

Aug. 28, 1951

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2,565,586

LEVER TYPE PIEZOELECTRIC TRANSDUCER

Filed July 26, 1949

2 Sheets-Sheet 1

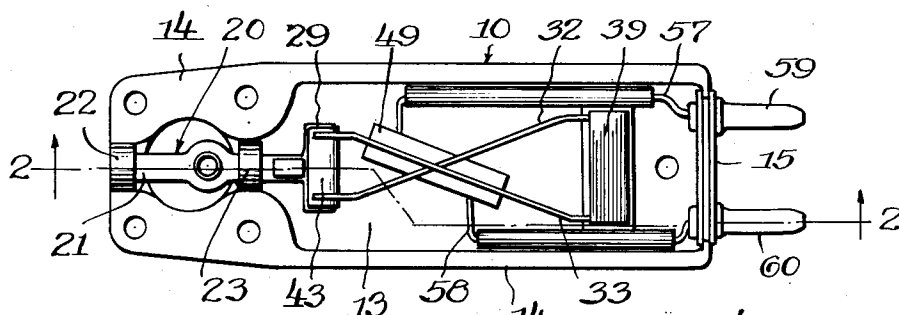


Fig. 1

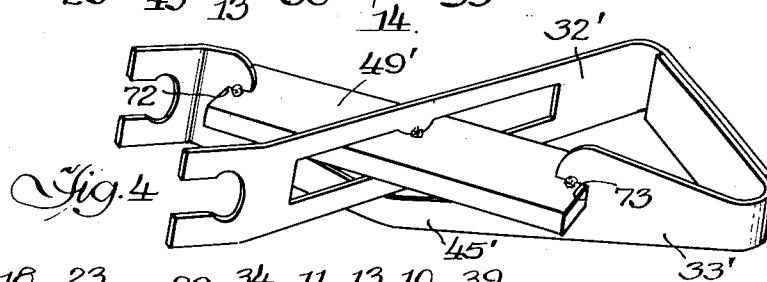


Fig. 4

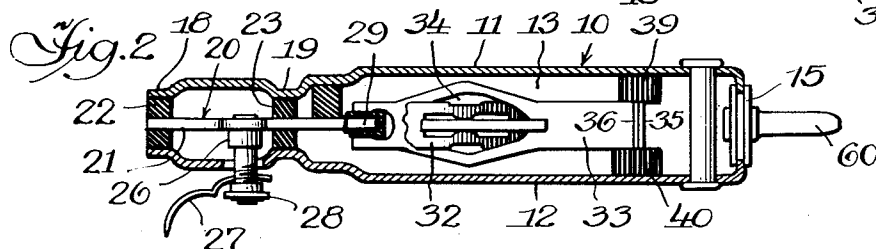
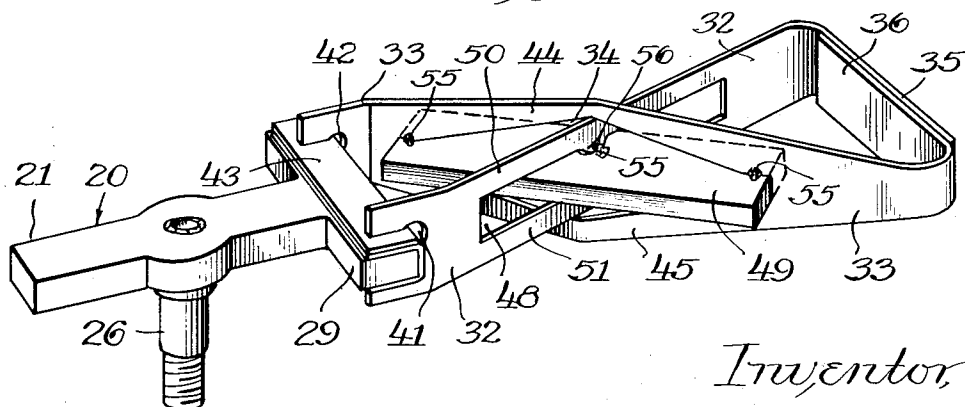


