United States Patent

Kawakami

[15] 3,649,775

[45] Mar. 14, 1972

[54] ELECTRO-STATIC PHONOGRAPH PICKUP

[72] Inventor: **Hirotake Kawakami**, Tokyo, Japan

[73] Assignee: **Sony Corporation**, Tokyo, Japan

[22] Filed: **Aug. 14, 1969**

[21] Appl. No.: **850,102**

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

[51] **Int. Cl.**.....**H04r 19/10**

[58] **Field of Search**.....179/100.41, 100.41 ES, 100.41 ST, 179/100.41 S, 100.41 LC, 100.4 A, 100.4 MO, 100.4 ST, 111

[56] **References Cited**

UNITED STATES PATENTS

1,732,393	10/1929	Andrewes	179/100.41
1,804,364	5/1931	Parker	179/100.41
2,033,479	3/1936	Murphy	179/100.41
3,005,060	10/1961	Weathers	179/100.41

FOREIGN PATENTS OR APPLICATIONS

332,996	8/1930	Great Britain	179/100.41

Primary Examiner—Bernard Konick

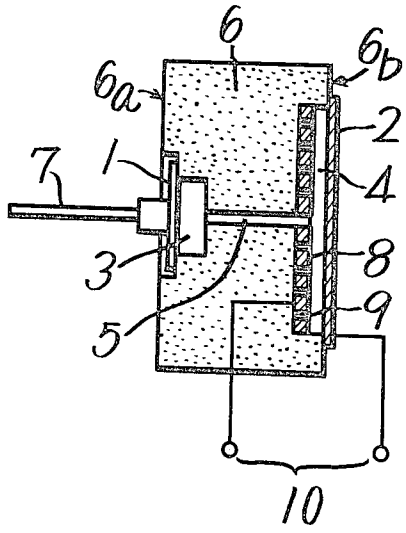
Assistant Examiner—Raymond F. Cardillo, Jr.

Attorney—Hill, Sherman, Meroni, Gross & Simpson

[57] **ABSTRACT**

A phonograph pickup cartridge including an electrostatic transducer with an air chamber having flexible walls connected to the transducer, and a stylus and an arm for converting the movement of the stylus into air pressure variations in the air chamber.

5 Claims, 6 Drawing Figures



PATENTED MAR 14 1972 3,649,775

SHEET 1 OF 2

Fig. 1

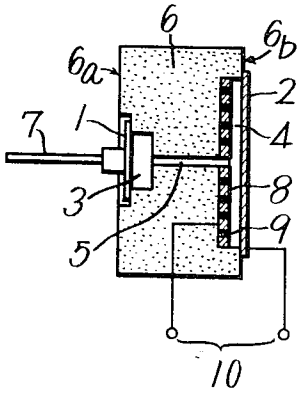


Fig. 2

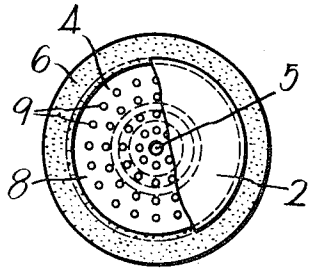


Fig. 3

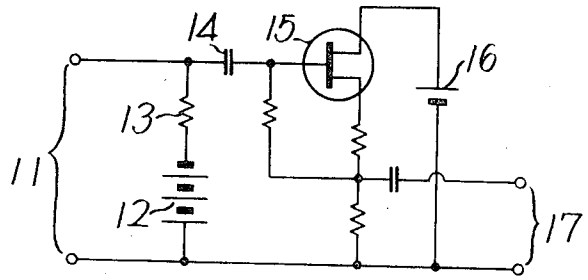
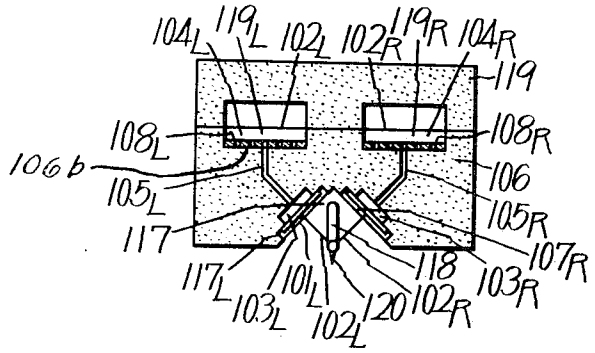


Fig. 4



INVENTOR.

