# *The Design of*
# A New Lacquer Recording Stylus

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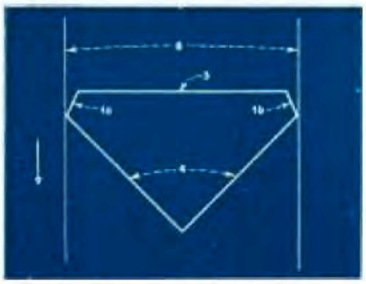

Fig. 1. Cross-section of standard lacquer recording stylus in unmodulated groove. Burnishing facets (1a and 1b) form 25° angles with groove walls (8). Arrow shows direction of record travel. Other facets: Cutting face (3) and clearance faces (4).

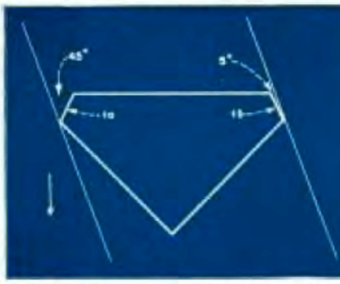

Fig. 2. Cross-section of same stylus in groove with 20° slope. Change in angular relationship between burnishing facets and groove is shown. Facet 1a forms angle of 45° with adjacent groove wall. Facet 1b on opposite side of stylus forms angle of 5° with its adjacent wall. In this and subsequent illustrations groove slopes in the opposite direction will merely reverse the effects described.


Fig. 3a. Same stylus cross-section in groove whose slope is 30°. Burnishing facet 1a forms angle of 55° with adjacent wall. Facet 1b cannot burnish with groove slope in excess of its basic angle. In fact, the edge formed by the meeting of cutting face and burnishing facet (*A*) will tear the adjacent groove wall.

Fig. 3b. (right) Diagram of a highly modulated groove showing areas (arrows) which will be rough where the burnishing facets (1a and 1b) cannot function properly.

A LACQUER recording stylus of modified design is now available which offers several advantages in the recording of high quality discs, particularly originals from which pressings are to be obtained. This modification relates to the burnishing facet which is an important part of the standard lacquer recording stylus.[1]

### Burnishing Facet Angle

The single burnishing facet of the standard stylus is usually polished at an angle of 25° to the side walls of an unmodulated groove (*Fig. 1*). In a dead groove this angle remains constant and burnishing action is steadily effective. When the groove is modulated, however, the stylus is carried on excursions of varying direction and slope from the axis of an unmodulated groove, causing radical changes in the angular relationship between the burnishing facet and its adjacent groove wall.

A study of the cross-section of such a stylus in grooves of varying slope is essential to an understanding of the effect modulation has upon the ability of the burnishing facet to polish the groove. By this means it is readily seen that the burnishing angle is reduced on one side of the groove and increased on the other according to the direction of the stylus excursion (see *Fig. 2*). For example, a groove slope of 20° finds one facet now forming a 5° angle to the adjacent groove wall while the other forms an angle of 45° with its adjacent groove wall. Under these conditions both walls are effectively polished.

When groove slope exceeds the angle of the burnishing facet, however, the facet on the side where the angle is diminished will not be able to burnish at all since it presents only a sharp point to the adjacent groove wall (see *Fig. 3*). The unpolished wall of such portions of a modulated groove will result in noise patches upon subsequent playback. This noise modulation will be particularly noticeable in the record because it occurs on the side of the groove which more positively drives the playback stylus (*Fig. 3b*).

The above condition could be remedied easily enough merely by increasing the angle at which the burnishing facet is

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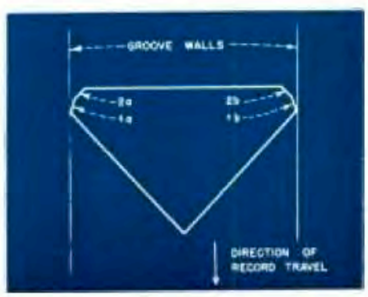
[1]Capps U. S. Patent No. 2187512.

Fig. 4a. Lower portion of a stylus having two burnishing facets along the cutting edge. The figures represent parts as follows: 1-shank; 3-cutting face; 4 clearance face; 5-back edge formed by meeting of clearance faces; 6-burnishing facets.

Fig. 4b. Cross-section of stylus shown in Fig. 4a. in an unmodulated groove. The trailing facets 1a and 1b form burnishing angles of 15° with adjacent groove walls.

