SC-R-64-1311

Sandia Corporation

MASTER

..... MONOGRAPH

A COMPILATION OF LONGITUDINAL AERODYNAMIC
CHARACTERISTICS INCLUDING PRESSURE
INFORMATION FOR SHARP- AND BLUNT-NOSE
CONES HAVING FLAT AND MODIFIED BASES

Compiled by

A. D. Foster

PATENT CLEARANCE OBTAINED. RELEASE TO
THE PUBLIC IS APPROVED. PROCEDURES
WILL BE ON FILE IN THE RECEIVING SECTION.

JANUARY 1965

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Published by
Sandia Corporation
a prime contractor to the
United States Atomic Energy Commission

—LEGAL NOTICE—

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

Printed in USA. Price \$8.96. Available from
Clearinghouse, Department of Commerce,
Springfield, Virginia 22151

SANDIA CORPORATION MONOGRAPH

A COMPILATION OF LONGITUDINAL AERODYNAMIC CHARACTERISTICS INCLUDING
PRESSURE INFORMATION FOR SHARP- AND BLUNT-NOSE CONES
HAVING FLAT AND MODIFIED BASES

(SC-R-64-1312 is a classified supplement to this monograph)

Compiled by

A. D. Foster, 7421-2

January 1965

†

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

ACKNOWLEDGMENT

The author wishes to express his thanks to the Design Definition Section C III for their effort in the inking of the figures in this report and to the Technical Information Section for their effort in the production of this report.

ABSTRACT

Only a limited amount of aerodynamic information is available on generalized cone geometries over a wide range of Mach number and angle of attack. This report presents an accumulation of a large amount of these unclassified cone stability and pressure data by order of the cone half-angle. Both experimental and theoretical data are included. A bibliography is also included which consists of several references to sources containing theoretical and/or experimental data on the aerodynamic characteristics of cones.

TABLE OF CONTENTS

	Page
NOMENCLATURE	
English	24
Greek	35
CHAPTER I. INTRODUCTION	39
CHAPTER II. RESULTS AND DISCUSSION	39
List of References	577

LIST OF ILLUSTRATIONS

<u>Figure</u>	<u>Page(s)</u>
1. Variation of Reynolds Number Per Foot with Mach Number for Tests of Bodies of Revolution of Fineness Ratios 3 and 5.	69
2. The Variation of the Foredrag Coefficient at Zero Lift of a Fineness Ratio 3 Cone.	70
3. The Variation of the Foredrag Coefficient at Zero Lift of Cones, 3/4-Power, 1/2-Power, 1/4-Power, and Tangent-Ogive Bodies Having Fineness Ratios of 3 and/or 5.	71
4. The Ratios of Foredrag Coefficients of Fineness Ratio 3 and 5 Bodies to Foredrag Coefficients of Cones as Functions of the Exponent, n , in the Equation Defining Body Shapes.	72
5. Profiles of Fineness Ratio 3 Bodies of Revolution.	73
6. Variation of Reynolds Number Per Foot with Mach Number for Tests of Bodies of Revolution of Fineness Ratio 3.	74
7. The Variation of Lift Coefficient with Angle of Attack, with Drag Coefficient, and with Center of Pressure for Cones of Fineness Ratios 3, 4, 5, and 7 at Various Mach Numbers.	75-77
8. Variation of the Lift-Drag Ratio with Lift Coefficient for Cones of Fineness Ratios 3, 4, 5 and 7 at $M = 4.01$.	78
9. Variation of the Lift-Drag Ratio with Lift Coefficient for a Cone of Fineness Ratio 5 at Various Mach Numbers.	79
10. The Variation of Lift Coefficient with Angle of Attack, with Drag Coefficient, and with Center of Pressure for Various Fineness Ratio 3 Bodies at Various Mach Numbers.	80-82
11. Variation of the Lift-Drag Ratio with Lift Coefficient for Various Fineness Ratio 3 Bodies at Various Mach Numbers.	83-85
12. Variation of Lift Coefficient with Angle of Attack, with Drag Coefficient, and with Center of Pressure for Various Fineness Ratio 5 Bodies at $M = 4.01$.	86
13. Variation of the Lift-Drag Ratio with Lift Coefficient for Various Fineness Ratio 5 Bodies at $M = 4.01$.	87
14. Comparison of Theoretical and Experimental Aerodynamic Force Characteristics of Cones Having Fineness Ratios of 3 and 5 for Various Mach Numbers.	88-90
15. Sketches of Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.	95
16. Range of Mach Numbers and Reynolds Numbers of Experimental Testing of Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.	96

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>	<u>Page(s)</u>
17. Variation of Total Drag Coefficient with Mach Number for Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.	97
18. The Effect of Bluntness on Total Drag Coefficient for Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.	98
19. The Effect of Bluntness on Total Drag Coefficient Based on Volume to the Two-Thirds Power for Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.	99
20. Variation of Wave Drag Coefficient with Bluntness for Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.	100
21. Variation of Wave Drag Coefficient with Mach Number for a Hemisphere.	101
22. Sketch Showing Pressure Orifice Locations and Dimensions of 5° and 10° Half-Angle Sharp- and Blunt-Nose Cones.	102
23. Variation of Induced Static Pressure Ratio with Distance from Leading Edge of 5° Half-Angle Cones at Various Free-Stream Mach Numbers and Values of Reynolds Number, R_d .	103-106
24. Variation of Induced Static Pressure Ratio with Distance from Leading Edge of 10° Half-Angle Cones at Various Free-Stream Mach Numbers and Values of Reynolds Number, R_d .	107-110
25. Sketch Showing Pressure Orifice Locations and Dimensions of 5° and 10° Half-Angle Sharp-Nose Cones.	111
26. Variation of Reynolds Number with Mach Number for Various Stagnation Pressures and Constant Stagnation Temperature. $T_o = 545^\circ R$.	112
27. Variation of Surface Pressure to Stagnation Pressure Ratio for a 5° Half Angle Cone.	113
28. Variation of Induced Static Pressure Ratio with $1/\sqrt{R_{x,L}}$ for a 5° Half-Angle Cone.	114
29. Variation of Induced Static Pressure Ratio with Hypersonic Interaction Parameter, $\bar{X}$, for a 5° Half-Angle Cone.	115
30. Variation of Surface Pressure to Stagnation Pressure Ratio for a 10° Half-Angle Cone.	116
31. Variation of Induced Static Pressure Ratio with $1/\sqrt{R_{x,L}}$ for a 10° Half-Angle Cone.	117
32. Variation of Induced Static Pressure Ratio with Hypersonic Interaction Parameter, $\bar{X}$, for a 10° Half-Angle Cone.	118
33. Sketch Showing Force Model Conventions.	119
34. Sketch Showing Dimensions of 6° 30' Half-Angle Cones Having Two Nose Bluntness Ratios.	120
35. Sketch Showing Dimensions of 9° Half-Angle Cones Having Two Nose Bluntness Ratios.	121
36. Variation of Aerodynamic Characteristics with Angle of Attack for a 6° 30' Half-Angle Cone Having a Nose Bluntness Ratio of 0.03.	122-125

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>	<u>Page(s)</u>
37. Variation of Aerodynamic Characteristics with Angle of Attack for a $6^{\circ} 30'$ Half-Angle Cone Having a Nose Bluntness Ratio of 0.145.	126-129
38. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having a Nose Bluntness Ratio of 0.03.	130-133
39. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having a Nose Bluntness Ratio of 0.30.	134-137
40. Variation of Aerodynamic Characteristics with Angle of Attack for a $6^{\circ} 30'$ Half-Angle Cone Having a Nose Bluntness Ratio of 0.03 for Different Mach Numbers.	138-141
41. Sketch Showing Pressure Orifice Locations and Dimensions of a $6^{\circ} 20'$ Half-Angle Cone Having Three Nose Bluntness Ratios.	145
42. Sketch Showing Pressure Orifice Locations and Dimensions of a 9° Half-Angle Cone Having Three Nose Bluntness Ratios.	146
43. Sketch Showing General Cone Nomenclature.	175
44. Cone Pressure Distributions for Bluntness Ratios ≥ 0.3 Along with Comparison of Assumed and Actual Cone Pressure Distributions for Bluntness Ratios ≤ 0.03 .	176
45. Variation of Total Zero-Lift Drag with Viscous Parameter for a 9° Half-Angle Blunt-Nose Cone at a Free-Stream Mach Number of 19.	177
46. Comparison of Theoretical and Experimental Forebody Drag in Continuum Flow Regime for a 6.34° Half-Angle Cone.	178
47. Comparison of Theoretical and Experimental Forebody Drag in Continuum Flow Regime for a 9° Half-Angle Cone.	179
48. Comparison of Theoretical and Experimental Forebody Drag in Continuum Flow Regime for a 13.5° Half-Angle Cone.	180
49. Comparison of Hypersonic, Cold Wall, Viscous Drag of Blunt, Slender Cones in Continuum and Rarefied Flow Regimes.	181
50. Sketch of 9° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base and Spherical Segment Afterbodies.	186
51. Variation of Normal Force, Axial Force and Pitching-Moment Coefficients with Angle of Attack for 9° Half-Angle Cones Having a Flat Base with Various Nose Bluntness Ratios. $M = 6.77$.	187
52. Variation of Lift and Drag Coefficients and Lift-Drag Ratio with Angle of Attack for 9° Half-Angle Cones Having a Flat Base with Various Nose Bluntness Ratios. $M = 6.77$.	188

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>	<u>Page(s)</u>
53. Variation of Normal Force, Axial Force and Pitching-Moment Coefficients with Angle of Attack for 9° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base and Spherical Segment Afterbodies. $M = 6.77$.	189-191
54. Variation of Lift and Drag Coefficients and Lift-Drag Ratio with Angle of Attack for 9° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base. $M = 6.77$.	192-194
55. Comparison Between Theory and Experiment for $C_{m\alpha}$, $C_{L\alpha}$, $(L/D)_{\max}$, and $(C_L)_{\max}$ for Various Bluntness Ratios. $M = 6.77$.	195
56. Sketch Showing Dimensions of 9° Half-Angle Cones Having Three Nose Bluntness Ratios.	196
57. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $Re/in. = 0.150 \times 10^6$.	197-199
58. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $Re/in. = 0.092 \times 10^6$.	200-202
59. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $Re/in. = 0.037 \times 10^6$.	203-205
60. Effect of Nose Bluntness on the Aerodynamic Characteristics of a 9° Half-Angle Cone at a Mach Number of 7.31 and a $Re/in. = 0.150 \times 10^6$.	206-208
61. Effect of Nose Bluntness on the Aerodynamic Characteristics of a 9° Half-Angle Cone at a Mach Number of 7.31 and a $Re/in. = 0.037 \times 10^6$.	209-211
62. Variation of Aerodynamic Characteristics with Bluntness Ratios for a 9° Half-Angle Cone at Various Angles of Attack and Reynolds Number. $M = 9.04$.	212-214
63. Effect of Mach Number and Reynolds Number on the Aerodynamic Characteristics of a 9° Half-Angle Cone at Various Angles of Attack.	215-217
64. Comparison Between the Isothermal Condition of the Model (Cold Wall) and the Free-Stream Tunnel Conditions (Hot Wall) for a 9° Half-Angle Cone. $M = 9.04$.	218-220
65. Effect of Reynolds Number on the Aerodynamic Characteristics of a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $M = 9.04$.	221-223
66. Effect of Bluntness Ratio on the Normal Force Curve Slope and on the Pitching-Moment Curve Slope for a 9° Half-Angle Cone at Two Reynolds Numbers. $M = 9.04$.	224
67. Effect of Reynolds Number on the Axial Force Coefficient of a 9° Half-Angle Cone at an Angle of Attack of Zero Degrees for Constant Bluntness Ratios and Mach Numbers.	225
68. Effect of Reynolds Number on the Axial Force Coefficient of a 9° Half-Angle Cone at an Angle of Attack of 15 Degrees for Constant Bluntness Ratios and Mach Numbers.	226

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>	<u>Page</u>
69. Comparison Between Theory and Experiment of the Normal Force Coefficient Variation with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $M = 9.04$.	227
70. Comparison Between Theory and Experiment of the Pitching-Moment Coefficient Variation with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $M = 9.04$.	228
71. Comparison Between Theory and Experiment of the Axial Force Coefficient at $\alpha = 0^\circ$ Versus the Free-Stream Reynolds Numbers for a 9° Half-Angle Cone. $M = 9$.	229
72. Sketch of a 9° Half-Angle Sharp-Nose Cone Model.	230
73. Comparison of Theoretical and Experimental Normal Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.79$. $Re/in. = 8740$.	231
74. Comparison of Theoretical and Experimental Normal Force Coefficient with Angle of Attack for a 9° Half-Angle Cone. $M = 4.05$. $Re/in. = 2670$.	232
75. Comparison of Theoretical and Experimental Axial Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.78$. $Re/in. = 8650$.	233
76. Comparison of Theoretical and Experimental Axial Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 4.05$. $Re/in. = 2580$.	234
77. Comparison of Theoretical and Experimental Pitching-Moment Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.83$. $Re/in. = 8940$.	235
78. Comparison of Theoretical and Experimental Pitching-Moment Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 4.06$. $Re/in. = 2630$.	236
79. Variation of Experimental Normal Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.48$. $Re/in. = 4460$.	237
80. Variation of Experimental Normal Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 3.89$. $Re/in. = 1510$.	238
81. Variation of Experimental Axial Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.47$. $Re/in. = 4610$.	239
82. Variation of Experimental Axial Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 3.87$ and 3.90 . $Re/in. = 1520$.	240
83. Variation of Experimental Pitching-Moment Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.52$. $Re/in. = 4370$.	241
84. Variation of Experimental Pitching-Moment Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 3.85$. $Re/in. = 1550$.	242

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>		<u>Page</u>
85.	Sketch of Spherically Blunted and Flat-Nosed 9° Half-Angle Cones.	243
86.	Shock Shapes Over Slender Blunted (5° and 9.1° Half-Angle) Cones.	244
87.	Shock Shapes Over Slender Blunted Cones in Terms of Cheng's Correlation Parameters.	245
88.	Shock Shapes Over a Spherically Blunted Cone at $M_\infty = 18.9$.	246
89.	Pressure Distribution Over a Spherically Blunted 9.1° Half-Angle Cone.	247
90.	Pressure Distribution Over a Flat-Nosed 9° Half-Angle Cone.	248
91.	Pressure Distribution Over Slender Blunted Cones.	249
92.	Sketch Showing Dimensions and Surface Pressure Tap Location for a 9° Half-Angle Sharp- and Blunt-Nose Cone.	250
93.	Base Pressure Orifice Locations and Average Base Pressure Values from Experiment on a 9° Half-Angle Cone.	251
94.	Experimental Base Pressure Data on a 9° Sharp- and Blunt-Nose Cone.	252
95.	Comparison of Experimental Base Pressure Data and Empirical Theories for Sharp Cones.	253
96.	General Correlation Curve Based on Data from Figure 94.	254
97.	Examples of Shear Layers on 9° Half-Angle Sharp and Blunt Cones.	255
98.	Comparison of Experimental Base Pressure to Surface Pressure Ratio with that from Empirical Theory for a 9° Half-Angle Sharp- and Blunt-Nose Cone.	256
99.	Variation of Base Pressure to Free-Stream Static Pressure Ratio with Mach Number for a 9° and a 30° Half-Angle Blunt-Nose Cone.	257
100.	Sketch of a 9° 32' Half-Angle Sharp-Nose Cone Having a Flat Base.	258
101.	Ballistic Normal Force Coefficient Versus Mach Number for a 9° 32' Half-Angle Sharp-Nose Cone.	259
102.	Normal Force Center of Pressure Versus Mach Number for a 9° 32' Half-Angle Sharp-Nose Cone.	260
103.	Magnus Moment and Damping Moment Coefficients Versus Mach Number for a 9° 32' Half-Angle Sharp-Nose Cone.	261
104.	Sketch of a 10° Half-Angle Sharp-Nose Cone Model.	263
105.	Variation of Normal Force Slope ($\alpha = 0^\circ$) and Center-of-Pressure with Mach Number for a 10° Half-Angle Sharp-Nose Cone.	264
106.	Sketch Showing Dimensions and Static Pressure Orifice Location for a 10° Half-Angle Conical Test Body.	265
107.	Time History of Free-Stream Mach Number and Reynolds Number of an Air-Launched Cone-Cylinder Test Vehicle.	266

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>	<u>Page(s)</u>
108. Time History of Static Pressure Measured on the Conical Portion of an Air-Launched Cone-Cylinder Test Vehicle.	267
109. Cone Static-Pressure Ratio and Cone Pressure-Drag Coefficient Versus Mach Number for a 10° Half-Angle Cone.	268
110. Sketch Showing Dimensions of 10° Half-Angle Cone-Cylinder Models and of an Ogive-Cylinder Model.	269
111. Variation of Forebody-Drag Coefficient with Lift Coefficient for an 8.5 Diameter Long Cone-Cylinder Model for Various Mach Numbers.	270-271
112. Variation of Forebody-Drag Coefficient with Lift Coefficient for an 8.5 Diameter Long Ogive-Cylinder Model for Various Mach Numbers.	272-273
113. Variation of Forebody- and Base-Drag Coefficients at Zero Angle of Attack with Mach Number for Cone-Cylinder and Ogive-Cylinder Models.	274
114. Sketch Showing General Nomenclature.	275
115. Variation of Cone Surface Mach Number and Shock Wave Angle with Free-Stream Mach Number for a 10° Half-Angle Cone.	276
116. Variation of Static Pressure and Density Ratio with Free-Stream Mach Number for a 10° Half-Angle Cone.	277
117. Sketch Showing Dimensions of a 10° Half-Angle Sharp- and Blunt-Nose Cone Having a Flat and a Spherical Segment Base.	279
118. Sketch Showing Static Pressure Orifice Locations on the Nose and on the Conical Surface of a 10° Half-Angle Blunt Nose Cone.	280
119. Comparison of Experimental and Theoretical Surface Pressure Distribution on a 10° Half-Angle Blunt-Nose Cone at a Free-Stream Mach Number of 4.74.	281
120. Momentum Thickness Reynolds Number as a Function of Free-Stream Reynolds Number per Foot for a 10° Half-Angle Sharp- and Blunt-Nose Cone.	282
121. Momentum Thickness Reynolds Number Distribution on a 10° Half-Angle Sharp-Nose Cone at a Free-Stream Mach Number of 2.74.	283
122. Momentum Thickness as a Function of Distance Along the Surface of a 10° Half-Angle Sharp- and Blunt-Nose Cone in Terms of Reynolds Number.	284
123. Base to Cone Pressure Ratio for a 10° Half-Angle Sharp- and Blunt-Nose Cone with Flat and Spherical Bases as a Function of $Re_{\theta,c}$.	285
124. Total Pressure Wake Profile for a 10° Half-Angle Blunt-Nose Cone.	286

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>	<u>Page(s)</u>
125. Variation of Wake Angle with $Re_{\theta,c}$ for a 10° Half-Angle Sharp- and Blunt-Nose Cone with Flat and Spherical Bases.	287
126. Base Pressure Distribution on a 10° Half-Angle Blunt-Nose Cone Having a Spherical Base and a Rough Surface Finish.	288
127. Local Skin Friction Coefficient as a Function of Re_θ for a 10° Half-Angle Sharp Cone.	289
128. Effect of Surface Roughness on the Base Pressure for a 10° Half-Angle Sharp- and Blunt-Nose Cone.	291
129. Sketch Showing Dimensions of a Blunt-Nose Cone Model with a Spherical Segment Base. $\theta_s \cong 11.6^\circ$.	292
130. Lift, Drag, and Pitching-Moment Coefficients for a Blunt-Nose Cone at Transonic Speeds. $\theta_s \cong 11.6^\circ$.	293
131. Sketch of $12\text{-}1/2^\circ$ Half-Angle Sharp- and Blunt-Nose Cones Having Flat and Spherical Segment Bases.	294
132. Variation of Reynolds Number with Mach Number for the Experimental Test of the $12\text{-}1/2^\circ$ Half-Angle Sharp- and Blunt-Nose Cones Having Flat and Spherical Bases.	295
133. Variation of the Dynamic Stability Characteristics with Angle of Attack for a $12\text{-}1/2^\circ$ Sharp-Nose Cone Having Flat and Spherical Bases.	296-298
134. Variation of the Dynamic Stability Characteristics with Angle of Attack for a $12\text{-}1/2^\circ$ Blunt-Nose Cone Having Flat and Spherical Bases.	299-302
135. Variation of the Static Stability Characteristics with Angle of Attack for a $12\text{-}1/2^\circ$ Half-Angle Sharp-Nose Cone Having Flat and Spherical Bases.	303-304
136. Variation of the Static Stability Characteristics with Angle of Attack for a $12\text{-}1/2^\circ$ Half-Angle Blunt-Nose Cone Having Flat and Spherical Bases.	305-306
137. Stability Derivatives and Axial-Force Coefficients Versus Mach Number at Zero Angle of Attack for a $12\text{-}1/2^\circ$ Half-Angle Sharp-Nose Cone Having Flat and Spherical Bases.	307-308
138. Stability Derivatives and Axial-Force Coefficients Versus Mach Number at Zero Angle of Attack for a $12\text{-}1/2^\circ$ Half-Angle Blunt-Nose Cone Having Flat and Spherical Bases.	309-310
139. Effect of Alternate Moment Centers on the Zero Angle of Attack Values of the Damping in Pitch for $12\text{-}1/2^\circ$ Half-Angle Sharp- and Blunt-Nose Cones Having Flat and Spherical Bases.	311
140. Effects of Sting Configuration on the Damping in Pitch for a $12\text{-}1/2^\circ$ Half-Angle Blunt-Nose Cone Having Flat and Spherical Bases.	312
141. Sketches of $12\text{-}1/2^\circ$ Half-Angle Blunt-Nose Cone Models Having a Flat Base, Variation in Base Radius, and Modifications to the Base Surface.	329-331

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>		<u>Page(s)</u>
142.	Variation of Reynolds Number with Mach Number Associated with Experimental Tests of 12-1/2° Half-Angle Blunt-Nose Cone Models.	332
143.	Variation of Static Characteristics with Angle of Attack for a 12-1/2° Half-Angle Blunt-Nose Cone; Basic Configuration.	333
144.	Variation of Damping in Pitch with Angle of Attack for a 12-1/2° Half-Angle Blunt-Nose Cone Having Various Base Radii and Base Geometries.	334-341
145.	Variation of Static Stability Derivatives at Zero Angle of Attack with Mach Number for a 12-1/2° Half-Angle Blunt-Nose Cone; Basic Configuration.	342
146.	Variation of Damping in Pitch with Mach Number for a 12-1/2° Half-Angle Blunt-Nose Cone Having a Flat Base, Various Base Radii, and Modifications to the Base Surface. $\alpha = 0^\circ$.	343
147.	Variation of Damping in Pitch with Mach Number for a 12-1/2° Half-Angle Blunt-Nose Cone Having a Flat Base, Various Base Radii, and Modifications to the Base Surface. $\alpha = 15^\circ$.	344
148.	Sketch Showing Dimensions of a 12-1/2° Half-Angle Sharp Cone Model Used in an Experimental Pressure Test.	345
149.	Spanwise Variation of the Pressure Coefficient on the Lower Forward and Aft Surface of a 12-1/2° Half-Angle Cone at Three Angles of Attack. [(a), (b), (c), and (d)]	346-349
150.	Spanwise Variation of the Pressure Coefficient on the Lower Forward Surface of a 12-1/2° Half-Angle Cone at Three Angles of Yaw.	350-351
151.	Spanwise Variation of the Pressure Coefficient on the Upper Forward Surface of a 12-1/2° Half-Angle Cone at Three Angles of Attack.	352-353
152.	Sketch Showing Dimensions of Two 15° Half-Angle Sharp Cone Models.	354
153.	Comparison of Experimental and Theoretical Total Drag Coefficient Variation with Free-Stream Reynolds Number on the Fore Portion of a 15° Half-Angle Cone.	355
154.	Viscous Drag Coefficient ($C_D - C_{D_1}$) for a 15° Half-Angle Cone Versus Free-Stream Reynolds Number.	356
155.	Variation of Measured Cone Pressure Coefficient (C_{p_c}) with Free-Stream Reynolds Number for a 15° Half-Angle Cone.	357
156.	Variation of Measured Force Coefficient (C_F) with Free-Stream Reynolds Number for a 15° Half-Angle Cone.	358
157.	Sketch Showing Pressure Orifice and Thermocouple Locations on 15° Half-Angle Sharp- and Blunt-Nose Cone Models.	367

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>	<u>Page(s)</u>
158. Heat-Transfer and Pressure Distributions on the Stagnation Line of 15° Half-Angle Sharp- and Blunt-Nose Cones at Various Angles of Attack. $M = 6$.	368-372
159. Heat Transfer and Pressure Distributions at an Angle of Attack of 0° for a 15° Half-Angle Sharp- and Blunt-Nose Cone. $M = 6$.	373
160. Pressure Coefficient on the Stagnation Line Versus Angle of Attack for a 15° Half-Angle Sharp- and Blunt-Nose Cone. $M = 6$. $Re_{\infty} = 6 \times 10^6$.	374
161. Circumferential Pressure Distributions at Various Angles of Attack for a 15° Half-Angle Sharp- and Blunt-Nose Cone. $M = 6$. $Re_{\infty} = 6 \times 10^6$.	375
162. Sketch Showing Pressure Orifice Locations on a 15° Half-Angle Conical Forebody.	376
163. Total Drag, Base Drag, and Forebody Pressure-Drag Coefficients and Typical Pressure Distributions Over the Conical Portion of a 15° Half-Angle Cone-Cylinder Model.	377
164. Comparison of Experimental and Theoretical Skin-Friction Coefficient Variation with Reynolds Number for a 15° Half-Angle Conical Forebody. $M = 2.41$.	378
165. Variation of Reynolds Number for Transition with Stagnation Pressure for a 10° Cone.	379
166. Sketch Showing Dimensions and Pressure Orifice Locations of a 15° Half-Angle Sharp Cone.	380
167. Variation of Experimental and Theoretical Surface and Base Static Pressure Ratios with Mach Number for a 15° Half-Angle Sharp Cone Having a Flat Base. [(a) and (b)]	381-382
168. Average Surface and Base Pressure Ratios Along with Theory, Versus Mach Number for a 15° Half-Angle Sharp Cone Having a Flat Base. [(a) and (b)]	383-384
169. Forward Surface and Center Base Pressure Ratios, Along with the Averaged Pressure Ratio, Versus Mach Number for a 15° Half-Angle Sharp Cone Having a Flat Base.	385
170. Variation of Reynolds Number with Mach Number Associated with the Experimental Testing of a 15° Half-Angle Sharp Cone Having a Flat Base.	386
171. Variation of the Stability Derivatives $C_{N_{\alpha}}$, C_{N_q} , and $C_{N_{\dot{\alpha}}}$ with Mach Number for a 10° Half-Angle Sharp Cone. [(a), (b), and (c)]	387-389
172. Variation of the Stability Derivatives $C_{N_{\alpha}}$, C_{N_q} , and $C_{N_{\dot{\alpha}}}$ with Mach Number for a 20° Half-Angle Sharp Cone. [(a), (b), and (c)]	390-392
173. Sketch Showing Dimensions of 20° Half-Angle Sharp- and Blunt-Nose Cone Models Having Flat Bases.	393
174. Damping-in-Pitch Derivatives Versus Angle of Attack for a Sharp- and a Blunt-Nose 20° Half-Angle Cone. $M = 8$.	394
175. Sketches of 20° Half-Angle Sharp- and Blunt-Nose Cone Models Having a Flat Base.	395

LIST OF ILLUSTRATIONS (CONTINUED)

Figure	Page(s)
176. Pitching-Moment, Axial Force, and Normal Force Coefficients Versus Angle of Attack for 20° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base. $M = 8$.	396
177. Variation of Lift and Drag Coefficients and Lift-Drag Ratio Versus Angle of Attack for 20° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base. $M = 8.0$.	397
178. Comparison of Experimental and Theoretical Values of Pitching-Moment and Normal Force Coefficients Versus Angle of Attack for 20° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base. $M = 8.0$.	398
179. Subsonic Laminar Skin-Friction Correction Factor for Slender Cones (Half-Angles Less than 20°). $\alpha = 0^\circ$.	399
180. Subsonic Turbulent Skin-Friction Correction Factor for Slender Cones (Half-Angles Less than 20°). $\alpha = 0^\circ$.	400
181. Relations Between Free-Stream Conditions and Conditions at the Surface of Sharp Cones (Shock Attached, $M_1 \geq 1$) Versus Cone Half-Angle. $\alpha = 0^\circ$. [(a), (b), and (c).]	401-403
182. Sonic Wave Drag of Cones. $\alpha = 0^\circ$.	404
183. Comparison of Theoretical Transonic and Supersonic Wave Drag of Thick Pointed Cone Cylinders with Cone Half-Angles of 20° and 35° with Some Experimental Data.	405
184. Wave Drag of Hemispheres. $\alpha = 0^\circ$.	406
185. Wave Drag of Slender Pointed Cones.	407
186. Regions of Applicability of Rules for Cone Wave Drag.	408
187. Stagnation Pressure Coefficient Across a Normal Shock.	409
188. Slope of the Normal Force Coefficient Curve for Various Cone Half-Angles and Free-Stream Mach Numbers. [(a) and (b).]	410-411
189. Sketch Showing General Cone Nomenclature for Sharp- and Blunt-Nose Cones Having Spherical Segment Bases.	414
190. Newtonian Drag Coefficient Versus Cone Half-Angle for Blunt-Nosed Cones Having Spherical Bases.	415
191. Variation of the Expression (W/R_b^2) Versus Cone Half-Angle for Various Sharp- and Blunt-Nose Cones Having Spherical Bases.	416
192. Variation of Fineness Ratio Versus Cone Half-Angle for Several Sharp- and Blunt-Nose Cones Having Spherical Bases.	417
193. Sketch of a Hemisphere and of a 30° Half-Angle Blunt Cone Model.	418
194. Variation of the Total Drag Coefficient with Mach Number for a Hemisphere and a 30° Half-Angle Blunt-Nose Cone.	419

LIST OF ILLUSTRATIONS (CONTINUED)

Figure	Page(s)
195. Sketch of Two Blunt-Nosed Cone Models Having Cone Half-Angles of 14.5° and 32° .	420
196. Effect of Change in Reynolds Number on the Aerodynamic Characteristics of a 14.5° Half-Angle Blunt-Nose Cone.	421-422
197. Effect of Change in Reynolds Number on the Aerodynamic Characteristics of a 32° Half-Angle Blunt-Nose Cone.	423-424
198. Aerodynamic Characteristics of a 14.5° Half-Angle Blunt-Nose Cone in Pitch for Several Mach Numbers, $R = 2.9 \times 10^6$ to 3.9×10^6 .	425
199. Aerodynamic Characteristics of a 32° Half-Angle Blunt-Nose Cone in Pitch for Several Mach Numbers, $R = 2.9 \times 10^6$ to 3.9×10^6 .	426
200. Summary of Stability and Axial-Force Characteristics of a 14.5° and a 32° Half-Angle Blunt-Nose Cone.	427
201. Effect of Angle of Attack on the Center-of-Pressure Location of a 14.5° and a 32° Half-Angle Blunt-Nose Cone.	428
202. Schematic Diagram Showing General Cone Geometry for Several Blunt-Nose Cones.	429
203. Cone Surface Pressure and Mach Number and the Drag Coefficient Along the Surface of Several Blunt-Nose Cones at Various Mach Numbers,	
(a) Bluntness, $\delta = 0.5$; $M_\infty = 3$	430-432
(b) Bluntness, $\delta = 0.5$; $M_\infty = 4$	433-435
(c) Bluntness, $\delta = 0.5$; $M_\infty = 6$	436-438
(d) Bluntness, $\delta = 0.5$; $M_\infty = \infty$	439-441
(e) Bluntness, $\delta = 1.0$; $M_\infty = 3$	442-444
(f) Bluntness, $\delta = 1.0$; $M_\infty = 4$	445-447
(g) Bluntness, $\delta = 1.0$; $M_\infty = 6$	448-450
(h) Bluntness, $\delta = 1.0$; $M_\infty = 10$	451-453
(i) Bluntness, $\delta = 1.0$; $M_\infty = \infty$	454-456
(j) Bluntness, $\delta = 1.5$; $M_\infty = 4$	457-459
(k) Bluntness, $\delta = 1.5$; $M_\infty = 6$	460-462
(l) Bluntness, $\delta = 1.5$; $M_\infty = \infty$	463-465
204. Family of Shock Waves for Several Blunt-Nose Cones at Various Mach Numbers,	
(a) Bluntness, $\delta = 0.5$; $M_\infty = 3$	466
(b) Bluntness, $\delta = 0.5$; $M_\infty = 4$	467
(c) Bluntness, $\delta = 0.5$; $M_\infty = 6$	468

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>	<u>Page(s)</u>
204. (Continued)	
(d) Bluntness, $\delta = 0.5$; $M_\infty = \infty$	469
(e) Bluntness, $\delta = 1.0$; $M_\infty = 3$ and 4	470
(f) Bluntness, $\delta = 1.0$; $M_\infty = 6$ and 10	471
(g) Bluntness, $\delta = 1.0$; $M_\infty = \infty$	472
(h) Bluntness, $\delta = 1.5$; $M_\infty = 4, 6, \text{ and } \infty$	473
205. Schematic Diagram of Supersonic Flow About a Nonlifting Cone.	474
206. Variation of Cone Half-Angle with Free-Stream Mach Number Showing Range of Applicability of Cone Solution for $\omega - \delta < 1$.	475
207. Variation of Flow Inclination Angle with Ray Angle for a 5° Half-Angle Cone Operating at Mach Numbers of 1.5058, 4.8602, and 13.196.	476
208. Variation of Flow Inclination Angle with Ray Angle for a 10° Half-Angle Cone Operating at Mach Numbers of 1.5957, 5.4223, 15.146.	477
209. Variation of Flow Inclination Angle with Ray Angle for a 20° Half-Angle Cone Operating at Mach Numbers of 1.4672, 5.5457, and 9.5928.	478
210. Variation of Flow Inclination Angle with Ray Angle for a 40° Half-Angle Cone Operating at Mach Numbers of 2.0242, 5.8336, and 13.101.	479
211. Variation of the Ratio of Local Velocity to Limiting Velocity with Ray Angle for a 5° Half-Angle Cone Operating at Mach Numbers of 1.5058, 4.8602, and 13.196.	480
212. Variation of the Ratio of Local Velocity to Limiting Velocity with Ray Angle for a 10° Half-Angle Cone Operating at Mach Numbers of 1.5957, 5.4223, and 15.146.	481
213. Variation of the Ratio of Local Velocity to Limiting Velocity with Ray Angle for a 20° Half-Angle Cone Operating at Mach Numbers of 1.4672, 5.5457, and 9.5928.	482
214. Variation of the Ratio of Local Velocity to Limiting Velocity with Ray Angle for a 40° Half-Angle Cone Operating at Mach Numbers 2.0242, 5.8336, and 13.101.	483
215. Variation of Pressure Coefficient with Free-Stream Mach Number for 5° , 10° , 20° , and 40° Half-Angle Cones.	484
216. Variation of Local Mach Number Along Ogives Corresponding to Four Values of the Similarity Parameter, K, for a Free-Stream Mach Number of 6.	485
217. Variation of Pressure Coefficient Along Ogives Corresponding to Four Values of the Similarity Parameter, K, for a Free-Stream Mach Number of 6.	486-487
218. Schematic Showing Cone Body-Axis System.	488

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>	<u>Page(s)</u>
219. Sketch Showing Dimensions of 30°, 35°, and 40° Half-Angle Blunt-Nose Cone Models.	489
220. Longitudinal Characteristics of a 30°, 35°, and 40° Half-Angle Blunt-Nose Cone Through a Wide Angle of Attack Range. $M = 24.5$.	490-492
221. Variation of the Lift Coefficient with Angle of Attack for a 30°, 35°, and 40° Half-Angle Blunt-Nose Cone. $M = 24.5$.	493
222. Variation of the Drag Coefficient with Angle of Attack for a 30°, 35°, and 40° Half-Angle Blunt-Nose Cone. $M = 24.5$.	494
223. Variation of the Lift-Drag Ratio with Angle of Attack for a 30°, 35°, and 40° Half-Angle Blunt-Nose Cone. $M = 24.5$.	495
224. Variation of the Pitching-Moment Coefficient with Angle of Attack for a 30°, 35°, and 40° Half-Angle Blunt-Nose Cone. $M = 24.5$.	496
225. Vertical Center-of-Gravity Offset Required to Trim at Various Lift Coefficients and Lift-Drag Ratios. $X_{cg}/D = 0.288$. $M = 24.5$.	497
226. Longitudinal Stability and Performance Characteristics of a 35° Half-Angle Blunt-Nose Cone as Determined From Experiments in Nitrogen and Helium and by Modified Newtonian Theory. $M = 18$ and 24.5 .	498-499
227. The Longitudinal Stability of a 35° Half-Angle Blunt-Nose Cone at Mach Numbers of 18 and 24.5 .	300
228. Sketches of Several Sharp-Nose Cone Models.	
(a) $\theta_s = 5^\circ$	501
(b) $\theta_s = 10^\circ$	502
(c) $\theta_s = 15^\circ$	503
(d) $\theta_s = 20^\circ$	504
(e) $\theta_s = 30^\circ$	505
(f) $\theta_s = 45^\circ$	506
229. Variation of Longitudinal Force Coefficients with Angle of Attack for a 5° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.	507
230. Variation of Longitudinal Force Coefficients with Angle of Attack for a 10° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.	508
231. Variation of Longitudinal Force Coefficients with Angle of Attack for a 15° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.	509
232. Variation of Longitudinal Force Coefficients with Angle of Attack for a 20° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.	510

