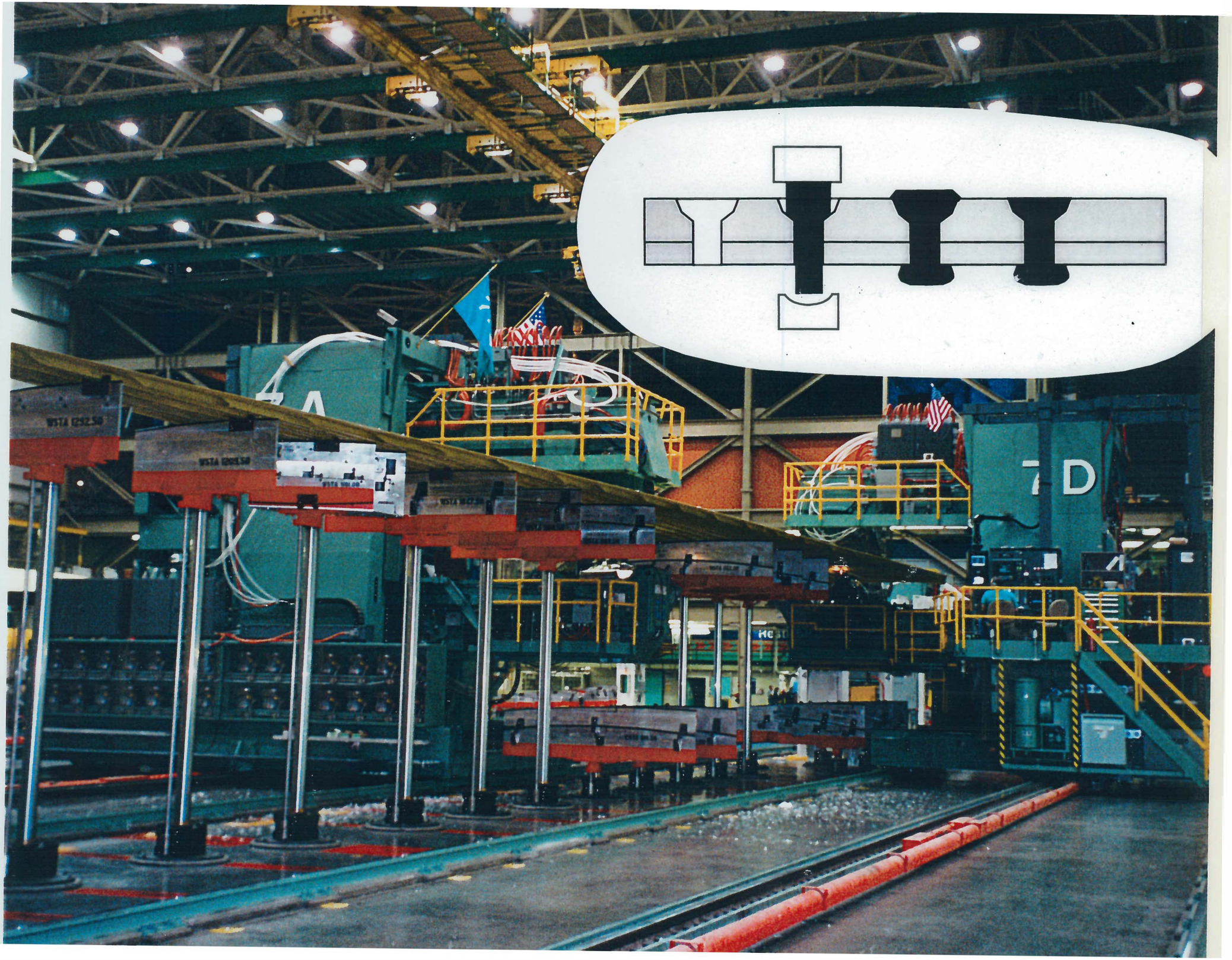
