VLBA Acquisition Memo # 122

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24 February 1989

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To: VLBA Data Recording Group

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Subject: Tracking offset sensitivity to capstan taper angle

Using the method (described in Memo #121) of peaking on a single recorded 40 μm track measurements were made to approximate the effects of a tapered or conical capstan. When combined with theory these results should allow us to predict (at least the order magnitude) of the effect of a taper on the capstan without the effort of actually making some conical capstans.

Measurements of tracking offset were made with a strip of 0.126" wide tape (0.002" thick) wound around the capstan at various positions relative to the center of the capstan. The results are as follows:

Tape Location from Center (inches)	Shift (Microns)
-0.378	-680
-0.252	-600
-0.126	-350
0	+ 10
+0.126	+100[1]

[1] Tape starting to contact baseplate in idler region.

A tracking offset -600 μm was also measured with a strip of 0.252" wide tape at -0.378" from tape center. If we assume that the 0.002" thick tape near one edge is more or less equivalent to a taper of 410 seconds of arc (cone apex half angle) then the approximate sensitivity is 1.5 μm per arc second.

<u>"Bending beam" model of tape path under action of a capstan with taper</u>

Figure 1 shows the geometry of the tape path. The tapered Capstan is assumed to act on the flexible in the following manner:

1] The plane containing tape edges must be perpendicular to the capstan where the tape wraps around the capstan.

2] The tape edges must be perpendicular to the capstan axis where the tape first contracts and leaves the capstan otherwise it will walk up or down the capstan to make this condition hold or the tape will slip on the capstan.

From these constraints plus a constraint on the conditions of the tape leaving the vacuum columns there are two models which I consider:

A] Tape leaves the vacuum column as a straight section with non-zero slope. For this case we can solve the bending beam polynomial and obtain the following equation for the deflection y as a function of the distance x from the edge guiding region.

$$y = \alpha \left[\frac{3L^2 x - x^3}{3R(R+2L)}\right]$$

where

α = taper angle
L = distance from capstan to edge guiding region (≈6")
R = capstan radius (≈0.55")

which is approximately 2.5 μm/arc second at the headstack.

B] Tape leaves vacuum column with zero slope in which case

$$y = \alpha \left[\frac{3L x^2 - 2 x^3}{6R(R+L)}\right]$$

meets the boundary conditions and the deflection at the headstack (≈5" from edge guiding) is 1.1 μm/arc second.

The first of these models would seem to be closer to actual situation since the tape is moderately free to pivot about the edge contact region in the vacuum columns, where as the second model has the tape completely constrained by the vacuum columns. The tape might in fact be more constrained come out of the vacuum columns with zero slope if the tape path operating point was made to have the bottom edge of the tape contact the base plate all the way from the idler region to the loop in the vacuum columns.

<u>Differential tape tension produced by capstan taper</u>

A tapered capstan will produce a significant difference in the tape tension from the inner to outer edge. With the taper shown in Figure 2 the outer edge of the tape will have more than the nominal 500 lbs/sq" (produced by the vacuum - See Memo #123) for 0.001" thick tape. In the vicinity of the capstan (x = L) the radius of curvature is

$$\frac{R}{\alpha} = \frac{EtW^3}{12T}$$

where

E = Young's modulus (≈7x10^5lbs/sq")

t = tape thickness (≈0.001)

W = tape width (= 1")

T = Torque

from which the torque can be calculated

$$T = \frac{EtW^3\alpha}{12R} \approx 5x10^{-4} \text{"lbs/arcsec}$$

or $\approx$ 3 lbs/sq"/arcsec

or as fraction of the nominal tension

$\approx$ 0.6%/arcsec

Thus a capstan with more than about 150 arcsec will cause the tape to loose contact with the headstack at the top or bottom edge, and a tapered capstan is probably the major cause of uneven headwear. [One problem capstan (serial #0300011AA85) showed a 100 arcsec taper (thicker near the outer end), which produced a -300 μm offset and a clear tendency for the outer tape edge to be much tighter than the inner edge.]

Summary

I suspect that the simulation of a capstan taper results in an underestimate and that the first model is more accurate. Thus without a better experiment with a truly tapered capstan I would assume a sensitivity of about 2 μm/arc second. This large coefficient emphasizes the dominant role that the capstan has to play in the tracking offsets and cleanliness of the capstan (already emphasized by Hans) is very important.

