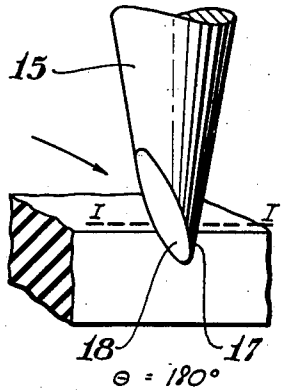
April 25, 1944. R. WAGNER 2,347,623

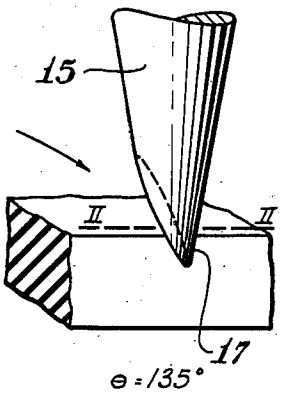
SOUND RECORD AND METHOD OF MAKING

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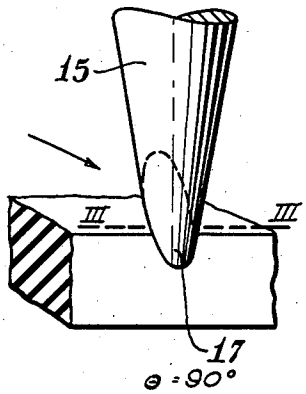
$\theta = 180°$

