E. W. JONES AND E. R. HARRIS.

PHONOGRAPHIC RECORD.

APPLICATION FILED JUNE 3, 1916.

1,425,018. Patented Aug. 8, 1922.

Fig. 9

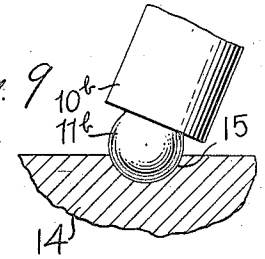


Fig. 8

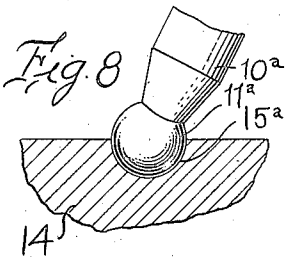


Fig. 1

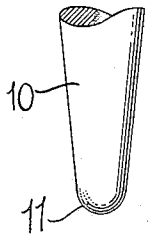


Fig. 2

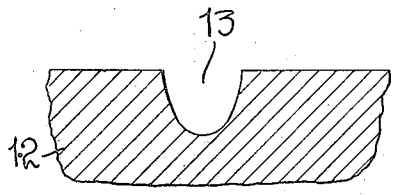


Fig. 3

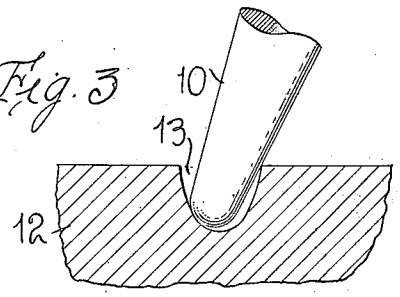


Fig. 4

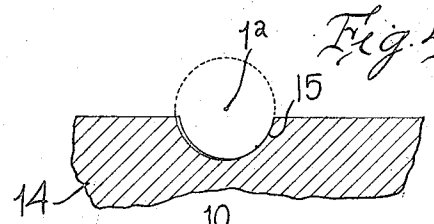


Fig. 5

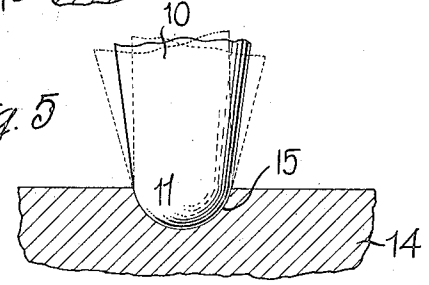


Fig. 6

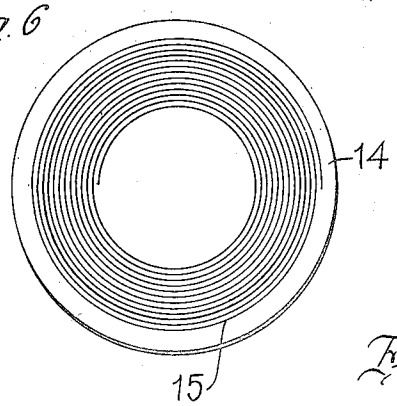
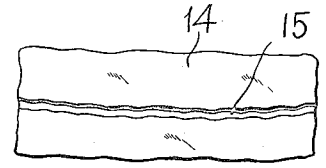


Fig. 7



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PHONOGRAPHIC RECORD.

1,425,018. Specification of Letters Patent. Patented Aug. 8, 1922.

Application filed June 3, 1916. Serial No. 101,550.

To all whom it may concern:

Be it known that we, EARLE W. JONES, a citizen of the United States, residing at New York city, in the county of New York and State of New York, and EDWARD R. HARRIS, a subject of the King of England, residing at Arlington, in the county of Hudson and State of New Jersey, have invented certain new and useful Improvements in Phonographic Records, of which the following is a specification.

This invention relates to improvements in sound records of either cylindrical or disk type, and specifically to those records in which the record groove is laterally undulatory as distinguished from record grooves which are "up and down," that is, in which the record is made by a stylus vibrating at right angles to the face of the record.

The general object of this invention is to attain a greater clarity of reproduction than has been heretofore possible, and further to very greatly increase the number of record lines to the inch, thus increasing the length of the record which can be placed upon any one record tablet or disk.

Still another object is to eliminate as much as possible the scraping or frictional engagement of the needle with the wall or walls of a record groove, and a still further object in this connection is to so form a record groove that the reproducing stylus may oscillate on a seat in this groove and yet have absolute engagement therewith at all times in the manner of a ball within a socket of a ball and socket joint.

