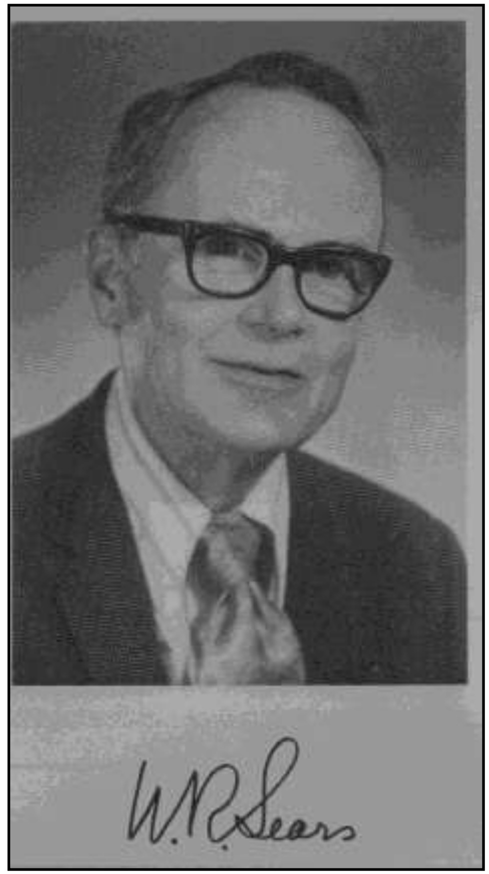
IN MEMORIAL TO THE LATE WILLIAM R. SEARS
1913 – 2003



“The Case of the Unsteady Boundary Layer Separation”

- 1938 PhD from Caltech with Theodore von Karman (Ludwig Prandtl)

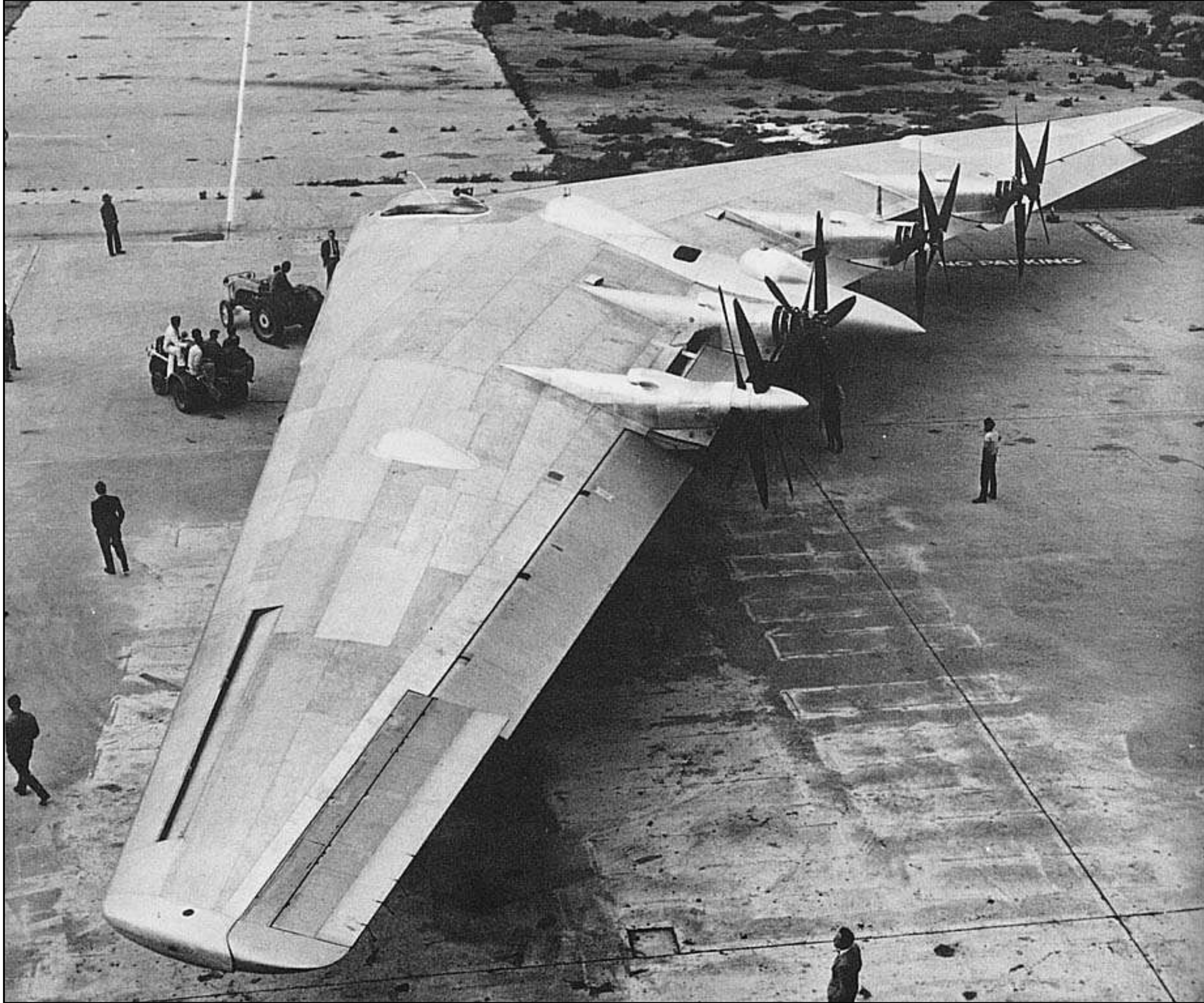
- 1940 Assistant Professor at Caltech

- 1941 Joined Northrop Aircraft Company as Chief of Aerodynamics and Flight Testing (age 28)
  - P61 Black Widow
  - Flying Wing
    - XB35
    - YB49 → B2

