 28, 1927

Fig.1

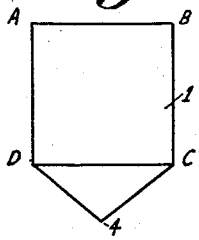


Fig.2

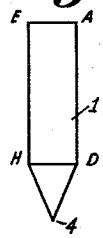


Fig.3

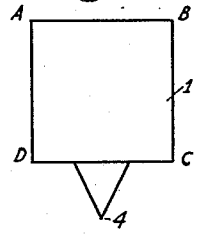


Fig.4

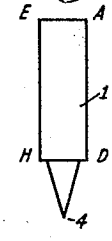


Fig.5

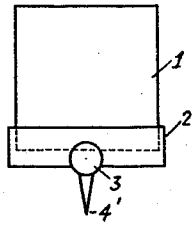


Fig.6

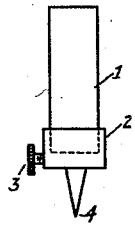


Fig.7

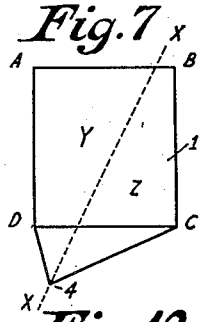


Fig.8

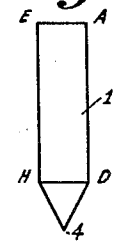


Fig.9

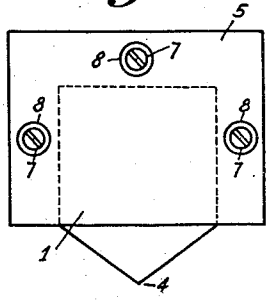


Fig.10

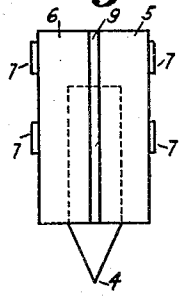


Fig.12

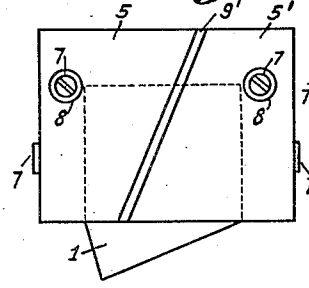


Fig.13

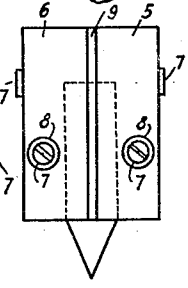


Fig.11

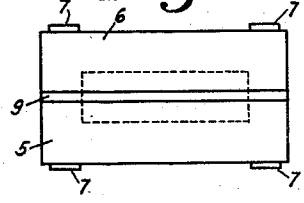


Fig.14

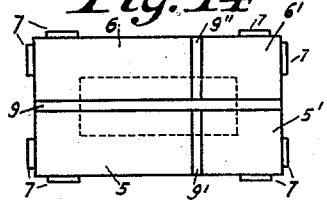


Fig.7A

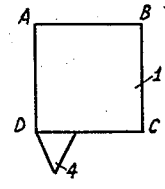


Fig.8A

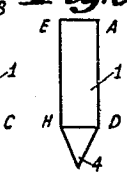
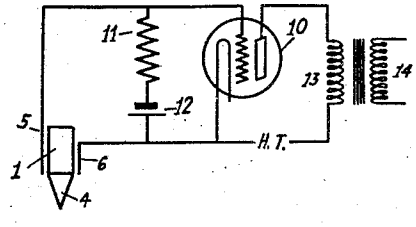


Fig.15



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Patented Nov. 26, 1929

1,737,253

UNITED STATES PATENT OFFICE

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MEANS FOR RECORDING AND REPRODUCING SOUND

Application filed September 28, 1927, Serial No. 222,543, and in Great Britain October 2, 1926.

This invention relates to means for recording and/or reproducing sound, and more particularly to means for recording sound upon gramophone and the like records and/or reproducing sound therefrom.

According to this invention means for recording or reproducing sound comprise a piezo-electric crystal, means for applying potential to or deriving potential from one or more of the faces of the crystal, and means for applying force to or deriving force from one or more of the faces of the crystal.

