Dec. 16, 1930. E. J. QUINBY 1,785,047

METHOD AND MEANS FOR CUTTING PHONOGRAPH RECORDS

Filed Sept. 14, 1927 3 Sheets-Sheet 1

Fig. 1

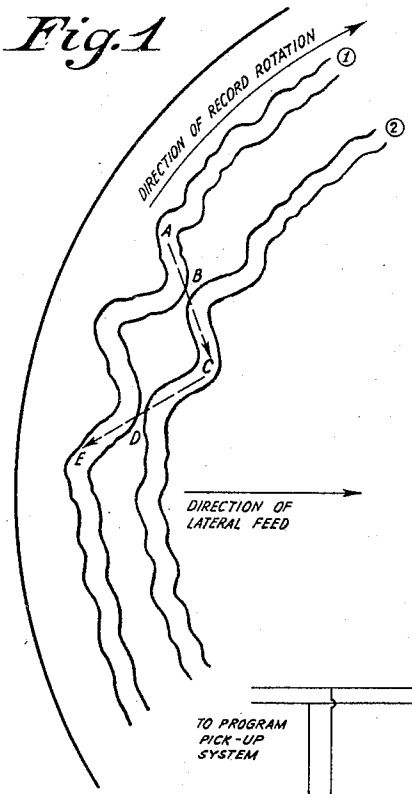


Fig. 2

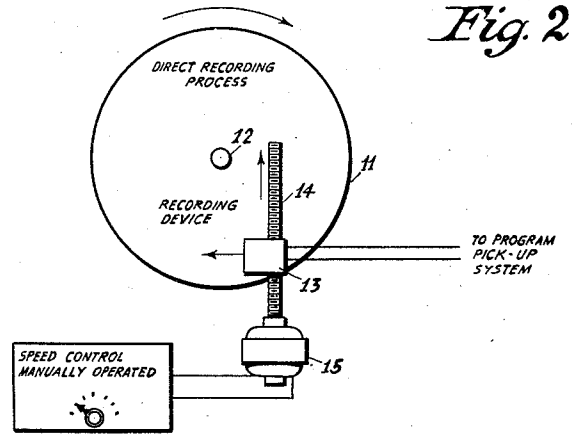


Fig. 3

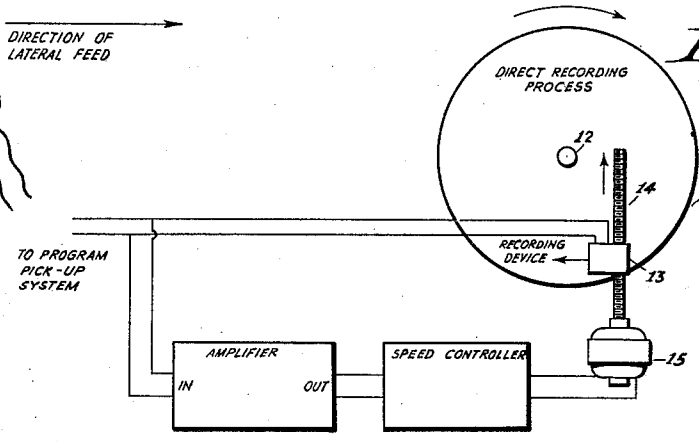
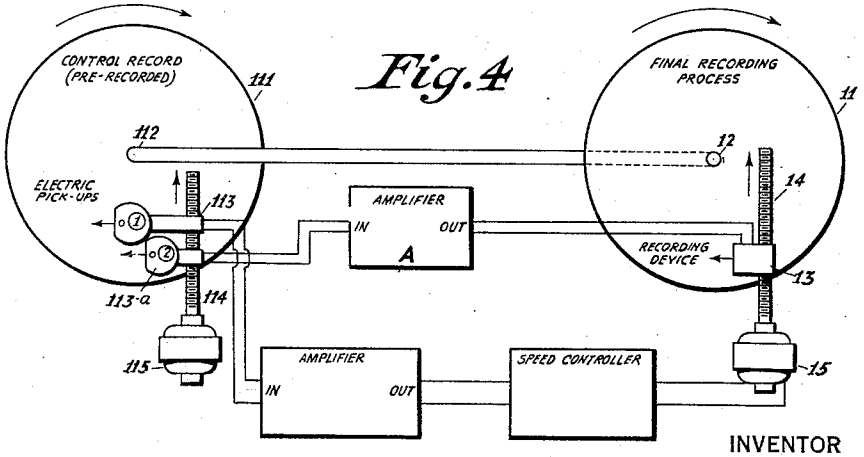


