July 19, 1932. H. C. HARRISON 1,868,321

SOUND RECORDING

Filed Nov. 4, 1929

FIG. 2

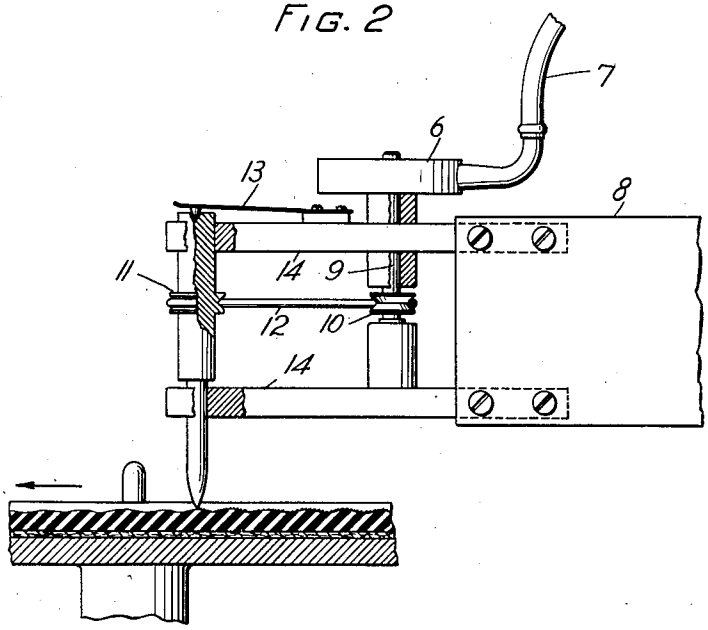
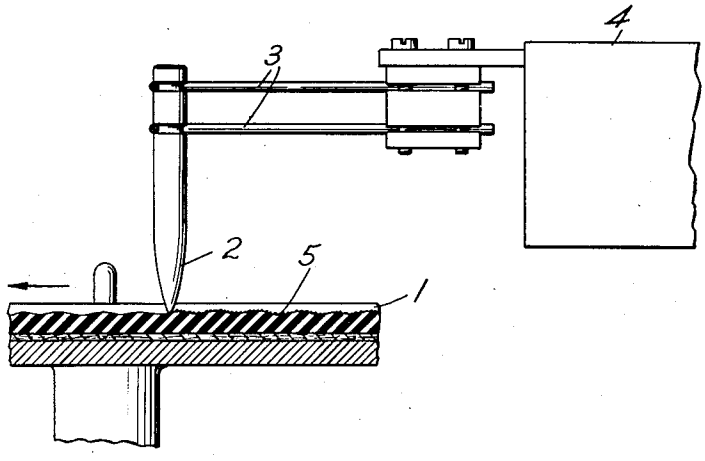


FIG. 1



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UNITED STATES PATENT OFFICE

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SOUND RECORDING

Application filed November 4, 1929. Serial No. 404,563.

This invention relates to the art of sound reproduction and particularly to methods and means for obtaining high quality reproduction from grooved records.

The object of the invention is in general to eliminate the extraneous noise incidental to the production of a phonograph record. This extraneous or "scratch" noise is due, in a large part at least, to unevenness in the record groove resulting from chipping or flaking of the record material in the recording process.

Heretofore various attempts have been made to eliminate "scratch", some of which involved the use of filters which were designed to discriminate against that part of the frequency range in which the major portion of the scratch was believed to occur. It has also been proposed to shift the frequency band to be recorded out of the range wherein the scratch is most objectionable and then, by means of filters and demodulators in the reproducing system, to eliminate the scratch noise in reproduction. A system of this kind is described in Patent 1,707,260, granted to C. H. Fetter, April 2, 1929. Obviously both of these schemes involve the use of extra apparatus in the recording system.

In the present invention, however, it is proposed to eliminate these undesired sounds by removing the condition which causes it, that is to say, by burnishing or smoothing out the extraneous irregularities in the grooves after the original record is made.

