Title: THE WEAR AND CARE OF RECORDS AND STYLI
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A study conducted by to determine the effective life of phonograph styli and the effect of worn styli and dust on record life and quality of reproduction.
Published in 1954 - out of print - now in public domain
Original Price $1.00

INTRODUCTION

The most neglected portion of record reproducing equipment is the phonograph needle, or stylus, as it is properly called. In the entire phonograph system, the stylus is the component subjected to the most wear and is most likely to be mishandled. Research indicates that the majority of listeners were damaging their valuable collections of records through the continued use of worn styli. This is not a trivial matter, if one stops to calculate the financial investment made in a record collection. And in many cases it involves irreplaceable recordings. Of equal importance is the fact that these same listeners are not enjoying the full tonal quality which their equipment and records are capable of producing. In addition, they are actually introducing considerable distortion into otherwise excellent music reproducing systems. It was a revelation to discover that even those who had acquired expensive fidelity reproducing equipment, were not entirely aware of the important part played by the stylus in record reproduction and record wear. This important matter has been far too often neglected, even by professionals. This booklet attempts to provide sufficient information that will enable anyone to increase the life of a record collection, and to reduce annoying background noise mistakenly referred to as "needle scratch." It will also show how it is possible to obtain far better reproduction from one's present equipment.

THE TURNTABLE AND PHONOGRAPH PICKUP CARTRIDGE

There are two general types of record turntables in use; the manually operated unit and the automatic player, called a record changer. Both types employ a device called a phonograph pickup cartridge, which is mounted in the tone arm and holds the stylus. This cartridge picks up a signal through the stylus and converts the microscopic impressions on the record into electrical energy, which

is then amplified and converted into sound by the loudspeaker and associated equipment. It is the process of picking up these microscopic impressions engraved upon the walls of the record groove which is of concerns, since the power created by the minute electrical impulses are later transformed into sound. The original signal is obtained from the force developed between the stylus tip and the sidewalls of the record groove. The proper relationship between the stylus tip and the record groove is extremely important. The impressions on the walls of the record groove are microscopic, three-dimensional duplicates of the sound waves which created them. The pickup stylus must follow with extreme exactitude the variations of these impressions. This can only be accomplished if the original shape of the stylus tip is maintained.

An elementary knowledge of how these impressions are created and converted into sound will help in the understanding of exactly why the quality of reproduction deteriorates as the stylus becomes worn, and how a worn stylus results in record wear and damage.

THE RECORD

Let's start with the source of the music, the record itself. A record is a flat disc made of a vinylite compound or a shellac compound, and contains a single spiral groove. There are three types of records in use; the 78 RPM, the 45 RPM, and the 33 1/3 RPM Long-Playing Record. The two latter types differ from the 78 RPM record in the use of slower playing speeds and finer grooves. The finer grooves allow a greater number of grooves per inch of record. The result is longer playing time. A 78 RPM record contains about 100 grooves per inch, each groove about the width of a human hair. A 33 1/3 RPM record has about 225 grooves per inch, each groove approximately one-half the width of a human hair. The groove on a 12 inch, 33 1/3 RPM record, if uncoiled, would be over one-half mile in length.

The record groove and the impressions it carries are created in the following manner. The sound waves created by the musicians are picked up by microphones, which convert the sound waves into electrical energy. This electrical energy is fed into equipment in a control room, where the volume and the balance between the microphones is controlled. This controlled signal is then amplified

and fed into a tape recorder. Tape recorders are used because tape is more easily edited and controlled than the earlier method which employed a disc for the same purpose. When an original recording is made on a disc, the entire performance must be absolutely perfect from start to finish, since the use of a disc permits no editing or alteration from the original. One mistake, and the entire recording session is wasted! But when the performance of a symphony orchestra, for example, is recorded on tape and an error occurs, the conductor stops the orchestra and repeats the passage, continuing on from a point just before the mistake was made, knowing that "editing" will remove the mistake and the "cut" sections will be spliced so that the correction cannot be detected aurally.

