United States Patent [19]

Watanabe et al.

[11] **3,731,009**

[45] **May 1, 1973**

[54] **PHONOGRAPH PICKUP HAVING CAPACITIVE TRANSDUCER DIRECTLY COUPLED TO CANTILEVER STYLUS ARM**

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[73] Assignee: **Tokyo Shibaura Electric Co., Ltd.,** Kawasaki-shi, Japan

[22] Filed: **Aug. 17, 1971**

[21] Appl. No.: **172,591**

[30] **Foreign Application Priority Data**

Nov. 4, 1970 Japan 45/96422
Aug. 17, 1970 Japan 45/81430

[52] **U.S. Cl.** ..... **179/100.41 K,** 179/100.4 A, 179/100.41 G, 179/100.41 B

[51] **Int. Cl.** **H04r 19/10,** G11b 3/00

[58] **Field of Search** ..... 179/100.41 K, 100.41 G, 179/100.41 B, 100.4 A

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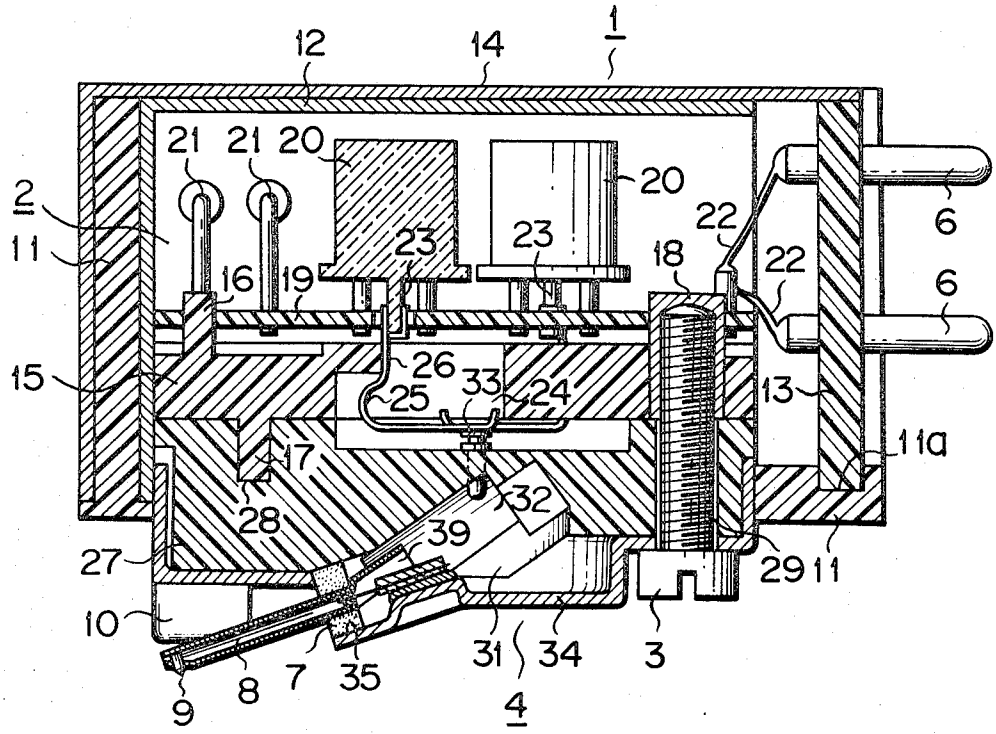
Primary Examiner—Raymond F. Cardillo, Jr.
Attorney—R. D. Flynn et al.

[57] **ABSTRACT**

A pickup device comprises a base in which an active circuit is assembled, and a transducer detachably mounted on the base and having a cantilever stylus arm extending therefrom. The transducer has a sealed portion, and a variable capacitor portion disposed within the sealed portion. The variable capacitor is comprised of a stationary electrode having an electret plate, and a movable electrode integrally provided at the rear end of the cantilever stylus arm in a manner to face to the stationary electrode.