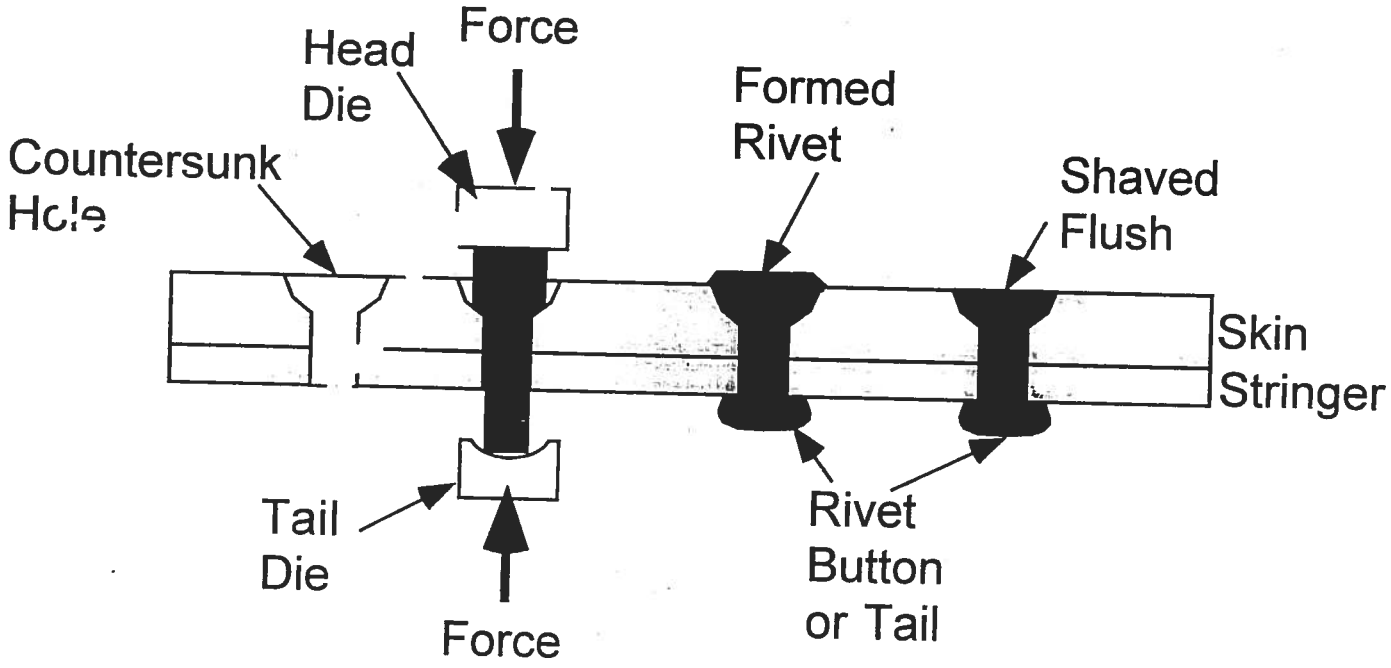