The music recorded on the tape is then transferred onto a lacquer disc. This disc is known as the "original". The music previously recorded on the tape is amplified and fed into the cutting head of a disc recorder, which transforms the amplified electrical energy into mechanical energy. This mechanical energy forces a cutting stylus to move from side to side and engrave impressions onto the rotating disc. The cutting head functions in a manner similar to the action which occurs in a loudspeaker, but instead of the back and forth motion of the loudspeaker cone, there is a side to side (lateral) motion of the cutting stylus. The shape and size of the impressions engraved in the rotating disc are determined by the pitch and level of the signal being recorded. The higher the pitch, the greater the number of times per second the cutting stylus will vibrate from side to side. The level of the sound being recorded also affects the impressions engraved upon the disc. Increasing the recorded level causes the cutting stylus to engrave deeper impressions into the walls of the grooves. Conversely, a reduction in level causes a reduction in the distance the cutting stylus swings from left to right, causing it to engrave shallower impressions. These impressions, as mentioned earlier, are microscopic three dimensional duplicates of the sound wave pattern.

When the cutting of the "original" lacquer disc is completed, the disc is then "metalized." This is accomplished by a process of dipping the newly cut disc into a solution of stannous chloride. The disc is then washed to remove any surplus solution, and sprayed with

silver nitrate. Chemical action between the stannous chloride and the silver nitrate results in depositing of a microscopic layer of silver upon the disc. This metalized disc is then electroplated. The metal plating is separated from the original lacquer disc and reinforced by a solid metal backing. The now complete assembly is called a "master".

The "master" is next electroplated. This new plating is again separated from the master and reinforced. The result is called the "mother" or "matrix". The matrix is plated in the same manner, and the plating is removed and reinforced. This final assembly is called a "stamper." A quantity of these stampers can be obtained from each matrix.

Next, a pellet of vinylite (for LP records) is placed in a hydraulic press which heat the stampers. These stampers are placed in the upper and lower jaws of the press. The jaws are closed with the pellet of vinylite between them, just as dough is placed in a waffle iron. The stampers transfer impressions into the vinylite. The disc produced is then cooled, and the record is finished. The entire process undergoes rigid inspection each step of the way. An idea of the extreme care used can be shown by the fact that the stampers are changed after each 250 pressings, since even the microscopic wear created in pressing is not tolerated in precision record manufacture. This is how a record is manufactured and how the impressions are created on the walls of the grooves.

THE STYLUS

A spherical stylus tip is not sharp pointed, like a needle, but is conical in shape and has a smooth hemispherical tip with a radius of curvature for long playing records of one thousandth of an inch (.001"). It is polished to an extreme degree of smoothness. The smoothness of the surface of the stylus tip is very important since the higher the polish the less friction generated between the tip and the groove walls of the record.

The difference in groove width between the old standard 78 RPM and the Long Playing records necessitates the use of two different size stylus tips. The long playing records, as we have discovered,

require a tip radius of 1.0 thousandth of an inch (.001") or less, whereas the older 78 RPM records require a tip radius of 2.5 thousandths of an inch (.0025").

The stylus tip, when in good condition, touches the groove walls at only two points. The entire weight of the stylus and the structure which holds it is concentrated at these two microscopically small points. When this concentration of pressure upon the points of contact is calculated, we find it to be approximately 26 tons per square inch. The walls of the record grooves are, of course, subject to the same pressure, but only for the fraction of a second required for a particular section to move past the tip as the record rotates. The stylus tip must travel well over one-half mile of surface each time a 12" LP record is played...with 26 tons of pressure per square inch. It is not surprising that the stylus tip wears out, despite the fact that the material of which it is made is harder than the vinylite record material.

As noted, the reproducer stylus tip follows the impressions engraved upon the walls of the record groove. These impressions, depending upon the pitch of the recorded sound, force the stylus tip to vibrate from side to side as fast as 10,000 times per second. The stylus tip in the record groove follows a path in much the same manner as automobile tires would follow the ruts in a country road. As mentioned, the stylus tip touches the groove walls at only two microscopically small points. The friction and resulting wear is concentrated at these points. This friction causes the gradual wearing away of the stylus material at these points, and creates what are called "flats". The amount and degree of wear are apparent when the tip is viewed from the side, using a microscope. It is these flats on the stylus tip which are the direct cause of increased record wear, distortion, and reduced tonal range. Although these flats appear on both sides of the stylus tip, the amount of wear is not the same on both sides because of the side thrust created by the tone arm mounting method. This can be off-set somewhat by proper setting of the anti-skate force.

