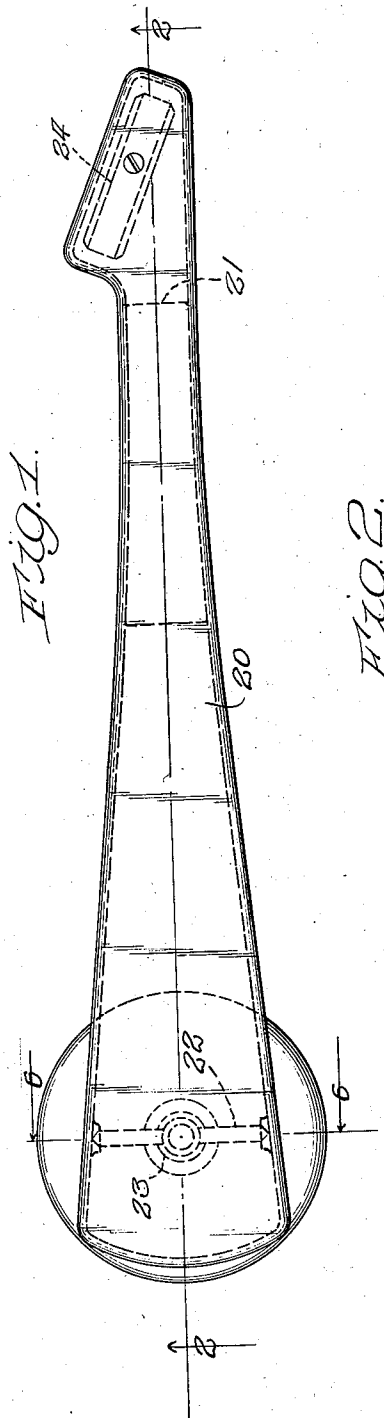
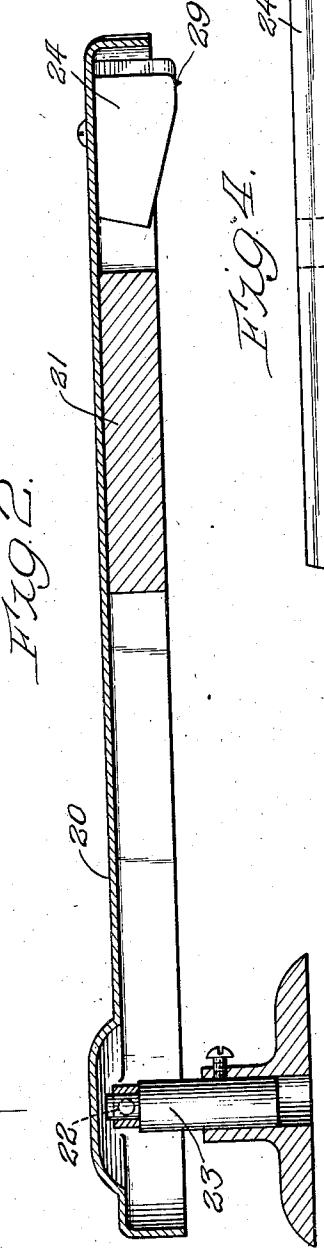
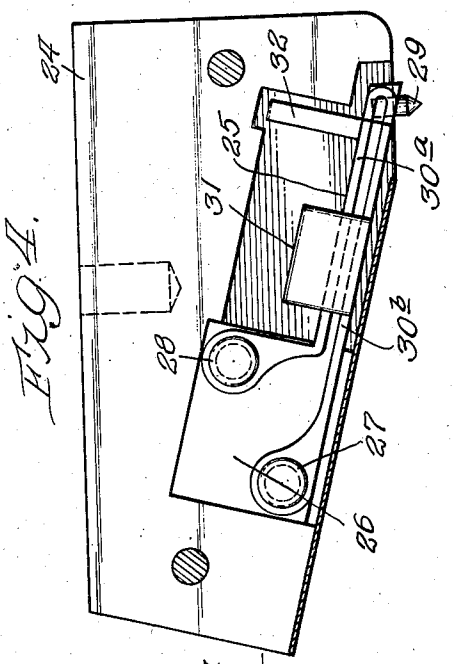
Sept. 14, 1943. K. J. GERMESHAUSEN 2,329,526

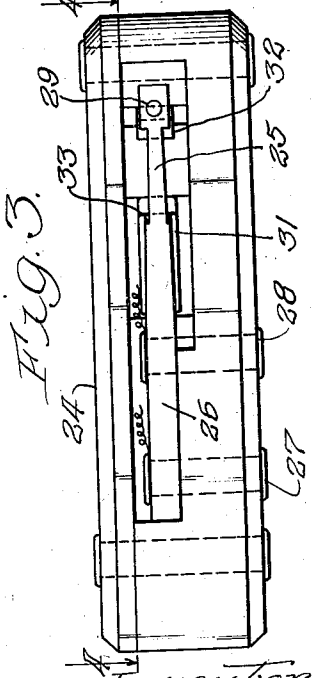
TRANSLATOR

Filed Sept. 17, 1941 3 Sheets-Sheet 1









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TRANSLATOR

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Fig. 5.

