Nov. 5, 1935. O. M. DUNNING 2,020,139

ELECTROMECHANICAL TRANSLATING DEVICE

Filed June 4, 1932 2 Sheets-Sheet 1

Fig. 1

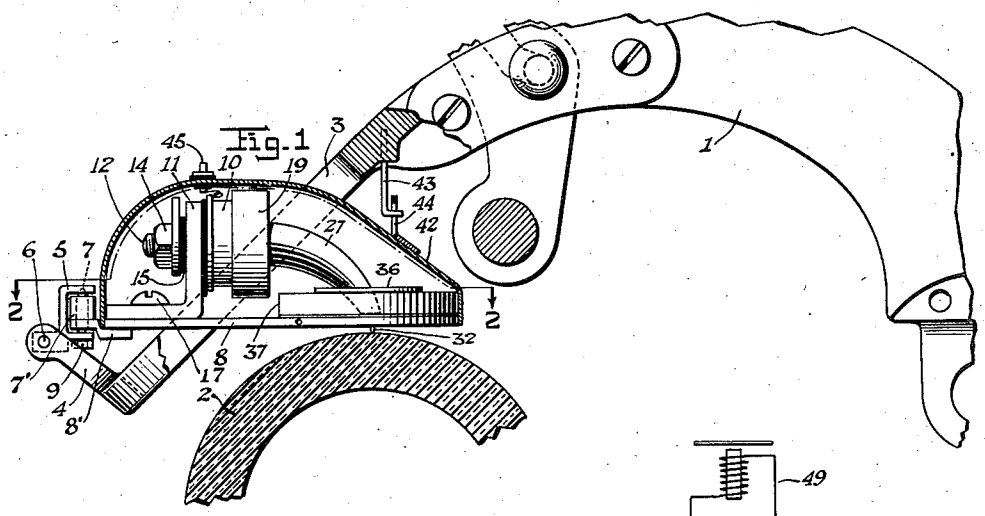


Fig. 2

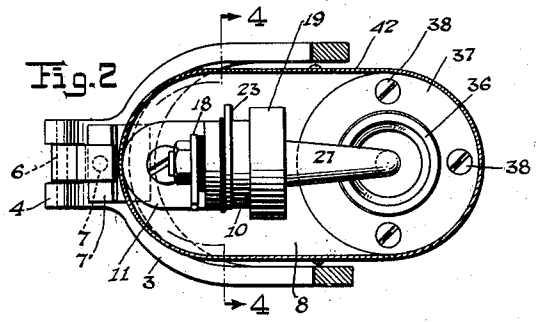


Fig. 3

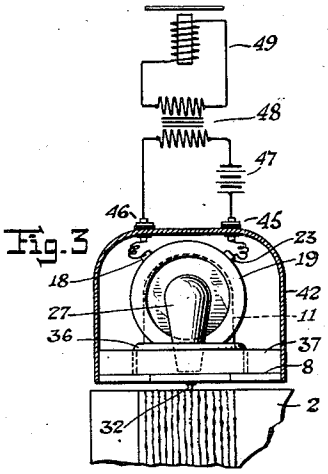


Fig. 4

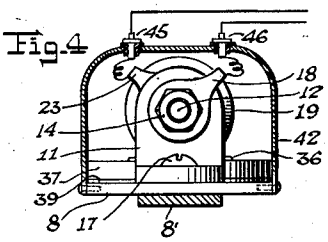


Fig. 5

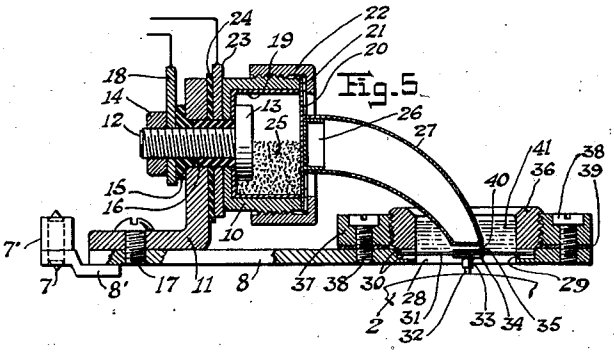
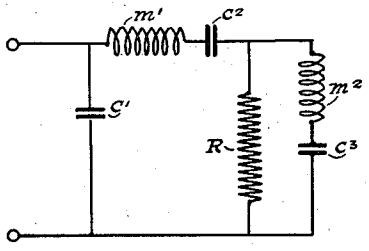


Fig. 6



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ELECTROMECHANICAL TRANSLATING DEVICE

