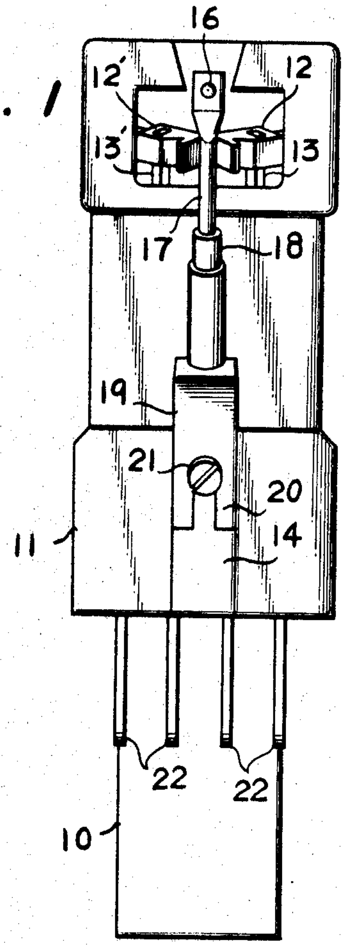
March 18, 1969 TOSHIHIKO KAWAGUCHI ET AL 3,433,487

PIEZOELECTRO-ACOUSTIC STEREOPHONIC PICKUP

Filed Sept. 5, 1967 Sheet 1 of 3

Fig. 1



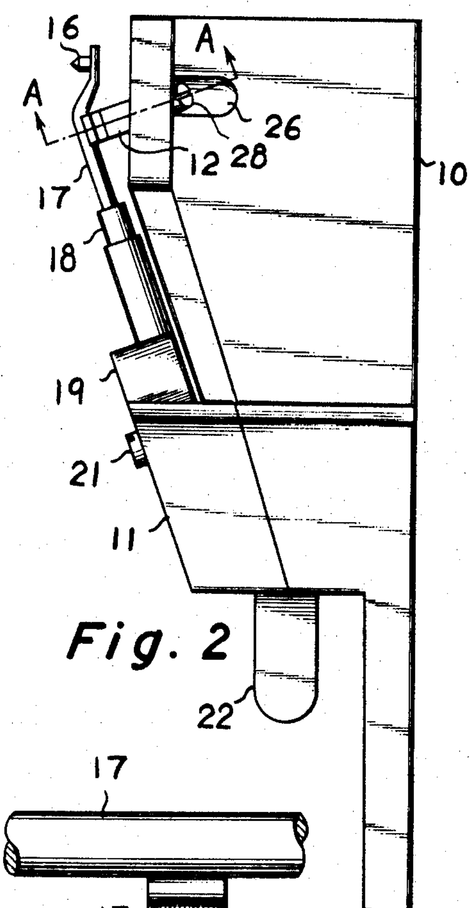




Fig. 2

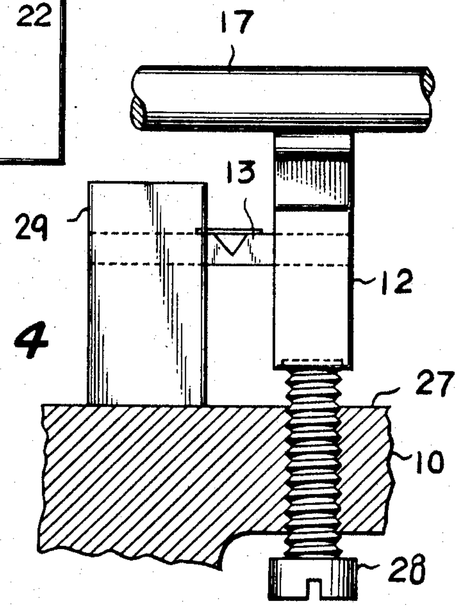



Fig. 4

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Fig. 3

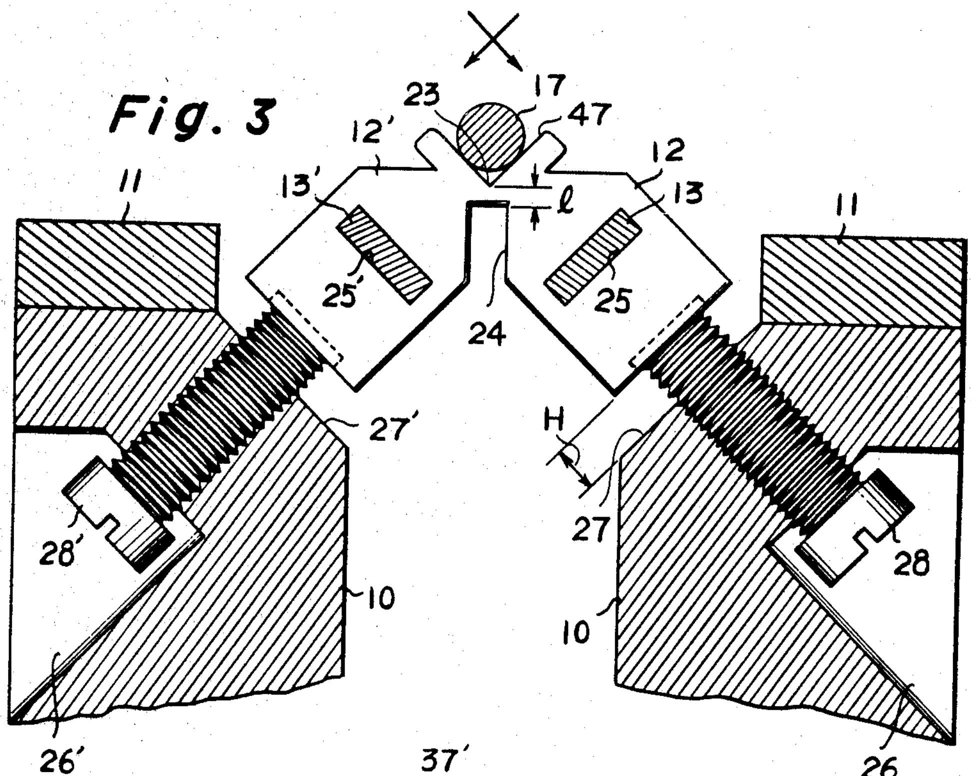


Fig. 5

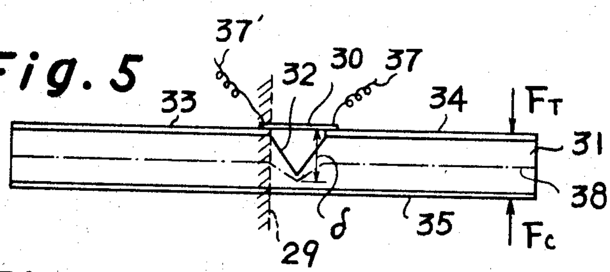


Fig. 6

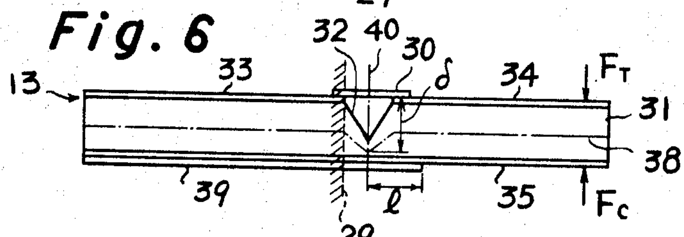


Fig. 7

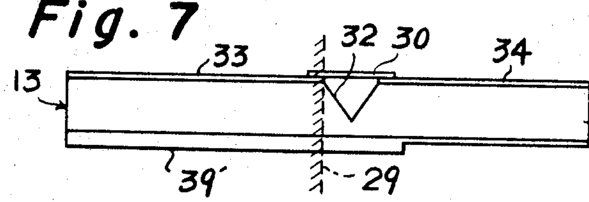


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Fig. 8

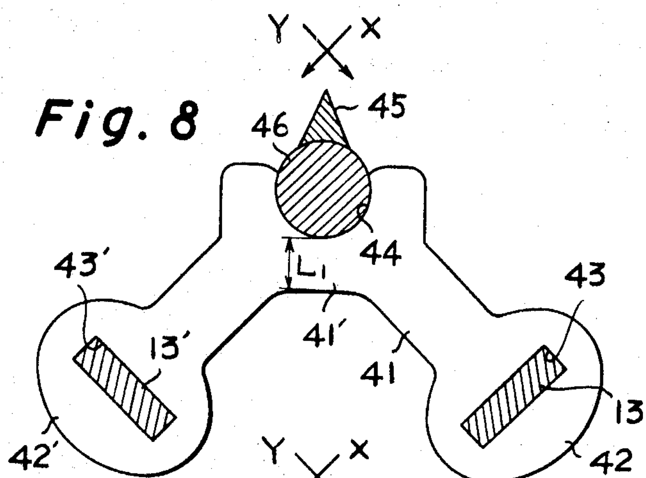



Fig. 9

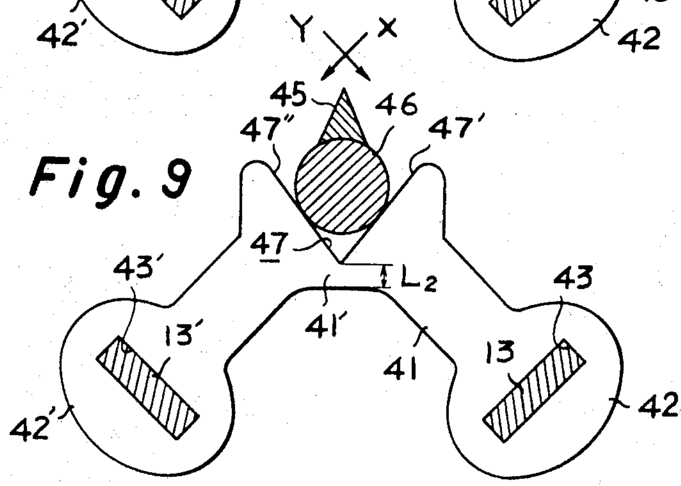
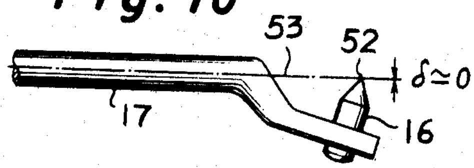



Fig. 10



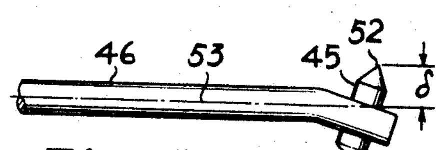
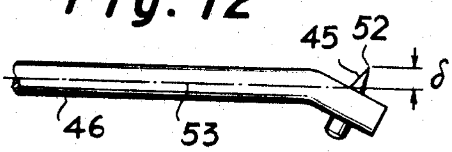
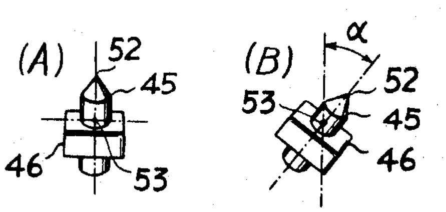




Fig. 11

Fig. 12

