Since propellant sloshes in the upper portion of the liquid, and since sloshing masses do not change considerably for values of $h/a > 1$, the experimental values of Ref 2 can be used for comparison with the theoretical results (Fig 3) and show good agreement

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Relative Magnitudes of the Space-Environment Torques on a Satellite

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ONE of the prerequisites for the design of a controlled orientation satellite is a knowledge of the torques due to the space environment Although the various space environment torques must be evaluated for each satellite design, nevertheless it is possible to gain an understanding of the relative magnitudes of the various influences by computing the torques on a typical satellite

The configuration selected for the comparison of torques was a 5-ft-diam circular cylinder 30 ft in length having the inertia characteristics indicated in Fig 1 Assuming that the vehicle is in a circular orbit, the torques are presented in Fig 2 as a function of altitude from 100 to 1000 naut miles Torques due to particle impingment were evaluated for the cylinder normal to the stream and a separation of the center of mass and center of pressure of 1 ft The gravity gradient torque was evaluated for an angle of 1° between the cylinder axis of symmetry and the earth radius vector The vehicle is assumed to have mass symmetry about the cylinder axis of symmetry The torque due to the magnetic field was computed assuming a 1-amp electric current in a single loop of wire around the length of the cylinder oriented to give the maximum torque (i e , the normal to the plane of the loop is perpendicular to the magnetic field vector)

Atmospheric density values were obtained from Ref 1 The value of the solar constant and the earth's magnetic field intensity were obtained from Ref 2 The cosmic dust torque was estimated using a nominal value of $1\ 5 \times 10^{-20}$ g/cm^3 for the density of the dust cloud surrounding the earth as reported in Refs 2–5

The methods for computing aerodynamic, solar radiation, and gravity gradient torques are presented in Refs 6–8, respectively Aerodynamic torques were computed using free-molecule flow theory Molecules were assumed to be reflected diffusely with a kinetic energy corresponding to a wall temperature of 500°R Solar radiation torques were computed using a reflectance of one

It is suggested in Ref 9 that electrodynamic and magnetohydrodynamic effects can also be important in the 100- to 1000-naut-mile altitude range However, these phenomena are not well understood, and little agreement exists between the various theories [9] For these reasons, these effects are omitted

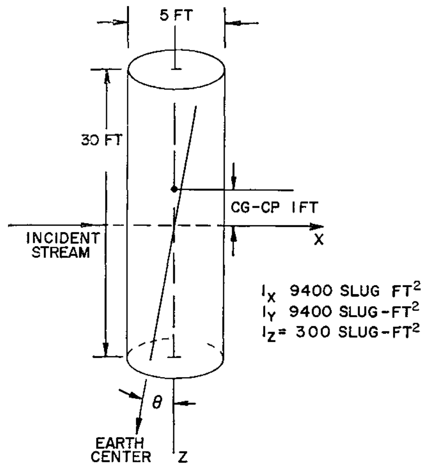

Fig 1 Satellite configuration

Figure 2 presents the comparison of the maximum torques on a cylindrical configuration It is easily seen that below 200 naut miles aerodynamic torques dominate, whereas above 300 naut miles gravity gradient torques are largest For one amp-turn around the length of vehicle, magnetic field torques are of the same magnitude as gravity gradient torques However, with sufficient electrical power, magnetic field torques can be made as large as desired Aside from gravity gradient and magnetic torques, solar radiation torque is the largest torque above about 550 naut miles Cosmic dust torques may be as large as aerodynamic torques in the neighborhood of 1000 naut miles

Note that all of the moments are linear in the parameter noted on Fig 2, including gravity gradient up to about 15° For example, to obtain the gravity gradient torque for θ = 10°, multiply the curve on Fig 2 by 10; for $CG - CP$ = 3 ft, multiply the proper curve by 3, etc It should be

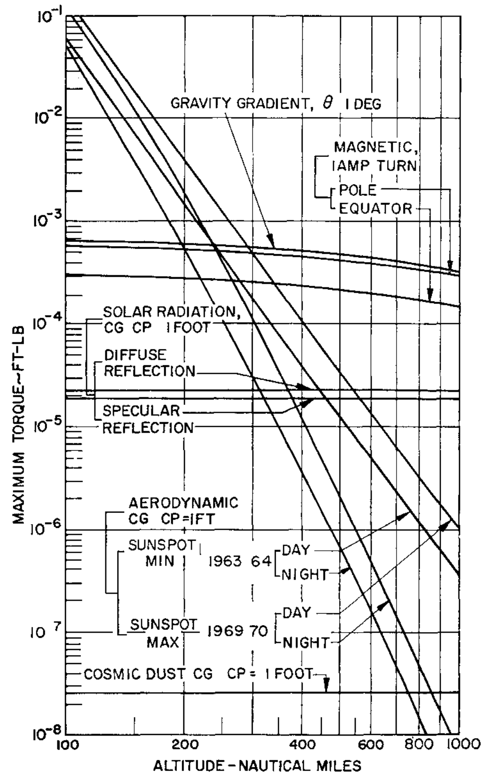

Fig 2 Relative magnitudes of the environmental torques on an earth satellite

Received January 15, 1964

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pointed out that, although solar radiation torques are an order of magnitude smaller than gravity gradient torques, solar radiation torques are nearly always oscillatory for earth satellites and may act as a forcing function to drive a gravity gradient stabilized satellite beyond its designed attitude envelope