Fig. 4



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METHOD AND MEANS FOR CUTTING PHONOGRAPH RECORDS

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Fig. 5

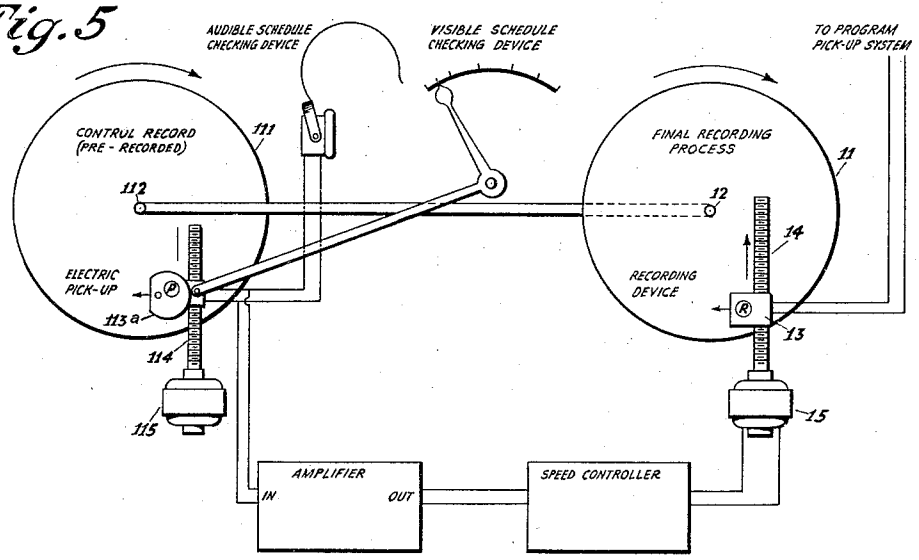
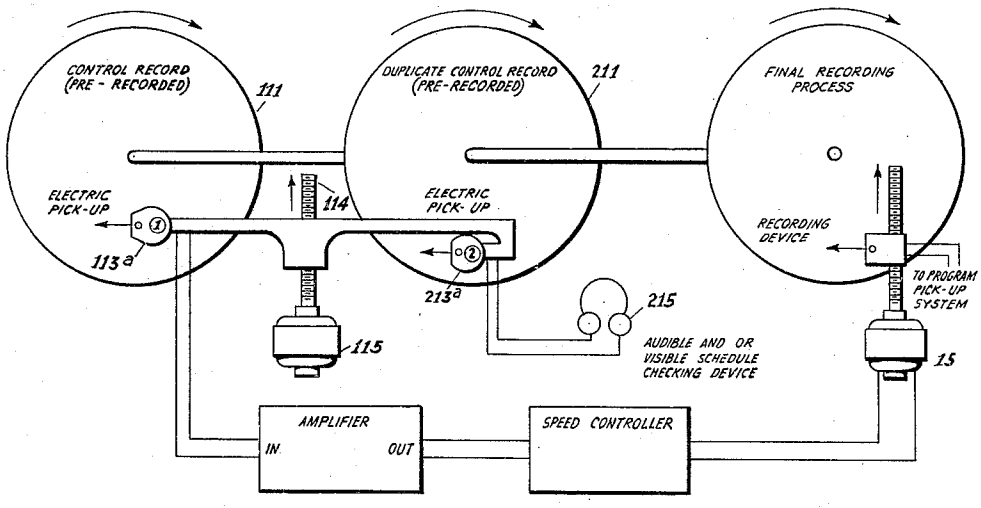


