VLBA ACQUISITION MEMO #140

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18 April 1989

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To: VLBA Data Recording Group

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Subject: Some order of magnitude calculations of the air entrapment at the idler

If we are to return to the use of the idler we must be sure that there is enough margin in the idler-tape contact to ensure the idler maintains its grip on the tape. At high speeds there can be excessive bearing friction (see Memo #138) and significant contact friction loss due to air trapping.

Very approximate theory

The rate of air entrapment is given by

$$\text{volume rate} \approx \frac{\Theta}{2} L^2 W \approx 0.3 \text{ cuft/min}$$

where Θ = angular rate (78 rpm at 270 IPS)

L = distance away from contact point for which air is trapped (initially assumed ≈0.2")

W = tape width (- 1")

If we now assume that this air must escape through the grooves in the idler roller we can calculate the pressure of this volume of air flow using the relation from the Machinery handbook (20th Edition, Industrial Press, page 2314).

$$V = 58 \left(\frac{p\, d^5}{0.07\, \ell} \right)^{1/2}$$ (assumes turbulent flow and grooves act like tubes)

where V = volume of air cuft/min (≈0.03 cuft/min/groove)

ℓ = length of tube in ft (≈0.1" for 10°wrap)

d = diameter of tube in inches (≈0.01")

p = pressure in lbs/sq"

from which

$$p = V^2\, 0.07\ell/(3364d^5)$$

$$\approx 1.5 \text{ lbs/sq"}$$

The available pressure from the tape with tension of 0.5 lb and wrap angle of 10 degrees is 1 lb/sq". Since the grooves occupy ~25% of the idler area the air entrapment reduces contract friction by about 40% at 270 IPS. This calculation is extremely uncertain due to the extreme dependence on d. Also L is very uncertain as air can escape sideways. Unfortunately these calculations don't really tell us the exact severity of the problem but they do suggest that greater margin could be gained by increasing the groove depth. Another possibility is to provide an air guard or scoop to remove air and hence reduce L.