The amount of record damage, distortion, and the reduction of tonal range due to worn styli increases in direct proportion to the size of

the flats on the stylus tip. Depending on the wear, the stylus tip can become a cutting tool, and if continued in use, it will eventually take the shape of a miniature chisel. Thus, when it is forced from side to side, it will cut and gouge minute particles from the groove walls as it travels. This cutting and gouging of wave crests is one form of record wear. The wearing process is also hastened by the abrasive action of dust in the grooves. The wear on both the stylus and the record groove can be considerable.

STYLUS PRESSURE

Another factor affecting both record and stylus wear is the downward pressure of the stylus tip on the record groove. The greater this pressure the greater the amount of friction generated between the walls of the record groove and the stylus tip. Increased friction naturally results in increased wear. However, the original pressure may change due to various mechanical conditions. The best method of counteracting this factor is to check the stylus pressure once a month. Periodic checking and correction, when required, can result in an increase of record and stylus life up to 10%. Most pickup arms have either a screw, nut, or lever by means of which the stylus pressure can be adjusted to the correct value. Several manufacturers produce stylus pressure gauges which are comparatively inexpensive and simple to operate. Due to their low cost, they can pay for themselves very quickly.

STYLUS WEAR AND REPRODUCTION

Let's now consider how stylus wear and record wear affect the quality of reproduction. Earlier it was stated that the impressions engraved upon the walls of the record groove were three dimensional duplicates of the sound waves which created them, and that the stylus must follow with extreme exactitude the variations in these impressions. This could only be accomplished if the original shape of the stylus tip was maintained.

A new spherical stylus fits into and can follow all of the variations engraved onto the walls of the groove. The surface of the spherical stylus tip, at the point of contact, is a perfect circle and can thus enter any of the engraved depressions or pass around any of the engraved wave crests. A worn stylus tip, at the point of contact, is like fitting a square peg into a round hole. A worn stylus tip will no

longer fit into the engraved depressions since the flat on the stylus tip is wider than the opening of the depression. Theoretically, this should result in a complete loss of signal. But, in actual practice, due to the resiliency of the vinylite record material, the worn stylus tip is forced part way into the depression due to the tremendous lateral pressure. Hence some signal is obtained. Since the stylus tip obviously cannot follow with "extreme exactitude" the variations in the groove, the signal is nowhere near a perfect replica of the original recorded sound wave. The sound produced with a worn stylus has a fuzzy quality which is difficult to define or describe, but is definitely unpleasant to hear.

Stylus wear occurs slowly over a comparatively long period of time. For this reason the distortion or fuzziness created by a worn stylus is also gradual. Therefore, the casual listener becomes aware that certain instruments do not sound the way they should. The distortion or fuzziness created by a worn stylus first manifests itself on the higher pitched sounds at the inside grooves toward the center of the record. As the flat on the stylus becomes progressively larger, the distortion becomes noticeable further and further toward the outside of the record and at the same time at lower and lower pitched tones. When the flat has become very large, sounds in the middle register are distorted or fuzzy over the entire surface of the record. Unfortunately, when this stage has been reached the stylus has already been damaging the records for some time.

Distortion or fuzziness should under no circumstance be used as an early indication of a worn stylus. Distortion created by a worn stylus becomes noticeable much sooner on high quality reproducing equipment than with less efficient equipment. This is because the higher the quality of the reproducing equipment the wider its tonal range, and any distortion of the high pitched sounds is immediately apparent. Since less expensive equipment does not reproduce the entire tonal range of the recording, it does not reproduce the higher pitched tones either. Consequently any distortion of these tones remains unnoticed. For this reason the distortion and fuzziness characteristic of a badly worn stylus shows up much later on less efficient equipment. The foregoing may sound like a point in favor of less efficient equipment, but it is definitely not so intended. The average record collection is usually worth more than the equipment on which it is used, and includes irreplaceable recordings. Thus, in

order to protect and preserve these treasured records, the stylus should receive as much attention when it is used with an inexpensive record player as it does with an expensive home music system. Preservation of the records should be the most important consideration.
The forcing of a worn stylus tip into the engraved depressions is another contributing factor to record wear and distortion. The sharp edges at the ends of the flat can remove record particles as they are forced into the groove depressions. This forcing of the worn stylus against the groove walls may also distort the walls beyond their elastic limit, which results in additional record wear and distortion of reproduction.