Fig. 6



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METHOD AND MEANS FOR CUTTING PHONOGRAPH RECORDS

Filed Sept. 14, 1927 3 Sheets-Sheet 3

Fig. 6-A

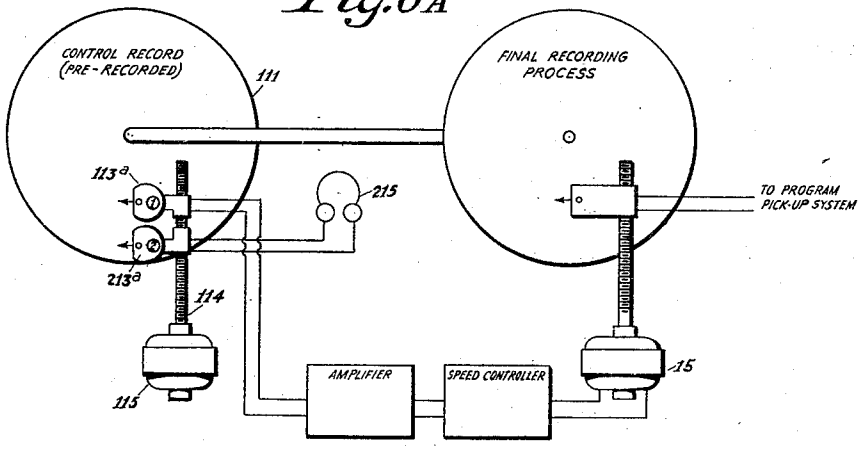
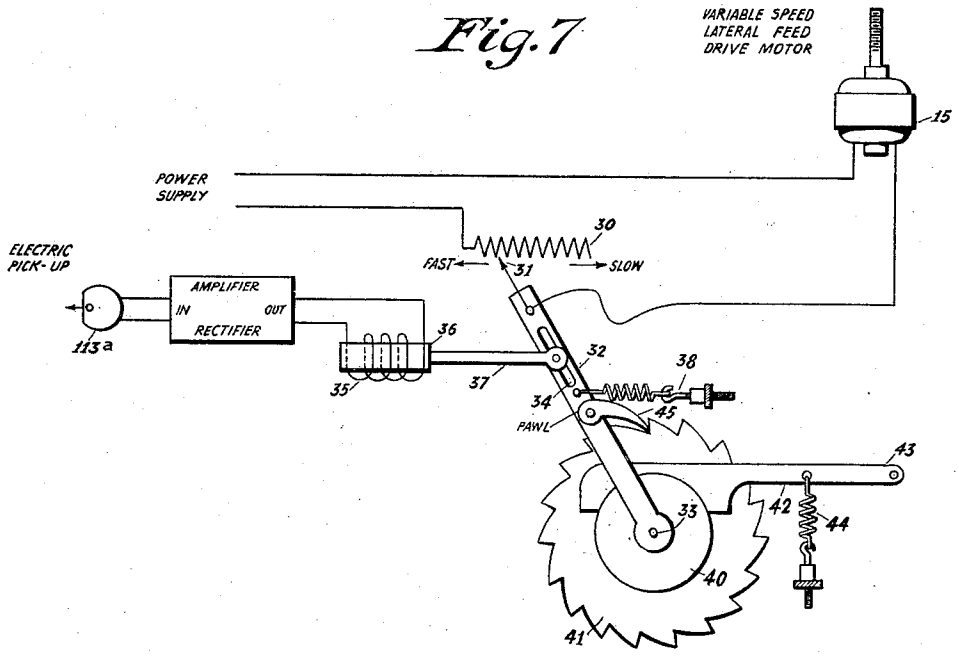


Fig. 7



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Patented Dec. 16, 1930 1,785,047

UNITED STATES PATENT OFFICE

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METHOD AND MEANS FOR CUTTING PHONOGRAPH RECORDS

Application filed September 14, 1927. Serial No. 219,522.

This invention relates to the art of phonograph record making and deals more specifically with a method and means for preventing "mistracking". "Mistracking" as applied to a phonograph record refers to the shifting of the needle from one groove to another, which obtains when the wall between two successive grooves in the record breaks down. For example, the Victor red seal record No. 6648—B, upon which is recorded the composition "Pomp and Circumstance", a large size $2.00 record made by the Chicago Symphony Orchestra with the grand organ, when examined under a magnifying glass illustrates clearly the possibilities of the phenomenon of "mistracking" after the record has been played a few times. In this particular record at those portions where there is recorded the lower register pipes of the grand organ augmented by the beating of the tympani, the super position of the high amplitude low frequencies of these instruments causes a wide displacement in the groove of the record. It so happens that at several portions of the record two adjacent grooves are formed with peaks which are positioned so that their crests are almost in contact with each other. This is shown, for example, in Fig. 1 of the drawing. Obviously, the thin wall which exists between the crests of these two peaks will soon break down, when the record is in use, and the needle of the reproducing device may thus be shifted radially from one groove to the other to produce mistracking.

Referring particularly to Fig. 1, if the needle jumps from A to C during the playing of the record this constitutes a skip and a portion of the record will be omitted; whereas if the needle, when it has reached the position C in groove 2, jumps back to the point E in groove 1, this constitutes a repeat with the consequent disagreeable effects when the record is being played.

This tendency to mistrack has been reduced in the past by the introduction of filters designed to eliminate, to various extents, some of the lower frequencies as, for instance, correspond to the lower register pipes of the organ. While it is true that this method helped to insure a more uniform wall thickness between grooves, it reduced the fidelity of reproduction and upset the "balance", or true volume relations between lower and higher frequencies. Another method which has been used in the past to reduce this tendency to mistrack, was by the introduction of volume controls. By certain manipulation, the volume controls reduced the high amplitudes resulting from extra loud passages, so that the efforts of the artists to color up their work with various volume shading and contrasts were defeated, and in the recordation the result tended towards a monotonous constant volume. In short, records made in accordance with these methods were lacking in the original volume expression, and the lower frequencies employed by the artists who performed for them were either totally or partially absent.

It is, therefore, an object of this invention to overcome the objection of mistracking in phonograph records without distorting the quality and fidelity of the sound recorded.

Further, it is an object of this invention to provide a phonograph record having grooves so spaced that the walls will not break down during normal use of the record over an extended period of time, and to accomplish this improvement without reducing the present playing-time standards and without increasing the present diameter standards of the records.

Further, it is an object of this invention to provide a record with grooves in which a substantially uniform wall thickness is provided between such grooves.

It is a further object of this invention to provide a method of cutting phonograph records, in which the lateral speed of the cutting tool is varied in such a way as to provide substantially uniform thickness of the walls between the grooves, regardless of the character of program reproduced thereon.