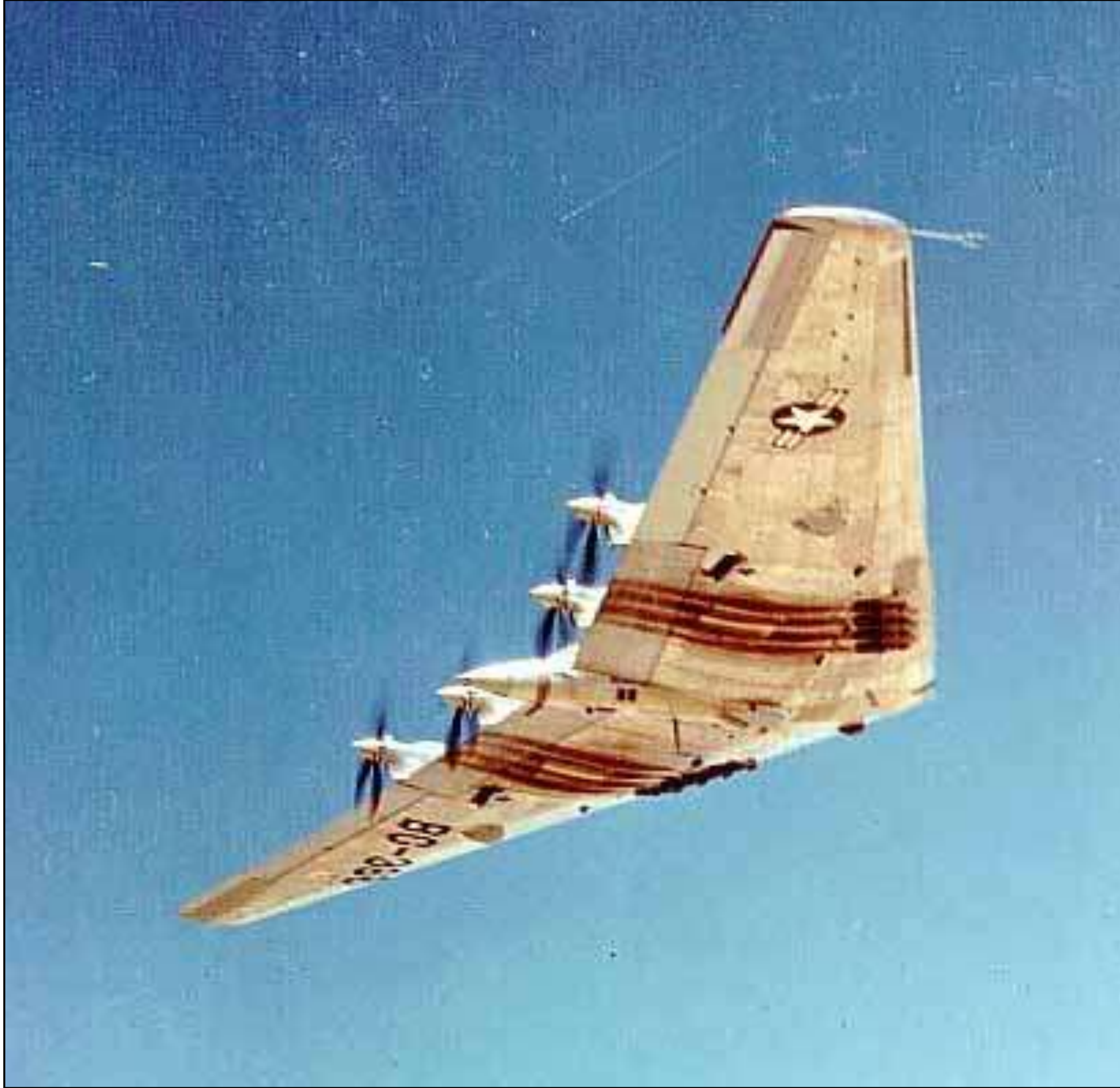

239728

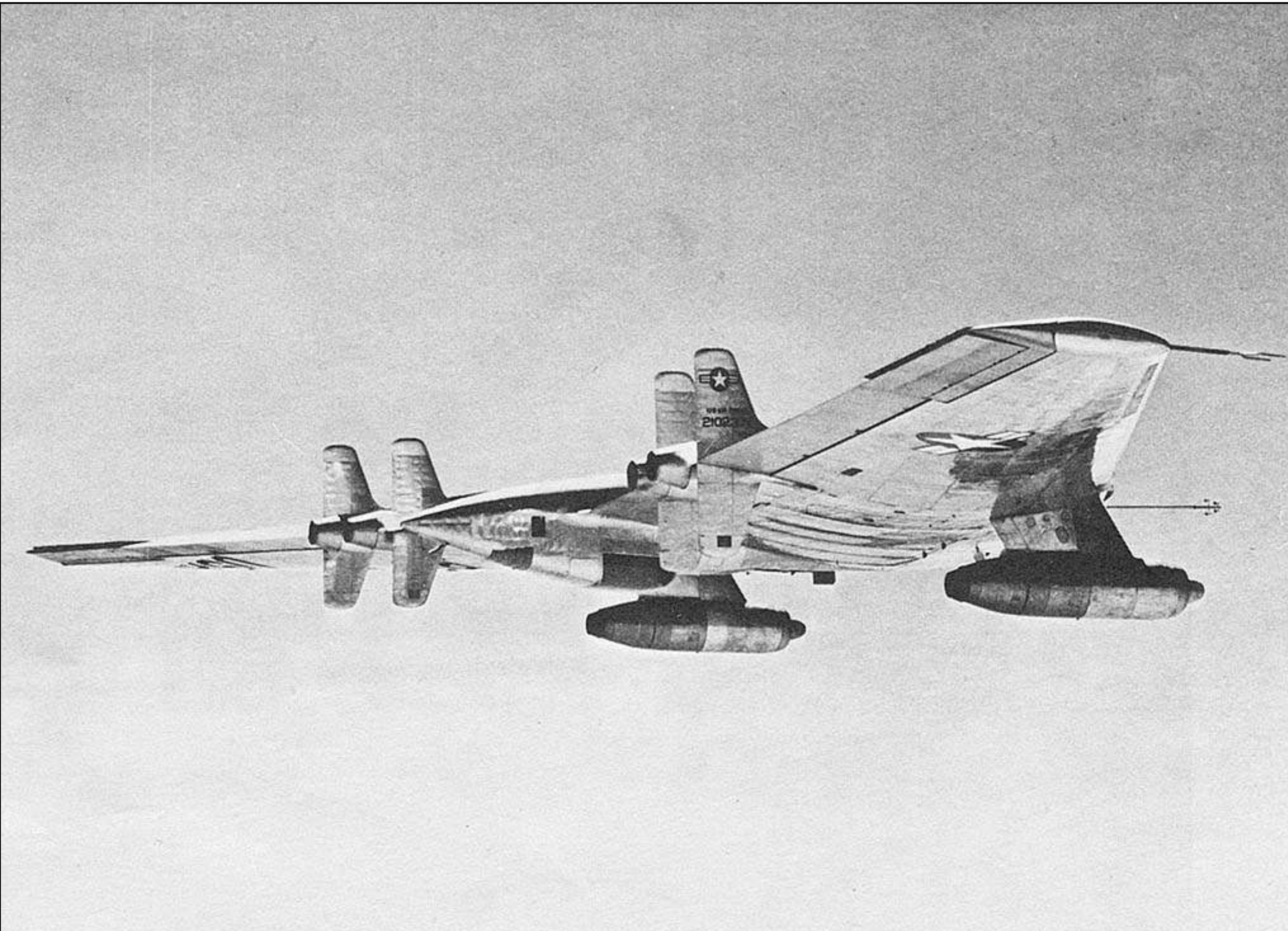

1369

BACK


NO PARKING

this is a rare photo of nine Northrop Flying Wing Bombers.
Many people do not realize that more than one or two prototypes were built of this design.
Here, for the first time, is actual proof of their existence.
Two of the big wing bombers are undergoing modifications from XB-35's to Flying Wing B-49 1t Bombers.
The entire project was later cancelled by the Air Force.





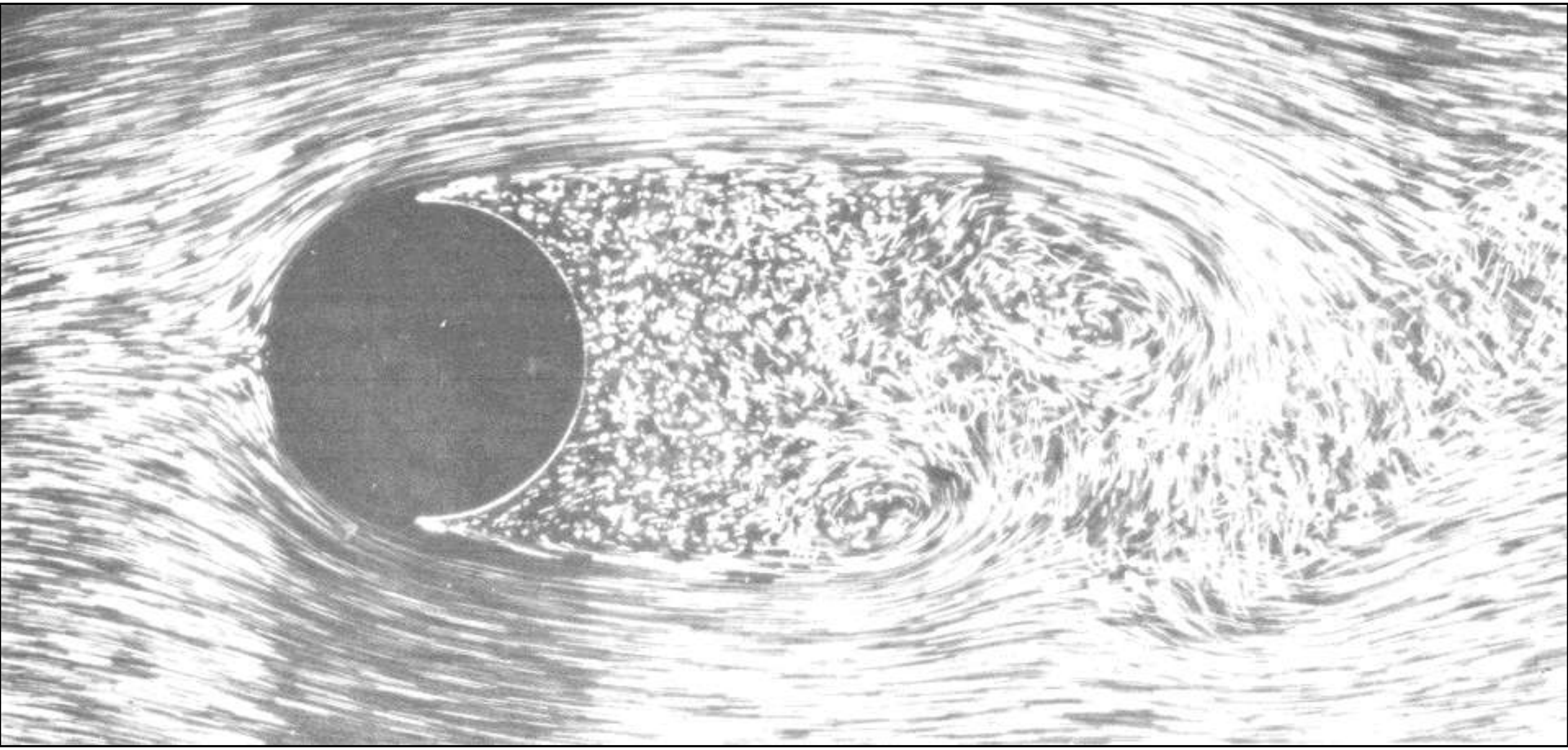
Northrop-Grumman B-2 Spirit "stealth bomber."