Fig. 2

Fig. 3



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Fig. 5

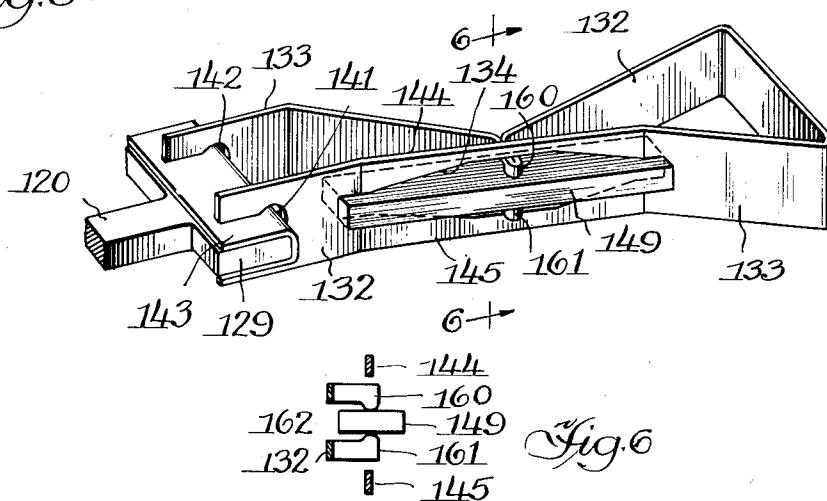


Fig. 6

Fig. 7

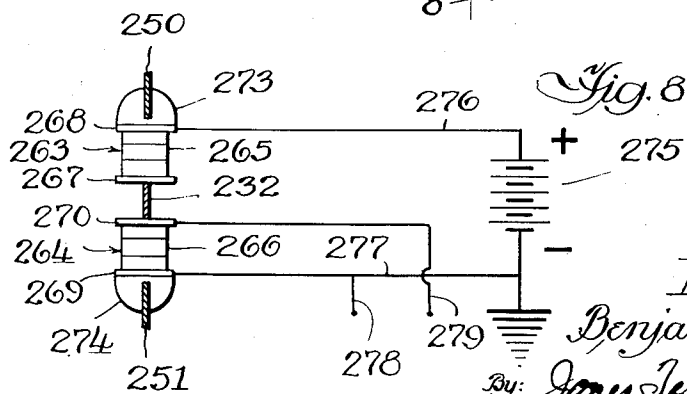
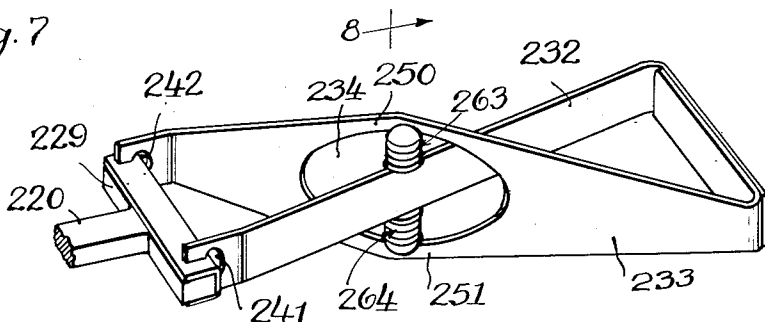


Fig. 8

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UNITED STATES PATENT OFFICE

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LEVER TYPE PIEZOELECTRIC TRANSDUCER

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11 Claims. (Cl. 179—100.41)

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This invention relates to improvements in mechano-electric transducers for the interconversion of mechanical and electrical vibratory energy and has especial application to phonograph pickups and record cutters. The invention relates particularly to improvements in transducers employing a lever system for the transmission of mechanical vibratory energy between the stylus and the transducing element, the latter usually being of the piezoelectric type.