Fig. 4(a) above. Fig. 4(b) below.



originally ground. To do so, however, would be to increase the angle between facet and wall on the opposite side of the groove to a dangerous degree. Shearing action takes place at an angle of 90°, the relationship of the cutting face to to the record material. It follows that any burnishing facet increased by groove slope to 60° or more will tend to become a cutting face and will tear rather than polish the groove wall.

Moreover, mastering levels frequently produce a groove slope of 40° or more. It would be necessary to grind the single facet at an angle of 45° in order to burnish such a groove on the side where the angle is diminished. This same groove slope would then increase the burnishing angle on the opposite side of the groove to 85°. It is clearly impossible, therefore, to grind a single burnishing facet at any angle which will guarantee effective polishing of both groove walls at the same time regardless of the direction or slope of the groove.

A modified stylus design[2] which provides multiple burnishing facets rather than one along the cutting edge offers a positive solution to the problem of burnishing angle at mastering levels. The facets of this stylus are polished at different angles so that groove slope naturally selects the facet which has an effective burnishing relationship to the adjacent groove wall. In the case where two facets are provided, for example (see *Figs. 4a & 4b*) the leading facet may be polished at an angle of 45°, the trailing facet at an angle of 15° in relation to the walls of an unmodulated groove. A groove slope of 40° would therefore find the leading facet operating at an angle of 5° on one side and the trailing facet at 55° on the opposite side (see *Fig. 5*). These angles may be changed to 50 and 10 degrees respectively so that even a groove slope of 45° will result in the same effective relationship between burnishing facets and groove walls.

That noise patches are effectively eliminated by styli of this modified design is illustrated in *Fig. 6*. Here actual photographs reveal the rough area left in a highly modulated groove cut with a single-faceted stylus and the absence of such rough areas in a similar groove cut with a multi-faceted stylus.

#### Other Features

The new stylus is called an Anti-Noise Modulation Stylus but its geometry provides additional benefits which largely overcome other limitations imposed upon the single burnishing facet[3]. Each of the two facets illustrated in *Fig. 4* may be so small that their aggregate dimension is less than the width of the standard single facet (see *Fig. 7*). And due to the wide

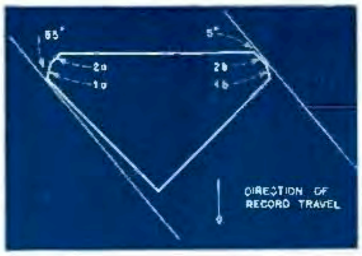



Fig. 5. Cross-section of same Anti-Noise Modulation Stylus in a groove whose slope is 40°. Leading facet 2b functions at an angle of 5° on the side where groove slope diminishes the burnishing angle. Facet 1a burnishes the opposite wall at 55°.

Fig. 6a. (below) Noise modulation in sidewall is not hard to see with a low-power microscope when properly lighted.

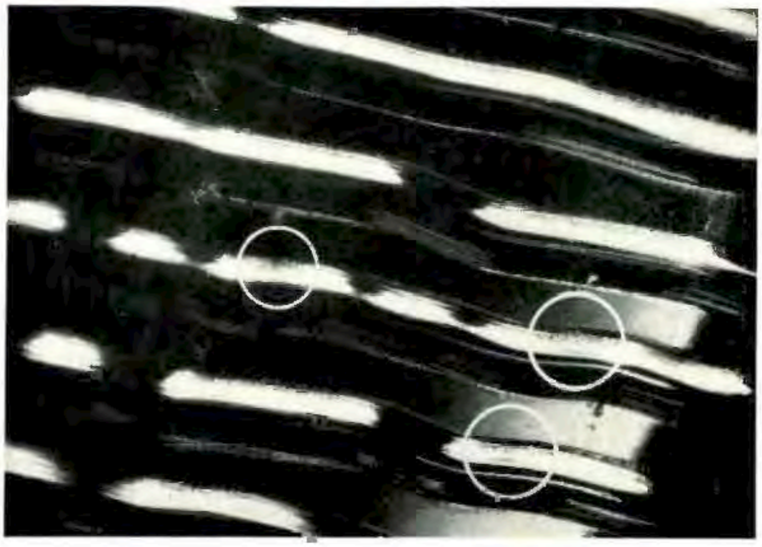


Fig. 6b. A record made with an anti-noise-modulation stylus shows no egregious sidewall speckling even with 40° excursions. Special microscope lighting must be arranged to produce sidewall illumination because the anti-noise-modulation stylus produces such a high polish. Although halation occurs in some spots, due to lack of retouching, direct viewing with the microscope eyepiece coupled with movement of the light sources discloses no unburnished sidewall areas. (Below)

