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To:	VLBA Data Acquisition Group
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Subject:	The Effect of Air flow and Tension on the Exit Side Behavior of a Flat Contoured Recording Head

1 Introduction

Recently Hans Hinteregger demonstrated experimentally that the high density recording is possible at high tape speeds on a flat head contour using a geometry shown in Figure 1 [1]. Based on experimental findings on the thin-film head Hinteregger indicated that there is a small signal loss at high speeds. It has been suggested that the signal loss may be caused by the tape displacement due to a moment generated by the reverse air flow on the exit side of the head. In this memorendum I look into such a possibility.

The geometry of the experimental setup is given in Figure 1. The contact length is approximately $3mm$. The free span of the tape on the entry side is 3/4" and on the exit side it is 1/8". The program that I used to analyze this geometry is called p4, and the theory behind it is explained in [2]. Currently, this code can only handle tape contact with cylindrical surfaces. Therefore, I approximated the $3mm$ long contact area by a cylindrical surface with $1m$ radius. See Table 1 for the rest of the necessary parameters used to define the geometry.

The pressure generated due to the reverse air flow on the exit side is approximated by the following relation [3],

$$P = 1.36\frac{V\mu}{r} \tag{1}$$

where P is the pressure, V is the tape speed, μ is the viscosity of air, and r is the distance measured from the exit point in the tape's running direction. The code p4 is modified according to this equation.

2 Results

The effects of the tape velocity and the tape tension, T, on the tape behavior over the contact zone is analyzed as follows;

1. We first set the tape velocity to zero, and looked at the tape displacement over the head for three different vacuum pressures (see Table 1). (Figures 3-5)

2. We then set the tape velocity to $8m/s$, the value at which there was an apparent signal loss, and applied the same tensions as before. (Figures 6,7)

The results of part 1 where the tape speed is zero are given in Figure 3-5. Figure 3 shows the tape displacement over the head. Figure 4 shows a magnification of Figure 3 at the exit side. This figure shows that there is a displacement boundary layer whose length decreases as a function of tension. For $4in$ vacuum the tape is displaced away from the surface by an amount close to $0.5nm$. Increasing the tape tension lowers the tape toward the surface. Contact pressures corresponding to this case are shown in Figure 5. The tape is supported on the corners of the head as evidenced by the spikes at the corners.

Turning the speed on and adding the subsequent moment due to the reverse air flow according to Eqn. (1) had no noticable effect on the displacements explained above. The comparison of displacements for $V = 0$ and $V = 8m/s$ cases can be seen in Figure 6. The contact pressures corresponding to these parameters are shown in Figure 7. We see in this figure that the contact pressure increases at the edge of the head due to the subambient pressure created on this side. However, the amount of moment applied to the tape is insufficient to create substantial tape rotation around the contact point.

3 Discussion and Conclusions

The existance of displacement boundary layer on a "nearly" flat surface is surprising. This finding gives a motivation to modify the program for contact with a flat surface. Only after that is done, the results about the displacement boundary layer near the edges will be reliable.

The effect of the "suction" created by the reverse air flow on the exit side is minimal. This result should be independent of the displacement effect mentioned in the above paragraph: The air pressure, calculated by Eqn. (1) is a very strong function of the distance r, The highest pressure is exerted at the contact point, and the pressure falls-off very rapidly as we move away from the exit corner. See Figure 8. Therefore the moment generated by the air pressure is very small, it can not over come the moment generated by the "wrap-pressure" due to the curvature. This situation should change when a completely flat geometry is analyzed.

4 References

1. Hinteregger, H. "Much Better than Expected Thin-film MR Head Performance Observed," VLBA Acquisition Memo # 388, MIT, Haystack Observatory, March 1995.

2. Müftü, S., Benson, R.C., "Modelling the Transport of Paper Webs Including the Paper Permeability Effects," submitted for review for the Proceedings of the ISPS at the ASME, WAM in San Fransisco, CA, November 1995.

3. Rogers, A.E.E, "Calculations concerning air entrapment at the headstack and the maintenance of good head-to-tape contact," VLBA Acquisition Memo, 254, MIT, Haystack Observatory, June 1991.

Head-Geometry		
R	Guide Radius	$1m$
$\theta_L = \theta_R$	See Fig. 1	0.086^o
θ_h	Side Angle	90^o
L_{ss}	Free tape span	$1.905cm, 3.175mm$
Tape		
T_x	Web tension	31.65, 79.125, 158.25 N/m 4, 10, 20 in. H2O
V_x	Web speed	8
E	Young's Modulus	4 GPa
μ	Poisson's ratio	0.3
ρ	Density	1400 kgm^{-3}
c	Web thickness	15.2 μm
σ_t	Asp. Cont. Height	15 nm
P_o	Asp. Compl. Cons.	10 MPa
Air		
μ	Air viscosity	$1.85 \times 10{-}5Nsm^{-2}$

Table 1: Variables used in Figures 1-4.