Fig. 1



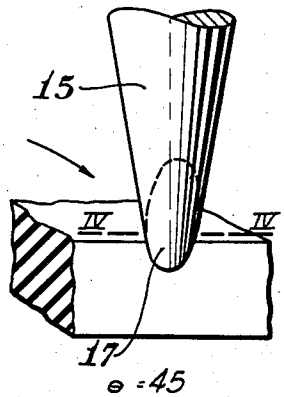
$\theta = 135°$

Fig. 2



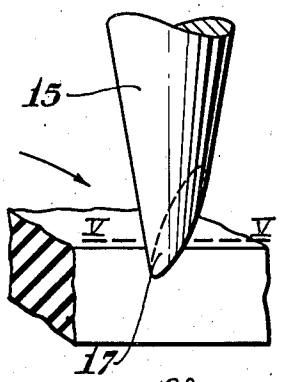
$\theta = 90°$

Fig. 3



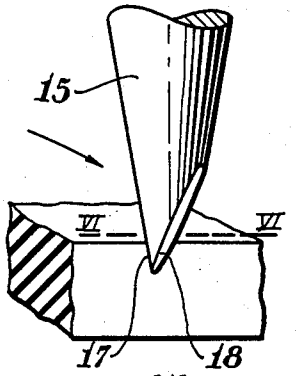
$\theta = 45$

Fig. 4



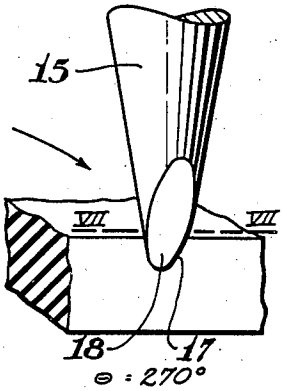
$\theta = 0°$

Fig. 5



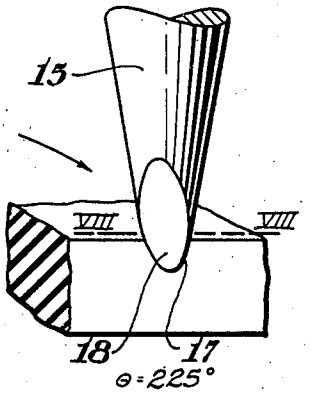
$\theta = 315$

Fig. 6



$\theta = 270°$

Fig. 7



$\theta = 225°$

Fig. 8

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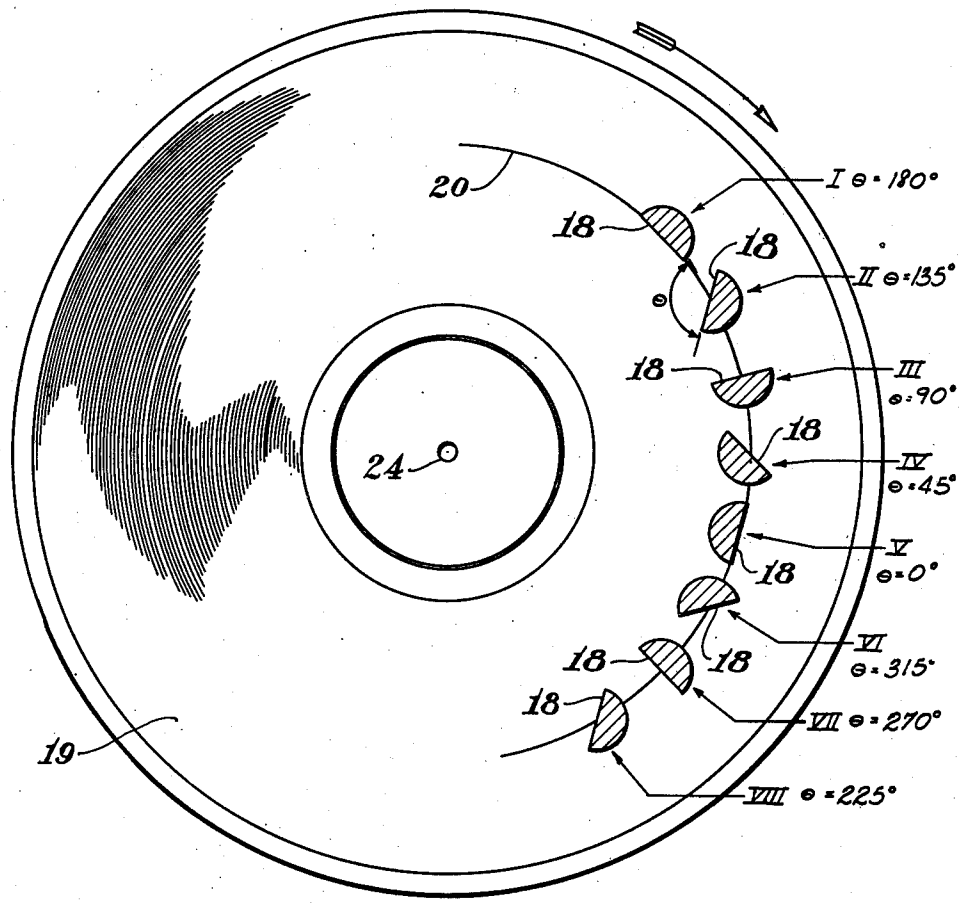


Fig. 9

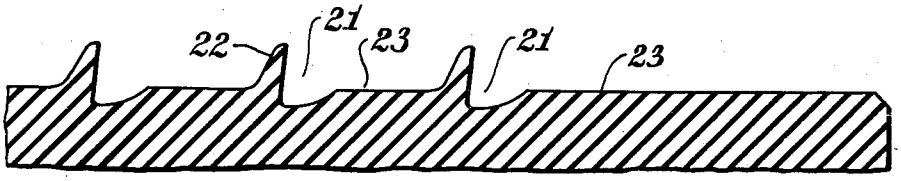


Fig. 10

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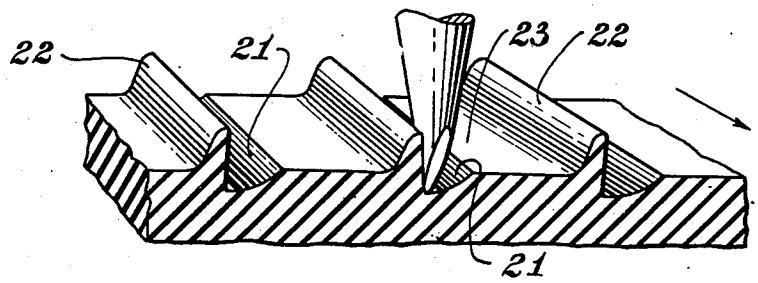