It is well known in the art of burnishing that for a satisfactory finish, the work should be done at fairly high velocity and with a pressure which is reasonably constant and of just sufficient magnitude to cause a very slight surface flow of the material without macerating it and thereby deforming the record groove as the burnishing tool moves along. Obviously then, to obtain this effect in playing back an original record, as for example one made in the soft wax commonly used, the vibration responsive system employed must be of much lower mechanical impedance than any structure now used for reproducers. If this impedence is made low enough the permissible initial steady pressure on the wax will be large with respect to the alternating reactions due to the groove variations so that the stylus point maintains reasonably constant pressure against all portions of the groove. It has been found that after one or more playings of this kind that, contrary to previous experience with the best known reproducers, the scratch noise heard upon reproducing the record in the normal manner is very appreciably reduced due, it is believed, to the burnishing or polishing effect of the stylus upon the groove surface. Since as already explained this treatment affects only the surface of the groove, the original amplitude response of the recorded sounds is not impaired. In some cases, depending upon such considerations as the impendance of the particular vibrating system used, the range of frequencies recorded and the physical characteristics of the material, it may be desirable to burnish at higher or lower speeds than used in recording. An increase in the effective burnishing speed may be obtained when desired by having a system of the proper impedance in which the stylus is rotated at a suitable speed while in contact with the groove. Although this treatment is very useful in cases where the original records are to be used for playback purposes, it is even more valuable from a commercial standpoint because of the fact that the improvement made in the original is also incorporated in any pressing made from it.

A clearer understanding of the invention may be had from a consideration of the following detailed description and the accompanying drawing in which Fig. 1 shows a stylus and resilient mounting in the simplest form suitable for the purposes of the invention and Fig. 2 shows a modification in which the stylus is rotated while in contact with the groove to be burnished.

While the invention is described with reference to its application to records of the hill and dale type it is of course equally applicable to lateral cut records, the only requirement being that the impedance at the stylus point and the bearing pressure shall be of the proper

values and correctly proportioned. For hill and dale recording it has been shown in a copending application of A. C. Keller, Serial No. 402,128, filed October 24, 1929, that a reproducing stylus of the type shown in the present invention will follow the groove faithfully at all times if its mass and elastic constants are so proportioned that the total force which tends to hold the reproducer on the record never becomes less than the product of the needle point velocity and the needle point impedance over the frequency range of the record. Expressed analytically, this becomes

$$F = SQ \geqq VZ$$

where F is the total force, S is the stiffness in dynes per centimeter of the stylus mounting, Q is the initial deflection in centimeters of the stylus mounting when the stylus is in contact with a blank groove of the record, V is the maximum velocity of the stylus point in centimeters per second and Z is the stylus point impedance in mechanical ohms, all of which are considered with reference to the stylus point.

The above equation may be written

$$Z \leqq \frac{SQ}{V}$$

and since for any given record V is determined it will be possible to reduce the impedance Z to any desired value within the limits of the equation. These design equations and the reference to the Keller application are given only by way of illustration as to how suitable vibratory structures may be obtained but this invention is, of course, primarily concerned with obtaining a burnishing effect and hence is not limited to the use of any particular structure.

Referring now to Fig. 1, 1 is a sectional view of a hill and dale groove moving under the stylus 2 in the direction indicated. The stylus should have almost negligible mass and in the structure shown is therefore composed of fibre or other lightweight material and made as short and as slender as practicable. Spring steel wires 3, 3 are looped around and secured to the stylus and clamped to the structure of the reproducer arm 4 to form the necessary elastic support. If this structure is properly designed and the record is rotated at the speed most suitable for the particular record it will be found that the minor surface variations 5 in the groove surface will be smoothed out as shown, as the undulations representing the recorded sounds pass under the stylus.

Since in some cases it may be desirable to obtain the effect of higher speeds than would be practical by increasing the speed of the record, a mechanism for rotating the stylus may be provided. In the structure shown for purposes of illustration in Fig. 2 this takes the form of a very small air motor 6 which is driven by means of a connection with a compressed air hose 7. The motor is carried upon the balanced reproducer arm 8 and its shaft 9 extends downwardly through the arm and carries a grooved pulley 10 which is connected to a similar pulley 11 on the stylus by a thread-like belt 12. The stylus is held in contact with the groove by means of its own mass and the restoring force of the reed spring 13 which is clamped in the arm 8 and connected to the center of the stylus as shown. Supports 14, 14 drilled to form stylus bearings at one end and secured to the arm 8 at the other hold the stylus in the proper position for the burnishing operation. In other respects this device operates in the same manner as the one already described.