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>		<u>Page</u>
233.	Variation of Longitudinal Force Coefficients with Angle of Attack for a 30° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_{\infty} = 6.83$.	511
234.	Variation of Longitudinal Force Coefficients with Angle of Attack for a 45° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_{\infty} = 6.83$.	512
235.	Variation of Lift-Curve Slope with Cone Half-Angle for Right Circular Cones. $M_{\infty} = 6.83$.	513
236.	Variation of Maximum Lift Coefficient and the Angle of Attack at Which it Occurs with Cone Half-Angle for Right Circular Cones. $M_{\infty} = 6.83$.	514
237.	Variation of Maximum Lift-Drag Ratio and the Angle of Attack at Which it Occurs with Cone Half-Angle for Right Circular Cones. $M_{\infty} = 6.83$.	515
238.	Variation of Lift Coefficient at the Point of Maximum Lift-Drag Ratio and Lift-Drag Ratio at the Point of Maximum Lift Coefficient with Cone Half-Angle for Right Circular Cones. $M = 6.83$.	516
239.	Variation of the Increments of Angle of Attack and Lift Coefficient Between $(L/D)_{\max}$ and $C_{L,\max}$ with Cone Half-Angle for Right Circular Cones. $M_{\infty} = 6.83$.	517
240.	Sketch Showing Several Sharp- and Blunt-Nose Cones Having Various Cone Half-Angles and Nose Bluntness Ratios.	518
241.	Nomenclature and Model Characteristics for Several Sharp- and Blunt-Nose Cone Models Having Various Cone Half-Angles and Nose Bluntness Ratios.	520
242.	Variation of Normal Force Coefficient Slope with Mach Number for Various Sharp- and Blunt-Nose Cones.	
(a)	$d/D = 0$	521
(b)	$d/D = 0.4$	522
(c)	$d/D = 0.8$	523
243.	Variation of Normal Force Coefficient Slope with Cone Half-Angle and Bluntness.	
(a)	$M = 0.68$	524
(b)	$M = 0.94$	525
(c)	$M = 1.05$	526
(d)	$M = 1.30$	527
(e)	$M = 1.50$	528
(f)	$M = 1.97$	529
(g)	$M = 2.75$	530
(h)	$M = 4.0$	531

LIST OF ILLUSTRATIONS (CONTINUED)

<u>Figure</u>		<u>Page</u>
244.	Variation of Center-of-Pressure with Mach Number for Various Sharp- and Blunt-Nose Cones.	
(a)	$d/D = 0$	532
(b)	$d/D = 0.4$	533
(c)	$d/D = 0.8$	534
245.	Variation of Center-of-Pressure with Cone Half-Angle and Bluntness.	
(a)	$M = 0.68$	535
(b)	$M = 0.94$	536
(c)	$M = 1.05$	537
(d)	$M = 1.50$	538
(e)	$M = 1.97$	539
(f)	$M = 2.75$	540
(g)	$M = 4.0$	541
246.	Variation of Foredrag Coefficient with Mach Number for Various Sharp- and Blunt-Nose Cones.	
(a)	$d/D = 0$	542
(b)	$d/D = 0.4$	543
(c)	$d/D = 0.8$	544
247.	Variation of Foredrag Coefficient with Cone Half-Angle and Bluntness.	
(a)	$M = 0.68$	545
(b)	$M = 0.94$	546
(c)	$M = 1.05$	547
(d)	$M = 1.50$	548
(e)	$M = 1.97$	549
(f)	$M = 2.75$	550
(g)	$M = 4.0$	551
248.	Relationship Between Geometric Parameters of Sharp and Spherically Blunted Cones.	
(a)	θ_s vs. L/D	552
(b)	θ_s vs. d/D	553
249.	Hypersonic Newtonian Normal Force Coefficient Slope for Cones of Varying Geometry.	554
250.	Hypersonic Newtonian Centers-of-Pressure for Cones of Varying Geometry.	555
251.	Hypersonic Newtonian Wave Drag for Cones of Varying Geometry.	556
252.	Axis System with Positive Directions of Forces, Moments, and Angles Indicated by Arrows.	557

LIST OF ILLUSTRATIONS (CONCLUDED)

<u>Figure</u>		<u>Page</u>
253.	Comparison of Predicted Values of C_A and C_{N_α} of a Series of Sharp Circular Cones with Cone Half-Angle with the Use of Newtonian and Exact Theories.	558
254.	Comparison of Experimental Results with Theoretical Results of the Variation in the Longitudinal Characteristics of a Series of Sharp-Nose, Circular Conic Bodies with Angle of Attack at $M = 6.7$.	559
255.	Comparison of Experimental Results with Theoretical Results of Variations in the Longitudinal Characteristics of a Series of Blunt-Nose Circular Conic Bodies with Angle of Attack for $M = 9.6$ and $h/R = 0.2$.	560
256.	Comparison of Experimental Results with Theoretical Results of the Variations in $C_{L,max}$ and $(L/D)_{max}$ for a Series of Circular Conic Bodies with Varying Cone Half-Angle.	561
257.	Comparison of Experimental Results with Theoretical Results of the Variations in the Longitudinal Stability Derivatives of a Series of Circular Conic Bodies with Varying Cone Half-Angle.	562

LIST OF TABLES

<u>Table</u>	<u>Page(s)</u>
I. Experimental Longitudinal Aerodynamic Characteristics for a Sharp Cone, Fineness Ratio 3.	91
II. Experimental Longitudinal Aerodynamic Characteristics for a Sharp Cone, Fineness Ratio 4.	92
III. Experimental Longitudinal Aerodynamic Characteristics for a Sharp Cone, Fineness Ratio 5.	93
IV. Experimental Longitudinal Aerodynamic Characteristics for a Sharp Cone, Fineness Ratio 7.	94
V. Surface Coordinates of the Cone Pressure Instrumentation for a 6°20' Half Angle Cone Model.	142
VI. Surface Coordinates of the Cone Pressure Instrumentation for a 9° Half-Angle Cone Model.	143-144
VII. Pressure Data for Three Sharp- and Blunt-Nose 6°20' Half-Angle Cones.	147-154
VIII. Pressure Data for Two 9° Half-Angle Blunt-Nose Cones.	
Part I	155-161
Part II	162-174
IX. List of a Sharp-Nose and Several Blunt-Nose Cone Drag Models Including Test Information and Drag Results.	182
X. Tabulated Zero-Lift Drag Data for a Sharp-Nose and Several Blunt-Nose Cone Models at Several Mach Numbers.	183-185
XI. Aerodynamic and Physical Data for a 9°32' Half-Angle Sharp-Nose Cone Model at Several Mach Numbers.	262
XII. Theoretical Results of the Conical Flow Properties of a Unyawed 10° Half-Angle Cone.	278
XIII. Pressure Orifice Locations on the Nose and on the Conical Surface of a Blunt-Nose 10° Half-Angle Cone Model.	290
XIV. Damping-in-Pitch Data for 12-1/2° Half-Angle Sharp- and Blunt-Nose Cones.	313-322
XV. Static Stability Data for 12-1/2° Half-Angle Sharp- and Blunt-Nose Cones.	323-328
XVI. Force and Pressure Test Data for 15° Half-Angle Sharp-Nose Cones.	359-363
XVII. Experimental Force and Pressure Data for 15° Half-Angle Cones Corrected to Mach Number of 2 and 4.	364-366
XVIII. Summary Results for the Minimum Free-Stream Mach Number Solution for Cones of Half-Angles Ranging from 2.5° to 30°.	412

LIST OF TABLES (CONCLUDED)

<u>Table</u>		Page(s)
XIX.	Computed Values of the Initial Slope of the Normal Force Coefficient for Cones of Half-Angles Ranging from 2.5° to 30° .	413
XX.	Characteristic Air Properties Associated with Scaled-Model Testing of Several Sharp- and Blunt-Nose Cones.	519
XXI.	Aerodynamic Characteristics of Circular Cone Bodies Having Half-Angles Ranging from 2.5° to 90° .	563-576

NOMENCLATURE

A reference number is associated with most of the symbols in this section as an aid to the reader in indicating to which source of information the symbol is related. The same symbol, in some cases, is used more than once, but each symbol is defined. Where a reference number is not associated with a symbol, it was felt that that particular symbol was adequately described or in such general use as to be clear to the reader.

English		Reference Number(s)
A	Area based on diameter D	154
A_B	Base area	81
A_f	Frontal area = $\pi L^2 \sin^2 \theta_s$	95
A_{max}	Maximum cross-sectional area of body (equal to base area)	81
A_w	Wetted area of body (surface area forward of base)	81
A_w	Wetted-surface area parallel to free-stream direction = $\int \int_{S_w} \cos \psi \, dS$ for a cone with base diameter D and length L, $A_w = (\pi/2)DL$	128
a	Local speed of sound	50,234
a	Area based on diameter d	154
a/A	Ratio of areas, $(d/D)^2$	154
a^*	Critical speed of sound; $a^* = V \sqrt{\frac{\gamma-1}{\gamma+1}}$	190
a_{cr}	Critical velocity of sound	30
B	Bluntness ratio = $\frac{\text{nose radius}}{\text{maximum radius}}$	128
C	Linear viscosity coefficient in relation $\mu_w/\mu_\infty = C(T_w/T_\infty)$ and determined from relation $C = (1 + \frac{\gamma-1}{2} M^2)^{\omega-1}$, for $N_{Pr} = 1$	53
C_A or C_c	Axial-force coefficient, $\frac{\text{Axial force}}{q_\infty S}$	
C_{c_a}	Axial-force coefficient at $\alpha = 0$ deg, sharp cone	1
$C_{c_{a,b}}$	Axial-force coefficient at $\alpha = 0$ deg, blunt cone	1
C_D	Drag coefficient, $\frac{\text{Total drag}}{q_\infty S}$ or, $C_A \cos \alpha + C_N \sin \alpha$	102
C_D	Total forebody drag coefficient based on base area (see Eq. 11, Ref. 234).	234
C_{D_B}	Base-drag coefficient, $P_B \frac{A_B}{A_{max}} = P_B$ (where $A_B = A_{max}$)	81

NOMENCLATURE (CONTINUED)

English		Reference Number(s)
$C_{D,b}$	Base-drag coefficient, $(p_{\infty} - p_b)/q_{\infty}$	150
C_{D_b}	Base-drag coefficient, $\frac{\text{base drag}}{q_{\infty} S}$	192
	or, $\frac{P - P_b}{q}$	154
C_{D_c}	Cone pressure - drag coefficient, $2D/\gamma p_o M_o^2 A$	
C_{D_F}	Skin-friction-drag coefficient = $\frac{A_w}{A_{ref}} C_F = K \frac{L}{D} C_F$	128
$C_{D,F}$	Forebody - drag coefficient, $C_D - C_{D,b}$	150
C_{D_f}	Fore drag coefficient, $(C_{D_t} - C_{D_b})$	154
$\bar{C}_{D_f}$	Average skin-friction coefficient based on similar solutions, $(\int_s \bar{\tau}_w dS_w)/q_{\infty} S_B$	234
$(\Delta C_{D_f})_p$	Incremental increase in average skin-friction coefficient caused by induced pressure (see Eq. 8, Ref. 234)	234
$(\Delta C_{D_f})_{tc}$	Incremental increase in average skin-friction coefficient caused by transverse curvature effects (see Eq. 10, Ref. 234)	234
$(\Delta C_D)_p$	Incremental increase in pressure drag caused by induced pressure (see Eq. 4, Ref. 234)	234
C_{D_1}	Inviscid drag coefficient	95
C_{D_N}	Inviscid model nose drag coefficient	234
C_{D_o}	Drag coefficient at zero lift	63
C_{D_o}	Inviscid pressure drag coefficient based on base area	234
C_{D_P}	Forebody pressure - drag coefficient $\int_0^L P \frac{d}{dx} \left(\frac{r}{r_{max}} \right)^2$	81
C_{D_T}	Total - drag coefficient, $\frac{\text{Total drag}}{q A_{max}}$	81
C_{D_t}	Total - drag coefficient	154
C_{D_V}	Total - drag coefficient based on volume to the two-thirds power, $\frac{\text{Total drag}}{q_{\infty} V^{2/3}}$	192
C_{D_W}	Wave drag coefficient, $\frac{\text{wave drag}}{q_{\infty} S}$	128, 192
$C_{D_W}^*$	C_{D_W} at $M = 1$	128

NOMENCLATURE (CONTINUED)

English		Reference Number(s)
C_e	Form of Chapman - Rubesin viscosity coefficient, $(\mu_w/\mu_e) (T_e/T_w)$	234
C_F	Average skin - friction coefficient, $\frac{1.328\sqrt{C}}{\sqrt{R}} \frac{2\sqrt{3}}{3} \frac{S_s q}{S_p q_\infty}$	159
	or, $\frac{1}{A_w} \iint_{S_w} C_f \cos \varphi \, ds$	128
C_F	Force coefficient, $\frac{F}{q_\infty A_f}$	95
C_f	Local skin-friction coefficient, $\frac{\tau}{q_\infty}$	118, 128
C_f	Skin friction coefficient, $\frac{A_B}{A_w} [C_{D_T} - (C_{D_P} + C_{D_B})]$	81
C_∞	Form of Chapman - Rubesin viscosity coefficient, $(\mu_w/\mu_\infty) (T_\infty/T_w)$	234
C.G.	Center of gravity	
C_L	Lift coefficient, $\frac{\text{Lift}}{q_\infty S}$	150
	or, $C_N \cos \alpha - C_A \sin \alpha$	102
$(C_L)_{\max}$	Maximum lift coefficient, $\frac{\text{Maximum lift}}{q_\infty S}$	147
ΔC_L	Increment of lift coefficient between $(L/D)_{\max}$ and $C_{L,\max}$	159
C_{L_α}	Lift-curve slope, $\frac{\partial C_L}{\partial \alpha}$, per degree or per radian	147, 159
C_β	Rolling-moment coefficient, $\frac{\text{Rolling moment}}{q_\infty S \ell}$, see Figure 252	229
C_{β_β}	$\frac{\partial C_\beta}{\partial \beta}$ at $\beta = 0^\circ$	229
c.m.	Center of mass in calibers from the nose	179
C_m	Pitching-moment coefficient, $\frac{\text{Pitching moment}}{q_\infty S (D \text{ or } \ell)}$, see Figure 252	229
C_{m_α}	Pitching-moment-curve slope, $\frac{\partial C_m}{\partial \alpha}$, per degree or per radian	214
C_{m_q}	$\frac{\partial C_m}{\partial (q\ell/2V_\infty)}$	224
$C_{m_{\dot{\alpha}}}$	$\frac{\partial C_m}{\partial (\dot{\alpha}\ell/2V_\infty)}$	
	Damping-in-pitch derivatives, 1/rad.	
$C_{m_q} + C_{m_{\dot{\alpha}}}$	Damping-in-pitch coefficient, $\frac{\partial C_m}{\partial (q\ell/V)} + \frac{\partial C_m}{\partial (\dot{\alpha}\ell/V)}$	227, 228
	or, $\frac{\partial C_m}{\partial (q\ell/V)} + \frac{\partial C_m}{\partial (\dot{\alpha}\ell/V)}$ per radian	
C_N	Normal-force coefficient, $\frac{\text{Normal force}}{q_\infty S}$, see Figure 252	229

NOMENCLATURE (CONTINUED)

English		Reference Number (s)
C_{N_α}	Normal-force curve slope, $\frac{\partial C_N}{\partial \alpha}$, per degree or per radian	154,214
$\left(\frac{dC_N}{d\alpha}\right)_{\alpha=0}$	Initial slope of normal-force coefficient curve	190
$C_{N_q} = \left[\frac{\partial C_N}{\partial \left(\frac{qL}{V}\right)}\right]_{q \rightarrow 0}$		209
$C_{N_{\dot{\alpha}}} = \left[\frac{\partial C_N}{\partial \left(\frac{\dot{\alpha}L}{V}\right)}\right]_{\dot{\alpha} \rightarrow 0}$		209
$C_{N_q} + C_{N_{\dot{\alpha}}}$	Damping-in-pitch normal-force coefficient, $\frac{\partial C_N}{\partial (qL/V)} + \frac{\partial C_N}{\partial (\dot{\alpha}L/V)}$ or, $\frac{\partial C_N}{\partial (qL/V)} + \frac{\partial C_N}{\partial (\dot{\alpha}L/V)}$, per radian	227
C_n	Yawing-moment coefficient, $\frac{\text{yawing moment}}{q_\infty S L}$, see Figure 252	229
$C_{n\beta}$	Yawing-moment curve slope, $\frac{\partial C_n}{\partial \beta}$, per deg. or per rad.	
C. P. or c. p.	Center of pressure	16,44
CP/D	Center of pressure location (from base)	154
CP _N	Normal force center of pressure	179
C_p	Pressure coefficient, $\frac{p-p_\infty}{q_\infty}$ or, $\frac{2}{\gamma M_\infty^2} (p_s - p_\infty - 1)$	38,102,170,234
$C_{p,max}$	Maximum pressure coefficient behind normal shock	147
C_p^*	Modified pressure coefficient, $\frac{p-p_c}{q_\infty}$	38
$C_{p,b}$	Base pressure coefficient	
C_{p_c}	Cone pressure coefficient, $\frac{p_c}{q_\infty}$	95
$\bar{C}_{p_c}$	Average inviscid pressure coefficient for conical section of body	234
C_X	Drag coefficient along the body wall	30
C_Y	Side force coefficient, $\frac{\text{Side force}}{q_\infty S}$, see Figure 252	229
D	Drag force, lb.	139
D	Base diameter or cone base diameter	102,150,154

NOMENCLATURE (CONTINUED)

English		Reference Number(s)
D	Maximum diameter of body of revolution	128
D_t	Total drag (lb.)	154
d	Diameter	53
d	Maximum diameter of body of revolution	51
d	Nose diameter	89
d	Diameter of spherical nose segment at station of tangency ($d/2r_n$)	154
d/D	Bluntness ratio	154
d_B	Base diameter	234
d_N or d_n	Nose diameter	121, 192, 234
F	Measured force	95
F	Fineness ratio, $F = \frac{L}{2R_b}$	44, 69
f	Body fineness ratio, $\frac{L}{D}$	44
h	Heat-transfer coefficient corrected for conduction, $\frac{q_w}{T_{aw}-T_w}$	38
h/R	Nose bluntness ratio, ratio of vertical height between spherical nose tangency point and model center line to radius of base	147
K	Supersonic-hypersonic similarity parameter, $\frac{\sqrt{M_\infty^2-1}}{L/D}$	128
K	Hypersonic similarity parameter, $(M_\infty \frac{d}{L})$	51
	or, $M_\infty \theta_c$	234
K	Reduced frequency parameter, $\frac{\omega D}{V}$	227
K	Bluntness ratio, r_n/R_b	69
K_D	Drag force coefficient, $K_D = \frac{\pi}{8} C_D$	179
K_H	Damping moment coefficient, $K_H = -\frac{\pi}{16} (C_{m_q} + C_{m_{\dot{\alpha}}})$	179
K_M	Overturning moment coefficient, $K_M = \frac{\pi}{8} C_{m_{\alpha}}$	179
K_N	Normal force coefficient, $K_N = -\frac{\pi}{8} C_{N_{\alpha}}$	179
K_T	Magnus moment coefficient, $K_T = -\frac{\pi}{16} C_{M_{p_{\alpha}}}$	179
$ K_i $	Magnitude of epicyclic yaw arms	179

NOMENCLATURE (CONTINUED)

English		Reference Number(s)
k	Nose drag coefficient = $[\text{nose drag}] / \left[\frac{1}{2} \rho_{\infty} u_{\infty}^2 (\pi/4) d_n^2 \right]$,	121
k_1	Axial radius of gyration in calibers	179
k_2	Transverse radius of gyration in calibers	179
L	Body length	81,154
L	Total or overall length of body	69,128,234
L	Distance along base surface	228
L	Slant length of cone	95
L	Axial length	118
L_s	Slant length of cone	
L/D	Lift-drag ratio, C_L/C_D	
L/D	Length-diameter ratio or fineness ratio	154
$(L/D)_{\max}$	Maximum lift-drag ratio	147
ℓ	Reference length or cone length	224
ℓ	Total length exposed to flow, "wetted" length	69
ℓ	Characteristic body length measured from vertex to most forward point of maximum diameter	51
ℓ	Distance of pressure tap normal to reference plane, in. (The reference plane for spanwise locations is the vertical plane through the model axis.)	170
M	Mach number	
M	Mach number along the body wall	30
M'	Inviscid Mach number on hypothetical, streamwise extension of base of body one diameter downstream	230
M''	Inviscid Mach number on hypothetical, streamwise extension of body immediately downstream of real base	230
M^*	Critical Mach number; $M^* = \left(\frac{v}{v_1} \right) \times \left(\frac{v_1}{a^*} \right)$	190
$(Me)_L$	Local surface Mach number at length, L	234
$M_{b\ell}$	Inviscid Mach number just ahead of base of blunt body	230
M_o	Free-stream Mach number	50,51,139
M_r	Reference Mach number, $M_r = \frac{M_{s\ell} + M_{b\ell}}{2}$	230
M_s	Minimum Mach number for shock attachment for pointed cones	154

NOMENCLATURE (CONTINUED)

<u>English</u>	<u>Reference Number(s)</u>
M_{sl} Inviscid Mach number just ahead of base of sharp body	230
M_{∞} Free-stream Mach number	30,150,230
N Number of yaw observations	179
N_{Pr} Prandtl number	53
N_T Number of time observations	179
u Exponent in equation defining shapes of experimental test bodies	44,50
P Pressure	98
P Pressure coefficient, $\frac{p_e - p_s}{q}$	81
P Static pressure	118
P Free stream static pressure (psf)	154
P_B Base pressure coefficient	81
P_b Base pressure (psi)	154
P_o Stagnation pressure	81
P'_o Pitot pressure	118
p Pressure, psia	121,170,234
p Local static pressure	38,51,139,203
p Pressure along the body wall	30
p Shift, in calibers, of c.m. from the centroid	179
P_b Pressure on base of body or cone	150,230
P_c Measured cone (housing) pressure	95
P_c Inviscid pressure on cone surface at nose, poi	89
P_{ci} Pressure at cone surface from inviscid theory	95
P_L Local static pressure	81
P_s Free-stream static pressure	81,227
p' Pressure, corresponds to M'	230
p'' Pressure, corresponds to M''	230
P_o Free-stream stagnation pressure	230
p'_o Stagnation pressure behind a normal shock	234

NOMENCLATURE (CONTINUED)

English		Reference Number (s)
p'_o	Stagnation pressure downstream of the shock, psia	121
p'_{o1}	Stagnation pressure downstream of a normal shock wave	230
p_1	Surface static pressure just ahead of base of body	230
Δp	Increase in pressure caused by displacement induced pressure gradient	234
Δp	Induced static pressure (measured pressure minus reference pressure)	89
p_∞	Free-stream static pressure	150, 230
q	Angular pitching velocity, rad/sec	224, 228
q	Dynamic pressure	38, 154, 170
$\dot{q}$	Heat flow per unit time and area	38
q_∞	Free-stream dynamic pressure, $0.7p_\infty M_\infty^2$, psf	150
	or, $1/2\rho_\infty u_\infty^2$	234
R	Reynolds number or local Reynolds number	98
R	Base radius	118
R	Universal gas constant	190
R_b	Radius of base of body, or cone base	230, 234
R_d	Reynolds number based on nose diameter	89
Re	Reynolds number, per inch, $(\rho_\infty u_\infty)/\mu_\infty$	121
	Reynolds number, per foot of model length, 1/ft.	38, 170
	Reynolds number, based on model length	224
Re/Ft	Free-stream Reynolds number per foot; $Re/Ft = \frac{U_\infty \rho_\infty}{\mu_\infty}$	118
Re_ℓ	Reynolds number based on wetted length and local conditions at outer edge of boundary layer just ahead of base of body	230
Re_s	Reynolds number based on distance along surface from stagnation point; $Re_s = \frac{U_e \rho_e s}{\mu_e}$	118
Re_θ	Reynolds number based on boundary-layer momentum thickness or momentum thickness Reynolds number, $Re_\theta = \frac{U_e \rho_e \theta}{\mu_e}$	118
$Re_{\theta,c}$	Re_θ at the downstream end of the cone	118
$Re_{\infty,D}$	Free-stream Reynolds number based on cone base diameter	1

NOMENCLATURE (CONTINUED)

English		Reference Number (s)
$Re_{\infty, L}$	Reynolds number based on model length, $(\rho_{\infty} U_{\infty} L) / \mu_{\infty}$	234
R_L	Free-stream Reynolds based on model length	81
R_n	Reynolds number, $\frac{\rho V L}{\mu}$	154
R_T	Transition Reynolds number based on axial length to transition point	81
$(R_2)_L$	Swerve associated with the lift force	179
R_{∞}	Free-stream Reynolds number	
r	Local body radius	81, 234
r	Radial distance from vertex of the cone	51
r_{max}	Maximum body radius	81
r_n	Radius of nose of body	230
r_n	Radius of spherical nose	154
r_n / R_b	Bluntness ratio	
r_s	Radius of the downstream side of the bow shock	121
S	Reference area; see particular area indicated on appropriate figures. This is usually the maximum cross-sectional, or base, area	
S	Area of model base, $(\pi/4)D^2$	150
S_B	Model base area	234
S_b	Base area of cone	159
S_p	Planform area of cone	159
S_s	Total surface area excluding base area	159
S_w	Surface area of body upstream of boundary-layer separation, ft. ²	128
S_w	Model wetted surface area	234
s	Local semi-span, in.	170
s	Gyroscopic stability factor	179
s	Distance along model surface from stagnation point	234
$\bar{s}$	Dynamic stability factor, $\bar{s} = 2(K_N - K_D - k_1^{-2} K_T) / (K_N - K_D + k_2^{-2} K_H - k_1^{-2} K_A)$	179
T	Temperature	234
T	Absolute temperature	53

NOMENCLATURE (CONTINUED)

<u>English</u>		<u>Reference Number (s)</u>
T_o	Stagnation temperature	53,81
T_t	Total temperature ($^{\circ}\text{F}$)	154
T_w	Wall temperature	53
T_{∞}	Free-stream temperature	
t	Skin thickness	38
U	Velocity in flow direction	118
U_{∞}	Free-stream velocity, ft/sec.	
u	Velocity	121,234
u	Velocity component parallel to ray passing through vertex of cone	51
u	Velocity along a conical ray, $\bar{u} = u/u_m$	203
u_m	Maximum velocity obtainable by expanding flow to zero absolute temperature	203
V	Free-stream velocity, ft./sec.	
V	Resultant velocity ($\sqrt{u^2 + v^2}$)	51,190
V	Volume of cone, cubic feet	192
$\hat{V}$	Maximum velocity obtainable by expanding to zero temperature	51
V_o	Free-stream velocity	51,139
V_1	Limiting velocity due to expansion into a vacuum; dimensional	190
V_{∞}	Free-stream velocity	224
v	Velocity component normal to ray passing through vertex of cone	51
v	Velocity normal to u or in a plane of radial coordinate, θ , $\bar{v} = v/u_m$	203
$\bar{V}_{\infty}$	Viscous parameter, $(\sqrt{C_{M_{\infty}}})/\sqrt{Re_{\infty,L}}$	234
x	Distance from leading edge of model, or from model nose- dimensional	44,89,150
x	Surface distance measured along a geodesic from the forward stagnation point	121
x	Distance along model axis of symmetry, from stagnation point	234
x,y	Coordinates of point on meridian curve of body (origin of coordinate system coincides with nose of body, and x axis coincides with axis of symmetry)	50
x_b, y_b	Coordinates of the shock wave	30
x_{fe}	Distance from leading edge of model	53

NOMENCLATURE (CONTINUED)

<u>English</u>		<u>Reference Number(s)</u>
x'	Distance measured along cone element from apex (or virtual apex) of cone	38
y	Vertical distance from body center line, in.	102
z	Cylindrical co-ordinate measured from the forward stagnation point	121
<u>English Subscripts</u>		<u>Reference Number(s)</u>
a	Ambient or free-stream	98
aw	Adiabatic wall	38
B or b	Base, or model base dimension	90,234
b	Values on base or sting	118
c	Conditions on the surface of the cone at an angle of attack of 0°	38
c	Conditions on the surface of a cone	51,139
c	Values on cone at most downstream station (1.5 inches upstream of base)	118
cg	Center of gravity	102
e	Values or conditions at outer edge of boundary layer	118,234
e	Local conditions external to boundary layer	38
l	Local inviscid condition	53
l	Local values	190
le	Leading-edge condition	53
m	Model surface condition	
m	Measured	98
n	Nose, or model nose dimension	121,234
s	Conditions on stagnation line of yawed cone (windward generator)	38
s	Conditions immediately behind the shock wave at the vertex of a body, or downstream side of the bow shock	51 121
s	Cone surface	98,190,203
t	Factor based on leading-edge thickness	53
t	Isentropic stagnation conditions	38
w	Wall (model surface) conditions	38,53,121,234
w	Immediately behind a conical or oblique shock	190,203
w	Values in the wake	118
x	Factor based on distance from leading edge	53
() _{ON}	Stagnation conditions behind normal shock	128

NOMENCLATURE (CONTINUED)

English Subscripts		Reference Number (s)
$()_1$	Conditions at the outer edge of the boundary layer or along the surface	128
o	Free-stream conditions	51, 139
o	Stagnation conditions	53
o	Total stagnation conditions	234
o	Supply conditions	118
o'	Stagnation conditions behind a normal shock	
1	Free-stream conditions at leading edge or nose	89
1	Flow quantities for the zero angle of attack condition	190
2	Conditions behind normal shock	38
2	Flow quantities related to the effect of angle of attack	190
$0, 1, 2$	Moment center locations	227
$0-1, \left. \begin{array}{l} 0-2 \end{array} \right\}$	Distance between moment centers, positive toward cone base	227
$1, 2, 3, 4$	Port location	98
∞	Free-stream conditions	53, 118, 170, 190, 203, 234
∞	Condition upstream of the shock	121
$'$	Total-pressure condition	53
Greek		Reference Number (s)
α	Angle of attack (angle between cone center line and wind vector) degrees or radians	190
$\Delta \alpha$	Increment of angle of attack between $(L/D)_{\max}$ and $C_{L, \max}$	
$\dot{\alpha}$	Variation of angle of attack with time, $\frac{\partial \alpha}{\partial t}$, radians/sec.	224, 227, 228
α_1	Damping rates of epicyclic yaw arms	179
α_m	Angle-of-attack location of maximum lift coefficient or maximum lift-drag ratio	
β	$\sqrt{M^2 - 1}$	
β	Angle of sideslip, deg., or radial angle about body axis measured from top of body	138
β	Angle of elevation (see Figure 118)	118
β'	Radial angle referred to wind axis	
γ	Ratio of specific heat at constant pressure to specific heat at constant volume	121, 190, 203

NOMENCLATURE (CONTINUED)

<u>Greek</u>		<u>Reference Number (s)</u>
δ	Position angle on model, degrees; or, local flow deflection angle, degrees; or, angle of flow inclination with respect to the body axis	147 51
δ	Magnitude of yaw	179
δ	Bluntness, ratio of the vertical and horizontal axes of the ellipsoid of revolution	30
δ^2	Mean squared yaw	179
ϵ	$\epsilon \equiv (\gamma-1)/(\gamma+1)$	121,234
ϵ	Wake angle	118
ϵ_1	Standard error in a coefficient or in a least squares fit	179
η	Angle between unit normal and wind vectors, deg.	
η	Tilt angle of shock wave, due to α	190
θ	Angle in the flow direction measured from the axis of symmetry, radians; or, conical coordinates angle; or, conical ray angle measured relative to the cone axis	121 190,203
θ	Circumferential angle measured about axis of cone from windward generator, where $\theta = 0^\circ$ corresponds to the forward stagnation line, otherwise denoted as windward generator	38
θ	Boundary-layer momentum thickness	118
$\Delta\theta$	Incremental change in θ	203
θ_s	Cone half-angle, also referred to as cone half-vertex angle, semivertex angle, semi-apex angle, or semiangle of cone, deg.	154,230,234
Λ	Yaw angle of windward generator	38
μ	Viscosity; or, coefficient of viscosity of air, lb.-sec./sq. ft.; or, gas viscosity	53,118 121,139 234
μ_w	Wall dynamic viscosity	159
μ_∞	Free-stream dynamic viscosity	159
ν	Spin, in radians per caliber	179
ρ	Density; static density; mass density of air; or, gas density	118,203 234

NOMENCLATURE (CONTINUED)

<u>Greek</u>		<u>Reference Number (a)</u>
ρ	Density in amagat units where 1 amagat unit is the density at one standard atmosphere pressure at 273.16°K (for nitrogen the density is equal to 2.42435×10^{-3} lb.-sec. ² /ft. ⁴)	121
ρ_{∞}	Density of the free stream	30
r	Slope of cone surface, R_b/L	
τ	Shear stress, lb./ft. ²	128
τ_w	Surface shear stress from similar solutions	234
ϕ	Angle of roll, degrees	235
ϕ'_1	Turning rates of epicyclic yaw arms	179
$\bar{X}$	Hypersonic interaction parameter, $M_e^3 \sqrt{C}/\sqrt{R_{x,L}}$	53
$\bar{X}$	Hypersonic viscous interaction parameter, $(\sqrt{C_e} M_e^3)/\sqrt{(\rho_e u_e s)/\mu_e}$	234
$\bar{X}_L$	Hypersonic viscous interaction parameter based on model length, L. $(\sqrt{C_e} M_e^3)/\sqrt{(\rho_e u_e L)/\mu_e}$	234
ψ	Angle of yaw, degrees	
ψ	Azimuth angle (see Figure 118)	118
ψ	Nose bluntness ratio, r_n/R_b	234
ω	Circular frequency of oscillation; or, angular frequency	227 224
ω	Cylindrical coordinate	
ω	Angle between axis of cone and ray passing through vertex of cone	51
ω	Viscosity power law index in relation $\mu_w/\mu_e = (T_w/T_e)^\omega$,	53
ω_o	Frequency of resultant-force coefficient, $2\pi/\text{Period}$, radians/sec.	
$\omega L/(2V_{\infty})$	Reduced frequency parameter, radians	224
φ	Local angle of inclination of body surface to free-stream direction, $= \tan^{-1} \frac{d f }{dx}$ where $f(x)$ describes profile shape, and x is measured positive in free-stream direction	128

NOMENCLATURE (CONCLUDED)

<u>Greek</u> <u>Subscripts</u>		<u>Reference</u> <u>Numbers</u>
local	Surface condition	159
max	Maximum or stagnation	159
min	Minimum	159
e	Edge of boundary-layer conditions	234
∞	Free-stream conditions	234
l	Local inviscid condition	53

CHAPTER I. INTRODUCTION

The aerodynamic characteristics of cones have been of interest for several years. The limits of this interest have also varied during this time. Theories have been developed which apply to distinct regions of interest. Other theories have attempted to compare, to modify, or to expand upon those previously in existence. Many experimental studies have also been conducted to substantiate these theories or to reach out beyond the scope of theoretical application. Many limitations have been imposed upon these experimental studies, however, such as the means of testing available, the range of interest for the data, or specific requirements which initially established the need for testing.

Today, as needs change due to the use of, or study of, various conical shapes, new regions of interest are generated, new problems are formed. More experimental studies are being conducted to determine the answers. With all this increased effort, however, there still exists a paucity of information on these shapes. Many of the limitations imposed upon experimental study still exist.

The intention herein is to present an accumulation of much of the available force, pressure, and stability data on several conical shapes. The effect of geometry changes, such as nose bluntness, cone half-angle, or base modifications, on the various aerodynamic coefficients and pressure distribution is shown. The dependence of these coefficients on such as Mach number, Reynolds number, and angle of attack is also shown.