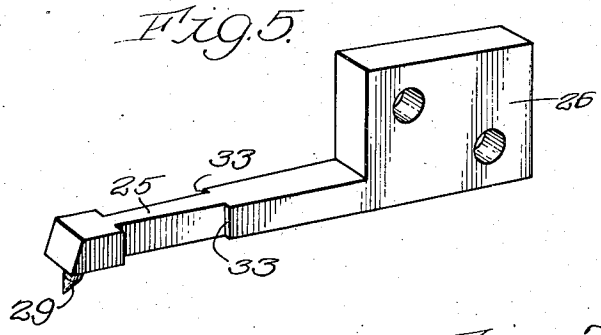


Fig. 6.

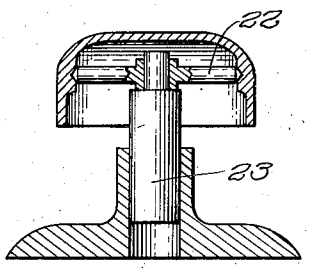


Fig. 7.

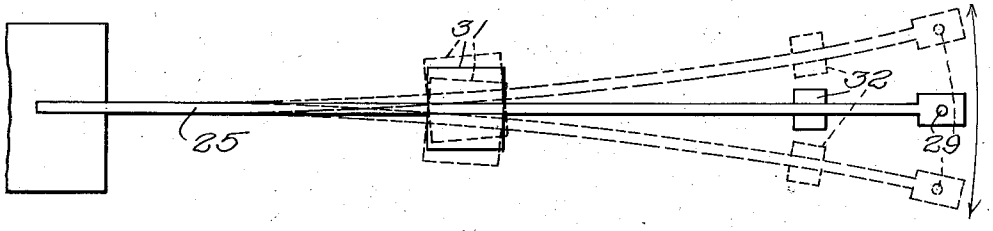


Fig. 8.

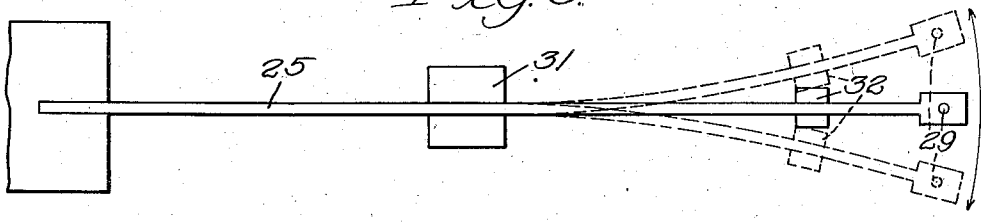
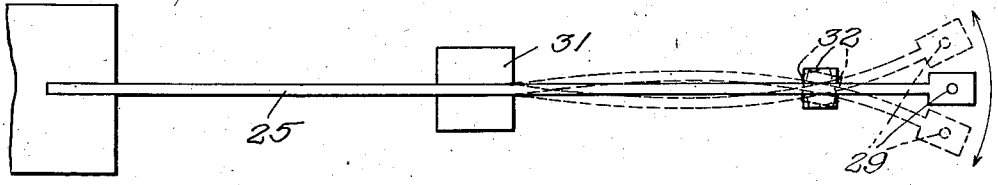


Fig. 9.



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Fig. 10.

