VLBA ACQUISITION MEMO #141

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To: VLBA Data Recording Group

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Subject: Head to tape contact profiles: Computation of inter-changeability of various tapes

Motivation for calculation

When the heads are lapped they form a profile characteristic of the lapping tape and tension. As a result of the tape specific profile it may be necessary to do a "prelap" or tape shuttle when changing to a different tape thickness to recontour the heads.

Theory

When a flexible beam is bent by pure tension there is a couple which is proportional to displacement of the beam for small displacements and the solution is of the form

$$y = e^{-x/\ell}$$

where y = displacement of beam

x = distance along the beam

ℓ = characteristic bending length

and where

$$\ell = \sqrt{\frac{Y\, t^3\, W}{T\ 12}} \approx 10 \text{ mils (for 5198 at 0.5 lb)}$$

where Y = Young's modulus ($\approx 7 \times 10^5$ lbs/sq")

t = tape thickness (3M5198 = 0.001")

W = tape width (= 1")

T = tension on tape (0.5 lb nominal)

The solution of the profile that the tape makes with the head involves combining the bending beam polynominal coefficients and the exponential term and solving for all the boundary conditions. Consider the geometry shown in Figure 1. The equation for the tape profile before it encounters the headstack is

$$y = ae^{-x/\ell} \qquad \text{when } x \geq 0$$

and across the headstack the equation is

$$y = bx + cx^2 + de^{x/\ell} + e \qquad \text{when } x < 0$$

assuming the tape touches only the edges of the headstack (the situation when the tape looses contact with the gap). Now these equations must be continuous in displacement, slope and curvature across the boundary at x = o so that

$$d + e = a$$

$$b + d/\ell = a/\ell$$

$$2c + d/\ell^2 = a/\ell^2$$

Further the slope of the tape at the center of the head must be at an angle equal to half the full wrap angle to the incoming tape so that

$$b - 2cL + (d/\ell)e^{-L/\ell} = -\Theta$$

where 2Θ = tape wrap angle ($\approx 10^o$)

$2L$ = contact length of the headstack (width of the headstep) ($\approx 300\ \mu m$)

The final constraint is that the torque applied to the tape at the "edge" of the headstack minus the torque in the center must be equal to the tension times the central height of the tape above the base of the profile so that

$$g = d\,(1-e^{-L/\ell}) = a + \Theta L + bL - cL^2 - de^{-L/\ell} - e$$

The solution of these equations gives

$$d = \Theta\, e^2\, L\, /(2L\ell + (2\ell + L)e^{-L/\ell})$$

The solution for the profile after the head has worn down the headstack and reached equilibrium has $d \approx 0$ since then each element across the headstack will have equal curvature and equal pressure on the headstack.

Result

Plotting the results (see Figure 2) of the solution shows some very interesting features which are not immediately intuitive. For example, if the heads are worn with 1 mil tape they cannot be immediately used for 0.5 mil tape (since the 0.5 mil profile is above the 1 mil profile) but could possibly be immediately used with 0.25 mil tape. The profile for 0.5 mil tape peaks giving worst gap to tape contact for a headstack previously worn to a lower profile at 0.5 lbs (10" vacuum) and drops for both low and high pressure. Generally headstacks worn with thin tape should give excellent gap to tape contact when making a transition to a thicker tape (a tape with a larger value of ℓ). Going from a thick to a thinner tape will often require a prelap but there are some conditions when a headstack worn with thick tape can be immediately used for thinner tape. The conditions, however, for which the transition from thick to thin could occur without lapping are somewhat limited unless the headstep is wider. With a 250 micron headstep half-width, going from 1 mil to a thinner tape will always reduce g (see Figure 2 curve c). However, while using a

headstack worn with the low profile of a thick tape may allow gap contact with a thinner tape the pressure at the gap will be lower than the edges until a higher profile is worn.

These calculations also give an estimate of length of time needed to change the head profile when going from 25 to 13 μm tape. Figure 2 shows about 1 μm of wear is required or about 130 hours if 38 microns (the initial depth of gap) corresponds to a 5000 hour head life.

Note that the way tape bends over the headstack depends only (as far as properties of the tape) on the characteristic bending length ℓ. A lapping tape can be made to produce the contour of a thinner tape by increasing the tension (eight-fold to half the effective thickness).

All of this is theory and needs to be tested in practice.

