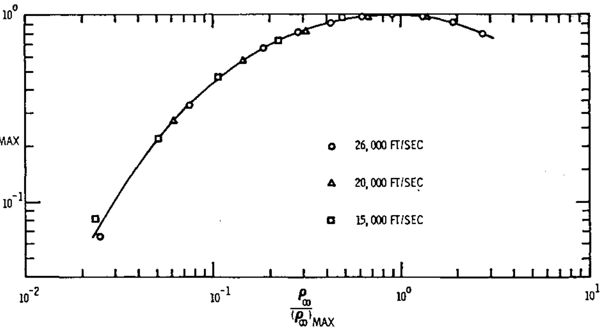

Fig. 3 Correlation of wall atom concentration.

noncatalytic surfaces in the viscous shock-layer regime through the use of correlation equations and curves. The heating rates calculated from these correlations include the simultaneous effects of chemical nonequilibrium and vorticity interaction for a stagnation region with an arbitrary surface temperature and body radius. By the use of the procedure presented, it is possible to predict the maximum and minimum heating rates for the major portion of a glide re-entry trajectory.

References

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Heat-Transfer Measurements of Entry Cones with Maneuvering Surfaces

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Tests were recently conducted in the Boeing 12-Inch Hypersonic Wind Tunnel with conical ceramic models and heat-sensitive paint. The models were simulated entry cones with maneuvering surfaces as shown in Fig. 1. The test conditions were a stagnation pressure of 1250 psia and a stagnation temperature of 770°F; at Mach 6.08 this results in a freestream Reynolds number of 13.75×10^6/ft. The purpose of the test was to compare the straight cone heating-rate values with the protruding control devices.

The tests were conducted by injecting the models and calibration spheres painted with Detectotemp† into the wind tunnel and recording the resultant color changes with a motion picture camera. This motion picture data was transformed into heat-transfer coefficients by a method developed at the Boeing Company.[1,2] This transformation results in a series of h vs time curves, one for each color change, and is shown in Fig. 2.

These curves are used by ascertaining the color-change time for an area of interest and by referring to the curves. If the area goes through three color changes, three coefficients will be obtained that will or should be essentially the same.

The experimental results are compared with theory in Fig. 3. It can be seen that these results agree well with laminar

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† Distributed by the H. V. Hardman Company, Belleville, N. J.

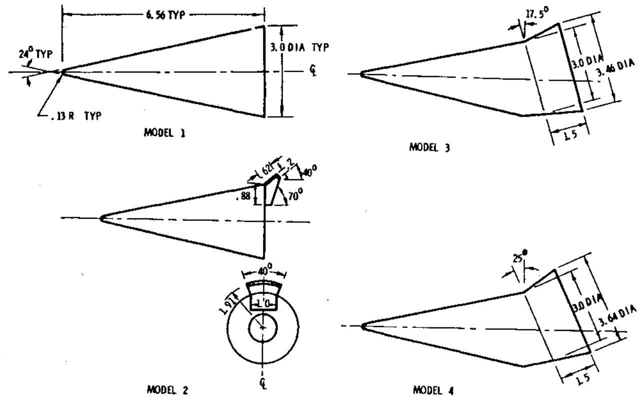

Fig. 1 Model configuration.

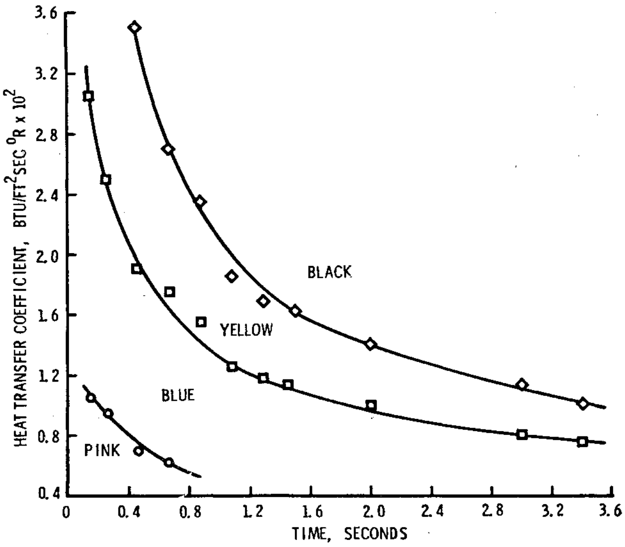

Fig. 2 Calibration curves.

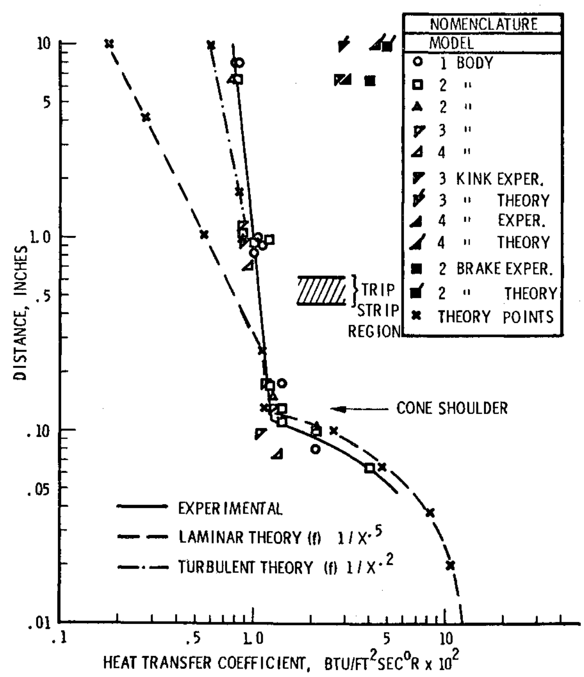

Fig. 3 Comparison of test results with theory.

cone theory‡ in the region upstream of the trip strip and with turbulent theory downstream. (schlieren photographs show that turbulent flow existed behind the trip strip.) The results for the various control surfaces can be summarized as follows: 1) the 17.5° kink model shows an increase in centerline heat transfer of 3.4 times the straight cone value; 2) the 25° kink model shows an increase of 3.75 times the straight cone value; and 3) the air brake tab model shows a factor of 5. There is also good agreement between these values and those generated from $(h_{cone}/h_{tab}) = (p_{cone}/p_{tab})^{4/5}$ with the pressures based upon theoretical values from the cone tables.

