May 28, 1946. H. E. ROYS 2,400,953

METHOD OF AND SYSTEM FOR RECORDING AUDIO FREQUENCY WAVES

Filed Sept. 13, 1943 2 Sheets-Sheet 1

Fig. 1.

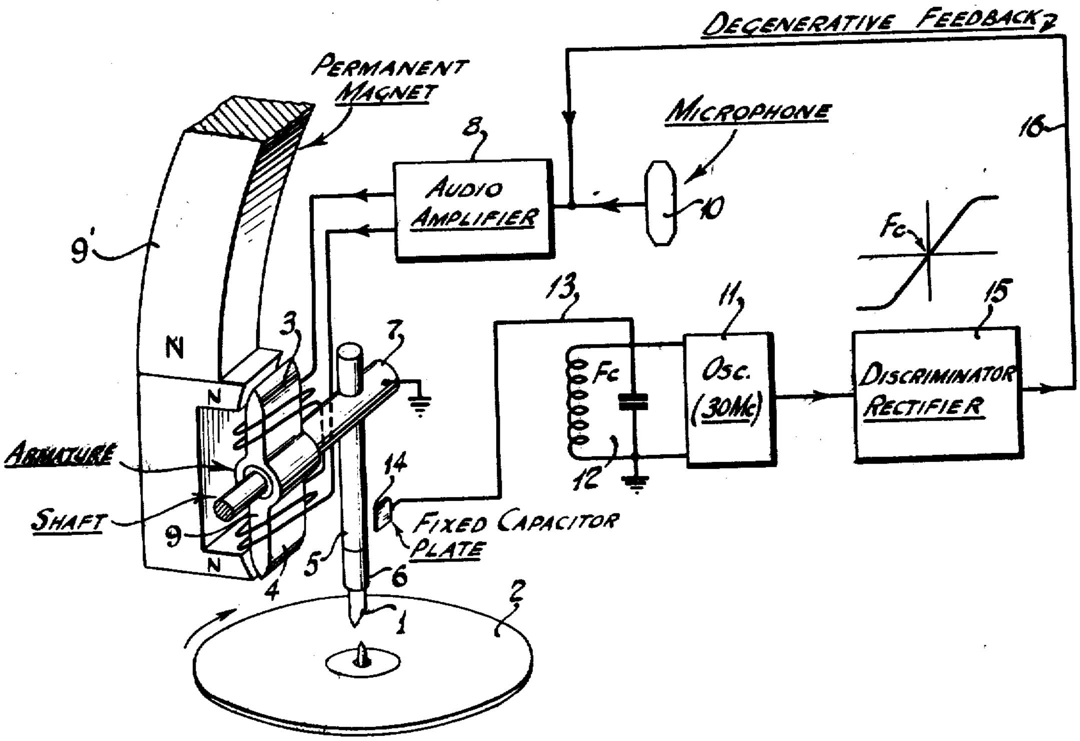


Fig. 2.

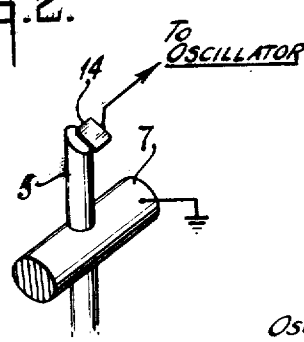
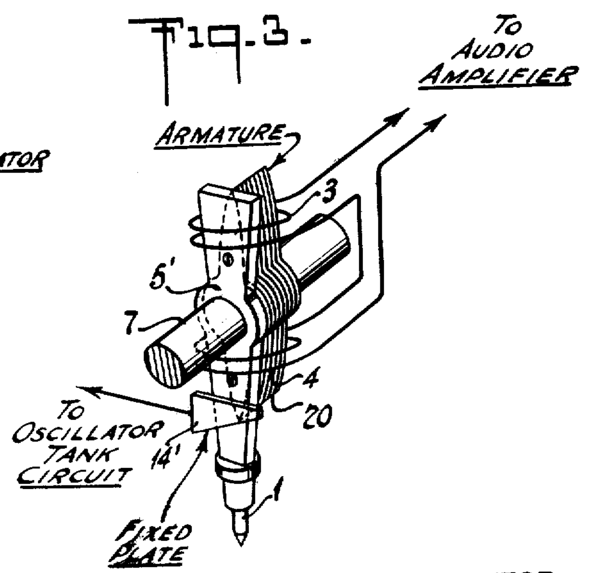


Fig. 3.



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METHOD OF AND SYSTEM FOR RECORDING AUDIO FREQUENCY WAVES

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Fig. 4.