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## PIEZOELECTRO-ACOUSTIC STEREOPHONIC PICKUP


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U.S. Cl. 274—37 10 Claims

Int. Cl. G11b *3/02, 3/44*



### ABSTRACT OF THE DISCLOSURE

A piezoelectro-acoustic stereophonic pickup comprising a pair of transducer elements each including an electromechanical transducer member attached to an opening of a V-shaped groove formed on a cantilever, an armature which receives a free end of said cantilever and is formed to provide a V-shaped groove on surfaces thereof, and a pickup stylus assembly resting in said V-shaped groove of said armature and mounting a stylus therein in such a manner that the moment of rotation about the axis of a stylus arm is substantially nil when the forward end of said stylus is driven by a recording medium. The armature has a smaller thickness portion below the bottom of said V-shaped groove, and the surfaces thereof opposite to the surfaces on which said V-shaped groove is formed are abutted by screws.


This invention relates to a piezoelectro-acoustic stereophonic pickup for simultaneously reproducing two separate electric signals recorded in a groove of a recording medium independently of each other.

In this type of pickup, two transducer systems independent of each other are generally actuated by a common stylus assembly to produce three dimensional electric signals. It is required, therefore, to minimize cross talk between the two transducer systems. In order to effect three dimensional reproduction of sound, it is required that the two separate transducer systems have identical frequency response characteristics which are as flat as possible within the required range of audible frequency, and that the conversion characteristics of the transducer systems be made as much linear as possible so as to minimize wave distortion.