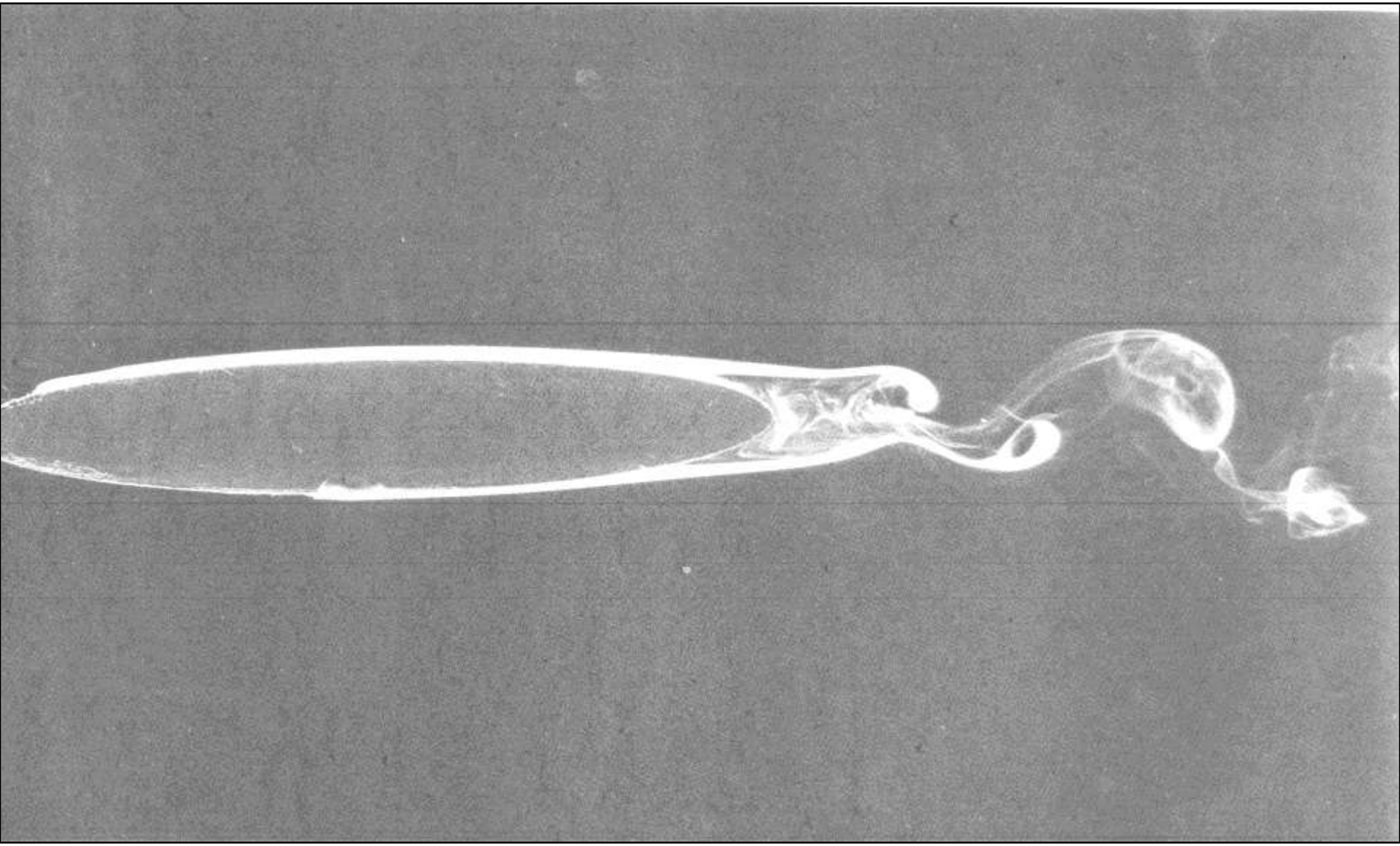
- 1947 Joined Cornel University, Director of the new Aero Graduate School

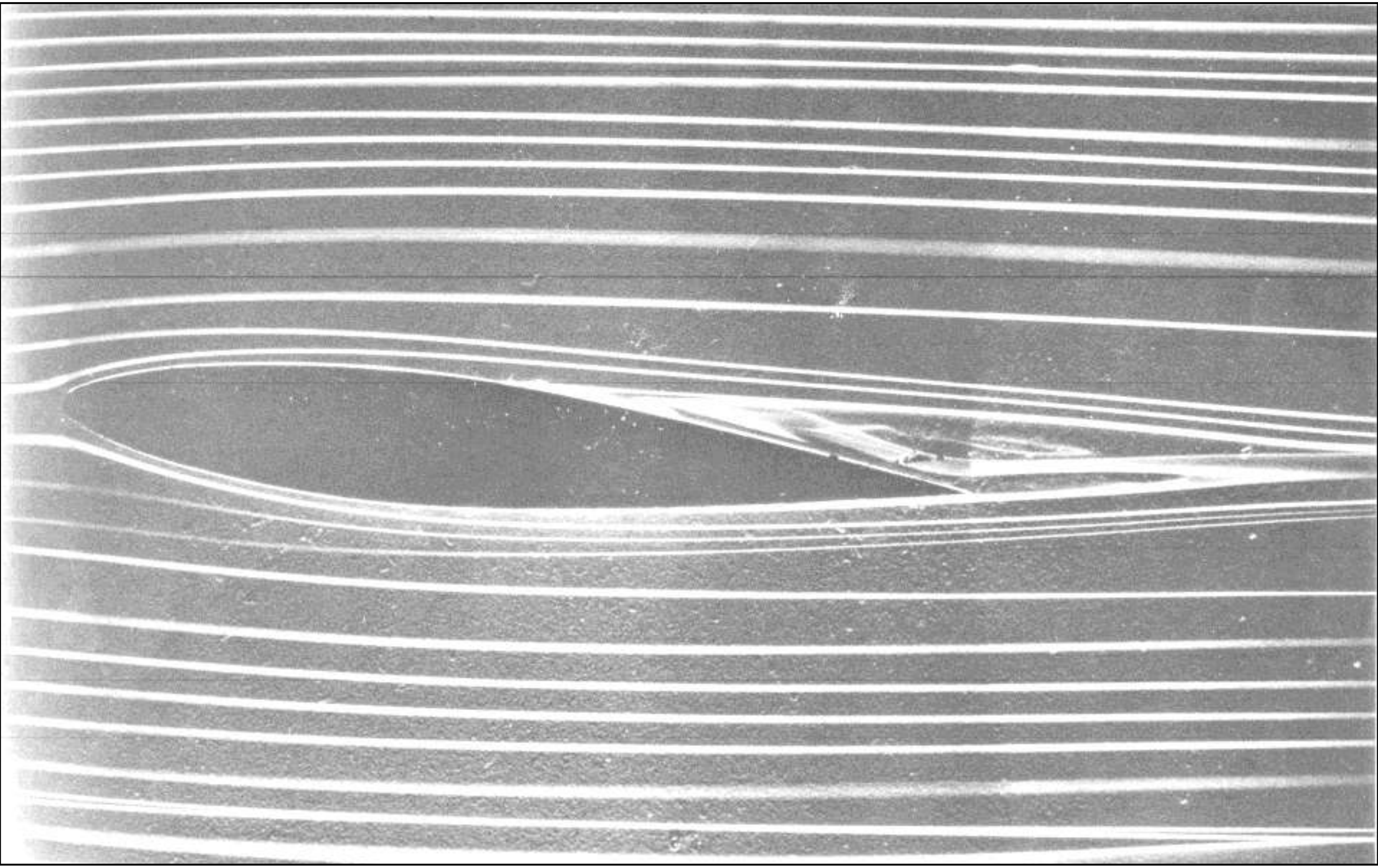
Themes of Research

- 3-D Boundary Layers
- Wing Theory
- Unsteady Flow in Turbomachinery
- Aerodynamic Noise
- **Unsteady Boundary Layers and their Separation**

- 1975 – 2003 Tuscon Arizona
- (Univ. of Arizona, Aerospace and Mechanical Eng)