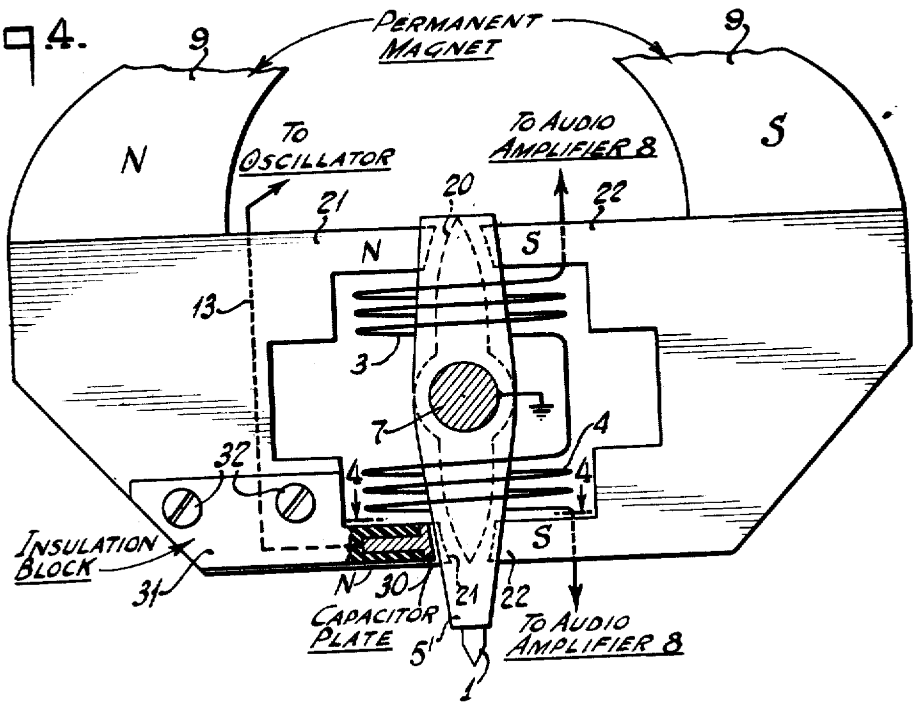


Fig. 5.

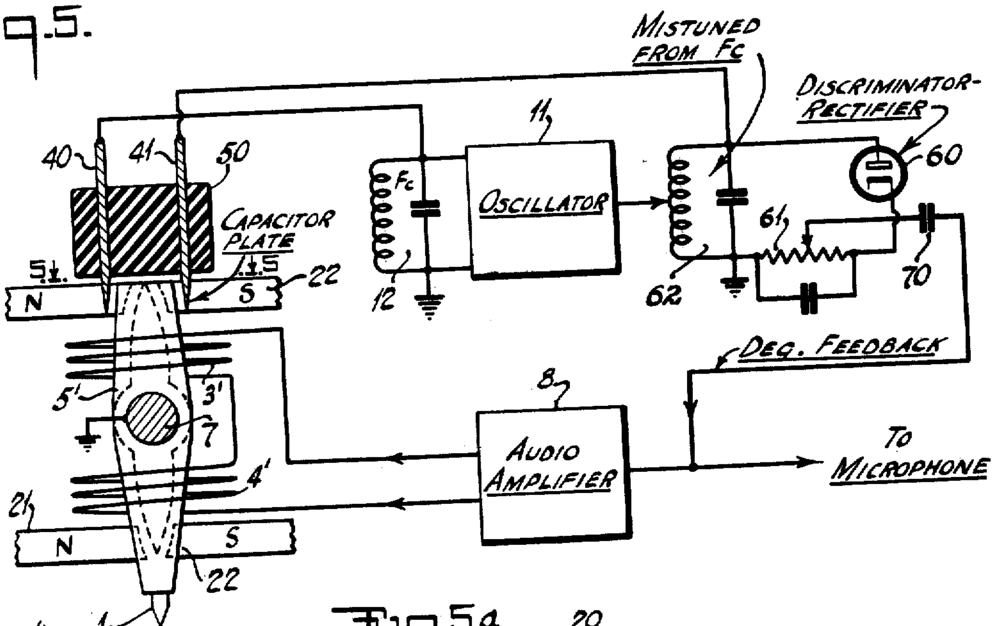


Fig. 4a.

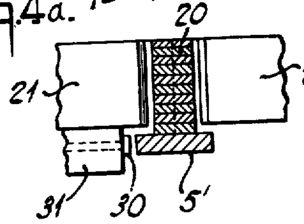
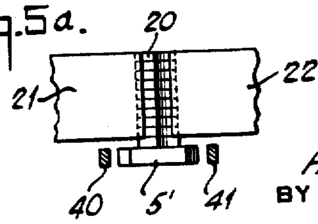


Fig. 5a.



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2,400,953

UNITED STATES PATENT OFFICE

2,400,953

METHOD OF AND SYSTEM FOR RECORDING AUDIO-FREQUENCY WAVES

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Application September 13, 1943, Serial No. 502,096

19 Claims. (Cl. 179—100.4)

My present invention is embodied in a method of and system for cutting disc records in accordance with sound waves, and more particularly to recording systems employing negative or degenerative audio frequency feedback.