It should be understood, of course, that the burnishing apparatus shown is drawn to a very large scale for the sake of clarity in illustration. In actual practice the physical dimensions of the stylus and its mounting would of necessity be very small. In the Keller application previously referred to, it was shown that a reproducer having an effective mass of .1 gram was capable of following the groove faithfully over a range extending far above the upper limit of audibility, but it is found that even this low value of mass is much too great in a burnishing device. Accordingly, the moving system of this invention must be proportioned to give an entirely new order of impedance and at the same time to fulfill the fundamental requirement for remaining in contact with the groove.

It has been found, for instance, that for soft wax records involving a range of frequencies of the order of 50 to 10,000 cycles, it is necessary to use a vibratory system having an effective needle point mass of .006 gram or less and to operate with a steady force of about 10 grams or less, if noticeable improvement with respect to scratch noise is to be obtained. The wax ordinarily used for an original recording has a stiffness of about $.06 \times 10^{11}$ dynes per centimeter as compared with about $.84 \times 10^{11}$ for commercial pressing and it is found that if the steady force is much greater than 10 grams, the stylus has a tendency to deform the groove, particularly for the higher frequencies recorded. It would be desirable to keep the steady force constant in value for all parts of the groove in order to obtain uniform burnishing action, but this of course is not possible since the total force on the record is, at any instant, the algebraic sum of the steady force due to the deflection of the elastic mounting and the alternating forces set up by the undulations in the record groove. However, as previously pointed out, if the impedance is made sufficiently low, as for

instance 1000 mechanical ohms maximum for the range under discussion, the alternating forces will be less than one-quarter of the steady force so that reasonably constant pressure is exerted on all parts of the groove. An impedance of this order is obtained when a mounting stiffness of .6 x 10^6 dynes per centimeter is used with the above mass of .006 gram, but it will be understood that even better results may be obtained by still further reducing these values.

Various other modifications with respect to exact values of the constants or the arrangement of the structure will occur to those skilled in the art, but the invention is intended to be limited only by the following claims.

What is claimed is:

1. The step in the method of producing a grooved phonograph record which consists in progressively subjecting all parts of the grooves of the original wax record to a reasonably constant pressure.

2. The step in the method of producing a grooved phonograph record which consists in rotating the record at a suitable speed and progressively subjecting all parts of the grooves of the original wax record to a reasonably constant pressure.

3. Apparatus for burnishing the grooves of high quality phonograph records in original recording material including a vibration responsive system having a stylus and an elastic mounting therefor, the impedance of the system being less than 1,000 mechanical ohms.

4. Apparatus for burnishing the grooves of high quality phonograph records in original recording material including a vibration responsive system having an impedance less than 1,000 mechanical ohms over the frequency range of 50 to 10,000 cycles.

5. Apparatus for burnishing the grooves of a phonograph record in original recording material comprising means for rotating the record, a stylus adapted to contact the grooves with a reasonably constant pressure and means for rotating the stylus to increase the relative velocity of the stylus and the groove.

6. Apparatus for burnishing the grooves of a phonograph record in original recording material comprising means for rotating the record at a speed in excess of the recording speed, a stylus adapted to contact the grooves with a reasonably constant pressure and means for rotating the stylus to increase the relative velocity of the stylus and the groove.

7. Apparatus for burnishing the grooves of high quality wax records including a vibration responsive system of such low mechanical impedance that the maximum value of the alternating reactions when the system is contacting a record groove is less than one fourth of the steady force whereby the initial pressure is maintained reasonably constant on all parts of the record grooves.

8. Apparatus for burnishing the grooves of high quality wax records including means for rotating the records at a speed in excess of the recording speed and a vibration responsive system having an impedance less than 1000 mechanical ohms over a frequency range of 50 to 10,000 cycles.

9. Apparatus for burnishing the grooves of high quality wax records including a vibration responsive system having an effective mass less than .006 gram cooperating with the record with a steady force less than 10 grams.

In witness whereof I hereunto subscribe my name this 1st day of November, 1929.

HENRY C. HARRISON.