Further, it is an object of this invention to provide a method and means for recording concert material in its natural state as produced by the artists without resorting to filtering or changing the relative volume values employed by the performing artists,

or other alteration to properly make the record.

It is a further object of this invention generally to improve the art of phonograph record cutting.

These and other objects of the invention will be readily apparent to those skilled in the art from the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a partial diagrammatic showing of a record which is subject to the phenomenon of mistracking;

Fig. 2 is a diagrammatic representation of a system embodying the invention;

Figs. 3 to 6*a* inclusive are diagrammatic representations of modifications of this invention; and

Fig. 7 is a detailed diagrammatic representation showing a form of control device used in connection with the speed control of the cutting tool.

Referring in detail to Fig. 2, a disc 11 upon which the record is to be made is rotatably mounted at 12. A cutting device 13, which may be of any of the types well known in the art, is carried by the shaft 14 which is rotatably coupled to the drive motor 15. The members 13 and 14 are in threaded relation so that rotation of the member 14 moves the member 13 radially of the record 11. A manually operated speed control device is connected to the motor 15 as shown. The cutting device 13 is connected to the program pick-up system which is well known in the art and which forms no part of the present invention.

The operation of this device is as follows:

While the program to be recorded is being played by the artists and the disc 11 is rotating, the lateral feed of the cutter 13 is controlled by an operator who varies the speed of the drive motor 15 as desired. Thus, when the program consists of very high amplitude low frequency notes or of extremely high volume material, the operator increases the speed of the motor 15, thus causing the cutter 13 to travel radially of the disc 11 at a greater rate of speed, with a consequent result that the walls between the two successive grooves are of greater thickness. Of course, as soon as the program material is changed in character the operator merely reduces the speed of the drive motor 15 accordingly.

To operate this control mechanism it is advisable that the operator be familiar with the composition recorded and also that he be able to read musical score. It has been found most desirable in controlling the changes of the speed of operation of the motor 15, to anticipate the occurrence of high ampltiude low frequencies, or to anticipate any great increase in amplitude of low frequencies, by one revolution of the record. The degree of lead, however, between the control mechanism and the cutting mechanism may easily be varied to suit any particular conditions without departing from the spirit of this invention.

Referring to Fig. 3, a modified form of the invention is shown in which the manually operated speed controller is replaced by an automatic speed controlling device. To accomplish this result an amplifier is shunted off the line from the program pick-up system to the recording device 13, the output of which amplifier operates electrically the speed controller. The particular form of speed controller used here forms no part of the present invention and may be of any type of automatic or electrical controller for a variable speed motor well known in the art.

The operation of this system is substantially the same as the system disclosed in Fig. 2 with the exception that in accordance with the present arrangement it is not possible to anticipate changes in volume, etc. but rather the speed of the motor 15 is changed substantially simultaneously with the changes which occur in the pick-up system.

Fig. 4 shows a modified form of the invention in which a prerecorded control record is made of the composition desired and this control record is used to make the final record.

The control record 111 mounted for rotation 112 is associated with a constant speed drive motor 115 which carries the threaded shaft 114. As this control record is made for use only in the recording laboratory, ample spacing between grooves is obtained therein by the simple expedient of using relatively fast constant feed lateral feed all the way through the same, resulting in a larger diameter record than the ordinary standard. Mounted upon the shaft 114 in threaded relation therewith are the electrical pick-up devices 113 and 113*a*. The disc 11 upon which the composition is to be recorded is mounted at 12 for synchronous rotation with the disc 11. The variable speed motor 15, the cutting device 13 and the threaded shaft 14 functions in a manner described in connection with Figs. 2 and 3. The speed of the drive motor 15 is controlled through the pick-up 113, the output of which is fed into an amplifier and then to a speed controller to govern the speed of the motor 15. The output of the pick-up 113*a* is fed to the recording device 13 through suitable amplification means indicated at A.

The amount of lead between the speed control pick-up 113 and the program recording pick-up 113*a* will vary with different conditions. In general, however, this lead will amount approximately 1 revolution of the disc.

It will be seen that by virtue of this arrangement it is possible to obtain the varia-

tions in speed of the cutting member and consequently the wall between the grooves in the final record may thus be automatically maintained at ample thickness.

The modification shown in Fig. 5 provides for the speed control of the motor 15 through the electrical pick-up 113*a* operated by the constant speed motor 115 and the threaded shaft 114, the pick-up 113*a* being operated by a pre-recorded control record 111 in the manner described in connection with Fig. 4. However, instead of making the final record 11 from the material recorded upon the pre-recorded control record, the composition is played over again by the artists and is recorded upon the final record through the member 13. It is advisable in accordance with this method of recording to prepare the control record immediately prior to the final performance in order to insure uniformity between the composition played for the control record and for the final record. Thus, by setting the control record a predetermined amount of time ahead of the final record, usually 1 revolution, the cutting device 13 is varied in speed in a manner necessary to anticipate changes in character of the final record material as described above thereby giving the predetermined thickness to the walls between two successive grooves in the final record.

