March 29, 1938. J. O. KLEBER 2,112,699

SOUND RECORD AND ITS PRODUCTION

Filed April 10, 1937

Fig. 1.

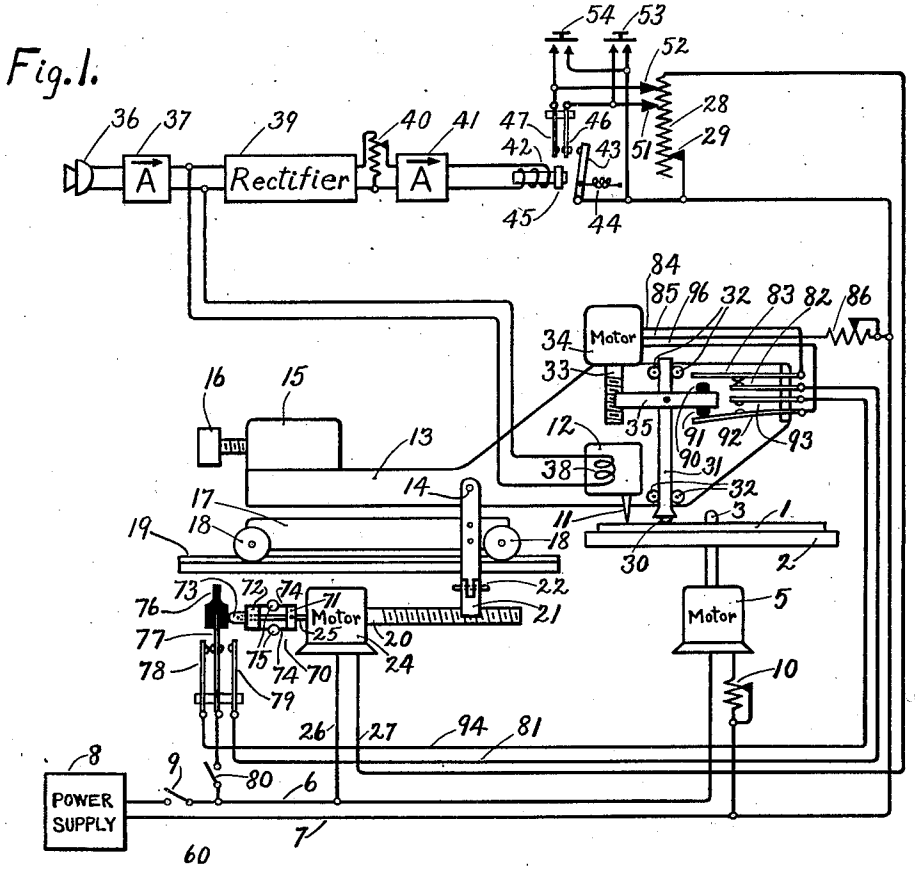


Fig. 2.

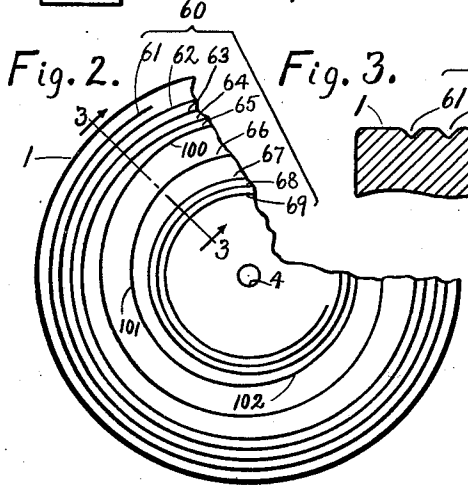
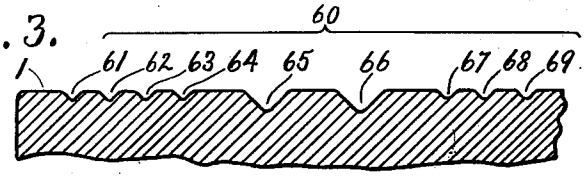


Fig. 3.



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SOUND RECORD AND ITS PRODUCTION

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3 Claims. (Cl. 179—100.4)

This invention relates to sound records and their production under the control of electric currents varying in accordance with sound.

