

July 19, 1949.

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2,476,414

PHONOGRAPH PICKUP HAVING PLASTIC TORSION ARM

Filed May 24, 1945

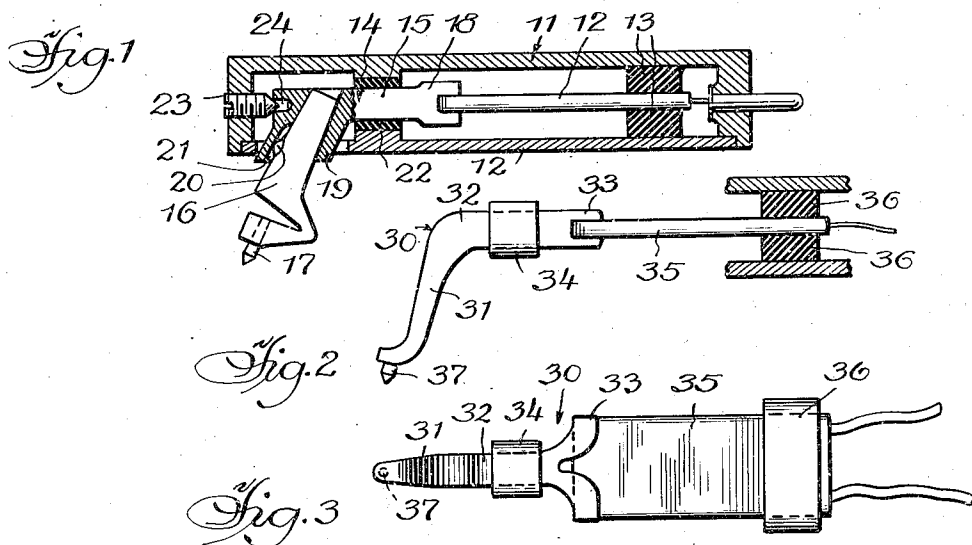
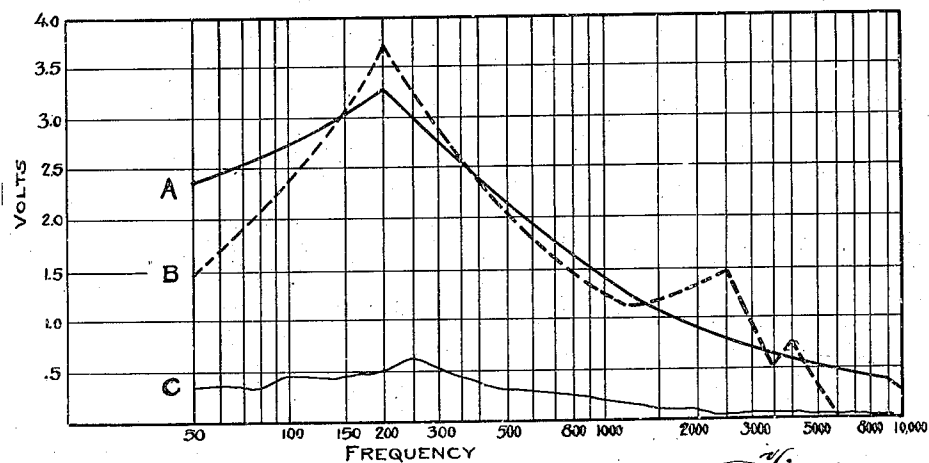
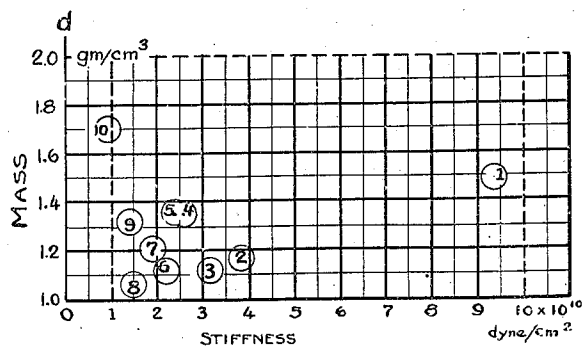


Fig. 5

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UNITED STATES PATENT OFFICE

2,476,414

PHONOGRAPH PICKUP HAVING PLASTIC
TORSION ARM

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Application May 24, 1945, Serial No. 595,576

6 Claims. (Cl. 179—100.41)

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My invention relates to improvements in phonograph pick-up construction.