In order that the conductor of the orchestra playing the material for the final record be able to conduct the orchestra in a manner which will insure uniformity betwen the control record and the final record, audible and/or visible schedule checking devices may be connected to the output of the pick-up 113*a*, which will enable the conductor to know in advance the charater of material to be played, and thus enable him to conduct the orchestra accordingly. The audible schedule checking device may preferably consist of a set of ear phones connected across the output of the pick-up 113*a*, which will thus enable the conductor to listen in to the material being played on the control record. The visible schedule checking device consists preferably of a bell crank lever one end of which is coupled to the pick-up 113*a* for movement therewith, while the other arm actuates a pointer carried over a scale. The position of the pick-up device in respect to the beginning and end of the control record may be indicated on the scale. Upon this scale, which may consist of a replaceable paper form, may be added suitable notations referring to various parts of the composition being used, or even the entire arrangement of the composition may be laid out across this scale, so that the pointer will constantly indicate at just what place the orchestra or artists should be playing, and so that the leader can keep them in synchronism with the control record.

In Fig. 6 there is shown another modification of the invention which differs from the modifiation shown in Fig. 5 in that a duplicate control record 211 is rotated in synchronism with the original control record 111. A constant speed motor 115 drives the pick-up device 113*a* which plays on the record 111 and also the pick-up device 213*a* which plays on the duplicate control record 211. The pick-up device 213*a* is made to actuate the audible and/or visible schedule checking device indicated at 215.

By virtue of this arrangement, the output of pick-up device 113*a* is utilized to control the speed of the lateral feed motor 15, and the output of pick-up 213*a* is used to actuate the audible and/or visible schedule checking apparatus. This latter apparatus is provided with its own independent operating record which is an exact duplicate of the original control record and which may be run in any predetermined relation with respect to the original control record and the final control record. It is obvious that this arrangement may be simplified by eliminating the second control record 211, and arranging the pick-up 213*a* to run on the first control record 111, beside and in suitable predetermined relation to the pick-up 113*a*, so that the control pick-up and schedule checking pick-up run on the same record. See Fig. 6*a*.

Referring in detail to Fig. 7, there is shown in a fragmentary diagrammatic view a specific embodiment of a device which is designed to retard the change in speed from fast to slow, yet which permits the change from slow to fast being made almost instantly. This arrangement is necessary for the reason that in any of the described arrangements, it may be desirable to maintain fast lateral feed on the cutting device for at least one revolution after the other control devices tend to cause a resumption of slow lateral feed on the said cutting device. For instance, considering the arrangement shown in Fig. 5, when the control record is set in advance of the program material to be played and a portion of the program occurs which requires that the wall between the mean line of the successive grooves be thicker, it is necessary to increase the speed of the drive motor 15 to insure this increased thickness of the wall. Also in view of the fact that the control record plays at least 1 revolution ahead of the final record it will be seen that when the end of the portion of the control record corresponding to the increase in volume or amplitude of low frequencies has been reached, the actual material to be recorded on the final record is still of large volume and high amplitude and it is still necessary that the motor 15 be driven at a relatively high rate of speed. Consequently the speed control device is provided with a lag producing arrangement which slows up the return of the control mem-

ber from fast to slow by a predetermined increment, thus enabling the control motor 15 to be maintained at a desired increased speed even though the control record at the particular instant tends to cause it to reduce its speed.

This speed control mechanism briefly consists of a high resistance 30 connected in the input circuit of the drive motor 15. The variable contact 31 plays over the resistance 30 and completes the circuit through varying portions of the resistance 30 in accordance with the position of the arm 32 which is rotatably mounted on a shaft 33. The electric pick-up 113*a* which is designed to operate the speed controlling mechanism is connected to an amplifier and rectifier which in turn is connected to a solenoid 35. The link 37 is coupled to the armature 36 at one end and its opposite end is pinned into the slot 34 for sliding engagement therein, thus permitting the armature 36 to move the arm 32 about the axis 33 to vary the amount of resistance 30 connected in the input circuit of the motor 15. An adjustable tension device is provided at 38 which tends normally to hold the arm 32 to the right, viewing Fig. 7, thus increasing the resistance 30 corresponding to the slow speed of the drive motor 15. When, however, a condition arises which requires an increase in speed of the drive motor 15 there is more power produced through the electric pick-up 113*a* due to the fact that this portion of the control record corresponds to a louder reproduction of the material thus causing an increased flow of current in the solenoid 35 which reacts upon the armature 36 and draws the arm 32 to the left, viewing Fig. 7, to cut out the amount of resistance 30 included in the input circuit of the motor 15. Obviously a critical balance between the tension on the spring of the device 38 with the amount of current necessary to draw the armature into the coil 35 may be obtained.

