WHO HAS THE PERFECT TIP?

BY A. J. van den HUL

In designing any stylus tip, an important thing to remember is the V-shape of the cutter, with the two sides forming a 90-degree angle. The cutter's front face is flat and is positioned vertically on the lacquer in the cutting process. The edge of the cutter has a small radius of 2 to 4 microns, depending on the manufacturer.

To fit optimally in the groove, the replay stylus tip must have the same shape as the cutter, but this is not always practical. One reason is that another groove could be cut over the existing groove in replay, which would require changing the shape of the replay stylus. The larger this change, the larger is the deviation from ideal, and the worse the tracking. The design of a new stylus tip is, therefore, always a compromise between an ideal shape and a shape in which the groove has the least wear.

When designing the van den Hul tip, I paid a lot of attention to this consideration. The shape of the cutter was the starting point. Calculations on the IBM 370 computer at the Technical University of Delft allowed me to examine a number of possibilities. The main problem was how to grind the tips. I reasoned that if the variety of possibilities was large, it could affect the ease of production. After making a number of theoretical examinations, with the aid of a second series of computer programs, I chose a definite shape.

Still, the questions of how to grind and polish such a shape without errors remained. A third computer program helped me determine the production values, but a severe problem arose in the tip-polishing process. Surplus material was often removed in the first shaping process, when maintaining the exact shape is critical. After solving this difficulty, I still had to deal with the problem of quantity production.

Which criteria are fundamental in the choice of the tip shape? You already know two—an optimal resemblance to the cutter and as little record wear as possible in the tracking process. A third is the replay process.

I understood the limitations of tracking high frequencies with a tip using a large side radius. For instance, conical tips (*Fig. 1*) have a typical radius of 18 microns. Even the Shibata (*Fig. 5*) suffers from front-to-back symmetry, which can produce considerable distortion. In particular, this shows up through the so-called "pinch effect" at high frequencies and near the center of a record. With all these considerations and many more in mind, I decided to adopt this unusual shape: an ultra-flat tip with a front-to-back radius of 3.5 microns and a vertical groove contact radius of 85 microns. I call this, naturally enough, the van den Hul tip.

Editor's Note: This essay is an exposition of the author's research into the factors involved in the stylus-to-groove relationship and his subsequent development of a new shape for stylus tips. Although this exposition may be viewed as a "plug" for the author's device, it is also, in our view, a clear description of the complex requirements of this important stylus/groove interface. We welcome other views and readers' responses.—E.T.D.

In the case of round and elliptical tips (*Figs. 1–3*), you need extra tracking force to keep the tip in contact with the groove. As a result, these two tip types can be very unkind to the record. In contrast, you can play the van den Hul tip with a lower tracking force to obtain an equivalent sonic performance. In addition, the low friction between tip and groove allows you to set the anti-skating force at a lower value.

Note that with a round tip, the temperature at the tip can go as high as 140 °C in high modulations, such as the ones on CBS test record STR 112 side A group 3a +12dB band. The van den Hul tip reduces the temperature to 70 °C, which is still high, but within the safe temperature limits of the vinyl. Using the recording lubricant LAST® reduces this value by 22 percent.

VERTICAL ORIENTATION. Due to the vertical position of the cutter, all record grooves have a vertical orientation. The replay tip should retain this orientation because deviations result in indefinite tracking. The cause of such deviations is the basic conical tip shape, which produces a 3-dimensional curve that does not have an exactly vertical contact line. The curvature of a tip in the forward or backward direction, especially when tracking high frequencies, also affects harmonic distortion. Obviously, no problem exists in an unmodulated groove. (The Shibata tip, *Fig. 5*, is always pictured in an unmodulated groove, but my experience with CD-4 disks has shown that this design still produces wear.)

By maintaining vertical contact, the van den Hul tip reproduces less random surface noise. Consequently, the cantilever does not vibrate in the longitudinal direction because of variable groove forces. This means a reduction in mechanical distortion of the cantilever, with an equal reduction in cantilever resonances, which are difficult to damp.