It is an object of the invention to provide a transducer in which a coupling system of the lever type transmits the vibratory energy between the stylus support, hereinafter called the driving member, and the transducing element substantially positively whereby the fidelity of performance is high and there is little loss of energy.

It is another object of the invention to provide a lever type coupling between the driving member and the transducing element which results in the stylus point exhibiting low impedance to vibration.

It is a further object of the invention to provide a transducer having a lever type coupling means between the driving member and the transducing element which undergoes substantially no deterioration with age whereby the performance of the device is maintained at a high level throughout a long useful life.

Other advantages will become apparent as the following description progresses. In the accompanying drawings:

Fig. 1 is a plan view of the transducer of the invention with the top half of the casing removed;

Fig. 2 is a sectional view along broken line 2—2 of Fig. 1;

Fig. 3 is an enlarged perspective view of a portion of the device of Figs. 1 and 2;

Figs. 4, 5 and 7 are views similar to Fig. 3 of different embodiments of the invention;

Fig. 6 is a sectional view taken along line 6—6 of Fig. 5, and

Fig. 8 is a sectional view taken along line 8—8 of Fig. 7 and includes a diagrammatic representation of circuit connections for the device.

The transducer illustrated in Figs. 1, 2 and 3 is particularly adapted for use with recordings having laterally cut grooves. The driving member is adapted to undergo angular oscillation about an axis in response to the transverse vibration of the stylus. The device comprises a casing 10 composed of complementary top and bottom casing members 11 and 12 of sheet metal or other suitable material which are dished to provide a compartment 13 and have flanges 14 along the side edges thereof which are adapted to abut together. The casing has an opening at the rearward end thereof which is closed by a terminal block 15 of insulating material.

At the forward end and also at a point spaced rearwardly from said end, the casing members are pressed inwardly to form bearings 18 and

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19 which support the stylus support or driving member 20 with the axis of the latter in substantial alignment with the longitudinal axis of the casing 10.

The driving member 20 has a longitudinally extending section 21 which at locations thereon registering with the bearings 18 and 19 has encircling flexible resilient bushings 22 and 23, which may be composed of an elastomer, examples of which are natural or synthetic rubber, plasticized cellulose nitrate, polyethylene, plasticized polystyrene and the like. The term "elastomer" or "elastomeric substance," when used herein in the specification or claims, embraces natural and synthetic rubber and the other flexible, resilient, rubber-like material such as those mentioned. The bushings 22 and 23 are under compression between the bearings 18 and 19 and the driving member 20 and serve as flexible resilient supports for the angular oscillation of the driving member about an axis passing longitudinally through the main section 21.

The main section 21 of driving member 20 has a stylus chuck section 26 integral therewith or rigidly fastened thereto as by riveting and extending transversely downward. Adjacent to its lower end, said section 26 has an opening there-through for the reception of the stylus 27 which is removably fastened in place by the collar 28 which is threaded upon the exterior of said section 26. At the rearward end of driving member 20 an arm 29 is connected thereto in motion transmitting relationship as by being integral therewith or rigidly connected thereto. The arm is connected at an intermediate portion thereof and extends transversely of the driving member axis. The said arm 29 serves as means for transmitting motion from the driving member to the lever system presently to be described.

In accordance with the present invention, the lever system serves to support the transducing element as well as transmit vibratory energy thereto. The system consists of a pair of levers 32 and 33, located in compartment 13 rearwardly of the driving member 20 and extending respectively in opposite diagonal directions and crossing each other at intermediate portions thereof. The levers are in the general form of a thin flat strip and are composed of a material having suitable stiffness and resilience, such as Phosphor-bronze, aluminum, iron, steel, or the like. The lever 33 has an elongated opening 34 in its mid-section and lever 32 passes through said opening. The branches 44 and 45 of the lever 33 on opposite sides of the opening 34 are spaced apart sufficiently to provide clearance for the relative motion of the two levers incident to their operation, which will be disclosed hereinafter. The levers are preferably joined together at their rearward ends by transverse end sections 35 and 36 thereof which are in overlapping relationship and fastened together as by welding, soldering,