4 Claims, 11 Drawing Figures



3 Sheets-Sheet 1

FIG. 1

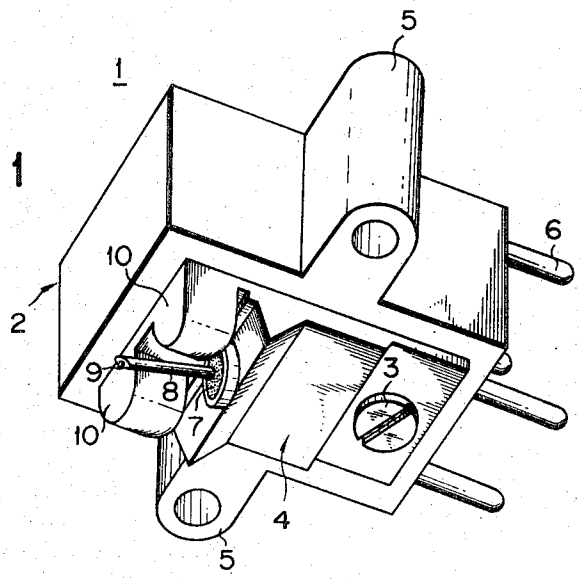


FIG. 2

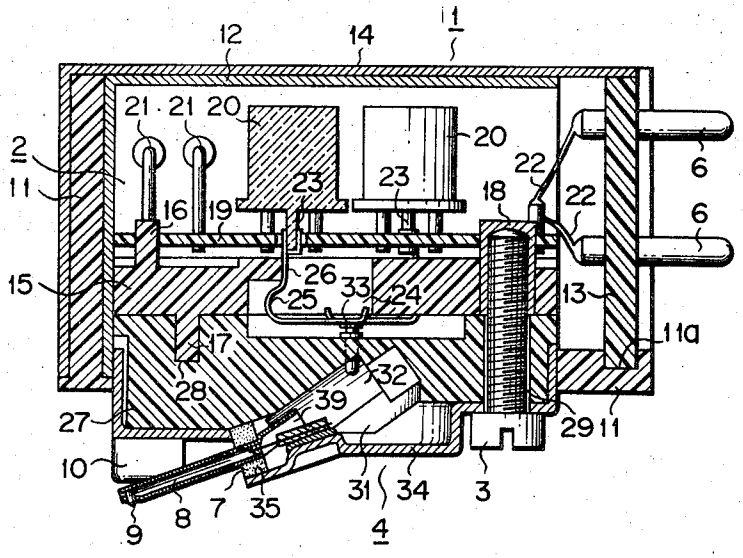


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FIG. 3

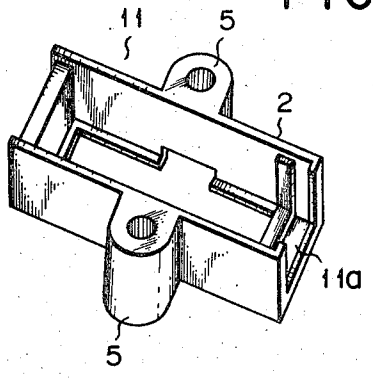


FIG. 4

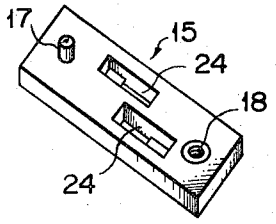
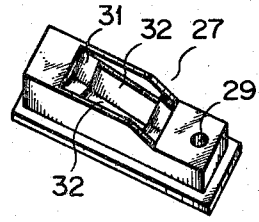


