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*Area Code 508*
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To: VLBA Data Recording Group

From: Alan E.E. Rogers

Subject: Tracking offset sensitivity to Capstan axis alignment

A single narrow track was recorded in the forward direction using REC #3 and played back with the same head. The head position for peak playback signal was determined for forward and reverse playback (at 135 IPS) for various capstan axis alignment angles determined by placing shims between the recorder precision plate and the motor assembly. The following results were obtained:

Shift due to axis change in the horizontal[1] plane = -0.63 + 0.05 μm/arc sec

Shift due to change vertical[2] plane = 0.08 ± 0.02 μm/arc sec

Notes:

1] Plane of tape as it passes over the head.

[A 0.017" shim under right hand capstan screw (one in middle of tape path produced -830 μm (+ve towards precision plate) change.]

2] Plane perpendicular to tape

[A 0.017" shim under right hand screw plus a 0.034" shim under upper left hand screw produced a shift +180 μm.]

Model for tape position shifts

If we assume that the tape is edge guided in the vacuum columns at a distance of 6" from capstan axis and that the tape always rides perpendicular to the capstan axis, then the expected shift for an arcsecond tilt of the capstan towards the vacuum columns will be -0.74 μm at the capstan and 5/6 of this amount (-0.62 μm) at the location of the headstack. If we assume that the shift from axis tilt in the vertical plane is purely geometric then a one second tilt upwards will produce a shift of 0.07 μm (one arc second times the capstan radius).

Forward and reverse offset

While the position shift (average of forward and reverse) is the first order effect of capstan axis change there is a smaller effect on the forward-reverse offset. The following coefficients were obtained:

For-rev shift due to axis change in horizontal = 0.04 ± 0.01 μm/arcsec

For-rev shift due to axis change in vertical = -0.04 ± 0.01 μm/arcsec

Model for forward-reverse tape position shift

The basic physical reason for any shift between forward and reverse motion is due to the non-reversible action of the capstan on a flexible medium. If a flexible medium is wound over a cylinder which grips the material the tendency for the material to be carried along the axis depends mainly on the alignment of material feeding the cylinder and very little on the alignment of the material leaving the rotating cylinder. Simply, this is because if the material is flexible and doesn't slip on the cylinder then misalignment on the output produces a force which will not pass the capstan while misalignment on the input produces a force which will be compensated by opposite force developed by motion of the material along the axis. Figure 3 illustrates the principle. The output alignment has little effect while the input alignment will result in motion along the cylinder axis to correct the input misalignment. On the Model 96 with headstack in upper position this means that forward tracking is mostly influenced by all components in the tape path up to the capstan and is very little influenced by components following the capstan. The measured forward-reverse shifts with Capstan axis change in the horizontal are hard to calculate because they are the result of assymetries in the particular machine being tested. Changes in the vertical plane can be explained as follows:

1) In the forward direction the vertical tilt has little effect other than the purely geometrical shift in tape position which would occur in the static case with the tape stopped.

2) In the reverse direction the geometric shift is corrected by motion of the tape on the capstan to correct the geometric shift.

A simpler experiment was performed by mounting dummy headstacks in the lower position. It was verified that the presence of the dummy headstack affects only the reverse offset. The dummy headstacks were then misaligned and found to produce a

$$-0.26 \pm 0.02 \ \mu m/arcsec$$

reverse shift for an axis change in the vertical plane. This sensitivity can be calculated by equating the moments of the force components shown in Figure 4 produced by the tilt of the dummy headstack to that produced by a tape displacement along the capstan axis as follows:

$$S = -L^2_h (\sin W_1 + \sin W_2) \phi / L = -0.2 \ \mu m/arcsec$$

*where* $S$ = *tape shift at headstack*

$L_h$ = *distance of headstack from edge guided region (≈5")*

$W_1, W_2$ = *dummy headstack wrap angles (≈11°)*

$\phi$ = *dummy headstack tilt*

L = distance to capstan (≈6")

The sensitivity to tilt of the dummy headstacks in the horizontal plane was extremely small. The forward-reverse offset with capstan axis tilt was remeasured with the dummy headstacks in place:

For-rev shift due to change in horizontal ≈ 0.03±0.02$\mu$m/arcsec

For-rev shift due to change in vertical ≈ -0.08±0.02$\mu$m arcsec

The For-rev shift now smaller - presumably because the system is now more symmetrical.

The For-rev shift due to the change in vertical alignment now agrees with the model discussed above.