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Fig. 7

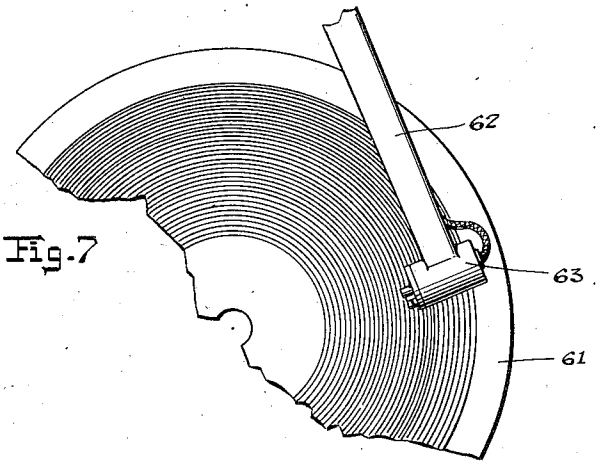


Fig. 8

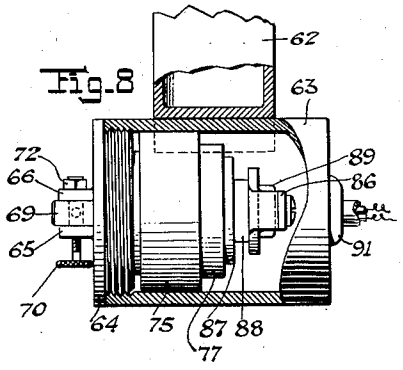


Fig. 9

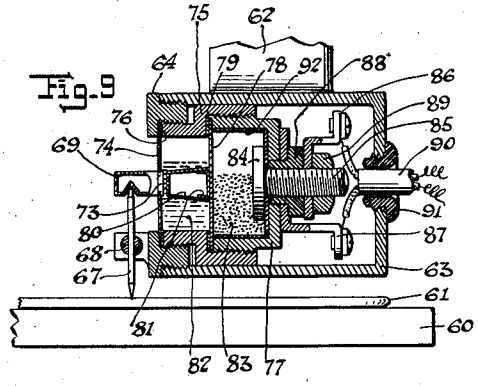
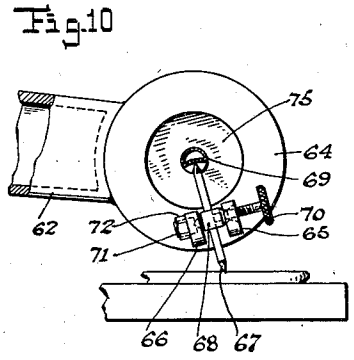


Fig. 10



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UNITED STATES PATENT OFFICE

2,020,139

ELECTROMECHANICAL TRANSLATING DEVICE

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Application June 4, 1932, Serial No. 615,306

15 Claims. (Cl. 179—100.41)

Electro-mechanical translating devices are used to change mechanical vibration into corresponding electrical impulses. The embodiments of my invention specifically described are directed to translating devices especially adapted for use as phonographic reproducers, but the general principles may also be applied to many other types of electro-mechanical translating devices such as, for instance, a microphone.

The performance of a phonographic reproducer may, in general, be judged upon three fundamental characteristics. These characteristics are: first, the range and uniformity of response to the various frequencies which are impressed upon the reproducer; second, the sensitivity of the device; and third, the mechanical impedance at the stylus point.

The range and uniformity of response of a reproducer to various frequencies gives a measure of the exactness with which the reproducer will translate mechanical vibrations into electrical vibrations. It is nearly always desirable that the range be as great as possible and that the response be uniform to frequencies over substantially the entire range in order that the voltage generated in the reproducer may closely correspond to the vibrations engraved upon the record.

The second characteristic mentioned, namely, the sensitivity of the device, may or may not be of great importance in any particular application. It is, of course, always possible to employ a thermionic amplifier to magnify the current generated by the reproducing device, but in any specific case, the degree of amplification required is determined by the sensitivity of the reproducer. With a reproducer of high sensitivity, it is possible to employ very simple amplifying apparatus or to eliminate amplifying apparatus entirely with a consequent reduction in the cost, complexity, distortion, and likelihood of failure in the system. High sensitivity is therefore, in most cases, an extremely desirable feature.

The third characteristic, namely, the mechanical impedance of the reproducer as viewed from the stylus point, is the factor which determines the extent of destruction of the record groove and of the stylus in the operation of a reproducer. It is always desirable that the wear on the record and the reproducer stylus be very small to insure long life. It is extremely important in the case of wax records that the mechanical impedance of the reproducer be kept very low to prevent serious damage to the record groove during the process of reproducing.