FIG. 5



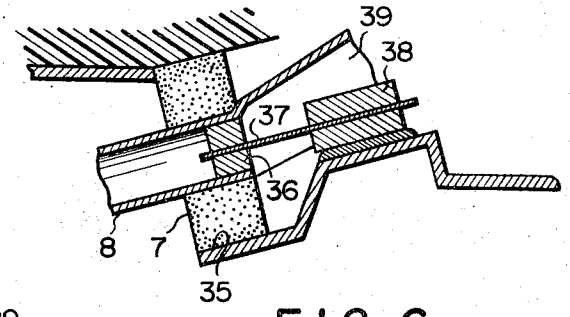


FIG. 6

FIG. 7

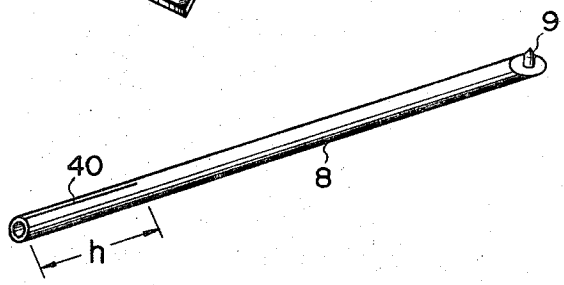


FIG. 8

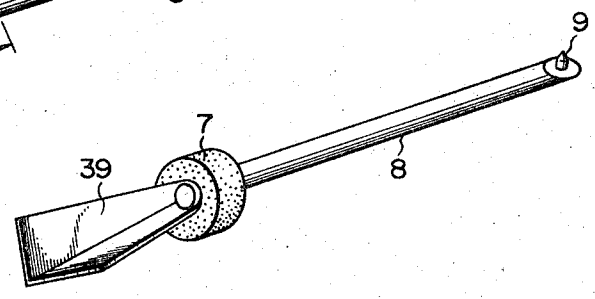


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FIG. 9

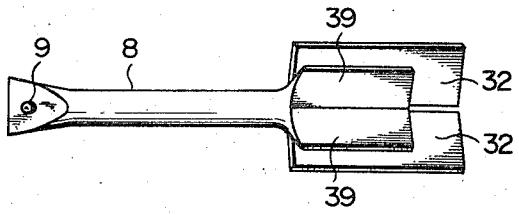


FIG. 10

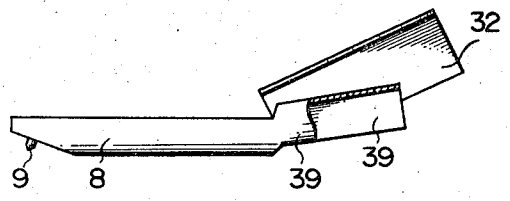
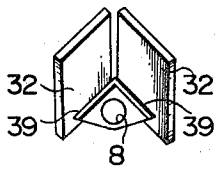


FIG. 11



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BY

PHONOGRAPH PICKUP HAVING CAPACITIVE TRANSDUCER DIRECTLY COUPLED TO CANTILEVER STYLUS ARM

This invention relates to a condenser type pickup device particularly suitable for use in phonographs.

A prior-art condenser type pickup has been constructed such that an armature is provided between a cantilever stylus arm and a movable electrode arranged in a manner to face to a stationary electrode, so as to transmit the vibration of the cantilever through the armature to the movable electrode. With such a pickup device, when a stylus traces a record groove, the variations of the stylus transmitted through the cantilever stylus arm and the armature to the movable electrode are small, and the electrically converted output signal attainable is not sufficiently large. Furthermore, since the vibration of the stylus is indirectly transmitted to the movable electrode through said armature, it may not be directly and faithfully transmitted to the movable electrode. In addition, the impedance of a variable capacitor consisting of a stationary electrode and a movable electrode is extremely high, so that the pickup device is liable to pick up stray fields, thereby giving a low signal to noise ratio. Furthermore, a high DC bias voltage has to be applied to the capacitor, and a DC power source therefor is necessary, thus rendering the circuit arrangement complicated.

An object of this invention is to provide a pickup device having a high sensitivity, high output and large signal-to-noise ratio, in which a condenser type transducer is constructed by providing a movable electrode at the rear end of a cantilever and forming an electret on a stationary electrode.