A phonograph pick-up comprises, in general, means to convert mechanical vibrations to correspondingly fluctuating electrical currents, and vibration transmitting means to transmit vibrations from a record engaging point to said converting means.

A pick-up desirably should be possessed of certain characteristics, such as a high voltage output, and a substantially uniform response throughout a given range, and this range should preferably be coextensive with the audible range of frequencies. By uniform response is meant absence of sharp resonance peaks in the audible range.

A primary object of this invention is to provide a phonograph pick-up having low mechanical impedance, and non-resonating characteristics. In terms of performance these characteristics contribute to higher voltage output, low record and stylus wear, uniform response, and improved tracking.

These objects are obtained by providing vibration transmitting means having a mass no greater than that required by the volume of material required to produce the requisite stiffness. I have found that a vibration transmitting member fabricated from that group of materials known as plastics and which includes synthetic resins and various cellulose base plastics, embody the proper degree of stiffness and mass. When such materials are used, greatly improved results are obtained over the metal vibration transmitting members of the prior art pick-ups.

This invention is a continuation in part of my copending application Serial No. 561,061, filed October 30, 1944, now U. S. Patent No. 2,451,221, granted October 12, 1948, which discloses plastic vibration transmitting means, and it is a continuation in part of my copending application Serial No. 529,269, filed April 3, 1944, now abandoned, which relates to a plastic needle.

In the principal embodiment of my invention herein shown and described, the conversion means comprises a piezoelectric crystal; however, it is understood that the principles of my invention apply equally well to pick-ups embodying other types of conversion means.

Another object of my invention is to provide a vibration transmitting member of such characteristics that the output impedance thereof matches the input impedance of the crystal or other conversion means, thereby permitting a direct coupling between the two. Thus, the use

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of a separate compliant coupling element between the vibration transmitting means and the crystal is eliminated, resulting in higher voltage output. Contributory objects are to provide a vibration transmitting member which has a distributed and a controllable damping effect or dissipative resistance, and which has distributed and controllable compliance.

A still further object is to provide vibration transmitting means of integral construction, thereby eliminating the tendency of the parts to resonate separately, and at different frequencies, due to the previously used inefficient forms of loose mechanical coupling for the separate parts, such as the ordinary screw clamp for securing a needle in a pick-up chuck.

A still further object is to provide an improved coupling between the vibration transmitting means and the crystal.

Heretofore, the vibration transmitting means have been made of metal which has a comparatively high density and a comparatively high stiffness. These characteristics contribute to a high impedance, which is generally proportional to the square root of the effective mass times stiffness.

The plastic materials above referred to have comparatively low density and a comparatively low stiffness, as compared with metal; hence, the plastic vibration transmitting means which comprises my invention has a much lower needle point impedance than the metal vibration transmitting members formerly used. This results in good tracking, which refers to the ability of the needle point to follow faithfully the record groove irrespective of variations in amplitude and frequency. These tracking characteristics are obtained without increasing the weight on the needle point; as a matter of fact, I have obtained perfect tracking with only a half ounce pressure for all frequencies from thirty up to ten thousand, as determined by a test record. This performance has been coupled with a comparatively high voltage output and uniform response.

Although there is considerable variation of voltage output between various types of present day commercial pick-ups, those with comparatively high voltage output are characterized by poor tracking, or non-uniform response, or both. More uniform response is obtained by the use of lumped damping, but which increases impedance and further accentuates poor tracking. This necessitates the use of a compliant coupling between the metal vibration transmission member and the crystal, which results in decreased voltage output. In other words, with metal vibration transmitting

means, high voltage output is incompatible with good tracking and uniform response.

This incompatibility is in large measure eliminated by following the practices of my invention.

