July 1, 1947. C. M. SINNETT 2,423,208

ELECTROSTATIC PICKUP

Filed May 30, 1944

Fig. 1.

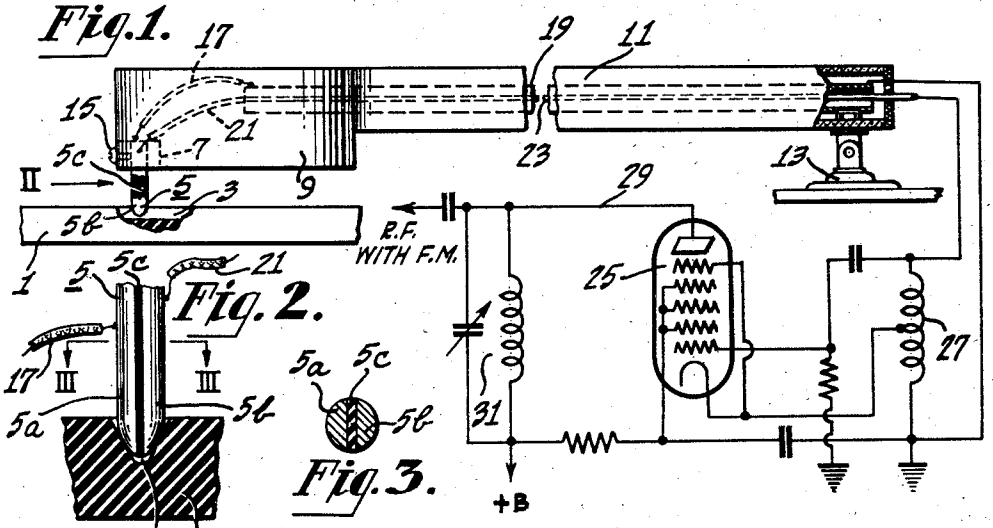

Fig. 2.

Fig. 3.

Fig. 4.

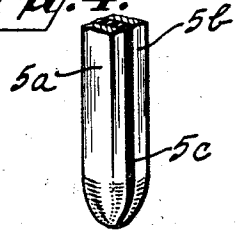

Fig. 8.

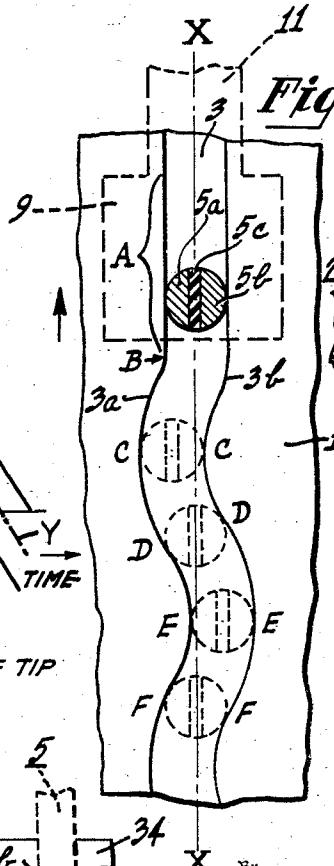

Fig. 5.

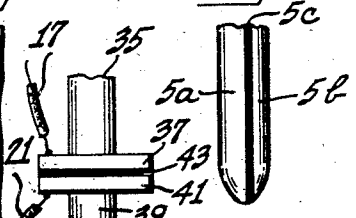

Fig. 11.

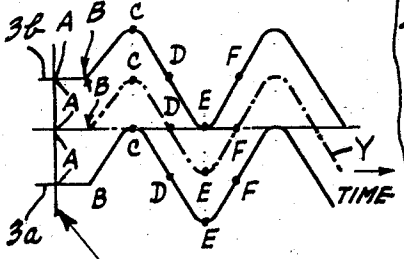

Fig. 9.

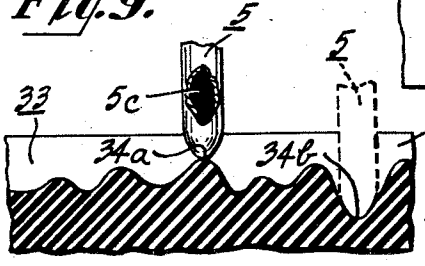

Fig. 10.