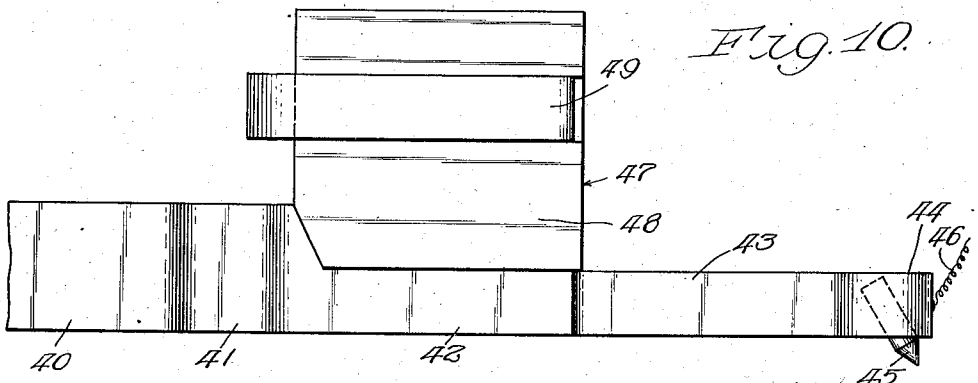


Fig. 11.

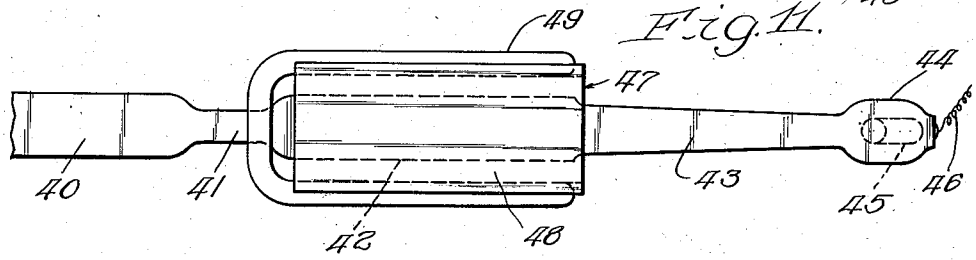


Fig. 12.

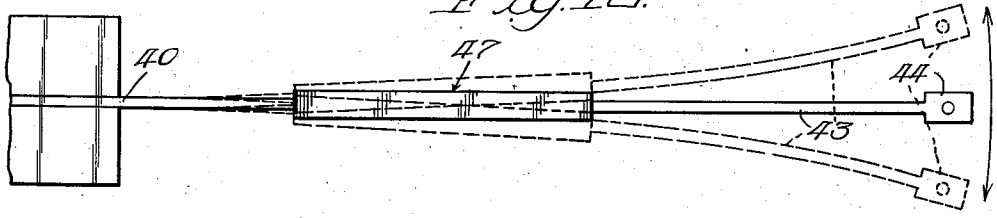
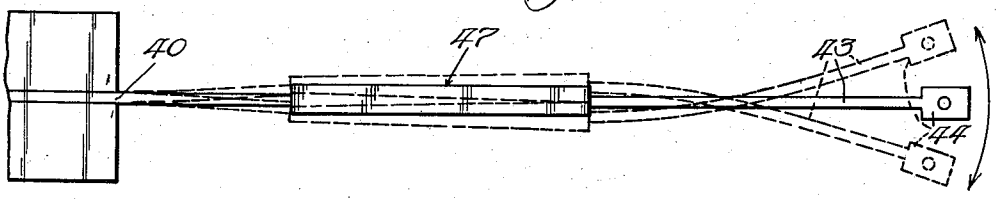


Fig. 13.



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UNITED STATES PATENT OFFICE

2,329,526

TRANSLATOR

Kenneth J. Germeshausen, Newton Center, Mass.

Application September 17, 1941, Serial No. 411,227

15 Claims. (Cl. 274—1)

Ths invention relates to a translator, and more particularly to an improved pick-up for translating mechanical variations in a record into electrical variations.

One feature of this invention is that it provides an improved pick-up providing a substantially flat electrical output, when used in conjunction with conventionally cut records, up to a frequency of at least five thousand cycles per second; another feature of this invention is that the pick-up automatically compensates for the reduction in amplitude of the mechanical variations in the record as the frequency to be reproduced rises; yet another feature of this invention is that the translator comprises a beam-like vibratile element in conjunction with means for causing the element to vibrate differently at different frequencies of actuation thereof; still another feature of this invention is that the translator is adapted to vibrate in simple manner at low frequencies and in complex manner at higher frequencies, whereby a mechanical multiplication of output for a given movement is attained at higher frequencies; a further feature of this invention is the use of a beam-like vibratile element of material having a low modulus of elasticity together with a damping mass of greater weight carried by the element and causing it to vibrate differently at different frequencies; still a further feature of this invention is the provision of an improved damping material; other features and advantages of this invention will be apparent from the following specification and the drawings, in which:

Figure 1 is a top plan view of a pick-up embodying my invention; Figure 2 is a longitudinal sectional view, along the line 2—2 of Figure 1; Figure 3 is a bottom view of the translator cartridge; Figure 4 is a view of the cartridge and translator element, with one side of the cartridge removed; Figure 5 is a perspective view of the translator; Figure 6 is a transverse sectional view of the tone arm mounting, along the line 6—6 of Figure 1; Figure 7 is a diagrammatic representation of the action of the element at low frequencies; Figure 8 is a diagrammatic representation of the action of the element at intermediate frequencies; Figure 9 is a diagrammatic representation of the action of the element at high frequencies; Figure 10 is a side elevational view of a preferred form of translator element; Figure 11 is a top plan view of the device shown in Figure 10; Figure 12 is a diagrammatic representation of the action of this latter form of translator element at low frequencies; and Figure 13 is a diagrammatic representation of the action of this latter form of element at intermediate frequencies.

Most present day records are laterally cut, having the mechanical variations in the side walls of the spiral grooves, and my invention will be described in connection with such records, although it will be understood to also be applicable to hill and dale records. Moreover, in order to avoid undue sharpness of slope in the variations at high frequencies, records are conventionally cut with an amplitude of cut proportional to the amplitude of the sound up to about 300 cycles per second, and then with the amplitude of cut decreasing thereafter proportionally to increase in frequencies, up to five or six thousand cycles per second, about as high as is usually recorded on the ordinary record. That is, the characteristic curve representing the ratio of depth of cut to sound amplitude would be flat to three hundred cycles per second, and then slope downward in a straight line from there to the neighborhood of five thousand cycles per second.

A desirable pick-up compensates within itself for this sloping characteristic curve, so that the electrical output of the translator is flat, or uniformly proportional to sound amplitude, up to a little over five thousand cycles per second. I have devised and am here disclosing and claiming a pick-up which provides this compensation by vibrating differently at different frequencies, so that a given movement thereof will result in a higher output at high frequencies of such movement than at low frequencies thereof; and by so doing I enable the output of the pick-up to be coupled directly to the input of an audio amplifier, without the necessity of complicated correction networks.

Referring now more particularly to Figures 1 to 6, a modification of my invention is shown which best illustrates how the translator may be designed to vibrate differently at different frequencies and to provide the desired multiplication of output as the frequency of vibration increases. A tone arm 20, preferably provided with a damping mass 21, is mounted in any desired manner, here shown as being carried by a shaft 22 to provide for rotation about a horizontal axis, this shaft in turn being carried by the shaft 23 to provide for rotation about a vertical axis. It will be understood that the tone arm would be mounted adjacent the record turntable, in conventional manner, so that the translator carried at the outer end of the tone arm would be brought into contact with the grooves of the record.

The tone arm has rigidly fastened to it near its outer end a translator housing or cartridge **24**. This cartridge serves as the protecting and mounting case for the translator element itself, and as a convenient means for mounting it in the tone arm and for providing electrical circuit connections to it.

Referring now more particularly to Figures 3, 4 and 5, this form of my translator will be described. It will be seen that the translator comprises a beam-like forward portion **25** and a rear or base portion **26** integral therewith. The portion which is here described as analogous to a beam is thus seen to be rigidly attached at one end, by being formed integrally therewith, to the base member **26**, this in turn being rigidly attached, as by rivets **27** and **28**, to the cartridge and through it to the tone arm. The other end of the beam-like element is free to vibrate transversely, having rigidly mounted therein a needle **29** adapted to ride in the record grooves and to effect desired movement of this end of the translator element.

My particular form of translator comprises insulating material having a low modulus of elasticity, as pure molded polystyrene or Celluloid, provided on one or more surfaces with a coating of material having its electrical resistance varied by strain, as finely divided graphite. Referring now particularly to Figure 4, it will be seen that a coating **30** extends from the rivet **28** forwardly along one side of the beam-like element **25**, near its upper edge, in a portion here identified as **30***a*, then back along the same side near the lower edge in a portion here identified as **30***b*, to connect with the rivet **27**. If a substantial voltage is applied across such a coating, as by connecting the plate voltage supply of an audio amplifier, through a load resistor, to the rivets **28** and **27**, movement of the outer end of the element will set up strains in the coating, as a result of flexure of the element, which vary the resistance of the coating and thus vary the voltage drop across it. This voltage variation may be applied between the grid and cathode of the first of a series of audio amplifying tubes, and subsequently reconverted into sound by a speaker. I have found such an arrangement to faithfully and efficiently translate mechanical variations in a record into corresponding electrical variations which can then be translated into corresponding sound waves. A coating of this kind can be applied to one or more surfaces of the translator by masking portions which are not to be coated and then spraying the coating material, as very finely divided graphite, into place. The inactive portion, on the base, is preferably covered with silver paint or metal foil in order to concentrate all of the resistance on the vibratile beam-like element. The preparation of a translator of this particular kind, and the circuits into which it is adapted to work, are not being further described here since they have been fully described in my earlier filed copending applications, these being Serial No. 340,156, filed June 12, 1940, and Serial No. 404,724, filed July 30, 1941. Another strain sensitive coating, superior to graphite in that it develops greater voltage variation for a given deflection of the element, can be formed of finely divided galena.