riveting, etc. The levers 32 and 33 are held in substantially fixed positions at their rearward ends by transverse supporting blocks 39 and 40 which are arranged respectively above and below the overlapping sections 35 and 36 and between said sections and the interior surfaces of the casing 10. The said blocks are preferably composed of a relatively firm elastomeric substance and the sections 35 and 36 are held in pressure engagement between the blocks whereby the latter serve as substantially fixed fulcrums for the rearward ends of the levers. At their forward ends, the levers 32 and 33 are arranged on opposite sides of and in transversely spaced relation to the axis of driving member 20. Said ends have slots or recesses 41 and 42 therein which fit over the end portions of transverse arm 29, and a layer or pad 43 of an elastomeric substance is folded over the surfaces of the arm and arranged between said arm and the edges of the slots 41 and 42. The arrangement is preferably such that the pad 43 is under compression, or if desired, the pad may be cemented to both the arm 29 and the levers 32 and 33 whereby firm motion-transmitting connections are made between the arm and the levers.

A transducing element 49 is mounted upon lever 33 in the opening 34 thereof with its ends supported at the ends of said opening 34. The transducing element is in the form of a thin, flat elongated slab and may be of any desired piezoelectric construction, such as the known bimorph element of Rochelle salt, ammonium phosphate, barium titanate, other titanate compounds, or the like, which when subjected to a flexing action generates a voltage at its terminals, and, conversely, when a voltage is applied to its terminals undergoes a flexing action. The element 49 is preferably arranged with its longitudinal axis in alignment with lever 33 and the branches 44 and 45 of lever 33 converge at their ends so as to fit the ends of the element and make positive motion-transmitting connections between the element and the lever. The lever 32 has an opening 48 therein through which the mid-portion of element 49 passes. The branches 50 and 51 of the lever 32 on opposite sides of opening 48 are connected in motion-transmitting relationship to the opposite surfaces of the element 49, preferably by providing a projection 56 upon each branch, which projections are in substantial contact with the opposite surfaces of an intermediate portion, preferably the mid-portion of the transducing element 49. Preferably, the engaging portions of the element 49 and levers 32 and 33 are joined together by a suitable cement as indicated at 55. The transducing element 49 has a pair of terminals in accordance with usual practice which are connected by means of the conductors 57 and 58 to the exposed terminals 59 and 60 of the device, which pass through and are held in position by the terminal block 15.

In operation, when the device is used as a pickup, the casing 10 is arranged with respect to the recording so that the stylus, in following the laterally cut groove, undergoes transverse vibration and induces angular oscillation of the chuck section 25 and the driving member 20 about the axis of the driving member. In this operation, the flexible resilience of the bushings 22 and 23 permit the oscillation of the driving member with respect to the bearings 18 and 19 while maintaining the axis of oscillation substantially stationary. The angular oscillation

of the driving member is transmitted to the transverse arm 29 and the ends of the latter undergo up and down vibratory motion in opposite directions. This motion is transmitted to the forward ends of levers 32 and 33 and converted into oppositely directed lateral motion of said ends, the rearward ends of the levers being held relatively fixed by the fulcrum blocks 39 and 40.

In a single half-cycle of the oscillatory motion of the driving member 20, the forward end of lever 32 moves downwardly, for example, and the forward end of lever 33 moves upwardly. As a result, the ends of transducing element 49 are moved upwardly by lever 33 while the intermediate portion is moved downwardly by lever 32 and the transducing element is subjected to a flexing in one direction. During the succeeding half-cycle, the levers move in the opposite direction and the element 49 is flexed in the opposite direction. In this manner, the transducing element undergoes a vibratory flexing in response to the angular oscillation of driving member. Such flexing of the transducing element produces, in a well known manner, voltage variations or impulses such that the output is an electrical energy which vibrates in conformity with the vibrations of the stylus. Conversely, when electrical vibratory energy is impressed upon the device at the terminals 59 and 60 the stylus 27 is caused to vibrate transversely.