Fig. 11

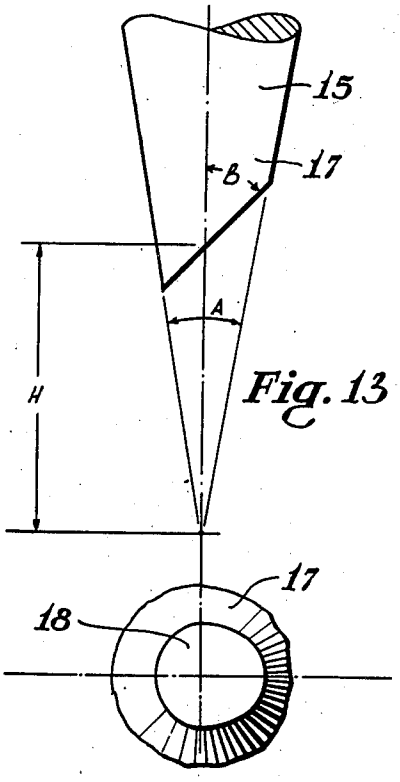


Fig. 13

Fig. 14

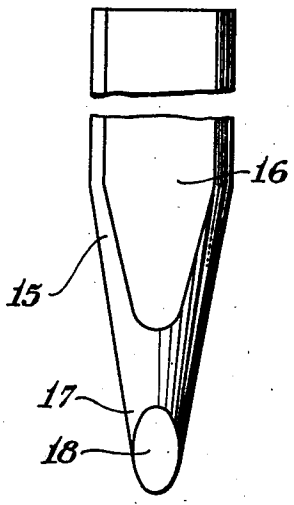


Fig. 12

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UNITED STATES PATENT OFFICE

2,347,623

SOUND RECORD AND METHOD OF MAKING

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Application September 15, 1941, Serial No. 410,945

8 Claims. (Cl. 274—46)

This invention relates to a method of making a sound record, and to the product thereby obtained. It relates in particular to a method which produces, in a sound record, whether a disc, film or cylinder, a laterally modulated groove or sound track having a shoulder on one side thereof raised above the plane of the record material a distance at least as great as the depth of the groove beneath that plane.

This application is a continuation-in-part of my co-pending application Serial No. 344,002, filed July 5, 1940.

Several methods of recording sound have been developed and are conventional in the art. The commonest method in use today is a lateral cutting method. Its principal disadvantage lies in the fact that this method of cutting records has always been accompanied by the formation of shavings, cuttings, threads, or other debris which must be wiped or brushed from the record surface as they are formed, and which constitute a needless waste of material and are a considerable cause of inconvenience. Another disadvantage of the customary record, made by lateral cutting methods, is the well-known tendency of the reproducing needle to jump from one shallow groove an another, due to the constant inward thrust of the reproducing head on a typical disc record, for example, and to the failure of the customary grooves to provide lateral support for the reproducing needle.

It is accordingly among the objects of the invention to provide a method of recording sound, particularly by lateral modulations, whereby the shavings, cuttings, or other debris incident to known practice are eliminated. Another object is to provide a method of recording sound whereby the sound track produced is capable of providing substantial lateral support and contact surface for reproducing needles. Articles incident to the method of the invention, a general advance in the art, and other and related objects, are contemplated as well.

To the accomplishment of the foregoing and related ends, the invention, then, consists of the method and product hereinafter fully described and particularly pointed out in the claims, the annexed drawings and the following description setting forth in detail one mode of carrying out the invention, such disclosed mode illustrating, however, but one of the ways in which the principle of the invention may be used.

In the said annexed drawings, forming a part hereof, wherein like reference characters are used throughout to designate like parts.

Figs. 1–8, inclusive, are views partially in perspective, showing positions of a recording stylus for use in the invention, successive figures showing the same stylus, rotated about its longitudinal axis by successive increments of 45°;

Fig. 9 is a plan view of a typical disc-form record having clockwise rotation, and showing, in greatly enlarged and exaggerated form, cross-sectional views of the recording stylus, taken along lines I—I, II—II, III—III, etc. . . . VIII—VIII, in Figs. 1–8, respectively, inclusive;

Fig. 10 is a cross-sectional view of a portion of the new sound record made according to the method of the present invention;

Fig. 11 is a part sectional, part perspective view of one type of sound track formed according to and embodying the invention;

Fig. 12 is a view of a stylus suitable for use in the method of the invention;

Fig. 13 is a greatly enlarged view, in vertical elevation, of a tip of a recording stylus, turned in the position shown in Fig. 5; and

Fig. 14 is a plan view of the working tip of the stylus shown in Fig. 13.