Other objects, features and advantages of this invention will become apparent as the description proceeds.

With reference now to the drawings, in which like reference numerals indicate like parts—

Fig. 1 is a sectional elevation through a pick-up showing one embodiment of my invention;

Fig. 2 is an elevation of a vibration transmitting means and crystal showing another embodiment of my invention, only a portion of the housing being shown;

Fig. 3 is a top view of the vibration transmitting means and crystal shown in Fig. 2;

Fig. 4 is a graph showing the response advantage obtained from a pick-up embodying my invention; and

Fig. 5 is a diagram showing the stiffness and density of representative types of plastic materials which may be used in accordance with my invention.

The principles of my invention may be applied to a vibration transmitting means in which the needle is separable from the chuck and yoke, as shown in Fig. 1, or it may be applied to a pick-up in which the yoke and needle are integral, as shown in Figs. 2 and 3.

In the Fig. 1 form of my invention, the reference numeral 11 designates the pick-up housing which may be in two separable parts, in accordance with the usual practice. A crystal 12 is mounted within the housing by means of gripping pads 13 which engage one end of the crystal. The other end of the crystal is coupled to vibration transmitting means generally designated by the reference numeral 14, which comprises two parts, a longitudinally disposed member 15, and a needle 16. Both of these members are made of an organic plastic material, as will be pointed out hereinafter in greater detail.

The lower end of the needle 16 is provided with a record engaging point 17 which may be of a suitable hard alloy, or which may be a sapphire. The longitudinally disposed member 15 terminates at one end in a yoke 18 which engages the crystal 12. The other end is provided with a chuck 19 which is adapted to receive the needle 16. The yoke may be cemented to the crystal.

The shank of the needle 16 is tapered, and it fits into a correspondingly tapered bore in the chuck 19, the tapering arrangement providing a very secure coupling between the two. A key 20 on the needle fits in a cooperating keyway 21 in the chuck to facilitate proper alignment of the parts. The construction of these parts is pointed out in greater detail in my co-pending application Serial No. 561,061, of which this is a continuation in part.

The vibration transmitting means is mounted in the housing by means of a rubber journal 22 which surrounds the cylindrically shaped intermediate portion of the longitudinally disposed member 15. A pivot screw 23 extends inwardly from the front wall of the housing 11 and engages a suitable bore 24 in the longitudinally disposed member 15. The screw and the bore are aligned with the longitudinal axis of member 15, and cooperate with rubber journal 23 to permit oscillation of the vibration transmitting means about said longitudinal axis.

In the form of my invention shown in Figs. 2 and 3, the vibration transmitting means 30 is

an integral member, and includes a downwardly extending arm portion 31, and a longitudinally disposed portion 32, the end of which terminates in a yoke 33. The yoke 33 comprises a plurality of pairs of fingers for the purpose of securing a firm grip on the crystal 35 irrespective of any surface irregularities. A rubber journal 34 surrounds the longitudinally disposed portion 32, the rubber journal being adapted to fit within the housing in the usual manner.

The yoke 33 grips one end of crystal 35, and the other end of the crystal is mounted between suitable damping pads 36 in the usual manner.

The lower end of the arm 31 is curved forwardly and carries a suitable record engaging point 37.

The vibration transmitting means 14 and 30 are composed of a low density, high molecular weight plastic material, such as those known as synthetic resins, or as plastic cellulose products. I prefer to use organic plastic materials having a density of less than two grams per cubic centimeter and having a Young's modulus of less than 10×10^{10} dynes per square centimeter.

Representative types of plastic materials are listed below under their usually accepted chemical designation and trade names, and the Young's modulus and density are given for each. These materials are numbered from 1 to 10, and I have found that a vibration transmitting member composed of any one of these ten materials gives the satisfactory results heretofore mentioned. For the purposes of comparison, the corresponding characteristics of certain metals are also given in the following table.