HIROTAKE KAWAKAMI

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

Fig. 5

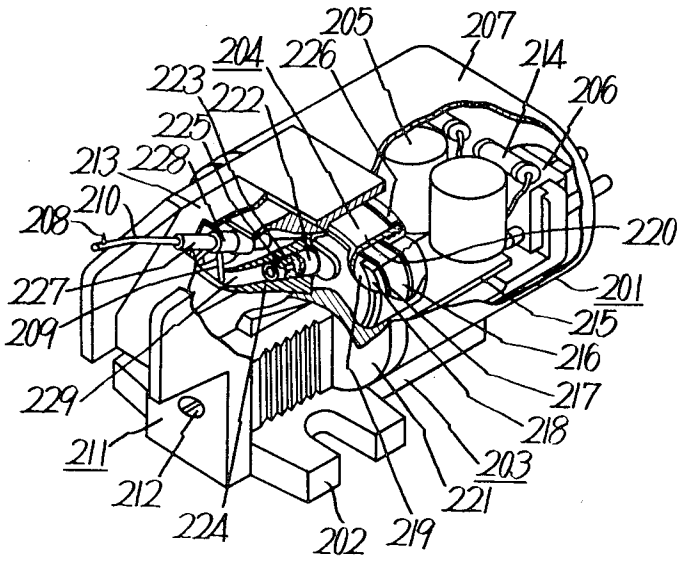
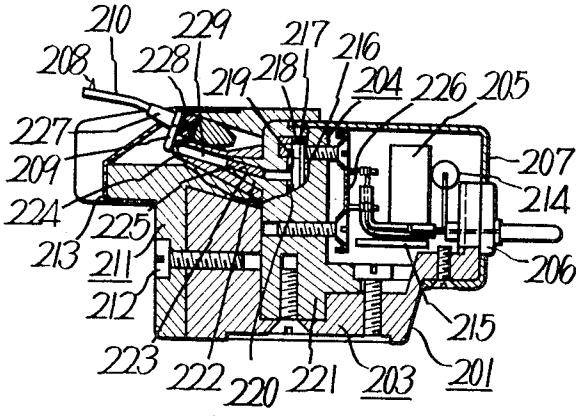


Fig. 6



INVENTOR.

HIROTAKE KAWAKAMI

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

ELECTRO-STATIC PHONOGRAPH PICKUP

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a phonograph pickup cartridge, and more particularly to a phonograph pickup cartridge which has low mechanical impedance and has a wide frequency response range.

2. Description of the Prior Art

Phonograph pickups employing electrostatic transducers, with the condenser-type pickups have been known in the art. Such pickups have extremely small effective moving masses and high compliance and have good frequency characteristics. However, since the output of such pickups are connected to an electrical circuit of high input impedance, such as FET circuits, it is necessary that the electrostatic capacity of the electrostatic transducers be large and that the electrical impedance of the output of the transducers be low. This requires that the contact area between the stylus and diaphragm to be large point. Also, the mass of the diaphragm must be large and causes the resonant frequency of the cantilever supporting the stylus is to lie in the audio range. Very thin diaphragms are subject to multimodal in thickness for decreasing its mass, causes the so-called multimodal vibrations which are undesired vibrations which decrease the efficiency of the diaphragm in the audio range. Multimodal vibration limits the upper cutoff frequency of the device and causes substantially decreases the frequency response of the pickup.

SUMMARY OF THE INVENTION

The phonograph pickup cartridge of this invention has a diaphragm which is not mechanically driven directly by the stylus. Instead movement of the stylus is coupled to a chamber to cause variations in air pressure. The chamber is flexible and the variations in air pressure cause the diaphragm to move.

In the pickup cartridge of this invention an air chamber is provided on one side of the diaphragm of the electrostatic transducer. The diaphragm thus forms one portion of the air chamber. A driving diaphragm or flexible member also forms a wall of the air chamber and is mechanically connected to the stylus. The driving diaphragm is driven by the stylus but the area of the driving diaphragm is small, and no undesired high-frequency vibrations are produced. Also, because the main or output diaphragm of the transducer is driven by air pressure which is uniform over the entire surface of the diaphragm, it will respond over the entire audio range.

This allows the distance between the output diaphragm and a capacitive backplate to be decreased thus increasing the electrostatic capacity. This reduces the pickup of external noise. Also the pickup cartridge of this invention has a low mechanical input impedance and wide band frequency response.