7 D

Two basic rivet types:

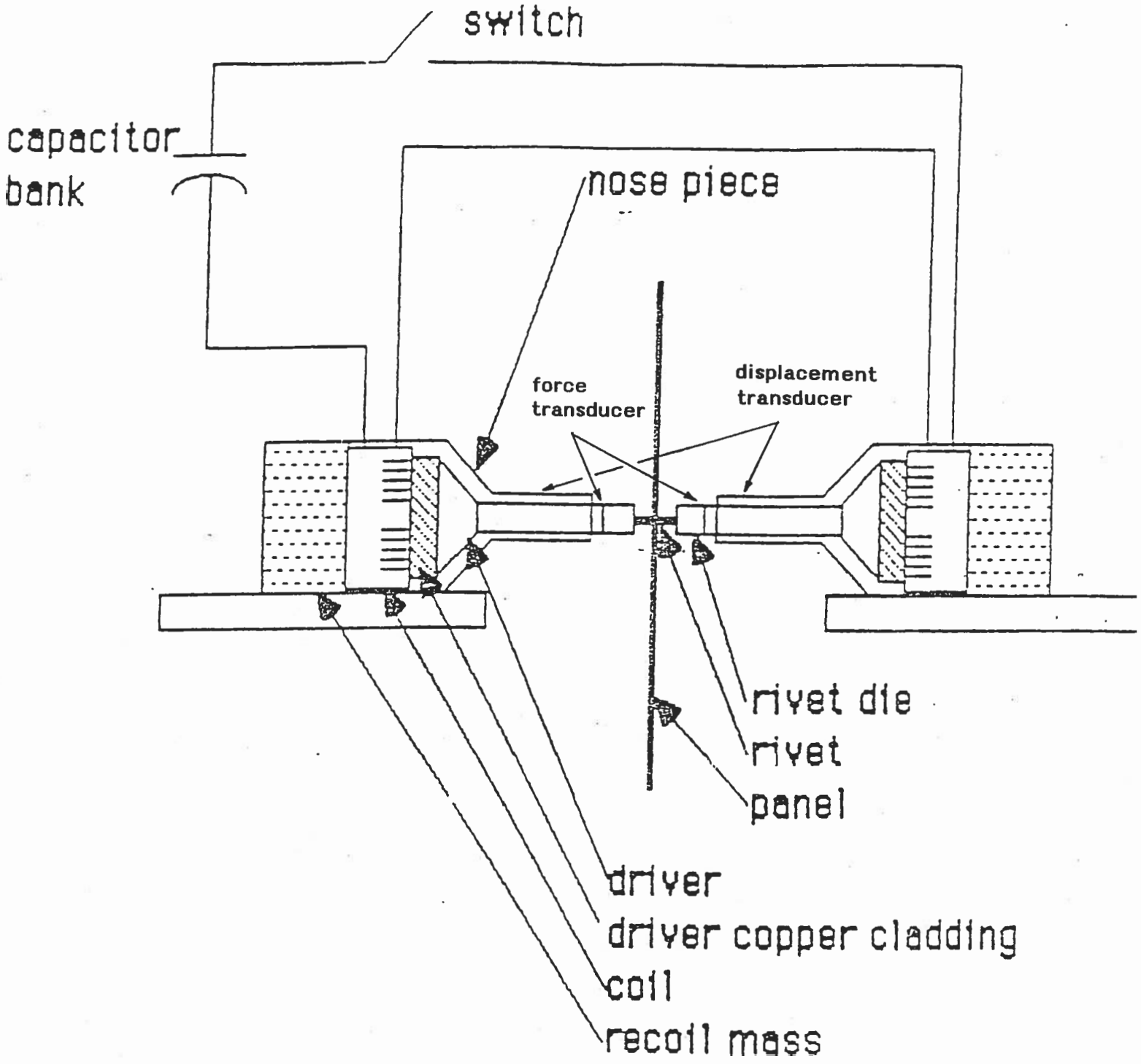