Accordingly, an object of the present invention is to provide an improved piezoelectro-acoustic stereophonic pickup in which cross talk between two separate transducer systems is minimized.

Another object of the invention is to provide an improved piezoelectro-acoustic stereophonic pickup in which transducer systems have improved frequency response characteristics.

Another object of the invention is to provide an improved piezoelectro-acoustic stereophonic pickup in which cross talk between the reproduced signals and wave distortion thereof are minimized.

Still another object of the invention is to provide improved piezoelectro-acoustic stereophonic pickup in which adjustments can readily be effected so as to make the frequency response characteristics of two separate transducer systems match with each other.

Still another object of the invention is to provide a piezoelectro-acoustic stereophonic pickup which has a high mechanical strength.

Other objects and features of this invention will become apparent from consideration of the description set forth hereunder and the accompanying drawings, in which:

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FIG. 1 is a front elevation of one embodiment of a pickup according to this invention;

FIG. 2 is a side elevation of the pickup of FIG. 1;

FIG. 3 is a view in section taken along the line A—A of FIG. 2;

FIG. 4 shows the manner in which an electro-mechanical transducer element of the bending type used as a piezoelectric element in this invention is mounted in a pickup case;

FIG. 5 shows one form of said electromechanical transducer element of the bending type;

FIG. 6 shows another form of said transducer element;

FIG. 7 shows still another form of said transducer element;

FIG. 8 shows one form of conventional armature portion of the pickup according to this invention;

FIG. 9 shows another form of said armature portion of the pickup according to this invention;

FIG. 10 shows one form of stylus of the pickup according to this invention;

FIG. 11 shows one form of conventional stylus of the pickup; and

FIG. 12 shows another form of conventional stylus of the pickup.

In the drawings, like reference characters designate similar parts.

In FIG. 1 and FIG. 2, **10** is a pickup case which has a cover **11**. As subsequently to be described, said cover **11** is secured integrally to said pickup case **10** by suitable means, such as screws or an adhesive, after an armature consisting of portions **12**, **12′** and electromechanical transducer elements of the bending type **13**, **13′** have been assembled and mounted in the pickup case **10**.

The cover **11** is formed to provide a groove **14** therein which has a metal strip attached to the bottom. **15** designates a pickup stylus assembly corprising a stylus arm **17** having a stylus **16** attached thereto, a stylus arm supporter **18** formed of rubber or other similar resilient material, and a mounting portion **19**. The stylus arm **17** is fitted into the supporter **18** which in turn is fitted into the mounting portion **19**. The mounting portion **19** is adapted to be received in the groove **14** of the cover **11**, the pickup stylus assembly being made integral with the pickup case when a fork **20** in the mounting portion **19** and the metal strip attached to the bottom of the groove **14** are firmly secured together by means of a screw **21**.

**22** are terminals connected to transducer element (not shown) for taking electric signals from the transducer elements **13** and **13′** out of the system.

As shown in FIG. 3, the armature portions **12** and **12′** are formed integrally of rubber or a synthetic resinous material, and the stylus arm **17** rests in a V-shaped groove **47** formed by the armature portions **12** and **12′**. In order to reduce the thickness of the armature at the bottom **23** of the groove, there is provided a rectangular groove **24** formed on the side opposite to the V-shaped groove. Slots **25** and **25′** for receiving and securing therein one end of transducer elements **13** and **13′** respectively are formed substantially in the center of the armature portions **12** and **12′** respectively in such a manner that elongated sides of each of said slots **25** and **25′** are disposed parallel to each side wall of the V-shaped groove.

Recesses **26** and **26′** are formed on the outer side surface of the case **10** at positions corresponding to the positions at which the armature portions **12** and **12′** are mounted (see FIG. 2). The inner surfaces of the case **10** at **27** and **27′** are formed parallel to the longitudinal length of the transducer elements **13** and **13′** at positions **27** and **27′** which correspond to the recesses **26** and **26′**, said surfaces **27** and **27′** extending at right angles to the face of FIG. 3. Threaded openings are formed in the recesses **26** and **26′** for threadably receiving therein screws

28 and 28′ which abut against the surfaces of the armature 12 and 12′ within a recess 12″ which recess has a diameter slightly greater than the diameter of the screws 28 and 28′. This recess is opposite to the surfaces on which the V-shaped groove is formed.