In practicing the present invention, a laterally modulated sound track is formed by a concurrent cutting and embossing operation performed on a disc, roll, or strip of a tough and flexible record material, in such manner that no shavings, scrapings, or other debris are separated from the record material, and that the surface of the material is slit at an acute angle thereto to form a continuous flap which is displaced laterally and upwardly from the sound track groove to form a substantial ridge or shoulder extending above the plane of the body of the material, integral at its base with that material.

According to one embodiment of the invention, the foregoing and related objects may be attained by using in a particular novel manner a recording needle heretofore known and used only for hill-and-dale recordings. Such a needle, or stylus 15, is shown in Figure 12, and is described in U. S. Patents 1,918,271 and 2,018,496. The stylus, per se, forms no part of the present invention, though the particular manner of its use is of considerable importance. For an understanding of the preferred embodiment of the invention to be described below, it is necessary first to describe briefly the principal features of the preferred stylus. The recording stylus 15 may have its working tip formed of steel, sapphire, or other suitable hard material and comprises a shank or body portion 16 and a tip or head 17. In the preferred form the tip 17 is the acute frustum of

a cone, and preferably of a right cone, as illustrated in Fig. 13. The tip 17 therefore presents a flat face 18 of elliptical contour, as is evident from Figs. 12 and 14.

The material operated on, i. e., that of which the record blank is composed, likewise forms no part of the invention, except as its properties may be important. The material used may be a cellulose ester or cellulose ether, or one of the commercially available plastics, or a metal, provided that it is capable of forming tough non-brittle films, sheets or cylinders. In thin sections the material should be flexible. Because of its toughness and high flexibility and its property of forming smooth, non-brittle surfaces, the ethyl cellulose of commerce, in either "standard" or "medium" ethoxy grades, is particularly desirable, and recording compositions having an ethyl cellulose basis are recommended.

The invention is illustrated herein as applied to a flat, circular disc record, but is not to be limited thereto, as it is clearly applicable as well to recording sound on film strips or loops, or on cylinders.

When preparing a sound record according to the method of the present invention, a flat circular disc 19, which may have at least a surface coating of ethyl cellulose or similar flexible and non-brittle material, is first provided. Such a disc is placed upon a conventional turntable, not shown, and a stylus 15 of the type above defined is addressed to the periphery of the disc. The stylus 15 is secured in the cutting head of a lateral modulation recording machine (also conventional in the art and not shown) so mounted on a carriage that, as the turntable rotates beneath it, the carriage moves on a radial line toward the center of the disc, thus providing a spiral groove. The relationship between the rate of rotation of the turntable and the radial movement of the cutting head can be adjusted in known manner to form any desired number of grooves per radial inch. During conventional operations on disc-form records, the distance between successive convolutions is constant. The construction and operation of recording machines, being well known in the art, will be understood without further detail.

It is apparent that the recording stylus 15 may be addressed to the record 19 in any of several positions of its flat elliptical face with respect to the oncoming record. Figs. 1–8, inclusive, illustrate eight typical positions of the tip 17 of the stylus, differing from one another by a rotation of the stylus 15 through successive angles of 45°. The same positions of the stylus 15 with respect to the oncoming record are illustrated in plan in Fig. 9. Not all of the positions illustrated are effective for use in the present invention, and, of those which are operative, certain positions are preferred over others. Thus, referring to Fig. 9, when the stylus 15 is positioned on the disc 19 with the plane of the elliptical face 18 in alignment with the path 20 of the oncoming record, as in positions I and V, the stylus 15 splits or tears the record 19 and attempts at reproduction give, at best, very unfaithful results. There is no well defined groove along which the play-back needle can track for sound reproduction. If the stylus 15 is positioned with its flat elliptical face 18 at right angles to the path 20 of the oncoming record 19 as in positions III and VII, a somewhat different but equally unsatisfactory result is obtained. In position III, the recording stylus 15 merely scratches the surface of the film 19, gouging out occasional pieces or threads of the material of which the record is made. In position VII, wherein the elliptical face 18 of the stylus 15 is the trailing edge, the stylus 15 behaves more nearly like the customary cone-tipped needles and cuts a continuous thread which must be brushed aside from the record surface before attempts can be made at reproduction. The usual disadvantages of past practices with other forms of stylus are attendant upon the use of the herein described stylus 15 in positions III and VII.