Comments

The tracking offset is very sensitive to the capstan axis alignment, especially in the horizontal plane. A thermal gradient of 1°F per inch would produce a deflection of 18 arcsecs across 6" and a tracking offset of 11 μm. However this large a thermally induced offset is unlikely as this temperature gradient could only be set up with 100 watts heat transfer over a 6" square. Two serious problems were noted:

1] The tracking offset is also sensitive to the idler post axis orientation and the present idlers are loose enough that a 50 μm tracking shift is easily produced by applying pressure to the idler with a finger. The idler post should be a tighter fit.

2] Without dummy headstacks in the lower position the lower edge comes very close to the plate and has worn a groove at this point on several transports. The capstan and/or head tilt needs to be adjusted to produce adequate clearance. If the tape touches at this point the tracking offset is not reproducible.

Conclusion

Figure 5 summarizes the sensitivities to tilts and some linear displacements (not described in this memo).

Attachments: Figures 1 thru 5

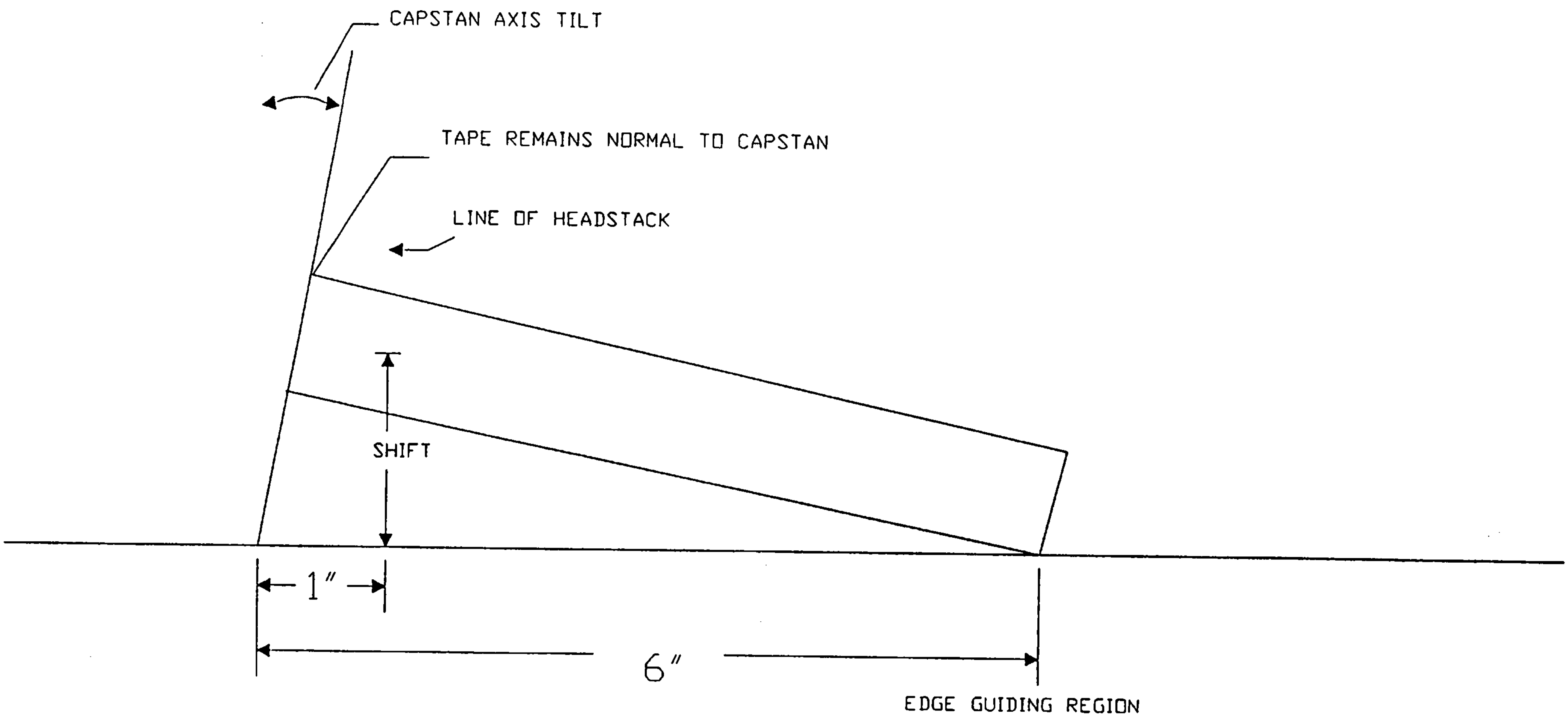


FIG. 1 TAPE POSITION SHIFT WITH CAPSTAN AXIS SHIFT IN HORIZONTAL PLANE

( DIMENSIONS ARE ONLY APPROXIMATE )