The range and uniformity of response of a phonographic reproducer are determined by the arrangement and the values of the masses and compliances of the various moving parts of the reproducer and by the compliance of the record grooves. The compliance of the record grooves is usually a predetermined factor and limits the design of the moving parts of the reproducer. In most cases, if the reproducer is to translate the higher frequencies without distortion, it is necessary that the mass of the moving parts of the reproducer be held to the lowest possible value. In most types of reproducers, this desirable low mass cannot be attained without an accompanying low sensitivity and in many cases it may be impossible to attain a sufficiently low mass to reproduce frequencies of the order of 4000 to 5000 cycles without reducing the sensitivity to a point where an impracticably high degree of amplification is necessary to raise the sound to the desired level.

The sensitivity of an electrical reproducer is determined by a number of factors, of which probably the most important is the translating medium which actually generates the voltages corresponding to the mechanical vibrations impressed upon the device. The medium most commonly used in electrical reproducers is that of an iron vane vibrated in a magnetic field and surrounded by a coil wherein such voltages are generated. This type of translating medium has, in practice, a fundamentally low sensitivity which it is not practical to increase when the range of frequency response and the mechanical impedance are considered. On the other hand, the granular carbon cell is normally a relatively high sensitivity device since it draws energy from an external source and, in consequence, acts as an amplifier of the electrical energy derived from the mechanical vibrations. The granular carbon cell will produce a voltage many times that of the magnetic translating medium for an equivalent displacement under ordinary phonographic conditions. However, the granular carbon cell is not suited for direct connection to the vibrating stylus of a reproducer as is the magnetic medium. Phonographic records are cut with the so-called constant velocity characteristic—that is, assuming a sinusoidal wave form, the product of the maximum amplitude of each cycle of the groove multiplied by its frequency is a constant for uniform loudness through the range of frequencies recorded. In such a record, the maximum velocity in each cycle imparted to a stylus driven thereby will be a constant for all frequencies while the maximum amplitude in each cycle is

inversely proportional to the frequency for constant loudness. The granular carbon cell, however, is independent of the velocity of motion, the voltage generated being determined by the amplitude only of vibration. It is therefore apparent that if a granular carbon cell were vibrated with the amplitude proportional to that engraved upon the phonograph record, the resulting response would not be uniform for all frequencies, but would rather exaggerate the lower frequencies in comparison to the higher frequencies. If a granular carbon cell is to be used as a translating medium, it is therefore essential that some form of compensation be introduced in order to secure uniform response to all frequencies from a recording of the constant velocity type. While the granular carbon cell has been employed in phonographic reproducers in the past, such reproducers necessarily produced a certain amount of distortion since the compensation used therein was not operative over a wide range of frequencies.

The mechanical impedance of a reproducer as viewed from the stylus should always be as low as possible in order to minimize the wear of and damage to both the stylus and the record groove. This requires particularly that the stiffness of the reproducer as viewed from the stylus be made as small as possible, and, coupled with the requirement of a large frequency range, necessitates the use of extremely small effective masses.

It is an object of this invention to provide an electro-mechanical translating device which will have substantially uniform response to a wide range of frequencies.

Another object of this invention is to attain high sensitivity in a translating unit without the introduction of serious distortion.

It is a further object of this invention to provide a phonographic reproducer having extremely low mechanical impedance as viewed from the stylus.

It is a further object of this invention to provide a phonographic reproducer having the combination of a wide frequency range, substantially uniform response through the frequency range, high sensitivity, and low mechanical impedance at its stylus.

It is still a further object of this invention to provide a translating device wherein the translating medium produces a voltage proportional to amplitude of vibration only, and wherein a transmitting and compensating means is provided to actuate said translating medium and to produce an amplitude of vibration at said translating medium proportional to the velocity of vibration impressed upon the device.

It is to be understood that the translating device of this invention may be applied to many uses other than to that as a phonographic reproducer, as herein described. As is well understood, devices which are applicable for use in phonographic reproducers may also be used for microphones and similar devices. In this specification, two embodiments of my invention are disclosed to illustrate the principles involved therein. One of these embodiments is a reproducer for vertically cut records, and the other, a reproducer for laterally cut records.