References

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‡ Eckert's reference temperature method.

Preliminary Results on Boundary-Layer Stability on a Flexible Plate

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THE effect of flexible walls on the stability of plane Poiseuille flow was presented in Ref. 1. The same numerical procedure was used to solve the stability of the laminar boundary layer on a flat plate whose surface is flexible. This note contains stability diagrams for the Tollmein-Schlichting mode modified by flexibility and preliminary results on the other modes.

The wall is a membrane of mass M stretched with tension T, and has a damping coefficient D. The flexible surface is assumed to remain in the position of a rigid wall until a small disturbance is introduced into the laminar boundary layer. The resultant pressure fluctuations produce oscillations of the wall which in turn alter the stability of the flow. Because the wall is now in motion, several other modes of instability appear in addition to the Tollmein-Schlichting waves.

The Orr-Sommerfeld equation was solved numerically for the eigenvalue c by the procedure outlined in Ref. 2 for each value of the wave number α and Reynolds number R. The boundary conditions specifying no slip at the wall are:

$$\zeta(d^3\phi/dy^3) + \phi = 0 \quad (1)$$

$$c(d\phi/dy) = -2.6564\phi \quad (2)$$

where

$$\zeta^{-1} = \left[K_2R + \frac{2.6564}{c}\right]\alpha^2 - i\left[\frac{K_3\alpha^3}{c} - m\alpha^3c\right] \quad (3)$$

In addition,

$$\left.\begin{array}{ll} K_2 = D/\rho_\infty u_\infty & K_3 = T/\mu_\infty u_\infty \\ m = Mu_\infty/\mu_\infty & R = \rho_\infty u_\infty\delta/\mu_\infty \end{array}\right\} \quad (4)$$

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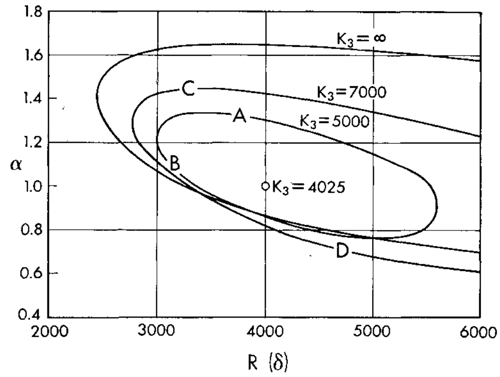

Fig. 1 Neutral stability curves for disturbances of wave-length $2\pi/\alpha$ as a function of Reynolds number for various values of wall tension. Blasius velocity profile on a flexible wall with $K_2 = m = 0$.

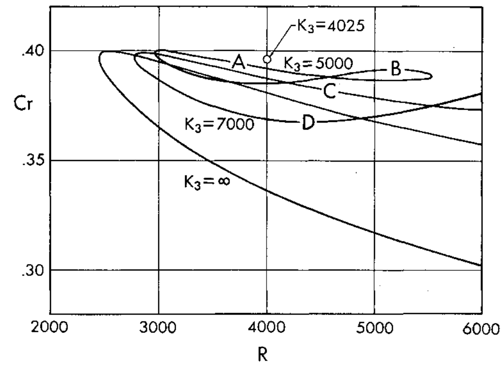

Fig. 2 Neutral stability curves for the wave propagation velocity c_r of disturbances as a function of Reynolds number for various values of wall tension. Blasius velocity profile on a flexible wall with $K_2 = m = 0$.

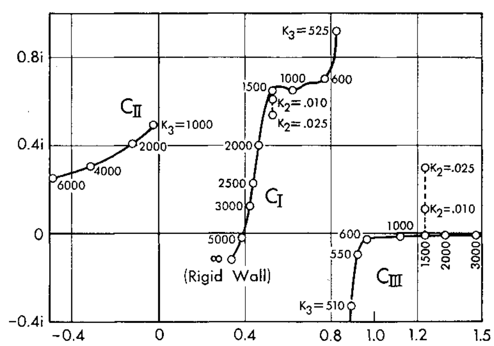

Fig. 3 Eigenvalues as a function of wall tension and damping. $\alpha = 1$, $R = 5000$, $m = 0$, and, unless specified otherwise, $K_2 = 0$.

where ρ_∞, u_∞, and μ_∞ are the freestream density, velocity, and viscosity, respectively. All lengths have been nondimensionalized with respect to the boundary-layer thickness δ.

The neutral stability curves for the wave number and the propagation speed are shown in Figs. 1 and 2, respectively, for the Tollmein-Schlichting waves over walls with increasing flexibility. The quantity K_3 has been nondimensionalized without the use of the thickness δ so that the change in Reynolds number must be interpreted as a change in δ only. The stability curves form closed loops and shrink until they disappear at a finite value of K_3. The curves probably do not form closed loops, but only shift to higher R if they are cross-plotted to allow change in R by variation of one of the other quantities such as u_∞. Preliminary results using double pre-