In order to cause the beam-like element to vibrate differently at different frequencies I here show it, in this particular form, provided with two damping masses **31** and **32**. The mass **31** is of substantial weight, preferably heavier than the beam-like element, and is cemented or otherwise fastened to it near its center but slightly offset toward the rigidly attached end; that is, this mass is mounted on the vibratile element slightly back of its center. The other mass **32** is much lighter, preferably long and thin as shown to prevent any torsional action in the element, this latter mass being cemented or otherwise fastened to the beam-like element near its outer end, just back of the needle **29**. These masses are of material having high resistance to flexure and low restoring force after flexure, preferably of a material to be hereinafter fully described. I have found that it may be desirable to make the circuit path of low resistance clear out to the shoulder **33** (best seen in Figure 5), and to concentrate the active or strain sensitive coating in this outermost portion of the beam-like element, which portion is also preferably tapered slightly (see Figure 3), as about two degrees on each side, in order to insure a relatively uniform arc or flexure in this section. That is, the most voltage will be secured for a given movement of the end of the element if the strain sensitive coating is concentrated in the portion of the element most bent; and there will be less distortion and more proportional voltage change for a given movement of the end if the active portion of the element bends on an arc.

Referring next more particularly to Figures 7, 8 and 9, the various modes or different vibrations of the element at different frequencies are schematically illustrated. The weight of the damping mass **31** should preferably be from one to three times the weight of the vibratile translator element, and should be so proportioned that the element vibrates in a simple manner, as a reed fastened at one end, up to frequencies of about 300 cycles per second, this form of vibration being illustrated in Figure 7. At these low frequencies the lighter mass **32** appears to have no effect whatsoever, and the mass **31** does not have sufficient effect to prevent vibration of the entire element.

Around 300 cycles per second the weight of the damping mass **31**, if properly chosen, imposes so much restraint upon movement of the center of the element that this part of the element begins to have relatively less movement than would be expected if there were no damping mass upon this portion of the vibratile element. As the frequency of vibration of the free end of the translator element is increased the effect of the damping mass **31** (being proportional to frequency) increases until by the time a frequency of about one thousand cycles per second has been reached the center of the translator element stands entirely still, and all of the vibration is concentrated in the outer portion of the element, as illustrated in Figure 8. It will be understood that there is not an abrupt change from vibration in the manner shown in Figure 7 to that shown in Figure 8, but rather a gradual shift.

The weight of the damping pass **32** is chosen, in relation to the size of the vibratile element, so that at a frequency of movement in the neighborhood of one thousand cycles per second it begins to impose substantial restraint upon movement of that portion of the element immediately beneath it. As the frequency of movement of the end of the element increases the portion under the damping mass **32** tends more and more to move less than it should if vibration were to continue in the form shown in Figure 8. Instead

of vibration continuing in this manner the portion of the element between the two damping masses begins to whip in a direction opposite to that of the end of the element, in what may be termed a fish pole effect. By the time the frequency of vibration has gotten up to a little over three thousand cycles per second that portion of the element under the damping mass **32** is standing substantially stationary, as is also the portion under and back of the mass **31**, and vibration then assumes a more complex character as illustrated in Figure 9.

None of these various forms of vibration are dependent upon resonance characteristics; in fact, damping masses of proper material practically iron out all resonance peaks or valleys. The translator element is thus able to vibrate in one or more of the various modes illustrated simultaneously, so that low and high frequency notes may both be brought out together in proper relation. It is believed to be readily apparent that, by causing the element to vibrate in different modes at different frequencies, a greater amplitude of output is secured for a given needle point deflection at higher frequencies, as is desirable to provide a so-called "flat" output. That is, by vibrating in a different manner at higher frequencies the active portion of the vibratile element is bent more sharply at higher frequencies for a given movement of the end; and since the electrical output is a function of the arc or degree of bending of the portion carrying the strain sensitive coating, the voltage variation will be correspondingly higher. It will be obvious that a lateral movement of .0004 inch at the end of the element will only cause a relatively moderate bending or flexure, and thus a relatively low output, at low frequencies when the element is vibrating as illustrated in Figure 7; this same amount of movement will cause twice the degree of bending, twice the strain in the coating and thus twice the output, at intermediate frequencies where the element is vibrating as illustrated in Figure 8; and it will cause a very much sharper bending, and thus a correspondingly multiplied output per unit deflection, at high frequencies when the active portion of the element is vibrating as illustrated in Figure 9.