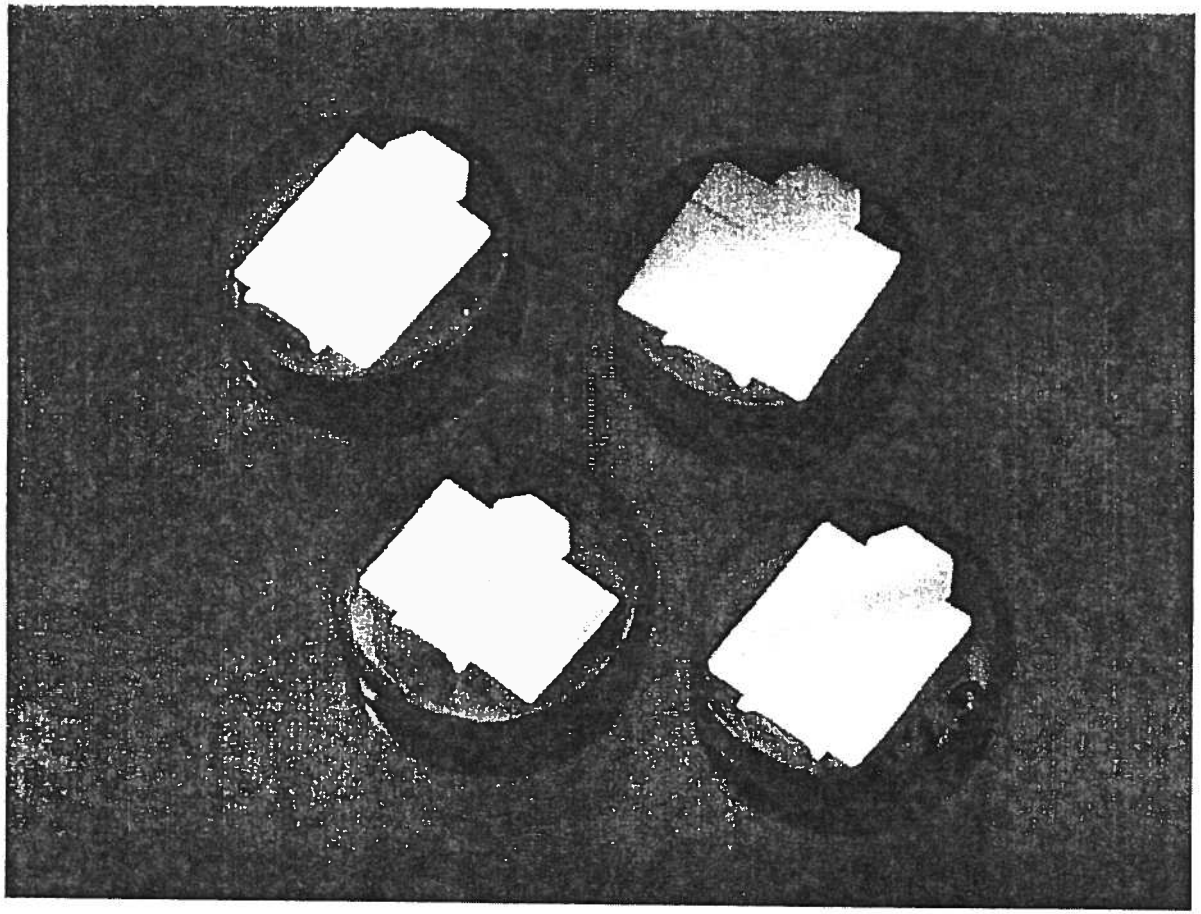
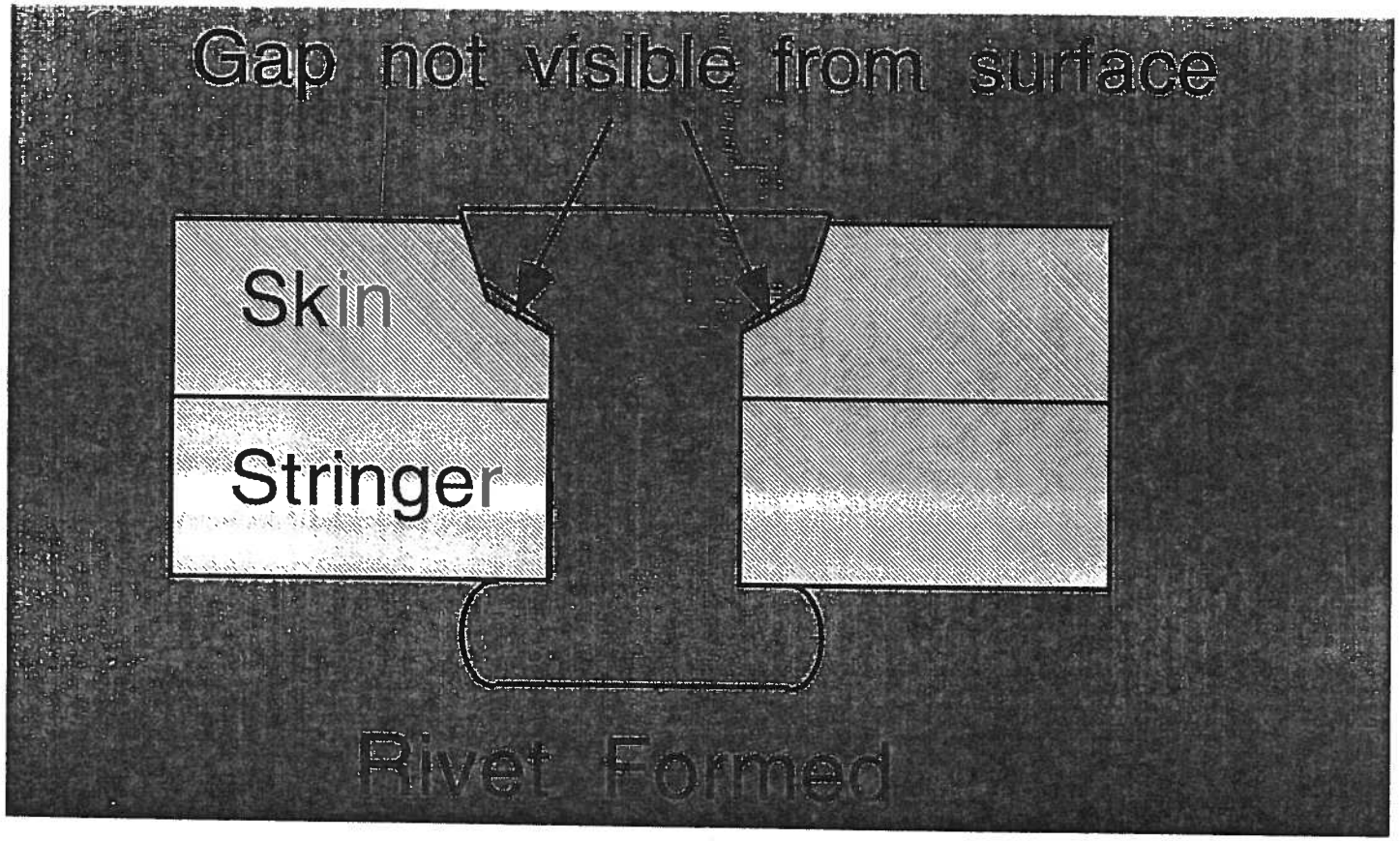