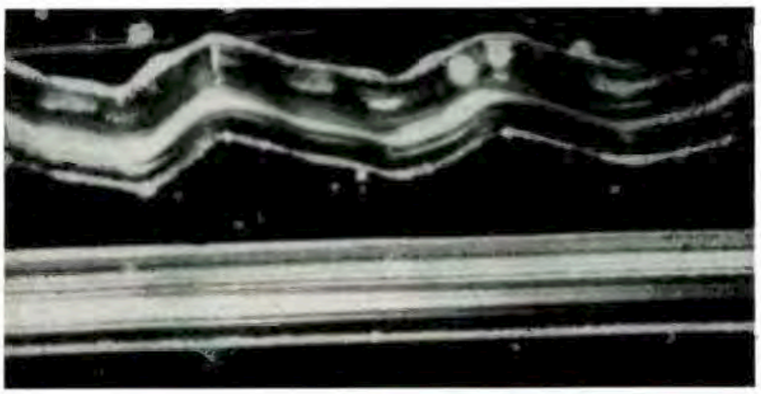
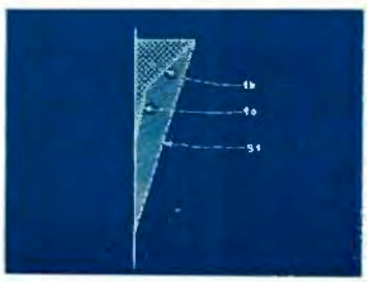


Fig. 7. (right) Enlarged view showing comparatively large width of a standard (0.0005) single facet (S1) in contrast with the small aggregate widths of the double facets (1a and 1b), each of which is 0.0001". Cross-hatched section shows amount of groove material that will be displaced by double-faceted stylus. This area plus shaded portion of the above stylus constitutes mass that will be displaced by single-faceted stylus.




[2]Capps and Cook, Patent applied for.

[3]Isabel Capps "Recording Styli" *Electronic Industries*, November 1946.

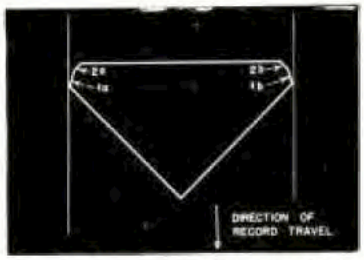



Fig. 8. Cross-section of an Anti-Noise Modulation Stylus having the leading facet 1a and 1b 0.0002" in width; and trailing facet 2a and 2b 0.0001" wide.

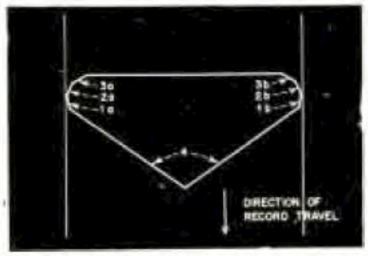



Fig. 9. Cross-section of an Anti-Noise Modulation Stylus provided with three burnishing facets, each 0.0001" wide. The leading facet (3a-3b) is polished at an angle of 60°; the middle facet (2a-2b) at 25°; the trailing facet (1a-1b) at minus 10°. The clearance faces (4) are polished at 35° to provide additional clearance in 45° groove slopes.


Fig. 10. Stylus cross-section of Fig. 9 in a groove slope of 45°. Here facet 1a (polished at minus 10°) burnishes the adjacent groove wall at 35°. On the opposite side leading facet 3b (polished at 60°) burnishes its adjacent groove wall at 15°.

## COMPARATIVE READINGS OF TYPICAL STYLI

| Stylus Type | Diameter | R P M | Normal Position | Offset 30° | Offset 40° |
|---|---|---|---|---|---|
| Regular stylus (single facet) | 16" | 78 | -55 | -25 | off scale |
| | 16" | 33⅓ | -60 | -20 | off scale |
| | 7" | 78 | -60 | -20 | off scale |
| | 7" | 33⅓ | -55 | -20 | off scale |
| Anti-Noise Modulation Styli (two facets) | 16" | 78 | -50 | -40 | -25 |
| | 16" | 33⅓ | -52 | -40 | -25 |
| | 7" | 78 | -50 | -35 | -20 |
| | 7" | 33⅓ | -48 | -35 | -20 |

difference in the angle provided, each facet may work independently of the other so that its own width is the only structural impedance offered to the registration of high frequencies. Distortion caused by wider single facets is also reduced since the smaller facet displaces less material in its polishing action with less subsequent restoration of the groove wall.