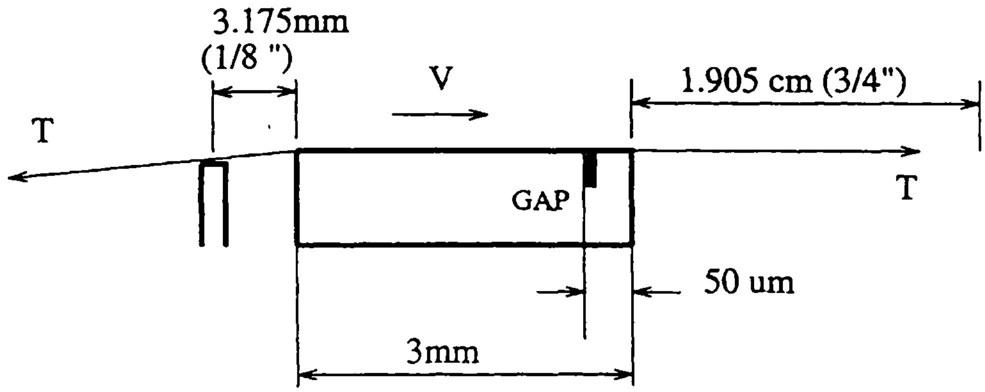

Figure 1: The schematic side view of the head-tape assembly in the experimental setup for recording over a flat surface.

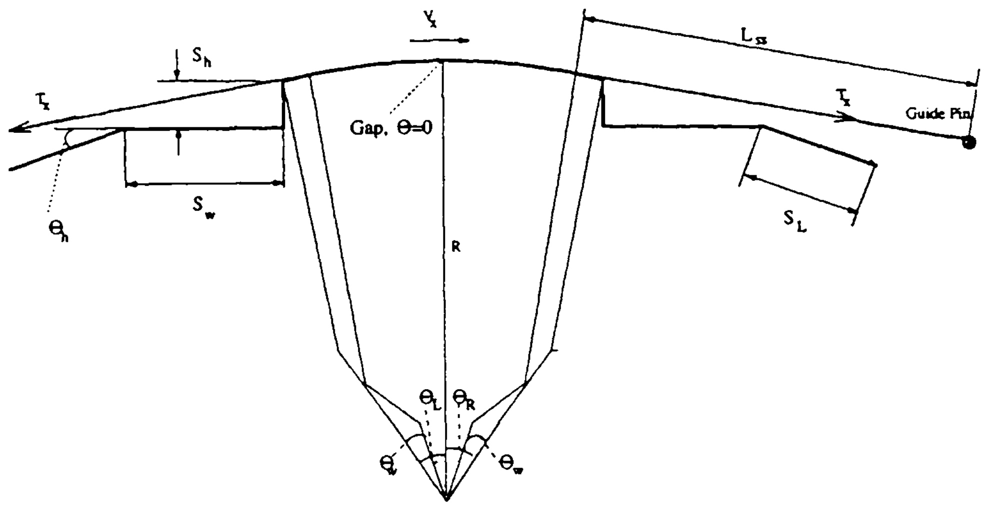

Figure 2: The schematic side view of the head-tape assembly for the input to the program bf p4. See Table 1 for the dimensions.

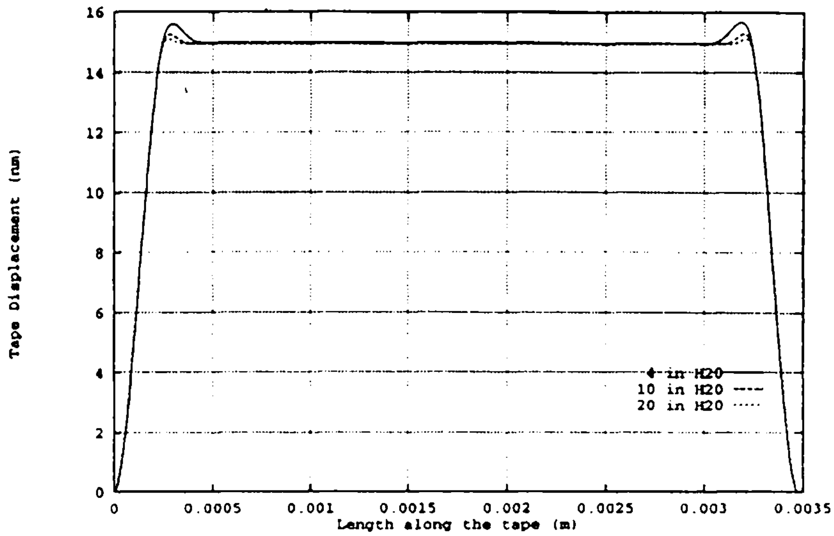

Figure 3: The tape displacement over the head as a function of tension, T. $V = 0m/s$.