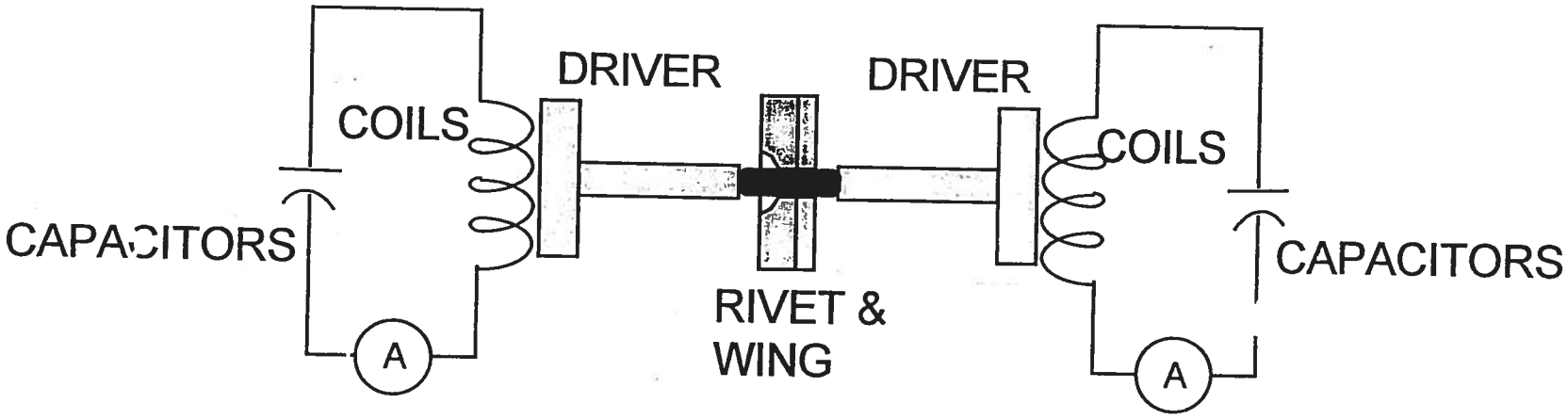

Figure 1.1
General arrangement of EMR

# Sectioned & Polished Rivets

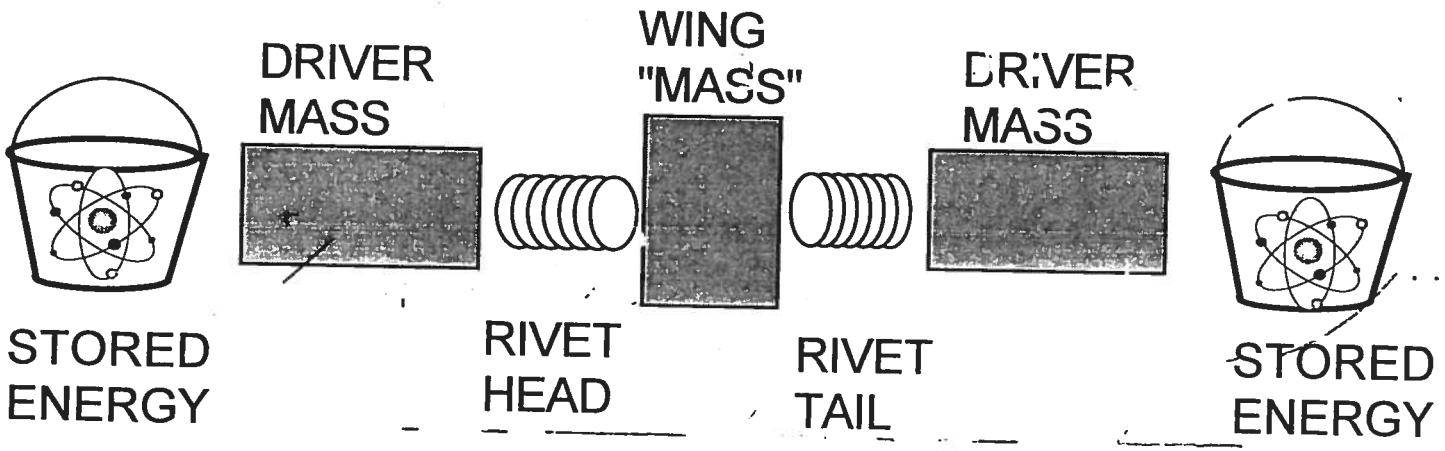


# Countersink Rivet Gaps






LVEMR SCHEMATIC

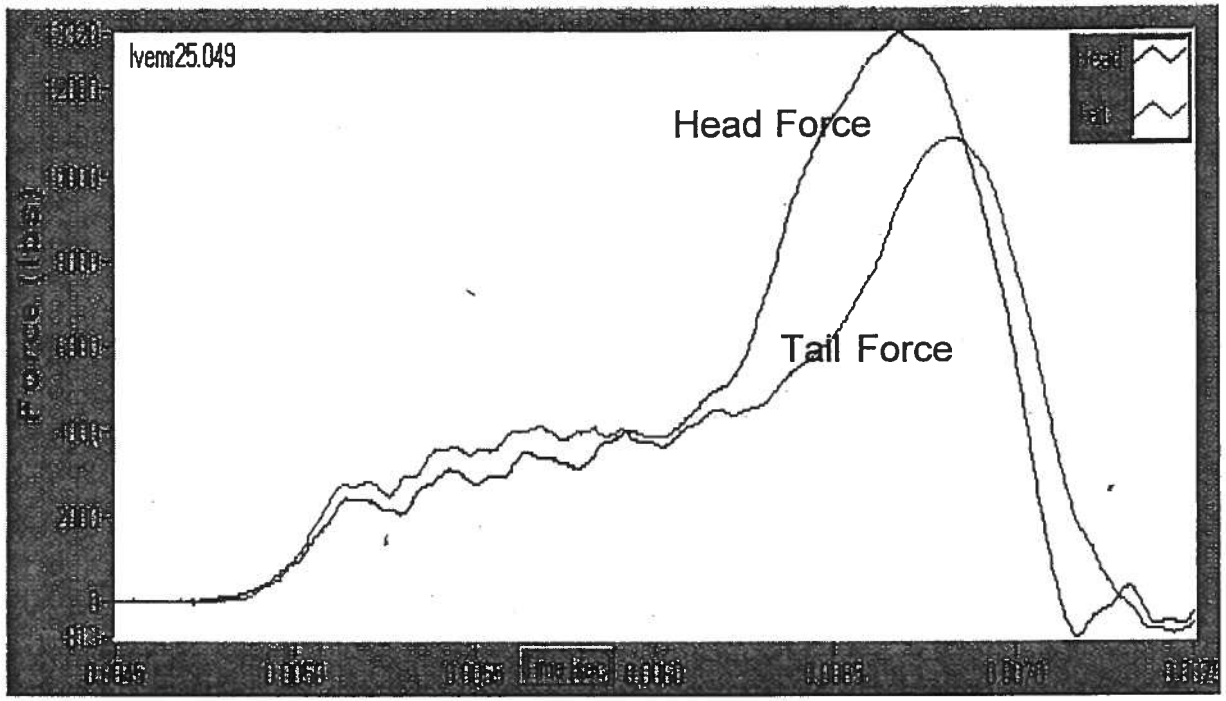



EQUIVALENT MASS-SPRING SYSTEM

## Slow vs Fast Riveting

| Slow (Gemcor) | Fast (LVEMR) |
|---|---|
| Quasi-Static<br>Control: Upset Force<br>(Head Force ≈ Tail Force) | Dynamic<br>Control: Upset Energy<br>(Forces are a function of input energy and distance driver travels to transfer the energy, i.e. "spring stiffness"; ( $E = \int F\,dx$ )) |
| Thermal energy created by plastic strain is dissipated during forming (near isothermal process). Material $\sigma-\varepsilon$ is under quasi-static, room temperature