These data have been compiled from many sources and are presented by grouping of the cone half-angle from the smallest to the largest value. Where a particular study was conducted to determine the effect of cone half-angle, for example, these data are presented as a subgroup within the general sequential display of the data. Comparisons of experimental and theoretical cone data with that from other shapes such as power series bodies and ogive bodies are also included. The results of several theories used to determine the aerodynamic coefficients and pressure are compared and discussed.

A bibliography is included which consists of several references to sources containing theoretical and/or experimental results of the aerodynamic characteristics and pressures of sharp and blunt cones.

CHAPTER II. RESULTS AND DISCUSSION

The data are presented in this chapter generally in the order of increasing cone half-angle. This has been done so that the reader may have most of the available data pertaining to a given cone angle more concentrated for his perusal.

The Reynolds numbers for the test, Reference 50, during which the foredrag coefficients were determined for several bodies of revolution is shown in Figure 1 and these were sufficiently low to insure laminar boundary layers for all the bodies tested.

A comparison is shown between the experimental foredrag coefficient for a cone, $L/D = 3$, and that determined by a relatively exact theory, Reference 50, in Figure 2. Eggers, Dennis and Resnikoff, Reference 50, determined the pressure drag from Reference 195, the skin-friction drag for a flat plate from the results of Reference 141, which was then modified by the transformation of Hantzche and Wendt, Reference 85, for the case of the cone. Reference 50 states that the increase in the foredrag coefficient at Mach numbers above 4.5 is due to the increase in friction drag. The decrease in Reynolds number in this Mach range as shown in Figure 1 coincides with the increase in friction drag.

Figure 3 shows the variation with Mach number of the foredrag coefficients at zero lift of cones and of 3/4-power, 1/2-power, 1/4-power, and tangent-ogive bodies having fineness ratios of 3 and/or 5 which are from Reference 50. It is seen that, for a given fineness ratio, L/D , the 3/4-power bodies have the minimum foredrag of all bodies tested.

Figure 4 shows the predictions of the impact theory and the modified impact theory along with experimental data for the above test bodies. This figure shows that the modified impact theory is noticeably superior to the impact theory at the lower values of n , corresponding to the blunter bodies.

The information on inclined body characteristics at high Mach numbers is limited. The theories of Stone and Ferri, References 201 and 58, are those available for predicting the forces and moments on inclined cones, and the impact theory of Newton, Reference 149, for bodies of arbitrary shape.

In general, these theories are limited to cones inclined at small angles with respect to the free-stream or to very large free-stream Mach numbers.

Force and pitching moment characteristics are presented in this report from Reference 44 for cones and tangent ogives having fineness ratios from 3 to 7 and for blunt-nosed shapes (3/4-power, 1/2-power and ogive bodies) having fineness ratios of 3 and 5. The data are for an angle-of-attack range of 0° to 25° , a Mach number range from 2.75 to 5.00, and Reynolds numbers based on body length which varied from 0.5 million to 6.4 million, see Figure 6. Figure 5 is a sketch of the body shapes reported on in Reference 44.

The variations of lift coefficient with angle of attack, with drag coefficient, and with center of pressure for cones of fineness ratios 3, 4, 5 and 7 are shown in Figure 7. It is seen that the effect of fineness ratio, f , is negligible for small angles of attack, less than 5° , but the lift coefficients generally decrease with increasing Mach number at angles of attack greater than approximately 10° . The center of pressure is shown to be approximately the same for all of the cones within the range of the angle of attack and Mach number tested.

For the above range of cone fineness ratios, Figure 8 shows that the lift-drag ratios increase as the cone fineness ratio increases. Figure 9 shows that at high lift coefficients, lift-drag ratio decreases with increasing Mach number for the fineness ratio 5 cone.

The effects on aerodynamic characteristics due to changes in profile shape of bodies of given fineness ratio, i.e., cone, 3/4-power body, 1/2-power body, and ogive, are shown in Figures 10, 11, 12, and 13.

Experimental results are compared with theoretical predictions of these aerodynamic characteristics for fineness ratio 3 and 5 cones in Figure 14.

A more complete tabulation of the experimental results for the cones of fineness ratio 3, 4, 5, and 7 are shown in Tables I through IV.

The drag near zero angle of attack is presented for five different cone shapes having a fineness ratio of 3 and nose bluntness ratios of 0, .075, .15, .30, and .50. These data were computed by various methods and determined experimentally, Reference 192. Figure 15 shows the various cone geometries. The Reynolds number variation with Mach number is shown in Figure 16.

The total drag coefficient variation with Mach number for each cone is shown in Figure 17. The blunter cones show a smaller decrease in drag coefficient with increasing Mach number. The effect of bluntness on total drag coefficient is also shown in Figure 18. Reference 192 shows in this figure that the nose bluntness for minimum drag decreases with increasing Mach number. This bluntness ranged from 28 percent at Mach number 1.2 to 11 percent at Mach Number 7. Figure 19 shows the effect of bluntness on total drag coefficient based on volume to the two-thirds power. These curves indicate, Reference 192, that moderate and even large bluntnesses (the degree of bluntness depending on Mach number) may be used to decrease the drag for equal volume. Reference 192 used the theoretical wave drag of the cone as determined from Reference 195 along with the total drag measured in their test to determine the wave drag. These data are shown in Figure 20 compared with the method of References 143 and 155. Reference 192 also determined the wave drag of the blunt cones by adding the wave drag of a hemisphere as shown in Figure 21, from References 88 and 92, to that of a conical afterbody obtained from the tables of Reference 195. The results of this method are shown in Figure 20.

Cone pressure distributions are presented in Figures 23 and 24 for 5° and 10° half-angle cones having four different nose bluntnesses. The Mach number varies from 17 to 23 and the angle of attack and angle of yaw is zero. See Figure 22 for a sketch of these cones showing the cone dimensions and pressure orifice locations. These results were obtained as a result of an investigation, Reference 89, which was an extension and amplification of the experimental work reported in Reference 53. The data are presented, as a result of the above investigation, as $\Delta p/p_c$ against x/d . The induced static pressure, Δp , is the measured pressure minus the reference pressure. For the cones, the reference pressure was calculated, Reference 89, from the inviscid shock equations and the free-stream static pressure at the nose. The results are compared with the theory of Reference 168. This theory assumes a sharp cone (Reynolds number based on nose diameter nearly zero, $R_d \approx 0$). In general, theory and experiment agree rather well for low R_d and high x/d , where the effect of nose bluntness would be expected to be small. Although tip

bluntness altered the pressure near the tip considerably, the effect is shown not to persist many nose diameters downstream. Reference 89 states that no reasons are known for the large deviation of experiment from theory at $M_1 = 21$ and $R_d = 2,450$ and at $M_1 = 23$ and $R_d = 3,140$ for the 5° half-angle cone. Reference 89 also states that, in the same manner as for the wedges tested, the inviscid prediction becomes better as the cone angle increases. Reference 89 concludes that the effect of compressive flow deflection is to greatly decrease the induced-pressure effects of blunt leading edges in both viscous and inviscid flow. As the cone angle increased, the measured pressures approached the inviscid pressure values predicted by cone shock theory. It is stated that induced-pressure effects are large only at zero or small positive flow-deflection angles.

Figure 26 from Reference 53, shows the free-stream test Reynolds numbers to be in the range from 0.9×10^6 to 1.5×10^6 per inch. Pressure distribution results in the form of surface pressure to stagnation pressure ratio for a 5° half-angle cone from Reference 53 are presented in Figure 27. The induced-static-pressure ratio for this cone is plotted against $1/\sqrt{R_{x,l}}$ and the hypersonic interaction parameter, $\bar{X}$, in Figures 28 and 29, respectively (Reference 53). A similar representation for the 10° half-angle cone is shown in Figures 30 to 32.

The surface pressures for the 5° half-angle cone are shown in Figure 27 to be slightly higher than the Taylor-Maccoll prediction. The zero axis of the ordinate scale in Figure 28 represents the calculated (Reference 53) inviscid pressure obtained by the Taylor-Maccoll theory. The greatest induced pressure is shown to be at the location nearest the cone apex and is 35 percent greater than the calculated inviscid pressure. This difference between experiment and Taylor-Maccoll theory decreases to 10 to 20 percent at the second orifice location. Reference 53 states that there appears to be no reasonable explanation of the pressure rise in the region of the last orifice. The variation of the ratio of experimental surface pressure to stagnation pressure along the surface of a 10° half-angle cone from Reference 53 is shown in Figure 30. The Taylor-Maccoll predictions are also presented for comparison, and for some conditions, the measured pressures are seen to be less than the theory. The experimental values of the induced-static-pressure ratio for the 10° cone are seen in Figure 31 to be within about 7 percent of the calculated (Taylor-Maccoll) inviscid pressure.

Reference 53 states that the results found therein on the 5° and 10° cones are consistent with the results reported by Munson, Reference 144, relative to the effect of cone angle. The surface static pressures measured by Munson on a 15° and 20° cone in helium at $M_\infty = 18.4$ were found to be in good agreement with the Taylor-Maccoll theory. The results from Reference 53 and those reported by Munson show that a closer agreement of the surface static pressure with the Taylor-Maccoll theory occurs as the cone angle is increased.

Hypersonic force and moment data for $6^\circ 30'$ and 9° half-angle cones, and pressure data for $6^\circ 20'$ and 9° half-angle cones are presented in this report which are from Reference 235. The data are for angles of attack from 0° to 40° or to 45° .

Figure 36 shows the normal force, pitching moment, axial force, and center of pressure for a $6^{\circ}30'$ half-angle cone having a nose radius to base radius ratio of 0.03 at a Mach number of 15 and for various Reynolds numbers. Figure 37 presents the same coefficients and center of pressure on a $6^{\circ}30'$ half-angle cone having a bluntness of 0.145. Figures 38 and 39 present the same order of aerodynamic data as above for a 9° half-angle cone having bluntness ratios of 0.03 and 0.30, respectively. Data for a $6^{\circ}30'$ half-angle cone having a bluntness of 0.03 are presented for Mach numbers of 15 and 21 with various Reynolds numbers in Figure 40.

Tables V and VI give the surface coordinates of the cone pressure instrumentation for the $6^{\circ}20'$ and the 9° half-angle cones, respectively.

Tables VII and VIII present the pressure data. The associated cone geometry and Reynolds number shown in other tables of pages in Reference 235 have been added to these tables. The remainder of the information on these tables is that which is shown in Tables VII to IX of Reference 235 and includes values for: absolute local pressure, the ratio of local pressure to the stagnation point value or the ratio to the free-stream value, and the local pressure coefficient. Pressure information is included for angles of attack up to 40° .

Table VII is for a $6^{\circ}20'$ half-angle cone having bluntnesses of .0019, .078, and .155. Table VIII - Part I presents the same pressure information for two 9° half-angle cones each having the same nose radii, but having values of bluntness of .30 and .205, resulting from a basic and an extended cone surface respectively, see Figure 42. Table VIII - Part II is a continuation of pressure data for the 9° half-angle cone having bluntnesses of .30, .0833, and .0017.

Table IX presents the geometrical parameters, and Figure 43 presents the nomenclature, for several sharp- and blunt-nose cones on which pressure and drag data were measured, Reference 234, for Mach numbers ranging from 9 to 22. The resultant experimental forebody drag data from Reference 234 are presented in Table X.

The similar solutions and integral method of Cohen and Reshotko, References 33 and 34, were used in Reference 234 to obtain a theoretical estimate of the Blasius-type shear stress distribution and hence total shear drag of the cones in Reference 234.

Reference 234 states that the correlation of characteristics solutions and measured pressure distributions given by Lewis, Reference 121, in terms of parameters proposed by Cheng, Reference 26, was used to specify the pressure distributions for the blunter ($\psi \geq 0.3$) cones. Lewis' data were replotted in Reference 234 in terms of pressure coefficient (Figure 44 in this report) and then were assumed independent of Mach number for this application. Experimental cone pressure data from Whitfield and Norfleet, Reference 231, were used in Reference 234 to specify the inviscid cone pressure. A smooth transition was used between this pressure level (sharp cone) and a hemispherical nose pressure distribution for the sharper cones ($\psi \leq 0.03$). The resulting pressure distribution is shown in Figure 44.

Reference 234 states that the total zero-lift drag estimate consists of the following terms:

1. inviscid pressure drag C_{D_o}
2. similar solution skin-friction drag, $\bar{C}_{D_f}$
3. displacement-induced pressure drag, (ΔC_{D_p})
4. displacement-induced friction drag, $(\Delta C_{D_{fp}})$
5. transverse-curvature-induced friction drag, $(\Delta C_{D_{f tc}})$

The total zero-lift drag then becomes, with zero base drag:

$$C_D = C_{D_o} + (\Delta C_{D_p}) + \bar{C}_{D_f} \left[1 + \frac{(\Delta C_{D_{fp}})}{\bar{C}_{D_f}} + \frac{(\Delta C_{D_{f tc}})}{\bar{C}_{D_f}} \right]$$

Figure 45 illustrates the drag, C_D , determined (Reference 234) from the above equation for a blunt 9° half-angle cone considered under hypersonic ($M_\infty = 19$) cold-wall ($T_w/T_o = 0.1$) conditions with nitrogen as a test gas.

The experimental total forebody drag coefficients of the sharp and blunt cones are compared with theory in Figures 47 and 48. The experimental drag data obtained (Reference 234) under cold-wall, low-density hypersonic conditions in the Low-Density Hyper-Velocity Tunnel are compared to the higher Reynolds number data and continuum theory in Figure 49.

A combination of impact and modified Newtonian theory was used to calculate the longitudinal aerodynamic characteristics for the cone configurations shown in Figure 50 (this report) throughout an angle-of-attack range of 0° to 180° , Reference 147.

Impact theory was used for the cone and cone frustums, and a modified Newtonian theory was used for the spherical segments and flat base. The impact theory, based on pure momentum consideration, assumes that the local pressure coefficient is given by the expression $C_p = 2 \sin^2 \delta$, where δ is the local flow deflection angle.

A modification to the impact theory is to replace the constant 2 by the maximum pressure coefficient behind a normal shock so as to improve the general agreement between theory and experiment in stagnation regions (Reference 158). The maximum pressure coefficient is given to good accuracy by Lees' approximate equation (Reference 116).

$$C_{p, \max} = \frac{\gamma+3}{\gamma+1} \left[1 - \frac{2}{(\gamma+3)M_\infty^2} \right]$$

Reference 159 shows that better agreement can be obtained by using a Newtonian coefficient of 2 for slender cones and using $C_{p, \max}$ for cones with larger included cone angles. In Reference 147 it was noted that a Newtonian coefficient of 2 seems reasonable for cones and cone frustums where the cone

half-angle is small, e.g., 9° . Also, the use of $C_{p,max}$ in the calculations for the spherical segments, as shown in Figure 53 (this report), Reference 147, seems justifiable due to the agreement with the stagnation values on the spherical segments.

Reference 117 shows that modified Newtonian theory gives good prediction of the pressure distribution on a spherical segment. The overall integrated coefficients can be computed by using the equations and tables given in Reference 229.

For a 9° half-angle cone at $M = 6.77$, increasing the nose bluntness on such a cone with a flat base decreases both the normal force and negative pitching-moment coefficients (Figure 51 of this report), Reference 147, throughout the entire angle-of-attack range from 0° to 180° . In addition, the axial force coefficients increase with increasing nose bluntness below angles of attack of about 40° , decrease in the vicinity of 90° , and remain relatively unchanged above an angle of attack of 120° .

An unusual behavior was exhibited in the variation of pitching-moment coefficients with angle of attack near 60° for all flat and spherical-base cones (see Figures 50, 51, and 53, of this report), Reference 147. Similar results were observed at lower angles of attack for cones reported in Reference 99 and at various supersonic Mach numbers for various cone configurations in References 211 and 214. It is stated in Reference 147 that this unusual behavior may be due to the flow between the shock and body changing from supersonic to subsonic in this angle-of-attack range. When this occurs, cone surface pressure "bleed-off" near the base can become appreciable giving experimental trends as shown.

Second stable trim conditions near 180° were shown to exist for the blunter cones (Figures 51 and 53), Reference 147, apparently due to the unsymmetrical pressure distribution over the flat base. An effective means of eliminating this trim condition was determined in Reference 147 by adding spherical afterbody caps.

Figure 55 shows the comparison between C_{L_α} and C_{m_α} for various nose bluntness.

Comparison of a combination of impact and modified Newtonian theory with experimental data, Reference 147, showed that, except for the stable region at an angle of attack of 180° for the blunt cones, the theoretical method will provide an adequate means of predicting the general trends of cone configurations throughout an angle-of-attack range of from 0° to 180° . This reference also showed that the magnitudes of the characteristics are predicted satisfactorily in many instances. The method overpredicts the lift-curve slope, C_{L_α} , and the negative pitching-moment-curve slope, C_{m_α} , for the cones with large nose bluntness, however, at an angle of attack of 0° .

A definite paucity of high Mach - low Reynolds number experimental aerodynamic characteristic data on cones exists today. Several groups are attempting to determine these data but still these are only applicable to restricted regions of study.

One of the recent studies, within the last two years, to determine the aerodynamic characteristics of conical shapes and the effects of geometry changes is presented in Reference 1.

Figure 56 shows a sketch of three 9° half-angle blunt-nose cones which were used to experimentally

determine, Reference 1, the normal forces, axial forces, and pitching moments at Mach numbers of 7.31 and 9.04. These data are presented in this report for an angle-of-attack range from -10 to +15 degrees and for a Reynolds number range from 0.037×10^6 to 0.150×10^6 per inch. Figures 57 through 61 show the results of the tests presented in Reference 1 for the force and moment coefficient variations with angle of attack for various Mach and Reynolds numbers. Figure 62 shows the variation of these coefficients with bluntness ratio for constant Reynolds and Mach number. It is seen that the normal force and pitching-moment coefficients decrease and that the axial force coefficient increases with increased nose bluntness. At a given nose bluntness, the normal force and pitching-moment coefficients increase and the axial force coefficient decreases with increased Reynolds number for most of, if not all of, the angle-of-attack range tested.

Figure 63 shows the effect of Mach and Reynolds number on these coefficients at constant angles of attack as the nose bluntness is increased. Figure 64 indicates the change in these coefficients between the isothermal condition of the model (cold wall) and the free-stream tunnel conditions (hot wall), Reference 1. Reference 1 states that the normal and axial force and pitching-moment coefficients were higher by an average of 3 percent when the model was exposed to the tunnel free stream for a period of time and the model surface temperature obtained steady-state conditions.

The effect of Reynolds number is also shown in Figure 65 which presents these coefficients versus angle of attack for constant bluntness ratios and maximum and minimum test Reynolds numbers at a Mach number of 9.04.

The slopes of normal force and pitching-moment coefficients at $\alpha = 0^\circ$ as a function of bluntness ratio for the minimum and maximum test Reynolds number and at a Mach number of 9.04 are presented in Figure 66.

Figures 67 and 68 show the effect of Reynolds number on the axial force coefficients as bluntness ratio and Mach number are held constant at an angle of attack of 0° and 15° respectively. Experimental and theoretical (Newtonian) values of the normal force and pitching-moment coefficients versus angle of attack are compared in Figures 69 and 70 respectively.

Figure 71 shows a comparison of the experimental and theoretical values of the axial force coefficients versus the free-stream Reynolds numbers which are based on the model base diameter.

Figure 72 shows the dimensions of a 9° half-angle sharp-nose cone model on which aerodynamic forces and moments were measured and reported on, Reference 137. Force and moment coefficients from this reference are presented in this report versus angle of attack from 0° to approximately 175° , and for Mach numbers ranging from 3.85 to 5.83 (See Figures 73 to 84). In Figures 73, 74, 75, 76, 77, and 78, Reference 137 has plotted the theoretical Newtonian values for the various coefficients, and the Newtonian-plus-viscous-correction values which were obtained by a method given in the Appendix of Reference 137. Reference 137 states that the Newtonian values were taken from the curves computed by the

authors of Reference 114.

Figures 73-74 show the good approximation of the Newtonian calculation to the measured C_N . The viscous corrections to C_N are shown to account for the difference between measured and Newtonian values.

The Newtonian theory gives a poor approximation to the axial force data for $\alpha < 90^\circ$ as is seen in Figures 75 and 76, Reference 137. Large viscous effects are also seen to be present.

The method given in the Appendix of Reference 137 gives a good estimate for these viscous effects. Since the theory does not take into account trailing edge effects, it would be expected that experimental values for C_X should be somewhat higher than the theory.

The experimental moment data are shown in Figures 77 and 78 to be considerably higher than the Newtonian-plus-viscous correction theory as given in Reference 137. The reference length is the base diameter and the reference area is the base area. The moment reference point was at 50 percent of the model length.

See Reference 147 for additional experimental data on 9° half-angle cones. Figure 53 shows the experimental normal force, axial force, and pitching-moment coefficients versus angle of attack for a 9° half-angle sharp-nose cone at a Mach number of 6.77 compared with a combination of impact and modified Newtonian theory. The agreement between experiment and theory is very good here except for the moment data near an angle of attack of 60 degrees.

Figure 85 presents schematics of spherically blunted and flat-nosed 9° half-angle cones over which the pressure distribution and shock shape were experimentally studied, Reference 121. The Mach numbers ranged from 16 to 19 and unit Reynolds numbers ($Re/in.$) were in the range from 0.19×10^5 to 0.65×10^5 . The results of the shock shape for the flat-nosed cone are shown in Figure 86. The experimental results for a 5° half-angle flat-nosed cone at $M_\infty = 12.5$ and the zero-order theory of Cheng (References 26 and 27) are also shown in this figure. These results are also presented in this report in Figure 87 in terms of the parameters proposed by Cheng, Reference 26.

Figure 88 shows the results from Reference 121 for the spherically blunted model along with the results of a real gas characteristic solution, Reference 74. This figure shows that the experimental shock wave appears to be located further away from the body than the theoretically computed shock from the nose-bluntness-induced theory. The slope of the shock wave, however, is well predicted by the theory. Reference 121 indicates that the shock shape over the spherically blunted model agrees well with the theory, and that the slope agrees with both theory and a characteristic solution. Reference 121 states that the experiments were made with nitrogen at nearly perfect gas conditions and that the characteristic solution contains unassessed real gas (air) effects. In addition, the boundary layer causes additional displacement of the shock wave from the body.

The results of the experimental pressure distribution on the spherically blunted model from Reference 121 are shown in Figure 89 along with a $M_\infty = 15$ characteristic solution (Reference 74).

This shows that within the experimental scatter of data, the agreement is good. The results of the measured pressure distribution over the flat-nosed 9° half-angle cone are given in Figure 90. Reference 121 also presents these data in terms of Cheng's zero-order pressure correlation parameters and are given in this report in Figure 91. Chernyi's theory, Reference 29, the experimental results of Bertram (Reference 7) for a 10° flat-nosed cone at $M_\infty = 6.85$ and at $Re/in.$ from 2.4×10^5 to 3.8×10^5 , and the experimental results for the spherically blunted cone are shown in Figure 91. It is seen that both Chernyi's and Cheng's theories predict an overexpansion of pressure followed by an overcompression (with respect to the sharp cone value). Reference 121 shows in this figure that Cheng's theory indicates an oscillation caused by the asymptotic behavior of the Bessel function solution, Reference 26, whereas Chernyi's theory indicates a monotonic approach to the sharp cone value after the pressure peak.

Surface and base pressure measurements were made, Reference 230, on several sharp- and blunt-nose cones (see Figure 92 for a general sketch and the model dimensions) and the results of this test are presented in this report compared with two well known methods for estimating base pressures (References 22 and 127). The base pressures which were used in the subsequent presentation in Reference 230, and therefore, in this report, are averages from four base orifices as shown in Figure 93. All of the measured data for the sharp and blunt cones, referred to in Reference 230, are shown in Figure 94. A comparison of the experimental data from the above reference with empirical theories for sharp cones is shown in Figures 95 and 96. Reference 230 presents experimental data (see Figure 97, this report) to show how stagnation pressure as read by a pitot tube varies normal to the surfaces of a sphere-cone and a sharp cone.

The variation of the ratio of base pressure to surface pressure with the reference Mach number for the 9° half-angle sharp- and blunt-nose cones is shown in Figure 98. Reference 230 defines this Reference Mach number, M_r as

$$M_r = \frac{M_{sl} + M_{bl}}{2}$$

where M_{sl} is the inviscid Mach number just ahead of the base of the sharp body and M_{bl} is the inviscid Mach number just ahead of the base of the blunt body. Reference 230 mentions a possible limitation on the above equation involving M_r . Presumably the limits are reasonably broad, but, as indicated, they are not yet defined.

A comparison of the base pressures on a blunt cone having a 9° half-angle and a similarly estimated (Reference 230) curve for a blunt cone with a 30° half-angle is shown in Figure 99.

Figures 101 and 102 show the ballistic normal force coefficient, $K_N = -\frac{\pi}{8} C_{Na}$, and the normal force center of pressure, CP_N , in calibers from the nose, versus Mach number for a 9°32' half-angle cone (see Figure 100). These data were obtained from Reference 179. Free-flight values are plotted along with supersonic wind tunnel (Reference 15) values and values predicted by Stone's Theory. The agreement

between theory and experiment is good. It is to be noted that Stone's value

$$CP_N = 2/3 \ell \sec^2 \theta_s = 2.05 \text{ cal. from nose, where } \ell \text{ is the length,}$$

and θ_s is the cone half-angle

is slightly better than the linearized value $2/3 \ell = 1.99$ cal. The values of the Magnus and damping moment coefficients are plotted as a function of Mach number in Figure 103.

Techniques for reducing the range data and obtaining coefficients are given in References 145 and 146.

Table XI gives the aerodynamic and physical data for the $9^\circ 32'$ half-angle cone, Reference 179. The mean squared yaw, $\bar{\delta}^2$, is given in square degrees. ϵ_{yaw} and ϵ_{swerve} are the standard errors in the yaw and swerve least squares fit given in Reference 146. The non-dimensional axial spin, ν , and average turning rates at mid-range, ϕ_i' , are given in radians per caliber. The damping rates, α_i , are in units of per caliber. s is the gyroscopic stability factor and $\bar{s} = 2 (K_N - K_D - k_1^{-2} K_T) / (K_N - K_D + k_2^{-2} K_H - k_1^{-2} K_A)$ is the dynamic stability factor, as defined in Reference 145, where k_1 and k_2 are the axial and transverse radii of gyration in calibers. $|K_i|$ are the magnitudes of the epicyclic yaw arms and $(R_2)_L$ is the radius of the swerve associated with the lift force as defined in Reference 146. N is the number of yaw stations and N_T is the number of timing stations. Values are tabulated in Table XI for K_M when $|K_i|$ are larger than .009 radians and for K_H and K_T when they are larger than .012 if, in addition, N is at least twelve. K_N is given when $(R_2)_L$ is larger than .12 inches. Average standard errors are given in the table for the coefficients because they did not vary much. For a discussion of the relations between the aerodynamic and ballistic nomenclature, see References 145 and 146.

Figure 105 shows the variation of C_{N_α} and center of pressure versus Mach number determined from wind-tunnel testing, Reference 16, for a 10° half-angle sharp-nose cone. A value of the center of pressure predicted by Stone's Theory, Reference 196, is also shown. The experimental values of C_{N_α} from Figure 105, Reference 16, are also shown in Figure 171, this report, for comparison with other theoretical values.

Figure 106 shows the conical forebody of an air-launched rocket boosted test vehicle, Reference 139, on which static pressure was measured and for which the pressure-drag coefficient was determined. The cone half-angle was 10° . The flight Mach number and Reynolds number (based on the body length and free-stream conditions) are shown in Figure 107. Rocket ignition occurred at 4.8 seconds after release.

The time history of the static-pressure measurement which was taken on the conical forebody (see sketch for static orifice location) is shown in Figure 108.

The ratio of cone to free-stream static pressure and the cone pressure-drag coefficient (based on maximum cross-sectional area) is shown in Figure 109 versus the free-stream Mach number. These data are shown, as in Reference 139, for the accelerating and decelerating portions of the flight. Theoretical values, Reference 31, of the cone static-pressure ratio are shown for comparison. Agreement

between experiment and theory is seen to be very good during acceleration. Experimental data are shown to be higher during deceleration, however, and Reference 139 suggests questionable telemeter accuracy during the latter part of the flight.

Lift and forebody-drag coefficients were determined, Reference 150, on an 8.5-diameter cone-cylinder and on an 8.5-diameter ogive-cylinder (see Figure 110) for a Mach number range from 0.6 to 1.6. Each model had base pressure orifices and a single longitudinal row of pressure orifices to obtain pressure distributions. The variation of the zero-lift forebody-drag coefficient for a series of Mach numbers for the cone-cylinder and ogive-cylinder can be obtained from Figures 111 and 112, respectively. A plot of the variation of forebody- and base-drag coefficients at zero angle of attack with Mach number is shown in Figure 113. Reference 150 states that, as was expected, the forebody-drag coefficients for the two bodies show excellent agreement at a Mach number of 0.60 and above a Mach number of 1.20, while demonstrating entirely different characteristics transonically.

Figures 115 and 116 are plots of the variation of cone surface Mach number and bow shock angle and the variation of static pressure and density ratio with free-stream Mach number respectively. These cone flow properties are shown for a range of the ratio of specific heats. Reference 203 has shown in this presentation that at a given Mach number, an increase in the ratio of specific heats increases the conical shock angle and the pressure ratio p_s/p_∞ and decreases the density ratio ρ_s/ρ_∞ and surface Mach number. This reference also shows that, in general, the influence of the ratio of specific heats becomes negligible at the lower Mach numbers. Solutions obtained, Reference 203, for a 10° half-angle cone for a ratio of specific heats of 1.40 is shown in Table XII.

Figure 117 shows the dimensional data for the 10° half-angle sharp-nose and blunt-nose cone models which were used to determine (Reference 118) the surface pressure and base pressure on these shapes and on which the wake and the boundary-layer total pressure surveys were made. These results are presented in this report. This reference also shows the base pressures which were measured and the corresponding wake-flow structures which were obtained from total-pressure wake surveys, schlieren photographs, and Prandtl-Meyer expansion computations. The results of this test are shown in this report for Mach numbers ranging from 2.66 to 2.76 for the sharp cone and from 4.74 to 4.85 for the blunt cone. The boundary-layer growth along the body contours were calculated, Reference 118, in order to have a momentum thickness Reynolds number, $Re_{\theta,c}$, with which to correlate the wake angles and base pressures of all the tests reported on in this reference. Reference 118 states that as a result of these tests it was established that the base pressure and the wake angle are the same for sharp- and blunt-nose cones of the same half-angle when the local Mach number and the Reynolds number based on boundary-layer momentum thickness at the downstream end of the cones are the same. The distribution and location of the static pressure orifices on the nose and on the conical surface of the blunt-nose cone are shown in Figure 118 and in Table XIII. Some of the results of this test, Reference 118, such as surface pressure,

momentum thickness Reynolds number, base pressure, total pressure wake profile, wake angle, local skin friction coefficient, and the effect of surface roughness on base pressure are shown in this report in Figures 119 through 128.

Figure 129 shows a blunt-nose spherical-base cone having a cone half-angle of approximately 11.6°. The lift, drag, and pitching-moment characteristics were determined for this shape, Reference 63, at Mach numbers from 0.70 to 1.30, through an angle of attack from 0° to 8° and for Reynolds numbers based on the maximum diameter from 4.7 to 6.0 million.

A derivation of the transfer equation for aerodynamic damping-in-pitch moment for an arbitrary longitudinal displacement of the moment center is given in Reference 227 and is repeated here in conventional coefficient form.

$$(C_{m_q} + C_{m_{\dot{\alpha}}})_0 = (C_{m_q} + C_{m_{\dot{\alpha}}})_1 + \frac{x_{0-1}}{D} (C_{N_q} + C_{N_{\dot{\alpha}}})_1 - \frac{x_{0-1}}{D} (C_{m_{\alpha}})_1 - \left(\frac{x_{0-1}}{D}\right)^2 C_{N_{\alpha}}$$

This equation was derived, Reference 227, with the usual limitations and assumptions involved in stability derivative concepts. The derivatives were assumed linear, at least for small variations of α , $\dot{\alpha}$, and q , and the principle of superposition was employed. It is seen from the above equation that the damping moment for location (1), the damping normal force, and the static stability characteristics must be known to compute the damping moment for center (0). If the damping moment and the static stability characteristics are known for two locations of the oscillation axis and if the damping normal force is eliminated from the moment transfer, Reference 227 presents the following equation:

$$(C_{m_q} + C_{m_{\dot{\alpha}}})_0 = \left[\frac{\frac{x_{0-1}}{D} (C_{m_q} + C_{m_{\dot{\alpha}}})_2 - \frac{x_{0-2}}{D} (C_{m_q} + C_{m_{\dot{\alpha}}})_1}{\frac{x_{0-1}}{D} - \frac{x_{0-2}}{D}} \right] - \left(\frac{x_{0-1}}{D} \right) \left(\frac{x_{0-2}}{D} \right) C_{N_{\alpha}}$$

where the terms x_{0-1} and x_{0-2} are the distances between the moment centers.

Figures 133 and 134 show the variations of the damping-in-pitch coefficients with angle of attack for the sharp- and blunt-nosed cones with both flat and rounded bases. The transferred values were calculated, Reference 227, for each moment center location by using the damping values from the curves faired through the measured readings of the other two locations. The comparison between the measured and transferred data are shown in Figures 133 and 134, and the agreement is shown to vary considerably depending on Mach number and configuration. Generally, the agreement is good. Measured data for other Mach numbers are given in Table XIV.

Figures 135 and 136 show the static characteristics for the cone models tested at Mach numbers 0.65, 1.00, 1.30, and 2.20 from Reference 227. Data for additional Mach numbers are presented in Table XV. Base pressure coefficients are also listed in Table XV.

The variation of the zero angle-of-attack values for both the static and dynamic stability derivatives with Mach number are shown in Figures 137 and 138.

The combination first- and second-order linear theory given in Reference 209 was used in Reference 227 to compare with the experimental data shown in Figure 137. This shows good agreement for the static characteristics and reasonable agreement for the damping in pitch.

Figure 139 shows the effect of alternate moment centers on the zero angle-of-attack values of the damping in pitch. Theoretical values and calculated transferred damping moments are shown in this figure. The effect of nose bluntness and of the addition of the spherical base are also shown.

In general, it is shown that a decrease in the damping-in-pitch moments results from blunting the nose of the cone or from changing from a flat to a spherical base. Subsonically, this shift in damping from a flat to spherical base was large enough to change the damping from stable to unstable.

It has been shown, such as in Reference 164, that blunted cones with flat bases are statically stable in both forward and rearward flight. It is usually judicious to design a vehicle, relative to heat protection, such that the vehicle is stable in only one position, or flight attitude, meaning that heat protection need only be provided then for one attitude. Reference 164 shows how the stability in the rearward attitude can be eliminated by modifying the base of the vehicle, but at the same time dynamic stability problems may be initiated. Reference 227 shows that a spherical segment base fairing causes a reduction in the level of the damping-in-pitch moment and that dynamic instability in the subsonic speed range could be a consequence.

Within the range of the test conditions, $M = .65$ to 1.60 , and of the cone diameter and sting length (Figure 140 of this report) Reference 227 shows that the damping is not affected by changes in sting length or cone diameter.

In order to retain the rearward flight static instability characteristics of cones with spherical bases while causing a minimum disturbance to the forward flight characteristics, several base modifications were investigated, Reference 228, and the results are presented in this report. Figure 141 shows sketches of the model tested along with the various base modifications investigated. Figure 142 gives the associated variation of Reynolds number with Mach number. The variation of the static characteristics with angle of attack for the basic configuration (shortest base radius) is shown in Figure 143. The axial force coefficient is the total axial force acting on the strain-gage balance, Reference 228, with no adjustment of base pressure. The data for only this configuration is presented, as stated in Reference 228, because the base modifications had no measurable effect on the forward flight static characteristics.

The measured damping-moment coefficients from Reference 228 are shown in Figure 144 as a function of angle of attack for all the configurations.

A summary of the static characteristics of Figure 143 is shown in Figure 145 as a function of Mach number for $\alpha = 0^\circ$.

The effects of various base radii, steps in the base, and fences, on the variation of the damping-moment coefficients with Mach number and angle of attack are shown in Figures 146 and 147.

Reference 228 shows (see Figure 146 of this report) that the only configuration that was dynamically stable throughout the entire Mach number range at $\alpha = 0^\circ$ was the model with the flat base. The above results showed that as the base radius decreased, the damping moment became more unstable. The reference goes on to state that increasing base radius and base modifications in the form of annular steps and fences on the base reduced the unstable damping moments, but failed to eliminate them. These unstable damping moments were limited to angles of attack less than 15° for all configurations.

Figure 148 shows the dimensional data for the 12.5° half-angle sharp-nose cone used to determine, Reference 170, the spanwise pressure distributions at one or more longitudinal body stations.