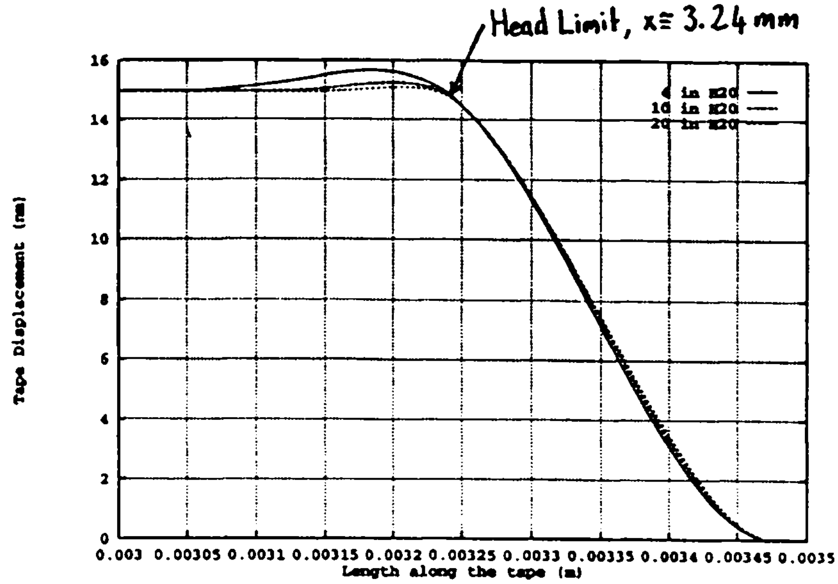

Figure 4: The detail of the tape displacement at the exit side of the head. $V = 0m/s$.

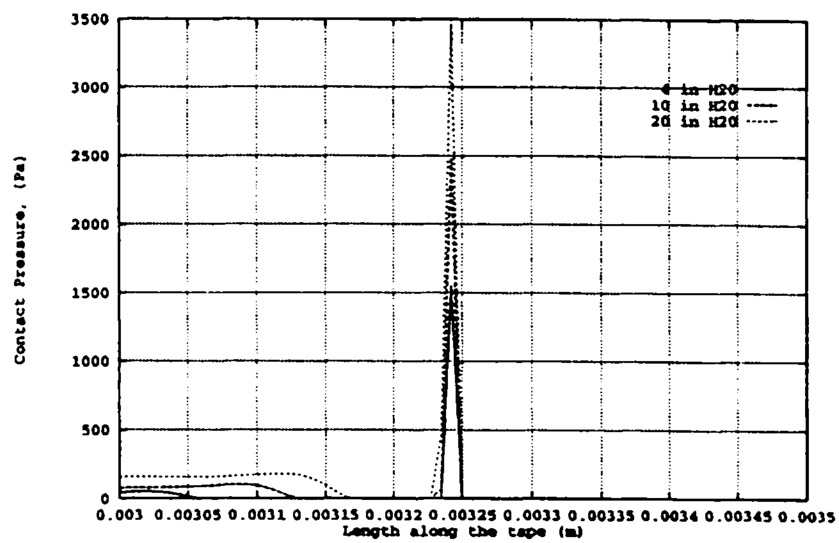

Figure 5: The contact pressure at the exit side of the tape. $V = 0m/s$.