Other objects will appear in the course of the following description.

This invention is illustrated in the accompanying drawings, wherein:

Figure 1 is a fragmentary elevation of the ordinary form of reproducing stylus;

Figure 2 is a fragmentary cross sectional view of a record tablet showing the shape of the ordinary groove formed therein;

Figure 3 is a cross sectional view of a record tablet showing a groove of substantially the same character as that illustrated in Figure 2, with a stylus point of ordinary construction in place therein;

Figure 4 is a sectional view of a record tablet showing the shape of the improved record groove formed therein and also showing in dotted lines the completed cylinder of which the groove is a segment;

Figure 5 is an enlarged section of Figure 4 but showing an ordinary stylus in engagement with the groove, and in dotted lines the positions to which the stylus may rock without losing its disengagement with the groove;

Figure 6 is a plan view of a record disk showing the groove spirally arranged upon the surface thereof; and

Figure 7 illustrates a part of the record showing a single record groove greatly magnified to disclose the lateral undulations of the groove corresponding to the sound vibrations; and Figures 8 and 9 are sectional views showing different forms of needle.

In order that this invention may be understood, it is necessary to refer briefly to the character of the reproducing stylus used with practically all commercial records having a laterally undulatory record groove as distinguished from an "up and down" groove, and to the form and assumed action of the laterally undulatory record grooves as formed in the commercial records of today.

The stylus which has been found to be most effective for reproduction, taking all things under consideration, is the stylus shown in Figure 1. This stylus 10 is substantially conical in form but its extremity 11 is a perfect hemisphere with every part of its hemispherical surface an equal distance from the center upon which the arc of the hemisphere has been struck. The diameter of the hemisphere has been carefully measured and is .005 of an inch.

This stylus was originally used with the record groove which is illustrated in the patent to J. W. Jones, No. 763,903, patented June 28, 1904. The record groove shown in this patent is a groove having a semi-circular bottom and parallel side walls perpendicular to the surface of the record, the groove being deeper than it is wide and deeper than the radius of the curved bottom. The stylus illustrated in Figure 1 is at present used with a record having a record groove thereon formed in the manner described in the patent to E. R. Johnson, No. 896,059, and also illustrated particularly clearly in the patent to Johnson, No. 778,975. Such a record groove is illustrated in Figure 2, where 12 designates the record tablet and 13 designates the groove itself, the groove being shown in section. This groove

13 is relatively deep, about .007 of an inch, and the width of the groove at its mouth is about .007 of an inch, the groove gradually diminishing in width toward the bottom thereof. The groove in cross section has the shape of the segment of an ellipse, widest at the mouth of the groove and gradually diminishing toward the bottom thereof.

As above referred to, this record groove is relatively deep and one reason for the depth of this groove, as found in all commercial records, is due to the necessity of cutting the master record in a wax tablet. It is impossible to cut a shallow record groove in wax as the cutting or recording tool will swing clear of the wax unless the groove is relatively deep. This is due to the fact that the cutting tool in making the lateral oscillations swings in an arc, and strong notes will cause the cutting tool or recording stylus to swing up and out of its line of cut. As a matter of fact, which is well known to all those skilled in the art of making master records, it is impossible to get "trackage" where it is attempted to make a shallow groove in wax.

According to the theory advanced in the Johnson patents above referred to, the form of the groove as shown in the patent to Jones, also before referred to, was in effective and deterrent to true tone reproduction because the conical stylus shown in Figure 1 would engage with the parallel side walls of the groove and wear the side walls away and also wear away the needle. Furthermore, the groove gripped the stylus too closely and prevented the free play of the stylus which was necessary to secure proper reproduction. To avoid this, Johnson devised the record groove illustrated in his patents and above referred to, and also illustrated in Figure 2, that is, a groove having the form of a section or a segment of an ellipse having as a consequence a rounded bottom with a curvature approximately the same as the curvature of the extreme end of the reproducing stylus but having diverging side walls, the walls being relatively flat and extending at a tangent to the arc of the bottom. The advantages alleged by Johnson for this form of groove are, first, that the groove so cut in the wax has a smooth and well defined wall, and second, that the reproducing stylus has greater freedom of oscillation and free swing to the full extent of its movement. As a matter of fact, however, as has been demonstrated by careful laboratory experiments and microscopic examination, the reproducing stylus when used with this record groove, bears against the side wall of the groove and the friction so produced impairs the purity of tone, particularly in those cases where the range of oscillation of the reproducing stylus is relatively great.