It is the discovery upon which the preferred embodiment of the present invention resides that when the stylus 15 is positioned with its flat elliptical face 18 neither in alignment with, nor vertical to, the path 20 of the oncoming record 19, i. e., when it is in any of the positions II, IV, VI, or VIII, the stylus 15 does not scratch or tear the record 19, nor does it cut a thread, but rather it partly cuts or slits the material of the record blank at an acute angle to its surface along the path 20 of the sound track 21, providing a flap 22, integral at its base with the main body of the record 19, and movement of the record 19 past the recording stylus 15 in any of these positions displaces the material forming said flap 22 laterally and upwardly to form an upstanding ridge or shoulder (also designated by reference No. 22) raised above the plane 23 of the material on one side only of the groove 21. To any of positions II, IV, VI, or VIII a high shoulder 22 is formed on one side of the groove 21 as is shown, for example, in Figs. 10 and 11. This shoulder 22 is of particular advantage during the play-back operation, since it provides a greater contact surface between the record material and the reproducing needle than has been available in the records of the prior art. The reproducing needle, therefore, rides freely along a relatively shallow groove 21 and against the raised shoulder 22.

The stylus in positions II and VIII throws the shoulder 22, above-described, to the right or outside of the groove 21 (when facing the oncoming record). In positions IV and VI it throws the shoulder 22 to the left or inside of the groove 21, and it is the result of a stylus 15 in position VI, which is illustrated in Figs. 10 and 11.

When the stylus 15 is in either of positions II or IV, its flat face 18 is the leading face, and greater recording pressures are required to produce a groove 21 of the same depth and fidelity as can be obtained when the stylus 15 is in positions VI or VIII, with the flat face 18 trailing. When the disc records 19 are of the conventional "outside-in" type, it is preferred that the raised shoulder 22 be disposed toward the center of the disc, thereby to provide at least partial support for the reproducing needle which will tend to be pulled toward the center of the record by the motion of the record and of the reproducing head. Since most records are of the outside-in type, by far the best results for most purposes have been attained through the use of the stylus 15 in position VI. If, however, the record is of the "inside-out" type, or if it is a cylinder record such as that employed in dictation machines, where the recording stylus 15 moves from left to right and the thrust of the reproducing needle likewise may be from left to right, it may often be desirable to have the raised shoulder 22 of the sound track 21 on the right side. In such

case, owing to the lower recording pressure required, position VIII of the stylus 15 has been found most effective.

The operation has been outlined with reference to the recording stylus 15 positioned with its flat elliptical face 18 at an angle of 45°, 135°, 225°, or 315° to the path 20 of the oncoming record 19. These particular values have been given by way of illustration, it being understood that similar results are obtained when the stylus 15 is rotated by about 35° either way from the suggested positions. The harder the recording composition, the greater is the permissible variation from the preferred positions, but in no case can the stylus be within 10° of any of positions I, III, V, or VII. Thus, position VI is illustrated as being one wherein the flat face 18 of the recording stylus 15 is at an angle of 315° to the path 20 of the record 19 passing beneath it. Very similar and substantially as satisfactory results are obtained when the stylus 15 is positioned with its flat face 18 at any angle between 280° and 350° to the path 20 of the oncoming record. Similarly, the stylus 15 in position VIII may be turned with its face 18 at an angle between 190° and about 260° to the path 20 of the record.

The specific method, therefore, which is at present representative of the preferred form of the invention, is one of making a laterally modulated sound record in tough material which is flexible and non-brittle in thin section, which comprises addressing a stylus to the surface of the record blank with its longitudinal axis at an angle thereto which may be selected between the vertical and a 10° drag therefrom, said stylus having a working tip which is an acute frustum of a cone, said tip being positioned for recording with the flat face of the frustum at an angle of $n(45°) \pm 35°$ with respect to the path traversed by the blank in passing the stylus, n being an odd integer, and moving the blank while imparting sound impulses thereto through the stylus in known manner, thereby slitting the surface of the record at an acute angle thereto along the path of the sound track to provide a partially severed portion, continuous at its base with the main body of the record, and displacing the partially severed portion laterally and upwardly to form a substantial upstanding ridge raised above the plane of the record, continuous with, and on one side only of the concurrently formed groove.