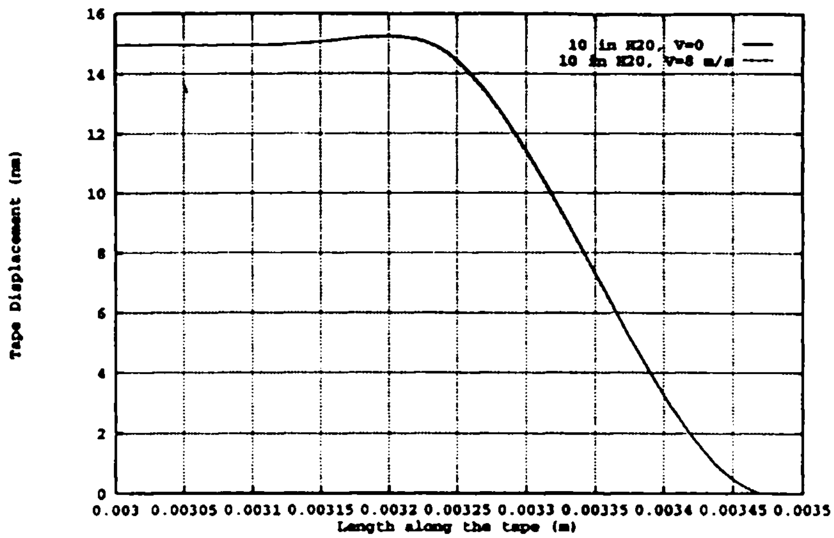

Figure 6: Comparison of tape displacement at the exit side at tape speeds 0 and $8m/s$. $T = 10inH20$.

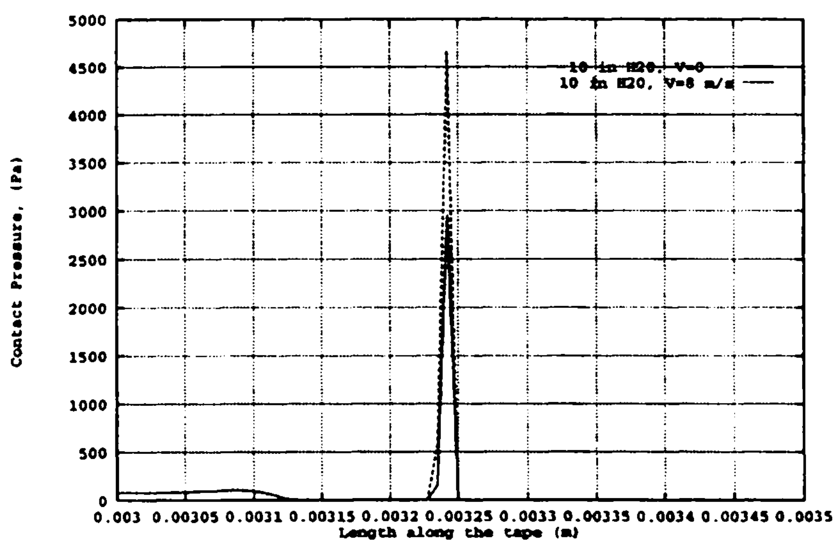

Figure 7: Comparison of contact pressures at the exit side at tape speeds 0 and $8m/s$. $T = 10inH20$.

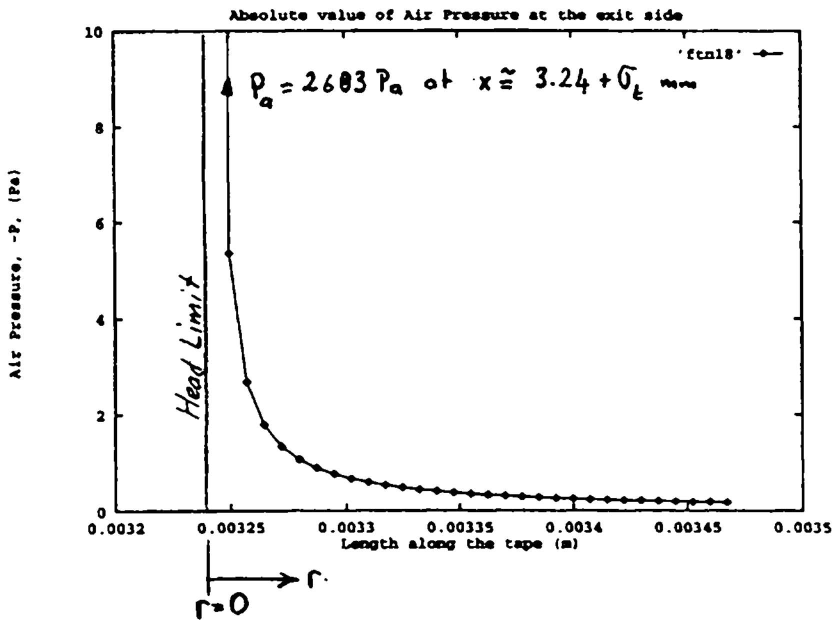

Figure 8: Air pressure along the tape at the exit side due to the reverse air flow. The Tape speed is $8m/s$.