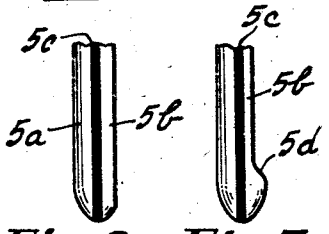

Fig. 6. Fig. 7.

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2,423,208

ELECTROSTATIC PICKUP

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Application May 30, 1944, Serial No. 538,072

19 Claims. (Cl. 179—100.41)

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This invention relates to signal translating apparatus, and more particularly to a signal translating device of the capacity type suitably for use especially in connection with phonograph records.

In my copending application Serial No. 459,375, filed September 23, 1942, I have disclosed a phonograph reproducing system employing a capacity type pickup which is used in modulating an oscillator the output of which is applied to a suitable discriminator for the purpose of providing frequency modulated signals corresponding to the signals to be reproduced. The frequency modulated signals may be detected in any suitable manner to provide amplitude modulated signals which may be amplified and applied to a loudspeaker for reconversion into sound. The particular pickup device illustrated in my aforesaid copending application may be of the type more particularly disclosed and claimed in my copending applications Serial No. 414,305, filed October 9, 1941, now Patent No. 2,376,456, dated May 22, 1945, and Serial No. 528,840, filed March 31, 1944. In each of these devices, I employ a stationary electrode and a movable electrode associated therewith in a manner to provide a capacitor, the record groove engaging needle being connected to the movable electrode. Such pickup devices provide very satisfactory results. I have found, however, that it is not necessary to provide a capacitor unit separate and apart from the record engaging needle but that, on the contrary, the capacitor may be advantageously embodied in the needle itself, and the primary object of my present invention, therefore, is to provide an improved capacity type pickup device which is of the utmost simplicity in construction and which involves a minimum number of parts.

More particularly, it is an object of my present invention to provide an improved phonograph record needle which can be used either in conventional manner with existing pickup devices for reproduction of sound from records in well known manner, or which can be utilized by itself as a capacity device in a system of the type disclosed in my aforementioned copending application Serial No. 459,375, filed September 23, 1942.

Another object of my present invention is to provide an improved capacity type pickup device for use with phonograph records which will provide reproduction with a minimum amount of distortion.

Still another object of my present invention

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is to provide an improved capacity type pickup as above set forth in which the mass of the moving parts is extremely low.

It is also an object of my present invention to provide an improved pickup device and needle of the character set forth which is sturdy in construction, exceedingly economical in cost, highly efficient in action, and which will have a long life.

In accordance with my present invention, I form the record reproducing needle or stylus as a capacitor which has a record engaging tip and which will itself cause the generation of signal voltages upon vibration thereof in response to a modulated record groove without requiring any additional electrodes. The needle may be made by splitting a conventional metallic needle in half longitudinally and interposing between the two halves a strip of dielectrical material. In another form of my present invention, the needle may be formed of a pair of flat strips of material which are more or less flexible longitudinally but which should be resilient so that they will restore themselves to the original form after being bent or flexed by an external force. The two strips are separated by a sheet of dielectric material, as in the case of the split needle, and one end of the capacitor so formed is suitably shaped to provide a tip which will cooperate with a record groove. The strip of dielectric material may be disposed longitudinally of the needle along the axis thereof, or, for reasons hereinafter pointed out more fully, it may be disposed to one side of the axis so as to provide conductive elements for the capacitor needle one of which is stiffer than the other. According to another embodiment of my present invention, the needle may be formed of two longitudinally separated parts with the dielectric member extending transversely across the needle, this form of the invention being suitable for reproduction from a hill and dale record. In any case, no additional electrodes are required when a needle according to my present invention is employed, so that the mass of the moving parts is reduced to a minimum. This permits exceedingly light needle pressure, thereby insuring longer life for the records.