The devices shown herein as illustrative of my invention, may be generally described as a system comprising, first, a pair of relatively movable spaced plates separated by a viscous fluid and so designed as to spacing and area that the principal reaction to relative movement of the plates is one of viscosity, wherein the force opposing the impressed motion is directly proportional to the velocity of the motion; second, a stylus or other means arranged to transfer the vibrations engraved in a phonographic record or other mechanical vibrations to one of the above mentioned spaced plates; and, third, a translating medium having a movable element which is connected to the other one of the above mentioned pair of spaced plates and which is so designed that its chief mechanical impedance over the range of frequencies to be reproduced, is one of compliance. If, then, a vibration is impressed by the stylus or other vibration transferring means upon the associated plate, a force proportional to the velocity of the vibration will be transmitted to the other plate. The latter plate is connected to the said movable element of the translating medium, the principal reaction of which part, over the range of frequencies of interest, is one of compliance. Since a force applied to a compliance will result in a displacement directly proportional to the force, it is obvious that when a constant sinusoidal velocity is applied to the stylus a constant sinusoidal amplitude of motion in the said movable element of the translating medium will result. If the translating medium, therefore, is one of a type which produces a voltage proportional to its amplitude only, it will produce a voltage proportional to the velocity of the stylus or other vibration transferring means.

For a clearer understanding of my invention, reference may be had to the drawings accompanying and forming part of this specification, wherein:

Figure 1 is an elevational view, with parts broken away, of one form of my invention as embodied in a reproducer for vertical cut records;

Fig. 2 is a section taken on the line 2—2 of Fig. 1;

Fig. 3 is a rear view, partly in section, of the translating unit shown in Fig. 1, a schematic diagram of the circuit employed with the unit also being shown;

Fig. 4 is a front view, partly broken away, of the translating unit shown in Fig. 1;

Fig. 5 is a sectional view of the translating unit shown in Fig. 1 with the cover removed;

Fig. 6 is the equivalent electrical circuit of the mechanical vibratory system of the translating unit shown in Fig. 1;

Fig. 7 is a plan view of another form of my invention as embodied in a reproducer for lateral cut records;

Fig. 8 is a plan view, partly broken away, of the translating unit shown in Fig. 7;

Fig. 9 is a longitudinal vertical sectional view of the translating unit shown in Fig. 7; and

Fig. 10 is a fragmental side view of the reproducer shown in Fig. 7.

In Fig. 1, one form of my improved translating unit is shown as embodied in a reproducer applied to a dictating machine having an arm 1 adapted to be fed transversely across a cylindrical record 2 by means of a feed screw or other suitable mechanism (not shown). The arm 1 is provided with an opening 3 in which the reproducer is suspended. At its outer end, the arm 1 has a bifurcated projecting lug 4. A bracket 5 is pivotally mounted within the fork of the lug 4 by means of a pin 6. Bracket 5 has a U-shaped projection of which the upper arm is suitably drilled to receive the upper conical end of a short shaft 7 fixedly mounted in a block 7' which is secured to a mounting bracket 8'. A lower pivot

bearing for the shaft 7 is formed in a set screw (not shown) threaded in the lower arm of the U-shaped bracket 5 and held in place by a lock nut 9, so that the pressure on the pivots may be adjusted.

A base plate 8 is secured to the mounting bracket 8' and serves as a support for the parts of the reproducer. A granular carbon cell of well known construction is mounted on the base plate 8 by means of a bracket 11 which is held in place by a screw 17 threaded into the base plate. The granular carbon cell comprises a cup 10 secured to the bracket 11 by a screw 12 and a nut 14 which are insulated from the bracket and the cup by means of an insulating bushing 16 and an insulating washer 15. The screw 12 is provided at its inner end with a head 13 forming an electrode which may be carbon faced. A terminal 18 is provided for connection to the rear electrode 13. The inside of the cup 10 is insulated by paper or other insulating material 19. A diaphragm 20 is held against and electrically connected to the cup 10 by means of a threaded shouldered annulus 22. A washer 21 of paper is provided between the shoulder of annulus 22 and the diaphragm 20 to clamp the diaphragm firmly. Electrical connection is made to the diaphragm 20 through the cup 10 and a terminal 23 which is insulated from the bracket 11 by a washer 24 of fiber or other insulating material. The interior of the cup 10 is filled slightly more than half-way by carbon granules 25 similar to those in common use for microphones.

To the front of the diaphragm 20 is fastened a small cup 26 which may be secured by soldering or other suitable manner. To the cup 26 is fastened a bent arm 27 of decreasing and circular cross section. The arm 27 and the cup 26 are preferably formed of light thin metal and may be constructed by electroplating on a suitable form with nickel to a thickness of .002 to .003 inch. The lower end of the arm 27 is closed and forms a small flat horizontal plate.

