The Cutting Sylus Problem In Microgroove Recording

"Stylus"

A discussion of the effect of burnishing-facet dimensions on frequency response.

THE CURRENT INTEREST in new methods of sound recording has made many an engineer re-examine more critically the faults of older systems. Modern disc recordists have become increasingly conscious of diameter effects, and particularly of loss of high-frequency response at smaller diameters. This loss occurs in two parts: First, a loss in *recording* due to the cutting stylus shape; and secondly, a loss in *reproduction* due to the reproducing stylus failing to follow the finer groove convolutions faithfully (tracing loss). Reproducing loss can be reduced by using a smaller stylus tip, within reason. In the case of lacquer, it can be reduced by using a harder lacquer, again within reason.

Only recently has there been much interest in minimizing recording loss. It is not generally realized that commonly used lacquer-cutting styli polish the groove walls by a burnishing action after cutting. This effect is comparable to the use of a dulled cutting tool in making a polished cut in brass.

As the polishing action is made more effective by increased burnishing-surface length, the high frequency response deteriorates. A glance at *Fig.* 1 will illustrate why. Effectively, there are flats on the sides of the stylus, which impede lateral motion.

The shape of the stylus and the nature of recording lacquer are such that it is not feasible to derive a solution by theoretical means, and so laboratory methods must be used. The only quantitative study of this phenomenon, which has been published, is that of LeBel[1] in 1942. While the original study was made with a standard-size groove, we believe that its conclusions may be applied to the microgroove without too much error. Every cutting stylus has a certain amount of personality of its own anyhow, and the variability so produced is superimposed on the general trend.

We have used the generalized solution given by the above reference—a graph showing the relation between the fraction: burnish length/wavelength, and the attenuation in recording. We have taken the liberty of continuing the main trend for a db further than the reference has, for reasons that will be evident on inspection of his data. This slightly modified graph appears as *Fig.* 2.

The tests on which this curve is based were run at a stylus velocity of 1½ inches, and checked at 2⅝ inches per second. Visual inspection of *Fig.* 1(A) will suggest that the loss might increase at very high peak velocities, but the velocities indicated include the range of velocities normally expected.

The LeBel study was made in terms of *tip* burnish length, which is the easiest to measure accurately. The

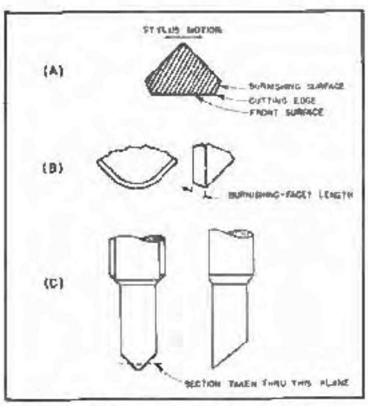

Fig. 1. (A) General view of lacquer cutting stylus. (B) Magnified view of cutting stylus tip. (C) Magnified cross section of tip.

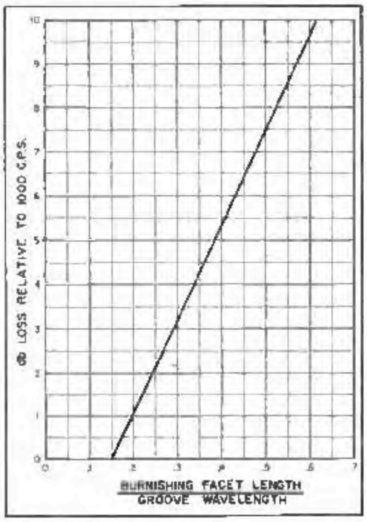

Fig. 2. Generalized effect of burnishing facet length.