When a sound record of the laterally or the perpendicularly undulating type is produced in the form of a spiral sound track of varying effective width and with turns of the track concentrated very close together, the large undulations tend to "over-cut", that is, the undulations in one turn of the sound track groove tend to cut into an adjacent turn of the groove, or to objectionably weaken the wall of material separating adjacent turns of the groove, so that when the sound is reproduced, the stylus on passing the "over-cut" place, may jump back into or cut across into the same turn it has just played, thus repeating the sound in this one turn, without progressing beyond it. The pitch of the spiral must, therefore, be large enough to furnish adequate free space for the widest parts of the sound track where the largest undulations are recorded.

When the groove is too shallow, the reproducing stylus may be subject to a difficulty known as "failure to track", and may have a tendency to jump entirely out of the track it should follow, thus interrupting the continuity of reproduction of the sound, particularly when the undulations are very large. The undulations, when large, exert a greater force on the reproducing stylus than when small, the frequency being the same in both cases. If the groove is too shallow, the small amount of material in the wall of the groove, required to force the stylus into vibration, cannot stand the strain and becomes too rapidly worn to retain its undulations in their original form, or becomes strained out of shape, or the stylus may actually cut across the undulations, in short-cut fashion, without following the detailed contour of the undulations, thus introducing objectionable sound disturbances and distortion, and mutilating the record. In order to record the undulations properly, therefore, the usual practice requires that throughout the length of the groove, the constant average depth of the groove be made large enough to insure that the reproducing stylus can not suffer a "failure to track" at places where the undulations are largest.

Another difficulty, called "echo", is also experienced when the grooves are packed too close together. By "echo" is meant an effect produced by the sound recorded in one groove upon the reproduction of sound from an adjacent groove. When the grooves are so close or the undulations are so large that the wall of material separating two adjacent grooves becomes very thin, the material becomes so deformed or weakened by the undulations and by the reproducing stylus, that the undulations in one groove control to some extent the vibrations of the stylus in an adjacent groove. Objectionable distortion and disturbance of the original characteristics of the sound may thus be produced.

One object of the present invention, is to overcome one or more of the difficulties referred to above.

Another object is to produce a concentrated sound record adapted for manufacture at low cost and capable of reproducing sound with high fidelity.

Another object is to concentrate a sound record to a greater extent than is ordinarily possible without introducing disturbances or distortion into the sound reproducible from the record.

Another object is to provide a method of and means for efficiently producing sound records of the kind referred to.

In accordance with one aspect of the present invention, a sound track having an envelope of variable width, is produced in response to sound currents and is traced in such directions on the surface of the record blank, that a plurality of similarly directed portions thereof in series with each other are positioned laterally close together in a compact row for the purpose of concentrating the record within a small space. These laterally adjacent portions of the track may constitute turns in a spiral and may be so close to each other as to approach but not quite reach the point of appreciable or substantial interference. When the amplitude of the sound currents and of the undulations recorded in one portion of the track exceeds a predetermined limit beyond which this portion might tend to interfere with another laterally adjacent portion, the direction of the track is changed to increase the spacing between the center lines of these portions sufficiently to dodge and avoid objectionable interference.

After the sound current amplitude decreases to less than the predetermined value, the direction of the track is changed back to reduce the unused waste space between the laterally adjacent portions of the track. A delay is preferably provided after the decrease of amplitude and before the track direction is changed, to avoid the possible objectionable effect of too sudden restoration of the direction when the

amplitude fluctuates rapidly between very large and small values.

By increasing the average depth of the sound track groove when the undulations increase from less to more than a predetermined amplitude and by decreasing the average depth after the undulations decrease from more to less than this predetermined amplitude, the small amplitude undulations make a narrower track than if the average depth were maintained constantly sufficient for the largest undulations, and consequently, portions of the track containing undulations of small amplitude may be packed more closely together without interference.

Provision is made for independently controlling the direction of the sound track groove and the depth of the groove, and for the manual or automatic control of both direction and depth in response to changes of amplitude of the sound current being recorded, thus permitting efficiently of a high degree of concentration of the record.

These and other objects and features of the invention will be understood in further detail by reference to the accompanying drawing and the detailed description and claims which follow.

It will be understood that the words "sound track", as used herein, when applied to a groove, refer not only to the configuration of the surface within the groove, but also to the modification of the metallic or non-metallic plastic material of the blank by the recording or reproducing stylus within the region inside or outside of the actual groove, as it affects the reproduction of sound from the record.

In the drawing, Fig. 1 is a schematic circuit diagram showing one form of apparatus adapted to produce sound records according to the present invention.

Fig. 2 is a fragmentary plan view of a record adapted to be made by the apparatus of Fig. 1, and showing exaggerated spacings between tracks for the purpose of clearness.