In the past, audio frequency recording systems have utilized negative or degenerative audio frequency feedback. In all such prior systems the degenerative audio frequency voltage was derived from the velocity of the cutting stylus. The derived audio frequency voltage was then applied to the input terminals of the amplifier driving the recording unit. In this way a reduction of distortion and a more uniform or flat frequency response curve was secured. Moreover, the prior feedback systems have generally employed a coil to translate the vibrations of the cutting stylus into an audio frequency voltage for the purpose of providing the degenerative feedback voltage. It has been found that undesired coupling reactions tend to arise between the cutter driving coils and the feedback coils and create difficulties in the design of such devices. In particular, such undesired coupling reactions necessitate shielding elements thereby increasing the expense of the cutting unit and also the weight thereof.

It may, therefore, be stated that it is one of the main objects of the present invention to provide a negative feedback circuit for a recording system, wherein there is no electromagnetic or electrostatic coupling between the cutter driving coils and the audio frequency feedback elements, such prevention of coupling being secured by the provision adjacent the cutting stylus of high frequency elements from which the audio frequency feedback voltage is derived, while the cutter driving coils operate at audio frequency.

Another important object of the invention is to provide a novel method of using frequency modulation to provide degenerative audio frequency voltage for improvement of sound recording; the frequency modulation circuit employed utilizing a capacitative pickup element which may be located very near the cutting stylus or other element movable with it thereby making possible a highly accurate translation of stylus motion into audio frequency feedback voltage.

Another object of my invention may be stated to reside in the provision of a method of deriving audio frequency voltage, necessary for negative feedback operation of a disc recording head, from a high frequency voltage produced by a combination of a high frequency oscillator and a discriminator-rectifier, the tuning of one of which is controlled by a condenser; at least one electrode of the condenser being preferably located near the cutting stylus without any shielding being employed and the other electrode of the condenser being constituted by the stylus holder or a member movable therewith; the mass of the moving system of the cutting head being preferably unaffected by the addition of the condenser electrode, and the discriminator-rectifier being of suitable form to convert the frequency modulated high frequency voltage to an audio frequency voltage for application to the audio amplifier driving the recorder.

Yet another object of the invention is to improve the operation of a conventional magnetic type of record cutter, wherein the armature has a stylus holder attached to it and the armature is part of an electro-magnetic system consisting of coils, pole pieces and a permanent magnet; my improvement consisting in employing at least one condenser electrode disposed closely adjacent to the stylus holder or other member movable with the stylus holder which then functions as the other electrode of a condenser; this condenser frequency modulating an oscillator whose output is detected and employed to provide negative feedback voltage for the input terminals of the driving audio amplifier; the condenser electrode being very small, not adding to the mass of the moving system, and being capable of location at almost any point adjacent to the stylus holder.

Still other objects of my invention are to improve generally the recording of audio frequency waves of any type, and more especially to provide recordings which are substantially distortionless, free of harmonics, of a low noise level, and of a high fidelity.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description, taken in connection with the drawings, in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 schematically represents one possible embodiment of my novel recording system,

Fig. 2 illustrates a modification of the frequency modulating condenser,

Fig. 3 shows a further modification of a frequency modulating condenser,

Fig. 4 shows a still further modification,

Fig. 4a is a detail taken along line 4—4 of Fig. 4, looking in the direction of the arrows,

Fig. 5 schematically represents another embodiment of the invention which utilizes so-called "balanced" frequency modulation,

Fig. 5a is a detail taken along line 5—5 of Fig. 5 looking in the direction of the arrows.

Referring now to the accompanying drawings, wherein like reference characters in the different figures designate similar circuit elements, there is shown in Fig. 1 a schematic representation of one embodiment of my invention. Various well-known units and elements employed in my improved method and system may be sufficiently described by generalized disclosures. For example, the cutter unit per se may assume a conventional and known form. In the specific figure the cutter is shown as of the electromagnetic type, the cutting stylus 1 being adapted to cut lateral recordings on a record disc 2 of any well-known form. The disc 2 will, of course, be rotated in the usual fashion, and the stylus 1 is vibrated laterally in response to audio frequency currents flowing through the coils 3 and 4.

The holder 5 is provided with a sleeve 6 for securing the stylus 1 in position. The holder is metallic, and may be in the form of a vertical arm rigidly secured to a horizontal metallic shaft. The latter may be considered as being at ground potential. The shaft 7 will be supported at each end thereof by bearings, and will also be properly centered for limited motion on the bearings. These mechanical details are too well-known to show in the figure, and are, therefore, omitted.

