VLBA ACQUISITION MEMO #136

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10 April 1989

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To: VLBA Data Recording Group

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Subject: Tracking offset sensitivity to idler tilt and taper angle

It has been shown (see Acquisition Memo #132)that the tracking offset sensitivity to capstan taper, capstan tilt and tape defects is significantly reduced (by at least a factor of 3) when using an idler roller in place of a fixed post. However, we now examine the effects of idler alignment and taper to see if the apparent advantages of using an idler are offset by problems with the idler itself.

Idler axis tilt

Tilting the idler away from the capstan will make the tape move out away from the precision plate as the tape must remain perpendicular to the rotation axis. Between the idler and the capstan the tape will form an arc to remain perpendicular to both rotation axes. The tape shift at a point between the idler and capstan is

$$\phi(L_1 + (3/8)\, L_2) \approx 0.5\ \mu\text{m/arcsec}$$

where ϕ = idler tilt

L_1 = distance from edge guiding region to idler (≈3")

L_2 = distance between capstan and idler (≈3")

using methods similar to those in previous memos. This coefficient has ben verified, at least approximately, by an experiment in which the idler was tilted.

Idler taper

The tracking shift due to idler taper angle is given by

$$\alpha\, L^2/6R \approx 0.34\ \mu\text{m/arcsec}$$

where L = distance from idler to edge guiding region (≈3")

R = idler radius (≈0.55")

α = idler taper angle

Tape operating angle which results from the bias in the vacuum columns

It was shown in Acquisition Memo #124 that there is a bias torque on the tape of about

0.003"/lbs. With perfect idler and capstan in perfect alignment this bias torque will bias the tape away from the precision plate. With the idler present the tape bias angle will be given by

$$\alpha = P\ \epsilon\ W^3/(12\ P\ W\ R\ L) \approx 230 \text{ arcsec}$$

where ϵ = slope of vacuum column walls ($\approx 3^o$)

W = tape width (= 1")

R = loop radius (= 1.3")

L = distance from idler to edge guiding region ($\approx$3")

and a resulting bias shift of about 85 μm.

<u>Forces on idler</u>

If the idler is tilted towards the capstan or the idler is tapered to move the tape out away from the precision plate the force on the idler is small because the tape is free to pivot in the vacuum columns. However if the capstan is tilted towards the vacuum columns or has the opposite taper the tape is forced into the precision plate and the forces can become sufficient to make the idler lose its grip on the tape. If we assume that the tape remains parallel to the precision plate the limiting tilt is given by

$$\phi_m = \frac{6\ T\ w\ f\ L^2}{E\ t\ W^3} \approx 40 \text{ arcsecs}$$

where T = tape tension ($\approx$0.5 lbs)

w = idler wrap angle ($\approx 11^o$)

f = coefficient of friction ($\approx$1)

L = distance to edge of precision plate ($\approx$0.5")

E = Young's modulus ($7\text{x}10^5$ lbs/sq")

t = tape thickness (= 0.001")

W = tape width (= 1")

ϕ_m = maximum tilt before tape slips

From this it is clear that the idler <u>must never be biased to force the tape into the precision plate</u> as the idler will slip if this bias reaches only 40 arcseconds beyond the 230 arcseconds bias.

<u>Conclusions</u>

The reduced sensitivity to capstan taper, capstan tilt, head tilt, is traded for a considerable sensitivity to idler tilt although the sensitivity to idler taper is relatively small. Overall, the idler reduces the machine sensitivity but the bigger gain is the reduced sensitivity to tape imperfections. The most worrisome aspect of using the idler is the danger that it may have a significant taper or tilt in a direction which forces the tape into the precision plate. The limit on the combined effect of idler tilt and taper in the direction forcing the tape towards the precision plate is 85 μm (i.e. tilt plus taper must be less than about 200 arcseconds). Another worrisome aspect of the idler, now being investigated, is the viscous bearing friction which may be a problem at 270 IPS.