As explained above it is necessary to provide a certain degree of lag when the pick-up playing on the control record has passed over that portion of the record which corresponds to high volume and high speed for the drive motor, before the contact 31 returns to the slow position of the resistance 30. A preferable embodiment of an arrangement to provide this lag is shown in Fig. 7 and consists of a brake drum 40 rotatably mounted on the shaft 33. A ratchet wheel 41 is attached to the drum 40 for rotation therewith. 42 indicates a brake shoe which is pivotably mounted at 43 and held in spring tension engagement with the drum 40 by means of the adjustable spring 44. A pawl 45 is carried by the arm 32 for engagement with the ratchet 41.

The operation of this mechanism is as follows:

Assuming the pointer 31 to be in contact with the right end of the resistance 30 corresponding to the slow speed for the drive motor 15, when there is an increase in volume on the control record the armature 36 through the link 37 draws the arm 32 to the left, slipping the pawl 45 over the teeth around the ratchet wheel 41, so that the brake shoe 42, and brake drum 40, do not tend to retard this motion, and moving the pointer 31 across the resistance 30 until a sufficient amount of such resistance is cut out of the circuit of the motor 15. The device continues in this state until the electric pick-up playing on the control record has reached a position which corresponds to a decrease in volume of the sound to be recorded. It is now desirable to delay the speed reduction of drive motor 15, by a predetermined space of time. At this time the current in the solenoid 35 is reduced to such a value that the tension spring of the member 38 would immediately move the arm 32 to the right, inserting more resistance 30 into the circuit, but as the pawl 45 is engaged in the ratchet 41, the drum must turn against the friction of the brake shoe 42, which retards the motion of the arm 32 and the contact 31 to the right, viewing Fig. 7. The amount of retardation obtained from the brake action of the member 42 on the drum 40 may be conveniently adjusted at 44. Obviously the lag producing device may be employed in connection with the modification disclosed in Fig. 2. That is, the manually operated speed control may be provided with an arrangement such as is disclosed in Fig. 7 which will permit immediate increase in the speed of lateral feed of the cutting tool, but provides for a certain predetermined lag in returning to a slower rate of speed.

While the present description has been directed to certain specific embodiments of this invention it is to be understood that these embodiments are merely illustrative of the invention contained herein and that many changes in the structure disclosed will readily suggest themselves to those skilled in the art. The scope of this invention, therefore, is not to be limited by the present disclosure except as outlined in the appended claims.

Having thus described my invention, what I claim is:

1. The method of cutting sound reproducing grooves in a phonograph record which comprises the steps of rotating the disc about a fixed pivot, subjecting said rotating record to a cutting tool, said cutting tool being responsive to the sound vibrations desired to be recorded, and feeding said cutting tool radially of said disc, the speed of said cutting tool being varied in accordance with the character of the material to be recorded.

2. The method of cutting sound reproducing grooves in a phonograph record which comprises the steps of rotating the disc about a fixed pivot, subject said rotating record

to a cutting tool, said cutting tool being responsive to the sound vibrations desired to be recorded, variably feeding said cutting tool radially of said disc, the speed of radial feed of said cutting tool being increased for high amplitudes of vibration of the cutting tool and decreased for relatively low amplitudes of vibrations of the cutting tool.

3. The method of cutting sound reproducing grooves in a phonograph record which comprises the steps of rotating the disc about a fixed pivot, subjecting said rotating disc to a cutting tool, said cutting tool being responsive to the sound vibrations desired to be recorded, variably feeding said cutting tool radially of said disc, the speed of radial feed of said cutting tool being constantly varied in accordance with substantial variations in amplitude of vibration of the cutting tool, whereby the wall formed between adjacent portions of said grooves is maintained about a certain minimum thickness.

4. The method of cutting sound reproducing grooves in a phonograph record which comprises the steps of rotating a disc upon which the record is to be formed, pressing a cutting tool upon said disc, said cutting tool being vibrated in accordance with the character of the material to be recorded, and automatically feeding said cutting tool radially of the disc at a speed which is varied in accordance with the amplitude of the material to be recorded.

5. The method of cutting sound reproducing grooves in a phonograph record which comprises the steps of mounting a disc upon which the record is to be made for rotation about a fixed pivot, pressing on said disc a cutting tool which is radially movable thereof, vibrating said cutting tool in accordance with the character of material to be recorded, rotating a control record in synchronism with said disc, and utilizing said control record as an automatic means to control the radial movement of said cutting tool, whereby the speed of the radial feed of the cutting tool is varied in accordance with the character of sound material to be recorded.

6. The method of cutting sound reproducing grooves in a phonograph record which comprises the steps of mounting a disc upon which the record is to be made for rotation about a fixed pivot, pressing on said disc a cutting tool which is radially movable thereof, vibrating said cutting tool in accordance with the character of material to be recorded, rotating a control record at a speed equal to the speed of rotation of said disc, and with a predetermined amount of lead between a point on the control record and the corresponding point on the disc, and controlling the radial movement of said cutting tool in accordance with the reproduction of the said control record, whereby the wall formed between adjacent portions of said groove is maintained at a predetermined minimum value.