The spanwise variation of the pressure coefficient, C_p , on the lower surface of the conical shape is shown in Figures 149a and 149b. These data are for nominal Mach numbers of 5 and 8 and Reynolds number per foot of model length of 2.0×10^6 and 3.3×10^6 .

Figures 149c and 149d show additional C_p variations for this shape. No explanation is given, Reference 170, for the difference between the C_p variations either at $M = 5.08$; $Re = 3.3 \times 10^6$ and $\alpha = 14^\circ$ in Figures 149a and 149c or between those values shown for $M = 8.08$, $Re = 2.0 \times 10^6$ and $\alpha = 20^\circ$ in Figures 149b and 149d.

The pressure coefficient variation for this shape at angles of yaw of 0° , -4.5° , and -15° are shown in Figure 150. Figure 151 presents the C_p variation for additional angles of attack.

Theoretical approaches to the definition of a rough estimate of the cone drag in the slip-flow regime are given in References 125 and 48.

Figure 152 shows two 15° half-angle cone models which were tested, Reference 95, in the slip-flow regime to determine the drag on the fore portion of the cones. The measured drag coefficients compared to theoretical curves derived from boundary-layer analysis, References 95, 52, and 205, are shown in Figure 153.

Figure 154 shows the drag due to viscous influences. This drag is defined by Reference 95 to be equal to the difference between the total drag and the inviscid drag, and can be interpreted as the sum of the shear drag and the increment of pressure drag caused by viscosity.

The cone surface pressure at the gap between the model and the housing, see Figure 152, is given in Figure 155. This is the pressure which was measured within the housing. Reference 95 states that the deviations shown between theory and experiment are probably because of imperfect gap alignment.

The variation of the measured force coefficient, C_F , with Reynolds number is shown in Figure 156. Reference 95 states that the sum of the force coefficient C_F and the cone pressure coefficient C_{p_c} of Figure 155, minus the free-stream pressure coefficient p_∞/q_∞ , is equal to the total drag coefficient.

Tables XVI and XVII from Reference 95 list the above data plus certain additional information.

Reynolds-number evaluation in Reference 95 was based on viscosity obtained from Sutherland's equation for air, as tabulated in Reference 152.

In the past, sharp and blunt cones have been studied in both laminar and turbulent flows and at zero and small angles of attack (see References 12, 47, 105, and 216).

Figure 157 shows a sketch of the 15° half-angle sharp- and blunt-nose cones on which pressure and heat transfer measurements were made, Reference 38. The sharp cone had a fineness ratio of 1.87. The blunt-nose cone had a fineness ratio of 1.66 and a bluntness ratio (ratio of nose radius to base radius) of 0.1428. Pressure measurements were made under steady-state conditions. Heat-transfer measurements were made during transient heating of the model.

Reference 38 has shown that comparison of the experimental results therein with simply applied theories showed that on the stagnation line, pressures may be predicted by Newtonian theory, and heat transfer may be predicted by local yawed-cylinder theory based on the yaw angle of the windward generator and the local radius of the cone.

Heat transfer and pressure measurements on the stagnation line are presented in Figure 158 at angles of attack of 45° , 60° , 70° , 80° , and 90° , and in Figure 159 for an angle of attack of 0° . Pressure measurements on the stagnation line are also shown as a function of angle of attack in Figure 160. Here, the experimental values of $C_{p,s}/C_{p,max}$ are plotted against angle of attack and are compared with Newtonian theory, where $C_{p,s} = C_{p,max} \cos^2 \Lambda$. $C_{p,max}$ is the pressure coefficient corresponding to the stagnation region behind a normal shock wave at $M_\infty = 6.1$ and Λ is the yaw angle of the windward generator ($\theta = 0^\circ$ corresponding to the forward stagnation line). The experimental values agree rather well with theory for angles of attack up to approximately 60° . At values of angle of attack greater than 60° , the experimental values are less than theory.

Reference 38 shows that at $\alpha = 45^\circ$ and $\alpha = 60^\circ$ (Figure 158, this report) the pressures do not appear to vary drastically along the cone element thus indicating flow with conical characteristics. At $\alpha = 80^\circ$ and $\alpha = 90^\circ$, of this figure, there is a definite trend to depart from conical flow, with a maximum variation in experimental and theoretical $C_{p,s}$.

In Figure 159, for an angle of attack of 0° , it is seen that the pressure coefficient on the sharp cone is in good agreement with conical-flow theory. The pressure coefficient is lower at x' less than 3 inches for the blunt cone than for the sharp cone and at $x' > 3$ inches both cone values are essentially the same.

Figure 161 presents data from Reference 38 for the ratio of the experimental pressure at a given θ to the experimental pressure on the windward generator at the same value of x' . The data is given for several angles of attack. Reference 38 states that it may be concluded that the pressure distribution along any generator on the windward side of the cone is essentially similar to that on the stagnation

line. Normal-flow Newtonian pressures defined by

$$c_p = c_{p,s} \cos^2 \theta$$

fall below the experimental data diverging progressively from the measured values as θ increases.

Tests were conducted, Reference 81, on a 15° half-angle conical shape having a very short cylindrical afterbody (see Figure 162). The Mach numbers were 1.62, 1.93, and 2.41. The results of these tests are presented in this report. Figure 163 shows the total drag and base drag coefficients for this test shape. Typical pressure distributions over the conical portion of the body and the variation of forebody pressure-drag coefficient with Reynolds number is also given on this figure.

Reference 81 states that the skin-friction data results left much to be desired with regard to the accuracy and scatter of the results. There were eight models mentioned in this reference which were tested. All the models had the same conical forebody but had various cylindrical afterbody lengths. The results extracted from these tests and presented in this report are for the test shape having the shortest afterbody, or, 0.125 caliber cylindrical extension. Because of the above mentioned accuracy and scatter, Reference 81 presented only typical results at $M = 2.41$. These data for the approximate conical shape are shown in Figure 164 along with theoretical results. The skin-friction coefficients were obtained, Reference 81, from the following expression:

$$C_f = \frac{A_B}{A_w} [C_{D_T} - (C_{D_P} + C_{D_B})]$$

where A_B is the base area, A_w is the wetted area of the body (surface area forward of base), C_{D_T} is the total-drag coefficient, C_{D_P} is the forebody pressure-drag coefficient, and C_{D_B} is the base-drag coefficient. The incompressible, turbulent, skin-friction coefficient (Theory A) and the extension to this theory by Frankl and Voishel (Theory B) are shown. Also shown on this figure from Reference 81 are the following theoretical results for laminar flow: the flat-plate incompressible result of Blasius, the incompressible result of Chapman and Rubesin, and the flat-plate values corrected to the cone-cylinder by the formula given in Reference 165,

$$C_f = C_{f \text{ flat plate}} \left[\frac{2}{\sqrt{3}} \frac{\sqrt{(s+a)(s+3a)}}{s+2a} \right]$$

where s is the slant height of the cone and a is the length of the cylindrical afterbody. Reference 81 states that this formula follows from the transformation by Mangler and does not consider changes in pressure along the body. Figure 165 shows the variation of Reynolds number for transition with stagnation pressure for a 10° cone as presented in Reference 81. A definite increase in Reynolds number for transition with increasing stagnation pressure is evident.

Figure 166 shows a sketch of a 15° half-angle right circular cone model used to experimentally determine, Reference 98, the surface and base static pressure over a Mach number range, from 0.3 to 1.3.

The model was wire supported in the tunnel. The results of this test are shown in this report in Figures 167a and 167b. The base pressure is seen not to vary a great deal with distance from the center of the cone base. The pressure port nearest the edge of the cone base is shown to have registered the lowest pressure.

Figures 168a and 168b show averages of the surface and base pressure versus Mach number. Reference 98 has also presented the experimental data from the above-mentioned test plotted along with the Taylor-Maccoll theory for the forward surface port (see Figure 169, this report). The experimental data is also compared with the M' , p' method of Chapman, Reference 23, for the center base port for Mach numbers of 0.5 to 2.0. The average of the surface and base pressures is also shown in this figure. The Reynolds number, based on the diameter of the model is shown in Figure 170.

Three methods of estimating the base pressure found in the literature are presented in Reference 98 and include the methods of von Kármán, Reference 70, Gabeaud, Reference 71, and Chapman, Reference 23, see Figure 167b. Reference 98 also took an experimental average from Reference 21 which is also shown in Figure 167b in this report.

An attempt is made in Reference 209 to overcome the limitations of the slender-body theory, which fails to predict a dependence of the aerodynamic coefficients either on Mach number or on body shape, as shown in Reference 177, and of the linear theory, which does by the way indicate a Mach number dependence, Reference 46, but whose application is limited to bodies of vanishingly small thickness. Reference 209 makes use of two theoretical methods derived in Reference 218. Numerical calculations were carried out in Reference 209 for two cones having half-angles of 10° and 20° . These calculations were made to indicate the nature of the results which were obtained from the theoretical methods developed in Reference 209. The results for the variation with Mach number of the stability derivatives C_{N_q} , $C_{N_{\dot{\alpha}}}$, and $C_{N_{\ddot{\alpha}}}$ are shown in Figures 171 and 172. The curves obtained from potential theory have been terminated at the high end at the Mach number for which the Mach cone lies on the body surface. In Figures 171a and 172a, a comparison is made between the various approximate results and the exact numerical result as obtained from Reference 196. The curves labeled "-exact C_p " and "-approximate C_p " are those based on calculations indicated in Reference 209.

In Figures 171b, 171c, 172b, and 172c, Reference 209 assumed that only the hybrid solutions are representative of the exact variations for all Mach numbers within the limits, the Mach number for bow-wave detachment, and the Mach number corresponding to $\beta_t = 1.0$. In Figures 171c and 172c it is seen that $C_{N_{\ddot{\alpha}}}$ as obtained from potential theory is positive throughout the Mach number range. Reference 209 states that at least for axes ahead of the center of loading due to α , the damping moment $C_{m_q} + C_{m_{\dot{\alpha}}}$ cannot be destabilizing, since a negative value of $C_{N_{\ddot{\alpha}}}$ can be the only destabilizing contribution. Figures 171c and 172c also show that $C_{N_{\ddot{\alpha}}}$ vanishes when the Mach cone lies on the body surface, which is in agreement with that obtained from impact theory. Reference 209 goes on to state that it can be shown

that by operating with the transfer equations therein, that $C_{m_q} + C_{m_{\dot{\alpha}}}$ is not a destabilizing damping moment for any position of the axis.

Figure 173 shows the geometry of the sharp-nosed and blunt-nosed 20° half-angle cones for which the dynamic stability was determined by testing, Reference 224.

The damping-in-pitch derivatives versus angle of attack for the two cones are shown in Figure 174. It is seen that the damping-in-pitch coefficient for the sharp cone decreases slightly with increasing angle of attack. The blunt cone, however, shows a slight increase in damping as the angle of attack is increased, and then shows a much greater damping increase above an angle of attack of approximately 9° . Reference 224 also shows in this figure that increasing the nose bluntness in this case reduced the damping at angles of attack up to approximately 10° .

Figure 175 shows the details of the geometry of the 20° half-angle sharp- and blunt-nose cone models used to obtain force and moment data at a Mach number of 8, Reference 138. These longitudinal force and moment data are presented in this report in Figures 176 and 177, for an angle-of-attack range from -3 to approximately 46° . It is seen that both the sharp- and the blunt-nose cones are longitudinally stable, for the moment reference shown in Figure 175 at all the angles of attack tested. The axial force for both cone shapes is shown to increase with angle of attack.

Figure 178 presents a comparison of the experimental normal force and pitching moment coefficients for both the sharp- and blunt-nose cones with theoretical estimates for low angles of attack. The experimental values for normal force agree well with estimates determined by the modified Newtonian theory as described in Reference 76. The experimental pitching-moment values, however, are somewhat lower than the theoretical estimates for the sharp- and blunt-nose 20° half-angle cones.

The subsonic laminar and turbulent skin-friction correction factors for slender cones (half-angle less than 20°) was determined in Reference 128 with the use of the method of Reference 176. These results are presented in this report as Figures 179 and 180. References 239 and 75 were used by Reference 128 to indicate the applicability of the results from the use of potential theory and of the "extended Prandtl rule" for a cone at zero-angle of attack in incompressible flow and the subsonic compressible flow respectively.

The relations between free-stream conditions and conditions at the surface of a cone in supersonic flow, as derived by Reference 128 from the data of Reference 2, are presented in this report in Figures 181a, 181b, and 181c.

Reference 128 gives the following relation between the skin-friction drag coefficient, C_{D_F} , and the average skin-friction coefficient, C_F , for bodies of revolution in a free-stream flow parallel to the body axis:

$$C_{D_F} = K \frac{L}{D} C_F, \quad \frac{A_w}{A_{REF}} = K \frac{L}{D}$$

where K is a constant and for a cone $K = 2$, for a circular-arc ogive ($L/D \geq 3$), $K = 8/3$, and for a hemisphere, $K = \frac{\pi}{2}$.

Figure 182 shows the sonic wave drag of cones as presented in Reference 128. This is the result of theoretical data, using the theoretical investigation of References 240 and 140 and an extrapolation of experimental data as shown in Reference 191. At a free-stream Mach number close to unity, the wave drag can be determined from this figure from the following relation given in Reference 140:

$$C_{D_W} = C_{D_W}^* + \frac{2(M_\infty^2 - 1)}{\gamma + 1}$$

Subsonically, this relation can be used to give, approximately, the free-stream Mach number at which $C_{D_W} = 0$. Figure 183 shows the theoretical wave drag for cones with half-angles between 20° and 35° in supersonic flow. Reference 128 presents these data from Reference 2 along with experimental data from Reference 191 for 20° and 25° half-angle cones in transonic flow. The two sources of data are shown to agree well in the common regions.

Reference 128 has compared experimental values of the wave drag of hemispheres from Reference 192 with those predicted by the modified Newtonian theory. These data are presented in Figure 184 in this report. It is seen that the experimental values are much less than those predicted by theory in the low supersonic range.

The wave drag of slender pointed cones was plotted in the form of

$$C_{D_W} (M_\infty^2 - 1) = f \left(\frac{\sqrt{M_\infty^2 - 1}}{L/D} \right)$$

in Reference 128 and is presented here in Figure 185. Theoretical and experimental data from References 2, 56, 81, 136, 191, and 192 are found to correlate very well. Reference 128 shows that for values of K less than about 4, the empirical relation:

$$C_{D_W} (M_\infty^2 - 1) = 0.705 K^{1.69}$$

gives a good approximation to the data of Figure 185.

Figure 186 is also from Reference 128 and shows the regions where the wave-drag rules discussed therein for pointed cones apply.

The assumption that the modified Newtonian pressure distribution, Reference 156, exists over the spherical portion of a blunted cone, and that the pressure on the conical skirt is the same as for a pointed cone with the same angle, gives a good approximation of the wave drag for these shapes. With these assumptions, Reference 128 writes the wetted-surface-pressure-drag, or wave drag, coefficient as follows:

$$C_{D_W} = B^2 (1 - \sin^4 \theta_s) (C_{D_W})_{\text{HEM}} + (1 - B^2 \cos^2 \theta_s) (C_{D_W})_{\text{CONE}},$$

where:

$$B = \text{bluntness ratio} = \frac{\text{nose-tip radius}}{\text{maximum radius}},$$

θ_S = cone half-angle (subscript S added so as to conform with general symbols of this report).

$(C_{D_W})_{\text{HEM}}$ = wetted-surface-pressure-drag coefficient for a hemisphere,

$(C_{D_W})_{\text{CONE}}$ = wetted-surface-pressure-drag coefficient for a pointed cone with half-angle θ_S .

Values of $(C_{D_W})_{\text{HEM}}$, as mentioned above, are given in Figure 184, and

values of $(C_{D_W})_{\text{CONE}}$ are taken from Figure 183 or Figure 185.

Reference 128 also presents the wetted-surface pressure drag of truncated (flat-nosed) cones and states that this drag can be computed in a manner similar to that for spherical-tipped cones. It was assumed, in this reference, that the pressure on the flat nose is the stagnation pressure behind a normal shock. The wetted-surface pressure drag coefficient is then:

$$C_{D_W} = B^2 C_{P_{\text{ON}}} + (1 - B^2) (C_{D_W})_{\text{CONE}}$$

Where:

$C_{P_{\text{ON}}}$ = pressure coefficient at the stagnation point downstream from a normal shock,

$$B = \text{bluntness ratio} = \frac{\text{nose radius}}{\text{base radius}}.$$

Reference 128 has taken data from Reference 2 and presented $C_{P_{\text{ON}}}$ as a function of Mach number. This is shown in Figure 187 of this report.

A method of characteristics solution for axially symmetric bodies of revolution at small angles of attack was developed by Ferri, Reference 59. The use of Stone's Theory in Reference 201 makes it possible to compute the flow field about a cone at a small angle of attack. Some solutions of Stone's Theory are available in Reference 196. Reference 190 states, however, that the manner in which these results are presented (in a wind fixed coordinate system) makes their use rather cumbersome. In addition, Reference 190 continues to state that, as pointed out in Reference 173, the flow component perpendicular to the meridian planes was computed incorrectly. The results contained in Reference 190 were computed in the same basic manner as those of Reference 196 with the correct velocity normal to the meridian planes. In addition, these results have been transferred into the body fixed coordinate system. This allows the use of the values tabulated in Reference 190, in conjunction with the respective zero angle of attack results of Reference 189, as starting conditions for the method of characteristics solution of the flow field about axially symmetric bodies of revolution at small angles of attack.

The slope of the normal force coefficient curve for twelve right circular cones having half-angles ranging from 2.5 to 30° are shown graphically as a function of free-stream Mach number and cone half-angle in Figures 188a and 188b, respectively. This information is from Reference 190 which presents

the results of the calculations of supersonic flow fields about right circular cones at small angles of attack. The calculations were performed using the theory of Stone in Reference 201.

Table XVIII gives complete summary results for the minimum free stream Mach number solution for each of the twelve cone angles. Values of the initial slope of the normal force coefficient in radians, which were computed, Reference 190, are given in Table XIX.

The results of the prediction of the Newtonian drag coefficient for the blunted cone having a spherical base, as given in Reference 69, are presented in this report. Figure 189 shows a sketch of the conical shape considered in Reference 69. The Newtonian drag coefficients as a function of cone half-angle are shown in Figure 190 for values of bluntness ratio varying from 0 to 0.5.

Reference 69 has used the predicted Newtonian drag coefficients for these cone shapes to define a relationship for the weight (lbs) necessary for a ballistic coefficient, given the cone half-angle, bluntness ratio and the base radius as

$$W = \left[W/R_b^2 \right] \left(R_b^2 \right) \left(\frac{\beta}{100} \right)$$

where β is the desired ballistic coefficient (lbs/ft²) and $W/R_b^2 = \pi C_D \beta$. Values of W/R_b^2 as a function of cone half-angle are presented, from Reference 69, in Figure 191 of this report and are based, for scaling convenience, on a ballistic coefficient of 100 lbs/ft². As presented in Reference 69, Figure 192, in this report, presents graphically for various bluntness ratios, the relation between cone half-angle and fineness ratio as expressed by the following equation

$$\sin \theta_s = (1 - K) / (2F - [K + 1])$$

where

θ_s = cone half-angle

K = bluntness ratio = $\frac{r_n}{R_b}$

F = fineness ratio = $L/2R_b$

L = total length of body

r_n = nose-radius of body

R_b = base-radius of body

Figure 193 shows a sketch of a hemisphere and a 30° half-angle blunt-nose cone which were gun-launched, Reference 24, at various velocities to determine the drag history which was essential to the reduction of the total heat-transfer data. The fact that the tests were made at constant density over deceleration-type trajectories, the free-stream Reynolds number, R_∞ , varied directly with the instantaneous velocity as follows:

$$R_\infty = 6.25 V_\infty D \times 10^3$$

where V_∞ was the flight velocity in feet per second, and D was the reference diameter in feet. The test Reynolds number was, therefore, approximately 1.43 million.

Figure 194 shows the total drag coefficient variation with Mach number of the hemisphere and the 30° half-angle blunt-nose cone for Mach numbers ranging from subsonic to $M = 8.0$. Drag data are included in this figure from Reference 24 which were from Reference 182.

Figure 195 shows a sketch of two blunt-nosed cone models having cone half-angles of 14.5° and 32° which were used to measure forces and moments for a Mach number range from 1.60 to 4.50. The angle-of-attack range of these tests was from approximately -4 to 184°. The Reynolds numbers per foot ranged from about 1.1×10^6 to 5.8×10^6 . The effect of a change in Reynolds number on the aerodynamic characteristics of these two shapes is shown in Figures 196 and 197. The aerodynamic characteristics for these shapes are shown for several Mach numbers in Figures 198 and 199. Figure 200 (Reference 214) shows a summary of the stability and axial force characteristics of both cones. The effect of angle of attack on the center-of-pressure location of both cones is shown for several Mach numbers in Figure 201.

From the above figures it may be seen that both models are in trim at an angle of attack of about 180°, but it is also seen that this is an unstable trim.

Figure 202 shows a sketch of a general cone surface having a nose bluntness of the form of an ellipsoid of revolution. Reference 30 presents results of calculations (Academy of Sciences, USSR) of supersonic flow about blunted cones in air at zero angle of attack in the form of tables and graphs. Some of the graphical results are presented in this report for cone half-angles of 0° (blunted cylinder), 5°, 10°, 20°, 30°, and 40°. The bluntness (ratio of the vertical and horizontal axes of the ellipsoid of revolution) was equal to 0.5, 1.0 (sphere) and 1.5.

The dependence of the pressure, p , Mach number, M , and drag coefficient, C_x , which occur along the body wall are presented in Figures 203a through 203d for various values of free-stream Mach number and bluntness values. The values of p and C_x for corresponding sharp cones are shown as horizontal lines on the graphs for the pressure and drag coefficient.

Figures 204a through 204h present families of shock waves for the above cone shapes at various free-stream Mach numbers.

There are several theories pertaining to supersonic flow. The use of the method of characteristics to determine the supersonic flow fields about nonlifting bodies of revolution, e.g., Reference 97, is accepted by many to be an accurate operation but it is also quite full of tedium and is time consuming. A more widely used simplified theory of axially symmetric supersonic flow is the linear theory, first made use of by Kármán and Moore, Reference 220, to study supersonic flow about a body of revolution.

A second-order supersonic flow theory was later developed by Van Dyke, Reference 217. The results from this theory are generally more accurate than those which are obtained with the linear or first-order theory. Van Dyke's second-order theory is specifically limited however to cases for which the product of the free-stream Mach number and maximum slope of the body is less than 1.0. It is, therefore, not very suitable for calculating the flow about bodies of more usual proportions at high supersonic, or hypersonic speeds.

Reference 51 makes the statement that perhaps Tsien made the first step in the direction toward providing simplified methods for determining axially symmetric flows in the high supersonic speed range, Reference 213. With the aid of the similarity law demonstrated by Tsien, the flow about a family of shapes all having the same thickness distribution can be easily determined, provided, however, that the ratio of the free-stream Mach number to the slenderness ratio is the same for all shapes, and also provided the flow about one of these shapes is known.

As again stated in Reference 51 the problem of calculating the flow about a representative body for each value of the similarity parameter, however, can only be solved with good accuracy by means of the method of characteristics.

Eggers and Savin, Reference 51, therefore undertook the development of and obtained a simplified theory which provides, with engineering accuracy, the Mach number and pressure distributions about pointed nonlifting bodies of revolution operating at high supersonic airspeeds. The theory demonstrates very good accuracy over a considerable range of supersonic airspeeds in the special case of flow about cones.

Figure 205 is a schematic diagram, similar to Reference 51, of supersonic flow about a nonlifting cone.

A well defined restriction exists on the range of applicability of the results of the analysis of Reference 51. The boundary defining this is shown in Figure 206 which indicates that there is a minimum value of cone half-angle for any free-stream Mach number, below which the cone solutions presented in Reference 51 do not apply. The boundary shown in Figure 206 was obtained by Eggers and Savin, Reference 51, by using the results of Reference 195. If the equations developed in Reference 51 were used, a boundary curve slightly below the one shown would have been obtained.

Figures 207 through 210, from Reference 51, show the variations of the angle, θ , of flow inclination with respect to the body axis with the angle, ω , between the axis of the cone and the ray passing through the vertex of the cone. This is shown for cones having semiapex angles of 5° , 10° , 20° , and 40° . The predictions of the slender-cone solutions, Reference 51, are shown to be in good agreement with the results of Reference 195 for both the 5° and 10° cones, see Figures 207 and 208, and in fair to good agreement for the 20° cone.

The variations of the ratio of local velocity to the limiting velocity, $V/\hat{V}$, with the ray angle, ω , throughout the flow fields about the above four cones are shown in Figures 211 through 214. Similar agreement is again found between the cone solutions of Reference 51 and the results of Reference 195 as was found for the flow inclination angle as a function of the ray angle. Reference 51 states that a rule of thumb for choosing the preferable solution is to employ the cone solution for which $\omega - \theta < 1.0$ whenever it is applicable (Figure 206, or equation (30) as seen in the above figures).

The surface pressure coefficients of the 5°, 10°, 20°, and 40° half-angle cones were calculated, Reference 51, using the two approximate solutions as defined in Reference 51 and the results are shown in Figure 215. These are compared with the predictions of second-order theory (taken from Reference 217) and the results obtained from Reference 195. It is seen that the two approximate solutions of Reference 51 are in good agreement with Reference 195. Reference 51 states that the second-order theory yields more accurate results than the slender cone theory for the 5° and 10° cones at the lower Mach numbers, although the reverse seems to be the case for the 20° cone. Neither second-order nor slender-cone theory is applicable to the 40° cone. Eggers and Savin suggest, Reference 51, that the simplified solutions of their report may be particularly useful at high supersonic speeds for accurately determining the conical flow fields about cones at Mach numbers not treated in the MIT tables, Reference 195.

Figures 216 and 217 are from Reference 51 and show, respectively, the Mach number and pressure distributions at the surface of a family of ogives operating at a free-stream Mach number of 6. These were calculated, Reference 51, using the simplified methods of this reference. This was done by Eggers and Savin to determine the accuracy with which the solutions for flow about cones in combination with the isentropic expansion equations predict the flow at surface of bodies of revolution other than cones. The results obtained from the method of characteristics include effects of rotation and were presented in Reference 51 from Reference 175.

Figures 218 and 219 show a sketch of the body-axis system and dimensional data, respectively, for three similar spacecraft configurations. The static longitudinal stability and performance characteristics of these configurations were determined, Reference 102, and are presented in this report. These tests were conducted at a Mach number of 24.5 in helium and for an angle-of-attack range from -8° to 188°. The Reynolds number, based on maximum configuration diameter, was 0.57×10^6 . Moment reference centers of the three configurations shown in Figure 219 were located 0.576 inch (.288 diameters) rearward of the nose.

Normal force, axial force, and pitching-moment coefficients versus angle of attack for the three configurations are shown in Figure 220. The longitudinal performance of the three configurations relative to the wind axis system, is compared in Figures 221 to 223.

Reference 102 states that the differences in configuration drag coefficients at zero angle of attack shown in Figure 222 are essentially due to varying the heat-shield corner radii, neglecting incremental differences in drag due to the changes in afterbody geometry.

A significant note to make about the lift-drag ratios of these configurations which are shown in Figure 223 is stated in Reference 102 that the maximum lift-drag ratios of the three configurations are attained at angles of attack which would expose the afterbodies to the flow. As a consequence, a substantial weight penalty might be incurred in providing adequate afterbody heat protection in order to allow the shapes to develop their full performance potential. Figure 223 shows that the configuration

incorporating a 35° half-angle conical afterbody and a heat-shield corner radius of 5 percent of the maximum diameter develops the greatest lift-drag ratio without exposing the afterbody to the flow.

Experimental pitching-moment coefficients for the three configurations are shown in Figure 224. This figure shows that the vehicles are statically stable about the moment reference center chosen for the tests, Reference 102, up to an angle of attack near 40° . Something of a more significant value perhaps, relative to the more general cone geometries presented in this report, is that all three configurations are stable at an angle of attack of 180° .

Figure 225, taken from Reference 102, shows the extent of center-of-gravity displacement required to trim the three configurations at lift coefficients up to the maximum and lift-drag ratios up to the maximum. The configuration having a 30° half-angle conical afterbody is seen to require the minimum c.g. displacement for trim at a given lift coefficient or lift-drag ratio.

Figures 226 and 227, from Reference 102, show the longitudinal stability and performance characteristics of a configuration having a 35° half-angle conical afterbody. These figures include data from experiments in nitrogen and helium, and compare these with values obtained by the modified Newtonian theory. In general, it is seen that modified Newtonian theory is in good agreement with the test results obtained in helium, Reference 102.

Both Newtonian and exact theories give excellent predictions of the sign and value of the initial lift-curve slope at $M = 6.83$ for the sharp cones shown in Figure 228 from Reference 159. The Newtonian concept also gives very good predictions of trends of the force characteristics and the locations with respect to angle of attack of the points of maximum lift, maximum drag, and maximum lift-drag ratio. Generally, the variation between the experimental data and theoretical estimates increases with cone half-angle.

Figure 236, Reference 159, shows a gradual increase in the maximum lift coefficient with increasing cone half-angle at $M = 6.83$ up to a maximum which occurs at a cone half-angle of approximately 25° . This figure also shows that the angle of attack at which $C_{L,max}$ occurs is predicted reasonably well by either the Newtonian theory or by the empirical relation which states that the sum of the cone half angle and the angle of attack at which the maximum lift occurs is equal to 56° . For cone half-angles greater than 25° , a rapid decrease in $C_{L,max}$ occurs with increasing θ_s until $C_{L,max} = 0$ for a cone having $\theta_s = 45^\circ$. Sketches of these cones are shown in Figures 228a to 228t.

Figure 237, Reference 159, shows that the $(L/D)_{max}$ decreases and the angle of attack at which $(L/D)_{max}$ occurs increases with increasing cone half-angle at $M = 6.83$. Similar effects are experienced by a body when the bluntness and hence, drag is increased. It is also seen in this figure that the cone half-angles for maximum lift-drag ratios of 2, 1, and $1/2$ are about 8° , 16.5° , and 26° , respectively.

Figure 238, this report, shows that the lift coefficient at $(L/D)_{max}$ increases with increasing cone half-angle and reaches a maximum of almost 0.5 for a 28° half-angle cone, and decreases rapidly

thereafter to zero for a 45° half-angle cone using the planform area as the reference area. The use of the base area or the $(\text{volume})^{2/3}$ as reference area gives similar trends to those shown in Figure 238 where the planform area was used; however, calculations, Reference 159, show that the use of these areas attained maximum values at lower cone half-angles of approximately 21° and 26° for base area and $(\text{volume})^{2/3}$, respectively.

Two of the more important force characteristics for re-entry trajectory calculations are the parameters C_L and L/D . The maximum lift coefficient is a factor in the longitudinal dynamics of a configuration and a parameter used in re-entry trajectory calculations. The maximum lift-drag ratio of a lifting re-entry body is important in the determination of the maximum range, maximum deceleration, loading, aerodynamic heating and control during re-entry trajectory calculations. Penland, Reference 159, made a first approximation, in his study of a series of conical bodies having various half-angles, as to what configuration might be optimum based on these parameters. Figure 235, this report, shows that the maximum lift-curve slope occurs for a cone having a 26° half-angle. The maximum lift coefficient, Figure 236, this report, occurs for a cone having approximately a 25° half-angle. Figure 238 shows that the product of the value of C_L at $(L/D)_{\max}$ and the value of L/D at $C_{L,\max}$ reaches a maximum for a cone having a 23° half-angle. This indicates that the cone having a 23° half-angle is the best compromise in the region between $(L/D)_{\max}$ and $C_{L,\max}$. Of course, other factors such as weight, size, aerodynamic heating and others enter into the determination of the final optimum shape.

Twelve cone models having cone half-angles of 10° , 13.3° , 25° , and 50° and three bluntness ratios (ratio of diameter of spherical nose segment at station of tangency, d , to the base diameter, D) of 0, 0.4, and 0.8 (see Figure 240) were tested, Reference 154, to determine the aerodynamic characteristics of these cone shapes and to determine the effects of bluntness. The characteristic air properties during the test operation are given in this report in Table XX. Figure 241 gives the geometric characteristics of the models. The results of this test along with other experimental and theoretical data, References 53A, 72, and 135 are presented in this report. Figure 240 is a sketch of the cones used in the experiments.

The normal force coefficient slopes at zero angle of attack are presented in Figures 242a through 242c versus Mach number for bluntness ratios of 0, 0.4, and 0.8. For cones having half-angles up to 30° , bluntness ratios of 0.8 produced very pronounced C_{N_α} peaks which, Reference 154 states, occurred approximately at those Mach numbers identified with shock attachment on pointed cones. Cross plots of C_{N_α} versus cone half-angles at various Mach numbers are shown in Figures 243a through 243h.

The cone centers of pressure values at zero angle of attack are shown in Figures 244a through 244c. These center of pressure locations versus cone half angle are shown in Figures 245a through 245g at various Mach numbers.

The variation of the forebody drag coefficient with Mach number for bluntness ratios of 0, 0.4, and 0.8 is shown in Figures 246a through 246c, respectively. Reference 154 states that, in general, the effects of bluntness on the forebody drag coefficient of a given cone are negligible for $M < M_s$ (where M_s is the minimum Mach number for shock attachment for pointed cone), but large at $M > M_s$ and small cone half-angles (see Figures 247a through 247g in this report). For cone half-angles of 40° and larger, the bluntness effects are almost negligible at all Mach numbers.

Figures 248 through 251 are also included in this report from Reference 154. Figures 248a and 248b show the relationship between geometric parameters of spherically blunted cones, i.e., cone half-angle versus fineness ratio for various bluntness ratios and versus bluntness ratio for various fineness ratios respectively. Figures 249 through 251 present the hypersonic Newtonian normal force coefficient slope, center of pressure, and wave drag, respectively, for cones of varying geometry.

Newtonian theory provides one of the simplest yet useful means of estimating the characteristics of complete conic bodies. There has been a considerable amount of work, both theoretical and experimental, performed by a number of people in the application of this theory to a number of body shapes. A theoretical development with Newtonian theory has been carried out in Reference 79 for a series of cone and cone-cylinder configurations over a range of angle of attack. The determination of the aerodynamic characteristics of any arbitrary body of revolution by the application of Newtonian theory is presented in Reference 169. Application of this theory was also made in Reference 134 for predicting the force and moment characteristics of arbitrary bodies of revolution undergoing either separate or combined angle of attack and pitching motions (see also Reference 209). The calculation of force and moment coefficients of blunted conic bodies using this theory is discussed in Reference 65. The development of closed-form expressions for some of the more commonly used body shapes (spheres and circular and elliptic cones and portions of these bodies) operating at combined angles of attack and sideslip is presented in Reference 229. Tabulations of aerodynamic characteristics of circular cone bodies over a wide range of angles of attack and sideslip are included from Reference 229.

Table XXI, this report, presents the force coefficients of a series of circular conic bodies of varying cone half-angle for a range of angle of attack from 1° to 85° and a range of sideslip angle from 0° to 15° . The results presented in this table are from Reference 229 and were calculated with the classical Newtonian relationship $C_p = 2 \cos^2 \eta$. The results can be easily altered to account for any desired modification to the coefficient of $\cos^2 \eta$ by multiplying the tabulated values by the ratio of the modified coefficient to 2. Comparisons of predicted results with the use of various modified forms of this theory with experimental data for a variety of body shapes are presented in References 3, 4, and 159.

The values of the coefficients in Table XXI (this report) were computed using the base area of the cone segment considered as the reference area.

Figure 253 (this report) shows a comparison of some of the characteristics of conic bodies predicted by Newtonian theory with those obtained from the cone theory of References 195 and 197. This shows that Newtonian theory agrees reasonably well percentage-wise with that of a more exact theory for high values of cone half-angle especially in the high Mach number regime.

Figure 254 (this report) shows that Newtonian theory provides an effective means of predicting the longitudinal aerodynamic characteristics of sharp-nose complete cones except for the C_D of the 40° half-angle cone at high angles of attack and of the more slender cones at low angles of attack where viscous effects are significant. (No skin friction was included in the computed values shown in Table XXI.) Similar results at $M = 6.83$ were also obtained in Reference 159. In addition, the results of Reference 39 for a 20° half-angle cone indicate that the pressure distribution as well as the force and moment coefficients for complete cones are well predicted by Newtonian theory.

Figure 255 shows that with nose bluntness the agreement between theory and experiment is again good only for the bodies of low fineness ratio. For the more slender blunt-nose bodies, however, the agreement in pitching moment is even poorer than for the sharp-nose bodies. The Newtonian coefficient of 2 was used in the calculations as noted in Reference 229 which yields predictions of the pressure coefficients over a spheric body which are somewhat high. It has been shown in Reference 132 that nose bluntness can produce significant changes in the pressure distribution over the afterbody section of the configurations, particularly near the nose-afterbody juncture. Reference 229 states that although these nose interference effects do not greatly influence the ability of theory to predict the lift and drag characteristics of the blunt-nose bodies, they can affect the ability to predict moment characteristics of the more slender bodies ($\theta_s < 20^\circ$) and, therefore, contribute further to the poorer agreement between experimental and theoretical moment characteristics of the blunt-nose configurations.