The driving coils 3 and 4 are connected in series, or parallel, between the output terminals of the audio frequency amplifier 8. The armature 9 may be of any construction desired. In Fig. 1 it is represented as being mounted on the shaft 7 in spaced relation to stylus arm 5. The armature may be laminated, if desired. Coil 3 surrounds the upper tapered section of the armature, while coil 4 surrounds the lower section of the latter. The coils are located between the pole pieces contacting a permanent magnet 9'. The coils are not wound directly on the armature, but are separate fixed coils which surround the respective ends of the armature and are spaced from it. The coils are not in the air gap field. The magnet is shown in part, since it is of symmetrical construction. The "N" (North) pole pieces are shown in alignment with the armature 9. It will be understood that the "S" (South) pole pieces are spaced from the armature 9 in the same manner. Audio frequency currents flowing through fixed coils 3 and 4 create a flux in the air gaps which when combined with the flux from the permanent magnet cause vibration, or rapid rocking, of the stylus arm 5 in accordance with the audio frequency currents. As a result the stylus 1 is caused to cut a lateral groove in the face of disc 2. The stylus may be secured to the sleeve 6 in any way best suited to the operator's purposes. The stylus may be a sapphire cemented into place, or it may be secured by a tapered collet sleeve. The construction thus far described is that of a conventional form of cutter head.

Assuming that the sound source 10 is a microphone whose audio frequency current output is applied to the input terminals of amplifier 8, it is desired to provide audio frequency voltage feedback, preferably negative or degenerative, to the input terminals of the amplifier. An important result produced by such negative feedback is a reduction in distortion accompanied by a more uniform or flat frequency responsive curve. According to my present invention, audio frequency feedback voltage is derived from the vibratory displacement of the stylus by a method employing frequency modulation.

Let it be assumed that the numeral 11 denotes a usual form of high frequency oscillator which is provided with a suitable resonant tank circuit 12. The low potential side of the tank circuit is indicated as being grounded, while its high potential side is conductively connected by a lead 13 to a relatively fixed metallic electrode 14. This electrode 14 is insulated from ground and may be located in close juxtaposition to the arm 5. It is to be clearly understood that the capacitor plate or electrode 14 is schematically represented. Actually it will be very small in comparison to the dimensions of the arm 5. Since the arm 5 is effectively at ground potential, it will be appreciated that the arm 5 and the electrode 14 cooperate to provide a condenser which is electrically connected in shunt across the oscillator tank circuit 12.

Merely by way of illustration, and in no way restrictive on the scope of this invention, let it be assumed that the oscillator has a normal oscillation frequency of 30 megacycles (mc.). This means that the tank circuit 12 is tuned to a normal frequency F_c of 30 megacycles. In addition, it will be understood that the condenser 5—14 has its normal capacity value when the stylus is at rest, and is in non-vibrating condition. This modulating condenser 5—14 is part of the total tank circuit capacity which with 5—14 in its normal position determines the mean oscillator frequency F_c. However, upon lateral vibratory displacement of the stylus arm 5, the capacity value of condenser 5—14 will vary in accordance with the displacement of the stylus arm. The capacity variation of the modulating condenser will, in turn, affect the frequency of circuit 12 in accordance with the instantaneous displacement of the stylus arm.

The frequency of the oscillations of oscillator 11 will be deviated relative to frequency F_c in accordance with the capacity variation of the modulating condenser. The extent of such frequency deviation will be a function of the amplitude of the audio frequency currents supplied to coils 3 and 4. The rate of frequency deviation will be a function of the velocity of motion of arm 5. The over-all frequency swing of oscillator 11 will be dependent upon the percentage change of the capacitance of the modulating condenser 5—14 with respect to the total tank circuit capacitance. The apparatus designer may work out the maximum frequency deviation to each side of F_c in accordance with the requirements of the system. By way of illustration, it may be assumed that an over-all frequency swing of 110 kilocycles (kc.) is permissible. The oscillator itself can be of conventional construction.

The frequency modulated oscillation energy is applied to a subsequent network 15 which is a discriminator-rectifier network. Such discriminator-rectifiers are well-known in the art of frequency modulation. Since any of many well known forms of discriminator-rectifiers may be used, there is shown above the rectangle 15 a characteristic idealized S-shaped response curve which relates the rectified output of network 15 to the frequency deviation of its input with respect to F_c. For example, there may be employed for network 15 a discriminator-rectifier of the type disclosed and claimed by S. W. Seeley in his U. S. Patent No. 2,121,103, granted June 21, 1938.

The rectified output voltage of network 15 will be of audio frequency, and will be an accurate representation of the movements of the stylus bar. These audio frequency currents flowing in the output circuit of network 15 are applied over the transmission path 16, denoted as "Degenerative feedback," to the input terminals of the audio amplifier 8 in a manner known to those skilled in the art, one of the known ways being shown in the U. S. patents to Wiebusch, 2,162,986, and Vieth et al., 2,161,489. It is to be understood that the feedback of the audio frequency voltage may be made to any desired point of the audio frequency amplifier 8 preceding its output terminals.