The novel features that I consider characteristic of my present invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description of

several embodiments thereof when read in connection with the accompanying drawing, in which

Figure 1 shows a sound reproducing system employing a novel capacitor needle according to my present invention, a portion of the needle being broken away for the sake of clearness,

Figure 2 is an enlarged, front elevation of the needle as viewed in the direction of the arrow II of Fig. 1,

Figure 3 is a sectional view thereof taken on the line III—III of Fig. 2,

Figure 4 is a perspective view of a somewhat modified form of capacitor needle according to my present invention,

Figures 5, 6 and 7 are views corresponding to Fig. 2 of still other forms of my present invention,

Figure 8 is an enlarged, fragmentary view of a record with a modulated groove and a stylus or needle according to my present invention positioned therein, this view being referred to hereinafter for the purpose of explaining the manner in which the present invention operates,

Figure 9 is a graph illustrating the manner in which the record groove of Fig. 8 operates upon my novel capacitor needle,

Figure 10 is a fragmentary view similar to Fig. 1 but showing the needle of my present invention in cooperation with a record of the hill and dale variety, and

Figure 11 is a view of another form of needle according to the present invention suitable for use with a hill and dale record.

Referring more particularly to the drawing, wherein similar reference characters designate corresponding parts throughout, there is shown, in Fig. 1, a phonograph record 1 having a laterally cut groove 3 therein in which is disposed a needle 5 according to my present invention. In appearance, the needle 5 may be generally quite similar to conventional phonograph record reproducing needles. The needle 5 comprises a pair of electroconductive members 5*a* and 5*b* which may be formed, for example, by splitting a metallic needle centrally or axially along its length. Disposed between and in engagement with the needle portions 5*a* and 5*b* is a strip of dielectric material 5*c*, which may be of mica, rubber, or any other suitable material, but preferably one which is compressible and which is resilient enough to flex more or less freely along its length. The conductive portions 5*a* and 5*b* are also more or less resilient so that they will flex transversely along the length of the needle shank and will resume their normal positions when a distorting force which has been applied thereto is removed. Since the needle portions 5*a* and 5*b* are electroconductive and they are separated by a dielectric strip 5*c*, it is apparent that the needle 5 constitutes a capacitor.

The needle 5 may be mounted in a block 7 of insulating material carried by a head 9 forming part of a pickup arm 11 which is pivotally mounted on a mounting member 13 for swinging movement over the record 1 in well known manner. The needle 5 may be removably secured in place in the block 7 by a screw 15, or it may be permanently set therein by cement or the like. One conductive portion of the needle 5 (for example, the portion 5*a*) is connected by a lead 17 to one conductor 19 of a concentric transmission line, the other conductive portion 5*b* of the needle being connected by a lead 21 to the other conductor 23 of the transmission line. The voltages generated by the capacitor needle 5 during cooperation with the record groove 3 in a manner to be more fully described hereinafter may be utilized to control the frequency of any tuned circuit and finds its particular application in modulating an oscillator in any suitable phonograph reproducing circuit, such as those more particularly disclosed and claimed in my above identified copending application Serial No. 459,375. By way of illustration, reference is made to Fig. 1, wherein the capacitor needle 5 is connected through the transmission line 19, 23 to an oscillator comprising a suitable oscillator tube 25 provided with an oscillator tuning inductance 27. The capacitor needle 5 is shunted across the inductance 27. The output circuit 29 of the oscillator tube 25 is provided with a tuned circuit 31 which may be tuned to resonance with the desired oscillation mid-frequency. The variation of the capacity of the needle 5 will cause the oscillation frequency to vary above and below the normal or mid-frequency, thereby resulting in a frequency modulated signal which is delivered to a suitable output circuit and may be utilized in any manner, as to operate a loudspeaker or the like (not shown).