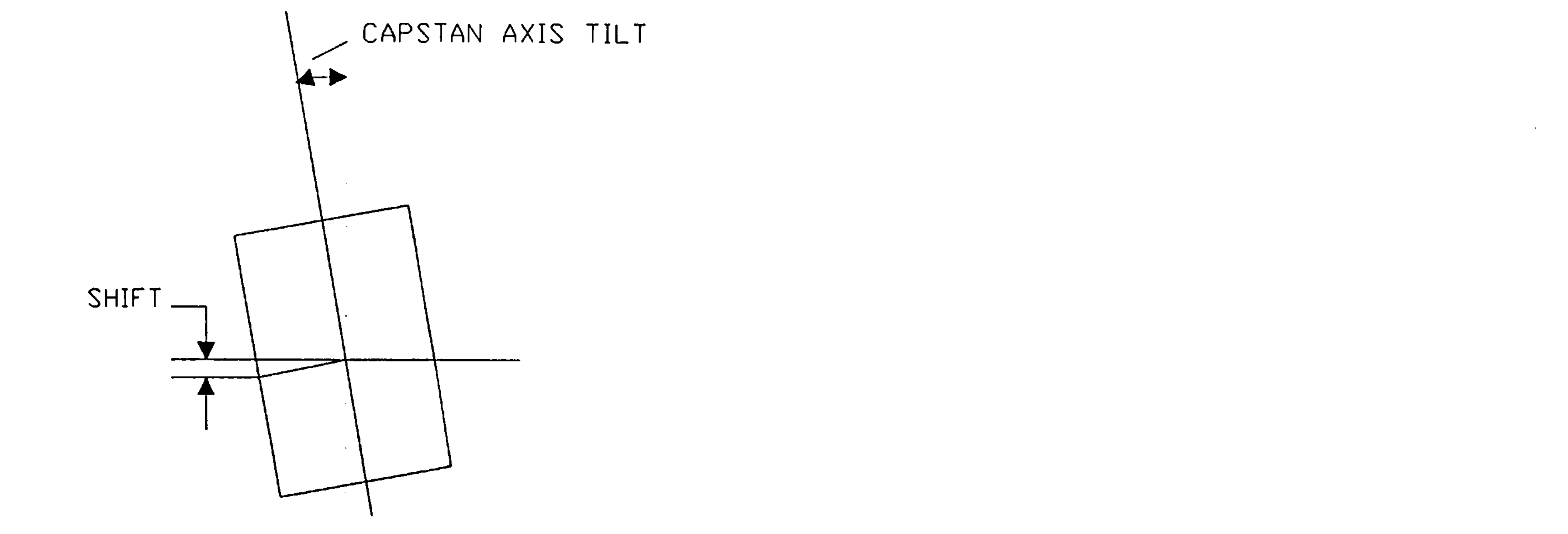


FIG 2. TAPE POSITION SHIFT WITH CAPSTAN AXIS SHIFT IN VERTICAL PLANE

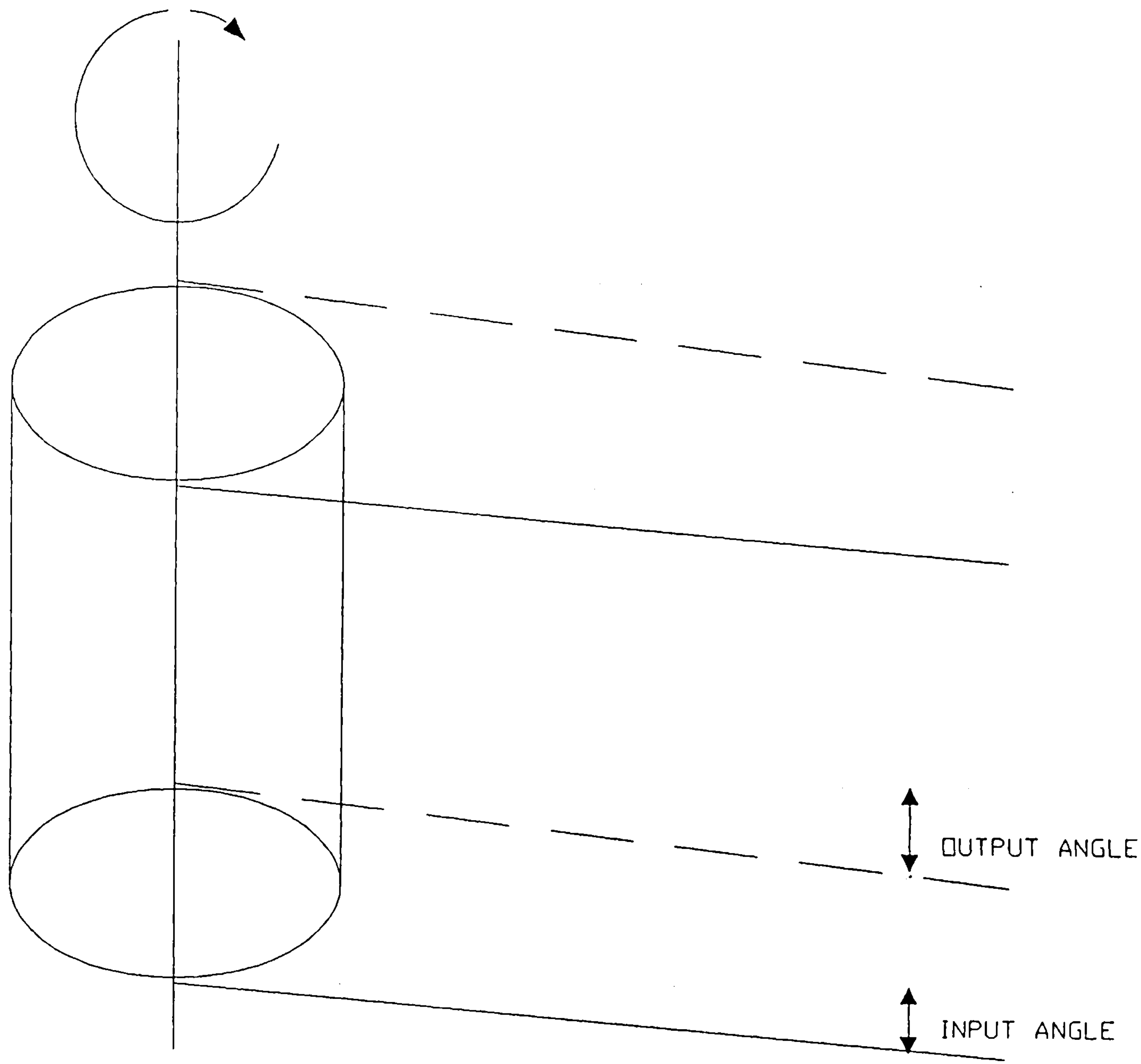