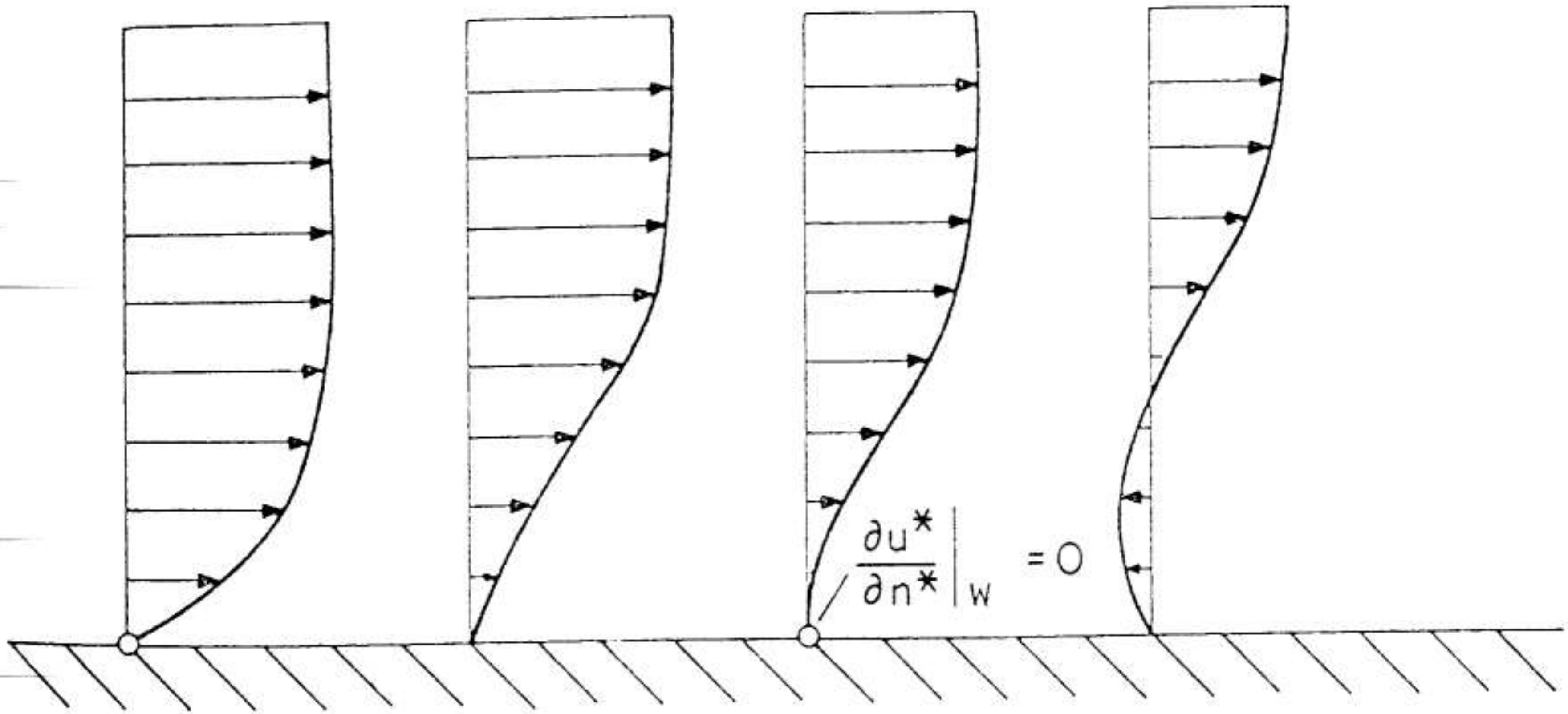




Steady Boundary Layer Equations

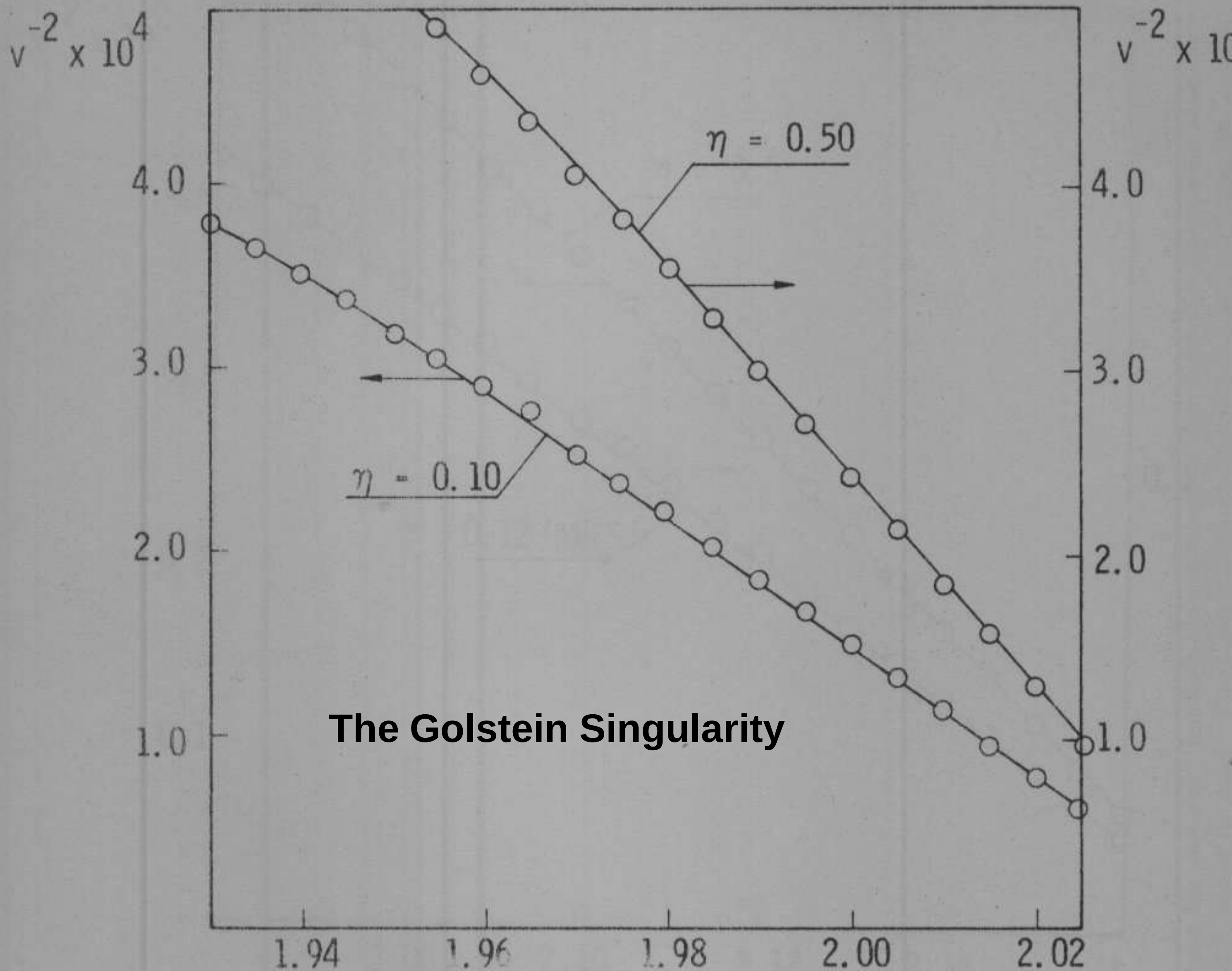
$$\frac{\partial u}{\partial s} + \frac{\partial v}{\partial N} = 0$$

$$u \frac{\partial u}{\partial s} + v \frac{\partial u}{\partial N} = U_e \frac{dU_e}{ds} + \frac{\partial^2 u}{\partial N^2}$$