Again, commercial records having a groove which is the segment of an ellipse are not of even depth. This is caused by the fact that the stylus is a lever pivoted intermediate its ends so that its free extremity moves in an arc, or would so move if the recording head were rigidly supported at a fixed distance from the disk or tablet on which the record is being made. The recording head is not so fixed, however, but drops and rises to compensate for the arc over which the needle moves, but due to the fact that the vibrations are at the rate of hundreds and even thousands of vibrations to the second, the recording head cannot react quickly enough so as to level all the swings or oscillations of the stylus and hence the lateral cuts of the recording tool must of necessity be unequal in depth, a fact which has been demonstrated by careful microscopic examination and measurement. This causes the reproducing stylus to grind as it travels on the bottom of the groove. Thus the reproducing stylus wears unevenly, the groove wears unevenly, and grinding and scratching sounds are caused which impair the purity of the reproduced tone. This is obviously true because in cutting in wax the point of the tool must rise nearer the surface when the tool is laterally inclined to the vertical than where the tool is vertical. It follows that the width of the groove will vary with the angle of the stylus, as the stylus swings laterally. If the stylus be at right angles to the record surface, that is, in a plane at right angles to this surface which plane is disposed at a tangent to a circle concentric to the center of motion of the record, the groove will have a width equal to the diameter of the stylus at the surface of the record. If, however, the stylus be laterally inclined, a cross section of the stylus will be an ellipse, assuming that the stylus is circular in cross section, having its major axis longer than the minor axis, and the minor axis being equal to the diameter of the stylus. This variable width and the variable depth which is hereafter adverted to makes it impossible to secure a ball and socket joint between the reproducing stylus and the record groove in the manner secured by us as hereafter stated.

Again in making a laterally undulatory record of the character already discussed, if the stylus is not disposed exactly in transverse alinement with the axis of rotation of the tablet, the stylus in moving inward from the outer edge of the record disk or tablet toward the center of the tablet will cut more deeply against one side or tends to cut more deeply in one direction than in the opposite direction. Thus if the recording stylus be disposed between said transverse line cutting the axis of the tablet and the pivot point of the stylus carrying arm, then the stylus

will cut against the inside wall of the record groove more strongly than against the outside wall and if on the contrary the stylus be disposed beyond said diametrical transverse line, then the stylus will tend to cut more strongly against the outside wall of the groove made by the stylus. Thus it is obvious that in the complete record the lateral oscillations will not be of even amplitude from a neutral line but will extend to a greater distance on one side than on the other, and also it will be seen that unless the reproducing stylus is disposed in alinement with a transverse line cutting the axis of the record, the reproducing stylus will also bear with greater strength against one wall of the groove than against the other, thus giving an untrue reproduction. It has been determined by very careful examination, as before stated, that the record grooves of commercial records of the laterally undulatory type are not substantially of even depth nor substantially of even width, but on the contrary the bottom of the groove is very uneven and the width of the groove is very uneven so that the walls at the intersection of the walls with the surface are not parallel.

In this connection it is important to point out that the main lateral undulations of the record grooves are not the complete sound record but that the undulating line of the groove is itself undulatory, that is, the record line is undulatory but the line between the main undulations is jagged. It is these minor undulations which give tonal quality to the music and differentiates the music of one instrument over the music of another, as for instance, the music of a violin from that of a flute. Microscopic examination shows that where the recording tool cuts strongest in one direction, as above referred to in the previous paragraph, these "partials" will be recorded more strongly against one wall than against the other, or be recorded entirely on one wall and not on the other, and that if the reproducing stylus contacts with only one wall, or mainly with one wall, as it does to a very large extent in playing commercial records having relatively deep and wide grooves as above stated, the recording stylus will jump across the minor undulations or irregularities and that the "partials" will as a consequence be lost. The reproducing stylus is not, therefore, positively guided or gripped so as to cause a positive vibration of the stylus in both directions from a truly vertical or median position, and will not therefore give the full amplitude of vibration to the diaphragm, but that the diaphragm will vibrate inward from its median position under the positive action of the groove and needle but will spring outward under its own resilience. With our record groove as hereafter described, the point of the reproducing stylus is positively gripped and held and as a consequence the stylus and the diaphragm are moved positively in both directions from a median or normal position.