Another manifestation of a worn stylus tip wear is considerably increased noise level in reproduction. This is because the stylus tip is in contact with the particles of dust and grit lying at the bottom of the groove. The effect of dust and grit on the noise level of a record can be easily understood as even the granular structure of the record material itself affects surface noise. This is one of the reasons that older shellac records are noisier than the vinylite or styrene records, even when new. The shellac base material is not uniform in structure but is built up of small grains. These grains, pressing against the stylus tip as the record rotates, create random impulses which are translated as noise. Dust, grit and stylus particles are often many times as large as these grains of shellac, and consequently affect reproduction to an even greater extent.

HOW LONG SHOULD A STYLUS LAST?

A worn stylus damages records, causes distortion, and affects tonal response. What, then, is the life of a phonograph stylus, and when should it be replaced? The first part of this question is rather difficult to answer with any degree of exactitude. Asking, "how long should a phonograph stylus last?" is like asking "what is the life of an automobile tire?" To answer such a question, even approximately, would require additional information, such as: the weight of the car; the speed at which it is usually operated; the type of roads over which it will travel; whether gravel, dirt, or asphalt; the quality of the tire itself, etc. Quite a number of variable factors! The life of a pickup stylus depends upon at least as many variables. Among the

factors influencing stylus wear are the material of which the stylus tip is made; the condition of the records with which it is used; and the stylus pressure. Also of considerable importance is the ability of the pickup itself to follow the impressions engraved upon the groove walls with the least resistance to the motion they cause. This is called "trackability" and is related to a specification called "compliance."

The second part of the question, "when should a stylus be replaced?" is not quite as difficult to answer, though the answer can only be an approximation. As a rule of thumb, a diamond stylus should be replaced after 800 to 1,000 hours of playing time.

LIFE TESTS OF DIAMOND STYLI

Tests were made on diamond tipped styli. However, before discussing these tests let's dispel one fallacy. DIAMOND STYLI DO NOT DAMAGE RECORDS! This misconception apparently stems from the fact that the diamond is the hardest material known. "Look at what a diamond does to glass, and a vinylite record is not as hard as glass." True, but to cut glass a diamond must have a point or a cutting edge. A diamond stylus tip has a smooth rounded surface, like a ball bearing. A smooth surface finish is important on a stylus tip, since the smoother the surface the lower the friction between the tip and the record groove. The lower the friction the less is the amount of wear on both the stylus tip and the record. Due to its great hardness, the diamond can be polished to a higher degree than any other substance. A higher polish results in a smoother finish, which greatly reduces friction.

One of the chief causes of record and stylus wear is abrasion caused by the material worn off from the stylus itself. These particles worn from the tip become lodged in the record groove and act as an abrasive which accelerates the wear on both the record and the stylus tip. The diamond, being harder than other older stylus materials, like sapphire, does not wear as rapidly and thus does not deposit as much material in the record grooves. This results in less abrasion and consequently less wear.

TEST RESULTS

The average flat on a worn diamond spherical tip measured .00145". Even this amount of wear results in distortion, increased noise and excessive record wear. To obtain a flat of .00075" required 140 hours of use. To obtain a flat of .001" required 300 hours of use. To obtain a flat of .00125" required 700 hours of use. To obtain a flat of .0015" required 1,500 hours of average use; this degree of wear resulted in reduced tonal response, high noise level, greatly increased distortion and a considerable amount of record wear.

DUST AND GRIT

The presence of dust, grit and particles worn from the stylus tip itself not only can damage records and reduce stylus life, but may affect tonal response. An analysis of the "dust" removed from a number of stylus tips, which had been used on dirty records, showed that it consisted of approximately; 12% jagged silica particles, 35% diamond dust, 40% miscellaneous particles, including soot, grit and particles worn from the record groove itself. The remaining 13% consisted of fibers and lint.