The right hand end of the base plate 8 is provided with a circular opening 28 having a shoulder 29. A diaphragm 31 is mounted within the shouldered opening 28. A washer 30 is disposed on each side of diaphragm 31. This diaphragm is secured in place by a threaded annulus 36 which is screwed into a threaded collar 37. The collar 37 is held in place on the base plate 8 by means of suitable screws 38. A washer or gasket 39 is provided between the collar 37 and the base plate 8. The diaphragm 31 carries a stylus holding member 33 preferably made of a strong alloy of aluminum or magnesium. Stylus holder 33 has a flange 34 bearing against the lower side of the diaphragm and an upwardly extending portion (not shown) which is secured to a washer 35 on the upper side of the diaphragm. A gap 40, which in this case is of the order of .010'' in thickness is formed between the upper side of the diaphragm and the lower flat end of the arm 27. A stylus 32 is provided for engagement with the record groove of the cylinder 2. The cup formed by the annulus 36 and the diaphragm 31 is filled with a suitable liquid 41 of desired viscosity. This liquid may, for example, be composed of a thick vegetable oil and a solvent.

The whole translating unit may be protected by means of a cover 42 which is arranged to make the entire unit oil-tight. A limit pin 43 fastened in the arm 1 cooperates with a V-shaped limit loop 44 on the case 42 in a well known manner so that as the arm 1 is raised, the reproducer is centered and raised from the surface of the record. The terminals 23 and 18 of the granular carbon cell are respectively connected to terminals 45 and 46 in cover 42. The circuit in which the unit is connected, as shown in Fig. 3, is from the terminal 23 to terminal 45, to a battery 47, to the primary of a suitable transformer 48, to terminal 46, and to terminal 18. The secondary of the transformer may be connected to a head phone 49 or to any other desired device for relaying the impulses.

The operation of the device above described is as follows: The stylus 32 is pressed against the record groove on the cylinder 2 by the weight of the translating unit. As the cylinder is revolved the stylus is vibrated in accordance with the depth of the groove and consequently causes the diaphragm 31 to vibrate in the same manner. The vibration of the diaphragm results in a reaction proportional to the velocity of the vibration, due to the viscosity of the fluid disposed within the cup-shaped member 36 and acting in the gap 40 formed by the diaphragm 31 and the adjacent end of the arm 27. The force acting on the end of the arm 27 will, therefore, be proportional to the velocity of the stylus. This vibratory force acting upon the flattened end of the arm 27 tends to move the arm 27 about a horizontal line through the center of the diaphragm 20. As will be seen from Fig. 5, if the force on the end of the arm 27 is in an upward direction the diaphragm 20 will be deflected outwardly below the said central horizontal line and inwardly above such line. If the force on the end of the arm 27 is downward, the opposite action will take place and the lower portion of the diaphragm 20 will be deflected inwardly and the upper portion deflected outwardly. With this arrangement, the carbon granules within the cup 10 will be compressed and relieved in accordance with the motion of the arm 27. It is to be understood that the construction consisting of arm 27 and diaphragm 20 acts as a bell crank or similar structure pivoted on a horizontal line through the center of the diaphragm 20 and that the motion imparted to the diaphragm 20 will have a smaller amplitude than the motion of the lower end of arm 27 by reason of the differences in the lever arms from the center of rotation to the points of application of the force.

Change in pressure on the carbon granules 25 changes the electrical resistance of the path through these granules, and consequently changes the current flowing through the circuit and supplied by the battery 47. The vibratory current generated will be proportional to the displacement of the diaphragm 20. It is to be understood that the mechanical impedance of the structure comprising the diaphragm 20 and its projecting arm 27 is to be made chiefly compliance throughout the band of frequencies to be reproduced. In other words, the effective mass of these parts must be made low enough and the stiffness high enough so that their resonance occurs at or near the highest frequency which is to be reproduced. It is extremely important therefore that the mass of the arm 27 be kept as low and the stiffness thereof as great as possible. The diaphragm 20 should be made of such stiffness that its effective value when viewed from the end of the arm 27 is sufficient to cause resonance with the effective mass of the arm 27 to occur at a frequency near the upper limiting frequency of the system.

Furthermore, it is extremely desirable to hold the mass and the stiffness of the diaphragm 31 to the lowest possible values. In the particular embodiment shown the diaphragm preferably has a free diameter of approximately ½ inch and is preferably formed of aluminum alloy .002" thick. The stylus holding member is formed of one of the strong alloys of aluminum or magnesium and is given the minimum possible dimensions consistent with safety in view of accidental stresses to which it may be subjected. The effective mass of the stylus, stylus holder and diaphragm as described in this embodiment is preferably approximately .012 gram.