The manner in which the transducer elements 13 and 13′ are mounted in the case 10 will now be explained. To enable the invention to be clearly understood, reference will be made to the element 13 and the armature portion 12 associated therewith. The element 13′ can be mounted in exactly the same manner as the element 13.

In FIG. 4, the inner surface 27 of the case 10 is shown as being oriented horizontally. A supporter 29 for the transducer which is formed of rubber or a synthetic resinous material much more hardened than the material for the armature is formed to provide a slot having elongated sides parallel to the inner surface 27 and adapted for receiving and securing therein the other end of the transducer element. Thus, the transducer element 13 is secured to the case 10.

In FIG. 5 is shown in detail one form of transducer element according to this invention. 30 designates a transducer member (a planar chip formed, for example, of silicon or germanium) having the so-called piezoelectric effect of producing variations in electric resistance when subjected to mechanical strain or a transducer member (a planar chip formed, for example, of Rochelle salt or ceramic) capable of developing an electric charge when subjected to mechanical strain. 31 is a lever having a V-shaped groove 32. The lever 31 has one end inserted into the slot 25 formed in the armature 12 (see FIG. 3) and the other end secured in place by the supporter 29 (see FIG. 4). Preferably, the lever 31 is formed of a relatively soft material, such as glass wool, for example, but the material consisting of glass wool hardened by epoxy resin is more optimum. The lever 31 has metal strips 33, 34 and 35 adhered to the upper surface and underside thereof, and the transducer member 30 is attached to the upper surface of the V-shaped groove 32.

The mechanical vibrations developed by the stylus 16 as it moves along a groove of a recording medium are transmitted to the stylus arm 17 and cause, through the armature portion 12, one end 36 of the lever 31 to move up and down. The vibrations are composed of a downwardly directed force $F_t$ and an upwardly directed force $F_c$. Assuming that only a force $F_t$ is applied, said one end 36 of the lever 31 will be moved to thereby cause said V-shaped groove 32 to expand its opening. This forces the transducer member 30 to be extended. Conversely, when a force $F_c$ is applied, the transducer member 30 is forced to be contracted. In this way, forces $F_t$ and $F_c$ are converted into electric signals, which are taken out of the system through leads 37 and 37′ attached to the opposite ends of the transducer member 30.

When a force $F_t$ is applied to the lever 31, for example, the portion of the lever above the stress neutralizing surface 38 is expanded, while the portion below the surface 37 is contracted.

The following are examples, by way of illustration only, of preferred mode of operating the transducer elements 13 and 13′ of the invention disclosed herein:

| | Millimeters |
|---|---|
| Lever length | About 10 |
| Lever width | About 1 |
| Lever thickness | About 0.5 |
| V-shaped groove width | About 1 |
| V-shaped groove depth | About 0.45 |
| Transducer member (formed of germanium): | |
| Length | 3.4 |
| Width | 0.5 |
| Thickness | 0.03 |
| Metal strip (copper foil): | |
| Thickness | 0.03 |

It has been found that said V-shaped groove 32 most advantageously has an opening angle of about 90 degrees.



In the form of transducer element shown in FIG. 6, a plate spring 39 (formed as of Phosphor bronze) is attached, as by an adhesive, to the upper surface of a metal strip 35 of the transducer element shown in FIG. 5. The plate spring 39 terminates at a point spaced apart from a center surface 40 of the V-shaped groove 32 a distance *l*. It will be noted that in the form of transducer element shown in FIG. 6 the stress neutralizing surface 38 of the lever 31 is disposed below the stress neutralizing surface 38 of the form of transducer element shown in FIG. 5 due to the addition of the plate spring 39. This causes the distance $\delta$ between the transducer member 30 and the stress neutralizing surface 38 to increase, with the result that stress sensitivity is improved. The provision of the plate spring 39 also has the effect of the fixed end (the portion of the lever 31 secured in place by the supporter 29) moving in effect toward the free end (the portion of the lever 31 inserted into the armature 12) when in motion. In other words, the moving part of the lever is reduced in length to all intents and purposes, with an attendant reduction in the effective mass of the moving part. This results in the frequency response characteristics of the transducer element 13 being extended to cover a high frequency range. On the other hand, this causes a reduction in compliance.