Again, with commercial records, which are records made in conformity with the Johnson patent, the record groove is .007 of an inch wide at the surface of the record and therefore only one hundred to one hundred and sixteen of the grooves can possibly be made to the inch. This greatly limits the amount of music which the record can contain inasmuch as a record disk for practical reasons well known to those skilled in the art cannot be over 14 inches in diameter. Furthermore, in actual practice the recording stylus has its cutting edges so formed that the cut or groove is nearly V-shaped, but round at the bottom. The groove is .007 of an inch at the surface of the record and tapers to .001 of an inch at the bottom, whereas the end of the reproducing stylus, as illustrated in Figure 1 and as commercially used, is a perfect hemisphere with a diameter of about .005. As a consequence this reproducing stylus fits into the groove, as illustrated in Figure 3, but the lower end of the reproducing stylus does not fit on the bottom of the groove but travels on the side wall of the groove. Furthermore, though the record groove is relatively wide at the face of the record due to the relatively great divergence of the sides, yet this does not permit the stylus to have free swing to the full extent of its movement. The reproducing stylus bears against the side wall of the groove and is limited in its movement by contact with the side walls while the friction so produced impairs the purity of tone.

In order to avoid these objections and after a long series of very careful experiments, we have determined that the form of the record groove should be of the particular shape shown in Figure 4. In this figure, 14 designates the record tablet or disk having the usual laterally undulatory record groove 15. This groove in cross section is an arc of a true circle, or, in other words, the groove is a segment of a cylinder instead of being the segment of an ellipse, the center 1^a of this circle on which the arc is struck being located above the surface of the disk in which the groove or cut is formed. The distance between this imaginary center from which the arc is produced and the surface of the record is about .002 of an inch.

Now in comparing this groove as illustrated in Figure 4, with the groove shown in the patent to Jones, it will be seen that the side walls of the groove are not parallel but have a uniform upward and lateral curvature to the surface of the record. Comparing this groove with the Johnson record, it will be seen that this groove is not a section of a cone or elliptical in cross section,

but the segment of a cylinder and that the width of the groove at the face of the record is about .0005 of an inch greater than the depth of the groove, and this width is approximately .001 against an extreme width of .007 for the groove of Johnson, and furthermore, that the shallower the groove is, the narrower is its width.

In Figure 5, we show the regular reproducing stylus in engagement with a record groove of the form devised by us and show in dotted lines the swing of which this stylus is capable when in place within the record groove. Now, as before stated, this stylus is formed at its lower end so as to provide a hemispherical extremity having an extreme diameter of .005. Now it will be obvious that inasmuch as the record groove in cross section presents the form of a segment of a circle having the same radius as the hemispherical end of the stylus, then the curved extremity of the stylus must fit exactly in this groove so that the extremity of the stylus and the groove coact with each other in the same manner as does the ball with the socket in a ball and socket joint. If the groove had a depth equal to the radius of the hemispherical end of the stylus it is plain that the stylus could not oscillate without being lifted from the groove by engagement with the corner formed at the intersection of the face of the record with the side wall of the groove. But by making the depth of the groove less than the radius of the hemispherical end of the stylus, the needle has free oscillation to a very considerable degree as shown in dotted lines in Figure 5, and yet the hemispherical end of the stylus, fitting as it does the arc of the groove, is at all times in full contact with the surface of the groove and thus neither rises out of the groove nor rides up on the side wall as the stylus oscillates laterally. Instead of the stylus acting as a lever, therefore, with the corner or side of the groove as a fulcrum, the stylus has a rotative engagement within the groove, which, while permitting the free and untrammeled oscillation of the stylus, in a manner acts to grip the stylus and hold it in the groove even though this groove be extremely shallow.

As before stated, it is impossible to make these shallow record grooves in wax, but we have devised a method whereby these shallow record grooves may be made in the form described, which method forms the subject-matter of a separate application filed coincidentally herewith Serial No. 101,548, this method being such that the record groove is made of absolutely even width throughout its entire extent and an absolutely even depth and so shallow that the width of the groove can be made as narrow as .00075 and yet at the same time secure perfect trackage for the reproducing stylus.