In order to operate most effectively, certain limitations must be placed upon the design of the various parts. For best results, it is important that the reaction resulting from the two spaced plates, formed by the diaphragm 31 and the end of the arm 27, with the intervening viscous medium, be proportional to the velocity of the impressed motion only. If the gap is made too small and/or the opposed areas of the plates is too large, the reaction will to some extent be one of compliance, while if the gap is made too large there will be an appreciable mass reaction. However, by properly dimensioning this gap, the reaction can be made substantially proportional to the velocity of motion only. It is furthermore desirable that the impedance of the structure comprising the arm 27 and the diaphragm 20 be higher than the impedance of the pair of spaced plates with the intervening viscous fluid at all frequencies which are to be reproduced. If this is not true, the reaction of the spaced plates and the interposed fluid will not control the motion of the diaphragm 20 as described above, and the response of the device to different frequencies will not be uniform.

The operation of the device above described may also be explained by using the electrical analogs of the various parts comprising the structure. Fig. 6 shows an electrical circuit which is equivalent to the mechanical structure of the translating unit of Fig. 1. In this figure the capacity $c1$ represents the compliance of the record groove; the inductance $m1$ represents the effective mass of the stylus, stylus holder and diaphragm; the capacity $c2$ represents the compliance of the diaphragm 31; the resistance R represents the impedance of the two spaced plates formed by the diaphragm 31 and the lower end of arm 27 with the intervening viscous fluid; the inductance $m2$ represents the effective mass of the arm 27 and the diaphragm 20 as viewed from the lower end of arm 27; and the capacity $c3$ represents the compliance of the diaphragm 20 as viewed from the lower end of the arm 27. It will be understood that the mechanical structure of the arm 27 with the diaphragm 20 is equivalent to an electrical transformer which is not shown, but which does not affect the frequency characteristic of the unit. In the above description, therefore, by the effective values of the inductance $m2$ and the compliance $c3$ are meant the values as seen on the primary side of such a transformer. Now it may be considered that the record is sending an alternating current of constant amplitude through the network at all frequencies of interest. If the impedance of the circuit through the inductance $m1$, the capacity $c2$, and the resistance R, is made lower at all frequencies of interest than the impedance of the path through the inductance $m1$, the capacity $c2$, the inductance $m2$, and capacity $c3$ or the circuit through the capacity $c1$, most of the current flowing into the network will flow through the resistance R. Since this current is assumed of constant amplitude, the voltage across the resistance R will be of constant amplitude throughout the range of frequencies. The voltage of constant amplitude across the resistance R is therefore applied across the inductance $m2$ and the capacity $c3$. Since the capacity $c3$ is made to have a higher impedance at all frequencies of interest than the inductance $m2$, it is the limiting impedance in this branch circuit and in consequence the amplitude of the current flowing through this circuit will be principally determined by it. The impedance of a capacity decreases with frequency and in consequence the amplitude of the current through this branch circuit will increase in proportion to the frequency of the applied voltage. If we have a current flowing through a condenser which has an amplitude proportional to the frequency we may define the current mathematically as

$$i=A\cdot\omega \sin \omega t$$

where A is a constant and ω is 2π times the frequency. If then we integrate i with respect to t, we will obtain Q, the charge. Then

$$Q=\int i dt=-A \cos \omega t$$

Now the charge in an electrical circuit is analogous to displacement in a mechanical system and from the above equation it is obvious that the amplitude of the displacement of the diaphragm 20 is independent of the applied frequency and constant under the conditions described above where a vibration having a velocity of constant amplitude is applied to the stylus.

Figs. 7 to 10 show a modification of my invention indicating in a general form the application thereof to a reproducer for laterally cut disc records. A disc record 61 is carried on a rotatable turntable 60. An arm 62 mounted on a vertical pivot (not shown) is provided for supporting the reproducer. The reproducer comprises a casing 63 which is suitably fixed to the arm 62. At its left hand end the casing 63 is threaded to receive a flanged ring 64. On its lower side the ring 64 is provided with two lugs 65 and 66. A small light shaft 68 is pivoted between the lugs 65 and 66. The lug 65 is provided with a cone bearing surface and the lug 66 is provided with a screw 71 drilled to accept the conical end of the short shaft 68, thus allowing adjustment of the pressure on the pivots. A nut 72 is provided to lock the screw 71 in desired position. The short shaft 68 is drilled vertically to receive a stylus 67. It is also drilled and threaded axially to receive a stylus holding screw 70 which locks the stylus 67 rigidly in place. At its upper end the stylus 67 coacts with a V-shaped notch 73 in a light hollow cylindrical member 69. Member 69 may be riveted or otherwise suitably fastened to a diaphragm 74. The diaphragm 74 is held in place by the flanged ring 64 and a shouldered cylindrical member 75. A washer 76 is provided between the diaphragm 74 and the member 75 to securely hold the diaphragm and to render the construction oil-tight. At its right hand enlarged end, the cylindrical member 75 is threaded to receive a cup 77 of a granular carbon cell. A diaphragm 78 is clamped tightly in place between the cup 77 and the shoulder of member 75, as shown in Fig. 9. A soft washer 79 is provided between the diaphragm 78 and the member