Since the drive diaphragm and the electrostatic transducer are connected by an air passage, the position of the stylus relative to the transducer can be selected at will and this allows great flexibility in the design of the pickup cartridge.

A permanently polarized dielectric material such as electret is used as the output diaphragm of the electrostatic transducer and the pickup cartridge of this invention does not require a polarizing voltage source. A field effect transistor and circuit may be incorporated into the cartridge without causing its size and weight to become unwieldy.

One object of this invention is to provide an electrostatic pickup cartridge which has a very low effective moving mass and has very high compliance.

Another object of this invention is to provide an electrostatic pickup cartridge which has a wide frequency response.

Another object of this invention is to provide a phonograph pickup cartridge wherein the movement of the stylus is converted into a varying air pressure and which has a large thin output diaphragm which is driven by the varying air pressure.

Another object of this invention is to provide a phonograph pickup cartridge which has a large electrostatic capacity and is relatively unaffected by external noise.

Another object of this invention is to provide a phonograph pickup cartridge which has an electrostatic transducer which uses an electret as the output diaphragm and utilizes a field effect transistor circuit.

Another object of this invention is to provide a stereo phonograph pickup cartridge employing a pair of electrostatic transducers.

Still another object of this invention is to provide a phonograph pickup cartridge which has low mechanical driving impedance and in which the vibrating portion has low inertia.

Other objects, features and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view schematically illustrating an electrostatic transducer device employed in the phonograph pickup cartridge of this invention;

FIG. 2 is a rear view of the device shown in FIG. 1;

FIG. 3 illustrates one example of a reproducing circuit of the electrostatic transducer;

FIG. 4 is a cross-sectional view schematically showing a stereo pickup cartridge employing the electrostatic transducer device depicted in FIG. 1;

FIG. 5 is a perspective view, partly in cross section showing another example of this invention; and

FIG. 6 is longitudinal-sectional view of the cartridge depicted in FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGS. 1 and 2 there is illustrated the construction of an electrostatic transducer device used in the phonograph pickup cartridge of this invention. Reference numeral 1 indicates a driving diaphragm and 2 a main diaphragm, which form walls of a front air chamber 3 and a rear air chamber 4. The air chambers 3 and 4 are connected with an opening 5, and the volume thus defined forms an airtight air chamber.

A cylindrical insulator 6 which has good insulation properties has a recess of a relatively small diameter formed in the front wall 6*a* substantially at the center to form its front air chamber 3. A recess of a relatively larger diameter is formed in the back 6*b* at the center at insulator 6 and provides the rear air chamber 4. The driving diaphragm 1 is mounted over of the front air chamber 3 and makes it airtight. The rear air chamber 4 is sealed by the main diaphragm 2. The driving diaphragm 1 may be formed of soft plastic or rubber, for example, and one end of a driving arm 7 is attached substantially to the center of the driving diaphragm 1 and extends at right angles thereto. The main diaphragm 2 may be a metal foil having a thickness of about 3 to 5 microns. It has an area several times that of the driving diaphragm 1, for example, it may be approximately 10 to 15 mm. in diameter. It may also be a plastic film having a thickness of about 5 to 15 microns which has a metallic film formed on one side thereof by means of vapor deposition or the like. The plastic film is mounted on the insulator 6 so that it is taut with the conductive face on the outer side and seals the rear air chamber 4. A backplate 8 of a conductive material is mounted in the rear air chamber 4 in opposing relationship to the main diaphragm 2. The spacing between the backplate 8 and the main diaphragm 2 is relatively narrow, such as for example, 15 to 30 microns. The sensitivity of the pickup increases as the spacing is decreased between the main diaphragm 2 and the backplate 8. However, if the spacing becomes too small the air viscosity resistance, increases which causes a decrease in the sensitivity of the pickup. To avoid this, many fine perforations are uniformly formed in the backplate 8 to decrease the air viscosity resistance and increase the sensitivity of the pickup. The air passage 5 is preferably located on an axis of the insulator 6.

The conductive layer of the main diaphragm 2 and the backplate 8 are respectively connected by leads to terminals 10. Normally, the conductive layer of the main diaphragm 2 will be grounded.