No.	Chemical Type	Trade Names	Young's Modulus ¹ Dyn./cm. ²	Density, gm./cm. ³
1	Urea	Beetle Plaskon	9.3	1.48
2	Acrylic	Lucite	3.8	1.18
3	Diamine	Nylon	3.1	1.13
4	Copolymer Vinyl	VY Vinylite	2.6	1.36
5	Styrene	Styramic	2.3	1.36
6	Ethyl Cellulose	Ethocel	2.1	1.14
7	Cellulose Acetate Butyrate	Tenite II	1.9	1.21
8	Styrene	Polystyrene	1.5	1.06
9	Acetate	Lumarith Tenite	1.4	1.32
10	Vinylidene	Saran	0.9	1.70
	Mg Alloy	Dow metal	43	1.74
	Al Alloy	Duraluminum	67.5	2.85
	Steel		190	7.7

¹ Times 10^{10} .

In Fig. 5 the numbers correspond to the numbers opposite the various plastic materials appearing in the above table, and the density of each material is plotted against the Young's modulus. It is evident that the values for the stiffness, as exemplified by Young's modulus, can be varied somewhat by the use of a proper plasticizer, the effects of which will be pointed out hereinafter.

Fig. 4 shows the response of various types of pick-ups in terms of voltage output at frequencies of 50 to 10,000 cycles per second. Curve A shows response from a pick-up made according to my invention; curve B shows the response of a pick-up in which the metal vibration transmitting member is undamped; and curve C shows the response of a typical commercial pick-up in which the metal vibration transmitting member is provided with damping in order to secure a substantially uniform response, and very loose coupling in order to secure tracking. The latter type of pick-up is often referred to as a high fidelity pick-up, due to the effort made to secure a uni-

form response. However, a comparison of curve C with the other curves will indicate that this uniformity of response is obtained at considerable sacrifice of voltage output.

A comparatively undamped pick-up, on the other hand, while its voltage output is more satisfactory, is characterized by various resonances which show up as peaks in curve B. The peak at 2500 cycles represents the crystal resonance, and the subsequent peak represents needle resonance. The peak at 250 cycles indicates the change over point of the test record from constant amplitude to constant velocity.

Curve A on the other hand, combines the uniform response of curve C with the voltage output of curve B. It is the combination of these desirable characteristics that is produced by the practice of my invention.

The low voltage output of curve C cannot be entirely compensated for by the speaker amplification in order to give acceptable results. This is for the reason that due to abrasives used in the manufacture of the record, there is a constant noise level which on Fig. 4 occurs at about 0.1 volt. Therefore the ratio of noise to signal in a high fidelity pick-up such as that whose response is shown in curve C, increases to an undesirable extent at frequencies of from 2000 to 10,000 cycles. This effect considerably diminishes the desirability of a so-called high fidelity pick-up. It will be noted that in curve A, a comparatively low ratio of noise to signal is maintained out to 10,000 cycles.

The reason for an improved performance of a pick-up embodying my invention are at present not fully understood. Without committing myself to any theory, however, it is believed that plastic materials have a much greater dissipative resistance, or internal resistance, than metals, due to their molecular structure. This higher internal resistance apparently is of assistance in damping out resonance peaks; and, in particular, it dispenses with the need of lumped damping.

A further advantage in the use of plastic materials is that it permits a much greater latitude in the mechanical design of the vibration transmitting members. The values listed in the foregoing table are not the sole determinants of the stiffness and mass of the vibration transmitting means; the dimensions of the parts must also be considered. The above table does indicate, however, that for a vibration transmitting means of given dimensions, a greatly reduced impedance may be expected if plastic is used instead of metal. While the resonance frequency of a plastic vibration transmitting means cannot be determined categorically by reference merely to the resonant frequency of a corresponding metallic vibration transmitting means, I have found that when the dimensions of the plastic vibration transmitting means are sufficient to withstand the net weight of the tone arm, the response curve of the pick-up is relatively absent from resonant peaks.

In general, the stiffness increases as the fifth power of the dimensions, whereas the mass increases as the third power of the dimensions, so that it is evident that a considerable variation in resonant frequency, which in general is proportional to the square root of the effective stiffness over the effective mass, may be effected by comparatively minor structural changes. Thus the resonance frequency may be empirically adjusted after the general design of the pick-up has been determined.