Fig. 3 shows an enlarged section of a portion of the record, taken on the line 3—3, Fig. 2.

In Fig. 1, the sound record blank 1, is in the form of a disk of wax, soft metal, such as aluminum, or other well known suitable plastic material. The horizontal table 2 is fast to the vertical shaft 3, the upper end of which projects through the central hole 4 of the disk 1, see Fig. 2. The table and shaft provide a holder for supporting the disk horizontally and for rotating it around its central axis. The shaft 3 is rotated at constant speed by the electric motor 5 which may include gearing, not shown, to suitably reduce the speed of shaft 3. Current for operating the motor 5 is supplied over wires 6, 7 from the source of power 8 by closure of the switch 9, and the motor speed may be adjusted by the rheostat 10, unless the motor be of the synchronous type energized from an alternating current source.

The recording stylus 11 is supported by the recording head 12, supported on the tone arm 13, which in turn is rotatable on a horizontal axis on the pivot 14 and may be balanced to any desired extent by the fixed counterweight 15 with the screw 16 serving as an adjustable counterweight. The pivot 14 is supported by and held in fixed relation to the carriage 17, mounted on the wheels 18, rolling on the track 19 which guides the carriage 17 and the stylus 11 in a path along a radius of the disk 1 and the table 2.

The carriage 17 is moved radially inward toward the shaft 3 by rotation of the screw 20, engaging with the threaded nut section 21, supported from the carriage and hinged relatively thereto on the pivot 22, so that the nut section may be swung away from meshing contact with the threads of screw 20 to permit of movement of the carriage independently of the screw.

The screw shaft 20 is rotated by the constant speed electric motor 24 which may include gearing, not shown, for suitably reducing the speed of the screw 20 below the speed of the motor shaft 25. The circuit for supplying power to the motor 24 may be traced from the source 8, through switch 9, conductors 6 and 26, motor 24, conductor 27, rheostat 28, sliding contact 29, and back to source 8 through conductor 7. Adjustment of rheostat 28 changes the constant speed of motor 24.

The advance ball 30 guides the stylus 11 in relation to the upper or horizontal surface of the blank 1, while the stylus cuts a spiral groove in this surface due to the circular movement of the blank while the stylus is fed radially or, in other words, laterally of the circular path of movement of the blank. The ball 30 is secured in the lower end of the rod 31, held between the guiding rollers 32, supported from the arm 13. The rod 31 is held in a fixed position vertically by the screw shaft 33 which in turn is supported by the motor 34, supported on the arm 13. The motor 34 has the circuit 84, 85 for rotating the shaft 33 in one direction and the circuit 85, 96, for rotating it in the opposite direction. The threads of screw 33 mesh with the threaded end of the cross arm 35, fastened to the rod 31. Rotation of screw 33 by motor 34, adjusts the vertical position of rod 31, and ball 30 relatively to the stylus 11.

The screw 16 is ordinarily adjusted to unbalance the arm 13 in such a direction as to press the ball 30 and stylus 11 toward the blank 1 with suitable pressure to insure maintenance of the desired position of the stylus point relatively to the surface of the blank to control the average depth of groove being cut by the stylus.

Sound waves to be recorded are impressed on the microphone 36, producing electric currents which may be increased to suitable amplitude by the adjustable amplifier 37, from the output of which the amplified sound currents are transmitted to the recording head 12, including with other suitable elements, the coil 38 or some other well known type of motor element for vibrating the stylus in accordance with the sound currents. The recording head 12 may be of the type in which vibrations of the stylus 11 produce perpendicular undulations on the blank or of the type producing lateral undulations thereon.

The rectifier 39, connected in parallel with the recording coil 38, converts the alternating sound currents into pulsating direct current of changing value corresponding approximately with the changes of amplitude or intensity of the sound currents.

The potentiometer 40 in the output circuit of the rectifier 39 is connected in the input of amplifier 41, and is adjusted to control the amplification of the direct current variations to the desired degree. The output circuit of amplifier 41 includes the electromagnetic relay 42 which has the armature 43, normally retracted by the spring 44. A low resistance short circuited ring 45, surrounding the armature end of the core of relay 42, is adjusted to allow armature 43 to attract promptly when the current energizing the relay increases to more than a predetermined value, and to cause a predetermined delay in restoration of armature

43, after the current energizing the relay decreases suddenly to less than said predetermined value.