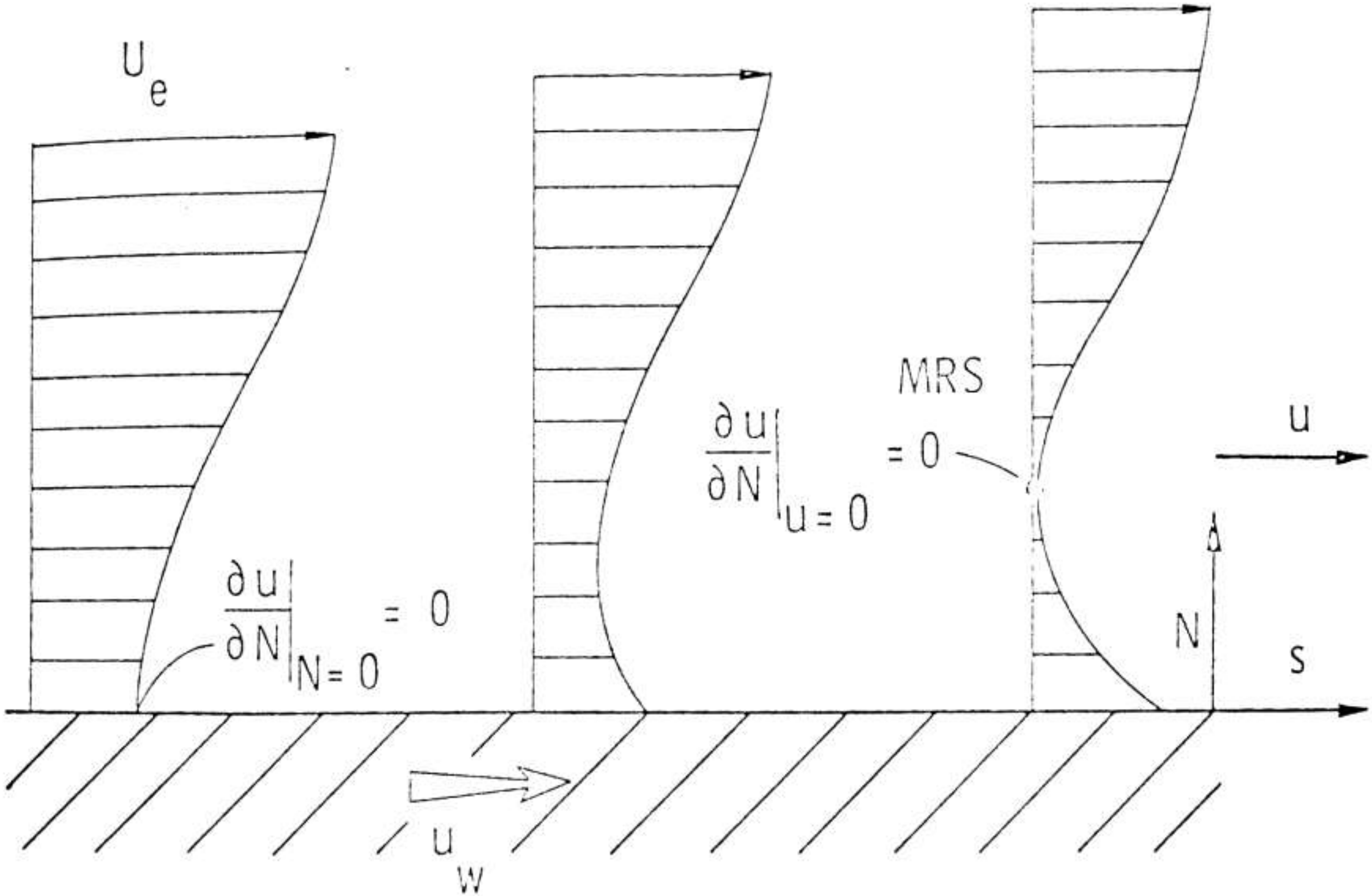


Schematic of the flow field in the neighborhood of a separation point.

The Golstein Singularity



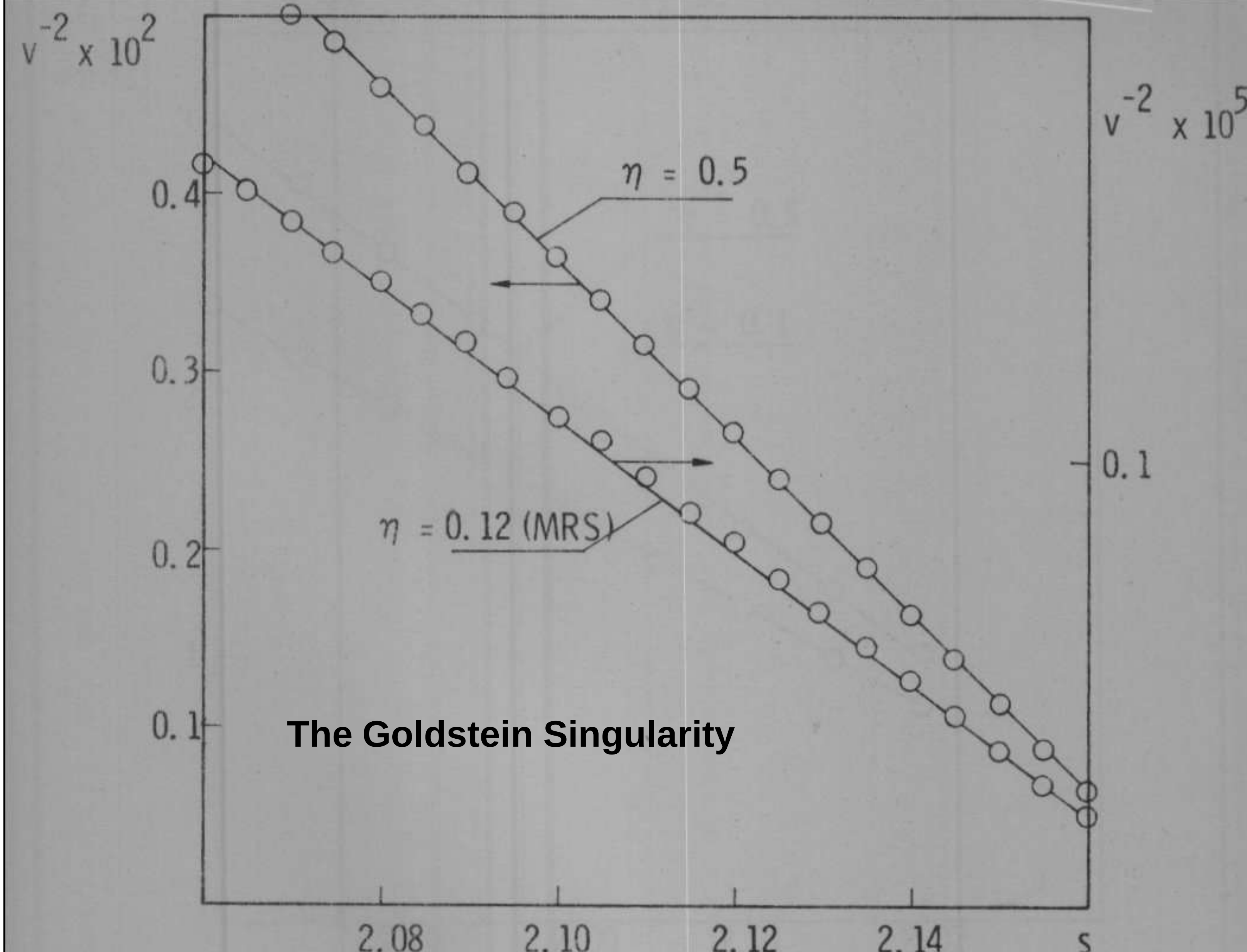
The inverse square of the v-component versus s for stationary walls.



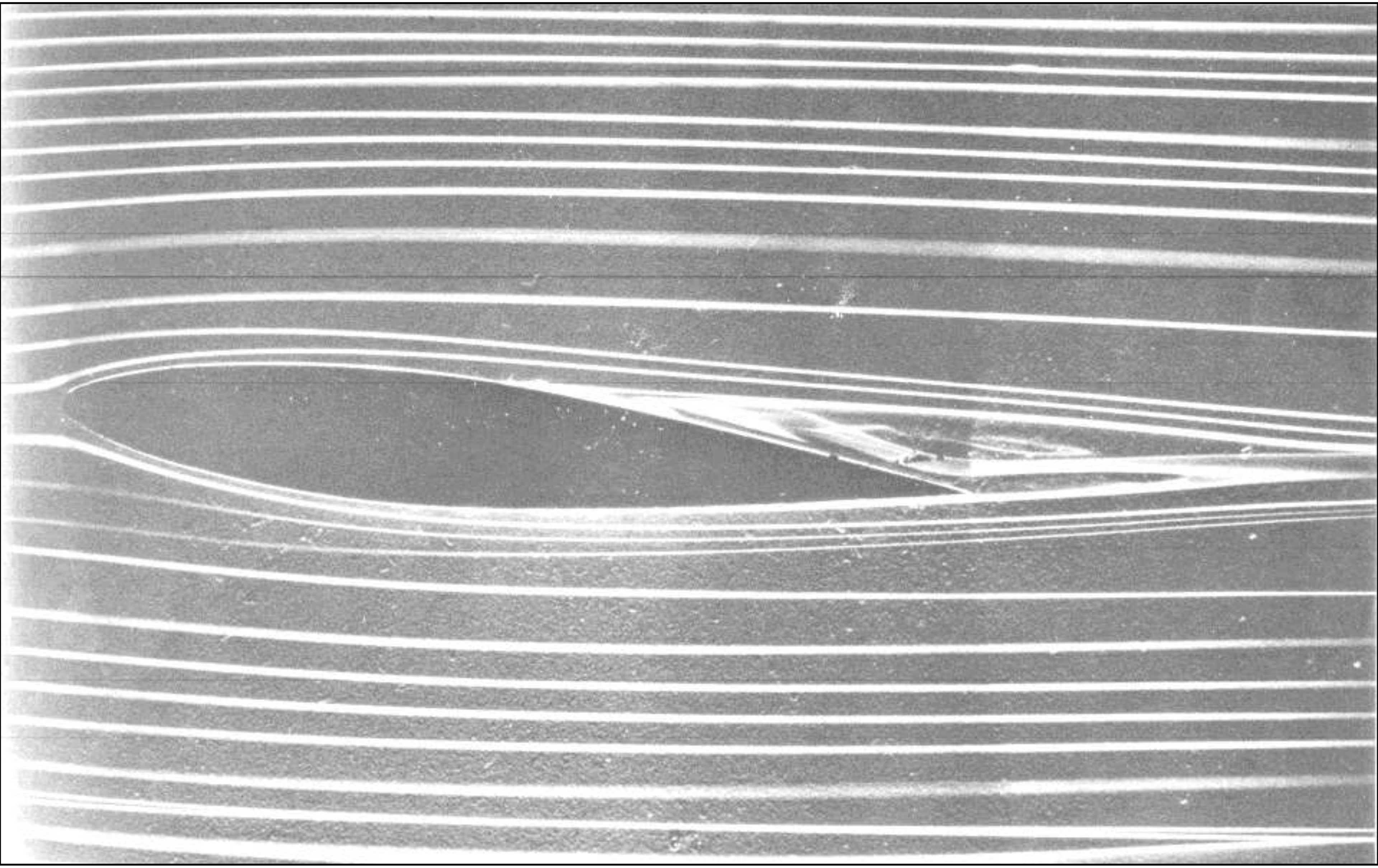
Schematic sketch of velocity profiles u(s,N) in the neighborhood of an MRS point (separation point) for steady flow over moving walls.