It will now be appreciated that according to my present system there has been provided a method of deriving audio frequency voltage, necessary for negative feedback operation of a disc recording head, by means of a frequency modulated oscillator 11 controlled by a condenser. One plate of this condenser is relatively fixed, and its other electrode is a part of the vibratory system itself. One advantage of the frequency modulation system for securing the degenerative audio frequency feedback is that there is no electromagnetic or electrostatic coupling between the driving coils 3—4 and the modulating condenser 5—14. Hence, the usual trouble arising from such coupling, where it exists, is avoided. It is emphasized that the driving coils 3—4 operate at audio frequency, while the modulating condenser 5—14 operates at a relatively high radio frequency. Due to the lack of magnetic or electrostatic coupling between the audio system driving the recorder and the frequency modulation system for deriving the feedback voltage, no shielding or wide separation of these parts is needed. This is a definite advantage, since the modulation capacitor plates may be located alongside of the stylus bar and near the stylus tip if desired. Such a location means, of course, that the feedback voltage is more truly representative of the stylus motion than if the parts had to be widely separated due to electrical coupling.

Another advantage of the frequency modulation system is that the modulation condenser may be made very small. The inertia of the moving, i. e. vibratory, system (i. e. for example armature, shaft, and stylus bar) need not be increased by additonal parts necessary to derive the feedback voltage. The over-all mass or weight of the entire recording head is not so important, but the mass of the moving system which affects the frequency range and power required to drive the moving system is important, and in all cases should be minimized. Hence, frequency modulation as used in my invention has an advantage in that no mass need be added to the moving system. This method of deriving the feedback voltage is not limited to a disc recording mechanism, but may be applied to any transducer, such as a loud speaker, for example. Moreover, my invention may be employed to produce, if desired feedback other than negative or degenerative.

The network consisting of the oscillator 11 and discriminator-rectifier 15 may be provided by the network disclosed and claimed by C. M. Sinnett in his application, Serial No. 459,375, filed September 23, 1942, particularly Fig. 1 of that application. Furthermore, similar results can be obtained by using a fixed-frequency oscillator, and varying the tuning of the discriminator circuit in accordance with the stylus motion so as to produce the required amplitude modulated voltage across the discriminator. In either case, whether the oscillator frequency is modulated or whether the oscillator frequency is fixed and the tuning of the discriminator circuit varied, a high frequency voltage of varying amplitude appears across the discriminator circuit and is applied to the rectifier. It is this voltage that, when rectified, is representative of the stylus motion. It is noted that the frequency modulation system including condenser 5—14, oscillator 11, and discriminator-rectifier 15 produces an audio frequency output voltage which is proportional to the amplitude of displacement of the capacitor electrodes, in contrast to electromagnetic pickup negative feedback systems in which the feedback voltage is proportional to the rate of change of flux, and hence velocity, of the armature or moving coil.

The location of the fixed capacitor plate 14 is subject to variation. For example, in Fig. 2 there is shown a modification in which the fixed metal capacitor plate 14 may be located adjacent the upper end of the stylus arm 5. In this case the upper end of the stylus arm is given an inclined face, and the inclined face then provides the opposite electrode of the modulating condenser.

In Fig. 3 there is shown still another method of providing the modulating condenser. In this case the fixed metal plate 14' is located in spaced relation to the flat face of the stylus arm 5'. It will be noted that the laminated armature 20 in this case has the stylus arm bolted directly to one end thereof. In other words, the armature 20 and the stylus arm 5' are provided as a single unit on the grounded shaft 7. The coils 3 and 4 surround, as previously explained, the opposite sections of the unit as shown in Fig. 3. This form of construction has advantages insofar as economy of production is concerned. However, the mode of operation is the same as in the case of the construction shown in Fig. 1. The fixed plate 14' will be always at a constant spacing from the face of arm 5'. However, the capacity variation here is due to area variation. This is accomplished by giving the lower edge of plate 14' an incline. As the stylus arm vibrates the effective are of plate 14' cooperating with the adjoining face of arm 5' will vary, and hence capacitative change of the modulating condenser 5'—14' will result. This capacitance change will be employed in the same manner as described in connection with Fig. 1.