While the translator element heretofore described best illustrates the principles of my invention, and gives a very flat output up to quite high frequencies (thus being particularly adapted for high fidelity records), a preferred commercial embodiment of my invention is illustrated in Figures 10 and 11. In these figures the translator element comprises a partially shown base portion **40**, a reduced neck portion **41** immediately adjacent the base, an enlarged portion **42**, an active portion **43**, and an end portion **44**. As before, the base portion would be attached by rivets or other appropriate means, preferably through an intermediate housing or cartridge, to the end of the tone arm; the outer end **44** of the translator element would carry a short needle member **45** adapted to be oscillated by mechanical variations in the record; and a strain sensitive coating would be applied to the active portion **43** of the element. As before, this may be of very finely divided graphite; but in my commercial pick-up I prefer to carry the coating out one side of the translator element, across at the end, and back on the other side, in order to secure a push-pull effect, that is, connections would be made to each end of the strain sensitive coating in the manner described before, and to a center point or center tap, as by the flexible lead **46**. The arrangement of such a coating, the circuits into which it is adapted to work, and its operation are fully described in my copending application, Serial No. 404,724, filed July 30, 1941. As mentioned before, the coating out to the active portion of the element should preferably be of silver paint, metal foil, or other good conducting material in order that the resistance may be concentrated in the active portion.

The reduced neck portion **41** is preferably of about half the width of the base portion **40** and the enlarged portion **42**, having a height about twice that of the portion **42**, as may be best seen in Figure 10. Thus the neck portion has about half the resistance to lateral movement of the portion **41**, so that at lower frequencies a great deal of the bending is concentrated in this reduced neck portion. It is rather important that this neck portion be about half as stiff as the portion **42**. If the neck portion were too weak and too flexible, too much movement would be concentrated there at low frequencies, so that at low frequencies a given deflection of the outer end of the element would result in very low amplitudes because of the small flexure in the active portion of the element; then as the damping mass **47** came into action flexure would tend to concentrate at a much more rapid rate in the active portion of the element resulting in a rising output characteristic curve. On the other hand, if the neck portion is too stiff, there would be too much flexure in the active portion of the element at low frequencies and there would be an undesirable downward slope to the output curve. The neck portion is reduced in width and then increased in height, instead of being merely reduced in width to the desired amount, in order to secure greater resistance to vertical movement, greater stiffness in that direction. Some vertical flexure is desirable in the element; but too much can cause distortion, and too flexible an element is subject to breakage at the neck portion. The portion of the element under the damping mass is made wider than the active portion of the element in order to concentrate as much flexure as possible out in the active end at higher frequencies, particularly near resonance, which occurs at about 5,500 cycles per second in the translator here disclosed.

The damping mass **47** comprises two portions, a portion **48** of flexible material resisting deflection but having little restoring force after deflection, and a loading portion **49**. The flexible portion **48** is cemented to the top of the element, over the portion **42**; and the portion **49** may be a horseshoe-shaped lead slug clamped in place around the upper part of the flexible portion. In order to get several times the weight of the vibratile element into the damping mass it would be necessary, if only the flexible material were used, to have an impracticable bulky damper. By the use of the arrangement disclosed a damping mass of one gram can be secured by loading a satisfactory amount (about three-tenths of a gram) of flexible damping material with a lead or similar metal mass of .7 of a gram.

A translator which I have built in accordance with the disclosures of Figures 10 and 11, and which has proved particularly satisfactory for commercial purposes, has its neck portion about one-eighth inch long, the portion **42** about one-fourth inch long, the active portion about one-fourth inch long, and the end portion about three-thirty-seconds inch long. Since no vibra-

tion takes place in the base, its dimensions may be determined entirely in accordance with ease of fastening it into the cartridge and in making connections to the coating. The portions 42 and 43 have a height of one-sixteenth inch, the neck portion having a height of one-eighth inch. The flexible portion of the damping mass is about five-sixteenths inch high by nine-thirty-seconds inch long by one-eighth inch wide, the horseshoe-shaped lead weight being about three-sixteenths inch above the portion 42. The material of the translator element itself is pure molded polystyrene; and the strain sensitive active coating is a very fine divided carbon sprayed on and subsequently protected with a lacquer coating.