The device has been found to have the advantage set forth heretofore, namely, a high fidelity of performance which is maintained throughout a long useful life. The levers are substantially rigid against bending in the direction of their lateral motion and the vibrations of the stylus are transmitted with great faithfulness to the transducing element. The device has the additional advantage of low needle point impedance. The latter feature is of great importance since the trend in phonograph reproducers has been toward the characteristic of very low needle pressure against the recording.

As a modification of the embodiment shown in Figs. 1, 2 and 3, the lever 33 may have one of the branches 44 and 45 omitted. Such a modification is illustrated in Fig. 4. The lever 33', which corresponds to lever 33 of the device shown in Figs. 1, 2 and 3, has an intermediate portion 45' shaped generally like the lower branch 45 of lever 33 and has recesses or notches 72 and 73 at the ends of portion 45' within which recesses the ends of the transducing element 49' are held. The other lever 32' is similar to lever 32 and the cooperation of levers 32' and 33' with element 49' is similar to the cooperation of levers 32 and 33 with element 49. The device is in other respects similar to the device known in Figs. 1, 2 and 3.

A different embodiment of the invention is illustrated in Figs. 5 and 6 in which the levers are not in mutually crossed relationship but rather approach each other at an intermediate portion. The casing, the driving member and the fulcrum blocks for the rearward ends of the levers are similar to and cooperate in the same manner as the corresponding parts of the device of Figs. 1, 2 and 3 and, except for a fragment of the driving member, the said parts are not illustrated. The parts of this embodiment are designated by numerals which are 100 greater than the numerals designating corresponding parts of the device of Figs. 1, 2 and 3. In this embodiment, the two levers 132 and 133 are preferably connected to-

gether at their rearward ends and are arranged respectively on opposite sides of and in spaced relationship to the axis of the driving member 120 and extend in the general direction of said axis. They approach each other at their mid-portions and are in the general shape of a shallow V. The lever 133 has an opening 134 at its mid-section and branches 144 and 145 on opposite sides of opening 134, the lever being flat for substantially the length of the opening and branches. The transducing element 149 is supported in said opening 134 in the same manner as transducing element 49 is supported in opening 34 in the device of Figs. 1, 2 and 3.

The lever 132 has a pair of spaced-apart lateral projections 160 and 161 extending from the base of the V thereof in a direction toward lever 133 to provide a slot 162 within which is received the edge portion of substantially the mid-section of the transducing element 149 (see Fig. 6). The lever 133 and the projections 160 and 161 are preferably cemented to the element 149 in the manner described heretofore in connection with the connection of levers 32 and 33 to transducing element 49. The forward ends of the levers 132 and 133 have slots 141 and 142 which fit over the end portions of the transverse arm 129 which is connected to the driving member 120. A pad 143 of elastomeric substance is preferably interposed between arm 129 and the levers 132 and 133.

In this embodiment, the operation is substantially the same as that described heretofore in connection with the embodiment of Figs. 1, 2 and 3. Angular oscillatory motion of the driving member 120 is converted into oppositely directed lateral motion of the forward ends of levers 132 and 133. During the half-cycle when lever 132 moves downwardly, the projections 160 and 161 transmit a downward motion to the mid-section of the transducing element 149, and lever 133, moving simultaneously in an upward direction, transmits an upward movement to the ends of the element 149, whereby the latter is subjected to a flexing action in one direction. During the next half-cycle it is subjected to a flexing action in the opposite direction. The element, therefore, undergoes a vibratory flexing in response to the angular oscillation of the driving member.

