Looking Through the Phonograph Record

Elements That Produce Surface Noise

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SOME years ago, when the phonograph was in its earlier stages of development, vaudeville performers often entertained their audiences with imitations of phonographic reproduction. All of the then characteristic tinny sounds with the usual accompaniment of scratching and snapping were more or less realistically imitated and the performances were quite apt to end with the repetition of a few sounds, indicative of the stylus traveling round and round in the same groove. In those days the phonograph was more of a novelty than it was a musical instrument, but the tremendous development which followed has made it one of the most popular of musical instruments.

As an entertainer it probably has no equal and has been the means of bringing music and entertainment to the most remote places. During the war we read of the sub-sea raiders lying quietly on the ocean bed while their crews listened to the latest in popular music on the phonograph. All of which goes to show that some really remarkable improvements must have been made, otherwise the demand for phonographs would have died out with the novelty. With the incentive of popular demand it is reasonable to expect that the development of the future will result in more faithful reproduction and greater clarity of tone with the elimination of all extraneous noises.

Recently a laboratory study of the standard phonograph records was undertaken with the object of comparing the different record surfaces so that the structural elements producing surface noise might be made more tangible and perhaps, thereby, facilitate the application of corrective measures.

Surface noise or "scratching" of phonograph records is one of the peculiar characteristics of phonographic reproduction

which, no doubt, everyone would like to see done away with. It results from contact of stylus and record and has several contributing causes, one of which is the character of the record surface.

To the unaided eye the surface of a record appears exceptionally smooth and highly polished but when played all records produce surface noise. If one were analytically inclined he probably would conclude that even though the record surface does appear smooth and polished it must have miniature hills and dales and be more or less granular. Even with the aid of a microscope and using methods which are usually applied when examining opaque objects the results are not satisfactory.

For the benefit of those who have not had actual experience in technical microscopy it may not be amiss to say that the mounting of objects for microscopic examination is somewhat of an art in itself and that the mode of procedure differs with the character of the specimen. In some cases the specimen is mounted as an opaque object and oftentimes its surface is etched with some reagent which will differentiate in the structure. In other cases very thin and transparent sections of the object are mounted in a suitable medium on a glass slide and protected above by a thin piece of glass called a cover glass.

For critical examination of a phonograph record by microscopic methods the conditions seemed to call for a very thin section from the record surface, a section of the skin so thin that it could be examined under considerable magnification by transmitted light. In making the section the surface of the record should not be disturbed even to the slightest extent, otherwise the true conditions would not be disclosed by the

FIG. 1

RECORD A
37 DIAMETERS

FIG. 2

FIG. 3

RECORD B
37 DIAMETERS

FIG. 4

FIG. 5

RECORD C
37 DIAMETERS

FIG. 6

FIG. 7

RECORD D
37 DIAMETERS

FIG. 8

FIG. 9

FIG. 10

FIG. 11

FIG. 12

RECORD E
37 DIAMETERS

RECORD F
37 DIAMETERS

subsequent microscopical examination. Moreover, this method of attack would permit the examination of crystalline matter by polarized light and also, it would allow the individual particles to be gaged by micrometry.

After much laboratory work of the most painstaking order and innumerable failures which are usually incident to work of this kind a delicate mode of procedure was developed whereby a section of the surface measuring approximately one centimeter square and only a few thousandths of a millimeter in thickness could be removed from the record. These sections were then mounted on glass slides in the manner described above after which it was possible by means of the microscope

and condition of the material forming the bottom of the record grooves. Even to one experienced in technical microscopy the results were startling and they seemed sufficiently convincing to warrant the speculation that the development of the phonograph record has not as yet reached its zenith. As a further aid in the investigation transverse sections also were prepared and a method of reproducing the record surface in a transparent medium was developed as will be described later. To reproduce the surfaces by photomicrography proved somewhat of a problem but by a special arrangement with a powerful illuminant together with the necessary optical system the photomicrographs reproduced here were taken.

In the selection of specimen records for examination every effort was made to secure thoroughly representative records from each manufacturer's product. In general, unused records of the latest production were procured from dealers whose sales are large and by careful selection it was felt that the results would be representative. In those cases where the record manufacturer also markets a phonograph the records were played on a machine of the same make; otherwise they were played on one of the standard available machines adapted to the record. The records selected include all of the standard makes with exception of the cheaper records in which a high degree of artistic or technical attainment should not be expected.

In order that the illustrations may be understood and cor-

rectly interpreted a brief description of record construction seems necessary. Phonograph records are made from that class of materials known as hot molded composition. They consist of a binder intimately mixed with suitable mineral and vegetable fillers and a small proportion of coloring matter. Under suitable conditions of temperature and pressure the mixture assumes a plastic condition and may be molded. The binder may be either a natural or synthetic gum or resin, or a combination of both. The commonly used natural resins or gums include shellac and resin. The synthetic resins (phenolic condensation products) have the property of resisting deformation under moderately elevated temperatures and, too, they produce a very hard surface which resists "brushing record" and consequently records made with these resins do not scratch and mar easily during handling. The natural resinous materials are often affected by heat and records made with them are apt to deform unless properly stored. Also the surface of such a record is somewhat soft and apt to be damaged by careless handling. The mineral fibers, such as rottenstone, chalk, etc., are used to impart hardness and strength. The vegetable fillers are usually cotton or wood fibers and their function is to help hold the mass tenaciously together and to counteract brittleness.