The delay in restoration of relay 42 to normal should be long enough to avoid reduction of the track spacing when the decrease of current amplitude is very brief, or when there are rapid fluctuations from large to small and back to large amplitudes. In a given case, for example, the relay 42 may be designed and adjusted in well known manner, to provide a delay equal to that of one half or a whole rotation of the blank 1. Ordinarily the delay should not be less than about one-tenth of a second, since a much briefer delay may have a tendency to introduce undesired audio frequency distortion components in the second reproducible from the track.

When the energizing current increases to more than the predetermined value capable of actuating relay 42, the armature 43 first contacts with spring 46, and many remain in contact therewith without being sufficiently attracted to establish contact with spring 47, unless the current increases to a substantially greater value.

Contacts 43 and 46 connect, respectively, with the sliders 29 and 51 of the rheostat 28 and bridge these sliders when closed, while contact 47 connects with the slider 52, so that closure of contacts 43, 46, 47, short-circuits the rheostat between the sliders 29 and 52.

The contacts of push button 53 are connected in parallel with contacts 43, 46, and those of push button 54 in parallel with contacts 43, 47, so that the same changes in rheostat 28 can be made manually by the push buttons 53, 54, as are made automatically by the relay 42.

The shaft 25 of the motor 24 has the speed responsive governor 70 of well known form, having the collar 71, fast to the shaft, and the collar 72, having the bearing on the shaft permitting it to slide freely axially of the shaft, and having a hollow stem 73 projecting therefrom. Leaf springs 74 are fastened at their ends to collars 71, 72, respectively, between which they are bridged with a very slight curvature radially outward from shaft 25. Weights 75, secured to springs 74 half way between their ends, move radially outward by centrifugal force when shaft 25 rotates, thus causing stem 73 to move to the right.

The insulating handle 76 is normally pressed to the right against the rounded free end of stem 73 by the contact spring 77, on which the handle 76 is supported. Outward bowing of the springs 74, permits the handle 76 to be moved manually to the right. When handle 76 is moved sufficiently to the right, either manually or by speeding up of motor 24 to more than some predetermined speed, spring 77 breaks contact with spring 78 and makes contact with spring 79, thereby closing a circuit for motor 34, traced from the power source 8, through switches 9 and 80, springs 77, 79, conductor 81 to spring 82 which is under tension making it contact with spring 83 when arm 35 is in its lowest position relatively to arm 13, then through the upper circuit 84, 85 of motor 34, through the rheostat 86 for regulating the speed of motor 34, and through lead 7 back to the source 8. Current through circuit 84, 85 causes motor 34 to rotate screw 33 in a direction to move arm 35 upward relatively to arm 13, thus lowering arm 13 and stylus 11 relatively to stem 31, advance ball 30, and the record blank 1, thereby causing the stylus to cut a deeper groove in the blank.

When arm 35 moves from its lowest to its highest position relatively to arm 13, the insulation 90, carried by arm 35, pushes spring 83 upward out of contact with spring 82, thus stopping rotation of the motor 34, while insulation 91 carried by arm 35, moves up and allows the upwardly tensioned spring 92 to make contact with spring 93.

When handle 76 is again moved to the left, as shown in the drawing, while contacts 92, 93 are closed, a circuit may be traced for motor 34, from the source 8, through switches 9, 80, springs 77, 78, lead 94, spring 93, 92, circuit 96, 85 of motor 34, rheostat 86, and back through lead 7 to source 8. Current through this circuit causes the motor 34 to rotate screw 33 in a direction to move arm 35 downward relatively to arm 13, thus raising the arm 13 and stylus 11 relatively to the advance ball 30 and the blank 1, and thereby causing the stylus to cut a more shallow groove. When the arm 35 moves from its highest to its lowest position relatively to arm 13, the insulation 90 moves down and allows spring 83 to re-establish contact with spring 82, while insulation 91 moves down and causes spring 92 to break contact with spring 93, as shown in Fig. 1, thus stopping rotation of motor 34.

When recording sound, the switch 9 is closed to rotate motors 5 and 24 and cause the stylus 11 to cut the groove 60, Figs. 2 and 3, along a spiral path on the upper surface of the blank 1. For the purpose of clearness, the spacings between the series turns 61, 62, 63, 64, 65, 66, 67, 68, of the spiral are considerably magnified or exaggerated in the drawing, to avoid overlapping of the lines representing the closest turns, and to show the other turns of the track with relatively larger spacings. The size of groove 60, Fig. 3 is also exaggerated to show its form more clearly.