For a clear understanding of the manner in which voltages are generated by the needle 5, reference is made to Fig. 8. Here, the groove 3 of the record is of the laterally undulating type and is shown as having an unmodulated region A followed by a modulated region B, C, D, E, F. By reason of the mass and inertia of the pickup arm 11, its head 9 and the parts carried thereby, the needle 5 tends to remain in a neutral or mid position in the groove 3 represented by the center line X, X. As long as the needle 5 is in the unmodulated portion A of the groove 3, it will remain with its axis along the center line X, X. As soon, however, as the point B of the groove 3 reaches the needle 5 upon movement of the record 1 relative to the needle in the direction of the appended arrow in Fig. 8, the side wall 3*b* of the groove 3 will exert a pressure on the needle 5 tending to move it to the left, as shown in Fig. 8. The needle portion 5*a* tends to remain stationary due to the inertia of the arm 11 and the parts carried thereby, as a result of which the needle portion 5*b* is pressed against the dielectric portion 5*c* relative to the needle portion 5*a* to thereby compress the dielectric layer 5*c* and increase the capacitance of the needle capacitor. This continues until the point of maximum modulation C has reached the needle. From the point C to the point E, the side wall 3*b* of the groove recedes from and the side wall 3*a* approaches the center line X, X. As a result, the side wall 3*a* of the groove 3 takes up the work upon the needle and gradually forces it back to the neutral or mean position D. During this time, the pressure on the needle portion 5*b* is relieved so that the capacitance of the capacitor is decreased. From the point D to point E, at the latter of which the excursion of the needle to the right has reached a maximum point, the side wall 3*a* of the groove exerts pressure on the needle portion 5*a*, and since the needle portion 5*b* now tends to remain stationary due to the inertia of the moving parts, it is apparent that the needle portion 5*a* will be pressed against the dielectric layer 5*c* to again compress the latter in accordance with the groove modulation. From the point E to the point F of the groove, the action is similar to the action between the points C and D thereof, but in the reverse direction. This brings the needle back to the position it occupied at the point B and completes one whole cycle.

Fig. 9 illustrates graphically the pressure on

the needle tip along the various portions of the groove. It will be noted that along the groove portion A, the pressure by the groove walls **3***a* and **3***b* is equal and opposite. When the point B is reached, pressure by the wall portion **3***b* is increased on the needle portion **5***b*, while pressure by the groove wall **3***a* is correspondingly decreased. These respective pressure variations continue until the point C of maximum pressure on the needle portion **5***b* and minimum pressure on the needle portion **5***a* has been reached. As the groove moves on under the needle from the point C to the point E, the pressure by the groove wall **3***b* is gradually decreased while that of the groove wall **3***a* is gradually increased through the neutral or mid position D and then on to the position E at which the pressure exerted by the groove wall **3***a* is a maximum while that of the groove wall **3***b* is a minimum. From the point E to the point F, pressure exerted by the groove wall **3***b* is again gradually increased while that of the groove wall **3***a* is gradually decreased, and thus the cycle continues. The average pressure to which the dielectric members **5***c* is subjected during the cycle is represented by the dot-and-dash line Y in Fig 9.

In Fig. 4, I have shown a somewhat modified form of needle in accordance with my present invention. The needle of Figs. 1 to 3 is cylindrical in cross-section and may be formed by splitting a metallic needle longitudinally in half and cementing between the two halves the layer of dielectric material **5***c*. In the needle of Fig. 4, the two conductive needle portions **5***a* and **5***b* are made of flat, resilient strips with the needle engaging tip thereof suitably rounded off for cooperation with the record groove **3**. The needles thus far described may have an over-all diameter or thickness of about .020 inch, their dielectric strips may be about .002 to .004 inch thick, and their record engaging tips may have a radius of about .004 inch. The conductive portions **5***a* and **5***b* may be made of any suitable material, such as steel, tungsten, various alloys which are specially desirable because of their hardness while having longitudinal flexibility so that the needle portions **5***a* and **5***b* can flex transversely along their lengths upon actuation by the groove **3**, and the dielectric material **5***c* may be made of any suitable material, such as mica, rubber, or the like. In one particular construction, the layer **5***c* was made of rubber dam of about 2 or 3 mils thickness. It is desirable that the dielectric material **5***c* be fairly compressible, and when the needle is first inserted into the groove, the side walls of the groove initially press the conductive portions **5***a* and **5***b* toward each other somewhat to give the layer **5***c* an initial compression.