Experimental and predicted variations in some of the longitudinal aerodynamic characteristics and stability derivatives of several complete conic bodies of varying cone half-angle are compared in Figures 256 and 257. The general conclusion reached in Reference 229 about the comparisons presented in these figures is that Newtonian theory provides an effective means of predicting the trends of the various parameters $C_{L,max}$, L/D_{max} , C_{m_α} , and C_{L_α} due to variations in cone half-angle.

Viscous forces comprise a major portion of the drag for the slender unblunted configurations, Reference 4, and as shown in Figure 256, from Reference 229, the predicted values of $(L/D)_{max}$ become substantially greater than experimental values for the more slender shapes. Increasing body slope reduces the ratio of viscous to total drag which, as expected, results in improved agreement between theoretical results and experimental results.

Figure 257 shows that the predicted values of the stability derivatives C_{m_α} and C_{L_α} agree quite well with experimental results for the complete cone bodies where no leeward-surface effects are present.

Reference 229 also points out that, in addition, a number of studies have shown that boundary-layer displacement can also have effects on the aerodynamic characteristics of many slender configurations. Theoretical treatment and experimental results of these displacement effects on three-dimensional bodies are included in References 8, 9, 53, 168, and 207. These references show that boundary-layer displacement can have some influence on the pressure distribution, and hence the force and moment characteristics, of slender bodies up to relatively high Mach numbers. Some of the disagreement noted between predicted values and experimental values of the stability derivatives C_{m_α} and C_{L_α} for the more slender sharp-nose body shapes ($\theta_S \approx 10^\circ$) may also be due to these displacement effects.

Figure 1. Variation of Reynolds Number Per Foot with Mach Number for Tests of Bodies of Revolution of Fineness Ratios 3 and 5.

Figure 2. The Variation of the Foredrag Coefficient at Zero Lift of a Fineness Ratio 3 Cone.

Figure 3. The Variation of the Foredrag Coefficient at Zero Lift of Cones, 3/4-Power, 1/2-Power, 1/4-Power, and Tangent-Ogive Bodies Having Fineness Ratios of 3 and/or 5.

Figure 4. The Ratios of Foredrag Coefficients of Fineness Ratio 3 and 5 Bodies to Foredrag Coefficients of Cones as Functions of the Exponent, n , in the Equation Defining Body Shapes.

Figure 5. Profiles of Fineness Ratio 3 Bodies of Revolution.

Figure 6. Variation of Reynolds Number Per Foot with Mach Number for Tests of Bodies of Revolution of Fineness Ratio 3.

Figure 7. The Variation of Lift Coefficient with Angle of Attack, with Drag Coefficient, and with Center of Pressure for Cones of Fineness Ratios 3, 4, 5, and 7 at Various Mach Numbers.

Figure 7. (Continued)

Figure 7. (Concluded)

Figure 8. Variation of the Lift-Drag Ratio with Lift Coefficient for Cones of Fineness Ratios 3, 4, 5, and 7 at $M = 4.01$.

Figure 9. Variation of the Lift-Drag Ratio with Lift Coefficient for a Cone of Fineness Ratio 5 at Various Mach Numbers.

Figure 10. The Variation of Lift Coefficient with Angle of Attack, with Drag Coefficient, and with Center of Pressure for Various Fineness Ratio 3 Bodies at Various Mach Numbers.

Figure 10. (Continued)

Figure 10. (Concluded)

Figure 11. Variation of the Lift-Drag Ratio with Lift Coefficient for Various Fineness Ratio 3 Bodies at Various Mach Numbers.

Figure 11. (Continued)

Figure 11. (Concluded)

Figure 12. Variation of Lift Coefficient with Angle of Attack, with Drag Coefficient, and with Center of Pressure for Various Fineness Ratio 5 Bodies at $M = 4.01$.

Figure 13. Variation of the Lift-Drage Ratio with Lift Coefficient for Various Fineness Ratio 5 Bodies at $M = 4.01$.

Figure 14. Comparison of Theoretical and Experimental Aerodynamic Force Characteristics of Cones Having Fineness Ratios of 3 and 5 for Various Mach Numbers.

(b) $M = 4.01$

Figure 14. (Continued)

Figure 14. (Concluded)

TABLE I
Experimental Longitudinal Aerodynamic Characteristics
for a Sharp Cone, Fineness Ratio 3.
 $\theta_s = 9^\circ 28'$

M	α	C_L	C_D	C_m	L/D	c. p.	M	α	C_L	C_D	C_m	L/D	c. p.
2.75	-1.0	-0.028	0.093	--	-0.030	--	4.01	12.3	0.392	0.185	-0.292	2.12	69.2
	0	-0.002	0.092	--	-0.016	--		14.1	0.450	0.221	-0.338	2.04	69.0
	1.0	0.028	0.093	-0.020	0.300	67.6		15.4	0.503	0.258	-0.382	1.94	68.9
	3.0	0.086	0.102	-0.062	0.845	67.8		16.2	0.520	0.277	-0.391	1.88	67.8
	5.0	0.140	0.111	-0.099	1.26	66.7		20.1	0.644	0.395	-0.501	1.63	67.6
	5.3	0.156	0.111	-0.114	1.40	68.5		23.2	0.723	0.483	-0.589	1.50	68.9
	7.8	0.232	0.130	-0.169	1.79	68.2							
	10.3	0.318	0.157	-0.234	2.02	68.7	4.48	-1.0	-0.027	0.088	--	-0.306	--
	12.9	0.413	0.196	-0.307	2.10	68.8		0	-0.002	0.088	--	-0.019	--
	15.1	0.513	0.239	-0.388	2.15	69.5		1.0	0.026	0.087	--	0.298	--
	15.4	0.518	0.243	-0.397	2.13	70.4		2.2	0.038	0.096	-0.028	0.394	67.0
	15.4	0.506	0.245	-0.382	2.07	69.1		2.8	0.075	0.096	-0.060	0.786	75.1
	20.2	0.714	0.382	-0.558	1.87	69.6		5.0	0.134	0.109	-0.094	1.22	65.8
	25.3	0.877	0.564	-0.718	1.56	69.7		7.8	0.228	0.136	-0.165	1.68	67.7
								8.3	0.257	0.134	-0.193	1.91	70.4
								10.3	0.326	0.162	-0.247	2.01	70.5
								11.8	0.376	0.185	-0.288	2.03	71.0
								13.2	0.423	0.210	-0.329	2.01	71.6
								15.3	0.487	0.260	-0.379	1.88	70.4
3.49	-1.0	-0.027	0.084	--	-0.325	--		17.1	0.550	0.312	-0.433	1.76	70.1
	0	0.002	0.084	--	0.021	--		18.1	0.582	0.336	-0.443	1.73	67.3
	1.0	0.028	0.084	-0.020	0.336	68.2		20.1	0.643	0.394	-0.490	1.63	66.3
	3.0	0.086	0.093	-0.062	0.927	68.0		22.1	0.697	0.462	-0.539	1.51	65.7
	5.0	0.145	0.104	-0.104	1.40	68.2	5.00	-0.85	-0.007	0.109	--	-0.061	--
	5.3	0.151	0.101	-0.107	1.50	67.0		0.13	0.005	0.099	--	0.050	--
	7.8	0.232	0.123	-0.166	1.89	67.3		1.1	0.046	0.100	-0.028	0.457	58.3
	10.3	0.315	0.152	-0.229	2.06	68.0		1.9	0.068	0.111	-0.049	0.618	67.8
	12.9	0.403	0.194	-0.296	2.08	68.0		2.5	0.104	0.090	--	1.15	--
	15.4	0.496	0.246	-0.373	2.02	68.6		4.9	0.169	0.106	-0.145	1.59	82.0
								6.8	0.221	0.114	-0.173	1.94	74.3
								9.7	0.301	0.159	-0.209	1.90	64.8
								13.3	0.417	0.223	-0.365	1.87	79.9
								15.3	0.470	0.266	-0.387	1.77	73.9
4.01	-1.0	-0.023	0.089	--	-0.261	--		17.3	0.533	0.335	-0.457	1.59	75.1
	0	0.006	0.088	--	0.065	--		17.5	0.483	0.314	-0.382	1.54	68.8
	1.0	0.028	0.088	--	0.320	--		20.0	0.547	0.401	-0.444	1.36	68.2
	3.0	0.090	0.088	-0.057	1.02	60.7		22.0	0.599	0.472	-0.502	1.27	68.6
	3.0	0.089	0.096	-0.065	0.927	69.0							
	4.0	0.118	0.098	-0.087	1.20	69.2							
	5.0	0.151	0.099	-0.101	1.52	63.3							
	6.5	0.205	0.110	-0.147	1.86	68.0							
	7.0	0.214	0.116	-0.147	1.84	64.8							
	8.3	0.262	0.127	-0.189	2.07	68.0							
	10.3	0.328	0.152	-0.237	2.15	67.8							
	10.4	0.337	0.163	-0.249	2.06	69.0							

TABLE II
Experimental Longitudinal Aerodynamic Characteristics
for a Sharp Cone, Fineness Ratio 4.
 $\theta_s = 7^\circ 7'$

M	α	C_L	C_D	C_m	L/D	c. p.	M	α	C_L	C_D	C_m	L/D	c. p.
2.75	-1.0	-0.028	0.064	--	-0.433	--	4.48	-1.0	-0.030	0.060	--	-0.495	--
	0	0	0.063	--	0	--		-1.0	-0.028	0.063	--	-0.449	--
	1.0	0.028	0.066	-0.017	0.417	58.2		0	0	0.059	--	0	--
	3.0	0.087	0.075	-0.058	1.16	64.2		1.0	0.023	0.062	--	0.375	--
	5.1	0.150	0.081	-0.103	1.86	65.8		2.8	0.072	0.071	-0.050	1.02	66.9
	5.1	0.161	0.081	-0.112	2.00	66.5		5.0	0.195	0.073	-0.166	2.67	82.6
	7.6	0.247	0.097	-0.173	2.55	66.9		7.8	0.301	0.109	-0.245	2.76	78.3
	10.2	0.349	0.125	-0.249	2.78	67.9		8.3	0.281	0.117	-0.209	2.40	70.9
	10.4	0.358	0.131	-0.259	2.73	68.9		10.3	0.366	0.149	-0.269	2.46	69.4
	12.7	0.458	0.168	-0.329	2.72	68.0		11.8	0.384	0.173	-0.275	2.22	66.9
	15.2	0.596	0.234	-0.431	2.55	67.8		13.2	0.460	0.196	-0.336	2.35	68.2
	15.3	0.585	0.230	-0.426	2.55	68.1		15.3	0.544	0.254	-0.404	2.14	68.3
	20.2	0.848	0.405	-0.638	2.10	68.2		17.1	0.619	0.306	-0.460	2.02	67.4
	25.3	1.067	0.623	-0.840	1.71	68.3		18.1	0.668	0.342	-0.501	1.95	67.6
4.01	-1.0	-0.025	0.054	--	-0.460	--	5.00	20.1	0.751	0.412	-0.572	1.82	67.5
	0	0.015	0.051	--	0.290	--		22.1	0.822	0.488	-0.641	1.68	67.8
	1.0	0.040	0.056	-0.033	0.730	79.6		-0.85	-0.018	0.064	--	-0.285	--
	3.0	0.100	0.065	-0.102	1.54	76.3		0.13	0.010	0.065	--	0.149	--
	3.0	0.099	0.063	-0.072	1.57	70.4		1.1	0.037	0.062	-0.028	0.588	74.3
	4.0	0.128	0.067	-0.092	1.91	69.4		1.9	0.057	0.067	-0.047	0.845	79.2
	5.0	0.168	0.074	-0.122	2.26	70.4		2.4	0.123	0.059	-0.100	2.08	79.9
	6.3	0.219	0.083	-0.151	2.62	66.7		4.9	0.208	0.081	-0.168	2.56	78.5
	7.0	0.239	0.090	-0.170	2.65	68.7		6.8	0.268	0.104	-0.205	2.57	73.7
	8.1	0.277	0.101	-0.193	2.74	66.9		7.1	0.221	0.099	-0.152	2.23	65.7
	10.1	0.360	0.124	-0.255	2.90	67.7		9.4	0.298	0.127	-0.197	2.35	62.6
	10.4	0.380	0.144	-0.277	2.64	69.2		9.4	0.298	0.114	-0.198	2.62	63.3
	11.4	0.394	0.150	-0.276	2.62	66.4		10.9	0.349	0.160	0.350	2.08	66.8
	12.2	0.445	0.166	-0.320	2.68	68.0		13.3	0.473	0.228	-0.379	2.08	73.8
	13.0	0.518	0.208	-0.379	2.49	68.5		15.3	0.548	0.292	-0.438	1.88	72.3
	15.4	0.560	0.239	-0.400	2.34	66.4		17.1	0.613	0.343	-0.495	1.79	72.0
	16.1	0.638	0.292	-0.471	2.18	67.9		17.9	0.596	0.353	-0.422	1.69	62.4
	19.4	0.721	0.361	-0.533	2.00	66.6		19.9	0.677	0.418	-0.478	1.62	61.4
	20.2	0.787	0.424	-0.598	1.86	67.6		21.8	0.738	0.496	-0.546	1.49	62.8
	24.2	0.939	0.597	-0.755	1.57	68.6							

TABLE III
Experimental Longitudinal Aerodynamic Characteristics
for a Sharp Cone, Fineness Ratio 5.
 $\theta_s = 5^\circ 43'$

M	α	C_L	C_D	C_m	L/D	c.p.	M	α	C_L	C_D	C_m	L/D	c.p.	
2.75	-1.0	-0.032	0.058	- - -	-0.548	- -	4.01	12.1	0.483	0.155	-0.346	3.13	68.6	
	0	-.002	.057	- - -	-.035	- -		13.9	.561	.215	-.410	2.61	68.8	
	1.0	.025	.057	- - -	.442	- -		15.6	.676	.279	-.513	2.42	70.8	
	3.0	.092	.060	- - -	1.54	- -		16.0	.680	.268	-.494	2.54	67.9	
	5.0	.161	.067	- - -	2.40	- -		20.0	.858	.416	-.639	2.06	67.3	
	5.0	.163	.064	-0.112	2.53	66.5		23.6	1.022	.579	-.790	1.76	67.5	
	7.6	.249	.082	-.172	3.02	66.7		4.48	-1.0	-.034	.044	- -	-.757	- -
	10.1	.371	.113	-.260	3.27	67.5			0	-.008	.042	- -	-.183	- -
	12.6	.499	.156	-.352	3.20	67.6			1.0	.022	.045	- -	.488	- -
	15.0	.651	.221	-.462	2.95	67.4			2.3	.056	.049	- -	1.14	- -
	15.2	.670	.231	-.488	2.91	69.0			2.8	.079	.052	-.065	1.53	79.9
	15.7	.677	.245	-.494	2.76	68.8			5.1	.155	.062	-.118	2.49	73.9
	20.1	.941	.413	-.687	2.28	66.7			7.5	.252	.080	-.175	3.16	67.4
	23.2	1.123	.565	-.841	1.99	67.3			7.9	.267	.088	-.198	3.03	71.3
3.49	-1.0	-.030	.053	- - -	-.558	- -	5.00	10.0	.361	.117	-.251	3.08	66.7	
	0	.001	.051	- - -	.015	- -		12.6	.486	.172	-.342	2.82	66.8	
	1.0	.027	.052	-.018	.529	63.6		13.1	.540	.236	-.391	2.29	67.4	
	3.0	.094	.055	-.067	1.71	69.4		15.2	.636	.250	-.490	2.55	72.1	
	5.0	.160	.062	-.109	2.59	66.6		17.2	.732	.324	-.564	2.26	71.0	
	5.0	.160	.061	-.109	2.63	66.6		17.4	.734	.321	-.542	2.29	68.1	
	7.6	.257	.080	-.179	3.22	67.7		- .85	-.026	.050	- -	-.518	- -	
	10.1	.372	.113	-.266	3.28	68.8			.13	.003	.048	- -	.069	- -
	12.6	.504	.167	-.361	3.02	68.3			1.1	.029	.054	- -	.534	- -
	15.0	.628	.290	-.460	2.16	67.4			1.9	.052	.049	- -	1.05	- -
	15.2	.643	.236	-.468	2.72	68.6			3.2	.093	.054	-.068	1.73	71.1
	20.1	.874	.478	-.658	1.83	66.8			5.0	.155	.069	-.119	2.24	74.4
	22.6	1.037	.553	-.810	1.88	69.2			6.7	.218	.084	-.171	2.61	75.8
	4.01	-1.0	-.027	.050	- - -	-.538			- -	7.5	.233	.095	-.137	2.46
0		.002	.043	- - -	.039	- -	9.4	.307	.124	-.190	2.47	58.7		
1.0		.025	.050	- - -	.505	- -	11.0	.380	.128	-.231	2.96	58.0		
2.5		.074	.055	-.059	1.34	76.9	13.3	.530	.190	-.419	2.79	75.0		
3.1		.107	.052	-.078	2.06	71.2	15.2	.608	.250	-.491	2.43	75.3		
4.0		.126	.059	-.093	2.14	71.7	17.2	.722	.329	-.582	2.20	73.9		
5.1		.179	.062	-.130	2.89	70.5	17.2	.727	.339	-.528	2.14	66.4		
6.3		.219	.065	-.153	3.36	68.0	19.7	.832	.434	-.636	1.92	68.4		
7.1		.256	.075	-.182	3.41	69.2	21.6	.899	.516	-.683	1.74	66.3		
8.1		.290	.084	-.203	3.46	67.8								
10.1		.375	.111	-.267	3.37	68.6								

TABLE IV
Experimental Longitudinal Aerodynamic Characteristics
for a Sharp Cone, Fineness Ratio 7.

$$\theta_s = 4^\circ 5'$$

M	α	C_L	C_D	C_m	L/D	c.p.	M	α	C_L	C_D	C_m	L/D	c.p.
2.75	-1.0	-0.035	0.049	- -	-0.713	- -	4.01	5.1	0.177	0.052	-0.124	3.40	68.6
	0	0	.046	- -	0	- -		7.1	.260	.065	-.181	3.94	68.0
	1.0	.030	.049	-0.017	.619	56.8		10.4	.462	.115	-.328	4.02	69.0
	3.0	.096	.047	-.061	2.03	62.3		13.4	.654	.184	-.465	3.55	68.5
	5.1	.152	.050	-.104	3.22	62.6	5.00	- .85	-.003	.039	- -	-.066	- -
	5.3	.130	.062	-.134	2.88	72.2		.13	.023	.037	- -	.620	- -
	10.3	.434	.114	-.301	3.83	67.4		1.1	.052	.045	-.042	1.13	78.8
	15.5	.811	.246	-.568	3.27	67.0		2.4	.093	.049	-.084	1.90	88.0
4.01	-1.0	-.030	.045	- -	-.664	- -		4.9	.174	.062	-.132	2.79	73.5
	0	.004	.046	- -	.095	- -		6.8	.244	.074	-.180	3.27	71.9
	1.0	.035	.044	-.023	.893	63.0		8.0	.267	.106	-.160	2.53	57.5
	3.0	.101	.042	-.067	2.40	64.9		9.9	.376	.122	-.233	3.10	59.5
	4.0	.136	.047	-.090	2.88	64.4

Figure 15. Sketches of Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.

Figure 16. Range of Mach Numbers and Reynolds Numbers of Experimental Testing of Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.

Figure 17. Variation of Total Drag Coefficient with Mach Number for Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.

Figure 18. The Effect of Bluntness on Total Drag Coefficient for Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.

Figure 19. The Effect of Bluntness on Total Drag Coefficient Based on Volume to the Two-Thirds Power for Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.

- FROM EXPERIMENT, ASSUMING $(C_{D_b} + C_{D_f})$ INDEPENDENT OF BLUNTNESS
 - - - - - EXTRAPOLATED TO HEMISPHERE
 ○ FROM EXPERIMENT, METHOD OF REFERENCES 143 AND 155
 - - - - - ESTIMATED BY METHOD OF REFERENCE 192

Figure 20. Variation of Wave Drag Coefficient with Bluntness for Several Low (5.2° to 9.5°) Half-Angle Sharp- and Blunt-Nose Cones Having Flat Bases.

Figure 21. Variation of Wave Drag Coefficient with Mach Number for a Hemisphere.

PRESSURE ORIFICE LOCATIONS

θ_s DEG	d_n	l	x_1	x_2	x_3	x_4	x_5
5 ↓	0.007	2.10	0.510	0.717	0.915	1.200	1.590
	.014	2.06	.475	.682	.880	1.165	1.555
	.029	1.97	.377	.584	.782	1.067	1.457
	.060	1.79	.197	.404	.602	.887	1.277
10 ↓	.005	1.04	.254	.414	.548	.708	.903
	.014	1.02	.234	.396	.526	.684	.876
	.028	.98	.190	.348	.486	.642	.826
	.060	.89	.098	.256	.390	.554	.750

ALL DIMENSIONS ARE IN INCHES

Figure 22. Sketch Showing Pressure Orifice Locations and Dimensions of 5° and 10° Half-Angle Sharp- and Blunt-Nose Cones.

(a) $M_1 = 17$

Figure 23. Variation of Induced Static Pressure Ratio with Distance from Leading Edge of 5° Half-Angle Cones at Various Free-Stream Mach Numbers and Values of Reynolds Number, R_d .

Figure 23. (Continued)

(c) $M_1 = 21$

Figure 23. (Continued)

Figure 13. (Concluded)

Figure 24. Variation of Induced Static Pressure Ratio with Distance from Leading Edge of 10° Half-Angle Cones at Various Free-Stream Mach Numbers and Values of Reynolds Number, R_d .

(b) $M_1 = 19$

Figure 24. (Continued)

(c) $M_1 = 21$

Figure 24. (Continued)

(d) $M_1 = 23$

Figure 24. (Concluded)

ALL DIMENSIONS ARE IN INCHES

PRESSURE ORIFICE LOCATIONS

$\theta_s = 5^\circ$:

(0°) $x_1 = 0.210$

(180°) $x_2 = 0.356$

(90°) $x_3 = 0.520$

(270°) $x_4 = 0.520$

$\theta_s = 10^\circ$:

(0°) $x_1 = 0.120$

(180°) $x_2 = 0.185$

(90°) $x_3 = 0.256$

(270°) $x_4 = 0.256$

Figure 25. Sketch Showing Pressure Orifice Locations and Dimensions of 5° and 10° Half-Angle Sharp-Nose Cones.

Figure 26. Variation of Reynolds Number with Mach Number for Various Stagnation Pressures and Constant Stagnation Temperature. $T_0 = 545^\circ\text{R}$.

Figure 27. Variation of Surface Pressure to Stagnation Pressure Ratio for a 5° Half-Angle Cone.

Figure 28. Variation of Induced Static Pressure Ratio with $1/\sqrt{R_{x,\rho}}$ for a 5° Half-Angle Cone.

Figure 29. Variation of Induced Static Pressure Ratio with Hypersonic Interaction Parameter, $\bar{X}$, for a 5° Half-Angle Cone.

Figure 30. Variation of Surface Pressure to Stagnation Pressure Ratio for a 10° Half-Angle Cone.

Figure 31. Variation of Induced Static Pressure Ratio with $1/\sqrt{R_{x,\ell}}$ for a 10° Half-Angle Cone.

Figure 32. Variation of Induced Static Pressure Ratio with Hypersonic Interaction Parameter, $\bar{X}$, for a 10° Half-Angle Cone.

Figure 33. Sketch Showing Force Model Conventions.

Figure 34. Sketch Showing Dimensions of $6^\circ 30'$ Half-Angle Cones Having Two Nose Bluntness Ratios.

Figure 35. Sketch Showing Dimensions of 9° Half-Angle Cones Having Two Nose Bluntness Ratios.

Figure 36. Variation of Aerodynamic Characteristics with Angle of Attack for a $6^\circ 30'$ Half-Angle Cone Having a Nose Bluntness Ratio of 0.03.

Figure 36. (Continued)

Figure 36. (Continued)

Figure 36. (Concluded)

Figure 37. Variation of Aerodynamic Characteristics with Angle of Attack for a $6^\circ 30'$ Half-Angle Cone Having a Nose Bluntness Ratio of 0.145.

Figure 37. (Continued)

Figure 37. (Continued)

Figure 37. (Concluded)

Figure 38. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having a Nose Bluntness Ratio of 0.03.

Figure 38. (Continued)

Figure 38. (Continued)

Figure 38. (Concluded)

Figure 39. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having a Nose Bluntness Ratio of 0.30.

Figure 39. (Continued)

Figure 39. (Continued)

Figure 39. (Concluded)

Figure 40. Variation of Aerodynamic Characteristics with Angle of Attack for a $6^\circ 30'$ Half-Angle Cone Having a Nose Bluntness Ratio of 0.03 for Different Mach Numbers.

Figure 40. (Continued)

Figure 40. (Continued)

Figure 40. (Concluded)

TABLE V
Surface Coordinates of the Cone Pressure Instrumentation
for a $6^{\circ}20'$ Half-Angle Cone Model.

POSITION	δ	SURFACE DISTANCE AFT OF NOSE, S ~ INCHES		
		$r_n = .003$	$r_n = .125$	$r_n = .250$
1	0	3.018	2.075	1.131
2	↓	5.031	4.087	3.144
3		7.043	6.100	5.156
4		9.055	8.112	7.168
5		11.068	10.124	9.180
6		13.080	12.137	11.193

TABLE VI
Surface Coordinates of the Cone Pressure Instrumentation
for a 9° Half-Angle Cone Model.

POSITION	δ	SURFACE DISTANCE AFT OF NOSE, S ~ INCHES	
		$r_n = .0025$	$r_n = .125$
1	180	3.79	3.18
2	↓	5.31	4.69
3		7.33	6.72
4		9.36	8.74
5		4.29	3.68
6	↓	6.32	5.71
7		8.34	7.73
8		4.29	3.68
9		6.32	5.71
10	↓	8.34	7.73

TABLE VI (Concluded)

POSITION	δ	SURFACE DISTANCE AFT OF NOSE, $s \sim$ INCHES
		$r_n = .450$
1		0
2	180	.47
3		1.58
4		3.10
5		5.12
6		7.15
7	0	2.08
8		4.11
9		6.13
10	90	2.08
11		4.11
12		6.13
13		BASE
14	180	8.77
15		10.80

BOTTOM VIEWS

Figure 41. Sketch Showing Pressure Orifice Locations and Dimensions of $6^\circ 20'$ Half-Angle Cone Having Three Nose Bluntness Ratios.

Figure 42. Sketch Showing Pressure Orifice Locations and Dimensions of a 9° Half-Angle Cone Having Three Nose Bluntness Ratios.

TABLE VII
Pressure Data for Three Sharp- and Blunt-Nose 6°20' Half-Angle Cones.

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_o	p_m/p_∞	$Re/ft \times 10^{-6}$
0.003	1.609	0.0019	14.71	0.00	0.00	1	0.0240	0.0327	0.0210	5.9542	0.173
						2	0.0169	0.0212	0.0149	4.2078	
						3	0.0219	0.0294	0.0193	5.4486	
						4	0.0231	0.0314	0.0203	5.7475	
						5	0.0220	0.0296	0.0194	5.4779	
						6	0.0221	0.0298	0.0195	5.5044	
0.003	1.609	0.0019	14.37	0.00	0.00	1	0.0089	0.0344	0.0221	5.9786	0.062
						2	0.0078	0.0294	0.0194	5.2512	
						3	0.0083	0.0317	0.0207	5.5894	
						4	0.0088	0.0339	0.0218	5.8959	
						5	0.0081	0.0308	0.0202	5.4552	
						6	0.0081	0.0307	0.0201	5.4336	
0.003	1.609	0.0019	13.81	0.00	0.00	1	0.0037	0.0323	0.0213	5.3154	0.025
						2	0.0031	0.0258	0.0178	4.4442	
						3	0.0033	0.0285	0.0193	4.8028	
						4	0.0034	0.0289	0.0195	4.8626	
						5	0.0031	0.0258	0.0178	4.4435	
						6	0.0033	0.0282	0.0191	4.7585	
0.125	1.609	0.078	14.65	0.00	0.00	1	0.0190	0.0253	0.0171	4.7940	0.164
						2	0.0162	0.0205	0.0145	4.0729	
						3	0.0183	0.0240	0.0164	4.6086	
						4	0.0138	0.0249	0.0169	4.7360	
						5	0.0201	0.0271	0.0180	5.0662	
						6	0.0210	0.0286	0.0189	5.2932	
0.125	1.609	0.078	14.68	5.00	0.00	1	0.0410	0.0600	0.0357	10.0529	0.171
						2	0.0489	0.0730	0.0426	12.0024	
						3	0.0519	0.0777	0.0451	12.7178	
						4	0.0545	0.0820	0.0474	13.3721	
						5	0.0492	0.0735	0.0429	12.0793	
						6	0.0506	0.0757	0.0440	12.4097	
0.125	1.609	0.078	14.66	10.00	0.00	1	0.1039	0.1573	0.0877	24.6762	0.174
						2	0.0906	0.1364	0.0765	21.5286	
						3	0.0933	0.1407	0.0788	22.1688	
						4	0.0983	0.1485	0.0830	23.3519	
						5	0.0945	0.1425	0.0798	22.4403	
						6	0.0950	0.1434	0.0802	22.5760	

TABLE VII (cont)
Pressure Data - $\theta_s = 6^\circ 20'$

r_n	R_b	r_n/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_o	p_m/p_∞	$Re/ft \times 10^{-6}$
0.125	1.609	0.078	14.66	20.00	0.00	1	0.2261	0.3509	0.1966	55.2846	0.169
						2	0.2131	0.3397	0.1853	52.0905	
						3	0.2156	0.3437	0.1874	52.7027	
						4	0.2086	0.3324	0.1814	50.9951	
						5	0.2142	0.3415	0.1863	52.3706	
						6	0.2231	0.3559	0.1940	54.5374	
0.125	1.609	0.078	14.68	30.00	0.00	1	0.4084	0.6572	0.3551	100.1184	0.171
						2	0.3497	0.5617	0.3041	85.7184	
						3	0.3803	0.6115	0.3307	93.2342	
						4	0.4041	0.6502	0.3514	99.0681	
						5	0.3612	0.5805	0.3141	88.5574	
						6	0.3821	0.6144	0.3322	93.6635	
0.125	1.609	0.078	14.67	40.00	0.00	1	0.6063	0.9596	0.5169	145.5073	0.173
						2	0.5158	0.8154	0.4397	123.7889	
						3	0.5822	0.9212	0.4963	139.7208	
						4	0.5941	0.9401	0.5065	142.5727	
						5	0.5263	0.8321	0.4487	126.3068	
						6	0.5687	0.8996	0.4848	136.4779	
0.125	1.609	0.078	14.68	20.00	90.00	1	0.0388	0.0551	0.0330	9.3178	0.174
						2	0.0334	0.0465	0.0284	8.0164	
						3	0.0331	0.0461	0.0282	7.9509	
						4	0.0344	0.0482	0.0293	8.2675	
						5	0.0319	0.0442	0.0272	7.6738	
						6	0.0329	0.0458	0.0281	7.9133	
0.125	1.609	0.073	14.67	40.00	30.00	1	0.0684	0.1045	0.0595	16.7502	0.170
						2	0.0604	0.0916	0.0525	14.8015	
						3	0.0629	0.0955	0.0547	15.3976	
						4	0.0632	0.0950	0.0549	15.4703	
						5	0.0587	0.0888	0.0511	14.3866	
						6	0.0598	0.0906	0.0520	14.6485	
0.125	1.609	0.078	14.66	10.00	90.00	1	0.0235	0.0311	0.0202	5.6831	0.170
						2	0.0240	0.0320	0.0207	5.8156	
						3	0.0263	0.0357	0.0227	6.3771	
						4	0.0265	0.0361	0.0228	6.4249	
						5	0.0239	0.0313	0.0206	5.7805	
						6	0.0280	0.0384	0.0241	6.7714	

TABLE VII (cont)
Pressure Data - $\theta_s = 6^\circ 20'$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_o'	p_m/p_∞	$Re/ft \times 10^{-6}$
0.250	1.609	0.155	14.68	0.00	0.00	1	0.0362	0.0524	0.0316	8.9051	0.170
						2	0.0182	0.0232	0.0159	4.4952	
						3	0.0173	0.0216	0.0151	4.2505	
						4	0.0176	0.0221	0.0154	4.3330	
						5	0.0159	0.0193	0.0139	3.9090	
						6	0.0171	0.0213	0.0149	4.2103	
0.250	1.609	0.155	14.63	5.00	0.00	1	0.0464	0.0678	0.0398	11.1616	0.167
						2	0.0319	0.0445	0.0274	7.6662	
						3	0.0386	0.0552	0.0331	9.2749	
						4	0.0506	0.0746	0.0435	12.1816	
						5	0.0497	0.0731	0.0426	11.9502	
						6	0.0513	0.0757	0.0441	12.3449	
0.250	1.609	0.155	14.67	10.00	0.00	1	0.0735	0.1125	0.0637	17.9439	0.170
						2	0.0877	0.1355	0.0761	21.4181	
						3	0.1051	0.1636	0.0911	25.6475	
						4	0.1052	0.1638	0.0912	25.6722	
						5	0.0945	0.1465	0.0819	23.0739	
						6	0.0987	0.1532	0.0855	24.0841	
0.250	1.609	0.155	14.69	20.00	0.00	1	0.2105	0.3410	0.1860	52.5285	0.170
						2	0.2021	0.3270	0.1785	50.4213	
						3	0.2162	0.3503	0.1910	53.9441	
						4	0.2297	0.3726	0.2029	57.2993	
						5	0.2094	0.3392	0.1850	52.2532	
						6	0.1961	0.3172	0.1732	48.9320	
0.250	1.609	0.155	14.17	0.00	0.00	1	0.0123	0.0480	0.0295	7.7428	0.063
						2	0.0064	0.0216	0.0154	4.0288	
						3	0.0062	0.0206	0.0148	3.8923	
						4	0.0052	0.0160	0.0124	3.2502	
						5	0.0073	0.0255	0.0174	4.5765	
						6	0.0066	0.0225	0.0158	4.1573	
0.250	1.609	0.155	13.17	0.00	0.00	1	0.0041	0.0299	0.0204	4.6292	0.024
						2	0.0024	0.0140	0.0119	2.6991	
						3	0.0023	0.0136	0.0117	2.6516	
						4	0.0018	0.0084	0.0089	2.0194	
						5	0.0028	0.0180	0.0140	3.1794	
						6	0.0024	0.0145	0.0122	2.7585	

TABLE VII (cont)
Pressure Data - $\theta_s = 3^\circ 20'$

r_n	R_b	r_n/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_o'	p_m/p_∞	$Re/ft \times 10^{-6}$
0.250	1.609	0.155	14.71	30.00	0.00	1	0.4238	0.6773	0.3659	103.5798	0.175
						2	0.3688	0.5886	0.3184	90.1382	
						3	0.3921	0.6262	0.3386	95.8440	
						4	0.3321	0.5294	0.2868	81.1804	
						5	0.4150	0.5632	0.3584	101.4451	
						6	0.4375	0.6395	0.3778	106.9414	
0.250	1.609	0.155	14.64	40.00	0.30	1	0.6254	0.9989	0.5378	150.9182	0.168
						2	0.4764	0.7594	0.4097	114.9717	
						3	0.5866	0.9365	0.5045	141.5509	
						4	0.4780	0.7619	0.4111	115.3488	
						5	0.7271	1.1625	0.6254	175.4741	
						6	0.5829	0.9306	0.5013	140.6712	
0.250	1.609	0.155	13.75	0.00	0.00	1	0.0043	0.0389	0.0249	6.1458	0.024
						2	0.0022	0.0164	0.0128	3.1703	
						3	0.0026	0.0202	0.0148	3.6703	
						4	0.0020	0.0138	0.0114	2.8288	
						5	0.0030	0.0249	0.0173	4.2896	
						6	0.0026	0.0199	0.0147	3.6347	
0.125	1.609	0.078	14.22	0.00	0.00	1	0.0071	0.0255	0.0174	4.6031	0.062
						2	0.0057	0.0190	0.0139	3.6863	
						3	0.0071	0.0255	0.0174	4.6140	
						4	0.0062	0.0212	0.0151	4.0034	
						5	0.0096	0.0369	0.0235	6.2251	
						6	0.0077	0.0235	0.0190	5.0318	
0.125	1.609	0.078	13.86	0.00	0.00	1	0.0029	0.0247	0.0172	4.3153	0.025
						2	0.0023	0.0177	0.0135	3.3849	
						3	0.0032	0.0274	0.0187	4.6848	
						4	0.0027	0.0217	0.0156	3.9236	
						5	0.0039	0.0355	0.0230	5.7671	
						6	0.0032	0.0280	0.0189	4.7578	
0.125	1.609	0.078	13.89	5.00	0.00	1	0.0073	0.0727	0.0429	10.8134	0.026
						2	0.0070	0.0692	0.0410	10.3478	
						3	0.0090	0.0909	0.0526	13.2681	
						4	0.0075	0.0740	0.0436	10.9934	
						5	0.0110	0.1122	0.0640	16.1420	
						6	0.0091	0.0920	0.0532	13.4236	