Attachment: Figure 1

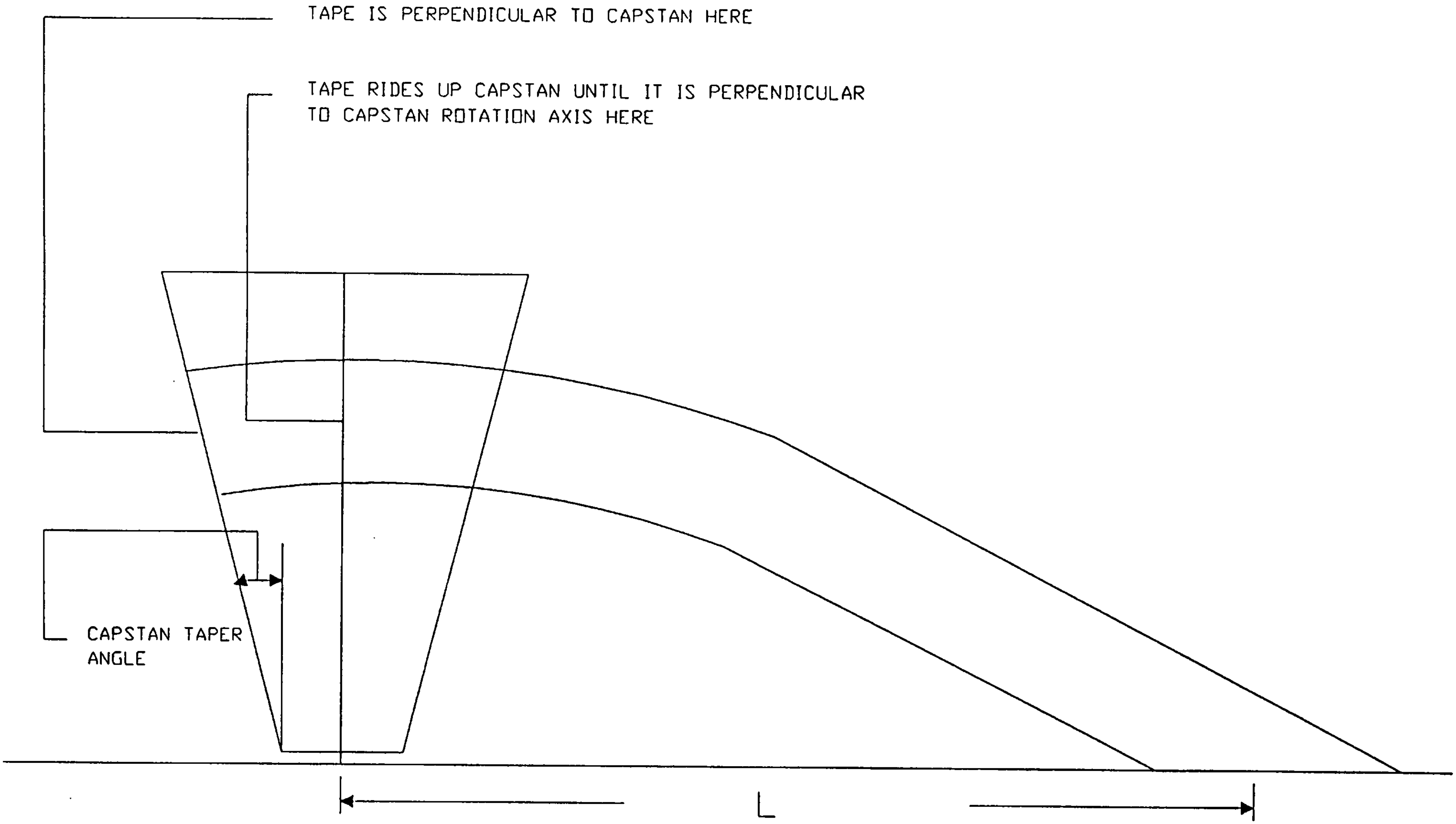

FIG 1 BENDING BEAM MODEL OF TAPE PATH UNDER ACTION OF A CAPSTAN WITH TAPER