SUMMARY OF THE INVENTION

In accordance with the present invention, a phonograph pickup device includes a casing having an opening on one side thereof, a support disposed within the casing and on which an active circuit is provided, and a transducer detachably mounted on the interior of the casing through the opening therein, the transducer being electrically connected to the active circuit. The transducer includes a base, a closed chamber and a cantilever arm movably carried on the base through a damper which forms one part of the chamber. The cantilever arm further has a front portion carrying a stylus tip at an extreme end thereof, and a rear portion located within the closed chamber. The transducer still further comprises a capacitor unit which includes a movable electrode having two surfaces substantially orthogonally disposed and two stationary electrodes respectively facing in parallel the two surfaces of the movable electrode, the movable electrode being integrally fixed to the rear end of the cantilever arm along the axis thereof and the stationary electrodes comprising two electret plates insulated from each other and fixed to the base with the two electret plates substantially orthogonally disposed relative to each other.

Since the pickup device has the electrets formed on the stationary electrodes, a DC bias power source becomes unnecessary, and hence, the circuit arrangement is simplified. The transducer including a high impedance component can be perfectly shielded, so that the influence of external noise is prevented. In addition, since the movable electrode of the transducer is directly attached to the cantilever arm without any intermediate body, the displacement of the stylus tracing the record groove is directly and faithfully transmitted to the movable electrode, thus attaining a transducer of a high sensitivity and high output.

The present invention can be more fully understood from the following detailed description when taken in conjunction with the appended drawings, in which:

FIG. 1 is a perspective view of a pickup device embodying this invention;

FIG. 2 is a side sectional view of the pickup device shown in FIG. 1;

FIG. 3 is a perspective view of an outer casing shown in FIG. 2;

FIG. 4 is a perspective view of a supporter shown in FIG. 2;

FIG. 5 is an inverted perspective view of a sealed casing shown in FIG. 2;

FIG. 6 is a sectional view of a mounting arrangement, to an enlarged scale as compared with FIG. 2;

FIG. 7 is a perspective view of the cantilever stylus arm prior to forming movable electrodes;

FIG. 8 is a perspective view of the cantilever stylus arm and movable electrodes which are formed from the arm of FIG. 7;

FIG. 9 is a front view showing the movable electrodes, the cantilver stylus arm and stationary electrodes;

FIG. 10 is a side view showing the electrodes and the cantilever stylus arm with parts cut away; and

FIG. 11 is an end view of the electrodes and the cantilever stylus arm.

Shown in FIG. 1 is a pickup device, i.e., a cartridge 1 which is to be mounted on an extreme end of a pickup arm (not shown). The cartridge 1 is composed of a base 2, and a transducer 4 detachably mounted on the base 2 by means of a screw 3. On both sides of the base 2 there protrude mounting portions 5 for mounting the cartridge 1 onto the pickup arm, while at the rear part of the base 2 plugs 6 are provided for supplying signals and for connecting to a power source. At the bottom of the transducer 4, a movable cantilever stylus arm 8 passes through an annular damper 7 of rubber material so as to project forwardly inclined to the top and sides of the base 2. Attached to the front end of the cantilver stylus arm 8 is a stylus tip 9, and in order to protect the stylus tip 9, stylus protectors 10 protrude downwardly from the front part of the bottom of the transducer 4 so as to cover the cantilever stylus arm 8. The stylus protectors 10 are constructed such that, in the state in which the stylus 9 is normally tracing a disc record, the bottom ends of said stylus protectors 10 are spaced from the record. The stylus protectors 10 are such that if an unduly large force is exerted upon the stylus 9, the stylus 9 arm 8 enters the space between the stylus protectors 10, 10, whereby the stylus 9 and the record are protected from damage.

Referring to FIGS. 2 to 11, the pickup device of this embodiment will be more fully described.

As shown in FIG. 3, the base 2 has the mounting portions 5 on its sides, and has an outer casing 11 which is open at the upper part, the bottom part and the rear part. The outer casing 11 is formed by a plastic molding process, and a conductive inner casing 12 open at the

bottom part and the rear part is secured to the outer casing 11 as illustrated in FIG. 2. Furthermore, a terminal board 13 with the plugs 6 secured thereto is fitted into a guide slot 11*a* which is provided at the rear part of the outer casing 11. The upper part and the front part of the outer casing 11 are covered with an L-shaped upper lid 14 made of metal. In the inner casing 12, a support 15 for supporting constituent components of an active circuit is fixed substantially horizontally. Projections 16 and 17 are respectively provided at the upper and lower surfaces of the front part of the support 15, while a conductive screw socket 18 is rigidly secured in a manner to penetrate through the rear part of the support 15. The head of the screw socket 18 projects out of the support 15, and a printed circuit board 19 engages the projecting head and the above-mentioned upper projection 16 and is thus mounted. On the printed circuit board 19, active elements 20 such as FET or IC elements and passive elements 21 such as a resistor and a capacitor are mounted to constitute an electric circuit. Portions of the electric circuit of the printed circuit board 19 are respectively connected through the screw socket 18 and lead wires 22 to the plugs 6.