TABLE VII (cont)
Pressure Data - $\theta_s = 6^\circ 20'$

r_n	R_b	r_n/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_o	p_m/p_∞	$R_e/ft \times 10^{-6}$
0.125	1.609	0.078	13.87	10.00	0.00	1	0.0147	0.1502	0.0844	21.2163	0.025
						2	0.0127	0.1285	0.0728	18.3011	
						3	0.0156	0.1595	0.0893	22.4614	
						4	0.0132	0.1345	0.0760	19.1011	
						5	0.0196	0.2025	0.1124	28.2564	
						6	0.0162	0.1665	0.0931	23.4077	
0.125	1.609	0.078	13.85	20.00	0.00	1	0.0404	0.4316	0.2350	58.9210	0.025
						2	0.0334	0.3562	0.1947	48.8047	
						3	0.0418	0.4466	0.2431	60.9431	
						4	0.0356	0.3794	0.2071	51.9229	
						5	0.0522	0.5606	0.3041	76.2420	
						6	0.0428	0.4576	0.2490	62.4217	
0.125	1.609	0.078	13.75	30.00	0.00	1	0.0671	0.7346	0.3972	98.2377	0.023
						2	0.0468	0.5104	0.2772	68.5550	
						3	0.0687	0.7527	0.4069	100.6265	
						4	0.0591	0.6466	0.3501	86.5884	
						5	0.0677	0.7413	0.4008	99.1164	
						6	0.0703	0.7703	0.4163	102.9621	
0.125	1.609	0.078	13.78	40.00	0.00	1	0.0866	0.9376	0.5059	125.6484	0.024
						2	0.0566	0.6094	0.3302	82.0207	
						3	0.0874	0.9455	0.5101	126.6943	
						4	0.0725	0.7832	0.4232	105.1191	
						5	0.1062	1.1510	0.6201	154.0122	
						6	0.0869	0.9405	0.5075	126.0379	
0.003	1.609	0.0019	14.19	0.00	0.00	1	0.0030	0.0279	0.0188	4.9375	0.025
						2	0.0023	0.0199	0.0144	3.7989	
						3	0.0027	0.0238	0.0165	4.3509	
						4	0.0020	0.0157	0.0122	3.2132	
						5	0.0029	0.0261	0.0178	4.6836	
						6	0.0023	0.0192	0.0141	3.7037	
0.003	1.609	0.0019	21.82	0.00	0.00	1	0.0026	0.0272	0.0161	10.0822	0.049
						2	0.0022	0.0227	0.0138	8.5889	
						3	0.0024	0.0244	0.0147	9.1572	
						4	0.0020	0.0200	0.0123	7.6815	
						5	0.0027	0.0279	0.0165	10.3293	
						6	0.0023	0.0230	0.0139	8.6765	

TABLE VII (cont)
Pressure Data - $\theta_s = 6^\circ 20'$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_o'	p_m/p_∞	$Re/ft \times 10^{-6}$
0.003	1.609	0.0019	21.52	0.00	0.00	2	0.0011	0.0324	0.0190	11.4954	0.018
						3	0.0003	0.0067	0.0052	3.1692	
						4	0.0010	0.0279	0.0165	10.0316	
						5	0.0007	0.0192	0.0119	7.2232	
						6	0.0006	0.0165	0.0105	6.3425	
0.003	1.609	0.0019	21.09	0.00	0.00	2	0.0007	0.0342	0.0200	11.6461	0.010
						6	0.0004	0.0160	0.0103	5.9594	
0.125	1.609	0.078	14.14	0.00	0.00	1	0.0027	0.0265	0.0180	4.7111	0.023
						4	0.0019	0.0162	0.0125	3.2694	
0.125	1.609	0.078	14.14	10.00	0.00	1	0.0138	0.1626	0.0908	23.9104	0.023
						2	0.0122	0.1431	0.0804	21.1684	
						3	0.0126	0.1475	0.0828	21.7337	
						4	0.0102	0.1174	0.0667	17.5503	
						5	0.0144	0.1693	0.0945	24.8598	
						6	0.0112	0.1299	0.0734	19.3090	
0.125	1.609	0.078	14.14	20.00	0.00	1	0.0349	0.4261	0.2319	60.7910	0.023
						2	0.0275	0.3342	0.1827	47.8982	
						3	0.0320	0.3892	0.2122	55.6118	
						4	0.0245	0.2965	0.1626	42.6080	
						5	0.0354	0.4322	0.2352	61.6426	
						6	0.0271	0.3292	0.1801	47.1958	
0.125	1.609	0.073	14.20	40.00	0.00	1	0.0892	1.0944	0.5897	155.4582	0.023
						2	0.0312	0.3785	0.2064	54.4244	
						3	0.0807	0.9896	0.5336	140.6723	
						4	0.0653	0.7991	0.4316	113.7834	
						5	0.0937	1.1496	0.6192	163.2415	
						6	0.0746	0.9143	0.4932	130.0260	
0.125	1.609	0.078	14.25	0.00	0.00	1	0.0213	0.0235	0.0163	4.3358	0.182
						2	0.0166	0.0165	0.0127	3.3645	
						3	0.0194	0.0207	0.0149	3.9465	
						4	0.0137	0.0168	0.0128	3.3949	
						5	0.0250	0.0287	0.0191	5.0847	
						6	0.0193	0.0205	0.0148	3.9209	

TABLE VII (cont)
Pressure Data - $\theta_s = 6^\circ 20'$

r_n	R_b	r_n/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_o	p_m/p_∞	$Re/ft \times 10^{-6}$
0.125	1.609	0.078	14.27	20.00	0.00	1	0.2729	0.3805	0.2073	55.2379	0.184
						2	0.1353	0.1851	0.1028	27.3886	
						3	0.2449	0.3407	0.1860	49.5684	
						4	0.1904	0.2634	0.1447	38.5466	
						5	0.2742	0.3823	0.2083	55.4896	
						6	0.2068	0.2866	0.1571	41.8564	
0.125	1.609	0.078	22.15	0.00	0.00	1	0.0023	0.0269	0.0159	10.2646	0.045
						2	0.0016	0.0187	0.0115	7.4407	
						3	0.0020	0.0241	0.0145	9.3189	
						4	0.0017	0.0193	0.0119	7.6451	
						5	0.0025	0.0296	0.0174	11.1957	
						6	0.0020	0.0240	0.0144	9.2701	
0.125	1.609	0.078	21.82	5.00	0.00	1	0.0055	0.0611	0.0343	21.2247	0.048
						2	0.0036	0.0382	0.0221	13.6455	
						3	0.0064	0.0709	0.0395	24.4544	
						4	0.0049	0.0534	0.0301	18.6539	
						5	0.0071	0.0787	0.0437	27.0429	
						6	0.0054	0.0594	0.0334	20.6551	
0.125	1.609	0.078	21.83	10.00	0.00	1	0.0133	0.1498	0.0817	51.0443	0.048
						2	0.0054	0.0597	0.0335	20.9346	
						3	0.0121	0.1364	0.0745	46.5616	
						4	0.0100	0.1125	0.0618	38.5824	
						5	0.0142	0.1604	0.0873	54.5597	
						6	0.0109	0.1224	0.0670	41.8780	
0.125	1.609	0.078	21.87	20.00	0.00	1	0.0315	0.3762	0.2027	127.7056	0.048
						2	0.0054	0.0620	0.0348	21.8897	
						3	0.0295	0.3523	0.1900	119.6622	
						4	0.0240	0.2858	0.1544	97.2498	
						5	0.0326	0.3900	0.2101	132.3548	
						6	0.0254	0.3029	0.1636	103.0345	
0.125	1.609	0.078	14.10	0.00	0.00	1	0.0026	0.0249	0.0171	4.4588	0.022
						2	0.0014	0.0098	0.0091	2.3671	
						3	0.0022	0.0208	0.0150	3.8979	
						4	0.0019	0.0165	0.0127	3.2899	
						5	0.0029	0.0290	0.0194	5.0424	
						6	0.0022	0.0206	0.0148	3.8616	

TABLE VII (Concluded)
Pressure Data - $\theta_s = 6^\circ 20'$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_{p_s}	p_m/p_o	p_m/p_∞	$Re/ft \times 10^{-6}$
0.003	1.609	0.0019	21.02	0.00	0.00	1	0.0005	0.0217	0.0133	7.6990	0.010
						2	0.0002	0.0077	0.0059	3.3896	
						3	0.0004	0.0175	0.0111	6.4164	
						5	0.0004	0.0182	0.0114	6.6154	
						6	0.0004	0.0160	0.0103	5.9498	
0.125	1.609	0.078	21.78	30.00	0.00	1	0.0588	0.6467	0.3473	215.4190	0.049
						3	0.0529	0.5813	0.3123	193.7507	
						4	0.0436	0.4795	0.2579	159.9809	
						5	0.0592	0.6520	0.3501	217.1892	
						6	0.0465	0.5111	0.2748	170.4740	
0.125	1.609	0.078	21.17	40.00	0.00	1	0.0866	1.0132	0.5431	336.4450	0.045
						3	0.0812	0.9496	0.5091	315.3825	
						4	0.0655	0.7649	0.4104	254.2272	
						5	0.0911	1.0653	0.5710	353.6854	
						6	0.0756	0.8842	0.4742	293.7495	
0.125	1.609	0.078	22.12	0.00	0.00	1	0.0007	0.0213	0.0130	8.2610	0.016
						3	0.0006	0.0198	0.0122	7.7488	
						4	0.0005	0.0163	0.0103	6.5527	
						5	0.0008	0.0240	0.0144	9.1936	
						6	0.0006	0.0172	0.0108	6.8664	
0.125	1.609	0.078	20.86	0.00	0.00	1	0.0005	0.0251	0.0151	8.6252	0.009
						2	0.0002	0.0079	0.0060	3.4035	
						3	0.0004	0.0157	0.0102	5.7863	
						4	0.0002	0.0051	0.0045	2.5566	
						5	0.0005	0.0207	0.0128	7.2887	
						6	0.0003	0.0146	0.0096	5.4418	

TABLE VIII - PART I
Pressure Data for Two 9° Half-Angle Blunt-Nose Cones.

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o'	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	15.43	0.00	0.00	1	0.5748	1.6657	278.6692	0.8948	0.125
						2	0.1430	0.4099	69.3387	0.2227	
						4	0.0150	0.0378	7.2959	0.0234	
						5	0.0105	0.0245	5.0775	0.0163	
						6	0.0100	0.0231	4.8565	0.0156	
						7	0.0209	0.0548	10.1456	0.0325	
						8	0.0188	0.0488	9.1373	0.0293	
						9	0.0126	0.0307	6.1110	0.0196	
						10	0.0219	0.0577	10.6243	0.0341	
						11	0.0116	0.0278	5.6400	0.0181	
						13	0.0018	-0.0007	0.8864	0.0028	
0.450	1.50	0.30	15.40	0.00	0.00	1	0.2454	1.7004	283.2356	0.9137	0.054
						2	0.0589	0.4037	68.0129	0.2194	
						3	0.0119	0.0765	13.6936	0.0442	
						4	0.0078	0.0484	9.0312	0.0291	
						5	0.0052	0.0300	5.9826	0.0193	
						6	0.0047	0.0265	5.3999	0.0174	
						7	0.0097	0.0616	11.2269	0.0362	
						8	0.0080	0.0498	9.2658	0.0299	
						9	0.0055	0.0324	6.3859	0.0206	
						10	0.0095	0.0597	10.9107	0.0352	
						11	0.0058	0.0345	6.7297	0.0217	
						13	0.0005	-0.0025	0.5862	0.0019	
0.450	1.50	0.30	15.22	0.00	0.00	1	0.1449	1.7742	288.7429	0.9532	0.029
						2	0.0350	0.4237	69.7136	0.2301	
						3	0.0042	0.0450	8.3060	0.0274	
						4	0.0043	0.0470	8.6263	0.0285	
						5	0.0030	0.0313	6.0785	0.0201	
						6	0.0027	0.0274	5.4473	0.0180	
						7	0.0054	0.0603	10.7744	0.0356	
						8	0.0047	0.0518	9.4012	0.0310	
						9	0.0032	0.0338	6.4776	0.0214	
						10	0.0052	0.0575	10.3183	0.0341	
						11	0.0034	0.0359	6.8272	0.0225	
						13	0.0002	-0.0031	0.4967	0.0016	

TABLE VIII - PART I (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	15.08	0.00	0.00	1	0.1008	1.7543	280.1675	0.9424	0.020
						2	0.0175	0.2997	48.6885	0.1638	
						3	0.0035	0.0554	9.8116	0.0330	
						4	0.0031	0.0479	8.6230	0.0290	
						5	0.0021	0.0308	5.9025	0.0199	
						6	0.0020	0.0286	5.5496	0.0187	
						7	0.0039	0.0312	10.7327	0.0361	
						8	0.0033	0.0506	9.0547	0.0305	
						9	0.0025	0.0367	6.8450	0.0230	
						10	0.0038	0.0609	10.6913	0.0360	
						11	0.0026	0.0398	7.3370	0.0247	
						13	0.0003	-0.0014	0.7824	0.0026	
0.450	1.50	0.30	15.38	0.00	0.00	1	0.2382	1.6483	273.8640	0.8857	0.053
						2	0.0623	0.4266	71.6227	0.2316	
						3	0.0090	0.0562	10.3059	0.0333	
						4	0.0075	0.0462	8.6505	0.0280	
						5	0.0052	0.0301	5.9830	0.0193	
						6	0.0047	0.0263	5.3601	0.0173	
						7	0.0098	0.0621	11.2873	0.0365	
						8	0.0082	0.0507	9.3957	0.0304	
						9	0.0056	0.0332	6.4963	0.0210	
						10	0.0090	0.0564	10.3380	0.0334	
						11	0.0054	0.0312	6.1690	0.0200	
						12	0.0056	0.0331	6.4819	0.0210	
0.450	1.50	0.30	15.10	0.00	0.00	1	0.1046	1.7172	275.0939	0.9226	0.021
						2	0.0323	0.5268	85.0816	0.2854	
						3	0.0041	0.0612	10.7693	0.0361	
						4	0.0039	0.0573	10.2305	0.0343	
						5	0.0024	0.0337	6.3744	0.0214	
						6	0.0023	0.0312	5.9855	0.0201	
						7	0.0047	0.0711	12.3460	0.0414	
						8	0.0040	0.0601	10.5854	0.0355	
						9	0.0027	0.0385	7.1394	0.0239	
						10	0.0049	0.0742	12.8490	0.0431	
						11	0.0030	0.0431	7.8771	0.0264	
						12	0.0028	0.0393	7.2749	0.0244	

TABLE VIII - PART I (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	$p_m/p_{o'}$	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	10.95	0.00	0.00	1	4.2581	1.5950	134.8658	0.8601	0.478
						2	0.8496	0.3087	26.9087	0.1716	
						4	0.1330	0.0383	4.2110	0.0269	
						5	0.0877	0.0212	2.7766	0.0177	
						6	0.0783	0.0176	2.4803	0.0158	
						7	0.1602	0.0485	5.0746	0.0324	
						8	0.1289	0.0367	4.0815	0.0260	
						9	0.0894	0.0218	2.8321	0.0181	
						10	0.1574	0.0475	4.9841	0.0318	
						11	0.0948	0.0238	3.0014	0.0191	
						12	0.0900	0.0220	2.8493	0.0182	
0.450	1.50	0.30	10.70	0.00	0.00	1	0.6890	1.5103	122.0411	0.8152	0.080
						2	0.1557	0.3315	27.5701	0.1842	
						3	0.0277	0.0488	4.9131	0.0328	
						4	0.0236	0.0396	4.1763	0.0279	
						5	0.0163	0.0235	2.8863	0.0193	
						6	0.0141	0.0188	2.5062	0.0167	
						7	0.0277	0.0488	4.9104	0.0328	
						8	0.0204	0.0326	3.6164	0.0242	
						9	0.0153	0.0214	2.7172	0.0181	
						10	0.0271	0.0473	4.7936	0.0320	
						11	0.0151	0.0209	2.6771	0.0179	
						12	0.0158	0.0225	2.8015	0.0187	
0.450	1.50	0.30	13.00	0.00	0.00	1	0.1694	1.6149	191.9985	0.8689	0.026
						2	0.0412	0.3868	46.7461	0.2116	
						3	0.0049	0.0388	5.5887	0.0253	
						4	0.0051	0.0404	5.7811	0.0262	
						5	0.0035	0.0249	3.9502	0.0179	
						6	0.0032	0.0220	3.6067	0.0163	
						7	0.0062	0.0513	7.0680	0.0320	
						8	0.0053	0.0421	5.9847	0.0271	
						9	0.0038	0.0275	4.2532	0.0192	
						10	0.0062	0.0512	7.0515	0.0319	
						11	0.0041	0.0307	4.6297	0.0210	
						12	0.0037	0.0274	4.2431	0.0192	

TABLE VIII - PART I (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	$p_m/p_{o'}$	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	17.46	0.00	0.00	1	0.0869	1.6189	345.8726	0.8690	0.026
						2	0.0217	0.3999	86.1947	0.2166	
						3	0.0026	0.0443	10.4403	0.0262	
						4	0.0023	0.0382	9.1338	0.0229	
						5	0.0017	0.0266	6.6716	0.0168	
						6	0.0015	0.0230	5.8929	0.0148	
						7	0.0028	0.0476	11.1393	0.0280	
						8	0.0025	0.0414	9.8296	0.0247	
						9	0.0018	0.0296	7.3077	0.0184	
						10	0.0029	0.0489	11.4144	0.0287	
						11	0.0018	0.0292	7.2277	0.0182	
						12	0.0018	0.0288	7.1421	0.0179	
0.450	1.50	0.30	17.69	0.00	0.00	1	0.1229	1.5896	349.0625	0.8534	0.039
						2	0.0346	0.4438	98.1673	0.2400	
						3	0.0038	0.0451	10.8668	0.0266	
						4	0.0033	0.0386	9.4528	0.0231	
						5	0.0024	0.0266	6.8278	0.0167	
						6	0.0022	0.0242	6.2960	0.0154	
						7	0.0043	0.0509	12.1386	0.0297	
						8	0.0037	0.0429	10.3986	0.0254	
						9	0.0026	0.0291	7.3716	0.0180	
						10	0.0043	0.0514	12.2452	0.0299	
						11	0.0025	0.0275	7.0153	0.0172	
						12	0.0026	0.0286	7.2685	0.0178	
0.450	1.50	0.30	17.34	0.00	0.00	1	0.2514	1.5270	340.6668	0.8196	0.080
						2	0.0622	0.3744	84.2784	0.2028	
						3	0.0096	0.0541	13.0438	0.0314	
						4	0.0076	0.0416	10.2531	0.0247	
						5	0.0053	0.0278	7.1798	0.0173	
						6	0.0046	0.0237	6.2767	0.0151	
						7	0.0096	0.0541	13.0257	0.0313	
						8	0.0078	0.0433	10.6215	0.0256	
						9	0.0054	0.0281	7.2506	0.0174	
						10	0.0095	0.0536	12.9266	0.0311	
						11	0.0054	0.0285	7.3353	0.0176	
						12	0.0052	0.0270	7.0049	0.0169	

TABLE VIII - PART I (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	$p_m/p_{o'}$	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	17.46	0.00	0.00	1	0.0894	1.5791	337.3717	0.8476	0.026
						2	0.0223	0.3898	84.0294	0.2111	
						3	0.0030	0.0489	11.4238	0.0287	
						4	0.0026	0.0407	9.6698	0.0243	
						5	0.0018	0.0277	6.8913	0.0173	
						6	0.0017	0.0250	6.3185	0.0159	
						7	0.0031	0.0502	11.6928	0.0294	
						8	0.0028	0.0440	10.3774	0.0261	
						9	0.0019	0.0296	7.2974	0.0183	
						10	0.0031	0.0505	11.7660	0.0296	
						11	0.0021	0.0327	7.9623	0.0200	
						12	0.0020	0.0306	7.5272	0.0189	
0.450	1.50	0.30	14.65	0.00	0.00	1	0.7434	1.7367	261.8575	0.9332	0.139
						2	0.1783	0.4115	62.8085	0.2238	
						3	0.0325	0.0695	11.4452	0.0408	
						4	0.0256	0.0534	9.0272	0.0322	
						5	0.0202	0.0408	7.1294	0.0254	
						7	0.0277	0.0584	9.7744	0.0348	
						8	0.0246	0.0509	8.6487	0.0308	
						9	0.0235	0.0485	8.2889	0.0295	
						10	0.0190	0.0380	6.7038	0.0239	
						11	0.0325	0.0695	11.4325	0.0407	
						12	0.0194	0.0388	6.8223	0.0243	
0.450	1.50	0.30	14.35	0.00	0.00	1	0.3474	1.6049	232.3070	0.8629	0.068
						2	0.0875	0.3990	58.5008	0.2173	
						3	0.0138	0.0570	9.2205	0.0342	
						5	0.0067	0.0240	4.4621	0.0166	
						6	0.0067	0.0242	4.4909	0.0167	
						7	0.0097	0.0380	6.4717	0.0240	
						8	0.0116	0.0468	7.7421	0.0288	
						9	0.0108	0.0434	7.2549	0.0269	
						10	0.0143	0.0593	9.5500	0.0355	
						11	0.0095	0.0373	6.3786	0.0237	
						12	0.0092	0.0357	6.1438	0.0228	

TABLE VIII - PART I (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o'	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	14.00	0.00	0.00	1	0.2180	1.7291	238.2061	0.9295	0.037
						2	0.0720	0.5660	78.6405	0.3069	
						3	0.0064	0.0437	6.9934	0.0273	
						4	0.0068	0.0467	7.4069	0.0289	
						5	0.0054	0.0355	5.8728	0.0229	
						7	0.0064	0.0438	7.0129	0.0274	
						8	0.0068	0.0468	7.4209	0.0290	
						9	0.0064	0.0438	7.0019	0.0273	
						11	0.0055	0.0368	6.0475	0.0236	
						12	0.0056	0.0375	6.1436	0.0240	
0.450	1.50	0.30	14.37	0.00	0.00	1	0.3645	1.6812	244.0232	0.9038	0.068
						2	0.0876	0.3987	58.6398	0.2172	
						3	0.0151	0.0629	10.0888	0.0374	
						4	0.0118	0.0477	7.8899	0.0292	
						5	0.0094	0.0366	6.2939	0.0233	
						6	0.0102	0.0401	6.8016	0.0252	
						7	0.0144	0.0600	9.6680	0.0358	
						8	0.0118	0.0480	7.9319	0.0294	
						9	0.0107	0.0425	7.1496	0.0265	
						10	0.0143	0.0591	9.5501	0.0354	
						11	0.0094	0.0364	6.2674	0.0232	
						12	0.0093	0.0363	6.2520	0.0232	
0.450	2.193	0.205	13.46	0.00	0.00	1	1.2134	1.2257	156.4493	0.6600	0.250
						2	0.3521	0.3500	45.3936	0.1915	
						3	0.0714	0.0647	9.2121	0.0389	
						4	0.0699	0.0631	9.0090	0.0380	
						5	0.0462	0.0391	5.9622	0.0252	
						6	0.0442	0.0371	5.7035	0.0241	
						7	0.0625	0.0557	8.0584	0.0340	
						8	0.0470	0.0399	6.0657	0.0256	
						9	0.0451	0.0380	5.8154	0.0245	
						14	0.0429	0.0357	5.5250	0.0233	
						15	0.0471	0.0400	6.0704	0.0256	

TABLE VIII - PART I (Concluded)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	$p_m/p_{o'}$	$Re/ft \times 10^{-6}$
0.450	2.193	0.205	13.45	0.00	0.00	1	1.2568	1.2711	161.9734	0.6843	0.247
						2	0.3575	0.3559	46.0722	0.1946	
						3	0.0687	0.0620	8.8490	0.0374	
						4	0.0681	0.0614	8.7815	0.0371	
						5	0.0435	0.0363	5.6017	0.0237	
						6	0.0409	0.0337	5.2689	0.0223	
						7	0.0617	0.0549	7.9478	0.0336	
						8	0.0471	0.0401	6.0758	0.0257	
						9	0.0425	0.0354	5.4786	0.0231	
						14	0.0399	0.0327	5.1460	0.0217	
						15	0.0455	0.0384	5.8670	0.0248	
0.450	2.193	0.205	13.42	10.00	0.00	1	1.2757	1.2873	163.3158	0.6928	0.242
						2	0.5321	0.5323	68.1166	0.2890	
						3	0.1354	0.1295	17.3288	0.0735	
						4	0.1943	0.1893	24.8752	0.1055	
						5	0.1935	0.1886	24.7755	0.1051	
						6	0.1922	0.1872	24.6020	0.1044	
						7	0.0383	0.0310	4.9025	0.0208	
						8	0.0260	0.0185	3.3288	0.0141	
						9	0.0216	0.0140	2.7624	0.0117	
						14	0.1924	0.1874	24.6380	0.1045	
						15	0.2050	0.2002	26.2485	0.1113	

