where the enthalpy of the fluid relative to that of its ideal gas at constant temperature $[(H_i - H)/T]_T$ is obtained from tables in Hougen, et al [2]

At the fusion point the enthalpy of the saturated liquid was defined as zero Along the triple-point line the enthalpy change is

$$\Delta H = T_f \, \Delta S \tag{8}$$

The enthalpy of solid-vapor mixtures below the fusion temperature was derived by iteration of the equation

$$H_{\text{mix}} = QH + (1 - Q)H \tag{9}$$

Specific volume data for the vapor phase were derived via the Wohl equation[5]:

$$P = \frac{RT}{V - B} - \frac{A}{T\ V(V - B)} + \frac{C}{V^3 T^{4/3}} \tag{10}$$

where $A = 6V^2P$, $B = 0\ 25\ V$, $C = 4V^3P$, and $R = 0\ 2329$ lb-ft³/in ²-lbm-°R, with other symbols as defined under Nomenclature Equation (10) was solved by iteration with the help of a high-speed computer In the two-phase region, the specific volume of the saturated liquid was included in the computations

Results

The data developed is presented as a temperature-entropy diagram in Fig 1 The accuracy of the data is estimated to be within 0 5% near the ambient conditions The accuracy decreases when temperature and pressure approach and exceed the critical values, with a possible deviation of about 2%

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Wake Transition

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In this note, a correlation for hypersonic wake transition based on the freestream Mach number M_∞ and the freestream transition Reynold number $R_{\infty X_t}$ is made using the new wake data published by Avco/RAD,[1] some unpublished data by the Naval Ordnance Laboratory (NOL)[2 3] made available to this author, and data published previously by Massachusetts Institute of Technology (MIT)[4 5] and Graduate Aeronautical Laboratory, California Institute of Technology [6] The Avco/RAD data were obtained in a ballistic range with conical models of 10°, 15°, and 27½° half-angles The model velocities range between 4000 and 17,000 fps, and range pressures vary from 15 to 380 mm Hg in air The NOL data are for conical models of 6 3° and 8° half-angles, Mach numbers ranging from 8 to 14 7, and range pressures varying from 80 to 100 mm Hg in air

Slattery and Clay,[4 5] by plotting the transition distance vs a normalized pressure $P_N(P_N = p_\infty d/0\ 5)$, were able to reduce their transition data to curves roughly dependent only on P_N but independent of projectile velocity However, when the new data are plotted (Fig 1), they cannot be reduced in the same manner Therefore, certain dependence of the transition distance on the flight velocity is indicated by these new data

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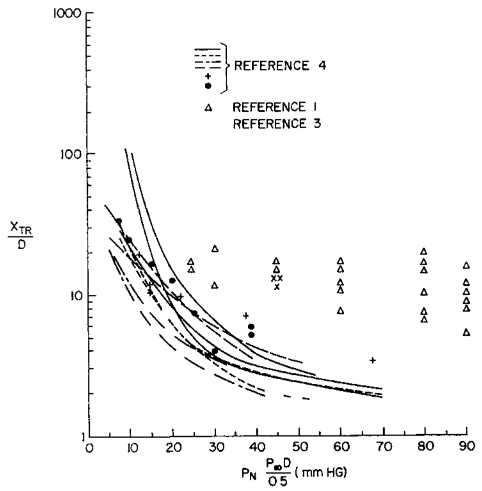