In Fig. 4 there is shown still another method of providing a modulating condenser whose capacitance variation will be a very accurate representation of the motion of the stylus bar and the stylus which is rigidly attached thereto. In Fig. 4 the pole pieces 21 and 22 are shown, but a portion of the permanent magnet 9 is broken away in order to preserve simplicity of disclosure. The stylus arm 5' and the armature 20 are of the type shown in Fig. 3. That is to say, the arm 5' is secured directly to the end of the laminated armature 20. The fixed driving coils 3 and 4 surround the opposite sections of the entire unit on opposite sides of the grounded shaft 7. The coils 3 and 4 are not in the air gap field. The capacitor plate 30 is here provided by a metallic element rigidly embedded in a block of insulation material 31. The block of insulation material is, in turn, rigidly secured by bolts 32 to the front face of pole piece 21. As shown in Fig. 4, the lower "N" pole of pole piece 21 is largely obscured by block 31. It bears the same symmetrical relation to the lower "S" pole which the upper "N" pole bears to the upper "S" pole.

The lead 13 to the high potential side of the oscillator tank circuit is run through the block 31 to the metal strip 30. It will be observed that the capacitor plate 30 on the insulation block 31 projects from the pole piece 21 in line with the lower section of the stylus arm 5'. This is more clearly shown in detail in Fig. 4a. However, it is to be clearly understood that the motion of the stylus arm will not be such during its greatest excursions as to permit contact between the stylus arm and plate 30. The lateral displacement of the stylus arm is highly restricted, and those skilled in the art will clearly understand that the spacing between plate 30 and the adjoining side of stylus arm 5' will be sufficiently great to prevent any contact whatever between the two. The advantage of locating the electrode 30 as close as possible to the stylus tip is that there is derived ultimately an audio frequency voltage which is exactly proportional to the stylus motion.

It will be appreciated that the insulation block 31 and its associated capacitor plate 30, being mounted on the fixed portion of the cutter head, do not add mass to the moving system, and thus do not adversely affect the recording itself. Not only is there no addition of mass to the moving system, but the mechanical phase shift distortion is minimized with this form of feedback system due to the proximity of said capacitor to the stylus tip. With a 0.004 to 0.005 inch spacing between the arm 5' and the plate 30, sufficient capacity variation for the purposes of the feedback system may be secured. The nominal displacement of the stylus tip during recording in present practice is about ± 0.001 of an inch.

In Fig. 5 I have shown a schematic form of the system wherein so-called "balanced" frequency modulation is utilized. In this form of the system a pair of modulation condensers is employed. One of these modulation condensers comprises a fixed capacitor plate 40 and an adjoining face of the stylus arm 5'. The second modulation condenser consists of the capacitor plate 41 and its respective adjoining face of stylus arm 5'. It will be noted that the condenser electrodes 40 and 41 are the projecting tips of a pair of metallic strips which are rigidly embedded in an insulation block 50. These metallic strips 40 and 41 are located on opposite sides of the upper end of the stylus arm 5' in front of the respective air gaps of the magnetic system. The stylus arm construction may be precisely as shown in Fig. 4, except for the fact that there is omitted the capacitor plate 30 of Fig. 4. Fig. 5a shows more clearly the relation between the strips 40, 41, and the stylus arm 5'. In this embodiment the oscillator 11 has its tank circuit 12 shunted by a first condenser consisting of electrode 40 and the stylus arm 5', and the normal frequency F_0 of the oscillator will therefore be varied in accordance with the capacity variation of modulation condenser 40—5'. The second modulation condenser 41—5' in this case varies the tuning of the tuned input circuit 62 of the discriminator-rectifier. The specific discriminator-rectifier shown comprises a diode rectifier 60 whose output load 61, bypassed for high frequency currents in the usual manner, is arranged in series with the resonant circuit 62.

The resonant circuit 62 is mistuned with respect to F_0; i. e., its resonant frequency is always on the same side of the oscillator frequency and sufficiently close to the oscillator frequency so that the latter falls on the resonance curve of circuit 62. The frequency modulated output of the oscillator 11 is applied to the mistuned input circuit 62. It will be recognized that this provides a very simple form of discriminator circuit, and that the frequency modulated oscillations are readily converted into amplitude modulated oscillations by such a mistuned input circuit. Concurrently with the frequency modulation of circuit 12, there is provided a tuning variation of the discriminator circuit 62 in acordance with the vibration of the stylus bar 5'. This concurrent tuning modulation of the discriminator circuit 62 is in opposite phase to the effect of the frequency modulation of circuit 12 in that when the frequency of the oscillator output is increased, the resonance frequency of circuit 62 is decreased and vice versa. In this connection it is pointed out that this balanced, or effective push-pull, form of frequency modulation of the oscillator and discriminator has been described and claimed by A. Badmaieff in application Serial No. 490,614 filed June 12, 1943, now Patent No. 2,371,373, granted March 13, 1945. For this reason, it is not believed necessary to describe the functioning of the balanced frequency modulation circuits in detail.