The piezo-electric crystal may be employed in conjunction with a separate stylus device, such as a steel point or a sapphire, but preferably such stylus device is formed integral with the crystal.

In carrying out the invention for the reproduction of sound from a gramophone or the like record, a suitably cut piezo-electric crystal is subjected to a compressive, followed in certain cases by a tensile, force, acting in such a manner as to produce a corresponding contraction or extension of the crystal in a plane containing any two of the principal axes thereof, the said force being applied by and due to the movement of a stylus, affixed to the said crystal, and in contact with the sound trace of a phonograph or gramophone record. These principal axes of a piezo-electric crystal are the optical axis, the electrical axis, and the geometrical axis which is perpendicular to the optical and electrical axes. The application of force to the crystal results in the generation therein of an electric potential, derived from two opposite faces of the crystal, either or both of which undergo the compression or tension.

It will be seen that the electrical potential developed will correspond with the sound trace on the record. This potential may be amplified in any known manner, and finally converted into sound waves by means of a telephone, or other suitable instrument.

Similarly, in the case of recording, the sound waves after amplification if desired are converted into corresponding electrical potentials, which are applied to opposite faces of a suitably cut piezo-electric crystal, thereby causing a physical deformation of the crystal, which is utilized to cut a sound trace on a gramophone or phonograph record.

In one form of construction the crystal is mounted in a holder or carriage attached by a flexible coupling to an arm positioned close to the record and pivoted in such a manner as to allow the carriage to move across the record face following the course of the sound trace. The weight, and therefore the inertia, of the carriage is such, and is so positioned, that it provides a substantially rigid holder for the crystal in relation to the surface of the record, while at the same time the flexible coupling prevents any unevenness in the movement of the record table (due, for example, to eccentricity of mounting), from affecting the crystal.

Although any known type of stylus, such, for example, as a steel point or sapphire, may be used with the piezo-electric crystal arrangements herein described, it is preferred to form the stylus from the body of the crystal itself.

In one such arrangement one face of the crystal is ground in such a manner that a point adapted to act as the stylus rises abruptly from the surface.

In another arrangement the face which would normally carry the stylus is formed with a pyramid thereon, and not as a plane surface, the apex of the pyramid being the stylus point.

Two examples of arrangements in accordance with the invention will now be described.

The first example relates to phonograph or pathephone reproduction.

From a piezo-electric crystal such a quartz, a rectangular plate is cut whose faces are parallel to the optical axis, the electrical axis, and a geometrical axis which is perpendicular to the optical, and electrical axes, respectively. In the center of the face containing the electrical and geometrical axes is affixed the stylus, or alternatively, this face may be ground with a projection shaped to act as the stylus. The crystal is mounted in a carriage so that the face carrying the stylus projects freely from it, and the opposite face bears on the body of the carriage. Two rectangular electrodes are provided on the two faces con-

taining the optic and geometric axes, and these electrodes may also assist in retaining the crystal in the carriage. Other side members may also be provided for retaining the crystal in position, if desired. The carriage is joined to a pivoted arm by a rubber or similar flexible coupling, the weight of the carriage being sufficient to provide a substantially rigid holder for the crystal with respect to the record. The crystal in its carriage is then mounted above the record, with the stylus in contact with the sound trace in the usual manner. It will be clear, therefore, that the varying contour of the sound trace will cause the stylus to move in a direction parallel to the optic axis, and this in its turn, since the carriage is substantially rigid, due to its inertia, will tend to cause the crystal to expand in the direction of the electrical and geometrical axes if the movement is compressive. Consequently, an electrical potential will be generated, corresponding to the contour of the sound trace, at the electrodes. This potential may now be amplified in a thermionic amplifier, the last stage of which is arranged to actuate a telephone or other instrument, thus producing sound waves in accordance with the original sound trace on the record.

The second example refers to gramophone reproduction.