Another embodiment of the invention is illustrated in Figs. 7 and 8 in which a pair of pressure-sensitive carbon elements are employed as the transducing element instead of a piezoelectric element. The general arrangement except for the transducing element and the electrical connections thereto are similar to those of the embodiment shown in Figs. 1, 2 and 3, and the casing, fulcrum blocks and a portion of the driving member are not shown. A detailed description will not be given, but rather the parts of this embodiment are designated by numerals which are 200 greater than the designating numerals for the corresponding parts of the embodiment of Figs. 1, 2 and 3. A difference which should be noted is that the lever 232 which passes through the opening 234 in lever 233 does not have an opening in the mid-portion thereof.

The transducing element consists of a pair of pressure-sensitive carbon elements 263 and 264, constructed in accordance with known practice, in which the electrical resistivity thereof varies inversely in accordance with the variations in compression to which the element is subjected. The element 263 comprises a carbon block 265

which is preferably composed of several segments or disks as shown, which are held in pressure contact with each other. A pair of metal conductive disks or electrodes 267 and 268 are held in pressure contact with the opposite surfaces respectively of carbon block 265. Element 264 is similarly constructed of a carbon block 266 and a pair of electrodes 269 and 270. The element 263 is arranged between lever 232 and the upper branch 250 of lever 233, and the lower element 264 is arranged between lever 232 and the lower branch 251 of lever 233. The electrodes 267 and 270 are electrically connected to lever 232 and attached thereto by suitable means such as a solder. Electrode 268 is attached to branch 250 by means of a slotted cap 273 of insulating material, such as glass, porcelain, synthetic resin or the like which is cemented to the electrode 268 and the branch 250, the said branch fitting into the slot of the cap and being electrically insulated from the electrode by the cap. The electrode 269 of element 266 is attached to and electrically insulated from lower branch 251 in the same manner by insulating cap 274. The arrangement is preferably such that the elements 263 and 264 are under a light permanent compression. This may be accomplished by installing the elements in position while spreading the branches 250 and 251 apart slightly and then releasing the spreading pressure from the branches. The resilience of the branches provides a satisfactory permanent compression upon the elements 263 and 264.

The electrical connections are shown diagrammatically in Fig. 8. A suitable source of direct current voltage such as the battery 275 is connected by the conductors 276 and 277 to the electrodes 268 and 269. A pair of output terminals 278 and 279 are connected respectively to the electrodes 269 and 270 of element 264.

In operation, a steady voltage is impressed across the two carbon elements 263 and 264 and a portion of such voltage, therefore, exists between the two output terminals 278 and 279. When the driving member 220 oscillates in the direction to move lever 232 downwardly and lever 233 upwardly the compression upon element 264 is increased and the resistance thereof is reduced. At the same time the compression upon the element 263 is reduced and its resistance is increased. As a result, the portion of the voltage of source 275 which exists between terminals 278 and 279 is substantially reduced. Conversely, when the movement of the driving member is in the opposite direction, the resistance of element 264 is increased while that of element 263 is reduced and the voltage between terminals 278 and 279 is increased. In this way, a voltage is produced at said terminals which varies in accordance with the vibrations of the driving member 220. The result is, therefore, generally similar to that which is obtained from the devices of Figs. 1 to 6 in which an output voltage is likewise obtained which varies in accordance with the vibration of the driving member 20. As an alternative, the output terminals 278 and 279 may be connected respectively to electrodes 267 and 268 of element 264, and the performance results will be substantially the same.

Only a few embodiments of the invention have been described and illustrated and various additional changes and modifications in structure may be made by those skilled in the art without departing from the spirit of the invention which

is to be limited only in accordance with the scope of the appended claims. When the terms "forward," "upward," "top" and the like are used herein, they are used to facilitate the description and not in a limiting sense, as the orientation of the device may be altered at will.