It is sufficient to point out that the audio frequency voltage developed across resistor 61, and applied through the audio frequency coupling condenser 70 to the degenerative feedback path, is substantially double the magnitude which would be secured when employing a single modulation condenser as shown in Fig. 1. Furthermore, the active electrode area of strips 40 and 41 may be very small, since the resultant audio frequency voltage produced by this balanced frequency modulation is double that produced by frequency modulation of solely the oscillator tank circuit 12. No claim is made in this application to the balanced or push-pull form of frequency modulation when used broadly in conjunction with transducers. This application, however, contains claims for the particular application of the push-pull frequency modulation circuit in providing degenerative audio frequency voltage in a recording system, as illustrated, for example, in Fig. 5.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In a method of recording sound waves wherein the sound waves are translated into audio currents which are amplified, and the amplified audio currents are translated into displacements of a record-cutting stylus, the improvement which includes translating the cutting stylus displacements into corresponding capacity variations, varying the frequency of a high frequency oscillator in accordance with said capacity variations, translating the frequency-variable oscillations into amplitude variations, rectifying and translating said amplitude variations into audio currents which are a substantially accurate representation of the displacements of said stylus, deriving an audio frequency voltage from said audio currents, degeneratively combining said audio voltage with a voltage derived

from said sound-wave currents, and amplifying the combined voltages to produce a current for translation into said displacements.

2. In combination, a source of control voltage, an amplifier for amplifying voltage derived from said source, a recording device, circuits for operating said recording device with said amplified voltage, a reactance the effective value of which is varied by operation of said recording device, an oscillation generator for generating relatively high frequency waves, circuits connecting said variable reactance to said generator whereby output waves thereof are varied under control of said reactance, circuits converting said output waves into waves variable in amplitude, a rectifier for rectifying the variable amplitude component of said converted waves, and a circuit for degeneratively feeding said rectified waves to said voltage amplifier whereby distortion in the recording of said control voltage is reduced.

3. A method of translating sound waves into a record thereof, which includes converting the sound waves into audio frequency currents, translating the audio currents into vibratory displacements of a recording element, providing reactance variations proportional to the vibratory displacements, translating the reactance variations into variations of the amplitude of high frequency currents, deriving audio currents from the said high frequency currents which correspond to said vibratory displacements, and combining the derived and original audio frequency currents.

4. In a record cutter unit of the type employing a permanent magnet provided with spaced pole pieces, a vibratory stylus holder, coils associated with the stylus holder and located between the pole pieces to provide vibration of the stylus holder; the improvement which comprises at least one metallic electrode located in spaced relation close to at least a portion of said stylus holder thereby to provide a condenser which consists of the electrode and the adjacent portion of the stylus holder, and a second electrode located in spaced relation close to a second portion of the stylus holder thereby to provide a second condenser.

5. In a record cutter unit of the type employing a permanent magnet provided with spaced pole pieces, a vibratory stylus holder, coils associated with the stylus holder and located between the pole pieces to provide vibration of the stylus holder; the improvement which comprises at least one metallic electrode located in spaced relation close to at least a portion of said stylus holder thereby to provide a condenser which consists of the electrode and the adjacent portion of the stylus holder, an audio frequency amplifier having output terminals connected to said coils, a network activated by high frequency power responsive to variations in capacitance of said condenser, and means for deriving audio frequency voltage from said network and for applying such derived voltage to said amplifier in degenerative phase with the audio frequency voltage at the amplifier input terminals.

6. In a method of recording sound waves wherein the sound waves are translated into audio currents which are amplified, and the amplified audio currents are translated into displacements of a record-cutting stylus; the improvement which includes translating the cutting stylus displacements into corresponding capacity variations, varying the tuning of a tuned circuit which is being acted upon by a high frequency current of constant frequency in accordance with said capacity variations, translating the resulting amplitude variation of the high frequency current due to the tuning variation of said tuned circuit into audio frequency currents, deriving an audio voltage from said audio currents, combining said audio voltage with a voltage derived from said sound wave currents in negative feedback relation, and amplifying the combined voltage to produce a current for translation into said displacements.

7. In a method of recording sound waves wherein the sound waves are translated into audio frequency currents which are amplified, and the amplified audio frequency currents are translated into displacements of a record-cutting stylus; the improvement which includes translating the stylus displacements into corresponding capacity variations, producing high frequency oscillations of a normal predetermined frequency, deviating the value of said frequency in accordance with said capacity variations, converting the frequency-deviated oscillations into corresponding audio frequency currents which are a substantially accurate representation of the first-mentioned audio frequency currents, deriving a negative audio frequency feedback voltage from said converted audio frequency currents, and utilizing said feedback voltage in the amplification of the first-mentioned audio frequency currents.

8. In combination, a source of control voltages, an amplifier for amplifying voltages derived from said source, a recording stylus, circuits for actuating said recording stylus with said amplified voltages, a reactance element the effective value of which is varied by displacements of said recording stylus, means for generating relatively high frequency waves, circuits connecting said variable reactance to said generating means whereby the frequency thereof is varied under control of said reactance, circuits converting waves of variable frequency to waves variable in amplitude, means for rectifying the variable amplitude waves, and a circuit for degeneratively feeding voltages derived from said rectified waves to said voltage amplifier whereby distortion in the recording of said control voltages is reduced.