Referring now more particularly to Figures 12 and 13, it will be seen that the damping mass 47 causes the element to vibrate differently at different frequencies. Below 300 cycles the particular damping mass disclosed above is practically ineffective to prevent a substantial amount of the bending taking place at the reduced neck portion, vibration at these lower frequencies being as illustrated in Figure 12. Above 300 cycles per second the damping mass becomes more and more effective to restrain motion of the portion 42, so that more and more flexure is concentrated in the outer or active portion of the element, this increase of effectiveness of the damping mass being inversely proportional to frequency, as is desirable. Around a thousand cycles per second the vibration becomes complex, with some whip in it, as illustrated in Figure 13, so that mechanical multiplication is secured and a higher output obtained for a given deflection of the end of the element. As the frequency goes up the mass 47 causes the portion 42 to become more and more stationary, so that the node portion of the complex vibration moves further toward the outer end of the element to increase the multiplication action.

The particular translator element illustrated has an almost perfectly flat output curve, when used with conventionally cut records, up to about 5,500 cycles per second. At about 5,500 cycles the multiplication of strain due to the whipping action has reached a maximum, this being about the resonance frequency of the active portion of the needle. Thereafter the output falls off very rapidly, a very desirable feature in that needle scratch and similar undesired noises are generally concentrated in ranges above this frequency. The frequency at which this cutoff occurs may be set at any desired value by adjusting the relative dimensions of the translating element.

The flexible material, or damping material, is very important to the proper operation of these translators, and I have found that rubber or other conventional damping materials are not fully satisfactory. Most damping materials, for example, result in a bad hump in the output curve, damping most at certain frequencies; or at some frequencies they have little or no effect at all, and permit rather erratic action of the translator. If rubber is used as a damping material, for example, it is fairly satisfactory at frequencies from one to five thousand cycles per second, but very unsatisfactory below one thousand cycles; and ordinary plastics, made sufficiently "rubbery" by conventional plasticizers, provide good damping up to about one thousand cycles, but fail at the higher frequencies. The preferable damper, of course, must absorb energy at a rate which increases with the frequency of vibration, and with a characteristic curve which is a straight line over the whole frequency range, as 30 to 5,500 cycles per second.

I have found that the best results are obtained when the base material or plastic has mixed with it a plasticizer which has a very high viscosity. There must be sufficient plasticizer to make the material "rubbery," capable of the desired amount of flexure; but there must be high internal friction and low restoring force. I have found that a substantial amount of plasticizer in the mix, where its viscosity is low, results in a mass which is too elastic at high frequencies, and does not have the necessary internal friction. My theory in this regard is that a plasticizer with a low viscosity results in too much "lubrication" between the molecules of the base material; but whatever the explanation, I have found that where a sufficient quantity of plasticizer is used to give the desired rubberiness and flexibility, the plasticizer must have a high viscosity if the desired straight line frequency curve is to be attained. Most conventional plasticizers have a relatively low viscosity, in the neighborhood of twenty centipoises at 20° C.; whereas I have found that plasticizers having at least three times and preferably about five times this viscosity rating are best. In order to get sufficient plasticizer into the mix without having it subsequently come back out, moreover, the plasticizer used should be a solvent for the plastic base material.

I have found that a very excellent damping material can be made by combining one hundred cubic centimeters of monomer methyl-methacrylate, one hundred twenty cubic centimeters of methyl phthalyl ethyl glycollate (a plasticizer sold commercially under the trade name of Santicizer M–17) and 1.1 grams of benzolyl peroxide, preferably in powdered form, shaking these together until the peroxide is dissolved. The mix should then be placed in tightly closed molds (large gelatin capsules are satisfactory) and held at a temperature of about 60° C. for twenty-four hours, polymerization generally being complete at about this time. The plasticizer mentioned above has a viscosity rating of 100, and is a solvent for the monomer. The resultant damping material is very flexible, yet very dead; that is, it can be moved, but it resists movement and has substantially no restoring force. Moreover, it operates well at all frequencies within the range for which my pickup is designed, without any particular response peaks or valleys.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. A pick-up of the character described, including: a beam-like translator element; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected; and means operatively associated with the element intermediate its ends for causing at least a portion of the element to be bent more sharply, for a given movement of said other end, at high frequencies of such movement than at low frequencies thereof.