Those parts of the printed circuit board 19 which input terminals 23 of the active elements 20 are located, are apertured, and thus, the input terminals 23 are positioned within the apertures so that the active elements themselves are spaced from said printed circuit board 19. The reason why the input terminals 23 are arranged not to touch the board 19, is to prevent the elements from being shunted by the board 19 which is of low impedance. At that part of the support 15 over which the active elements 20 are located, openings 24 are provided (see FIG. 4). Each of the openings 24 is of step form. As shown in FIG. 2, an L-shaped connector 26 is fitted into the opening 24, which connector has a bent portion 25 projecting outwardly into the stepped portion of said opening 24. A vertical part of the connector 26 is connected to the input terminal 23 of the active element 20. The curved part 25 of the connector 26 allows vertical displacements of a horizontal part of said connector 26.

The transducer 4 which is detachable mounted on the base 2 is constructed as described below.

A base 27 is formed with a hole 28 adapted to engage the projection 17 of the support 15 and a hole 29 in registration with the screw socket 18. At the bottom of the base 27, a concave hole 31 has an oblique extension. Stuck onto the inner wall of the concave hole 31 are a pair of stationary electrodes 32 having electret plates. As illustrated in FIG. 5, the two stationary electrodes 32 are stuck to the inner wall of the concave hole 31 with a facing angle of substantially a right angle therebetween. The respective stationary electrodes 32 correspond to the right and left channels in the stereophonic reproduction. Each stationary electrode 32 are electrically connected to a terminal pin 33 embedded in the base 27, while the upper end of the terminal pin 33 protrudes out of the upper surface of the base 27 to contact the horizontal part of the connector 26. Accordingly, the stationary electrodes 32 are electrically connected through the terminal pins 33 and the connectors 26 to the input terminals 23 of the active elements 20.

At the bottom of the base 27, a stylus supporting body 34 made of a conductive material and substantially in the shape of a box is provided in a manner to cover the bottom part of the base 27. An opening 35 is formed in the bottom of the stylus supporting body 34 in registration with the concave hole 31. In the opening 35, the damper 7 is secured so as to tightly close it. Thus, a sealed space is defined in the base 27 by the concave hole 31 and the supporting body 34.

Referring to FIG. 6, the cantilever stylus arm 8 is movably supported on the damper 7 so that is passes through substantially the center of said damper. The cantilever stylus arm 8 is formed of conductive material and into a hollow tube, and has the rear part blocked by means of a conductive cylindrical member 36. At the center of the conductive cylindrical member 36, an end of a conductive thin wire 37 arranged along the axis of the cantilever stylus arm 8 is secured so as to pass therethrough. The other end of the thin wire 37 is secured to a cylindrical holder 38 which is rigidly mounted on the stylus supporting body 34 by means of an electrically conductive bonding material. The holder 38 is also made of a conductive material such as a solder. With the construction as described above, the cantilever stylus arm 8 is supported so as to pivot about the point that wire 37 is secured to the holder 38 and is prevented from moving longitudinally by the thin wire 37. Accordingly, when the record stylus 9 traces the groove of a record, no longitudinal displacement occurs. Tracing distortion is therefore reduced.