Fig 1 Variations of X_t/d with "normalized" pressure

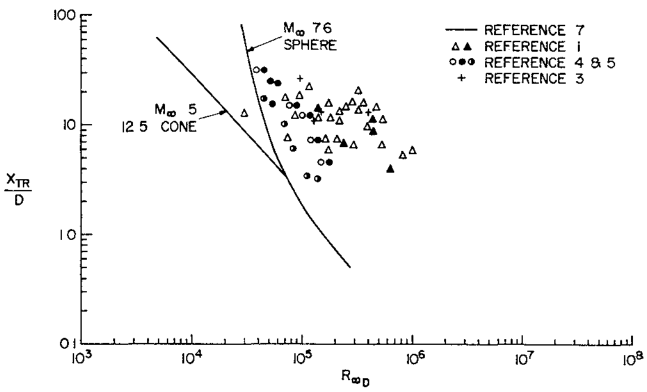

Fig 2 Variations of X_t/d vs $R_{\infty d}$

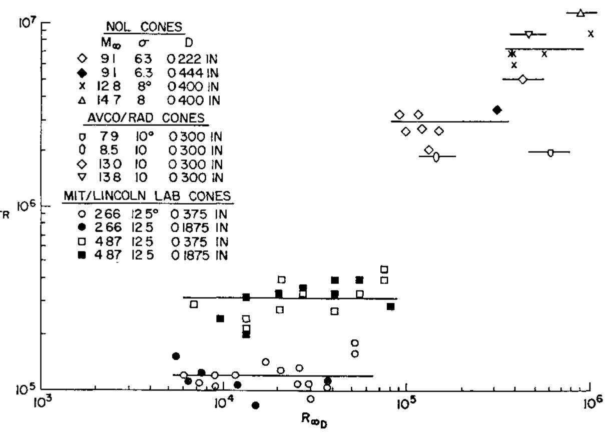

Fig 3 Variations of $R_{\infty X_t}$ vs $R_{\infty d}$ for cones (from Ref 2)

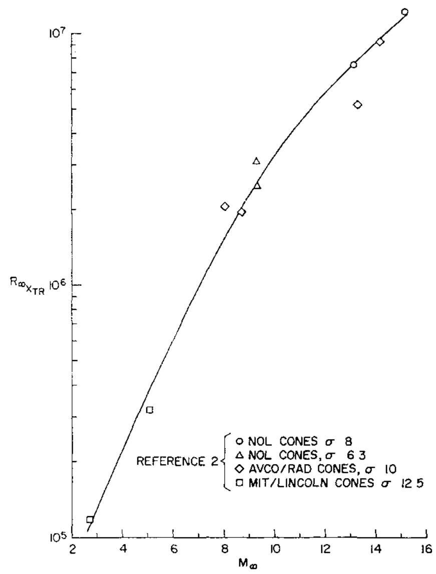

Fig 4 Variations of $R_{\infty X_t}$ vs M_∞ foı cones

In Refs 6 and 7, the conclusion has been arrived at that a constant transition Reynolds number (based on either the freestream or local conditions) exists in the region $X_t/d < 30$ but has different values for sharp and blunt bodies When the new data are plotted in a similar manner ($R_{\infty d}$ vs X_t/d), it is not evident that the transition Reynolds number is constant (Fig 2)

Levensteins,[2] plotting some of the cone wake data obtained in NOL, Avco/RAD, and MIT Lincoln Laboratory as $R_{\infty X_t}$ vs $R_{\infty d}$, found that the transition Reynolds number $R_{\infty X_t}$ is independent of the body Reynolds number $R_{\infty d}$ (Fig 3) but dependent on the freestream Mach number M_∞ (Fig 4) If the MIT Lincoln Laboratory wake data for sphere[5] were replotted as $R_{\infty X_t}$ vs $R_{\infty d}$ (Fig 5), they also would show that $R_{\infty X_t}$ depends essentially on M_∞ but is independent of $R_{\infty d}$ (Fig 6)

Compaıison of the cone and the sphere data (Fig 6) further shows that the difference of $R_{\infty X_{tr}}$ between the cone and the sphere increases with increasing Mach number For $M_\infty > 14$, $R_{\infty X_t}$ stays near 10^7 for cone and 10^6 for sphere, indicating a different wake transition characteristic for blunt and slender bodies at hypeısonic conditions