With conical and elliptical tips (*Figs. 1–4*), contact is over a small part of the groove. These contact "islands" move around the tip as the stylus traces a modulation wave in the groove. This produces incorrect tracing and, consequently, intermodulation distortion, especially at high frequencies. In a short time, these regions show a permanent deformation.

With the van den Hul tip, contact between the groove and the tip is in the form of a long "island," with very small dimensions longitudinal to the groove. Since the line of contact is long, having a vertical radius of about 85 microns, and constant, the direct force on the groove wall is lower, with less op-

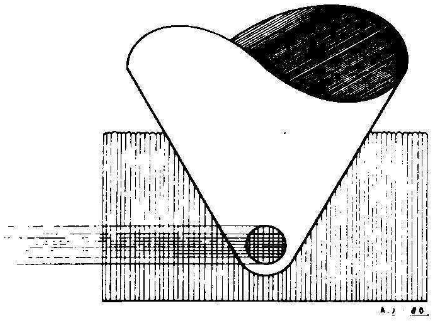

FIGURE 1: Round or conical tip.

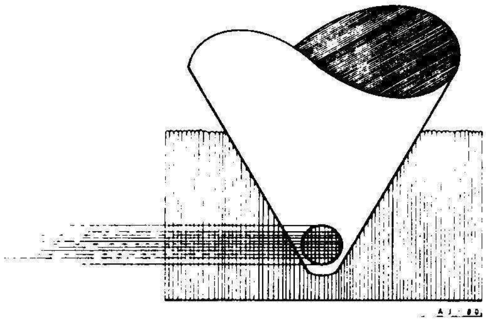

FIGURE 2: Pseudo-elliptical tip.

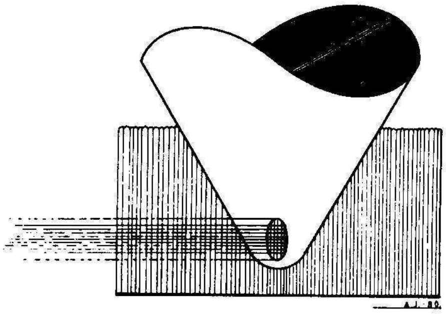

FIGURE 3: Elliptical tip.

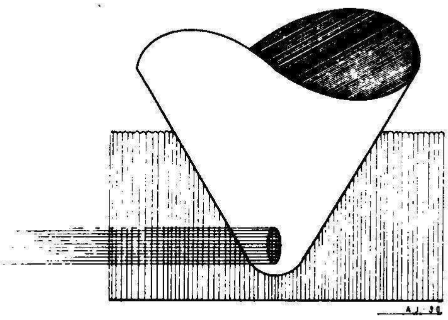

FIGURE 4: Hyper-elliptical tip.

portunity to produce deformation. Also, if you use this tip to play records previously tracked by conical and elliptical shapes, it "walks" over the old deformations, making the record sound new. In addition, the van den Hul's small radius in forward or backward directions tracks only one modulation wave at a time, eliminating intermodulation, especially at high frequencies.

CONTACT RADIUS. Because of the small contact radius of the van den Hul tip (*Figs. 6* and 7) in the front-to-back direction, it traces only a small part of the groove. In the case of a large diameter spherical tip, contact with the groove wall can cover several cycles of a short wavelength modulation. The positive aspect of the van den Hul tip is that, because it has a small contact radius, it can track any portion of the groove at only one specific moment. Tip movement is, therefore, exactly the same as groove modulation. On the other hand, a round tip produces an average motion derived from several groove modulations as cut by a 2-micron radius cutter. Obviously, a tip with a contact radius of 18 microns cannot replicate the movement of a cutter with a 2 micron radius.

Many cartridge manufacturers "build in" a cantilever resonance or produce a higher output at high frequencies to flatten the overall output frequency curve. Unfortunately, this also produces a loss of definition. Obviously, using the real groove modulations would eliminate this problem. Having a small side radius, the van den Hul shape permits the tracking of the smallest groove modulations, thus eliminating the need for mechanical cantilever resonance to produce a flat frequency response. The maximum traceable frequency from this tip is 85kHz, preventing problems in tracing frequencies from 20Hz to 20kHz. No other tip has this extension of frequency range.