TABLE VIII - PART II

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	a	δ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	15.19	5.00	0.00	1	0.1555	1.3565	300.9640	0.9971	0.027
						2	0.0292	0.3441	56.5908	0.1875	
						3	0.0044	0.4630	84.7810	0.0281	
						4	0.0033	0.0332	6.3662	0.0211	
						5	0.0021	0.0188	4.0350	0.0134	
						6	0.0018	0.0153	3.4717	0.0115	
						7	0.0089	0.1003	17.2002	0.0570	
						8	0.0092	0.1045	17.8879	0.0593	
						9	0.0078	0.0876	15.1512	0.0502	
						11	0.0025	0.0240	4.8726	0.0161	
						12	0.0042	0.0439	8.0923	0.0268	
0.450	1.50	0.30	15.23	10.00	0.00	1	0.1518	1.8465	300.6498	0.9919	0.027
						2	0.0226	0.2695	44.7431	0.1476	
						3	0.0018	0.0161	3.6174	0.0119	
						4	0.0023	0.0217	4.5215	0.0149	
						5	0.0015	0.0123	2.9929	0.0099	
						6	0.0013	0.0098	2.5962	0.0086	
						7	0.0146	0.1720	28.9123	0.0954	
						8	0.0206	0.2448	40.7296	0.1344	
						9	0.0182	0.2161	36.0677	0.1190	
						10	0.0050	0.0548	9.8889	0.0326	
						11	0.0065	0.0731	12.8588	0.0424	
						12	0.0050	0.0543	9.8055	0.0323	
0.450	1.50	0.30	15.19	20.00	0.00	1	0.1302	1.5655	253.7684	0.8413	0.026
						2	0.0123	0.1420	23.9226	0.0793	
						3	0.0017	0.0144	3.3209	0.0110	
						4	0.0016	0.0131	3.1201	0.0103	
						5	0.0012	0.0081	2.3021	0.0076	
						6	0.0010	0.0056	1.9113	0.0063	
						7	0.0438	0.5221	85.3039	0.2828	
						8	0.0490	0.5849	95.4351	0.3164	
						9	0.0366	0.4352	71.2733	0.2363	
						10	0.0058	0.0637	11.2834	0.0374	
						11	0.0056	0.0613	10.9027	0.0361	
						12	0.0070	0.0779	13.5729	0.0450	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	15.19	30.00	0.00	1	0.1103	1.3216	214.3930	0.7108	0.026
						2	0.0061	0.0674	11.8865	0.0394	
						3	0.0015	0.0121	2.9464	0.0098	
						6	0.0010	0.0054	1.8792	0.0062	
						7	0.0743	0.8880	144.3816	0.4787	
						8	0.0850	1.0163	165.0948	0.5473	
						9	0.0627	0.7483	121.8195	0.4039	
						11	0.0076	0.0857	14.8370	0.0492	
						12	0.0090	0.1019	17.4500	0.0579	
0.450	1.50	0.30	15.17	40.00	0.00	1	0.0778	0.9141	148.3101	0.4926	0.026
						2	0.0032	0.0313	6.0484	0.0201	
						3	0.0013	0.0089	2.4417	0.0081	
						6	0.0012	0.0080	2.2890	0.0076	
						7	0.1051	1.2378	200.4860	0.6659	
						8	0.1196	1.4087	228.0294	0.7574	
						9	0.0921	1.0837	175.6569	0.5834	
						11	0.0100	0.1123	19.0994	0.0634	
0.450	1.50	0.30	15.19	10.00	180.00	1	0.1522	1.8135	293.7522	0.9741	0.027
						2	0.0578	0.6855	111.6574	0.3703	
						3	0.0132	0.1521	25.5456	0.0847	
						4	0.0179	0.2082	34.6167	0.1148	
						5	0.0159	0.1845	30.7792	0.1021	
						6	0.0163	0.1891	31.5229	0.1045	
						7	0.0031	0.0309	5.9946	0.0199	
						8	0.0024	0.0225	4.6375	0.0154	
						9	0.0017	0.0137	3.2148	0.0107	
						10	0.0057	0.0622	11.0332	0.0366	
						11	0.0045	0.0482	8.7751	0.0291	
						12	0.0044	0.0460	8.4262	0.0279	
0.450	1.50	0.30	15.19	20.00	180.00	1	0.1426	1.6910	274.1696	0.9085	0.027
						2	0.0859	1.0163	165.1671	0.5473	
						3	0.0355	0.4168	68.3242	0.2264	
						4	0.0463	0.5454	89.0963	0.2952	
						5	0.0351	0.4112	67.4210	0.2234	
						6	0.0403	0.4735	77.4812	0.2568	
						7	0.0020	0.0178	3.8721	0.0128	
						8	0.0018	0.0147	3.3825	0.0112	
						9	0.0012	0.0084	2.3504	0.0078	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o'	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	15.19	20.00	180.00	10	0.0052	0.0558	10.0158	0.0332	0.027
						11	0.0046	0.0484	8.8112	0.0292	
						12	0.0056	0.0606	10.7873	0.0357	
0.450	1.50	0.30	13.43	0.00	0.00	1	1.6211	1.5972	202.6416	0.8588	0.240
						2	0.3533	0.3419	44.1618	0.1872	
						3	0.0634	0.0548	7.9214	0.0336	
						4	0.0488	0.0404	6.0945	0.0258	
						5	0.0329	0.0246	4.1070	0.0174	
						6	0.0312	0.0229	3.8961	0.0165	
						7	0.0594	0.0509	7.4240	0.0315	
						8	0.0479	0.0395	5.9874	0.0254	
						9	0.0333	0.0250	4.1601	0.0176	
						10	0.0617	0.0532	7.7183	0.0327	
						11	0.0362	0.0280	4.5287	0.0192	
						12	0.0405	0.0321	5.0576	0.0214	
0.450	1.50	0.30	13.43	10.00	0.00	1	1.5348	1.5118	191.8551	0.8131	0.240
						2	0.2019	0.1920	25.2359	0.1070	
						3	0.0358	0.0275	4.4693	0.0189	
						4	0.0288	0.0206	3.5961	0.0152	
						5	0.0177	0.0096	2.2141	0.0094	
						6	0.0147	0.0066	1.8368	0.0078	
						7	0.1512	0.1418	18.8985	0.0801	
						8	0.2159	0.2059	26.9916	0.1144	
						9	0.1710	0.1614	21.3795	0.0906	
						10	0.0601	0.0516	7.5094	0.0318	
						11	0.0402	0.0319	5.0280	0.0213	
						12	0.0472	0.0388	5.8959	0.0250	
0.450	1.50	0.30	13.41	20.00	0.00	1	1.3994	1.3975	176.9157	0.7519	0.233
						2	0.1200	0.1126	15.1746	0.0645	
						3	0.0289	0.0211	3.6560	0.0155	
						4	0.0247	0.0168	3.1203	0.0133	
						5	0.0134	0.0055	1.6978	0.0072	
						6	0.0102	0.0023	1.2843	0.0055	
						7	0.4579	0.4520	57.8950	0.2461	
						8	0.5149	0.5092	65.0964	0.2767	
						9	0.3675	0.3612	46.4653	0.1975	
						10	0.0700	0.0623	8.8473	0.0376	
						11	0.0563	0.0486	7.1151	0.0302	
						12	0.0717	0.0640	9.0609	0.0385	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	$p_m/p_{o'}$	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	13.45	40.00	0.00	1	0.7603	0.7693	98.1005	0.4158	0.232
						2	0.0300	0.0228	3.8760	0.0164	
						3	0.0152	0.0076	1.9632	0.0083	
						4	0.0119	0.0042	1.5345	0.0065	
						5	0.0114	0.0038	1.4747	0.0063	
						6	0.0096	0.0019	1.2349	0.0052	
						7	1.0518	1.0672	135.7127	0.5753	
						8	1.1604	1.1783	149.7347	0.6347	
						9	0.8958	0.9078	115.5832	0.4899	
						10	0.1022	0.0966	13.1918	0.0559	
						11	0.0871	0.0811	11.2332	0.0476	
						12	0.1056	0.1001	13.6304	0.0578	
0.450	1.50	0.30	13.48	0.00	0.00	1	1.5261	1.5840	202.4936	0.8518	0.231
						2	0.3662	0.3741	48.5835	0.2044	
						3	0.0687	0.0638	9.1136	0.0383	
						4	0.0537	0.0481	7.1193	0.0299	
						5	0.0421	0.0361	5.5881	0.0235	
						6	0.0469	0.0411	6.2291	0.0262	
						7	0.0657	0.0606	8.7109	0.0366	
						8	0.0528	0.0472	7.0046	0.0295	
						9	0.0508	0.0452	6.7435	0.0284	
						10	0.0665	0.0615	8.8217	0.0371	
						11	0.0453	0.0394	6.0159	0.0253	
						12	0.0434	0.0374	5.7603	0.0242	
0.450	1.50	0.30	13.47	5.00	0.00	1	1.5963	1.6478	210.2907	0.8859	0.231
						2	0.2875	0.2903	37.8716	0.1595	
						3	0.0516	0.0457	6.8037	0.0287	
						4	0.0371	0.0306	4.8827	0.0206	
						5	0.0262	0.0193	3.4570	0.0146	
						6	0.0258	0.0188	3.3929	0.0143	
						7	0.0950	0.0907	12.5138	0.0527	
						8	0.0986	0.0944	12.9922	0.0547	
						9	0.1216	0.1183	16.0234	0.0675	
						10	0.0658	0.0604	8.6666	0.0365	
						11	0.0470	0.0409	6.1943	0.0261	
						12	0.0449	0.0387	5.9199	0.0249	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	$p_m/p_{o'}$	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	13.46	10.00	0.00	1	1.6314	1.6913	215.4598	0.9091	0.229
						2	0.2312	0.2329	30.5342	0.1288	
						3	0.0414	0.0352	5.4621	0.0230	
						4	0.0312	0.0246	4.1190	0.0174	
						5	0.0219	0.0149	2.8946	0.0122	
						6	0.0209	0.0139	2.7567	0.0116	
						7	0.1512	0.1496	19.9723	0.0843	
						8	0.2166	0.2177	28.6111	0.1207	
						9	0.2574	0.2602	33.9905	0.1434	
						10	0.0670	0.0619	8.8511	0.0373	
						11	0.0489	0.0431	6.4605	0.0273	
						12	0.0500	0.0442	6.6064	0.0279	
0.450	1.50	0.30	13.45	20.00	0.00	1	1.4428	1.4688	186.9919	0.7900	0.231
						2	0.1304	0.1256	16.9050	0.0714	
						3	0.0299	0.0227	3.8734	0.0164	
						4	0.0252	0.0179	3.2683	0.0138	
						5	0.0163	0.0088	2.1161	0.0089	
						6	0.0136	0.0060	1.7608	0.0074	
						7	0.4489	0.4516	58.1860	0.2458	
						8	0.5111	0.5152	66.2419	0.2799	
						9	0.5188	0.5231	67.2424	0.2841	
						10	0.0767	0.0706	9.9456	0.0420	
						11	0.0652	0.0588	8.4501	0.0357	
						12	0.0731	0.0669	9.4764	0.0400	
0.450	1.50	0.30	13.43	30.00	0.00	1	1.3037	1.2977	164.8313	0.6984	0.233
						2	0.0742	0.0664	9.3836	0.0398	
						3	0.0239	0.0160	3.0229	0.0128	
						4	0.0188	0.0109	2.3791	0.0101	
						5	0.0119	0.0040	1.5010	0.0064	
						7	0.7796	0.7729	98.5738	0.4177	
						8	0.8692	0.8625	109.8964	0.4657	
						9	0.8767	0.8700	110.8442	0.4697	
						10	0.0883	0.0805	11.1670	0.0473	
						11	0.0892	0.0814	11.2817	0.0478	
						12	0.0902	0.0824	11.4006	0.0483	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	P_m	C_p	P_m/P_∞	P_m/P_0	$R_e/\text{ft} \times 10^{-6}$
0.450	1.50	0.30	13.43	5.00	180.00	1	1.6389	1.6538	209.7438	0.8889	0.230
						2	0.4620	0.4605	59.1205	0.2506	
						3	0.0977	0.0911	12.5022	0.0530	
						4	0.0893	0.0826	11.4261	0.0484	
						5	0.0929	0.0863	11.8875	0.0504	
						6	0.1209	0.1146	15.4669	0.0656	
						7	0.0537	0.0465	6.8723	0.0291	
						8	0.0404	0.0330	5.1651	0.0219	
						9	0.0340	0.0265	4.3455	0.0184	
						10	0.0676	0.0606	8.6504	0.0367	
						11	0.0469	0.0396	6.0040	0.0254	
						12	0.0437	0.0364	5.5948	0.0237	
0.450	1.50	0.30	13.44	20.00	180.00	1	1.5368	1.5240	193.6918	0.8196	0.236
						2	0.8044	0.7940	101.3842	0.4290	
						3	0.3288	0.3199	41.4431	0.1754	
						4	0.4173	0.4080	52.5891	0.2225	
						5	0.3999	0.3908	50.4073	0.2133	
						6	0.4198	0.4106	52.9089	0.2239	
						7	0.0329	0.0249	4.1423	0.0175	
						8	0.0248	0.0168	3.1268	0.0132	
						9	0.0188	0.0109	2.3747	0.0100	
						10	0.0686	0.0604	8.6417	0.0366	
						11	0.0570	0.0489	7.1839	0.0304	
						12	0.0639	0.0558	8.0560	0.0341	
0.450	1.50	0.30	13.48	10.00	180.00	1	1.5693	1.6997	217.2495	0.9137	0.222
						2	0.5422	0.5821	75.0609	0.3157	
						3	0.1212	0.1240	16.7775	0.0706	
						4	0.1514	0.1568	20.9538	0.0881	
						5	0.1808	0.1889	25.0302	0.1053	
						6	0.2175	0.2288	30.1159	0.1267	
						7	0.0398	0.0354	5.5096	0.0232	
						8	0.0300	0.0248	4.1558	0.0175	
						9	0.0263	0.0208	3.6453	0.0153	
						10	0.0605	0.0580	8.3740	0.0352	
						11	0.0425	0.0384	5.8874	0.0248	
						12	0.0441	0.0401	6.1073	0.0257	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	c	ϕ	Surface pressure No.	p_m	C_p	F_m/p_∞	p_m/p_o	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	13.45	40.00	180.00	1	0.8585	0.9027	115.3099	0.4872	0.223
						2	1.2503	1.3183	167.9261	0.7095	
						3	0.9209	0.9689	123.6820	0.5226	
						4	1.2736	1.3429	171.0499	0.7227	
						5	0.9390	0.9881	126.1206	0.5329	
						6	0.8606	0.9049	115.5833	0.4884	
						8	0.0119	0.0048	1.6042	0.0068	
						9	0.0119	0.0047	1.5962	0.0067	
						14	0.9205	0.9684	123.6281	0.5223	
						15	0.9816	1.0333	131.8387	0.5570	
0.450	1.50	0.30	13.42	10.00	90.00	1	1.2757	1.2850	163.0044	0.6916	0.227
						2	0.3654	0.3623	46.6832	0.1981	
						3	0.0699	0.0629	8.9319	0.0379	
						4	0.0698	0.0628	8.9204	0.0378	
						5	0.0477	0.0404	6.0887	0.0258	
						6	0.0498	0.0425	6.3643	0.0270	
						7	0.0646	0.0576	8.2576	0.0350	
						8	0.0543	0.0471	6.9321	0.0294	
						9	0.0500	0.0427	6.3841	0.0271	
						14	0.0535	0.0463	6.8420	0.0290	
						15	0.0583	0.0511	7.4454	0.0316	
0.450	1.50	0.30	13.41	20.00	90.00	1	1.2218	1.2468	157.9499	0.6711	0.222
						2	0.3448	0.3461	44.5718	0.1894	
						3	0.0760	0.0701	9.8254	0.0417	
						4	0.0834	0.0777	10.7869	0.0458	
						5	0.0660	0.0599	8.5386	0.0363	
						6	0.0667	0.0606	8.6275	0.0367	
						7	0.0718	0.0657	9.2762	0.0394	
						8	0.0671	0.0610	8.6751	0.0369	
						9	0.0697	0.0636	9.0103	0.0383	
						14	0.0678	0.0617	8.7634	0.0372	
						15	0.0715	0.0654	9.2378	0.0393	
0.450	1.50	0.30	13.44	30.00	90.00	1	0.9781	1.0215	130.1416	0.5507	0.221
						2	0.2887	0.2959	38.4087	0.1625	
						3	0.0780	0.0741	10.3718	0.0439	
						4	0.1046	0.1022	13.9225	0.0589	
						5	0.0828	0.0792	11.0156	0.0466	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o'	$Re/ft \times 10^{-6}$
0.450	1.50	0.30	13.44	30.00	90.00	6	0.0793	0.0755	10.5487	0.0446	0.221
						7	0.0803	0.0766	10.6818	0.0452	
						8	0.0892	0.0859	11.8636	0.0502	
						9	0.0871	0.0838	11.5948	0.0491	
						14	0.0786	0.0748	10.4629	0.0443	
						15	0.0833	0.0798	11.0833	0.0469	
0.450	1.50	0.30	13.45	20.00	180.00	1	1.2119	1.2654	161.2592	0.6812	0.223
						2	0.8130	0.8463	108.1828	0.4570	
						3	0.3322	0.3411	44.1969	0.1867	
						4	0.5514	0.5714	73.3625	0.3099	
						5	0.3934	0.4055	52.3514	0.2211	
						6	0.4026	0.4151	53.5738	0.2263	
						7	0.0304	0.0240	4.0442	0.0171	
						8	0.0213	0.0144	2.8284	0.0119	
						9	0.0145	0.0074	1.9336	0.0082	
						14	0.4099	0.4228	54.5467	0.2304	
						15	0.4362	0.4504	58.0465	0.2452	
0.125	1.50	0.0833	13.48	0.00	0.00	1	0.0432	0.0372	5.7368	0.0241	0.233
						2	0.0514	0.0457	6.8169	0.0287	
						3	0.0611	0.0558	8.1010	0.0341	
						4	0.0626	0.0575	8.3077	0.0350	
						5	0.0378	0.0316	5.0172	0.0211	
						6	0.0562	0.0507	7.4530	0.0314	
						7	0.0584	0.0531	7.7516	0.0326	
0.125	1.50	0.0833	13.44	5.00	-90.00	1	0.0414	0.0348	5.4028	0.0229	0.228
						2	0.0485	0.0422	6.3309	0.0268	
						3	0.0535	0.0473	6.9796	0.0295	
						4	0.0564	0.0504	7.3668	0.0312	
						5	0.0477	0.0414	6.2314	0.0264	
						6	0.0615	0.0556	8.0328	0.0340	
						7	0.0632	0.0574	8.2546	0.0349	
0.125	1.50	0.0833	13.45	10.00	-90.00	1	0.0485	0.0428	6.4211	0.0271	0.226
						2	0.0526	0.0471	6.9634	0.0294	
						3	0.0529	0.0474	6.9995	0.0296	
						4	0.0534	0.0479	7.0597	0.0298	
						5	0.0453	0.0395	5.9997	0.0254	
						6	0.0618	0.0567	8.1744	0.0345	
						7	0.0624	0.0573	8.2518	0.0349	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o'	$Re/ft \times 10^{-6}$
0.125	1.50	0.0833	15.54	0.00	-90.00	1	0.0093	0.0404	7.8308	0.0248	0.066
						2	0.0107	0.0473	9.0013	0.0285	
						3	0.0113	0.0507	9.5798	0.0303	
						4	0.0123	0.0553	10.3546	0.0328	
						5	0.0086	0.0371	7.2654	0.0230	
						6	0.0125	0.0567	10.5792	0.0335	
						7	0.0128	0.0581	10.8304	0.0343	
0.125	1.50	0.0833	14.21	0.00	-90.00	1	0.0091	0.0390	6.5062	0.0246	0.055
						2	0.0101	0.0437	7.1812	0.0272	
						3	0.0110	0.0486	7.8674	0.0298	
						4	0.0117	0.0521	8.3608	0.0317	
						5	0.0086	0.0362	6.1237	0.0232	
						6	0.0120	0.0534	8.5504	0.0324	
						7	0.0124	0.0555	8.8463	0.0335	
0.125	1.50	0.0833	14.50	0.00	-90.00	1	0.0053	0.0426	7.2699	0.0265	0.044
						2	0.0059	0.0490	8.2097	0.0299	
						3	0.0063	0.0522	8.6824	0.0317	
						4	0.0065	0.0546	9.0354	0.0330	
						5	0.0048	0.0379	6.5786	0.0240	
						6	0.0069	0.0380	9.5338	0.0348	
						7	0.0070	0.0593	9.7226	0.0355	
0.125	1.50	0.0833	13.48	0.00	-90.00	1	0.0418	0.0346	5.4064	0.0227	0.237
						2	0.0493	0.0423	6.3778	0.0268	
						3	0.0576	0.0508	7.4568	0.0314	
						4	0.0609	0.0542	7.8867	0.0332	
						5	0.0541	0.0472	7.0041	0.0295	
						6	0.0574	0.0505	7.4261	0.0312	
						7	0.0579	0.0511	7.4933	0.0315	
0.125	1.50	0.0833	13.48	10.00	-90.00	1	0.0547	0.0468	6.9588	0.0293	0.241
						2	0.0569	0.0491	7.2459	0.0305	
						3	0.0568	0.0489	7.2235	0.0304	
						4	0.0582	0.0504	7.4066	0.0312	
						5	0.0625	0.0546	7.9512	0.0334	
						6	0.0593	0.0514	7.5406	0.0317	
						7	0.0575	0.0497	7.3186	0.0308	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o	$Re/ft \times 10^{-6}$
0.125	1.50	0.0833	14.63	10.00	-90.00	1	0.0063	0.0520	8.7890	0.0315	0.049
						2	0.0064	0.0528	8.9137	0.0319	
						3	0.0068	0.0568	9.5107	0.0341	
						4	0.0067	0.0562	9.4265	0.0333	
						5	0.0071	0.0601	10.0083	0.0359	
						6	0.0070	0.0589	9.8308	0.0352	
						7	0.0067	0.0557	9.3442	0.0335	
0.125	1.50	0.0833	14.66	20.00	-90.00	1	0.0082	0.0722	11.8508	0.0423	0.049
						2	0.0082	0.0727	11.9350	0.0426	
						3	0.0085	0.0747	12.2312	0.0437	
						4	0.0083	0.0730	11.9718	0.0428	
						5	0.0089	0.0787	12.8275	0.0458	
						6	0.0087	0.0768	12.5485	0.0448	
						7	0.0083	0.0733	12.0133	0.0429	
0.125	1.50	0.0833	14.65	5.00	-90.00	1	0.0056	0.0482	8.2363	0.0295	0.048
						2	0.0059	0.0513	8.7113	0.0312	
						3	0.0061	0.0534	9.0242	0.0323	
						4	0.0065	0.0569	9.5390	0.0341	
						5	0.0065	0.0565	9.4851	0.0339	
						6	0.0067	0.0588	9.8235	0.0351	
						7	0.0066	0.0582	9.7389	0.0348	
0.125	1.50	0.0833	14.66	0.00	-90.00	1	0.0053	0.0442	7.6486	0.0273	0.049
						2	0.0059	0.0505	8.5926	0.0307	
						3	0.0063	0.0544	9.1821	0.0328	
						4	0.0065	0.0559	9.4091	0.0336	
						5	0.0061	0.0519	8.8169	0.0315	
						6	0.0067	0.0574	9.6418	0.0344	
						7	0.0067	0.0575	9.6546	0.0345	
0.0025	1.50	0.0017	14.62	0.00	-90.00	1	0.0062	0.0518	8.7581	0.0314	0.048
						2	0.0065	0.0548	9.1989	0.0330	
						3	0.0065	0.0547	9.1797	0.0329	
						4	0.0067	0.0565	9.4528	0.0339	
						5	0.0067	0.0566	9.4754	0.0340	
						6	0.0068	0.0571	9.5408	0.0342	
						7	0.0067	0.0569	9.5078	0.0341	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	p_m/p_o	$Re/ft \times 10^{-6}$
0.0025	1.50	0.0017	14.61	5.00	-90.00	1	0.0065	0.0544	9.1286	0.0328	0.048
						2	0.0065	0.0542	9.0936	0.0327	
						3	0.0066	0.0550	9.2112	0.0331	
						4	0.0066	0.0549	9.2080	0.0331	
						5	0.0060	0.0495	8.3965	0.0302	
						6	0.0069	0.0580	9.6616	0.0347	
						7	0.0067	0.0562	9.3989	0.0338	
0.0025	1.50	0.0017	14.66	10.00	-90.00	1	0.0067	0.0588	9.8443	0.0351	0.048
						2	0.0072	0.0632	10.5040	0.0375	
						3	0.0069	0.0607	10.1311	0.0362	
						4	0.0076	0.0672	11.1176	0.0397	
						5	0.0071	0.0624	10.3899	0.0371	
						6	0.0073	0.0648	10.7450	0.0384	
						7	0.0071	0.0626	10.4238	0.0372	
0.0025	1.50	0.0017	14.64	20.00	-90.00	1	0.0083	0.0676	11.1434	0.0399	0.051
						2	0.0112	0.0939	15.0852	0.0540	
						3	0.0083	0.0671	11.0747	0.0396	
						4	0.0078	0.0629	10.4381	0.0374	
						5	0.0082	0.0667	11.0113	0.0394	
						6	0.0082	0.0662	10.9391	0.0391	
						7	0.0082	0.0635	10.9805	0.0393	
0.0025	1.50	0.0017	14.41	0.00	-90.00	1	0.0167	0.0538	8.8193	0.0325	0.079
						2	0.0157	0.0502	8.2901	0.0305	
						3	0.0168	0.0542	8.8781	0.0327	
						4	0.0172	0.0556	9.0766	0.0334	
						5	0.0167	0.0537	8.8027	0.0324	
						6	0.0170	0.0548	8.9652	0.0330	
						7	0.0167	0.0539	8.8316	0.0325	
0.0025	1.50	0.0017	13.45	0.00	-90.00	1	0.0557	0.0515	7.5239	0.0318	0.227
						2	0.0558	0.0516	7.5396	0.0319	
						3	0.0561	0.0520	7.5847	0.0321	
						4	0.0563	0.0522	7.6074	0.0321	
						5	0.0569	0.0523	7.6912	0.0325	
						6	0.0562	0.0521	7.6012	0.0321	
						7	0.0555	0.0513	7.4977	0.0317	

TABLE VIII - PART II (cont)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_n/R_b	M_∞	α	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	$p_m/p_{o'}$	$Re/ft \times 10^{-6}$
0.0025	1.50	0.0017	13.46	10.00	-90.00	1	0.0533	0.0458	6.8086	0.0287	0.235
						2	0.0528	0.0452	6.7354	0.0284	
						3	0.0557	0.0481	7.1069	0.0300	
						4	0.0559	0.0484	7.1395	0.0301	
						5	0.0569	0.0494	7.2606	0.0306	
						6	0.0574	0.0499	7.3319	0.0309	
						7	0.0575	0.0500	7.3434	0.0310	
0.0025	1.50	0.0017	13.44	20.00	-90.00	1	0.0719	0.0643	9.1359	0.0387	0.233
						2	0.0734	0.0659	9.3291	0.0395	
						3	0.0696	0.0620	8.8443	0.0374	
						4	0.0681	0.0605	8.6532	0.0366	
						5	0.0681	0.0605	8.6547	0.0366	
						6	0.0681	0.0605	8.6553	0.0366	
						7	0.0685	0.0610	8.7111	0.0369	
0.0025	1.50	0.0017	13.41	40.00	-90.00	1	0.1028	0.0969	13.1998	0.0561	0.224
						2	0.1048	0.0990	13.4621	0.0572	
						3	0.1029	0.0971	13.2176	0.0562	
						4	0.1050	0.0992	13.4860	0.0573	
						5	0.1062	0.1004	13.6413	0.0580	
						6	0.1054	0.0995	13.5277	0.0575	
						7	0.1048	0.0990	13.4552	0.0572	
0.125	1.50	0.0833	13.45	40.00	-90.00	1	0.1018	0.0977	13.3778	0.0565	0.228
						2	0.1011	0.0969	13.2757	0.0561	
						3	0.1010	0.0969	13.2665	0.0560	
						4	0.1041	0.1000	13.6690	0.0577	
						5	0.1033	0.0992	13.5681	0.0573	
						6	0.1030	0.0989	13.5240	0.0571	
						7	0.1014	0.0972	13.3145	0.0562	
0.125	1.50	0.0833	13.45	30.00	-90.00	1	0.8215	0.8478	108.3509	0.4578	0.228
						2	0.0833	0.0789	10.9935	0.0464	
						3	0.0835	0.0791	11.0181	0.0466	
						4	0.0848	0.0804	11.1802	0.0472	
						5	0.0478	0.0418	6.2988	0.0266	
						6	0.0873	0.0830	11.5140	0.0486	
						7	0.0858	0.0814	11.3130	0.0478	

TABLE VIII - PART II (Concluded)

Pressure Data - $\theta_s = 9^\circ$

r_n	R_b	r_r/R_b	M_∞	a	ϕ	Surface pressure No.	p_m	C_p	p_m/p_∞	$p_m/p_{o'}$	$Re/ft \times 10^{-6}$
0.125	1.50	0.0833	13.45	20.00	-90.00	1	0.0660	0.0592	8.4786	0.0359	0.228
						2	0.0632	0.0564	8.1242	0.0344	
						3	0.0661	0.0593	8.4366	0.0360	
						4	0.0674	0.0607	8.6532	0.0367	
						5	0.0335	0.0261	4.3002	0.0182	
						6	0.0665	0.0598	8.5489	0.0362	
						7	0.0668	0.0600	8.5783	0.0364	
0.0025	1.50	0.0017	14.57	0.00	-90.00	1	0.0069	0.0566	9.4182	0.0340	0.047
						2	0.0069	0.0563	9.3600	0.0338	
						3	0.0070	0.0579	9.6076	0.0347	
						4	0.0070	0.0579	9.6076	0.0347	
						5	0.0058	0.0468	7.9600	0.0288	
						6	0.0068	0.0555	9.2502	0.0334	
						7	0.0068	0.0559	9.3099	0.0336	
0.0025	1.50	0.0017	13.48	0.00	130.00	1	0.0552	0.0474	7.0253	0.0295	0.241
						2	0.0545	0.0466	6.9339	0.0292	
						3	0.0582	0.0504	7.4055	0.0311	
						4	0.0604	0.0525	7.6819	0.0323	
						5	0.0358	0.0280	4.5577	0.0192	
						6	0.0574	0.0495	7.2984	0.0307	
						7	0.0568	0.0489	7.2238	0.0304

CONE NOMENCLATURE

Figure 43. Sketch Showing General Cone Nomenclature.

CONE PRESSURE DISTRIBUTIONS FOR BLUNTNESS RATIOS ≥ 0.3

ASSUMED AND ACTUAL CONE PRESSURE DISTRIBUTIONS FOR BLUNTNESS RATIOS ≤ 0.03

Figure 44. Cone Pressure Distributions for Bluntness Ratios ≥ 0.3 Along with Comparison of Assumed and Actual Cone Pressure Distributions for Bluntness Ratios ≤ 0.03 .

Figure 45. Variation of Total Zero-Lift Drag with Viscous Parameter for a 9° Half-Angle Blunt-Nose Cone at a Free-Stream Mach Number of 19.

a. $\psi = 0.03$ b. $\psi = 0.3$

Figure 46. Comparison of Theoretical and Experimental Forebody Drag in Continuum Flow Regime for a 6.34° Half-Angle Cone.

SYMBOL	MODEL	M_∞	ψ	T_w/T_0
●	3	~ 17	~ 0	~ 0.1
○	4, 5, 6	~ 19	0.03	~ 0.1
◇	CAL (REF. 235)	~ 15	0.03	~ 0.1
□	7a	~ 10	0.03	~ 0.75
▮	JPL (REF. 1)	~ 9	~ 0	~ 0.75

SYMBOL	MODEL	M_∞	T_w/T_0
○	8, 9, 10	~ 19	~ 0.1
◇	CAL (REF. 235)	~ 15	~ 0.1
□	11a	~ 10	~ 0.75
▮	JPL (REF. 1)	~ 9	~ 0.75

Figure 47. Comparison of Theoretical and Experimental Forebody Drag in Continuum Flow Regime for a 9° Half-Angle Cone.

Figure 48. Comparison of Theoretical and Experimental Forebody Drag in Continuum Flow Regime for a 13.5° Half-Angle Cone.

Figure 49. Comparison of Hypersonic, Cold Wall, Viscous Drag of Blunt, Slender Cones in Continuum and Rarefied Flow Regimes.

TABLE IX
List of a Sharp-Nose and Several Blunt-Nose Cone Drag
Models Including Test Information and Drag Results.

Model	θ_s	ψ	d_B , in.	VKF Tunnel	Test Gas	T_w/T_o	C_{D_o}
1	6.34	0.03	2.50	16-in. hotshot	N ₂	0.1	0.030
2	6.34	0.30	2.50	16-in. hotshot	N ₂	0.1	0.104
3	9	~0	0.985	16-in. hotshot	N ₂	0.1	0.060
4	9	0.03	3.00	50-in. hotshot	N ₂	0.1	0.063
5	9	0.03	2.50	16-in. hotshot	N ₂	0.1	0.063
6	9	0.03	0.985	50-in. hotshot	N ₂	0.1	0.063
7a	9	0.03	0.50	50-in. Mach 10	Air	0.75	0.063
7b	9	0.03	0.50	LDH*	N ₂	0.2-0.25	0.063
8	9	0.30	3.00	50-in. hotshot	N ₂	0.1	0.130
9	9	0.30	2.50	16-in. hotshot	N ₂	0.1	0.130
10a	9	0.30	0.97	16-in. hotshot	N ₂	0.1	0.130
10b	9	0.30	0.97	50-in. hotshot	N ₂	0.1	0.130
11a	9	0.30	0.50	50 in. Mach 10	Air	0.75	0.130
11b	9	0.30	0.50	LDH*	N ₂	0.2-0.25	0.130
12	13.5	0.38	4.00	16-in. hotshot	N ₂	0.1	0.220
13	13.5	0.38	1.10	16-in. hotshot	N ₂	0.1	0.220
14a	13.5	0.38	0.50	50-in. Mach 10	Air	0.75	0.220
14b	13.5	0.38	0.50	LDH*	N ₂	0.2-0.25	0.220

* Low-Density Hypervelocity Tunnel

TABLE X
Tabulated Zero-Lift Drag Data for a Sharp-Nose and
Several Blunt-Nose Cone Models at Several Mach Numbers.

Model	θ_s	ψ	T_w/T_o	M_∞	$Re_{\infty, L}$	$\bar{v}_\infty$	C_D
1	6.34°	0.03	0.1	14.7	150,500	0.0353	0.099
1	6.34°	0.03	0.1	16.2	572,000	0.0200	0.072
1	6.34°	0.03	0.1	17.2	161,000	0.0399	0.109
1	6.34°	0.03	0.1	17.4	338,000	0.0278	0.084
1	6.34°	0.03	0.1	17.5	258,000	0.0321	0.101
2	6.34°	0.30	0.1	15.9	412,000	0.0231	0.136
2	6.34°	0.30	0.1	16.9	172,000	0.0379	0.185
2	6.34°	0.30	0.1	17.5	109,000	0.0494	0.179
2	6.34°	0.30	0.1	18.0	224,400	0.0354	0.164
3	9°	~ 0	0.1	17.0	63,000	0.0631	0.167
3	9°	~ 0	0.1	18.0	47,800	0.0765	0.181
3	9°	~ 0	0.1	17.0	60,300	0.0646	0.181
3	9°	~ 0	0.1	17.0	42,200	0.0771	0.180
4	9°	0.03	0.1	22.4	257,000	0.0414	0.129
4	9°	0.03	0.1	21.0	99,200	0.0621	0.162
4	9°	0.03	0.1	21.6	507,000	0.0283	0.116
4	9°	0.03	0.1	22.0	245,000	0.0414	0.130
5	9°	0.03	0.1	17.4	247,000	0.0326	0.112
5	9°	0.03	0.1	16.1	395,400	0.0238	0.110
5	9°	0.03	0.1	17.4	122,400	0.0463	0.143
5	9°	0.03	0.1	17.2	143,800	0.0423	0.134
6	9°	0.03	0.1	22.4	84,600	0.0717	0.192
6	9°	0.03	0.1	21.0	32,700	0.1081	0.246
6	9°	0.03	0.1	21.6	167,000	0.0493	0.154
6	9°	0.03	0.1	22.0	80,700	0.0721	0.185
6	9°	0.03	0.1	21.8	44,000	0.0967	0.235
6	9°	0.03	0.1	21.4	26,300	0.1230	0.318
6	9°	0.03	0.1	21.0	18,300	0.1445	0.336
7a	9°	0.03	0.75	10.18	240,900	0.0169	0.121
7a	9°	0.03	0.75	10.15	169,000	0.0202	0.120
7a	9°	0.03	0.75	10.19	318,730	0.0148	0.109
7a	9°	0.03	0.75	10.19	321,400	0.0147	0.101
7a	9°	0.03	0.75	10.19	165,200	0.0204	0.111
7a	9°	0.03	0.75	10.15	166,600	0.0204	0.120
7a	9°	0.03	0.75	10.07	67,400	0.0318	0.148
7a	9°	0.03	0.75	10.04	39,400	0.0414	0.167
7a	9°	0.03	0.75	10.07	66,800	0.0346	0.148
7a	9°	0.03	0.75	10.04	39,100	0.0416	0.181
7a	9°	0.03	0.75	10.02	29,800	0.0474	0.208

TABLE X (cont)

Model	θ_s	ψ	T_w/T_o	M_∞	$Re_{\infty, L}$	$\bar{v}_\infty$	C_D
7b	9°	0.03	0.20	9.23	818	0.2728	0.704
7b	9°	0.03	0.20	9.23	818	0.2728	0.712
7b	9°	0.03	0.20	9.00	883	0.2570	0.663
7b	9°	0.03	0.20	8.77	959	0.2413	0.637
7b	9°	0.03	0.20	8.77	959	0.2413	0.625
7b	9°	0.03	0.25	9.66	1529	0.2120	0.567
7b	9°	0.03	0.25	9.66	1529	0.2120	0.572
7b	9°	0.03	0.25	9.40	1657	0.1983	0.556
7b	9°	0.03	0.25	9.40	1657	0.1983	0.551
7b	9°	0.03	0.25	9.13	1807	0.1845	0.526
7b	9°	0.03	0.25	9.13	1807	0.1045	0.515
8	9°	0.30	0.1	19.8	245,000	0.0372	0.173
8	9°	0.30	0.1	21.2	176,000	0.0471	0.190
8	9°	0.30	0.1	20.2	232,000	0.0390	0.185
8	0°	0.30	0.1	18.6	94,100	0.0652	0.214
9	9°	0.30	0.1	16.3	253,000	0.0302	0.173
9	9°	0.30	0.1	17.0	81,200	0.0557	0.199
9	9°	0.30	0.1	17.1	82,300	0.0556	0.200
9	9°	0.30	0.1	18.0	126,000	0.0472	0.189
10a	9°	0.30	0.1	17.7	67,000	0.0635	0.200
10a	9°	0.30	0.1	17.9	73,500	0.0616	0.208
10a	9°	0.30	0.1	17.8	71,300	0.0598	0.206
10a	9°	0.30	0.1	15.8	90,000	0.0491	0.186
10a	9°	0.30	0.1	16.8	30,300	0.0896	0.260
10a	9°	0.30	0.1	17.0	29,200	0.0924	0.250
10a	9°	0.30	0.1	17.0	27,900	0.0939	0.245
10a	9°	0.30	0.1	15.9	102,300	0.0463	0.182
10b	9°	0.30	0.1	19.8	81,000	0.0646	0.230
10b	9°	0.30	0.1	21.5	57,100	0.0838	0.250
10b	9°	0.30	0.1	20.2	76,600	0.0680	0.228
11a	9°	0.30	0.75	10.15	126,000	0.0235	0.189
11a	9°	0.30	0.75	10.19	240,000	0.0171	0.169
11a	9°	0.30	0.75	10.18	170,000	0.0198	0.182
11a	9°	0.30	0.75	10.18	210,800	0.0182	0.165
11a	9°	0.30	0.75	10.10	64,000	0.0327	0.192
11a	9°	0.30	0.75	10.07	58,000	0.0335	0.200
11a	9°	0.30	0.75	10.07	49,200	0.0372	0.207
11a	9°	0.30	0.75	10.03	29,280	0.0482	0.235
11a	9°	0.30	0.75	10.00	15,140	0.0665	0.286
11a	9°	0.30	0.75	10.02	22,300	0.0552	0.259
11b	9°	0.30	0.20	9.23	610	0.3161	0.760
11b	9°	0.30	0.20	9.23	610	0.3161	0.758
11b	9°	0.30	0.20	9.23	610	0.3161	0.772
11b	9°	0.30	0.20	9.00	658	0.2978	0.724
11b	9°	0.30	0.20	9.00	658	0.2978	0.731
11b	9°	0.30	0.20	8.77	714	0.2796	0.699
11b	9°	0.30	0.20	8.77	714	0.2796	0.684
11b	9°	0.30	0.20	8.77	714	0.2796	0.696

TABLE X (Concluded)

Model	θ_s	ψ	T_w/T_o	M_∞	$Re_{\infty, L}$	$\bar{v}_\infty$	C_D
11b	9°	0.30	0.25	9.66	1139	0.2456	0.642
11b	9°	0.30	0.25	9.66	1139	0.2456	0.648
11b	9°	0.30	0.25	9.40	1235	0.2297	0.590
11b	9°	0.30	0.25	9.40	1235	0.2297	0.608
11b	9°	0.30	0.25	9.13	1346	0.2138	0.577
11b	9°	0.30	0.25	9.13	1346	0.2138	0.585
11b	9°	0.30	0.25	9.13	1346	0.2138	0.565
12	13.5°	0.38	0.1	17.9	202,000	0.0371	0.247
12	13.5°	0.38	0.1	17.5	205,000	0.0360	0.255
12	13.5°	0.38	0.1	17.8	184,000	0.0386	0.265
13	13.5°	0.38	0.1	17.6	51,800	0.0722	0.273
13	13.5°	0.38	0.1	18.1	61,000	0.0685	0.275
13	13.5°	0.38	0.1	17.3	15,100	0.1310	0.340
13	13.5°	0.38	0.1	17.2	21,500	0.1100	0.322
13	13.5°	0.38	0.1	17.4	28,500	0.0960	0.305
14a	13.5°	0.30	0.75	10.15	78,960	0.0296	0.291
14a	13.5°	0.30	0.75	10.19	151,400	0.0214	0.266
14a	13.5°	0.30	0.75	10.18	113,800	0.0248	0.263
14a	13.5°	0.30	0.75	10.10	40,980	0.0406	0.278
14a	13.5°	0.30	0.75	10.04	18,400	0.0606	0.315
14a	13.5°	0.30	0.75	10.04	18,400	0.0606	0.336
14a	13.5°	0.30	0.75	10.07	30,600	0.0472	0.299
14a	13.5°	0.30	0.75	10.02	14,290	0.0685	0.339
14b	13.5°	0.38	0.20	9.23	381	0.4000	0.836
14b	13.5°	0.38	0.20	9.23	381	0.4000	0.837
14b	13.5°	0.38	0.20	9.00	411	0.3768	0.789
14b	13.5°	0.38	0.20	9.00	411	0.3768	0.794
14b	13.5°	0.38	0.20	8.77	446	0.3538	0.725
14b	13.5°	0.38	0.20	8.77	446	0.3538	0.756
14b	13.5°	0.38	0.25	9.66	712	0.3108	0.702
14b	13.5°	0.38	0.25	9.66	712	0.3108	0.664
14b	13.5°	0.38	0.25	9.66	712	0.3108	0.715
14b	13.5°	0.38	0.25	9.40	771	0.2907	0.678
14b	13.5°	0.38	0.25	9.40	771	0.2907	0.672
14b	13.5°	0.38	0.25	9.13	841	0.2706	0.642
14b	13.5°	0.38	0.25	9.13	841	0.2706	0.650

CONES

AFTERBODIES

- NOTES: 1. MOMENT REFERENCE FOR ALL CONES AT 0.098D AHEAD OF CENTROID OF PLANFORM AREA OF BASIC CONES WITHOUT SPHERICAL AFTERBODIES.
2. CENTERS OF CURVATURE FOR AFTERBODIES COINCIDE WITH MOMENT REFERENCE LOCATION.

CONE MODEL	ANGLE-OF-ATTACK RANGE, DEG	DIMENSION, D IN.
I	0 to 57	1.950
I	45 to 135	1.575
I	130 to 180	1.950
II and III	0 to 30	2.250
II and III	30 to 180	1.950

Figure 50. Sketch of 9° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base and Spherical Segment Afterbodies.

Figure 51. Variation of Normal Force, Axial Force and Pitching-Moment Coefficients with Angle of Attack for 9° Half-Angle Cones Having a Flat Base with Various Nose Bluntness Ratios. $M = 6.77$.

Figure 52. Variation of Lift and Drag Coefficients and Lift-Drag Ratio with Angle of Attack for 9° Half-Angle Cones Having a Flat Base with Various Nose Bluntness Ratios. $M = 6.77$.

(a) CONE I: AFTERBODY I: $h/R = 0$.

Figure 53. Variation of Normal Force, Axial Force and Pitching-Moment Coefficients with Angle of Attack for 9° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base and Spherical Segment Afterbodies. $M = 6.77$.

(b) CONE II: AFTERBODY II: $h/R = 0.32$.

Figure 53. (Continued)

(c) CONE III: AFTERBODY III: $h/R = 0.65$.

Figure 53. (Concluded)

(a) CONE I; $h/R=0$. L/D VALUES ARE DENOTED BY THE FLAGGED SYMBOLS IN THIS PART.

Figure 54. Variation of Lift and Drag Coefficients and Lift-Drag Ratio with Angle of Attack for 9° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base. $M = 6.77$.

(b) Cone II; $h/R = 0.32$

Figure 54. (Continued)

(c) CONE III; $h/R = 0.65$.

Figure 54. (Concluded)

Figure 55. Comparison Between Theory and Experiment for $C_{m\alpha}$, $C_{L\alpha}$, $(L/D)_{\max}$, and $(C_L)_{\max}$ for Various Bluntness Ratios. $M = 6.77$.

Figure 56. Sketch Showing Dimensions of 9° Half-Angle Cones Having Three Nose Bluntness Ratios.

Figure 57. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $Re/in. = 0.150 \times 10^6$.

Figure 57. (Continued)

Figure 57. (Concluded)

Figure 58. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $Re/\text{in.} = 0.092 \times 10^6$.

Figure 58. (Continued)

Figure 58. (Concluded)

Figure 59. Variation of Aerodynamic Characteristics with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $Re/in. = 0.037 \times 10^6$.

Figure 59. (Continued)

Figure 59.. (Concluded)

Figure 60. Effect of Nose Bluntness on the Aerodynamic Characteristics of a 9° Half-Angle Cone at a Mach Number of 7.31 and a $Re/in. = 0.150 \times 10^6$.

Figure 60. (Continued)

Figure 60. (Concluded)

Figure 61. Effect of Nose Bluntness on the Aerodynamic Characteristics of a 9° Half-Angle Cone at a Mach Number of 7.31 and a $Re/in. = 0.037 \times 10^6$.

Figure 61. (Continued)

Figure 61. (Concluded)

Figure 62. Variation of Aerodynamic Characteristics with Bluntness Ratios for a 9° Half-Angle Cone at Various Angles of Attack and Reynolds Number. $M = 9.04$.

$$\theta_s = 9^\circ$$

MACH NO. = 9.04

- $Re = .037 \times 10^6$
- △ $Re = .092 \times 10^6$
- $Re = .150 \times 10^6$

Figure 62. (Continued)

$$\theta_s = 9^\circ$$

MACH NO. = 9.04

Figure 62. (Concluded)

Figure 63. Effect of Mach Number and Reynolds Number on the Aerodynamic Characteristics of a 9° Half-Angle Cone at Various Angles of Attack.