The form of the groove, shown in Fig. 3 for the purpose of illustration, has an ordinary V-shaped section with an angle of about 90 degrees between its arms. The bottom of the V is rounded in the usual manner with a circular shape. The profile of the section corresponds with that of the cutting edge of the stylus. The radius of curvature of the bottom of the V may be about .002 of an inch, for example. It will be seen that a sound track made with this type of groove, has an envelope of varying width, whether the sound is recorded as perpendicular or as lateral undulations.

Sound recorded as perpendicular undulations, produces a groove having two edges, each of which contains undulations consisting of lateral displacements in opposite directions at opposite edges of the groove, while sound recorded as lateral undulations, produces a groove having undulations in each edge consisting of lateral displacements in the same direction at opposite edges of the groove. The resulting envelopes of the undulations vary in width with changes of amplitude of the undulations. Consequently the narrow strip representing the area between the outer envelopes of the undulations at opposite edges of the groove, increases in width as the amplitude of the sound current increases, and this area encroaches more and more on the area between turns of the spiral track. Since the spacing between turns is limited by the close packing of the turns, it is possible with any given spacing to record only those sounds having less than a predetermined amplitude without risking objectionable interference with a portion of the sound track in a laterally adjacent turn.

The amplifier 37 is adjusted to supply sound currents of suitable amplitude to coil 38 to vibrate stylus 11 adequately for recording the weakest components to be reproduced. The constant speed of motor 5 is adjusted by slider 29 of rheostat 28, to feed stylus 11 radially of the blank 1 at the desired speed relatively to the circular speed of the blank, to provide the desired constant spacing between turns of the spiral. The desired spacing may be determined in part by the character of the sound recorded. If the character is such that the amplitude remains at a relatively small value most of the time and there are only a few trains of undulations of much larger amplitude, the turns may be packed very close together for the low amplitudes.

For a highly concentrated record, the potentiometer 40 is adjusted so that relay 42 will close contacts 43, 36 as soon as the sound currents exceed the predetermined amplitude chosen as the largest value recordable without interference at the desired smallest spacing between turns. Instruments, not shown, may be provided to indicate visually the current in the various parts of the circuit to facilitate adjustments of the circuit, but it will be understood that such instruments are not essential.

Closure of contacts 43, 46 speeds up rotation of motor 24, thus increasing the rate of radial feed of stylus 11 and widening the spacing between the center lines of any two laterally adjacent portions of the track. Closure of contacts 46, 47, still further increases the spacing to accommodate still larger undulations. Adjustment of sliders 51, 52 control the amount of increase in spacing between turns of the track corresponding with the successive attracted positions of armature 43. Additional contacts and motor speed adjustments, not shown, may be similarly provided for relay 42. The ring 45 on relay 42 causes a delay in the opening of contacts 46, 47, similar to the delay described in connection with the opening of contacts 43, 46.

The undulations recordable in the closest turns of the spiral are of such small amplitude that they do not require the depth of groove needed for larger amplitudes, and consequently the width of the groove and therefore of the sound track may be less than for the larger amplitudes, in contrast with the usual practice where the depth of groove, throughout its length, is kept large enough to handle large amplitudes. Appreciable space may thus be saved by the present invention.

The governor 70 is preferably so adjusted that when the sound amplitude increases enough to operate relay 42, the corresponding increase of speed of motor 24 causes spring 77 to move to the right. When switch 80 is closed and spring 77 makes contact with spring 79, the stylus 11 is moved down to cut a deeper groove which can be made of sufficient depth to handle adequately the undulations of increased amplitude.

The sound at the beginning of the record, Figs. 2 and 3, is below the predetermined amplitude necessary to cause actuation of relay 42, and the turns 61, 62, 63, 64 and part of 65, may be considered to be packed as closely as can be permitted without interfering effects between turns. For example, these turns may be packed to a concentration of 150 turns to the inch measured on a radius of the blank, but it will be understood that a concentration of 175 turns to the inch, or even considerably higher may be possible under favorable conditions. At 150 turns to the inch, the width of groove may be .0042 of an inch.

At the point 100 on the sound track, the amplitude of the sound currents and of the undulations has exceeded the predetermined value necessary to actuate relay 42, and contacts 43, 46 have closed to cut out section 29, 51 of rheostat 28, thereby speeding up motor 24 and increasing the rate of displacement of the sound track laterally of the circular path of movement of the blank, per unit angle measured around the axis of rotation, or in other words, increasing the spacing between turns of the spiral so that a larger space is now available for recording the larger undulations without interference.