M: Moore, R: Rott, S: Sears

The Goldstein Singularity



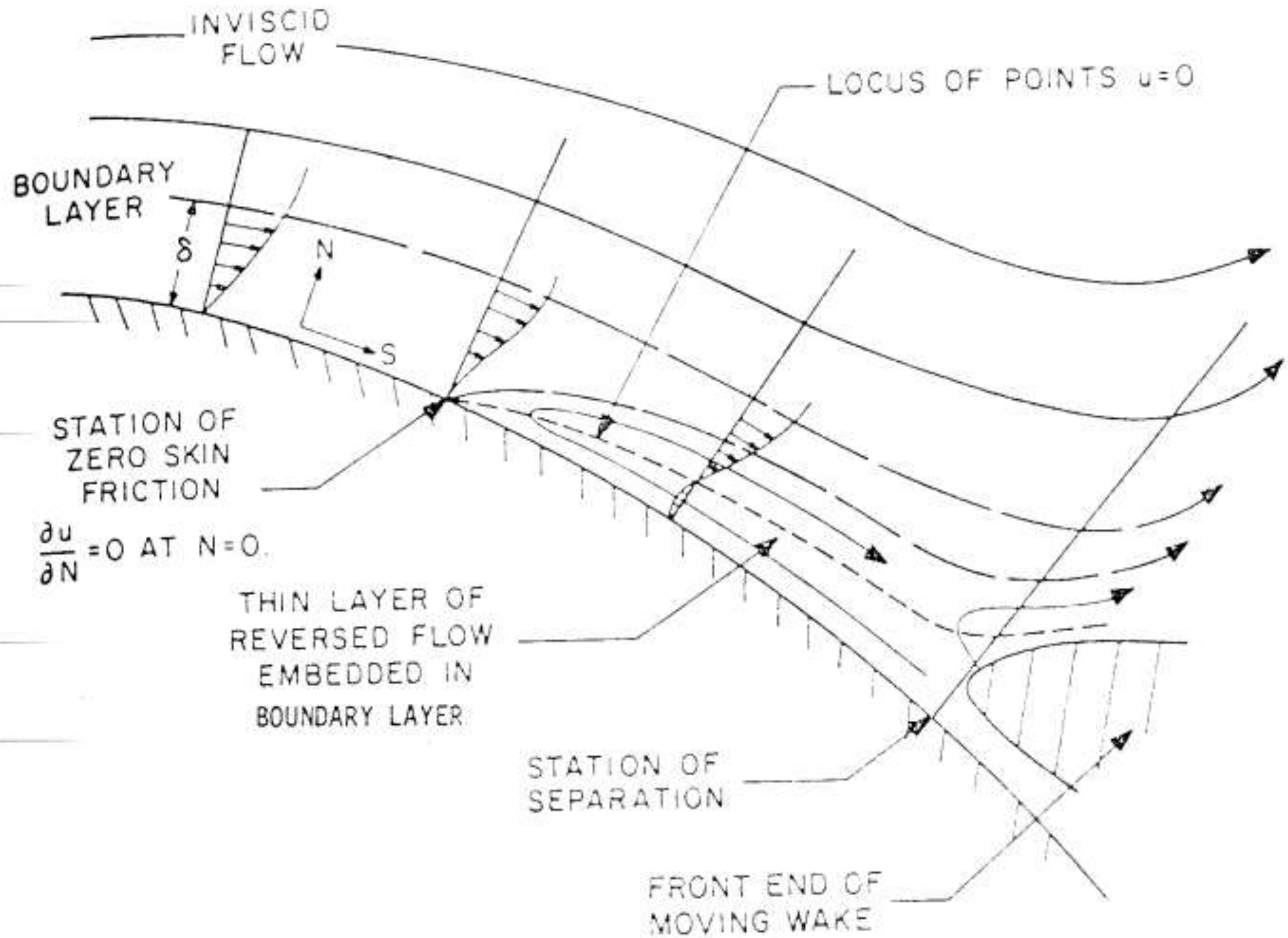
The inverse square of the v-component versus s for u_w/U_∞ = 0.01.