conditions. | Thermal energy created by plastic strain is NOT dissipated during forming (near adiabatic process). Material $\sigma-\varepsilon$ experiences thermal softening (leads to plastic instability resulting in flow lines) |

s. DISPLACEMENT




Force Trace (F vs. Time) for a "typical" LVEMR installation
(force measured at head and tail side dies)

Large Force imbalance.

Head Force peaks at a greater magnitude and prior to tail force.

Substantial tail force exists when head side is unloaded.

Countersink Gap formed.

# Low Voltage Electromagnetic Riveting (LVEMR)

## Known:

Deformation Energy ($E_{rivet}$) = Stored Electrical Energy - Energy Loss ($E_{loss}$)

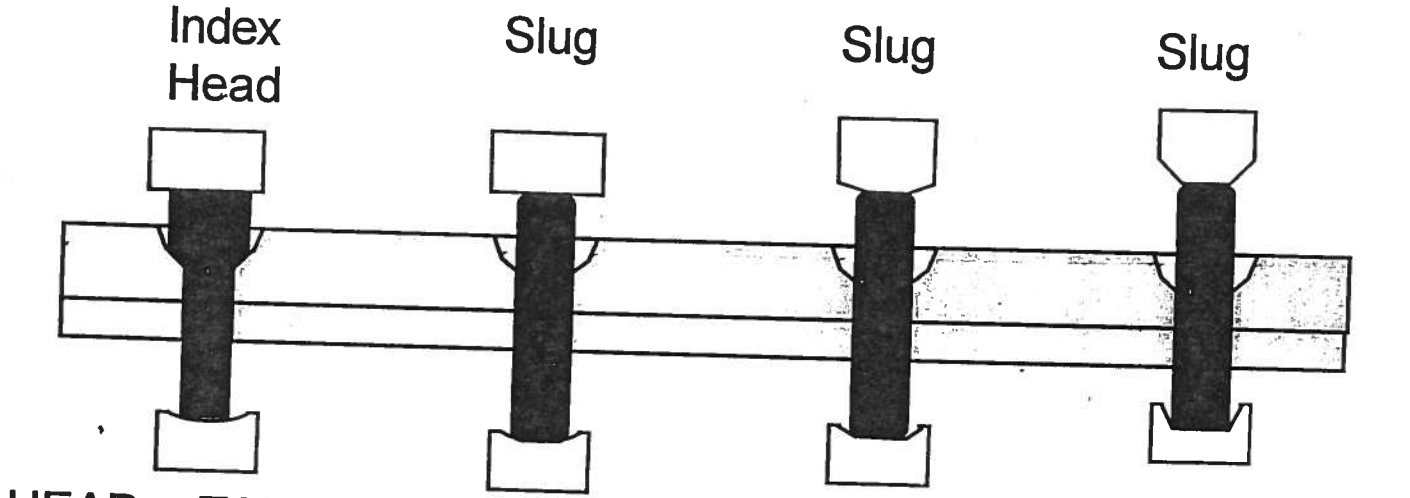
$E_{rivet} = \int F\,dx$ (area under F-Displacement curve)