What is claimed is:

1. In a mechano-electric transducer, the combination of a driving member, means for mounting said driving member for angular oscillation about an axis, a pair of levers, said levers being in relatively remote spaced apart relationship at forward and rearward portions thereof and being in relative proximity to each other at portions intermediate said forward and rearward portions, said intermediate portions of said levers being movable with respect to each other, means for converting angular oscillatory motion of said driving member into oppositely directed lateral motion of said forward portions of said levers respectively and vice versa, fulcrums for said rearward portions of said levers, a transducing element, said levers being connected at said intermediate portions thereof in motion transmitting relationship to different portions of said transducing element.

2. A transducer as claimed in claim 1, in which the levers are joined together at their rearward ends by a transverse section.

3. A transducer as claimed in claim 1, in which the means for converting angular oscillatory motion of the driving member into lateral motion of the levers comprises an arm extending transversely of said axis and connected at an intermediate portion to said driving member and at the end portions thereof to said levers.

4. A transducer as claimed in claim 1, in which the fulcrums comprise an elastomer.

5. A transducer as claimed in claim 1, in which the means for connecting the driving member to the forward lever portions comprises a layer of an elastomer.

6. In a mechano-electric transducer, the combination of a driving member, means for mounting said driving member for angular oscillation about an axis, a pair of levers, said levers being spaced apart at forward and rearward portions thereof and approaching each other at portions intermediate said forward and rearward portions, means for converting angular oscillatory motion of said driving member into oppositely directed lateral motion of the forward portions of said levers respectively and vice versa, fulcrums for the rearward portions of said levers, a transducing element, said levers being connected at said intermediate portions thereof in motion transmitting relationship to said transducing element, said connection with the first of said levers being at two spaced apart portions of said transducing element, and the connection with the second of said levers being at a point of said transducing element intermediate said spaced apart portions thereof.

7. In a mechano-electric transducer, the combination of a driving member, means for mounting said driving member for angular oscillation about an axis, a pair of levers, said levers being in convergent-divergent relation and being in proximity to each other at intermediate portions thereof, said intermediate portions of said levers being movable with respect to each other, means for converting angular oscillatory motion of said driving member into oppositely directed lateral motion of the forward portions of said levers respectively and vice versa, fulcrums for the

rearward portions of said levers, a transducing element, said levers being connected at said intermediate portions thereof in motion transmitting relationship to said transducing element, said connection with the first of said levers being at two spaced apart portions of said transducing element, and the connection with the second of said levers being at a point of said transducing element intermediate said spaced apart portions thereof.

8. In a mechano-electric transducer, the combination of a driving member, means for mounting said driving member for angular oscillation about an axis, a pair of levers extending respectively in opposite diagonal directions with respect to said axis and being in mutually crossed relationship at an intermediate portion thereof, said levers providing a clearance for mutual relative lateral motion, fulcrums for rearward portions of said levers, the forward portions of said levers being respectively on opposite sides of said axis and spaced transversely therefrom, means for connecting said driving member in motion-transmitting relationship to said forward lever portions and converting angular oscillation of said driving member into oppositely directed lateral motion of said forward lever portions respectively and vice versa, a transducing element, said levers being connected at said intermediate portions thereof in motion transmitting relationship to said transducing element, said connection with the first of said levers being at two spaced apart portions of said transducing element, and the connection with the second of said levers being at a point of said transducing element intermediate said spaced apart portions thereof.

9. A transducer as claimed in claim 8, in which one of said levers has an opening therein and the other lever passes through said opening.

10. A transducer as claimed in claim 8, in which both levers have openings therein and the second lever passes through the opening in the first lever, and the transducing element is held at its ends by the first lever and passes through the opening in the second lever and is connected at an intermediate portion thereof to the second lever.

11. A transducer as claimed in claim 8, in which the transducing element is of elongated shape and has its longitudinal axis substantially in alignment with the first lever and is held at its ends by said first lever and is connected at an intermediate portion thereof to the second lever.

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