Note also that, for an interplanetary craft, i e , one for which gravity gradient, magnetic, and aerodynamic torques are absent, solar radiation torque is the dominant space environment effect

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Boundary-Layer Transition on a Slender Cone in Hypersonic Flow

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In this note the author presents new experimental data on boundary-layer transition on a slender flared cone in hypersonic flow The importance of the knowledge of the state of the boundary layer (i e , laminar, transitional, or turbulent) hardly can be overemphasized Drag, performance, and heat-transfer rates depend on the location of transition on the surface of a body in flight While the effects of freestream turbulence, pressure gradients, surface curvature, surface roughness, and heat transfer on transition are at least known qualitatively, the effect of compressibility in the high Mach number range is still a subject of speculation At low supersonic Mach numbers various wind tunnel tests indicate a general decrease of transition Reynolds number with increasing Mach number [1 2]

Korkegi[3] conducted some transition studies on an insulated flat plate $M = 5\ 8$ which give some insight as to the effects of compressibility In particular, a very high transition Reynolds number based on distance along the plate, in excess of 5×10^6, was noted along with the inability of various disturbances to trip transition at low Reynolds numbers This appears to indicate greater stability of the laminar boundary layer in hypersonic flow than at lower speeds Zakkay et al [4] have investigated the effects of surface discontinuities on transition However, upstream of the discontinuity, for the range of test conditions considered, transition Reynolds numbers based on momentum thickness Re_θ on cones at Mach numbers of 3–5 were observed to be in the range of 600–700

The data presented in this note are the partial results of more complete model tests The data were taken on a slightly blunted (ratio of base-to-nose radius $R_0/R_N = 150$) 3 5° half-angle cone with a flared skirt (Fig 1) and a model length of 52 in Thus, for all practical purposes, the cone can be considered as pointed Surface pressures and transient temperatures giving heat flux were measured The fore-

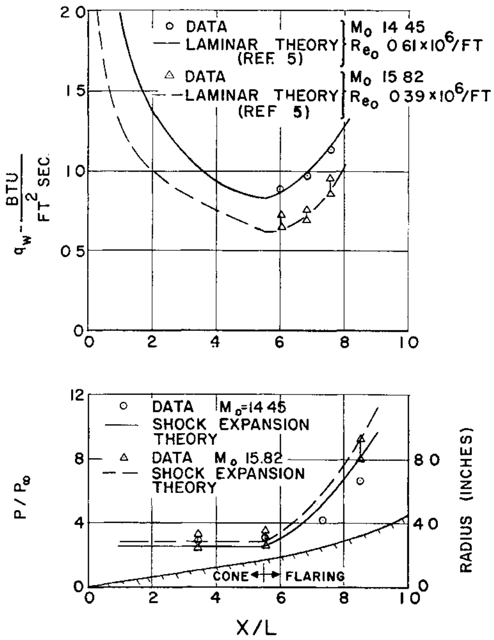

Fig 1 Pressure and heat-transfer distribution for M = 14 45 and 15 82

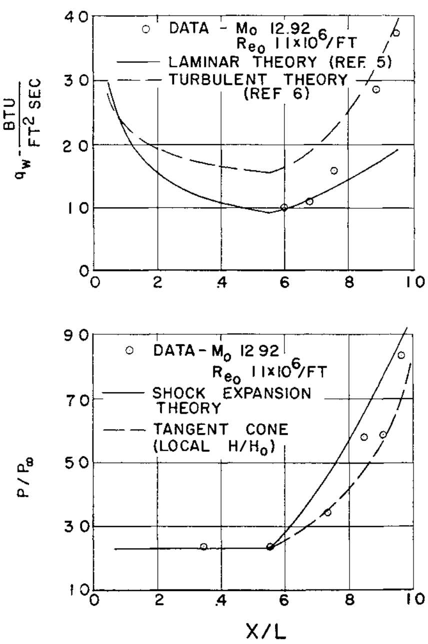

Fig 2 Pressure and heat-transfer distribution for M = 12 92

Received January 13, 1964 This paper presents the partial results of more complete research carried out at General Applied Science Laboratories under Contract No AF 33(657) 7911, sponsored by the Aeronautical Systems Division Technical monitoring was done by William L Woodruff, AeroPropulsion Laboratory

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