This is generally similar to the example just described, but a different method of mounting the crystal is adopted, and the position of the stylus on the face of the crystal is also altered. The reason for this alteration is due to the difference between the sound trace on a phonograph or pathephone and a gramophone record, the first producing an up and down movement of the stylus, while the second gives a side to side movement. In other respects the procedure is as before. The crystal is cut in a similar manner, and the faces containing the optical and geometrical axes are again provided with electrodes, but the stylus, instead of being positioned in the center of the face containing the electrical and geometrical axes, is now positioned at the center of one of the edges of this face which is parallel to the electrical axis.

The crystal with its carriage is then positioned above the gramophone record with the side carrying the stylus in the center making a tangent with the circular groove of the sound trace, the stylus being of course in contact with the said trace. The resulting movement of the stylus in one direction, due to the sound trace, will therefore cause the whole or a part of the face containing the optical and geometrical axes to contract, while movement in the other direction will cause it to expand. This expansion and contraction will generate electrical potential as before, which may be amplified as desired.

It is to be understood that the foregoing examples are by way of illustration only, and that other arrangements may be adopted without departing from the scope of the invention. For example, the shape of the crystal has been described as rectangular but other shapes may be used, as, for instance, one in which two or more of the faces are triangular. Also the electrodes have been described as rectangular, but again other shapes may be used, as, for instance, triangular, and the said electrodes need not be of the same shape as the faces of the crystal on which they are positioned. Again, the relative position of the axes in relation to the carriage, stylus and record may be interchanged and varied.

Further, if desired, the stylus in the case of the gramophone may be placed at any other desired position on the face of the crystal, and not only on one side as hereinbefore described.

In one such modified arrangement the potential generated on one face of the crystal only is utilized, and another electrode is positioned near to, but insulated from, this face, this second electrode serving as the second pole, between which and the electrode on the crystal face, the varying potential is generated.

The invention is illustrated in the accompanying drawings.

Referring to Figures 1 and 2, which show in front and side elevation respectively a piezo-electric crystal cut to a form suitable for phonograph recording and reproduction, 1 is the main body of the crystal and 4 a part of the said crystal cut to form a point adapted to form, in effect, a stylus. The edge A B is parallel to the optic axis of the crystal, the edge A D parallel to the geometric axis, and the edge A E parallel to the electric axis thereof. The part 4 may be cut to any desired degree of sharpness.

Figures 3 and 4 show in front and side elevation respectively a slightly modified form of crystal in which the part 4 is cut more abruptly.

In the modification shown in front and side elevation respectively in Figures 5 and 6, the part 4, formed in the above described constructions integrally with the main body of the crystal, is replaced by a steel stylus needle 4′ of known form, clamped in a trough-shaped member 2 by means of a set screw 3, the said trough retaining the crystal 1.

Figures 7 and 8 show in front and side elevation respectively a form of crystal suitable for use in gramophone reproduction. This form is generally similar to the forms shown in Figures 1, 2, 3 and 4, except that the part 4, which is formed integrally with the main body of the crystal, is displaced towards the face A—H instead of being located substantially at the center of the face C—H.

When such a crystal is mounted perpendicular to the surface of a gramophone record, with the part 4 in contact with the trace thereof and the face A B C D at right angles to the said trace, the said part 4 will experience forces in a direction parallel to the edge D C. Therefore, when a force tends to move the part 4 to the left, the area Y of the crystal to the left of the line X X will experience compression, while the area Z to the right thereof will experience tension, a reversal of these forces taking place when a force tends to move the part 4 to the right. It will be clear that under the influence of the forces, electrical potentials will be generated in the areas to left and right of the line X X. If therefore a pair of connected electrodes be placed in contact with area Y on the front of the crystal and area Z on the back thereof, and a second pair of connected electrodes insulated from the first pair be placed in contact with area Z on the front of the crystal and area Y on the back thereof, equal potentials of opposite sign may be collected from the pairs of electrodes. These potentials may be utilized to actuate any known form of electrical sound translating device, such as a telephone.

In a modification (illustrated in front and side elevation respectively in Figures 7A and 8A) of the last described arrangement, the stylus is formed as an abrupt point similar to that shown in Figures 3 and 4, but displaced towards the face A H. In this case a force, tending to move the stylus 4 to the left, will cause substantially the whole of the face A B C D to undergo tension, while a force, tending to move the stylus to the right, will cause a corresponding compression over substantially the whole face A B C D. With this modification, therefore, only two electrodes are required covering substantially the whole of the face A B C D and the corresponding rear face.