FIG 3. ANGLE OF TAPE WITH RESPECT TO CAPSTAN AXIS

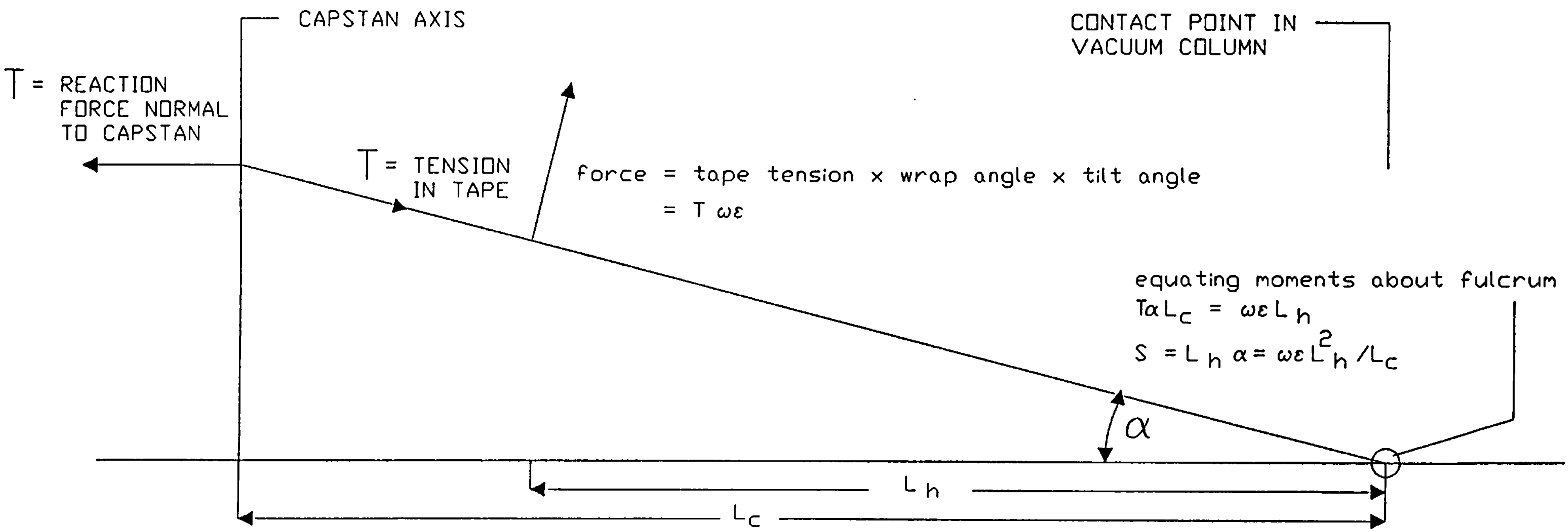