2. A pick-up of the character described, including: a beam-like translator element; a mem-

ber having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected, the vibration of the element at low frequencies being simple in character; and means operatively associated with the element intermediate its ends for causing the vibration of the element to be complex in character at high frequencies, whereby at least a portion of the element is bent more sharply, for a given movement of said other end, at high frequencies of such movement than at low frequencies thereof.

3. A pick-up of the character described, including: a beam-like translator element; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected; and a damping mass, of material having high resistance to flexure and low restoring force, operatively associated with the element intermediate its ends for causing at least a portion of the element adjacent said other end to be bent more sharply, for a given movement of said other end, at high frequencies of such movement than at low frequencies thereof.

4. A pick-up of the character described adapted to provide a substantially flat frequency-output characteristic curve to at least 5,000 cycles per second when used with conventional records, including: a beam-like translator element of material having a low modulus of elasticity; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected; a damping mass carried by the element intermediate its ends for causing at least a portion of the element adjacent said other end to be bent more sharply, for a given movement of said other end, at high frequencies of such movement than at low frequencies thereof, said mass having a weight exceeding that of the vibratile element; and a coating on said portion of the element, the coating comprising material having its electrical resistance varied by strain.

5. A pick-up of the character claimed in claim 4, wherein said mass comprises a portion of material having high resistance to flexure and low restoring force, and a metal portion carried thereby.

6. A pick-up of the character claimed in claim 4, wherein said element is reduced in the direction of its vibration near the rigidly attached end and enlarged immediately therebeyond, said mass being carried by the enlarged portion.

7. A pick-up of the character claimed in claim 4, wherein said element is reduced in the direction of its vibration near the rigidly attached end and enlarged immediatley therebeyond, said mass being carried by the enlarged portion of the element and comprising a portion of material having high resistance to flexure and low restoring force, and a metal portion carried thereby.

8. A pick-up of the character claimed in claim 1, wherein the last mentioned means comprises a damping mass, of material having high resistance to flexure and low restoring force, carried by the vibratile element near its center but slightly offset toward the rigidly attached end.

9. A pick-up of the character described, including: a beam-like translator element; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected; and a damping mass carried by the element intermediate its ends for causing at least a portion of the element adjacent said other end to be bent more sharply, for a given movement of said other end, at high frequencies of such movement than at low frequencies thereof, the mass having a weight exceeding that of the vibratile element.

10. A pick-up of the character described, including: a beam-like translator element principally comprising material having a low modulus of elasticity; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected; and means operatively associated with the element intermediate its ends for causing the element to vibrate differently at different frequencies of movement of said other end.

11. A pick-up of the character described, including: a beam-like translator element; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected, the vibration of the element at low frequencies being simple in character; and means for causing the vibration of the element to be complex in character at high frequencies, whereby at least a portion of the element is bent more sharply, for a given movement of said other end, at high frequencies of such movement than at low frequencies thereof, said portion being provided with a coating of material having its electrical resistance varied by strain.

12. A pick-up of the character described, including: a beam-like translator element; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected; and a damping mass carried by the element intermediate its ends for causing at least a portion of the element adjacent said other end to be bent more sharply, for a given movement of said other end, at high frequencies of such movement than at low frequencies thereof, said element principally comprising material having a low modulus of elasticity and said portion being provided with a coating of material having its electrical resistance varied by strain.

13. A pick-up of the character described, including: a beam-like translator element; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected; and a damping mass carried by the element intermediate its ends for causing at least a portion of the element adjacent said other end to be bent more sharply, for a given movement of said other end, at high frequencies of such movement than at low frequencies thereof, said element being reduced in the direction of its vibration near the rigidly attached end and enlarged immediately therebeyond, said mass being carried by the enlarged portion.

14. A pick-up of the character described, including: a beam-like translator element; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected; and means for causing the element to vibrate differently at different frequencies of movement of said other end, said last mentioned means comprising a damping mass

carried by the vibratile element near its center, and a lesser damping mass near said other end.

15. A pick-up of the character described, including: a beam-like translator element; a member having one end of the element rigidly attached thereto; means at the other end of the element whereby oscillatory movement of such end may be effected; and means for causing the element to vibrate differently at different frequencies of movement of said other end, said last mentioned means comprising a damping mass carried by the vibratile element near its center but slightly offset toward the rigidly attached end, and a lesser damping mass carried by the element immediately adjacent its other end.

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