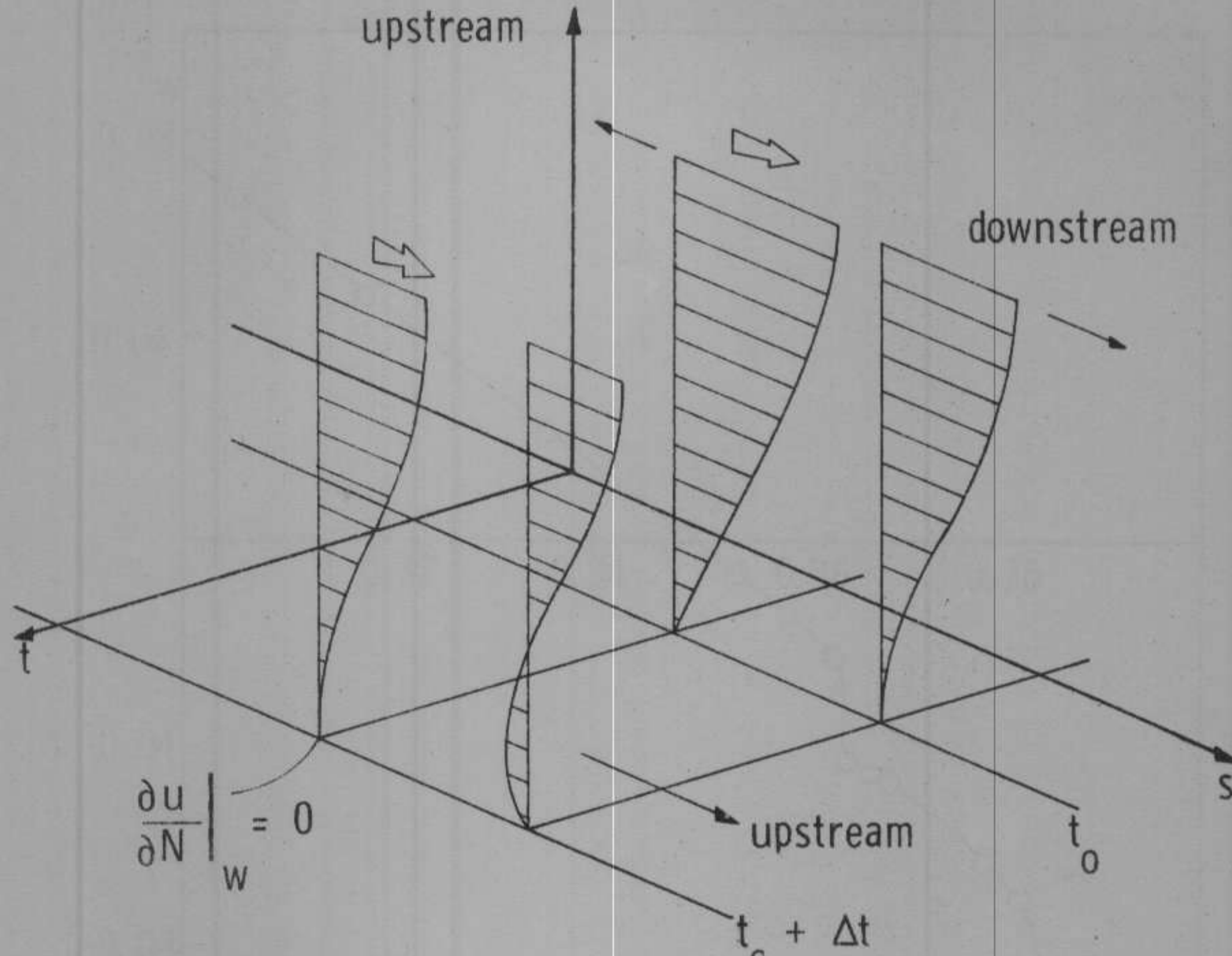
Unsteady Boundary Layer Equations

$$\frac{\partial u}{\partial s} + \frac{\partial v}{\partial N} = 0$$

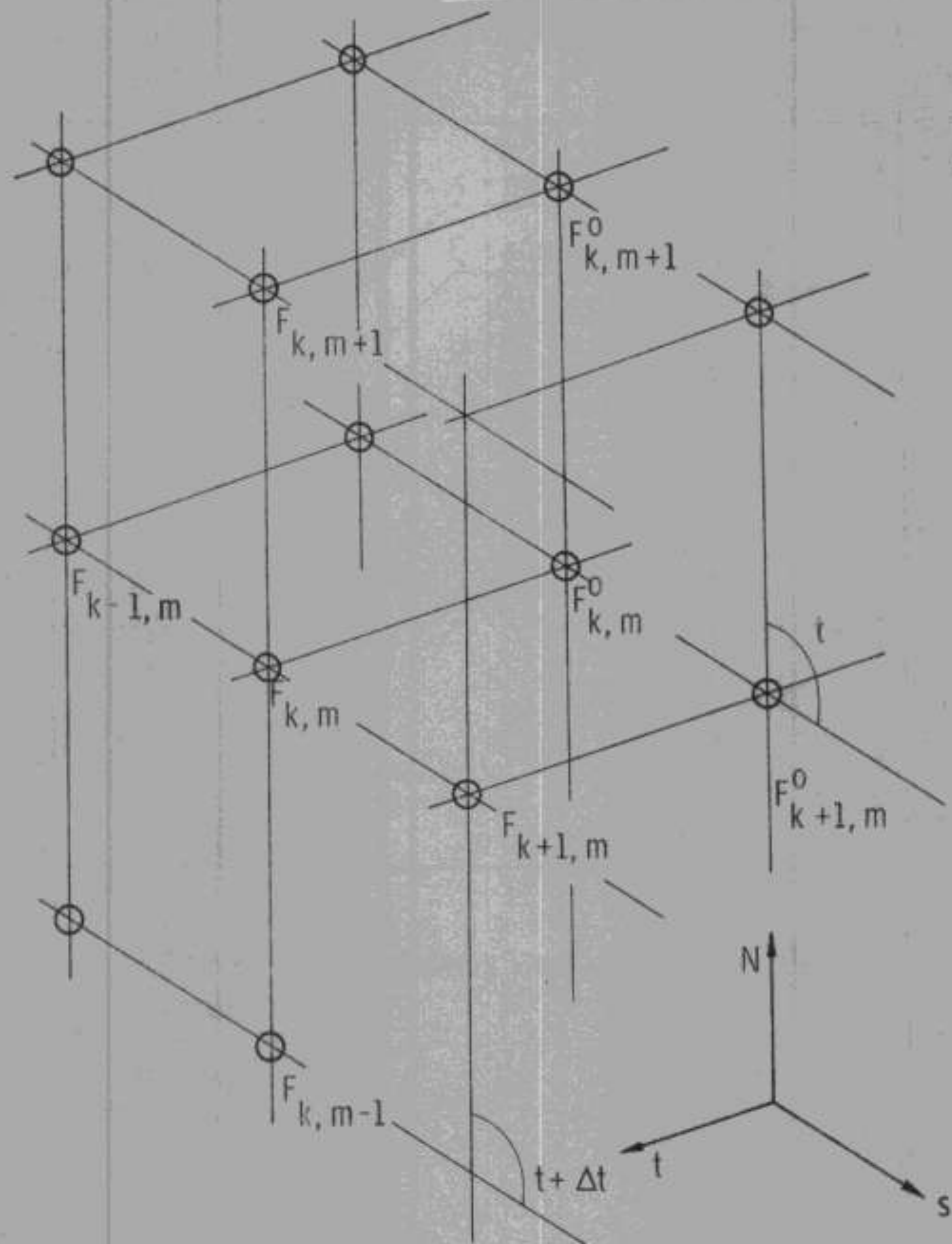
$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial s} + v\frac{\partial u}{\partial N} - \frac{\partial U_e}{\partial t} - U_e\frac{\partial U_e}{\partial s} = \frac{\partial^2 u}{\partial N^2}$$



Schematic of the flow field in the neighborhood of unsteady separation.



Schematic sketch of the flow field



Three-dimensional mesh configuration

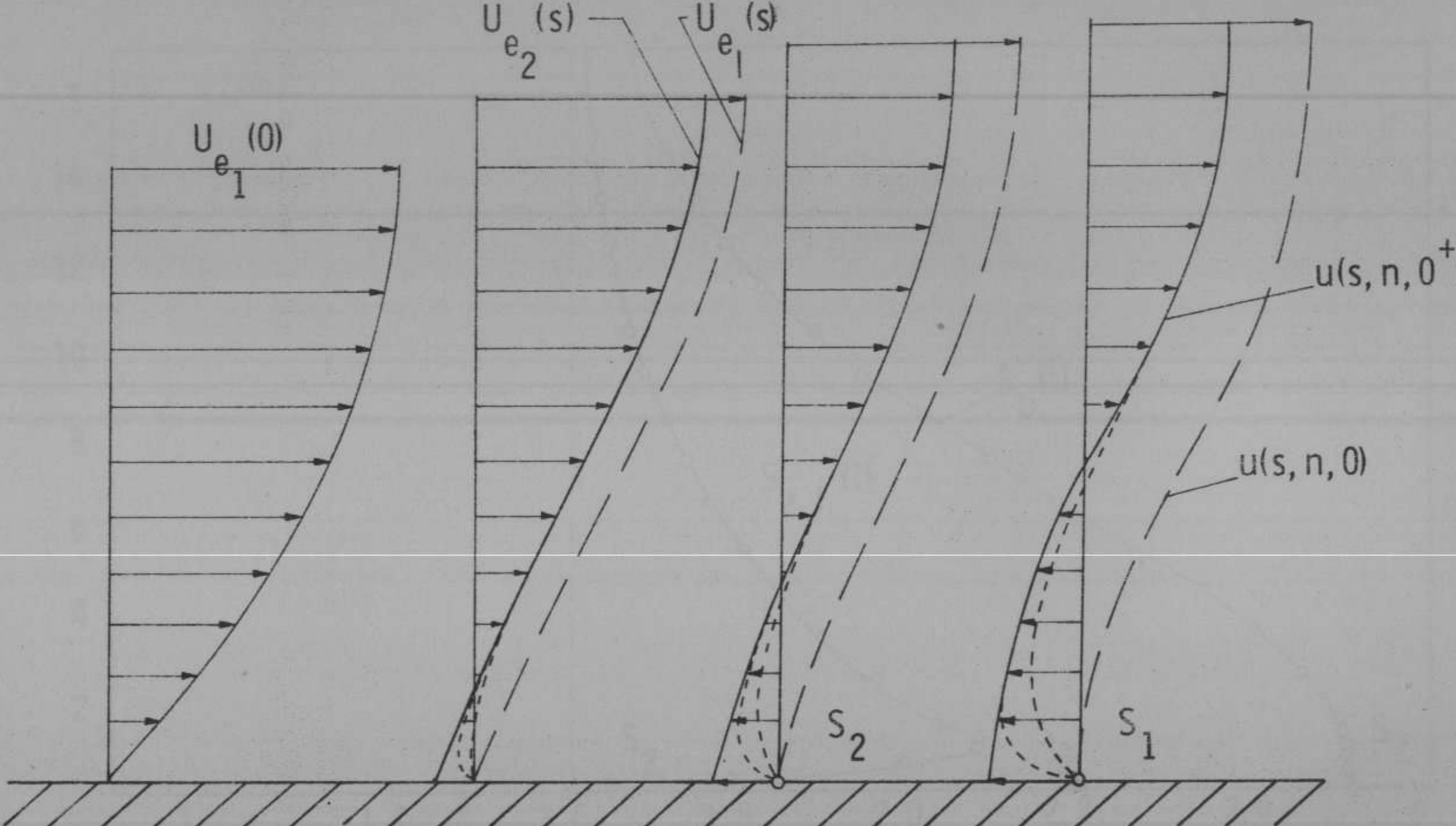
UPWIND DIFFERENCING

The Mixed Version

$$\left.\frac{\partial F}{\partial \xi}\right|_{k,m} \cong \frac{1}{\Delta\xi}\left(F^0_{k+1,m} - F_{k,m}\right)$$