A further element of latitude in mechanical design is occasioned by the fact that stiffness may be varied considerably by regulating the amount of plasticizer used. Thus the compliance may be increased, and the output impedance regulated to match the input impedance of the crystal. One result of impedance matching, either by change in dimensions, or by the proper use of plasticizer is the elimination of the tendency of the vibration transmitting means, or various parts thereof, to resonate separately from the crystal, or at lower frequencies than the crystal resonance.

The addition of plasticizer may also be expected to increase the internal or dissipative resistance of the vibration transmitting means.

To sum up the foregoing, the use of plastic materials for vibration transmitting means provides distributed damping, and permits the selection of a design which is free from resonant peaks, and which also permits impedance matching.

The designs shown in Figs. 1 to 3 have been found to give satisfactory results when fabricated from a diamine type of plastic sold under the trade name of nylon. It will be noted that in these designs no separate coupling element is used between the vibration transmitting means and the crystal. This results in more efficient coupling, and hence greater voltage output. I have also found it desirable to grip the crystal near its edges, thereby subjecting a greater area of the crystal to deformation.

The foregoing description has illustrated my invention as applied to a crystal pick-up embodying a twister construction and adapted for use with lateral cut records. It will be evident however, that the principles of my invention may be applied to other types of pick-ups than crystal pick-ups, and also to pick-ups adapted for use in connection with hill and dale cut records. Furthermore, the invention may be applied to bender type pick-ups as well as to twister type.

Furthermore, it is apparent that my invention is applicable also to other plastic substances than those specifically enumerated herein. The foregoing description and the appended drawings are deemed to be illustrative only and the invention is to be limited only by the appended claims.

I claim:

1. In a phonograph pick-up, a crystal, means for transmitting torsional vibrations to said crystal, and a stylus connected to said vibration transmitting means, said vibration transmitting means being formed entirely from a non-elastomeric organic plastic material having a density of less than 2.0 grams per cubic centimeter and a Young's modulus of less than 10×10^{10} dynes per square centimeter, and comprising an elongate member having a yoke at one end thereof engaging said crystal and a portion connecting said yoke with said stylus, the thickness and width dimensions of said connecting portion being substantially equal to each other, and said stylus projecting outwardly from said elongate member and away from the axis thereof whereby lateral vibration of said stylus will cause torsional vibration of said vibration transmitting means.

2. A phonograph pick-up as claimed in claim 1 in which said organic plastic material is nylon.

3. In a phonograph pick-up, a crystal, means for transmitting torsional vibrations to said crystal, and a stylus connected to said vibration transmitting means, said vibration transmitting means being formed entirely from a non-elastomeric organic plastic material having a density

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of less than 2.0 grams per cubic centimeter and a Young's modulus of less than 10×10^{10} dynes per square centimeter, and comprising an elongate member having a yoke at one end thereof engaging said crystal and a portion connecting said yoke with said stylus, said connecting portion being of substantially uniform cross sectional area and said stylus projecting outwardly from said elongate member and away from the axis thereof whereby lateral vibration of said stylus will cause torsional vibration of said vibration transmitting means.

4. A phonograph pick-up as claimed in claim 3 in which said organic plastic material is nylon.

5. In a phonograph pick-up, a crystal, means for transmitting torsional vibrations to said crystal, a stylus connected to said vibration transmitting means, said vibration transmitting means being formed entirely from a non-elastomeric organic plastic material having a density of less than 2.0 grams per cubic centimeter and a Young's modulus of less than 10×10^{10} dynes per square centimeter, and comprising an elongate member having a yoke at one end thereof engaging said crystal and a portion connecting said yoke with said stylus, and said stylus projecting outwardly from said elongate member and away from the axis thereof whereby lateral vibration of said stylus will cause torsional vibration of

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said vibration transmitting means, and means engaging said vibration transmitting means to support the same for torsional vibration about its longitudinal axis.

6. A phonograph pick-up as claimed in claim 5 in which said organic plastic material is nylon.

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