Referring now to Figs. 13 and 14, it will be observed that among the variables which are of importance to the structure of the working tip 17 of the recording stylus 15 are the angle A of the cone of which that tip 17 is a part, the angle B between the truncating plane and the axis of the cone, and the distance H from the apex of the cone to the intersection of the truncating plane with the axis of the cone. For any given angle A, larger values of angle B will give smaller values for H, and the area of the ellipse 18 becomes smaller. Similarly, under the circumstances just enumerated, the cutting tip 17 will tend to cut into the record to a lesser extent than when a more acute angle B is employed. It is not the province of the present application to discuss all possible variations in the recording stylus 15, but it may be said that very satisfactory results have been obtained employing a recording stylus 15 whereof angle A may lie between 22° and about 60°, but preferably is about 24°; angle B is at least 30°, is not over 80°, and preferably is 37° to 45°; and distance H is of the order of 0.03 to 0.08 inch. Numerous variations in the specific needle tip 17 may, of course, be employed.

In a specific example, a film of ethyl cellulose of about 46 per cent ethoxy content, and 0.015 inch thick, was provided in the form of a circular disc 19 having the customary center holes 24 for positioning the disc on a turntable of a lateral modulation recording machine. The machine employed was adapted to make an outside-in cut with about 80 grooves per radial inch. The recording stylus 15 was mounted nearly vertical to the recording medium 19, dragging by a few degrees. The tip 17 of the stylus had an angle A of about 24°, an angle B of about 40°, and a distance H of about 0.045 inch. Angle θ was chosen as 315°, i. e., the stylus 15 was addressed to the record 19 with its flat elliptical face 18 in position VI. Sound was conveyed through the recording machine to the film 19 by electro-duplication from another record. A faithful reproduction was obtained on play-back. The record was then cut to obtain a small piece which was then mounted, in known manner, in a microtome, and thin sections were made and mounted on microscope slides. Photomicrographs were made, showing clearly the cross-sectional shape of the sound tracks herein reproduced in Fig. 10. The grooves 21 were found to extend 0.0015 inch below the plane 23 of the record 19, and to be about 0.004 inch wide. The upstanding shoulders 22 projected above the plane 23 of the record 19 about 0.0033 inch, and were about 0.0015 inch thick at their juncture with the main body of the film.

The method herein described may be adapted easily for use with any of the conventional lateral modulation sound recording systems on the market. The cutting head of the various machines need only be adjusted so as to cooperate with the shank portion 16 of the recording stylus 15 to position that stylus with its flat face 18 at the proper angle within one of the 90° arcs between alignment with the path of the oncoming record and a line at right angles thereto.

The invention has been described with respect to the use of a particular type of stylus as the means of forming the novel sound track of the invention. Other means may be devised for forming a track of this description. Thus, for example, if the conical stylus tip is truncated parallel to an element of the cone, a flat face of parabolic contour may be formed which is operative in the same manner as the elliptical faced tips described above. Similarly, a stylus tip of hyperbolic contour may be made in known manner, and used as described. It is, therefore, to be kept in mind that the description and example above given are purely illustrative, and that the inventor does not limit himself thereto, except as indicated in the following claims.

I claim:

1. A method of making a sound record in tough material which is flexible and non-brittle in thin section, which comprises slitting the surface of the record at an acute angle thereto along the path of the sound track to provide a partially severed portion, continuous at its base with the main body of the record, and displacing the partially severed portion laterally and upwardly to form a substantial upstanding ridge raised above the plane of the record, continuous with, and on one side only of the concurrently formed groove.

2. A method of making a sound record in a disc having a surface of a tough material which is flexible and non-brittle in thin section, which

comprises slitting the surface of the record at an acute angle thereto slanting inwardly toward the center of the disc along the spiral path of the outside-in sound track, to provide a partially severed portion, continuous at its inwardly disposed base with the main body of the record, and displacing the partially severed portion inwardly and upwardly to form a substantial upstanding ridge raised above the plane of the record, continuous with, and on one side only of the concurrently formed groove.