If the forward end of the plate spring 39 is disposed near the center surface 40 of the V-shaped groove 32 or displaced toward the fixed end of the lever 31 therefrom, the provision of the plate spring 39 will have no effect. Conversely, if the forward end of the plate spring 39 extends to almost reach the free end of the lever 31, the effective mass of the moving part will increase, thereby aggravating frequency response characteristics of the element in the higher frequency range. It is important, therefore, to select the length of the plate spring 39 such that its forward end will be disposed at an intermediate position so as to realize the advantage of the provision of the plate spring 39.

From the foregoing description, it will be understood that the provision of the plate spring 39, though having the disadvantage of a reduction in compliance, has the effect of improving stress sensitivity. It also has the effect of improving mechanical strength and frequency response characteristics in a higher frequency range.

Alternatively, the plate spring 39 shown in FIG. 6 may be replaced by a plate spring 39′ which, as shown in FIG. 7, has a forward end portion smaller in thickness (about one third the thickness of the remainder) than the rest of the spring 39′.

The armature of the pick up according to this invention will now be explained. FIG. 8 shows one form of conventional armature of this kind. 41 generally designates an armature formed of rubber or a synthetic resinous material and shaped like a letter V as a whole. The armature 41 has open ends 42 and 42′ formed to provide slots 43 and 43′ respectively, and a base formed with a fitting portion 44. Said slots 43 and 43′ receive transducer elements of the bending type 13 and 13′ respectively, while said fitting portion 44 receives a stylus arm 46 having a stylus 45 mounted therein.

The armature shown in FIG. 8 and described above holds the stylus arm 46. This form of construction has the following disadvantage: When one signal or a vibration in the direction of arrow X is transmitted, such vibration will of course be transmitted to the left side transducer elements 13′ but part of the vibration will also be transmitted to the right side transducer element 13, with the result that there is much cross talk. This is because of the facts that the thickness $L_1$ of a connecting portion at the base of the armature 41 is great and that the stylus arm 46 is held by the armature 41.

In FIG. 9 is shown one form of armature according to this invention which obviates the disadvantage of the conventional armature referred to hereinbefore. The armature 41 as shown is formed to provide at its base a

V-shaped groove **47** with the walls thereof being disposed at right angles to each other in section. A connecting portion **41'** of the armature **41** at the base thereof has a thickness smaller than the connecting portion of the conventional form of armature. This is conducive to greatly reduced cross talk.

Assuming that a vibration in the direction of arrow Y is introduced from a stereophonic recording medium through the stylus arm **46**, pressure will be brought to bear on the right wall **47'** of the V-shaped groove **47** at right angles thereto, whereby said vibration is transmitted to the right side transducer element **13** but not to the left side transducer element **13'**. This is because of the facts that the stylus arm **46** vibrates in a direction substantially parallel to the left wall **47''** of the V-shaped groove **47** and that the base of the armature **41** has a small thickness in its connecting portion **41'** so as to permit said portion to expand, contract and be bent. In like manner, a vibration in the direction of arrow X is not transmitted to the right side transducer element **13**.

When the armature of the construction as described hereinabove is used, the vibration system of such armature tends to develop resonance at a higher frequency range of 15 to 20 kilocycles, with the result that the amplitude of the transducer elements near this frequency range becomes too great and consequently an electric signal of too high a value is produced. Thus, the armature of this form does not meet the requirements for a good pick up of having flat frequency response characteristics in an audible frequency range, causing a marked reduction in the performance of the pick up.

An embodiment of the present invention which can obviate all of the disadvantages referred to hereinabove is shown in FIG. 3, the construction thereof having already been explained. It will be noted that since the surfaces of the armature **12** and **12'** opposite to the surface which are positioned against the stylus arm **17** are abutted by the screws **28** and **28'** respectively, the parts of the armature **12** and **12'** disposed between the transducer element **13** and the screw **28** and between the transducer element **13'** and the screw **28'** respectively will serve as dampers for diminishing resonance, if the material for the armature **12** and **12'** is selected to have a proper hardness. Thus, the pickup according to this invention permits to obtain damping characteristics as desired to cope with resonance.

It will also be noted that the armature shown in FIG. 3 is shaped such that the base of the armature below the bottom **23** of the V-shaped groove has a thickness $l$ smaller than the base of the conventional armature, so that cross talk can be minimized as in the pick up using the armature shown in FIG. 9.