Figures 1 to 19 inclusive are photomicrographs of the nine prominent records which were selected for investigation. The bright spots are the particles which transmitted the light more brilliantly than the adjacent particles and from a consideration of the illustrations it seems evident that what to the eye appears to be smooth and polished is actually a rough and rugged road, at least in so far as the stylus is concerned.

From a critical examination of the illustrations one probably would conclude that record "H" should have the least surface noise and this assumption would check exactly with the facts. The record consists of a disk of cheap composition faced with a pure phenolic condensation product. Therefore, the record grooves are made up of a very smooth, hard, homogeneous substance, free from mineral and vegetable matter such as is found in other records. The irregularities shown in Figure 15 were found to consist of small cracks, voids and air bells and

FIG. 13

FIG. 14

FIG. 15

FIG. 16

RECORD G
37 DIAMETERS

RECORD H
37 DIAMETERS

FIG. 17

RECORD I
37 DIAMETERS

FIG. 18

TRANSPARENCY 75 DIAM.
FIG. 19 RECORD G 37 DIAM.
FIG. 20

also of foreign particle inclusions such as dust. This photomicrograph is of special interest because it shows the order of imperfections which commercial molding may be expected to yield when working with a clear homogeneous material. So far as freedom from surface noise is concerned this record left little to be desired but unfortunately the surface coating displayed a tendency to warp and crack; due, apparently, to an inherent physical weakness in the record construction.

On the listening test record "I," Figures 17 and 18, was found to be next in order of freedom from surface noise, although there was quite a gap between it and record "H." In most of the records the surface noise was not especially pronounced and probably would not be objectionable to the average listener except, perhaps, in records reproducing soft music. Figures 17 and 18 show clean-cut molding and quite uniform structure.

In addition to the usual scratching sound, occasional "snaps and cracks" are often heard and these seem to have their origin in a different source. In record "B," Figure 3, certain imperfections in the record surface are to be seen and it seems probable that when the stylus strikes such obstructions as these the reproducer must register some sort of a violent protest. These molding imperfections were found to be more pronounced in this particular record, but they were by no means absent in the other records. Record "B" also had considerable surface noise which one would expect from the nature of the structure as shown by Figures 3 and 4.

Record "F," Figures 11 and 12, illustrates a novelty in construction. In Figure 11 it will be seen that the record body consists of a coarse structure which is faced with a finer composition. Between the body and the surface coating on each side is a fibrous separator. The surface of this record is of finer structure than record "B" and, as might be expected, the surface noise was less intense.

Records "A," "C," "D" and "E" on the listening test were found to be much the same so far as surface noise was concerned. Some differences did exist but it will be seen from the illustrations that the surfaces are inclined to be rough and in some instances the structure is coarse.

As might be expected from Figures 13 and 14 record "G" had the most surface noise of any of the records studied. In some records the scratching assumed very disagreeable proportions and detracted greatly from the musical value of the record. The grooves were found to consist of

small and large mineral particles and splintery bundles of wood fiber. The large mineral particles were present in abundance as will be noted and their origin was a mystery until treated by a method of microscopic analysis. Since a large proportion of the record consisted of wood flour it was decided to examine some representative samples of this material. The results showed that the wood flour carried large inclusions of mineral particles similar to those found in the record surface. Following the wood flour to its origin it was found to consist of sawdust ground to fineness in a stone mill. Apparently in this way particles of the grindstones were being conveyed to the record surface. In Figure 22 the coarse and splintery structure of the wood flour is shown by means of a photomicrograph taken by dark ground illumination. A large mineral particle is much in evidence. An idea of the extent to which mineral particles were found to be present in wood flour may be judged from Figure 20 which shows the inorganic matter found in about one per cent of the wood flour which could be heaped on a ten-cent piece. The wisdom of using material of this kind would seem open to serious consideration, especially in view of the fact that chemically separated wood fiber free from foreign inclusions may readily be obtained. Wood fiber of this nature is illustrated in Figure 21. It will be noted that the wood has been reduced to its ultimate fiber, which is the best possible condition for molding plastics.

As a further aid in the investigation a transparent medium which would take an impression from the record surface was developed, the idea being that differences in level would be disclosed by differences in the depth of color of the impression when viewed by transmitted light. That is, a mount of this kind when examined under the microscope would constitute a relief map of the record surface. Figure 19 is from an impression taken from record "G" and the similarity of Figures 13 and 19 is quite evident. In Figure 19 the light colored bands are the ridges and the broad darker bands are the grooves from which it is clear that a dark area indicates a

depression in the record surface and a light area an elevation. This method of examination has the advantage of being quicker but does not permit qualitative and quantitative analyses by means of the microscope.

From a consideration of the data obtained it would seem that future improvements in surface conditions appear most hopeful along lines which will result in a finer and a more homogeneous structure.

FIG. 21. FIBERS OF WHITE
SPRUCE SEPARATED BY CHEMICAL
MEANS. ENLARGED 37
DIAMETERS FIG. 22. GROUND WOOD FLOUR
WITH COARSE MINERAL PARTICLE
INDICATED BY THE
ARROW