Because the cutter has a constant radius of 2 microns over the total side cutting line, the replay tip should ideally have the same value. No value even close to this occurs with elliptical or conical stylii. The van den Hul tip shape has an almost constant contact radius, even extending around the tip itself, where the small radius does not exceed 3.5 microns. No other tip has this important feature. In addition, the high-frequency response of many tips is dependent on the level of the low-frequency modulations: the larger the amplitude of the low frequencies, the worse the definition of the high frequencies. This does not hold true for my tip. The response, therefore, gains in dynamic range, especially in the high frequencies, without any change in the frequency response.

In normal tracking, any tip vibrates at a very high mechanical frequency (between 100 and 300kHz). One advantage of the long contact line between the van den Hul tip and the groove in the vertical direction is that it produces better damping of these unwanted motions.

In addition, because the two contact lines between the van den Hul tip and the groove are exact opposites, the plane through the connecting line goes through the middle of the tip. Consequently, the tip will not

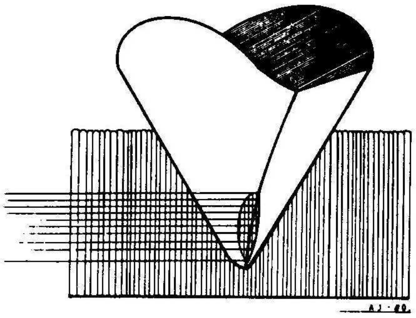

FIGURE 5: Shibata tip.

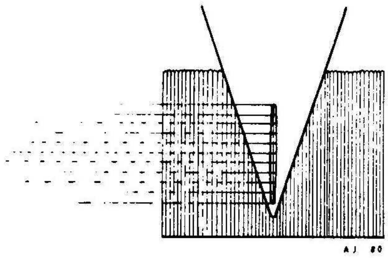

FIGURE 6: van den Hul tip, type I.

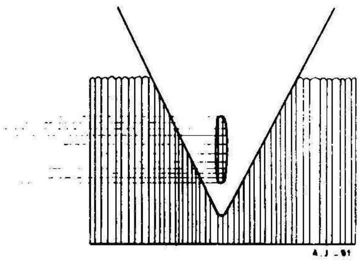

FIGURE 7: van den Hul tip, type II.

show any rotation around the center line, which reduces tip vibration and produces better channel separation and lower distortion.

PRODUCTION CONSIDERATIONS. Other manufacturers mount and grind the tip across the corners of the diamond, but we grind across the hardest sides, the flats. Because we do this, tip wear is comparatively low. By grinding the tip parallel to the sides of the square shank, we also require a smaller hole in the cantilever. This allows us to reduce the cantilever's weight, which in turn raises the mechanical resonance frequency. The cantilever diameter can also remain smaller.

An optimal polishing technique, especially on the contact lines, reduces friction between tip and groove. This minimizes tip and record wear and allows us to set the anti-skating force at a lower value.

Often with other tips, especially elliptical types, a manufacturing fault in the orientation occurs. This fault is impossible with our tip because the contact line between tip and groove is clearly fixed, and the use of a square diamond bar ensures correct mounting. The production and mounting tolerances also have closer values, with a more uniform quality than with any other tip.

Because of the ultra-flat shape of the tip, it contains less material than any other tip, reducing the groove forces necessary to move it. The mechanical deformation of the groove is also less and is restricted to the plastic deformation range of vinyl, which will restore after tracking.

With other tips, the wearing process on the side of the tip produces so-called "eyes," which quickly acquire a diameter of 10 microns. This produces extra record wear. The "eye" on the van den Hul tip is much smaller than 10 microns, which reduces groove wear.

One further advantage of the van den Hul tip is that production at one factory under strictly controlled circumstances results in a consistent tip shape over time. This facilitates replacement and ensures that exactly the same shape is always available.

In sum, a carefully selected tip shape produces a significant increase in overall reproduction quality and less record wear. If care is an accurate indication, the van den Hul tip will ensure quality reproduction and better preservation of your valuable recordings. □