The reason why the surfaces of the armature **12** and **12'** opposite to the surfaces thereof which are positioned against the stylus arm do not bear directly against the pickup case but are abutted by the screws **28** and **28'** will now be explained. If armatures are permitted to directly bear against the pickup case, various disadvantages will occur: if the pickup case is not true to the specifications in dimensions, the armature will bear too strongly against the pickup case or the armature will be out of engagement with the pickup case. In addition, it will become difficult to maintain the right and left channels balanced. Such disadvantages can be obviated by effecting adjustments of the positions of screws **28** and **28'** recessed into the armature **12** and **12'**.

As described previously, the armature **12** and **12'** are formed integrally as a unit, instead of being formed separately and assembled together. Owing to this arrangement, the armatures according to this invention have a higher mechanical strength and are adapted for mass production, such armatures being produced with the slots **25** and **25'** by punching in a single operational process. Thus, the armatures according to this invention are simple in construction and can readily be assembled with transducers of the bending type **13** and **13'** being inserted in said slots **25** and **25'** respectively.

A pickup stylus according to this invention will now be explained. Styli of the prior art of this type are shown in FIGS. 11 and 12. These styli have hitherto had the disadvantages of poor frequency response characteristics, wave distortion, cross talk and the like.

In the example shown in FIG. 11, a stylus arm **46** has a forward end portion which is bent to mount a stylus **45** therein. Since the stylus **45** projects from the axis **53** of the stylus arm **46** by a distince $\delta$, said stylus will move in rotational motion from a stationary position shown in FIG. 11A to a position shown in FIG. 11B through an angle $\alpha$ while being driven to right and left when a pivot point **52** of the stylus is driven by a recording medium. This rotational motion results in the reproduction of signal not recorded on the recording medium. Thus, the pickup stylus of this form has irregular frequency response characteristics, wave distortion and cross talk particularly in a higher frequency range.

A proposal has been made to use a small stylus **45** as shown in FIG. 12. The disadvantages of this form of stylus have been that difficulty is encountered in manufacturing a stylus of small size, and that the small sized stylus is very low in strength.

A pickup stylus according to this invention which can obviate the disadvantages referred to hereinabove is shown in FIG. 10. The stylus arm **17** shown has a forward end portion which is shaped like a crank in such a manner that when the stylus **16** is mounted at the front end said angle $\alpha$ becomes nil or substantially nil. Accordingly, no rotational moment is imparted to the stylus arm **17**, with the result that poor frequency response in a higher frequency range, wave distortion and cross talk can be minimized.

From the foregoing description, it will be appreciated that according to the present invention the use of the transducer elements as shown in FIG. 6 or FIG. 7 enables to produce a pick-up of high sensitivity, and the use of the armature shown in FIG. 3 and the stylus arm as shown in FIG. 10 in combination with said transducer element enables to obtain a pick-up of good frequency response characteristics in a higher frequency range.

It is to be noted, moreover, that the use of the stylus arm shown in FIG. 10 enables to provide a pickup in which cross talk can be minimized. The arrangement in which the armatures are held in place by means of screws permits to match the frequency response characteristics of right and left transducer elements and also to protect these elements against mechanical shock.

The fact that the stylus arm of the pick-up according to this invention is free from rotational motion is conducive to reduce wave distortion, permitting to use a large sized stylus having a high mechanical strength. The size of the stylus has, however, to be determined in such a manner as to fall within the overall allowable mass range.

Thus, the pickup according to this invention offers many advantages.

While the invention has been shown and described with reference to some of its embodiments, it is to be understood that the invention is not limited thereto, but that many changes and modifications may be made therein without departing from the spirit and scope of the invention.

What we claim is:

**1.** A piezoelectro-acoustic stereophonic pickup comprising a pickup case, a pair of electromechanical transducer elements each including a transducer member of the bending type attached to an opening of a V-shaped groove formed on a lever having one end secured to said pickup case through a supporter, an armature which receives the other end of said lever and formed to provide a V-shaped groove on the surfaces thereof having side walls at right angles to each other and parallel to said lever in the longitudinal direction, and a pickup assembly including a stylus arm resting in said V-shaped groove formed on said armature.

2. A piezoelectro-acoustic stereophonic pickup as claimed in claim 1 in which said lever of each of said electromechanical transducer elements has a plate spring attached to the surface thereof opposite to the surface on which said first mentioned V-shaped groove is formed, said plate spring extending from the end of said lever secured to the pickup case to a point intermediate between the free end of said lever and a center surface of said V-shaped groove.