75 to clamp the diaphragm evenly around its periphery and to provide an oil-tight joint. A tapering cup-shaped member 80 is fastened to the front of the diaphragm 78 by means of a small attachment member 81 which may be soldered or otherwise fastened to the diaphragm 78 and said member 80. The flat end of the member 80 is placed opposite the center of the diaphragm 74 and is spaced about .010 inch away. The space between the diaphragms 74 and 78 is partially filled with a viscous material as described hereinbefore. The two spaced plates, formed by the end of member 80 and the opposed portion of diaphragm 74, together with the intervening viscous material, serve as a means of transmission of the vibrations from the stylus to the granular carbon cell. The construction of the granular carbon cell is similar to that previously described hereinbefore and comprises a threaded stud 85 having a head 84 constituting a rear electrode, internal insulation 92 within the cup 77, carbon granules 83, terminals 86 and 87, a flanged insulating bushing 88, and a nut 89. Connections to the granular carbon cell are brought out through a two conductor cable 90 fastened in an insulating bushing 91 in casing 63.

The operation of this reproducer for lateral cut records is equivalent to that of the reproducer for vertical cut records previously described. The only substantial difference in the operation is that the diaphragm of the carbon cell has the same amplitude of vibration as the driven plate formed by the ends of the member 89, whereas, in the previous case, a step-down leverage was used so that the amplitude of vibration of the diaphragm was less than the amplitude of the plate formed on the lower end of the arm 27. In this case also the applied forces tend to move the diaphragm as a whole, that is, these forces on the diaphragm tend to translate it rather than to rotate it. The equivalent electrical circuit of Fig. 6 may also be applied to this form of reproducer wherein the capacity $c1$ represents the compliance of the record groove; the inductance $m1$ represents the combined effective mass of the stylus 67, the shaft 68, the projecting member 69, and the diaphragm 74; the capacity $c2$ represents the compliance of the diaphragm 74; the resistance R represents the impedance of the two spaced plates formed by the diaphragm 74 and the opposed end of the member 80 with the intervening viscous fluid; the inductance $m2$ represents the effective mass of the member 80 and the diaphragm 78, and the capacity $c3$ represents the compliance of the diaphragm 78. It is to be understood that the various limitations applied to the design of the reproducer for vertical cut records previously described should preferably be applied to the design of this reproducer.

The structures hereinbefore described for transmitting vibrations from sound records to the translating medium may also be applied to many other forms of translating mediums than the granular carbon cell. It is well known that there are other forms of translating mediums wherein the voltage produced is independent of the velocity of motion and depends only upon the amplitude of the vibrations. Any of these devices therefore are applicable for use in this type of reproducer and may be substituted for the granular carbon cell of the embodiments described herein. As examples of other devices which might be substituted for the granular carbon cell, I may mention the condenser and the piezo-electric crystal. Any such device may replace the granular carbon cell as shown herein without departure from my invention.

Since in any case the mass and the stiffness of all the moving parts in the system have very low effective values, the input impedance of the translating unit will be very low and in consequence in the case of a phonograph reproducer there will be very little destruction of the walls of the record grooves. Consequently those forms of my invention specifically disclosed herein are particularly applicable for reproducing records engraved on wax wherein the stiffness of the record walls is very small. Furthermore, because of the high sensitivity of the granular carbon cell as a translating medium, the sensitivity of these translating units has been found under equivalent conditions to be very much higher than a similar device using electro-magnetic translating medium and having approximately the same input impedance.

The value of the resistance R may vary considerably due to changes in viscosity of the fluid used and to expansion or contraction of the metallic parts of the translating unit. However, such variations will not greatly affect the frequency characteristics of the device if the limitations set forth herein are conservatively met. Such changes, however, will somewhat affect the sensitivity of the unit but sensitivity changes can be readily compensated and are therefore usually unimportant. If it is so desired, any of a number of various arrangements may be employed for compensating for the change in viscosity or the change in dimensions of the parts. Such compensating arrangements are disclosed in prior art relating to damping devices and are not therefore described herein.