FIG 4 MODEL FOR BALANCE OF THE MOMENTS OF FORCE

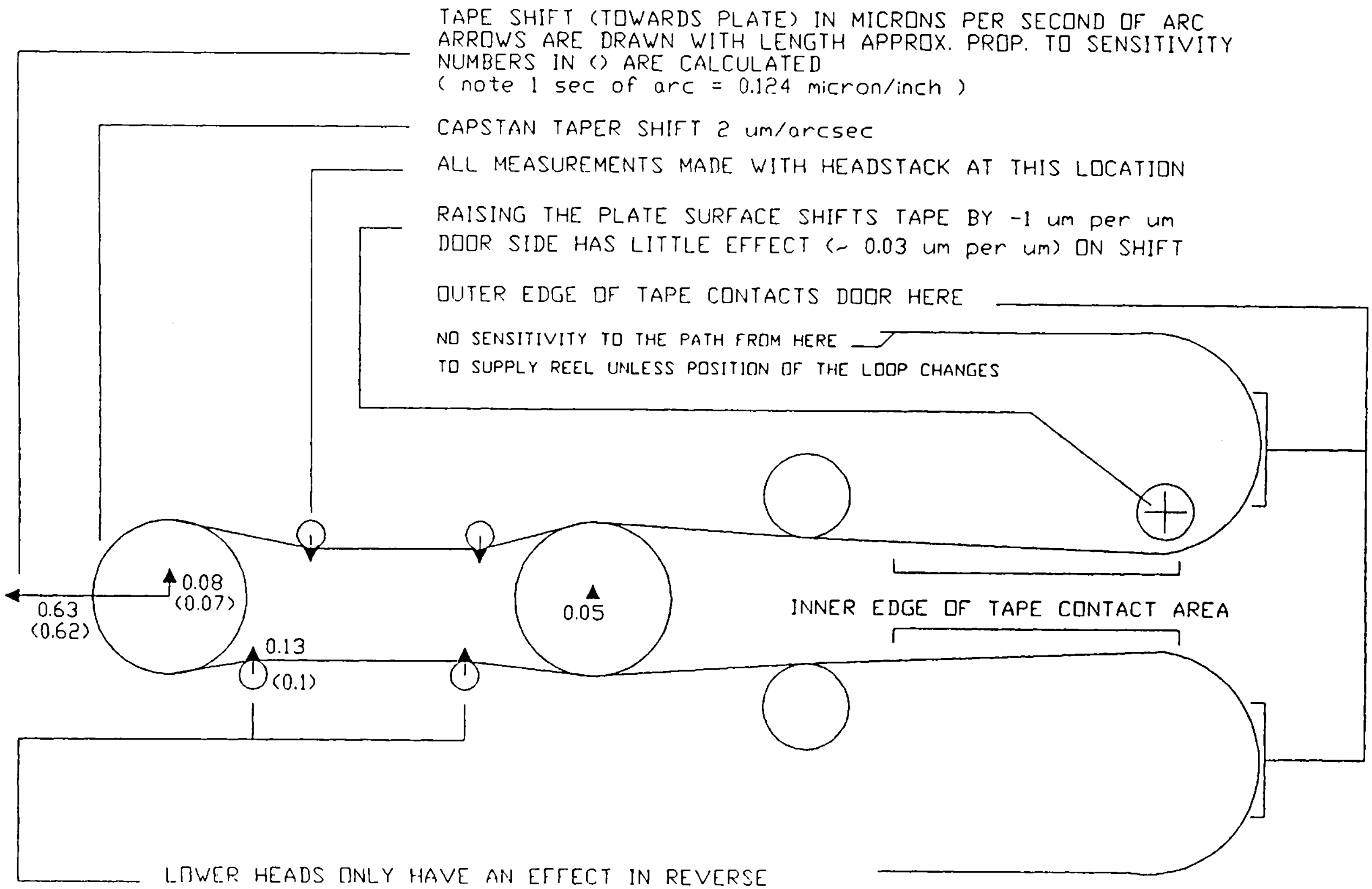


FIG 5. TAPE PATH AND SENSITIVITIES TO TILTS AND LINEAR MOTION