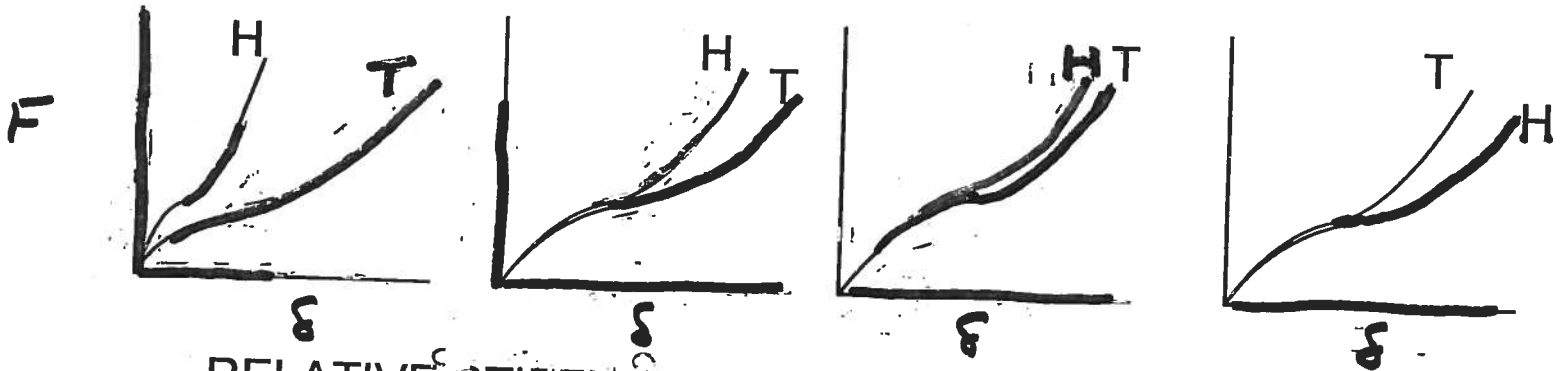
[redacted] rivet spring stiffness

Hypotheses:

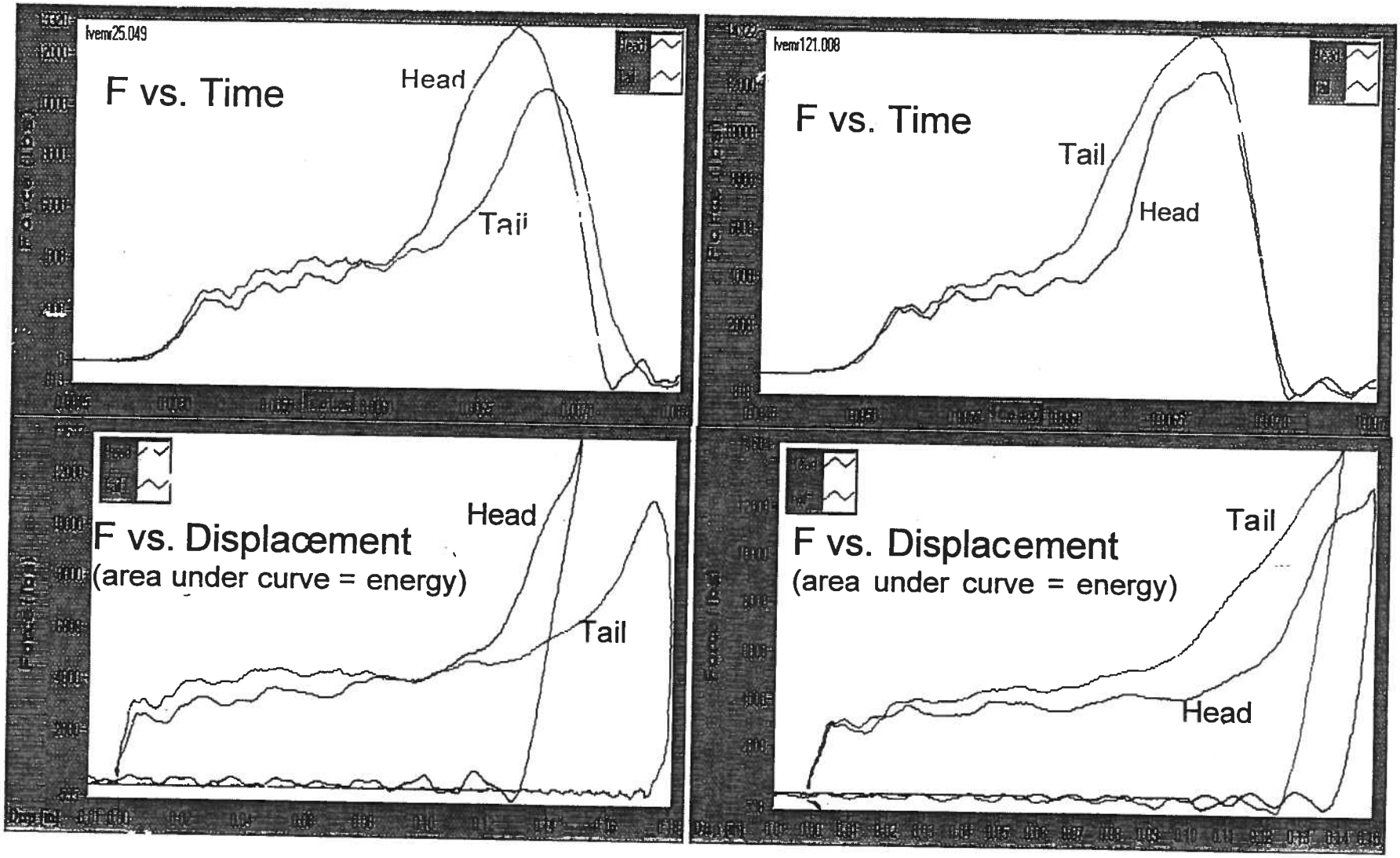
1) Countersink gaps are caused by rivet "push-out"
   (Tail Force > Head Force)
2) Force can be adjusted by
   a) changing rivet "spring stiffness"
   b) changing the magnitude of stored electrical energy