7. The method of cutting reproducing grooves in a phonograph record which comprises the steps of rotating a disc in which the grooves are to be cut about a fixed pivot, cutting a groove in said disc spirally from a point near the circumference of said disc to a point adjacent to the center thereof or vice versa, the amplitude of vibration of said cutting tool being varied in accordance with the character of sound material to be recorded, playing a pre-recorded control record simultaneously with the cutting of said disc with a lead of a predetermined amount between the rotation of said control record and the rotation of said disc, and varying the radial feed of said cutting tool in accordance with the character of material reproduced from said control record.

8. The method of cutting reproducing grooves in a phonograph record which comprises the steps of rotating a disc in which the grooves are to be cut about a fixed pivot, cutting a groove in said disc spirally from a point near the circumference of said disc to a point adjacent to the center thereof or vice versa, the amplitude of vibration of said cutting tool being varied in accordance with the character of sound material to be recorded, playing a pre-recorded control record simultaneously with the cutting of said disc with a lead of a predetermined amount between the rotation of said control record and the rotation of said disc, and automatically increasing the speed of radial feed of the cutting tool when the amplitude of vibrations reproduced from the control record are increased and reducing the speed of the radial feed of said cutting tool when the vibrations reproduced by said control record are reduced.

9. The method of cutting sound reproducing grooves in a phonograph record which comprises the steps of rotating a disc in which the grooves are to be cut at a constant speed, pressing a cutting tool upon said disc, playing the program material to be recorded on the disc, utilizing this material to actuate the said cutting tool, playing a pre-recorded control record of the same composition simultaneously with said first mentioned playing, utilizing the reproduction of said control record as a means to direct said first mentioned playing and also as a means automatically to control the speed of radial feed of said cutting tool as it passes over said disc.

10. The method of cutting sound reproducing grooves in a phonograph record which comprises the steps of rotating at a constant speed a disc in which the grooves are to be cut, pressing a cutting tool upon said disc, playing the program material to be recorded on the disc, utilizing this material to actuate the said cutting tool, playing a pre-recorded control record of the same composition simul-

taneously with said first mentioned playing a predetermined amount in advance thereof, utilizing the reproduction of said control record as a means to direct said first mentioned playing and also as a means automatically to control the speed of radial feed of said cutting tool as it passes over said disc.

11. In a system for cutting sound reproducing grooves in a phonograph record, the combination of means to rotate at a constant speed a disc upon which the record is to be made, means to cut the grooves in said disc, means to feed said cutting means radially of said disc, and means separate and independent of said disc rotating means to vary the speed of said radial feed means.

12. In a system for cutting sound reproducing grooves in a phonograph record, the combination of means to rotate at a constant speed a disc upon which the record is to be made, means responsive to the program material to be recorded for cutting grooves in said disc, means to move said cutting means radially of the disc, and means under control of said program material for automatically controlling the radial movement of said cutting means.

13. In a system for cutting sound reproducing grooves in a phonograph record, the combination of a first means to rotate at a constant speed a disc upon which the program material is to be recorded, means responsive to the program material for cutting sound reproducing grooves in said disc, means to feed said cutting means radially of said disc, a second means to rotate a prerecorded control record at a speed equal to the speed of said disc, means to reproduce the program material of said control record, and means to control the speed of said feeding means in accordance with the reproduction of the control record.

14. In a system for cutting sound reproducing grooves in a phonograph record, the combination of means to rotate at a constant speed a disc upon which the program material is to be recorded, means responsive to the program material for cutting sound reproducing grooves in said disc, means to feed said cutting means radially of said disc, and means responsive to the amplitude of vibration of said program material to control the speed of said feeding means.

15. In a system for cutting sound reproducing grooves in a phonograph record, means for varying the speed of the radial feed of the cutting means in accordance with the character of program material being recorded, said means comprising a device for reproducing a control record, means to convert the sound of said control record into electrical oscillations or impulses, means responsive to said oscillations or impulses, to cause a substantially instantaneous movement of said control means when the amplitude of vibration of the reproduction from said control record exceeds a certain predetermined value, and means to cause a retarded return motion of said control means when the amplitude of oscillations or impulses reproduced from said control record are reduced to a predetermined value.

16. In a system for cutting sound reproducing grooves in a phonograph record, means for varying the speed of the radial feed of the cutting means in accordance with the character of program material being recorded, said means comprising a pick-up device designed to be operated by a control record, means responsive to the reproduction from said control record for increasing the speed of said variable feed means substantially instantaneously with an increase in amplitude of reproduction from the control record, and a delay return device for decreasing the speed of said feed mechanism a predetermined interval of time after the reduction of amplitude of material reproduced by said control record.

17. In a system for cutting sound reproducing grooves in a phonograph record, the combination of means to rotate at a constant speed a disc upon which the record is to be made, means to cut grooves in said disc, means to vary the speed of lateral feed of said cutting means, and means to permit a substantially instantaneous increase in the said speed of lateral feed and to provide for a retarded decrease in the said speed of lateral feed.