Attention is particularly called to the fact that with the groove illustrated in Figures 4 and 5 the reproducing needle or stylus wears evenly because of the fact that it has transversely the same curvature of surface that the groove has so that the oscillations of the needle simply act to rotate it in this groove and thus all portions of the lower end of the needle or stylus are worn an equal amount. Therefore, the stylus may be used longer than with the ordinary record and the record groove itself does not become defaced by wear and its irregularities smoothed down. Again, and this is a most important feature of this invention, by using the form of groove illustrated in Figures 4 and 5 as heretofore described, we have found in practice that it is possible to make absolutely perfect records with a far greater number of grooves to the inch than is possible with the form of groove illustrated in Figure 2, and it has been actually demonstrated that it is possible to make thoroughly good records in which every partial is properly recorded having grooves ranging from 200 to 300 to the inch. Now it is plain that the reduction in the width of the groove means a like reduction in the depth of the groove, but because of the peculiar shape of the groove and of the "ball and socket" engagement of the stylus with the groove the stylus will track perfectly even in a shallow groove. The shallower the groove the greater the freedom of oscillation of the needle and the less friction the less wear there is. We have succeeded in making grooves having a width of only .00075 as against .007 of the ordinary commercial record and dispose 300 of these grooves per inch of radius of the plate where, using the form of groove illustrated in Figure 2, it is impossible to place more than 100 grooves to the inch on the record.

Again reverting to the record groove of the form shown in Figure 2 and cut in wax, it is, theoretically at any rate, the bottom of the cut which is the record and the side walls of the cut would not and cannot form the record so long as the stylus has the free swing which is described in the Johnson patent. These walls, therefore, are so much waste as far as reproduction is concerned and serve no useful purpose, but on the contrary in actual practice frictionally engage the point of the stylus, impede its free movement and generate extraneous noises. Even where the recording stylus makes its record upon one side of this groove, the groove itself at this junction with the surface of the tablet does not form the means whereby the stylus is given this lateral oscillation. The recording stylus is not gripped by these walls because the width of the groove at the intersection with the surface is greater than the width of the stylus itself. With our

record, on the contrary, the whole surface of the groove is a true and accurate record from the intersection of the surface of the record tablet with the groove to the very bottom of the groove, and yet the reproducing stylus is allowed to freely vibrate laterally which is not the case with the record made in accordance with the Jones patent and previously adverted to. Furthermore, it will be obviously impossible for the corners of the record groove formed by the intersection of the surface of the tablet with the groove to have a form corresponding truly to the sound vibrations where the groove varies in width as it does for the reasons stated previously in this specification.

It is also to be pointed out that a narrow record groove has another advantage over a wide groove. Assume that the recording stylus swings laterally so as to trace an arcuate line or groove, that is a groove whose direction is not, except in a general way, concentric to the rotative axis of the record, and that in this length of groove there are various minor deflections, indicating "partials." Now it will be obvious that both the inner wall and the outer wall of the groove will have corresponding crests and valleys, but inasmuch as this portion of the groove is arcuate, the lines cutting the corresponding crests or valleys will be radially arranged and that the crests or valleys upon the outer wall will be longer than the corresponding crests or valleys on the inner wall and that the crests or valleys on the inner wall will be relatively crowded or close together. It will be obvious that the wider the groove, the greater will be the discrepancy between the lengths of the crests and valleys on the inner and outer walls. In reproducing, the stylus bears against the inner wall and, as a consequence, these relatively adjacent crests and valleys cramp the over-tones and partials. Now the importance of a narrow groove will be realized. The wide groove cramps the over-tones or partials into a small space, making these corrugations or waves very liable to wear and making these minor undulations too small to have a full effect on the needle. This small vibration in the inside curve of each sound wave forces the needle out of its central position on either side and unless they are perfect and sufficiently large to engage the needle point perfectly, the fact that the outside wall of each sound wave has corresponding crests and valleys controlling over-tones or partials, means nothing, as there is nothing to force the needle to enter them.

While we have referred to the use of the ordinary needle or stylus which has a tapering body and a hemispherical extremity, it is obvious that other needles besides the needle illustrated in Figure 1 might be used and that these needles need not be tapered. Thus in Figure 8 we show a record tablet 14 having therein a semi-cylindrical groove 15^a which differs from the groove 15 in that it is a segment of a circle which is equal to one-half the circle instead of being equal to less than one-half, and we have illustrated a stylus 10^a which is formed with a nearly spherical extremity 11^a. It is obvious in this case that the stylus may have free lateral movement without losing its engagement with the record groove. In Figure 9 we show a slightly different form of stylus with a relatively shallow record groove, the groove being designated 15 and formed in the tablet 14. This groove is the same as that shown in Figure 5 but the stylus 10^b has a hemispherical extremity 11^b which is formed by reducing the end of a cylindrical needle 10^b. The form of needle shown in Figure 9 would give great volume while the form of needle shown in Figure 8 would permit a cut to be made of a width equal to the diameter of the globular head 11^a. It is obvious also that the reproducing stylus might be made of saphire or other precious or semi-precious stone with an extremely small spherical head formed upon its extremity.