Enclosures: Figure 1. Geometry of Tape Going Over Headstack
Figure 2. Head to Tape Contact Profiles

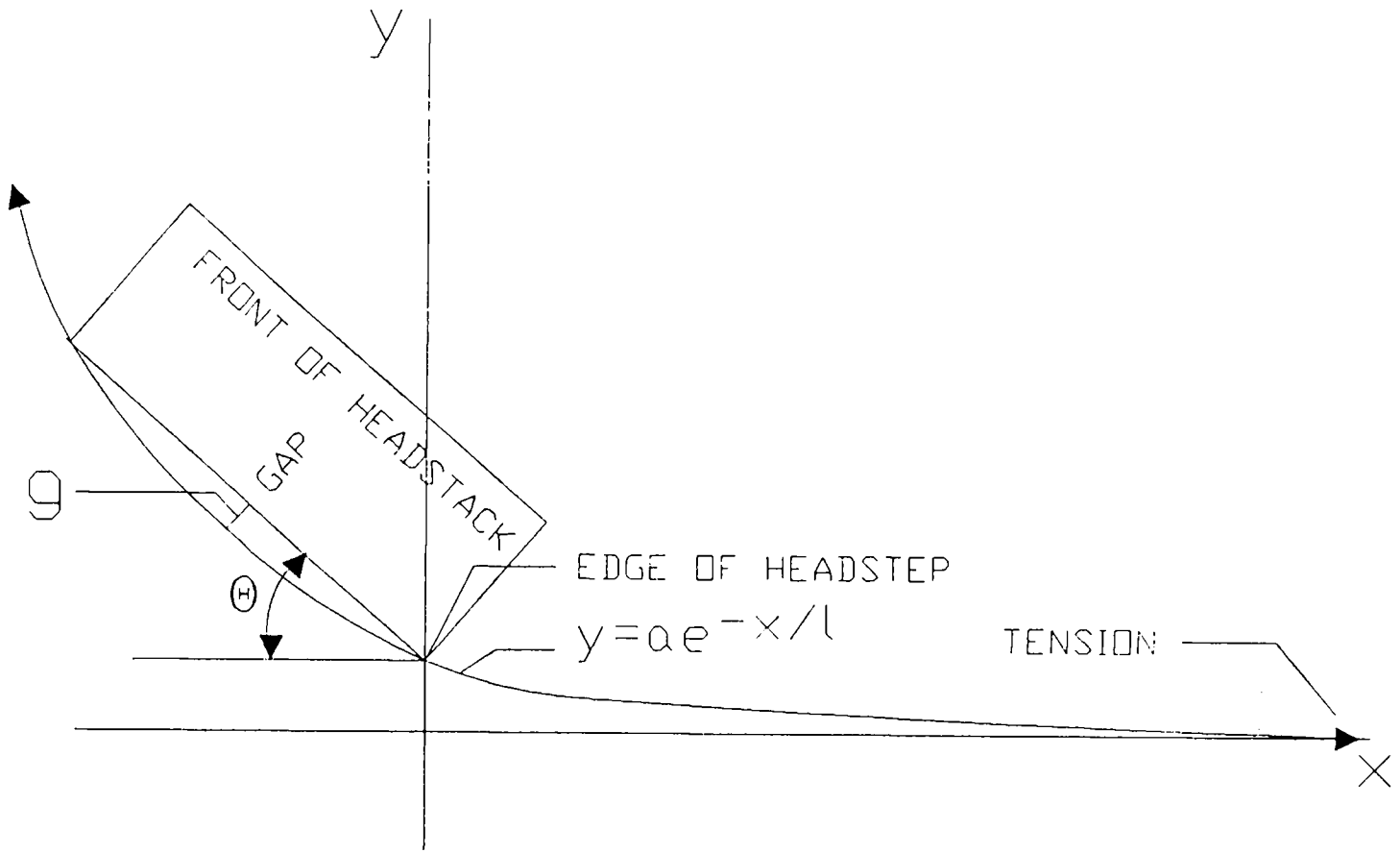

FIG 1 GEOMETRY OF TAPE GOING OVER HEADSTACK

YOUNG'S MODULUS = 7E05 LBS/SQ"
TAPE WIDTH = 1" TAPE WRAP ANGLE = 10 DEG (FULL ANGLE)
PROFILES MARKED WITH * ARE AFTER HEADSTACKS HAVE BEEN LAPPED OR WORN WITH TAPE OF THIS THICKNESS
ALL OTHERS ARE INITIAL PROFILES WITH TAPE ONLY TOUCHING THE EDGE OF THE HEADSTEP
NOTE: SPACING LOSS = 54.6 (SEPARATION/WAVELENGTH) DB