In the forms of my invention thus far described, where each of the conductive portions **5***a* and **5***b* has the same thickness in a direction transversely of the groove **3**, the voltage generated by the needle will be largely the second harmonic of the fundamental frequency of the modulated groove. This will be apparent from an inspection of Fig. 9. To overcome this, the needle may be formed as shown in Figs. 5, 6 and 7. The needle of Fig. 5 is similar to that of Figs. 1 to 3 with the exception that, instead of disposing the dielectric layer **5***c* longitudinally along the axis of the needle, the layer **5***c* is disposed to one side of the axis. Thus, in the form of my invention shown in Fig. 5, the conductive portion **5***a* is thicker and therefore stiffer at the shank than the conductive portion **5***b*. This has the effect of shifting the curves to

one side of the abscissa of Fig. 9 (this effect being similar to that of placing an initial polarizing or biasing force on a diaphragm in a magnetic type telephone receiver) and thereby doing away with the second harmonic.

In the modification shown in Fig. 6, the dielectric layer **5***c* is retained along the axis of the needle. However, in order to render the shank of the portion **5***b* less stiff than the portion **5***a*, it is made thinner than the latter portion. By making the conductive needle portion **5***b* thinner than the portion **5***a* as in Fig. 6, it may be necessary to reduce the length of the record engaging tip on the portion **5***b*, which, in some cases, may be undesirable. To avoid this, the construction of Fig. 7 may be employed. In the latter form of my invention, the needle tip is retained in full, as in Figs. 1 to 5, but the portion **5***b* is reduced along a shoulder **5***d* immediately above the needle tip to thereby reduce the over-all thickness of the needle shank transversely across the needle in the direction normal to the plane of the dielectric portion **5***c* to a dimension which is smaller than the maximum dimension of the needle tip. In needles formed as shown in Figs. 5, 6 and 7, the thicker conductive portion **5***a* may be .012 inch thick, the thinner conductive portion **5***b* may be .005 inch thick, and the dielectric strip **5***c* may be about .003 inch thick.

The modifications of my invention thus far described are particularly useful in connection with a record having a laterally undulating, modulated groove. The same needles may, however, also be employed with a hill and dale record, as illustrated in Fig. 10. Here, the record **33** is shown with a vertically modulated groove **34**. It is apparent that when the needle **5** rests on the groove portion **34***a* of minimum depth, it is surrounded by much less dielectric material of the record than when it is resting in a portion **34***b* of the groove of greater depth. Since the capacity of the capacitor needle will be determined not only by the amount of dielectric material **5***c* between its conductive portions **5***a* and **5***b* but also by the amount of dielectric material of the record **33** which surrounds the portions **5***a* and **5***b*, it is apparent that penetration of the needle **5** more or less into the record **33** will cause its capacitance to vary. Thus, changes in capacity will be set up thereby corresponding to the modulations of the groove **34**, and these capacity variations may be utilized as above described.

Fig. 11 shows another form of needle which may be employed with a hill and dale record. In this form of my invention, the needle comprises a shank portion **35** terminating in a plate **37** and a lower portion **39** also having a plate **41** at its upper end and terminating in a record engaging tip **39***a* at its lower end. The plate members **37** and **41** are of conductive material, while the shank **35** and the portion **39** may or may not be of conductive material, as may be found most suitable. Thus, for example, the needle portion **39** may be made of sapphire or other material which has long life but which is not necessarily conductive. Between the conductive members **37** and **41**, there is disposed a dielectric layer **43** of any suitable material. The shank **35** and the portion **39** are preferably axially aligned, and the dielectric layer **43** may be secured to each of the conductive members **37** and **41** by cement or the like. As the needle tip **39***a* rides in the groove **34**, pressure variations are applied thereto by the modulated groove to thereby variably compress the dielectric layer **43**, since the needle portion **35** and its

flange 37 tend to remain stationary in a vertical direction by reason of the mass and inertia of the moving parts. As in the case of the modification of Fig. 1, the conductive needle portions 37 and 41 may be connected, respectively, by the leads 17 and 21 to the transmission line 19, 23.