Shorter Protrusion = Greater Stiffness
Captivating Die = Greater Stiffness



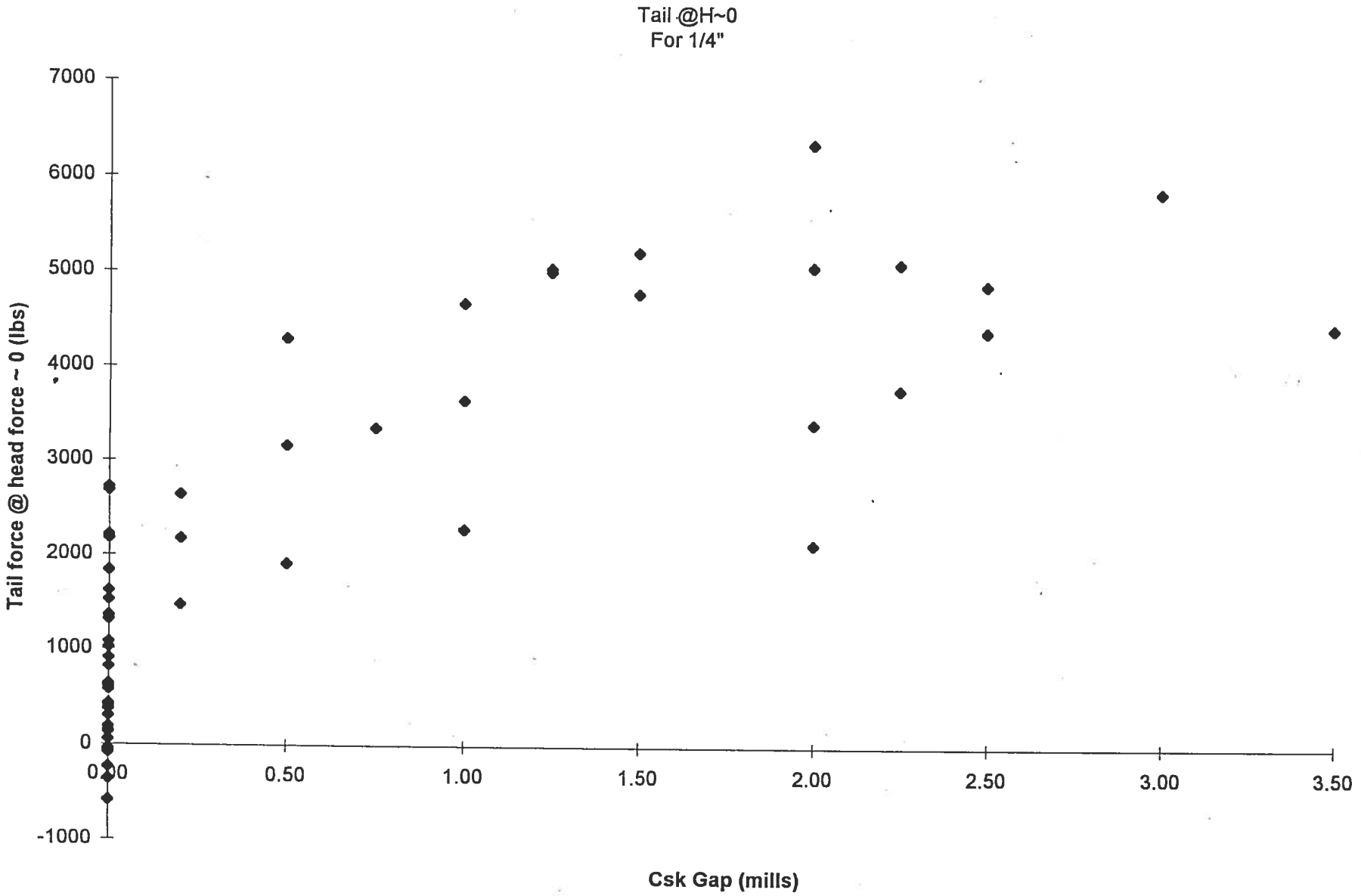




RELATIVE STIFFNESS (FORCE vs. DISPLACEMENT)




Head "Stiffness" >> Tail "Stiffness"
Tail Force > Head Force on unloading
Countersink Gap Created

Head "Stiffness" < Tail "Stiffness"
Tail Force ≈ Head Force on unloading
No Countersink Gap


Tail @H~0
For 1/4"
7000
6000
5000
4000
3000
2000
1000
0
-1000
Tail force @ head force ~ 0 (lbs)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Csk Gap (mills)