To the rear part of the cantilever stylus arm 8, there are attached movable electrodes 39 which are arranged so as to confront the stationary electrodes 32 with a predetermined spacing therefrom. The movable electrodes 39 and the stationarly electrodes 32 form variable capacitors. The movable electrodes 39 may be constructed by making a cut 40 in the tubular cantilever stylus arm 8 at a predetermined distance from the rear end thereof as is illustrated in FIG. 7, and bending and forming the rear part of the arm 8 from the cut 40 into a V-shape approximately 90° in cross section as shown in FIG. 8. The cantilever stylus arm 8 may be formed of an electrically insulating material such as a synthetic resin and the movable electrodes 39 may then be constructed by forming conductive films by evaporation by sticking conductive plates onto the surfaces of the movable pieces which face the stationary electrodes 32. Two capacitors are formed by the two stationary electrodes 32 fixed to the concave hole 31 and the movable electrodes 39. The arrangement of the stationary electrodes 32 and the movable electrodes 39 is such that, as shown in FIGS. 9, 10 and 11, the spacing between the electrodes 32, 39 is narrow at a point near to the cantilever stylus arm 8 and is wide at a point remote from the same, the extensions of the surfaces of the electrodes 32, 39 passing through the central point of vibration of the cantilever stylus arm 8. When the cantilever stylus arm 8 vibrates as the stylus 9 tracks the record groove with the above-described arrangement, the change in the distance between the movable electrodes 39 and the stationary electrodes 32 is substantially constant over the entire area of the electrodes.

The transducer 4 constructed as described above is fitted to the base 2 and is fixed by the screw 3, whereby

the stylus supporting body 34 is electrically connected through the screw 3 and the screw socket 18 to the electric circuit on the printed circuit board 19. In addition, the stylus supporting body 34 is electrically connected through the conductive holder 38 and the thin wire 37 to the movable electrodes 39 provided on the cantilever stylus arm 8. Thus, the movable electrodes 39 are electrically conducted to the electric circuit on the printed circuit board 19. Accordingly, the capacitors constituted by the movable electrodes 39 and the stationary electrodes 32 which are connected through the terminal pins 33 and connectors 26 to the input terminals 23 of the active elements 20, are incorporated into the electric circuit, which forms an output circuit of the pickup device. In this pickup device, the capacitors for electrostatic conversion are connected to the active elements 20 for impedance conversion at the shortest distance inside the pickup 1. As a result, the high input impedance which each of the capacitors has, is converted into a low impedance by the electric circuit on the printed circuit board 19. Since the capacitors are connected through the plugs 6 to an external circuit after such conversion of high impedance into low impedance, the influence of external noise due to their matching with external noise which include high impedance components is sufficiently reduced, and reproduction may be obtained at a good signal-to-noise ratio.

Each stationary electrode 32 is provided with an electret, so that it is unnecessary to apply a high DC bias voltage to the capacitors for the electrostatic conversion type pickup devices of the DC system. Accordingly, the power supply circuit may be simplified, and little attention need be paid to electric insulation.

Moreover, since the capacitor section for the electrostatic conversion is disposed within a sealed space, there is avoided undesirable change in impedance due to the introduction of moisture and dust into the space between electrodes as occurs in conventional electrostatic conversion type pickup devices using DC bias.

Usually, the lower-limit frequency of the reproduced signals which may pass in an electrostatic pickup device is determined by the capacitive impedance of the input circuit. Since, however, the mass of the movable parts should be made as small as possible, the area of the movable electrode may not be made sufficiently large, and the capacitance of the capacitor may be approximately 1pF only. Even if stray capacitances are included, the total capacitance of the input circuit may reach approximately 2.5pF only. In order to make the lower-limit frequency of the pass band become as low as 10 Hz, the input impedance requires an extremely high impedance over approximately 10^{10} Ω as is evaluated from the following formulas:

$$f=1/2\pi\sqrt{CZ} \therefore Z=1/(2\pi f)^2C$$

where f represents the lower-limit frequency in Hz, C the capacitance in farad, and Z the impedance in Ω. The input impedance is regulated by the insulation resistances of the base 27 and the support 15 which hold the respective conducting components, i.e., the terminal pin 33, the connectors 26, etc. Therefore, the support 15 and the base 27 are formed of materials of extremely high insulation resistance, such as Teflon (Registered Trade Mark), (10^{18-20} Ω-cm or below in insulation resistance), polyphenyloxide (10^{16} Ω-cm), polycarbonate (10^{18} Ω-cm), polyethylene (10^{18} Ω-cm) and polystyrene (10^{16} Ω-cm). Since the printed circuit board 19 absorbs moisture due to a surface treating agent its insulalation resistance can be as considerably low as 10^7 Ω-cm. Therefore, openings are provided in the printed circuit board 19, and the input terminals 23 of the active elements 20 are arranged in the openings without touching the printed circuit board 19 as prevously mentioned. In the completed pickup device, moisture exists on the surface of the base 27. As a result, the input impedance fall, but it is still sufficiently high at 10^{10} to 10^{11} Ω and may maintain the lower limit of the signal frequency in the active circuit at 10 Hz or below.

Furthermore, the high impedance capacitors and the connectors connected thereto are accommodated in the lower part of the inner casing 12 and the elements 20 and 21 in its upper part. Therefore, if parts of the circuit on the printed circuit board 19 which are electrically connected to the body 34 and the inner casing 12 are at ground potential, the transducer 4 is shielded against externally induced noise. In addition, the high impedance in the transducer 4 is converted into a low one by the active circuit of the printed circuit board 19, and is connected through the plugs 6 to the external circuit. Therefore, in the connection to the external circuit, the introduction of externally induced noise hardly occurs.

In this embodiment, the capacitor electrodes for effecting the electrostatic conversion are provided integrally on the rear part of the cantilever stylus arm. Therefore, excessive weight of an armature etc. as in the prior art is not exerted upon the cantilever stylus arm. The mechanical vibration section is made light in weight, and the vibration characteristics in the high-frequency band are improved.

With an actual device, recorded signals up to approximately 40 kHz could be reproduced. Since the movable electrodes 39 are never susceptible to the influence of the natural oscillation of an interposed member such as an armature, the vibration of the cantilever stylus arm 8 is almost perfectly transmitted to the movable electrodes 39, so that the recorded signals are reproduced at a good signal-to-noise ratio. Furthermore, the movable electrodes 39 face the stationary electrodes 32, which are arranged so as to face each other at the predetermined angle for the stereophonic reproduction, are bent at a substantially equal angle to the facing angle of the stationary electrodes 32, and said movable electrodes facing the respective stationary electrodes are integrally constructed. Therefore, it is easy to arrange and hold the stationary electrodes 32 and the movable electrodes 39 in the optimum angular state for the reproduction of stereo signals.

We claim:

1. A phonograph pickup device comprising:
a casing 5 having an opening on one side thereof;
a support 15 disposed within said casing 5 and on which an active circuit 20 is provided;
a transducer 4 detachably mounted on the interior of said casing 5 through said opening and electrically connected to said active circuit, said transducer 4 comprising a base 27, a closed chamber 31 and a cantilever arm 8 movably carried on said base

through a damper 7 forming one part of said chamber 31, said cantilever arm 8 having a front part with a stylus tip 9 at an extreme end thereof and a rear part located within said closed chamber; and

a capacitor unit comprised of a movable electrode 39 having two surfaces substantially orthogonally disposed and two stationary electrodes 32 respectively facing in parallel with said two surfaces of said movable electrode, said movable electrode 39 being integrally fixed to the rear end of said cantilever arm 8 along the axis thereof and said stationary electrodes 32 comprising two electret plates insulated from each other and fixed to said base with said two electret plates substantially orthogonally disposed.

2. The phonograph pickup device according to claim 1, wherein said cantilever arm is formed of a light metal tube, and said movable electrode is of roof-shaped configuration.

3. The phonograph pickup device according to claim 1 wherein said casing is made of a conductive material.

4. The phonograph pickup device according to claim 1, wherein said transducer includes a conductive frame which is substantially box shaped and which forms the external surface of said transducer.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,731,009 Dated May 1, 1973

Inventor(s) Shoji WATANABE et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 58, delete "arm 8";

IN THE CLAIMS:

The reference numerals appearing in claim 1 are deemed to be enclosed within parenthesis.

Signed and sealed this 8th day of January 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.