While we have described the record as being formed in a tablet having essentially the composition of tablets already on the market, we have found by experiments that it is possible, by means of the process described in my pending application before referred to, to make the record groove in celluloid, by imprinting by means of a proper die the record upon the celluloid, this very thin celluloid facing being backed up by commercial stock or other backing.

Again referring to the Johnson patent and the record groove formed in accordance therewith, it may be observed that theoretically in the Johnson patent the record, as before remarked, is formed by the bottom of the groove and the side walls of the groove would not form a record. It was also noted previously in the specification that this groove at its bottom was about .001 in width with walls extending upward and outward therefrom, and that the extremity of the stylus was approximately .007. Now it is obvious that with the diameter of the stylus .005 either the groove must be relatively wide or if it is narrow the stylus will be supported upon the inclined walls of the groove and only sometimes engage the bottom of the groove which theoretically contains the record. As a matter of fact, under ordinary circumstances, the reproducing stylus often rides upon the sides of the groove and does not rest entirely and firmly upon the bottom of the groove.

We find in practice that a groove .00025 of

an inch deep gives better results than a deeper record groove and practically eliminates all surface noise. By the "side faces" of the groove, as herein referred to, we mean the opposite faces of the groove extending from the intersection of the groove with the face of the tablet to the lowermost portion of the groove and by "face" of the groove we mean the surface of the groove extending down one wall across the bottom of the groove and up the other side of the groove.

Having described the invention, what we claim is:

1. A sound record having therein a laterally undulatory record groove having the form in cross section of the segment of a true circle.

2. A sound record having therein a laterally undulatory record groove having the form in cross section of the segment of a true circle, the depth of the groove being less than its width at the surface of the record.

3. A sound record having therein a laterally undulatory record groove, the face of the groove being an arc of a true circle, the radius of which circle is equal to the radius of the hemispherical extremity of a reproducing stylus.

4. A sound record tablet having therein a laterally undulatory record groove, the face of the groove describing an arc of a true circle, the surface of the tablet intersecting said groove on the chord of said arc, the arc being concentric to a center disposed above the face of the record tablet.

5. A sound record having a laterally undulatory groove, the lateral walls of the groove curving uniformly in opposite directions from the bottom of the groove to the surface of the record.

6. A sound record having formed therein a spirally disposed laterally undulatory groove of substantially even depth, said groove in cross section being a segment of a true circle.

7. A sound record having formed therein a spirally disposed laterally undulatory groove of substantially even depth, said groove in cross section being the segment of a true circle, the axis of which is above the surface of the record.

8. In a sound record reproducing device, a record having a laterally undulatory groove therein of substantially constant depth and width, and a cross section of which has the configuration of a segment of a true circle, the said segment being symmetrical and of maximum width at the mouth of the groove.

9. A sound record tablet for talking machines having formed therein a laterally undulatory groove, the surface of the groove being the arc of a true circle, the plane of the surface of the tablet intersecting the groove on a chord of said circle.

10. A sound record tablet for talking machines having formed therein a laterally undulatory groove, the side walls of the groove describing an arc of a true circle, the plane of the surface of the tablet intersecting the groove on a chord of said circle, the axis of the circle being above the plane of the surface of the tablet.

11. A sound record tablet for talking machines having upon its face a laterally undulatory record groove of a uniform width and having a width at its widest part less than the diameter of the hemispherical extremity of a coacting reproducing stylus and having a uniform depth along its entire extent.

12. In a sound reproducing machine, the combination with a record tablet having formed therein a laterally undulatory groove, said groove having the form of the segment of a true circle, the axis of which is disposed above the surface of the tablet, of a stylus having its extremity formed in cross section as one half of a circle of the same diameter as the circle of which the record groove is a segment.

13. The combination with a record tablet having formed therein a laterally undulatory groove, said groove having the form of the segment of a true circle, the axis of which is disposed above the surface of the tablet, of a stylus having its extremity formed in cross section as one half of a circle of the same diameter as the circle of which the record groove is a segment.

In testimony whereof we affix our signatures in the presence of two witnesses.

EARLE W. JONES.
EDWARD R. HARRIS.

Witnesses:
FREDERIC B. WRIGHT,
EUGENE C. SMITH.