Figures 9, 10 and 11 show in front and side elevation and plan respectively a convenient form of carriage and electrode arrangement. This arrangement, which is adapted to carry any of the forms of crystal shown in Figures 1 to 6, comprises a metal box consisting of two halves 5 and 6, insulated from one another by a member 9 (or by an air space rendering the said member 9 unnecessary) and carrying between them the crystal 1 which is held in position by means of screws 7 passing through the said halves but insulated therefrom by ebonite or the like bushings 8.

In this way the box halves 5 and 6 serve the double function of retaining the crystal and serving as electrodes in contact with the crystal faces containing the optic and geometric axes. If desired, the box halves 5 and 6 may be insulated from the crystal faces containing the electric and geometric axes by narrow strips of mica, ebonite or the like.

It will be seen that with the arrangement shown in Figures 9, 10 and 11, if the crystal in its mounting be located above a phonograph record, with the part 4 in contact with the sound trace thereon, the said part will be subjected to varying degrees of pressure in a direction perpendicular to the face of the record, and this pressure will be imparted to the body of the crystal, tending to cause the crystal to expand in a direction perpendicular to the face A B C D. Corresponding electrical potentials will therefore be generated on those faces which are in contact with the electrodes 5 and 6, and these potentials may be applied preferably after amplification, to actuate any known form of electrical sound translating device, such as a telephone.

Figures 12, 13 and 14 show in front and side elevation and plan respectively a convenient form of carriage and electrode arrangement, suitable for use in gramophone recording or reproduction, with a crystal such as that shown in Figures 7 and 8. In this arrangement the carriage comprises four members 5, 6, 5′ and 6′, clamped together to retain the crystal by means of screws 7 insulated by bushings 8. 9, 9′, 9″ are insulating members which may, however, be dispensed with if the members, 5, 6, 5′, 6′, are so shaped and are of such size that when in position about a crystal there is a sufficient air space between their edges to provide the required insulation.

Figure 15 shows in diagrammatic form a suitable amplifier arrangement for use with any of the foregoing crystal arrangements. Referring to this figure, 10 is a thermionic valve whose grid and cathode are connected across the potential generating electrodes. For example, with the arrangement shown in Figures 9 to 11, the grid and cathode would be connected across electrodes 5 and 6, while in the arrangement shown in Figures 12 to 14, the said grid and cathode would be connected across the pairs of electrodes 5, 6′ and 5′, 6. 11 is an impedance connected in series with a bias battery 12, between the said grid and filament. 13, 14 are the primary and secondary of a transformer, the secondary of which is adapted to actuate a telephone, loud speaker or the like (not shown).

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. A reversible electrical reproducer comprising a piezo electric crystal section, said section having a body portion and a projecting portion, said last mentioned portion being shaped to fit the grooves of a record, and electrodes connected to two opposite faces of said body portion.

2. In an electrical reproducer adapted to

generate electrical impulses in accordance with groove variations in a record device, a stylus shaped to fit said grooves, said stylus being formed of a piezo electric material.

3. In an electrical reproducer adapted to generate electrical impulses in accordance with groove variations in a record device, a piezo electric body adapted to transform mechanical vibrations into electrical oscillations or electrical oscillations into mechanical vibrations, and a stylus integrally formed on said body and of the same material.

4. In an electrical reproducer adapted to generate electrical impulses in accordance with groove variations in a record device, a piezo electric crystal section adapted to transform electrical oscillations into mechanical vibrations and mechanical vibrations into electrical oscillations, said crystal comprising a body portion, a stylus integral with and projecting from said body portion, and a pair of electrodes connected to said body portion.

5. In an electrical reproducer adapted to generate electrical impulses in accordance with groove variations in a record device, a piezo electric crystal section comprising a body portion and a stylus integrally formed with said body portion and of the same material.

6. In an electrical reproducer adapted to generate electrical impulses in accordance with groove variations in a record device, a piezo electric crystal parallelopiped and a pyramidal extension integrally formed at one side of said parallelopiped, said extension being shaped to fit into said groove variations.

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