9. A method of translating audio frequency waves into a record thereof which includes converting the waves into audio frequency currents, translating the audio currents into vibratory displacements of a recording element, providing reactance variations proportional to the vibratory displacements, translating the reactance variations into frequency-variable oscillations, deriving audio currents from said last oscillations which correspond to said original audio frequency currents, and combining the derived and original audio currents in degenerative phase.

10. In a record cutter unit of the type employing a magnet provided with pole pieces, a vibratory metallic stylus holder, coils associated with the stylus holder and located between the pole pieces to provide vibration of the stylus holder; the improvement which comprises a pair of metallic electrodes located in spaced relation close to said stylus holder thereby to provide a pair of condensers each of which consists of each electrode and the adjacent portion of the stylus holder.

11. In a record cutter unit of the type employing spaced pole pieces, a vibratory stylus holder, coils associated with the stylus holder and located between the pole pieces to provide vibra-

tion of the stylus holder; the improvement which comprises a metallic electrode located in spaced relation to said stylus holder thereby to provide a condenser which consists of the electrode and the adjacent portion of the stylus holder, an audio amplifier having output terminals connected to said coils, a frequency modulation network responsive to variations in capacitance of said condenser, and means for deriving audio voltage from the frequency modulation network and for degeneratively applying such derived voltage to said amplifier.

12. In a system provided with a transducer coupled to the output terminals of an amplifier of audio frequency voltage; the improvement comprising means for translating amplifier currents fed to the transducer into audio modulated high frequency waves, deriving from said waves audio modulation currents, and applying to said amplifier in degenerative phase voltage derived from said audio modulation currents.

13. In combination with a signal amplifier having input and output terminals, means to apply signals to said input terminals, means for utilizing the signal output at the output terminals, a degenerative feedback path from the output terminals to input terminals, said path including means for translating the signals into modulation components of a modulated high frequency wave, and other means for deriving said modulation signals from the modulated wave.

14. In a method wherein sound waves are translated into audio frequency currents which are amplified, and the amplified audio currents are translated into displacements of a physical element, the improvement which includes translating the displacements of said element into corresponding reactance variations, varying the frequency of high frequency oscillations in accordance with said reactance variations, translating the frequency-variable oscillations into amplitude variations, rectifying and translating said amplitude variations into audio frequency currents which are a substantially accurate representation of said displacements, deriving an audio frequency voltage from said audio currents, degeneratively combining said audio voltage with a voltage derived from said sound-wave currents, and amplifying the combined voltages to produce a current for said translation into said displacements.

15. In combination, a source of pulsating voltage, an amplifier for amplifying voltage derived from said source, a transducer, circuits for operating said transducer with said amplified voltage, a reactance the effective value of which is varied by operation of said transducer, means for generating relatively high frequency waves, circuits connecting said variable reactance to said generating means whereby output waves thereof are varied under control of said reactance, circuits converting said output waves into waves variable in amplitude, a rectifier for rectifying the variable amplitude component of said converted waves, and a circuit for degeneratively feeding said rectified waves to said voltage amplifier.

16. A method which includes converting sound waves into audio frequency currents, translating the audio frequency currents into vibratory displacements of a physical element, providing reactance variations proportional to the vibratory displacements, translating the reactance variations into variations in amplitude of superaudible frequency currents, deriving audio frequency currents from the said superaudible frequency currents which correspond to said vibratory displacements, and combining in phase opposition the derived and original audio frequency currents.

17. In a record cutter unit of the type employing a permanent magnet provided with spaced pole pieces, a vibratory stylus holder, a laminated armature having said holder secured to one side thereof, coils surrounding the holder and armature and located between the pole pieces to provide vibration of the stylus holder; the improvement which comprises at least one metallic electrode located in spaced relation close to at least a portion of said stylus holder thereby to provide a condenser which consists of the electrode and the adjacent portion of the stylus holder.

18. In a record cutter unit of the type employing a magnet provided with pole pieces, a vibratory metallic stylus holder, provided with an armature coil surrounding the stylus holder and armature, located between the pole pieces to provide vibration of the stylus holder; the improvement which comprises a pair of metallic electrodes located close to the upper end of said stylus holder and in spaced relation to opposite edges thereof thereby to provide a pair of condensers each of which consists of each electrode and its respective adjacent edge of the stylus holder.

19. In a system provided with a transducer coupled to the output terminals of an amplifier of audio frequency voltage; the improvement comprising means for translating amplifier currents fed to the transducer into frequency modulated high frequency waves, deriving from said waves audio frequency modulation currents, and applying to said amplifier in predetermined phase relation a voltage derived from said audio frequency modulation currents.

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