The stylus tip could not, of course, remove particles which had already become embedded in the groove walls. From this analysis, we can see that almost 65% of the extraneous material is harder than the comparatively soft record material and, therefore, is capable of scratching and damaging it. This material in the record grooves also increases the amount of friction between the stylus and the record groove as we have found.

Increased friction results in increased wear on both record and stylus and also increases the amount of static electricity generated. Most plastics are insulators and retain a static charge. The friction created between the stylus tip and the groove accelerates the generation of static electricity. Even the friction generated by slipping the record into its jacket increases the static electricity. From the foregoing paragraphs, it is apparent how closely allied are dust, grit, and static electricity in creating excessive record and stylus wear.

Dust was mentioned among the factors contributing to excessive record and stylus wear. Dust and grit in the record grooves were found to be the primary cause of exceptional wear found in the tested styli. These findings led to an additional series of tests on

styli to determine to what extent dirt and grit lodged in the record grooves affected record and stylus life. Brand new records were used to create wear on one group of styli. A second group was worn with used records. A third group of styli were then worn with clean used records, and a fourth group with used records which had not been cleaned.

Tests showed that both airborne dust and debris worn from the stylus tip itself are the greatest cause of excessive record and stylus wear. Complete removal of dust and grit from the record grooves resulted in increases of up to 60% in the useful life of both records and styli.

Many methods have been devised and improvised to combat the problem of dust on records and to reduce its effect on wear and reproduction. However, none of these methods were ever completely effective, and they all passed into oblivion with one exception, the cleaning pad. Unfortunately this device is in general use in 1954, despite the fact that it does not clean records! A record pad can actually damage records by scratching them and grinding microscopic particles of dust and grit into the grooves. In addition to causing excessive wear of records and styli, these dust particles also increase the noise level of the record. Since the particles of dust and grit are often as large as the recorded impressions in the record groove which create the sound, they will affect the stylus movement, causing random impulses which are translated as noise. This increase in noise level due to dust and grit is the biggest contributing factor to the hissing sound commonly and mistakenly referred to as "needle scratch." The dust problem is further aggravated by the fact that the new vinylite records actually attract dust and retain it, due to their electrostatic properties. Dust in the air and grit are attracted to the surface of records due to static electricity. Careful handling, storage and cleaning of one's record collection is more than repaid in better reproduction and greatly increased record and stylus life.

The grooved section should never be touched, since the skin oils and grease from the hands is transferred to the record, causing any airborne dust to adhere to the spot or area touched. Between the

electrostatic attraction of the record and the natural affinity of dust and grit for grease, the grooves in the area touched soon become dust laden and consequently noisy.

Cleaning records has been a highly controversial subject since the invention of the phonograph. When the average person bothers to clean records it is usually done with a slightly damp cloth on the assumption that the cloth will pick up the dust and the dampness will eliminate the electrostatic charge. This method of cleaning does accomplish these functions to some extent. What actually does occur is that the cloth picks up some of the dust and grit. The remainder, however, is ground into the grooves by the rubbing action. The dampness of the cloth does reduce the electrostatic charge, but only temporarily, since it quickly builds up again as the record dries. However any attempt to clean records is commendable and even a poor cleaning is better than none.

Completely removing dust and grit from a record is not a simple problem. A number of factors must be considered. Firstly, the cleaner must not contain any gummy substance that will remain in the engraved depressions in the record groove. Secondly, the cleaner must completely penetrate these same depressions and remove any dust or grit they may contain. Thirdly, the cleaner must not affect the record material itself in any manner. Record dust/dirt when examined under a microscope consists of grease, stylus particles, abrasive material, and solids which resemble wool fibers covered with a soft waxy substance.

Clean grooves result in greatly reduced record and stylus wear. Once the dust and grit have been removed from the record grooves, consider the use of an anti-static agent as its repeated use will prevent the attraction of airborne dust or grit. No anti-static agent should be used which results in a sticky residue, and the record should be recoated as often as is necessary since the anti-static agent does not have a permanent effect. The importance of anti-static properties is indicated by the fact that record companies are searching for some method of incorporating this feature into the manufacture of their vinylite records.