3. A piezoelectro-acoustic stereophonic pickup as claimed in claim 1 in which said lever of each of said electromechanical transducer elements has a plate spring attached to the surface thereof opposite to the surface on which said first mentioned V-shaped groove is formed, said plate spring having a smaller thickness portion extending from a position intermediate between the free end of said lever and a center surface of said V-shaped groove to said free end of the lever.

4. A piezoelectro-acoustic stereophonic pickup as claimed in claim 1 in which said armature has a smaller thickness portion below the bottom of said last mentioned V-shaped groove.

5. A piezoelectro-acoustic stereophonic pickup as claimed in claim 4 in which said armature has surfaces disposed opposite to the surfaces thereof on which said last mentioned V-shaped groove is formed and abutted by screws threadably connected to the pickup case.

6. A piezoelectro-acoustic stereophonic pickup as claimed in claim 1 in which said stylus arm has a forward end portion shaped like a crank, and a stylus is mounted in said forward end portion of said stylus arm in such a manner that the moment of rotation of the pivot point of said stylus about the axis of said stylus arm is substantially nil.

7. A piezoelectro-acoustic stereophonic pickup as claimed in claim 1 in which said lever of each of said electromagnetic transducer elements has a plate spring attached to the surface thereof opposite to the surface on which said first mentioned V-shaped groove is formed, said plate spring extending from the end of the lever which is secured to the pickup case to a position intermediate between a center surface of said V-shaped groove and the free end of the lever, said armature has a smaller thickness portion below the bottom of said last mentioned V-shaped groove, said armature also has surfaces disposed opposite to the surfaces thereof on which said last mentioned V-shaped groove is formed and abutted by screws threadably connected to the pickup case whereby the distance between the pickup case and the surfaces of the armature on which said V-shaped groove is formed can be adjusted and varied.

8. A piezoelectro-acoustic stereophonic pickup as claimed in claim 1 in which said armature has a smaller thickness portion below the bottom of said last mentioned V-shaped groove, said armature also has surfaces disposed opposite to the surfaces thereof on which said last mentioned V-shaped groove is formed and abutted by screws threadably connected to the pickup case whereby the distance between the pickup case and the surfaces of the armature on which said V-shaped groove is formed can be adjusted and varied, said stylus arm has a forward end portion shaped like a crank, and a stylus is mounted in said forward end portion of said stylus arm in such a manner that the moment of rotation of the pivot point of said stylus about the axis of said stylus arm is substantially nil.



9. A piezoelectro-acoustic stereophonic pickup as claimed in claim 1 in which said lever of each of said electromechanical transducer elements has a plate spring attached to the surface thereof opposite to the surface on which said first mentioned V-shaped groove is formed, said plate spring extending from the end of said lever which is secured to the pickup case to a position intermediate between the free end of said lever and a center surface of said V-shaped groove, said stylus arm has a forward end portion shaped like a crank, and a stylus is mounted in said forward end portion of said stylus arm in such a manner that the moment of rotation of the pivot point of said stylus about the axis of said stylus arm is substantially nil.

10. A piezoelectro-acoustic stereophonic pickup as claimed in claim 1 in which said lever of each of said electromechanical transducer elements has a plate spring attached to the surface thereof opposite to the surface on which said first mentioned V-shaped groove is formed, said plate spring extending from the end of said lever which is secured to the pickup case to a point intermediate between the free end of said lever and a center surface of said V-shaped groove, said armature has a smaller thickness portion below the bottom of said last mentioned V-shaped groove, said armature also has surfaces disposed opposite to the surfaces thereof on which said last mentioned V-shaped groove is formed and abutted by screws threadably connected to the pickup case whereby the distance between the pickup case and said surfaces of the armature on which said last mentioned V-shaped groove is formed can be adjusted and varied, said stylus arm has a forward end portion shaped like a crank, and a stylus is mounted in said forward end portion of said stylus arm in such a manner that the moment of rotation of the pivot point of said stylus about the axis of said stylus arm is substantially nil.


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F. J. D'AMBROSIO, *Assistant Examiner.*

U.S. Cl. X.R.

179—100.41; 310—8.5