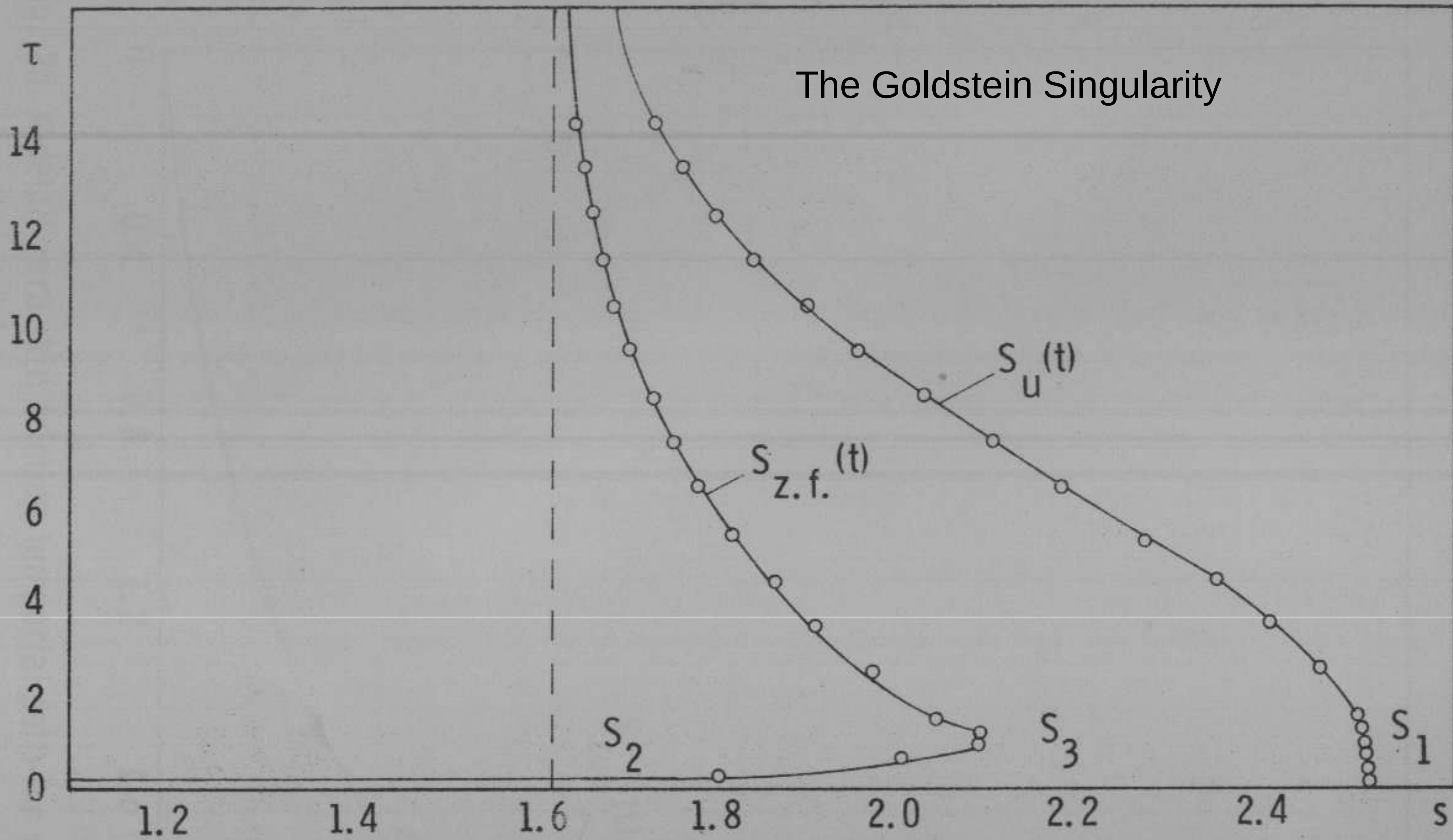
The Krause Version

$$\left.\frac{\partial F}{\partial \xi}\right|_{k,m} \cong \frac{1}{2\Delta\xi}\left[\left(F^0_{k+1,m} - F^0_{k,m}\right) + \left(F_{k,m} - F_{k-1,m}\right)\right]$$



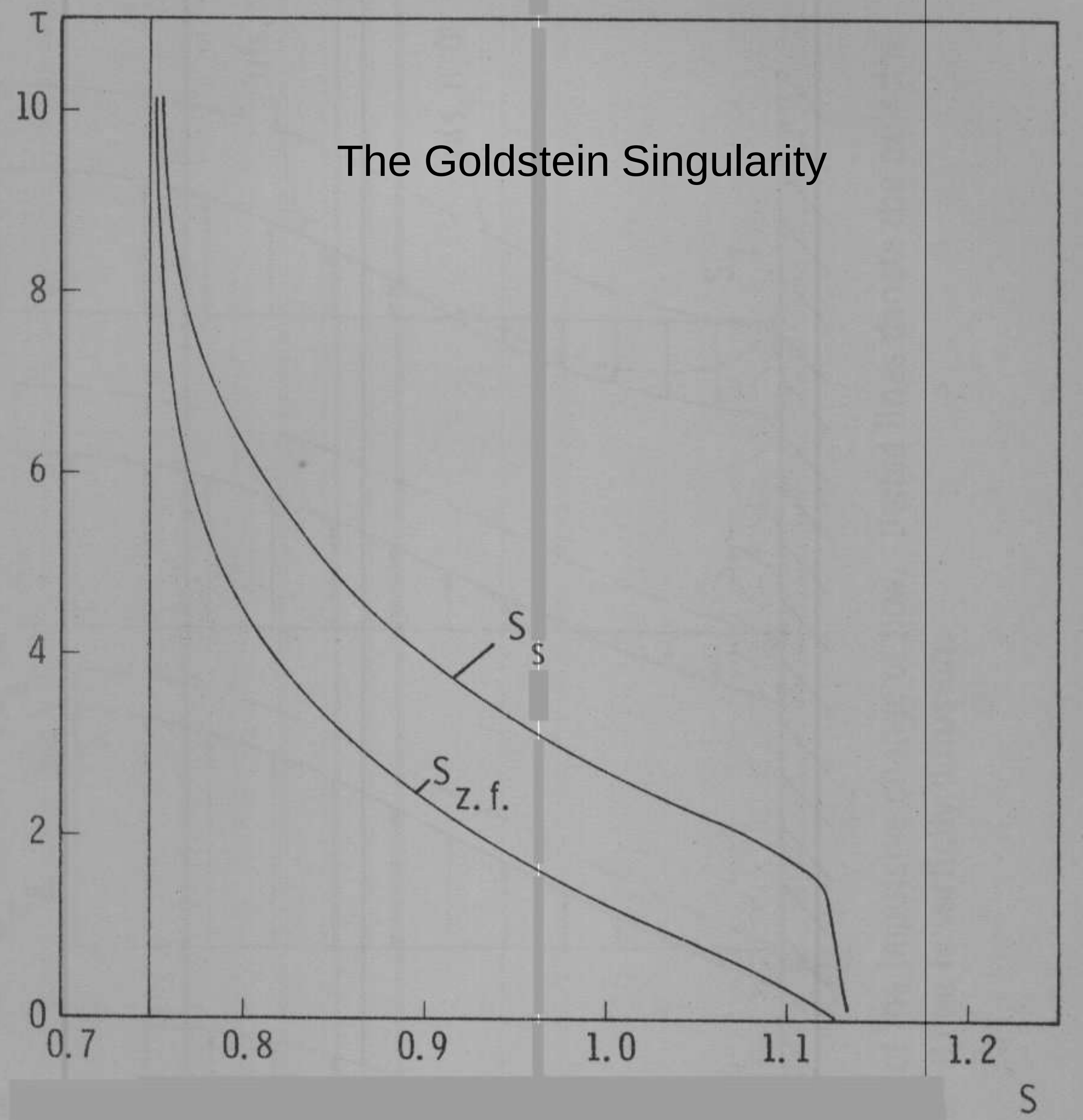
Schematic of the impulsive change of flow. Dotted lines denote the expected change t = 0 due to vorticity diffusion.

The Goldstein Singularity



Temporial path of the points of zero skin friction and separation for an impulsive change

The Goldstein Singularity



Temporal path of the points of zero skin friction and separation in unsteady flow