From the foregoing description, it will be apparent that I have provided a novel electrical sound reproducing device which employs no other parts than the needle itself for generating the signal voltages. This permits making the mass of the moving system and the pressure on the record a minimum, thereby insuring longer record life.

Although I have shown and described a number of modifications of my present invention, it will undoubtedly be apparent to those skilled in the art that many other variations thereof are possible. I therefore desire that my invention shall not be limited except insofar as is made necessary by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. An electrical signal translating device comprising a pair of electroconductive members each adapted to simultaneously engage and cooperate with a phonograph record groove, and a dielectric member separating said first named members.

2. An electrical signal translating device comprising a pair of electroconductive members each terminating in a tip adapted to engage and cooperate with a phonograph record groove simultaneously with the other tip, and a dielectric member separating said first named members.

3. An electrical signal translating device comprising a support, and a capacitor having a pair of electrodes both of which are vibratively carried by said support, said capacitor terminating in an integral tip adapted to be received in a phonograph record groove for cooperation therewith.

4. An electrical signal translating device comprising a support, and a phonograph needle vibratively carried by said support, said needle comprising a pair of electroconductive portions and a dielectric portion interposed between said conductive portions to thereby constitute a capacitor, said portions being movable relative to each other upon vibration of said needle in response to a record groove whereby to vary the capacity of said capacitor.

5. An electrical signal translating device comprising a support, and a phonograph needle vibratively carried by said support, said needle comprising a pair of electroconductive portions and a compressible dielectric portion interposed between and in contact with each of said conductive portions to thereby constitute a capacitor, said conductive portions being movable relative to each other upon vibration of said needle in response to a record groove to thereby more or less compress said dielectric portion and thereby vary the capacity of said capacitor.

6. A signal translating device according to claim 5 wherein said conductive portions have different stiffnesses.

7. A signal translating device according to claim 5 wherein one of said conductive portions is thinner than the other.

8. A signal translating device according to claim 5 wherein said dielectric portion is disposed longitudinally along said needle.

9. A signal translating device according to claim 5 wherein said electroconductive portions and said dielectric portion are integrally united and wherein said dielectric portion is disposed at an angle to the axis of said needle.

10. A phonograph record needle comprising a capacitor having a pair of longitudinally flexible, electroconductive members and a similarly flexible dielectric member interposed therebetween, said members being shaped at one end of the needle for cooperation with a record groove.

11. A phonograph record needle according to claim 10 wherein said dielectric member is constituted of a compressible material.

12. A phonograph record needle comprising a capacitor having a pair of electroconductive members which are resilient transversely along the length of the shank portion of the needle and a similarly resilient dielectric member interposed therebetween, said members being shaped at one end of the needle for cooperation with a record groove.

13. A phonograph record needle according to claim 12 wherein said conductive members have different stiffnesses along the shank portion.

14. A phonograph record needle according to claim 12 wherein said dielectric member extends longitudinally along the axis of said needle.

15. A phonograph record needle according to claim 12 wherein said dielectric member extends longitudinally along said needle to one side of the axis thereof.

16. A phonograph record needle according to claim 12 wherein said record groove cooperating portion is of tapered configuration, and characterized further in that said tapered end has a maximum diameter which is greater than the cross-sectional dimension of the shank of said needle in at least one direction.

17. A phonograph needle comprising a capacitor having a pair of electroconductive members spaced from each other longitudinally of said needle, and a dielectric member separating said conductive members, one of said conductive members being shaped at its free end for cooperation with a record groove.

18. A phonograph record needle having a shank of electroconductive material and a tip for cooperation with a record groove, said shank being constituted by two parts in spaced relation to each other, and a member of dielectric material interposed between and maintaining said shank parts in said spaced relation, said shank parts and said dielectric member together constituting a capacitor.

19. A phonograph record needle comprising a pair of electrodes and a dielectric therebetween whereby to constitute a capacitor, said electrodes both having portions adapted to engage and ride in a record groove.

CHESTER M. SINNETT.

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