3. The method of making a laterally modulated sound record in tough material which is flexible and non-brittle in thin section, which comprises addressing a stylus to the surface of the record blank with its longitudinal axis at an angle thereto which may be selected between the vertical and a 10° drag therefrom, said stylus having a working tip which is an acute frustum of a cone, said tip being positioned for recording with the flat face of the frustum at an angle of $n(45°)\pm35°$ with respect to the path traversed by the blank in passing the stylus, n being an odd integer, and moving the blank while imparting sound impulses thereto through the stylus in known manner, thereby slitting the surface of the record at an acute angle thereto along the path of the sound track to provide a partially severed portion, continuous at its base with the main body of the record, and displacing the partially severed portion laterally and upwardly to form a substantial upstanding ridge raised above the plane of the record, continuous with, and on one side only of the concurrently formed groove.

4. The method of making a laterally modulated sound record in tough material which is flexible and non-brittle in thin section, which comprises addressing a stylus to the surface of the record blank with its longitudinal axis at an angle thereto which may be selected between the vertical and a 10° drag therefrom, said stylus having a working tip which is an acute frustum of a cone, said tip being positioned for recording with the flat face of the frustum trailing at an angle of $n(45°)\pm35°$ with respect to the path traversed by the blank in passing the stylus, n being one of the integers 5 and 7, and moving the blank while imparting sound impulses thereto through the stylus in known manner, thereby slitting the surface of the record at an acute angle thereto along the path of the sound track to provide a partially severed portion, continuous at its base with the main body of the record, and displacing the partially severed portion laterally and upwardly to form a substantial upstanding ridge raised above the plane of the record, continuous with, and on one side only of the concurrently formed groove.

5. The method of making a laterally modulated sound record in tough material which is flexible and non-brittle in thin section, which comprises addressing a stylus to the surface of the record blank with its longitudinal axis at an angle thereto which may be selected between the vertical and a 10° drag therefrom, said stylus having a working tip which is an acute frustum of a cone, said tip being positioned for recording with the flat face of the frustum leading at an angle of $n\ (45°)\pm35°$ with respect to the path traversed by the blank in passing the stylus, n being one of the integers 1 and 3, and moving the blank while imparting sound impulses thereto through the stylus in known manner, thereby slitting the surface of the record, at an acute angle thereto along the path of the sound track to provide a partially severed portion, continuous at its base with the main body of the record, and displacing the partially severed portion laterally and upwardly to form a substantial upstanding ridge raised above the plane of the record, continuous with, and on one side only of the concurrently formed groove.

6. The method of making a laterally modulated sound record in tough material which is flexible and non-brittle in thin section, which comprises addressing a stylus to the surface of the record blank with its longitudinal axis at an angle thereto which may be selected between the vertical and a 10° drag therefrom, said stylus having a working tip which is an acute frustum of a cone, said tip being positioned for recording with the flat face of the frustum trailing at an angle of $315°\pm35°$ with respect to the path traversed by the blank in passing the stylus, and moving the blank while imparting sound impulses thereto through the stylus in known manner, thereby slitting the surface of the record at an acute angle thereto along the path of the sound track to provide a partially severed portion, continuous at its base to the left of the oncoming sound track to the main body of the record, and displacing the partially severed portion laterally and upwardly to form a substantial upstanding ridge raised above the plane of the record, continuous with, and on the left side only of the concurrently formed groove.

7. The method of making a sound record in tough material which is flexible and non-brittle in thin section, which comprises addressing a stylus to the surface of the record blank with its longitudinal axis at an angle thereto which may be selected between the vertical and a 10° drag therefrom, said stylus having a working tip which is an acute frustum of a cone, said tip being positioned for recording with the flat face of the frustum trailing at an angle of $225°\pm35°$ with respect to the path traversed by the blank in passing the stylus, and moving the blank while imparting sound impulses thereto through the stylus in known manner, thereby slitting the surface of the record at an acute angle thereto along the path of the sound track to provide a partially severed portion, continuous at its base to the right of the oncoming sound track to the main body of the record, and displacing the partially severed portion laterally and upwardly to form a substantial upstanding ridge raised above the plane of the record, continuous with, and on the right side only of the concurrently formed groove.

8. A sound record having a laterally modulated sound track consisting of a spiral groove of substantially uniform depth throughout its length and, immediately adjacent thereto and on one side only thereof, a substantial ridge projecting above the plane of the record a distance at least as great as the depth of the groove below said plane and formed from the material displaced from the groove.

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