Using this correlation between M_∞ and $R_{\infty X_t}$ and extrapolation to Mach number larger than 14, the transition distance behind the base of a cone has been calculated as a function of altitude for a flight speed 20,000 fps and is shown in Fig 7 It is seen that the laminar wake can run as long as 70 ft at an altitude of 150,000 ft

It should be mentioned that, in Ref 1, a similar correlation has been made but using the local inviscid condition for the density, speed of sound, and the viscosity coefficient and local velocity difference between the inviscid and the axis conditions The wake transition distances for a 12° cone of three different body lengths at 22,000 fps have been calculated in the same reference using such correlation for altitudes equal to 200, 150, and 100 kft These results are also plotted in Fig 7 It is seen that the results of the transition distance based on these two different correlations agree with each other reasonably well between 200 and 150 kft altitude However, since the transition distance can be obtained much more readily from $M_\infty - R_{\infty X_t}$ than from the $\bar{M}_1 - \bar{R}_{X_t}$ correlation once the freestream conditions are given, the $M_\infty - R_{\infty X_{tr}}$ correlation offers a convenient way for reasonable transition estimate without having to go through elaboıate numerical procedure to obtain the local conditions

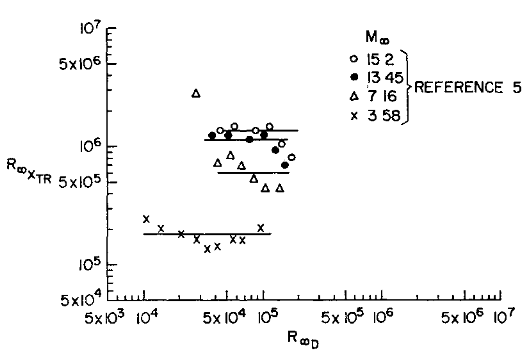

Fig 5 Variations of $R_{\infty X_t}$ with $R_{\infty d}$ for spheıes

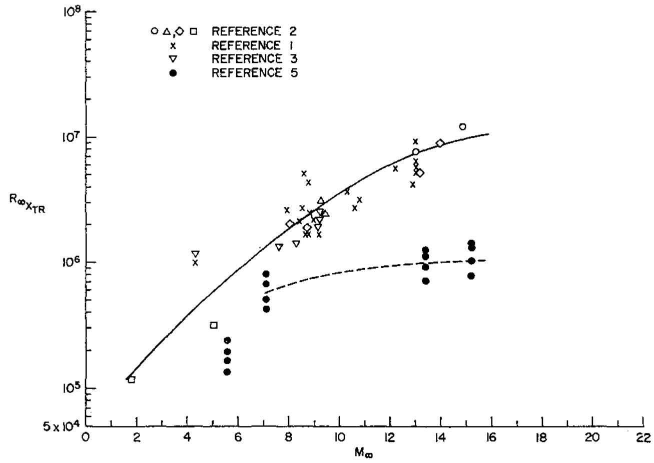

Fig 6 Vaıiations of R_∞ vs M_∞ foı cones and spheıes

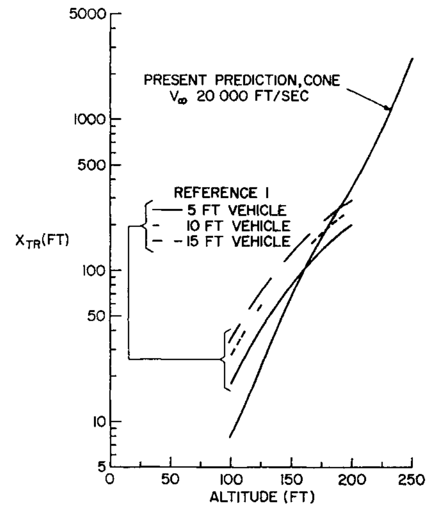

Fig 7 Pıedicted wake transition distance as function of altitude for cones

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