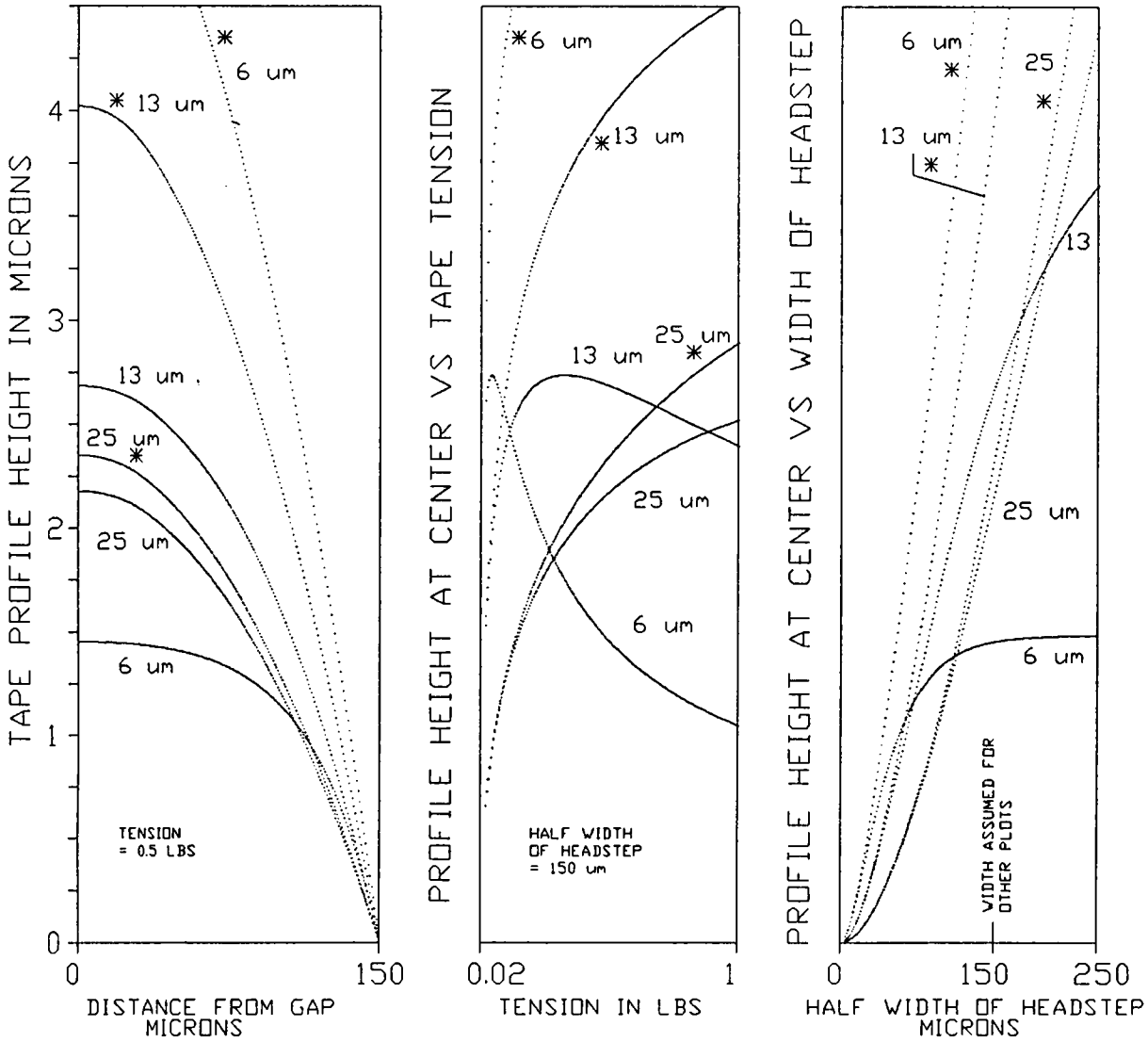

FIG 2 HEAD TO TAPE CONTACT PROFILES