### Variations Possible

Three types of styli embodying the principles of this modified design have been used with highly satisfactory results. The first two provide double facets of 50 and 10 degrees respectively as illustrated in *Fig. 4*. However, in one the facets are equal in width, each being 0.1 mils wide. The other enlarges the leading facet to 0.2 mils (*Fig. 8*) thereby enabling it to give a higher degree of polish to the groove wall which drives the playback stylus.

The third variation provides three burnishing facets along the cutting edge as follows:

A leading facet polished at 60°, a middle facet at 25°, and a trailing facet at minus 10°, all angles given in relation to the side wall of an unmodulated groove (see *Fig. 9*). The advantage here lies in the fact that even a groove slope of 45° increases the burnishing angle between the rear facet and its adjacent groove wall only to 35° (see *Fig. 10*), a more effective burnishing angle than the 55° resulting from the first two types.

### New Method of Rating Noise Factor

To the stylus itself, an excursion of any slope is the equivalent of being twisted to that degree in the cutting head while making an unmodulated groove. This method has been temporarily adopted therefore to measure the factor of merit[4], (noise below a signal of 10 c/s) in styli having multiple facets. Comparative readings in round figures of typical styli of both the single and multi-facet type are given in the chart above.

The readings given reveal the advantage enjoyed by the Anti-Noise Modulation Stylus when degrees of groove slope common at mastering levels are reached. As stated, the figures are given in round terms but accurately represent the average of many styli of both types tested.

Full appreciation of the improved quality obtainable with the Anti-Noise Modulation Stylus must come with its use. There are probably almost as many ways of determining what constitutes a "good stylus" as there are recording technicians. Some judge the stylus entirely by its shadowgraphed outline. Some make test cuts, unmodulated, on the outside diameter of the disc at 78 rpm. If the groove is "quiet" (virtually inaudible at full gain) and the flash lines parallel to the groove axis are shiny and unbroken, the stylus is considered good.

[Continued on page 41]

[4]Emory Cook, AUDIO ENGINEERING, Dec., 1947.

Fig. 11 (left) & 12 (right). Contact prints of shadowgraphed two-faceted styli. The dotted line indicates the functional portion for 100 lines per inch and consequently the portion below this line will be the resultant groove shape. Deviation from "ideal" shape lies in the fact that in Fig. 11 the radius does not blend perfectly with the angle on one side.

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Others apply the same criterion but make the test cuts at 33⅓ rpm at diameters of from 5 to 6 inches. Still others inspect a groove under the microscope and, unless it is jet black in color, the stylus is rejected. A few ask for the best possible conditions in the aforementioned respects with burnishing facet dimensions which allow higher frequency registration and low distortion.

The latter few along with the majority of critical listeners will find that the modified design of the new stylus gives them that last speck of recorded quality they have previously been missing. Judged by the other methods described however, this stylus might be rejected.

As shown by the above chart, readings on unmodulated grooves show the new stylus type to be 5 VU noisier than the old stylus type. It is the modulated noise which is most important to the record, however, and here a multi-faceted stylus produces readings at least 15 to 20 VU better than those obtained with the single-faceted stylus.

Again, the groove will not necessarily be jet black. It will have a high luster, however, and provided the record material is free from foreign particles, the flash lines will be shiny and uninterrupted, even when modulation is at mastering level.

Finally, the shape will not necessarily

be as perfect as in the case of the Master stylus. The size and angle of the burnishing facets are of utmost importance to the recording and manufacturing tolerance must favor these factors above ideal shape. *Figs. 11* and *12* are photographs of such styli. No processing difficulties or poor playback fit will result from grooves having the contour of either one of these styli.

## Conclusion

Widespread conversion of the recording industry from wax to lacquer materials in the cutting of originals has emphasized the need for lacquer recording styli particularly adapted to this critical purpose. The Master Stylus was the first development towards this end and because of the controls possible in its specifications has contributed largely to improved recordings. This latest stylus development assures still further improvements. In fact, records of extremely high fidelity have already been obtained by its use.