In the electrostatic transducer device vibration of the driving diaphragm 1 caused by the vibration of the driving arm 7 causes compression and expansion of air in the air chambers 3 and 4 and in the air passage 5, and the main diaphragm 2 will be vibrated. This causes the distance between the main diaphragm 2 and the backplate 8, to vary which changes the capacitance between them. This change is detected at terminals 10. FIG. 3 is an electrical schematic of a circuit for detecting the capacitance variations. Reference numeral 11 indicates a pair of input terminals which are connected to the output terminals 10 of the electrostatic transducer. A polarizing voltage of about 50 to 100 v. is applied between backplate 8 and the conductive layer of the diaphragm 2 from a DC power source 12 through a resistor 13 which may have a resistance of about 100 megohm. The variations of capacitance of the transducer are detected as voltage variations across the resistor 13 and are applied through a coupling capacitor 14 to the gate of a field effect transistor 15 FET 15 comprises an amplifier to connected as a source follower. An output is supplied to output terminals 17. Reference numeral 16 designates a power source for the field effect transistor 15.

Very little power is required for the transducer device of this invention. The driving diaphragm 1 is small. Driving input impedance decreases in inverse proportion to the square of the ratio of the areas of the diaphragms 1 and 2, and thus the driving power may be extremely low. Since the mechanical input impedance can be made very low, the influence upon a mechanical driving source can be very small although the coupling of the driving diaphragm 1 with the driving arm 7 occurs at a single point, the area of the diaphragm 1 is small, and thus the diaphragm 1 vibrates uniformly over its complete surface even when excited by high frequencies. The main diaphragm 2 is large in area and is driven by air pressure variations uniformly over its entire surface. The diaphragm 2 therefore vibrates over the entire frequency range including high frequencies and its vibrations can be converted into an electric signal which accurately represents the driving source. Since, the effective area between the main diaphragm 2 and the backplate 8 is large and the spacing between them is small, relatively high capacitance may be obtained. The capacitance obtainable with prior art devices is about 0.4 pF. With the present invention, capacitance in the range of 10 to 30 pf. can be easily obtained, and an output at terminals 10 can be obtained which faithfully converts the vibrations of the diaphragm 2 into an electrical signal without picking up external noise. Further, vibration of the diaphragm 2 up to about 40 kc. can be readily converted into electric signals. The air passage 5 and the front and rear air chambers 3 and 4 constitute an acoustic transformer.

The air passage 5 connecting the front and rear air chambers 3 and 4 need not be straight but may be curved and the relative position between the coupling point of the driving arm 7 with the diaphragm 1 can be selected at will to allow great flexibility in the design of the pickup.

It is possible to eliminate the polarizing power source 12 by using electret material as the main diaphragm 2. In this case, the main diaphragm 2 is formed of a high molecular plastic film such as polypropylene or polyester or the like and is subjected to a polarizing treatment and is thereafter permanently electrified. The polarizing treatment is achieved by placing a dielectric film having a clean metallic coating on one surface between a pair of flat plate electrodes. A DC voltage of about 300 to 500 v. is applied to the electrodes in an atmosphere of approximately 200° C. for 15 minutes or so, and are then cooled to room temperature. This produces appreciably stable permanent electrification.

FIG. 4 shows one example of this invention pickup cartridge in which the electrostatic transducer device described above has been applied to a stereo cartridge. A triangular recess 117 which has an apex that forms a right angle, is formed in one side of an insulator 106. Recesses are formed in the right angular spaced inner walls 117L and 117R and these form front air chambers 103L and 103R, which are covered with driving diaphragms 101L and 101R. Driving arms 102L and 102R are respectively mounted on the diaphragms 101L and 101R at the centers and are coupled at their free ends to a cantilever 118. In the other side of the insulator 106 rear air chambers 104L and 104R are respectively formed. These are covered with main diaphragms 102L and 102R. The front and rear air chambers 103L, 103R and 104L, 104R are respectively, connected by air passages 105L and 105R. Capacitive backplates 108L and 108R are provided in the rear air chambers 104L and 104R adjacent to the diaphragms 102L and 102R. The back portion 106*b* of the insulator 106 may be covered by cover 119 having recesses 119L and 119R aligned with the rear air chambers 104L and 104R. Main diaphragms 102L and 102R are mounted in chambers 104L and 104R. Reference numeral 120 indicates a stylus mounted on the cantilever 118. As shown in the figure, the air cavities 105L and 105R may be curved to allow the rear air chambers 104L and 104R to be mounted close to each other so as to form a compact cartridge. Since the driving mechanical impedance is small, because the inertia of the vibrating members is small, the pickup cartridge of this invention has a wide band response and gives high-fidelity response.