18. In a system for cutting sound reproducing grooves in a phonograph record, the combination of means to rotate at a constant speed a disc upon which the record is to be made, means to cut grooves in said disc, means to vary the speed of lateral feed of said cutting means in accordance with the character of material to be recorded, means to permit said speed varying means to function substantially instantaneously when the material to be recorded is of one predetermined character and to retard the functioning of said speed varying means when the material to be recorded is of another predetermined character.

19. In a record cutting apparatus utilizing a variable rate of radial feed of the cutting tool, means to permit a substantially instantaneous increase in the speed of radial feed of the cutting tool when the amplitude of the sound vibrations to be recorded is increased and to retard the decrease in said speed after said increase when the said amplitude is diminished, said means comprising in combination, a variable speed electric motor, a speed regulating device therefor, a pick-up device responsive to a phonograph record, means actuated by said pick-up device to operate said speed regulating device to increase the speed of said motor substan-

tially instantaneously, a spring to return said speed regulating device to normal position, and a brake operable to retard said return.

20. In combination, a brake drum rotatably mounted on a shaft, a brake shoe held in spring pressed relationship therewith, whereby to retard the rotation of said drum, a link loosely and rotatably mounted on the shaft of said drum, a ratchet mounted on the shaft of said drum and rotatable with said drum, a pawl carried by said link, a movable electrical contact carried by said link, means to actuate said link freely in one direction, and means to return said link when said last mentioned means is released, the said pawl engaging with the said ratchet during said return of the link, whereby the return movement of the link is retarded by the action of the brake shoe on the brake drum.

21. In combination, a brake drum rotatably mounted on a shaft, a brake shoe held in spring pressed relationship therewith, whereby to retard the rotation of said drum, means to vary the friction of said shoe on said drum, a link loosely and rotatably mounted on the shaft of said drum, a ratchet mounted on the shaft of said drum and rotatable with said drum, a pawl carried by said link, a movable electrical contact carried by said link, means to actuate said link freely in one direction, and means to return said link when said last mentioned means is released, the said pawl engaging with the said ratchet during said return of the link, whereby the return movement of the link is retarded by the action of the brake shoe on the brake drum.

22. In combination, a brake drum rotatably mounted on a shaft, a brake shoe held in spring pressed relationship therewith, whereby to retard the rotation of said drum, a link loosely and rotatably mounted on the shaft of said drum, a ratchet mounted on the shaft of said drum and rotatable with said drum, a pawl carried by said link, a movable electrical contact carried by said link, means to actuate said link freely in one direction, spring means to return said link to its normal position when said last mentioned means is released, and means to vary the tension of said spring means, the said pawl engaging with the said ratchet during the said return of the link, whereby said return movement of the link is retarded.

23. The method of recording sound vibrations on a record which consists in recording the sound vibrations on the record in adjacent paths, and in varying the distance between the paths according to the character of the vibrations to be recorded.

24. The method of recording sound vibrations on a record which consists in recording the sound vibrations on the record in paths, and in varying the distance between the paths according to the amplitude of the vibrations.

25. The method of recording sound vibrations on a record which consists in recording the vibrations in paths, and in increasing and decreasing the distance between the paths in accordance with increases and decreases in the amplitude of the recorded vibrations.

26. The method of recording sound vibrations on a record which consists in recording the vibrations in paths, and in increasing the distance between the paths as the amplitude of the vibrations to be recorded increases.

27. The method of recording sound on a record which consists in recording the sound vibrations on a control record, subsequently recording the sound vibrations on a second record in adjacent paths, and varying the distance between paths on the second record in accordance with the character of the vibrations on the control record.

28. The method of recording sound on a record which consists in recording the sound vibrations on a control record in widely but equally spaced paths, in subsequently recording the sound vibrations on a second record in paths unequally spaced from each other, and in varying the spacing between the paths on the second record in accordance with the amplitude of the vibrations recorded on the control record.

29. Apparatus of the class described comprising a record adapted to have sound vibrations recorded thereon, means for recording sound vibrations on said record in adjacent paths, and means for varying the distance between adjacent paths according to the character of the sound to be recorded.

30. Apparatus of the class described comprising a record adapted to have sound vibrations recorded thereon, means for recording sound vibrations on said record in adjacent paths, and means for increasing the distance between adjacent paths when the amplitude of the vibrations to be recorded is large and for decreasing the distance between adjacent paths when the amplitude of the vibrations to be recorded is small.

31. Apparatus of the class described comprising a record adapted to have sound vibrations recorded thereon, means for recording sound vibrations on said record in adjacent paths, means for increasing the spacing between adjacent paths a predetermined period before the vibrations to be recorded increase in amplitude, and means for decreasing the spacing between adjacent paths a predetermined period after the vibrations to be recorded thereon decrease in amplitude.

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