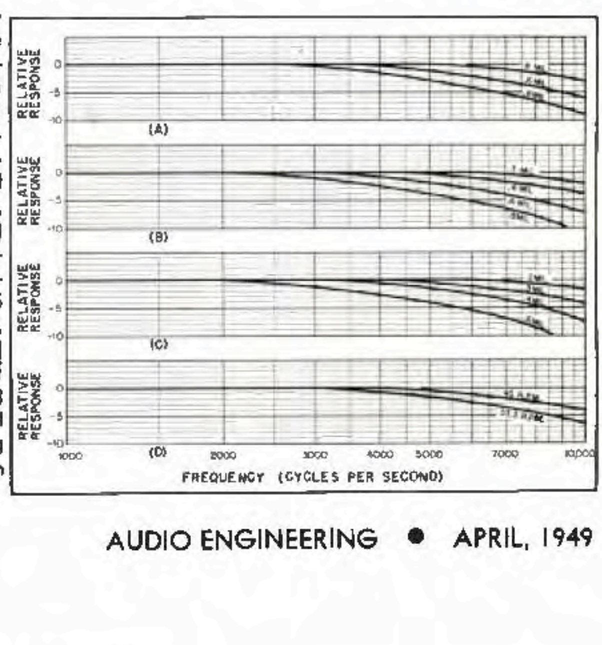

Fig. 3. (A) Frequency response of recording stylus at 8 inch diameter, 33.3 rpm. (B) Frequency response of recording stylus at 7 inch diameter, 33.3 rpm. (C) Frequency response of recording stylus at 5 inch diameter, 33.3 rpm. (D) Comparison of response at 33.3 and 45 rpm, .4 mil burnishing facet, 5 inch diameter.

length at the sides may be slightly less, with the decrease somewhat under the control of the lapidary.

The following formula is too obvious to require derivation:

$$\frac{\text{Burnish length}}{\text{Groove wavelength}} = \frac{f\,l}{\pi D n}$$

where f = frequency in cps
l = burnish length, inches
D = recording diameter, inches
n = speed in rps

A glance will show that the fraction increases with frequency and burnish length, and decreases with an increase of speed or diameter. From this formula the graphs of *Fig.* 3 were computed.

A condition typical of standard high-quality 16-inch transcription recording is shown in *Fig.* 3(A). By the use of 136 or 144 pitch, the inner diameter is limited to 8 inches.

At (B) we have a condition occurring in many broadcast stations which have continued to record transcriptions with the pitch of ten years ago. This results in an inner diameter of 7 inches. The injurious effect of a given burnish is measurably greater, as can be seen by looking at the 10 kc response. Incidentally, this is fairly close to the outer recording diameter of a 7-inch microgroove disc.

Conclusions

Finally, we go in to the innermost diameter of a microgroove record—about 5 inches—at (C). A very small burnish is necessary, else the high frequency loss rises rapidly.

Just for comparison, at (D) we have plotted the response of a .4 mil burnish at 5 inches diameter at 33.3 and 45 rpm. The higher speed eases response problems, by 3 db at 10 kc in this case. This saving taken alone

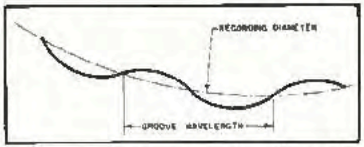

Fig. 4. Groove wavelength and recording diameter.

would not be significant, but similar savings accrue at other stages in the recording process, making a significant total.

With current interest in higher fidelity, it is evident that burnish length will have to be limited. The high quality transcription recordist and the microgroove specialist will both have to use care.

Transcription work will have to use a burnish of not over a half mil, approximately. It is not difficult to make such a stylus satisfactorily quiet. A great many 10- and 12-inch microgroove discs are recorded in to only a 7-inch diameter, and a similar stylus will often suffice. On the other hand, the recordist working with 7-inch microgroove discs will be faced with a real problem. Compelled to use a burnish of about a quarter mil, he may have difficulty in getting a quiet groove unless he uses a higher cost stylus. It is a good deal harder to get a quiet groove when using a small burnish, and the lapidary may have to be much more careful than he is with a half-mil burnish.

In spite of all these precautions, not every stylus will have equally good frequency response, and it may be desirable for the recordist working at less than 6-inch diameter to check each stylus individually, using the poorer points for less critical work.

It should also be recognized that small-burnish styli of the best quality are not all equally quiet. Some are satisfactory all the way in to 5 inches, while others start to become noisy at the 6-inch diameter. It is highly desirable to segregate the latter for use at the larger diameters only. Again we may say that each stylus has a personality of its own.

One may object that this is a lot of work. True, unfortunately, for the secret of good recording quality has always been meticulous care, and we see no chance of the future remedying the situation.

Reference

1. C. J. LeBel, Properties of the Dulled Lacquer Cutting Stylus, *J. Acous. Soc. Am.*, Vol. 13, No. 3, pp 265—273, January 1942.