FIGS. 5 and 6 illustrate another embodiment of this invention as applied to a stereo pickup cartridge. Flexible bellows are used instead of the driving diaphragms.

A cartridge 201 includes a baseplate 203 formed integral with a bracket 202, an electrostatic transducer 204, amplifier circuits 205, a terminal board 206 and a covering shield case 207. A cantilever holder 211 supports a cantilever 210 which carries a stylus 208 driving arms 209. Hold 21 is removably mounted on the cartridge 201 by means of a screw 212. When the stylus 208 cannot be used further, the entire cantilever holder 211 is replaced with a new one. Reference numeral 213 designates a dust cover mounted on the cantilever holder 211. And 214 a resistor 214 and a capacitor 215 are also mounted in the dust cover.

The electrostatic transducer 204 has of a backplate 216. An electret diaphragm 219 is mounted on a ring 218 disposed opposite the backplate 216. A spacer 217 is mounted to case 220 and and the electrostatic transducer 204 is mounted on a transducer holder 221. The transducer holder 221 has a projection 222 formed integrally therewith and a cavity 223 interconnects the projection 222 and the holder 221. The projection 222 has fitted thereon bellows 224 made of rubber, for example. The electret diaphragm 219 of the electrostatic transducer 204, the transducer holder 221 and the flexible sacks 224 form an airtight air chamber 229. The cavity 223 of the projection 222 is filled with a damping material 225. Reference numeral 226 indicates a clamping plate that is attached by a screw to the transducer holder 221.

The cantilever 210 is a tube made of aluminum, for example, and one end which carries a stylus 208 and the other end which is attached to an insulating support 227 having a reduced diameter at an intermediate portion. The support 227 has two driving arms 209 formed integrally therewith which extend at an angle of 45° to each other. A rubber ring 228 serves as a damper and is tightly mounted on the support 227 at the reduced diameter portion. The end of the support 227 is inserted into a hole (not shown) of the cantilever holder 211. The cantilever 210 is movable relative to the reduced diameter portion.

When the cantilever holder 211 has been fixed by the screw 212 to the baseplate 203, the driving arms 209 the top ends of the flexible bellows 224 a small amount. Accordingly, when a 45/45 stereo record is played with the use of the cartridge 201, the top ends of the flexible bellows 224 are respectively deformed by the driving arms 209 in response to sounds picked up from the right and left channels, thus changing the air pressure in the air chamber 229. As a result, the distance between the electret diaphragm 219 and the backplate 216 of the electrostatic transducer 204 varies thus changing the capacitance therebetween. Accordingly, the electric signal is produced which is amplified by the amplifier circuit 205 and is

fed out from terminal board 206. A power source for the amplifier circuit 205 is not illustrated but a miniature battery may be used.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of this invention.

I claim as my invention:

1. A phonograph pickup cartridge having a stylus comprising:

a body member formed with a first cavity;

a first driving planar diaphragm to which said stylus is coupled covering said first cavity;

a second cavity formed in said body member;

a first output planar diaphragm larger in area than said first driving planar diaphragm mounted over said second cavity, said first and second cavities in fluid communication; and

capacitive pickup means coupled to said output diaphragm to convert movement of said output diaphragm to electrical signals.

2. A phonograph pickup cartridge according to claim 1 wherein said output diaphragm has an electrical conductive portion, an electrical conductive porous backplate mounted in said second cavity adjacent said output diaphragm and said capacitive pickup means comprising a pair of electrical conductors connected to said backplate and said output diaphragm.

3. A phonograph pickup cartridge according to claim 2 comprising:

a third cavity formed in said body member;

a second planar driving diaphragm covering said third cavity and coupled to said stylus;

a fourth cavity formed in said body member;

a second planar output diaphragm larger in area than said second planar driving diaphragm mounted over said fourth cavity, said third and fourth cavities in fluid communication; and

second capacitive pickup means coupled to said second output diaphragm to convert movement of said second output diaphragm to electrical signals.

4. A phonograph pickup cartridge according to claim 3 wherein said second output diaphragm has an electrical conductive portion, a second electrical conductive porous backplate mounted in said fourth cavity adjacent said second output diaphragm, and said second capacitive pickup means comprising a second pair of electrical conductors connected to said second backplate and said second output diaphragm.

5. A phonograph pickup cartridge according to claim 4 wherein said stylus moves said first and second driving diaphragms at right angles to each other.

* * * * *