The motor 24 continues to rotate at the higher speed up to the point 101 on the sound track, when the current suddenly decreases to a small amplitude below that necessary to maintain actuation of relay 42, but the relay remains actuated, owing to the ring 45, and consequently motor 24 maintains its higher speed until the point 102 is reached, when contacts 43, 46 open. Motor 24 then slows down to the minimum speed and produces the minimum spacing between turns 67, 68, 69. The above described steps may be repeated many times during the production of a single record.

By closing switch 80, the circuit of motor 34 and the associated apparatus is effective automatically to increase the average depth of the groove 60 when the amplitude of sound currents changes from below to above the predetermined value sufficient to actuate relay 42, and is effective automatically to reduce the average depth of groove when the sound currents decrease from above to below this predetermined value.

When the point 100 is reached on the blank 1, the speed of motor 24 is sufficient to open contacts 77, 78 and close contacts 77, 79, thus causing the operation of motor 34 to increase the average depth of groove, as shown by the deeper groove 65, 66 in Fig. 3. Since the depth of groove is not increased until after the radial feed speed of the stylus 11 is increased by motor 24, there is less tendency for interference resulting from increase of groove width before the spacing between turns increases, than if the depth increase occurred without this delay.

At the point 102, when the relay 42 releases and the speed of motor 24 decreases, the contacts 77, 79 open and contacts 77, 78 close to operate motor 34 to decrease the average depth of groove, as shown by the shallower groove 67, 68, 69 Fig. 3. By means of the method and apparatus described, the average depth of the groove and consequently the effect of groove depth on the width may be kept to a minimum.

Concentration of the sound track by controlling the pitch of the spiral and the average depth of the groove, either independently or together, as referred to above, results in a concentration of sound tracks considerably in excess of that of prior records having a spiral of constant pitch and a groove of constant average depth throughout its length. This concentration is obtained without incurring the difficulties referred to above in connection with prior records.

Records produced by the above described methods are adapted for reproduction by the usual equipment, not shown, for reproducing sound from ordinary disk records. The reproducing pick up, such as a stylus for example, follows and is guided by the sound track in the direction in which it was recorded.

The method, described above, of changing the

spacing between laterally adjacent portions of sound tracks, is useful not only for the closest packed tracks, but is also advantageously applicable to much larger predetermined spacings where space in excess of the predetermined amount is to be conserved.

If desired, the average depth of the groove may be adjusted to any desired value by manual operation of the switch handle **76**. The switch **80** may then be opened and the record produced while automatically controlling the pitch of the spiral by relay **42**, without automatically controlling the depth of the groove.

It will be understood that the dimensions and shape of the groove and stylus, the amount of spacing between laterally adjacent portions of the track, the geometrical shape of the blank and of the path of the track, and even the type of sound track and blank, are susceptible to considerable departure from the specific details of the embodiments chosen as illustrations of the invention, without actually departing from the invention itself in its broader aspects as disclosed and claimed herein.

I claim:

1. A sound record having a record surface arranged for rotation in a circular path and having a sound track groove on said surface disposed spirally around the axis of rotation, said groove containing a section having a predetermined average depth and having undulations of less than a predetermined amplitude and having a predetermined rate of displacement laterally of said circular path per unit angle measured around said axis, and another section of said groove having more than said predetermined average depth and having undulations of more than said predetermined amplitude and having a greater rate of lateral displacement per unit angle than said first mentioned rate.

2. The method of recording sound on a record blank, which comprises producing a sound track groove on the surface of the blank in response to sound currents, causing said track to be traced in such a direction as to produce in series a plurality of similarly directed portions laterally disposed close to each other, and changing the direction and average depth of the groove in response to predetermined changes in the amplitude of said currents.

3. Apparatus for recording sound on a record blank, including a recording stylus, a holder for supporting the blank in recording relation to said stylus, means for producing relative motion between said holder and said stylus in such directions that the stylus traces on the blank a sound track groove having in series a plurality of similarly directed portions disposed so close to each other laterally as to approach interference, a circuit for sound currents, means responsive to current in said circuit for imparting to said stylus the vibrations to be recorded and for producing undulations in the sound track within a narrow area of varying width on the surface of the blank, means for changing the average depth of said groove, means for changing the direction of the sound track, and means responsive to predetermined changes of current in said circuit for controlling the operation of said depth and direction changing means.

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CERTIFICATE OF CORRECTION.

Patent No. 2,112,699. March 29, 1938.

JACKSON O. KLEBER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 21, for the word "many" read may; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 26th day of April, A. D. 1938.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)