Having thus described my invention, I claim:

1. A device for translating mechanical vibrations into corresponding electrical current comprising a member for receiving mechanical vibrations, translating means having a movable element, said means having an output voltage proportional to the displacement of said movable element, and transmitting means between said member and said movable element for vibrating the latter with a sinusoidal displacement of constant amplitude over a range of frequencies when said member receives a sinusoidal vibration having constant maximum cyclic velocity.

2. In a device for translating mechanical vibrations into corresponding electrical currents, a vibration receiving member, and transmitting means actuatable by said member, which means is adapted to transmit sinusoidal force of constant amplitude over a range of audio frequencies when said member receives sinusoidal vibrations having constant maximum cyclic velocity.

3. In a translating device, vibration receiving means, translating means comprising a movable element and having an output voltage proportional to the displacement of said element, and means for transmitting vibrations from said receiving means to said element, said transmitting means having a force reaction directly proportional to the velocity only of the vibrations impressed thereon.

4. An electrical phonographic reproducer comprising a vibration receiving member, means cooperative with said member and consisting of a substantially pure mechanical resistance for transmitting vibratory forces, and translating means having a movable element to receive said vibratory forces and having an impedance higher

than that of said transmitting means over most of the range of frequencies to be reproduced.

5. An electrical phonographic reproducer comprising a stylus for engagement with a record groove, a member resiliently supporting said stylus, translating means having a movable element, and transmitting means between said member and said element, said transmitting means impressing forces on said element proportional to the velocity of said member when the member is driven at sound frequencies.

6. An electrical phonographic reproducer comprising a stylus for engagement with a record groove, a member resiliently supporting said stylus, translating means comprising a movable element and having an output voltage proportional to the displacement of said movable element, and transmitting means between said member and said element, said transmitting means impressing forces on said element proportional to the velocity of said member.

7. A translating unit comprising vibration receiving means including a vibratile member, a translating medium having a movable element, and transmitting means between said member and said element, said transmitting means impressing forces on said element proportional to the velocity of said member when the member is driven at sound frequencies.

8. A translating unit comprising vibration receiving means, translating means having a movable element and having an output voltage proportional to the displacement of said movable element, and transmitting means between said receiving means and said translating means, said transmitting means displacing said element in proportion to the velocity of said receiving means.

9. An audio frequency translating unit comprising resilient vibration receiving means, translating means having a movable element, and transmitting means between said receiving means and said translating means having a gap filled with viscous material, said gap being bounded on one side by a portion of said receiving means and on the other side by a portion of said movable element, said portions being arranged to coact with said viscous material to form a mechanical impedance comprising chiefly resistance, said resistance having a smaller value than the impedance of said movable element over most of the range of frequencies to be transmitted.

10. A translating device comprising resilient vibration receiving means, a granular carbon cell having a movable electrode, and transmitting means between said receiving means and said cell, said transmitting means displacing said electrode in proportion to the velocity of said vibration receiving means.

11. In a translating unit, resilient vibration receiving means, a granular carbon cell having a movable element comprising an electrode, and transmitting means between said receiving means and said element having a gap filled with viscous material, said gap being bounded on one side by a portion of said receiving means and on the other side by a portion of said element, said portions being arranged to coact with said viscous material to form a mechanical impedance comprising chiefly resistance.

12. In an electrical phonographic reproducer, a resilient member, a stylus having connection with said member, a granular carbon cell having a movable element, and transmitting means between said member and said element having a gap filled with viscous material, said gap being bounded on one side by a portion of said diaphragm and on the other side by a portion of said element, said portions being arranged to coact with said viscous material to form a mechanical impedance comprising chiefly resistance.

13. An electrical phonographic reproducer comprising a stylus, a translating medium having a movable element, transmitting means having a smaller mechanical impedance than said element over most of the range of frequencies to be reproduced and comprising a pair of relatively movable spaced plates, the space between said plates being filled with viscous material, said spaced plates being arranged to coact with said viscous material to form a mechanical impedance due principally to the viscosity of said material, one of said spaced plates being connected to said movable element, and means to transmit vibrations from said stylus to the other plate.

14. In a translating unit, vibration receiving means, a movable element, and a coupling means therebetween which when actuated by vibrations having a constant maximum cyclic velocity characteristic, produces vibrations in said element having a constant maximum cyclic amplitude characteristic.

15. A phonographic roproducer comprising a diaphragm, a stylus connected with said diaphragm, a granular carbon cell having a vibratable diaphragm, a light, stiff arm fastened to the latter diaphragm and having an end portion opposed to and spaced from said first named diaphragm, said arm rocking said carbon cell diaphragm about a diameter thereof when force is applied to said end portion, and viscous material filling the space between said end portion and the opposed diaphragm.

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