Figure 63. (Continued)

Figure 63. (Concluded)

Figure 64. Comparison Between the Isothermal Condition of the Model (Cold Wall) and the Free-Stream Tunnel Conditions (Hot Wall) for a 9° Half-Angle Cone. $M = 9.04$.

$\theta_s = 9^\circ$
 MACH NO. = 9.04
 $Re = .150 \times 10^6$

Figure 64. (Continued)

$\theta_s = 9^\circ$
 MACH NO. = 9.04
 $Re = .150 \times 10^6$

Figure 64. (Concluded)

Figure 65. Effect of Reynolds Number on the Aerodynamic Characteristics of a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $M = 9.04$.

Figure 65. (Continued)

Figure 65. (Concluded)

Figure 66. Effect of Bluntness Ratio on the Normal Force Curve Slope and on the Pitching-Moment Curve Slope for a 9° Half-Angle Cone at Two Reynolds Numbers. $M = 9.04$.

$\theta_s = 9^\circ$
 ANGLE OF ATTACK = 0°

Figure 67. Effect of Reynolds Number on the Axial Force Coefficient of a 9° Half-Angle Cone at an Angle of Attack of Zero Degrees for Constant Bluntness Ratios and Mach Numbers.

Figure 68. Effect of Reynolds Number on the Axial Force Coefficient of a 9° Half-Angle Cone at an Angle of Attack of 15 Degrees for Constant Bluntness Ratios and Mach Numbers.

Figure 69. Comparison Between Theory and Experiment of the Normal Force Coefficient Variation with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $M = 9.04$.

Figure 70. Comparison Between Theory and Experiment of the Pitching-Moment Coefficient Variation with Angle of Attack for a 9° Half-Angle Cone Having Three Nose Bluntness Ratios. $M = 9.04$.

Figure 71. Comparison Between Theory and Experiment of the Axial Force Coefficient at $\alpha = 0^\circ$ Versus the Free-Stream Reynolds Numbers for a 9° Half-Angle Cone. $M = 9$.

Figure 72. Sketch of a 9° Half-Angle Sharp-Nose Cone Model.

Figure 73. Comparison of Theoretical and Experimental Normal Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.79$. $Re/in. = 8740$.

Figure 74. Comparison of Theoretical and Experimental Normal Force Coefficient with Angle of Attack for a 9° Half-Angle Cone. $M = 4.05$. $Re/in. = 2670$.

Figure 75. Comparison of Theoretical and Experimental Axial Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.78$. $Re/in. = 8650$.

Figure 76. Comparison of Theoretical and Experimental Axial Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 4.05$. $Re/in. = 2580$.

Figure 77. Comparison of Theoretical and Experimental Pitching-Moment Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.83$. $Re/in. = 8940$.

Figure 78. Comparison of Theoretical and Experimental Pitching-Moment Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 4.06$. $Re/in. = 2630$.

Figure 79. Variation of Experimental Normal Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.48$. $Re/in. = 4460$.

○ Figure 80. Variation of Experimental Normal Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 3.89$. $Re/in. = 1510$.

Figure 81. Variation of Experimental Axial Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.47$. $Re/in. = 4610$.

Figure 82. Variation of Experimental Axial Force Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 3.87$ and 3.90 . $Re/in. = 1520$.

Figure 83. Variation of Experimental Pitching-Moment Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 5.52$. $Re/in. = 4370$.

Figure 84. Variation of Experimental Pitching-Moment Coefficient with Angle of Attack for a 9° Half-Angle Sharp Cone. $M = 3.85$. $Re/in. = 1550$.

a. SPHERICALLY BLUNTED CONE

ALL DIMENSIONS IN INCHES

b. FLAT-NOSED CONE

Figure 85. Sketch of Spherically Blunted and Flat-Nosed 9° Half-Angle Cones.

Figure 86. Shock Shapes Over Slender Blunted (5° and 9.1° Half-Angle) Cones.

Figure 87. Shock Shapes Over Slender Blunted Cones in Terms of Cheng's Correlation Parameters.

Figure 88. Shock Shapes Over a Spherically Blunted Cone at $M_\infty = 18.9$.

Figure 89. Pressure Distribution Over a Spherically Blunted 9.1° Half-Angle Cone.

Figure 90. Pressure Distribution Over a Flat-Nosed 9° Half-Angle Cone.

Figure 91. Pressure Distribution Over Slender Blunted Cones.

Figure 92. Sketch Showing Dimensions and Surface Pressure Tap Location for a 9° Half-Angle Sharp- and Blunt-Nose Cone.

Figure 93. Base Pressure Orifice Locations and Average Base Pressure Values from Experiment on a 9° Half-Angle Cone.

Figure 94. Experimental Base Pressure Data on a 9° Sharp- and Blunt-Nose Cone.

Figure 95. Comparison of Experimental Base Pressure Data and Empirical Theories for Sharp Cones.

Figure 96. General Correlation Curve Based on Data from Figure 94.

Figure 97. Examples of Shear Layers on 9° Half-Angle Sharp and Blunt Cones.

Figure 98. Comparison of Experimental Base Pressure to Surface Pressure Ratio with that from Empirical Theory for a 9° Half-Angle Sharp- and Blunt-Nose Cone.

Figure 99. Variation of Base Pressure to Free-Stream Static Pressure Ratio with Mach Number for a 9° and a 30° Half-Angle Blunt-Nose Cone.

Figure 100. Sketch of a $9^\circ 32'$ Half-Angle Sharp-Nose Cone Having a Flat Base.

Figure 101. Ballistic Normal Force Coefficient Versus Mach Number for a $9^\circ 32'$ Half-Angle Sharp-Nose Cone.

Figure 102. Normal Force Center of Pressure Versus Mach Number for a $9^\circ 32'$ Half-Angle Sharp-Nose Cone.

Figure 103. Magnus Moment and Damping Moment Coefficients Versus Mach Number for a $9^\circ 32'$ Half-Angle Sharp-Nose Cone.

TABLE XI
Aerodynamic and Physical Data for a 9°32' Half-Angle
Sharp-Nose Cone Model at Several Mach Numbers.

Round No.	M	$\frac{2}{d}$	K_D	K_N	K_M	K_T	K_H	ϵ_{yaw} (rad.)	ϵ_{swerve} (in.)
2173	1.684	5.3	0.1405	0.77	0.110	-0.049	0.97	0.003	0.042
1589	1.718	0.3	0.1360						
2172	1.720	7.0	0.1406	0.75	0.102	-0.069	1.03	0.004	0.027
2178	1.736	17.6	0.1412	0.74	0.105	-0.036	0.74	0.003	0.029
2169	1.890	0.9	0.1252						
2179	2.347	44.4	0.1196	0.77	0.109	-0.038	0.65	0.005	0.037
2175	2.529	1.7	0.0972						
2176	2.547	13.7	0.1062	0.72	0.098	-0.014	0.49	0.004	0.020
2177	3.269	12.4	0.0872	0.75	0.093	-0.014	0.48	0.002	0.014

Round No	$ K_1 $	$ K_2 $	$(R_2)_{T_1}$ (in.)	s	$\frac{s}{s}$	$a_1 \times 10^3$	$a_2 \times 10^3$	N-N _T
2173	0.024	0.020	0.24	2.87	0.82	0.558	0.334	22 - 8
1589								- 7
2172	0.029	0.031	0.38	2.87	0.93	0.519	0.406	20 - 8
2178	0.042	0.053	0.73	3.12	0.89	0.390	0.277	22 - 8
2169								- 7
2179	0.058	0.086	0.37	1.35	1.03	0.335	0.326	18 - 7
2175								- 7
2176	0.040	0.048	0.77	3.24	0.90	0.292	0.212	19 - 7
2177	0.055	0.028	0.50	3.33	0.93	0.283	0.224	12 - 6

ν is approximately 0.12 rad/cal for all rounds except 2179 where

ν is 0.08 rad/cal. For reduction purposes K_A was assumed to be 0.003.

Average Turning Rates rad/cal			Average Standard Errors				
ν	ϕ_1'	ϕ_2'	ϵ_{K_D}	ϵ_{K_N}	ϵ_{K_M}	ϵ_{K_T}	ϵ_{K_H}
0.12	0.0313	0.0030					
0.08	0.0172	0.0043	0.0004	0.02	0.001	0.005	0.05

Physical Characteristics

The material which was used is bronze. $\theta_s = 9^\circ 32'$ $d = 0.6$ inches $m = 20.4$ grams $c.m. = 2.18$ cal. from the nose. Length = 2.98 cal.

$$k_1^{-2} = 11.94 \frac{1}{\text{cal.}^2}$$

$$k_2^{-2} = 2.48 \frac{1}{\text{cal.}^2}$$

Figure 104. Sketch of a 10° Half-Angle Sharp-Nose Cone Model.

Figure 105. Variation of Normal Force Slope ($\alpha = 0^\circ$) and Center-of-Pressure with Mach Number for a 10° Half-Angle Sharp-Nose Cone.

DIMENSIONS ARE IN INCHES

Figure 106. Sketch Showing Dimensions and Static Pressure Orifice Location for a 10° Half-Angle Conical Test Body.

Figure 107. Time History of Free-Stream Mach Number and Reynolds Number of an Air-Launched Cone-Cylinder Test Vehicle.

Figure 108. Time History of Static Pressure Measured on the Conical Portion of an Air-Launched Cone-Cylinder Test Vehicle.

Figure 109. Cone Static-Pressure Ratio and Cone Pressure-Drag Coefficient Versus Mach Number for a 10° Half-Angle Cone.

OGIVE NOSE PROFILE (AGARD):

$$r = \frac{X}{3} \left[1 - \frac{1}{9} \left(\frac{X}{D} \right)^2 + \frac{1}{54} \left(\frac{X}{D} \right)^3 \right]$$

WHERE $D = 1.800$, $LENGTH = 3D$

Figure 110. Sketch Showing Dimensions of 10° Half-Angle Cone-Cylinder Models and of an Ogive-Cylinder Model.

Figure 111. Variation of Forebody-Drag Coefficient with Lift Coefficient for an 8.5 Diameter Long Cone-Cylinder Model for Various Mach Numbers.

Figure 111. (Concluded)

Figure 112. Variation of Forebody-Drag Coefficient with Lift Coefficient for an 8.5 Diameter Long Ogive-Cylinder Model for Various Mach Numbers.

Figure 113. Variation of Forebody- and Base-Drag Coefficients at Zero Angle of Attack with Mach Number for Cone-Cylinder and Ogive-Cylinder Models.

Figure 114. Sketch Showing General Nomenclature.

Figure 115. Variation of Cone Surface Mach Number and Shock Wave Angle with Free-Stream Mach Number for a 10° Half-Angle Cone.

Figure 116. Variation of Static Pressure and Density Ratio with Free-Stream Mach Number for a 10° Half-Angle Cone.

TABLE XII
Theoretical Results of the Conical Flow Properties
of an Unyawed 10° Half-Angle Cone.
Cone Results for $\gamma = 1.4$, $\theta_s = 10^\circ$

M_∞	M_s	θ_w	p_s/p_∞	ρ_s/ρ_∞	C_p	$\Delta\theta$
1.5154	1.3902	42.150	1.1959	1.1363	0.12189	0.220
2.0200	1.8527	30.897	1.2958	1.2033	0.10355	0.138
2.9860	2.6985	21.794	1.5462	1.3647	0.087517	0.078
4.0032	3.5333	17.705	1.8899	1.5716	0.079331	0.051
5.0040	4.2952	15.601	2.3097	1.8030	0.074722	0.037
7.1180	5.7032	13.464	3.4707	2.3398	0.060664	0.025
7.9101	6.1645	13.027	4.0035	2.5452	0.068576	0.021

DIMENSIONS ARE IN INCHES

Figure 117. Sketch Showing Dimensions of a 10° Half-Angle Sharp- and Blunt-Nose Cone Having a Flat and a Spherical Segment Base.

Figure 118. Sketch Showing Static Pressure Orifice Locations on the Nose and on the Conical Surface of a 10° Half-Angle Blunt Nose Cone.

Figure 119. Comparison of Experimental and Theoretical Surface Pressure Distribution on a 10° Half-Angle Blunt-Nose Cone at a Free-Stream Mach Number of 4.74.

Figure 120. Momentum Thickness Reynolds Number as a Function of Free-Stream Reynolds Number per Foot for a 10° Half-Angle Sharp- and Blunt-Nose Cone.

Figure 121. Momentum Thickness Reynolds Number Distribution on a 10° Half-Angle Sharp-Nose Cone at a Free Stream Mach Number of 2.74.

Figure 122. Momentum Thickness as a Function of Distance Along the Surface of a 10° Half-Angle Sharp- and Blunt-Nose Cone in Terms of Reynolds Number.

Figure 123. Base to Cone Pressure Ratio for a 10° Half-Angle Sharp- and Blunt-Nose Cone with Flat and Spherical Bases as a Function of $Re_{\theta,c}$.

Figure 124. Total Pressure Wake Profile for a 10° Half-Angle Blunt-Nose Cone.

Figure 125. Variation of Wake Angle with $Re_{\theta,c}$ for a 10° Half-Angle Sharp- and Blunt-Nose Cone with Flat and Spherical Bases.

Figure 126. Base Pressure Distribution on a 10° Half-Angle Blunt-Nose Cone Having a Spherical Base and a Rough Surface Finish.

Figure 127. Local Skin Friction Coefficient as a Function of Re_θ for a 10° Half-Angle Sharp Cone.

TABLE XIII
Pressure Orifice Locations on the Nose and on the Conical Surface
of a Blunt-Nose 10° Half-Angle Cone Model.
(see also Figure 118)

BLUNT CONE				SHARP CONE		
Tap No.	Angle of Elevation β From Centerline (degrees)	Azimuth Angle ψ (degrees)	Distance Along Surface From Stagnation Point s (inches)	Distance From Centerline (inches)	ψ (degrees)	s (inches)
0	0	0	0			
1	10	45	0.262			
2	-20	225	0.524			
3	30	90	0.786			
4	-40	270	1.047			
5	50	135	1.300			
6	-60	315	1.571			
7	70	180	1.833			
8	-80	0	2.095			
	Distance From Centerline Y (inches)					
9	1.497	135	2.227			
10	1.522	90	2.359			
11	1.570	270	2.623			
12	1.630	315	2.940			
13	1.682	45	3.258			
14	2.740	90	9.365	2.740	90	15.776
15	2.740	225	9.365	2.740	225	15.776
16	2.740	315	9.365	2.740	315	15.776
Flat Base			10.865			17.276
17	On Sting at Intersection with Flat Base					
18	On Sting at Intersection with Spherical Base; 1.0625 inches downstream of Flat Base					
	Distance From Sting Along Base Surface (inches)					
19	0.830					
20	1.140					
21	1.460					
22	1.770					
23	2.080					
24	2.400

Figure 128. Effect of Surface Roughness on the Base Pressure for a 10° Half-Angle Sharp- and Blunt-Nose Cone.

Figure 130. Lift, Drag, and Pitching-Moment Coefficients for a Blunt-Nose Cone at Transonic Speeds. $\theta_s \cong 11.6^\circ$.

Figure 131. Sketch of $12\frac{1}{2}^\circ$ Half-Angle Sharp- and Blunt-Nose Cones Having Flat and Spherical Segment Bases.

Figure 132. Variation of Reynolds Number with Mach Number for the Experimental Test of the $12\text{-}1/2^\circ$ Half-Angle Sharp- and Blunt-Nose Cones Having Flat and Spherical Bases.

(a) SHARP CONE WITH FLAT BASE; $M = 2.20$ AND 1.30 .

Figure 133. Variation of the Dynamic Stability Characteristics with Angle of Attack for a $12\frac{1}{2}^\circ$ Sharp-Nose Cone Having Flat and Spherical Bases.

(b) SHARP CONE WITH FLAT BASE; $M=1.00$ AND 0.65

Figure 133. (Continued)

(c) SHARP CONE WITH SPHERICAL BASE; MIDDLE MOMENT CENTER

Figure 133. (Concluded)

(a) BLUNT CONE WITH FLAT BASE; $M=2.20$ AND 1.30

Figure 134. Variation of the Dynamic Stability Characteristics with Angle of Attack for a $12\frac{1}{2}^\circ$ Blunt-Nose Cone Having Flat and Spherical Bases.

(b) BLUNT CONE WITH FLAT BASE; $M = 1.00$ AND 0.65

Figure 134. (Continued)

(c) BLUNT CONE WITH SPHERICAL BASE; $M=2.20$ AND 1.30

Figure 134. (Continued)

(d) BLUNT CONE WITH SPHERICAL BASE; $M = 1.00$ AND 0.65

Figure 134. (Concluded)

(a) SHARP CONE WITH FLAT BASE

Figure 135. Variation of the Static Stability Characteristics with Angle of Attack for a $12\ 1/2^\circ$ Half-Angle Sharp-Nose Cone Having Flat and Spherical Bases.

(b) SHARP CONE WITH SPHERICAL BASE

Figure 135. (Concluded)

(a) BLUNT CONE WITH FLAT BASE

Figure 136. Variation of the Static Stability Characteristics with Angle of Attack for a $12\text{-}1/2^\circ$ Half-Angle Blunt-Nose Cone Having Flat and Spherical Bases.

(b) BLUNT CONE WITH SPHERICAL BASE

Figure 136. (Concluded)

(a) SHARP CONE WITH FLAT BASE

Figure 137. Stability Derivatives and Axial-Force Coefficients Versus Mach Number at Zero Angle of Attack for a $12\text{-}1/2^\circ$ Half-Angle Sharp-Nose Cone Having Flat and Spherical Bases.

(b) SHARP CONE WITH SPHERICAL BASE; MIDDLE MOMENT CENTER.

Figure 137. (Concluded)

(a) BLUNT CONE WITH FLAT BASE.

Figure 138. Stability Derivatives and Axial-Force Coefficients Versus Mach Number at Zero Angle of Attack for a $12\text{-}1/2^\circ$ Half-Angle Blunt-Nose Cone Having Flat and Spherical Bases.

(b) BLUNT CONE. WITH SPHERICAL BASE.

Figure 138. (Concluded)

$$\theta_s = 12 \frac{1}{2}^\circ$$

Figure 139. Effect of Alternate Moment Centers on the Zero Angle of Attack Values of the Damping in Pitch for $12\frac{1}{2}^\circ$ Half-Angle Sharp- and Blunt-Nose Cones Having Flat and Spherical Bases.

ANGLE OF ATTACK AT ZERO, AND FORWARD MOMENT CENTER

Figure 140. Effects of Sting Configuration on the Damping in Pitch for a $12\ 1/2^\circ$ Half-Angle Blunt-Nose Cone Having Flat and Spherical Bases.

TABLE XIV
Damping-In-Pitch Data for 12-1/2° Half-Angle
Sharp- and Blunt-Nose Cones.

(a). Sharp cone with flat base; center of moments at
0.834d from model base.

α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K
M = 0.25			M = 1.00			M = 1.60		
-02.1	-1.055	.0832	-01.9	-2.247	.0227	-01.9	-1.545	.0160
-03.2	-1.190	.0827	-01.0	-2.356	.0225	-02.9	-1.422	.0161
-05.1	-1.327	.0826	00.8	-2.503	.0225	-04.6	-1.141	.0161
-02.1	-1.215	.0821	-01.8	-1.932	.0226	-02.0	-1.395	.0161
-01.1	-1.209	.0821	-02.7	-1.779	.0227	-01.3	-1.485	.0160
00.8	-1.177	.0830	-04.6	-1.795	.0229	00.6	-1.546	.0161
03.8	-1.351	.0825	-07.1	-1.355	.0231	-07.2	-1.017	.0162
06.8	-1.309	.0824	-10.1	-1.256	.0233	-09.8	-0.941	.0162
09.7	-1.485	.0818	-12.4	-1.285	.0232	-12.3	-0.987	.0163
12.7	-1.320	.0813	-13.3	-1.255	.0233	-13.1	-1.039	.0163
15.8	-1.658	.0820						
M = 0.65			M = 1.10			M = 1.90		
-02.1	-1.232	.0332	-01.8	-1.893	.0210	-01.8	-1.243	.0142
-01.2	-1.165	.0332	-00.8	-2.074	.0209	-02.7	-1.347	.0143
00.7	-1.269	.0330	00.9	-2.320	.0208	-04.5	-0.814	.0144
03.6	-1.391	.0332	-01.7	-2.014	.0210	-01.8	-1.153	.0143
06.5	-1.545	.0329	-02.6	-1.995	.0210	-00.9	-1.357	.0142
09.5	-1.467	.0329	-04.6	-1.668	.0211	00.8	-1.468	.0142
12.3	-1.547	.0329	-07.1	-1.480	.0213	03.6	-1.981	.0143
14.4	-1.468	.0329	-09.8	-1.377	.0213	-07.1	-0.603	.0143
-02.1	-1.227	.0331	-12.5	-1.223	.0215	-09.7	-0.559	.0145
-03.0	-1.227	.0331	-13.2	-1.239	.0215	-12.2	-0.622	.0145
-05.0	-1.157	.0331				-13.0	-0.661	.0145
M = 0.80			M = 1.20			M = 2.20		
-02.0	-1.323	.0276	-01.7	-1.570	.0198	-01.4	-1.425	.0132
-01.2	-1.403	.0276	-00.8	-1.672	.0198	-02.3	-0.599	.0132
00.7	-1.464	.0276	00.9	-2.192	.0196	-04.0	-0.786	.0133
03.5	-1.719	.0277	-01.7	-1.527	.0198	-01.3	-1.460	.0131
06.2	-1.611	.0275	-02.5	-1.509	.0199	-00.4	-1.502	.0131
-02.1	-1.503	.0276	-04.4	-1.321	.0199	01.5	-1.567	.0131
-03.0	-1.510	.0278	-06.9	-1.162	.0199	-06.7	-0.765	.0132
-04.8	-1.333	.0277	-09.5	-1.262	.0200	-09.4	-0.961	.0132
-07.6	-1.209	.0277	-12.0	-1.425	.0200	-12.0	-1.112	.0133
-10.4	-1.104	.0279	-12.9	-1.296	.0199	-13.1	-0.495	.0133
-13.1	-1.251	.0279						
-14.0	-1.035	.0279						
M = 0.90			M = 1.30					
-01.9	-2.006	.0247	-01.8	-1.568	.0186			
-01.0	-2.110	.0246	-01.0	-1.886	.0185			
00.7	-2.083	.0246	00.6	-2.277	.0185			
03.6	-2.507	.0247	-01.9	-1.766	.0186			
-01.9	-1.926	.0247	-02.7	-1.808	.0187			
-02.9	-1.901	.0248	-04.5	-1.491	.0187			
-04.6	-1.515	.0249	-07.0	-1.064	.0188			
-07.2	-1.608	.0250	-09.5	-0.878	.0189			
-10.0	-1.366	.0251	-12.0	-1.106	.0189			
-12.8	-1.311	.0252	-12.9	-1.291	.0189			
-13.5	-1.317	.0251						

TABLE XIV (cont)

(b). Sharp cone with flat base; center of moments at 0.677d from model base.

α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K
M = 0.25			M = 1.00			M = 1.60		
-01.4	-0.551	.0966	-01.0	-1.664	.0258	-01.4	-1.277	.0179
-02.3	-0.538	.0972	-02.1	-1.540	.0259	-02.4	-1.103	.0179
-04.3	-0.563	.0966	-04.1	-1.472	.0260	-04.3	-0.983	.0181
-01.2	-0.654	.0777	-01.1	-1.575	.0257	-01.3	-1.217	.0179
-00.3	-0.603	.0977	-00.1	-1.770	.0255	-00.3	-1.205	.0179
01.6	-0.607	.0983	01.8	-1.854	.0257	01.5	-1.431	.0178
04.7	-0.570	.0971	04.9	-1.767	.0256	04.6	-1.071	.0179
07.7	-0.761	.0970	08.0	-1.654	.0259	07.6	-0.685	.0181
10.7	-0.803	.0971	11.1	-1.212	.0261	10.5	-0.891	.0181
13.8	-0.623	.0970	14.1	-1.162	.0261	13.5	-0.986	.0181
16.8	-0.563	.0970	17.2	-1.305	.0260	16.5	-0.987	.0181
M = 0.65			M = 1.10			M = 1.90		
-01.4	-0.700	.0384	-01.1	-1.618	.0237	-01.2	-1.382	.0160
-02.4	-0.852	.0386	-02.1	-1.491	.0239	-02.2	-1.118	.0161
-04.4	-0.835	.0386	-04.1	-1.324	.0241	-04.2	-1.025	.0162
-01.4	-0.743	.0385	-01.1	-1.615	.0237	-01.2	-1.267	.0160
-00.4	-0.735	.0384	-00.1	-1.731	.0236	-00.2	-1.046	.0160
01.6	-0.752	.0384	01.9	-1.873	.0237	01.7	-1.075	.0160
04.7	-0.779	.0384	04.8	-1.851	.0238	04.8	-0.792	.0161
07.7	-0.794	.0384	08.0	-1.657	.0239	07.8	-0.741	.0162
10.9	-0.695	.0383	11.1	-1.201	.0242	10.8	-0.608	.0162
14.0	-0.688	.0382	14.0	-0.995	.0241	13.9	-0.837	.0162
17.2	-0.788	.0379	17.1	-1.261	.0240	16.8	-0.721	.0161
-01.4	-0.835	.0383						
M = 0.80			M = 1.20			M = 2.20		
-01.4	-1.043	.0318	-01.1	-1.365	.0222	-00.3	-1.086	.0149
-02.3	-1.046	.0317	-02.0	-1.043	.0223	-01.6	-1.221	.0150
-04.4	-0.993	.0310	-04.0	-1.120	.0223	-03.6	-0.903	.0151
-01.3	-0.974	.0317	-01.1	-1.356	.0222	-00.6	-1.311	.0149
-00.4	-0.927	.0316	-00.2	-1.590	.0221	00.3	-1.233	.0149
01.6	-1.069	.0315	01.8	-1.593	.0220	02.3	-1.192	.0150
04.7	-1.007	.0317	04.9	-1.234	.0222	05.3	-1.204	.0150
07.8	-0.958	.0317	08.0	-1.001	.0223	08.3	-0.980	.0150
10.8	-0.919	.0316	10.9	-0.926	.0223	11.3	-0.899	.0150
14.0	-0.761	.0316	14.0	-1.009	.0221	14.4	-0.795	.0150
17.2	-0.969	.0311	17.2	-1.196	.0220	17.3	-0.792	.0150
M = 0.90			M = 1.30					
-01.1	-1.331	.0282	-01.3	-1.410	.0208			
-02.2	-1.334	.0281	-02.3	-1.186	.0209			
-04.2	-1.187	.0283	-04.3	-1.069	.0211			
-01.2	-1.549	.0287	-01.2	-1.392	.0209			
-00.2	-1.425	.0282	-00.3	-1.598	.0209			
01.8	-1.478	.0282	01.7	-1.846	.0208			
04.8	-1.333	.0282	04.7	-1.050	.0210			
07.9	-1.398	.0284	07.7	-0.834	.0212			
10.9	-1.293	.0284	10.8	-0.876	.0211			
14.1	-1.329	.0283	13.7	-1.122	.0210			
17.2	-1.405	.0283	16.8	-1.179	.0208			

TABLE XIV (cont)
(c). Sharp cone with flat base; center of moments at
0.520d from model base.

α	$C_{m_q} + C_{m_a}$	K		α	$C_{m_q} + C_{m_a}$	K		α	$C_{m_q} + C_{m_a}$	K
M = 0.25				M = 1.00				M = 1.00		
-00.4	-0.805	.1104		-00.2	-1.112	.0278		-00.6	-1.090	.0193
-01.5	-0.805	.1111		-01.3	-0.994	.0278		-01.7	-0.938	.0194
-03.5	-0.721	.1105		-03.6	-1.120	.0279		-03.9	-0.853	.0195
-00.4	-0.624	.1098		-00.2	-0.872	.0277		-00.6	-1.070	.0192
00.5	-0.617	.1097		00.7	-0.977	.0276		00.4	-1.017	.0193
02.5	-0.678	.1117		02.9	-1.125	.0276		02.6	-1.120	.0192
05.5	-0.680	.1116		06.3	-0.987	.0278		06.1	-0.856	.0193
08.6	-0.747	.1110		09.9	-0.818	.0281		-05.5	-0.865	.0163
11.7	-0.415	.1110		13.2	-0.830	.0280		12.9	-0.697	.0193
14.7	-0.272	.1097		14.4	-0.828	.0280		14.2	-0.739	.0193
17.8	-0.236	.1110								
M = 0.65				M = 1.10				M = 1.90		
-00.6	-0.708	.0416		-00.3	-0.913	.0256		-00.3	-0.971	.0172
-01.6	-0.629	.0418		-01.4	-1.111	.0256		-01.4	-1.015	.0172
-03.8	-0.795	.0419		-03.6	-1.110	.0257		-03.7	-1.038	.0173
-00.5	-0.737	.0417		-00.2	-1.052	.0257		-00.4	-1.072	.0172
00.4	-0.788	.0416		00.7	-1.141	.0257		00.6	-1.051	.0172
02.5	-0.674	.0417		03.0	-1.281	.0255		02.8	-1.015	.0172
05.9	-0.758	.0417		06.3	-1.102	.0257		06.1	-0.822	.0173
09.1	-0.554	.0421		09.7	-0.890	.0259		09.5	-0.620	.0173
12.3	-0.494	.0419		13.1	-0.797	.0259		12.9	-0.789	.0172
15.6	-0.468	.0421		14.2	-0.840	.0258				
18.0	-0.590	.0421						M = 2.20		
M = 0.80				M = 1.20				00.2	-0.893	.0162
-00.6	-0.836	.0341		-00.3	-1.002	.0236		-00.7	-1.147	.0162
-01.6	-0.670	.0341		-01.4	-0.993	.0237		-02.5	-0.851	.0163
-03.9	-0.864	.0341		-03.7	-0.949	.0238		00.2	-0.976	.0162
-00.6	-0.745	.0341		-00.3	-0.861	.0237		01.3	-1.285	.0161
00.4	-0.626	.0341		00.7	-1.015	.0236		03.4	-1.057	.0162
02.6	-0.702	.0339		02.9	-1.195	.0236		06.7	-0.720	.0162
05.9	-0.623	.0342		06.4	-0.720	.0237		10.0	-0.634	.0162
09.3	-0.501	.0343		09.8	-0.909	.0237		13.3	-0.805	.0161
12.7	-0.596	.0343		12.2	-0.901	.0237		16.6	-0.845	.0161
13.8	-0.625	.0343								
14.9	-0.635	.0342		M = 1.30						
M = 0.90				-00.6	-1.066	.0222				
-00.4	-1.051	.0303		-01.6	-1.113	.0222				
-01.4	-0.865	.0305		-03.9	-0.932	.0223				
-03.7	-0.937	.0302		-00.5	-1.099	.0222				
-00.3	-0.933	.0302		00.4	-1.119	.0222				
00.6	-0.932	.0303		02.7	-1.092	.0222				
02.8	-0.939	.0303		06.2	-0.801	.0223				
06.2	-1.011	.0303		09.6	-0.887	.0223				
09.5	-0.809	.0305		13.1	-0.726	.0224				
13.0	-0.819	.0305								
14.1	-0.815	.0306								
15.2	-0.976	.0305								

TABLE XIV (cont)

(d). Sharp cone with spherical base; center of moments at 0.677d from model base; center of spherical base at 0.677d.

α	$C_{m_q} + C_{m_a}$	K		α	$C_{m_q} + C_{m_a}$	K		α	$C_{m_q} + C_{m_a}$	K
M = 0.25				M = 1.00				M = 1.60		
-01.3	0.330	.0928		-01.1	-1.381	.0256		-01.5	-0.975	.0178
-02.2	0.438	.0955		-02.1	-1.437	.0255		-02.4	-1.027	.0179
-04.2	0.344	.0955		-04.0	-1.241	.0257		-04.6	-0.749	.0179
-01.4	0.441	.0960		-01.1	-1.369	.0256		-01.3	-1.011	.0179
-00.4	0.394	.0960		-00.1	-1.429	.0256		-00.4	-1.116	.0178
01.6	0.443	.0960		01.8	-1.553	.0254		01.5	-1.102	.0179
04.7	0.637	.0953		04.9	-1.690	.0256		04.6	-1.087	.0180
07.6	0.687	.0952		08.0	-1.509	.0256		07.5	-0.584	.0180
10.7	0.688	.0949		11.0	-1.193	.0257		10.6	-0.689	.0180
13.6	-0.348	.0950		14.2	-1.033	.0256		13.6	-0.828	.0180
16.7	-0.816	.0954		17.3	-1.105	.0256		16.6	-0.864	.0179
M = 0.65				M = 1.10				M = 1.90		
-01.5	0.353	.0388		-01.2	-1.329	.0236		-01.1	-1.080	.0160
-02.3	0.470	.0387		-02.1	-1.269	.0236		-02.2	-0.988	.0160
-04.3	0.113	.0386		-04.2	-1.088	.0237		-04.2	-0.824	.0161
-01.4	0.470	.0387		-01.1	-1.437	.0236		-01.1	-0.995	.0159
-00.4	0.447	.0388		-00.1	-1.474	.0236		00.0	-1.000	.0159
01.5	0.588	.0388		01.8	-1.466	.0234		01.7	-1.006	.0159
04.5	0.705	.0387		04.9	-1.807	.0235		04.7	-0.638	.0160
07.6	0.709	.0384		08.0	-1.288	.0235		07.8	-0.775	.0160
10.7	0.258	.0382		11.0	-1.104	.0237		10.8	-0.760	.0160
13.7	-0.498	.0382		14.0	-1.109	.0237		13.8	-0.696	.0160
17.0	-0.715	.0378		17.2	-1.097	.0237		16.5	-0.901	.0160
M = 0.80				M = 1.20				M = 2.20		
-01.3	-0.174	.0320		-01.2	-1.152	.0223		-00.6	-0.730	.0148
-02.4	-0.297	.0321		-02.0	-0.822	.0221		-01.6	-0.895	.0149
-04.4	-0.369	.0319		-04.0	-0.825	.0227		-03.5	-0.853	.0149
-01.5	-0.134	.0320		-01.0	-1.003	.0223		-00.6	-1.208	.0148
-00.4	-0.216	.0321		-00.1	-1.389	.0222		00.3	-1.037	.0148
01.5	-0.115	.0320		01.8	-1.557	.0220		02.3	-0.752	.0148
04.6	-0.171	.0319		04.8	-0.972	.0220		05.3	-1.155	.0148
07.6	-0.091	.0318		07.8	-0.900	.0220		08.3	-0.661	.0149
10.7	-0.514	.0316		11.0	-1.039	.0220		11.3	-0.873	.0148
13.8	-0.913	.0314		14.0	-0.898	.0219		14.3	-0.884	.0148
17.0	-0.887	.0311		17.1	-1.147	.0217		17.3	-0.920	.0148
M = 0.90				M = 1.30						
-01.2	-0.976	.0283		-01.2	-1.298	.0207				
-02.3	-0.872	.0286		-02.3	-0.950	.0207				
-04.2	-0.945	.0286		-04.2	-0.960	.0208				
-01.3	-0.965	.0285		-01.2	-1.330	.0207				
-00.2	-0.938	.0284		-00.2	-1.253	.0207				
01.7	-0.983	.0283		01.7	-1.520	.0208				
04.7	-1.039	.0284		04.7	-1.028	.0208				
07.8	-1.188	.0282		07.8	-0.847	.0210				
10.9	-1.031	.0284		10.7	-0.972	.0209				
13.9	-1.211	.0283		13.6	-0.796	.0208				
17.0	-1.170	.0280		16.8	-1.101	.0207				

TABLE XIV (cont)
(e). Blunt cone with flat base; center of moments at
0.562d from model base.

α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K
M = 0.25			M = 1.00			M = 1.60		
-01.0	-0.471	.1216	-00.7	-1.453	.0318	-00.9	-0.522	.0229
-01.9	-0.539	.1201	-01.7	-1.398	.0318	-01.7	-0.522	.0230
-03.9	-0.403	.1202	-03.6	-1.279	.0320	-03.6	-0.460	.0230
-00.8	-0.491	.1188	-00.7	-1.414	.0319	-00.8	-0.611	.0230
00.0	-0.521	.1208	00.2	-1.465	.0318	00.1	-0.633	.0229
02.0	-0.636	.1208	02.2	-1.435	.0316	01.9	-0.670	.0229
05.1	-0.488	.1207	05.2	-1.643	.0318	04.7	-0.958	.0230
08.0	-0.684	.1192	08.3	-1.574	.0319	07.4	-0.507	.0231
11.0	-0.675	.1213	11.4	-1.793	.0321	10.3	-0.471	.0231
14.1	-0.501	.1213	14.3	-1.552	.0323	12.9	-0.512	.0231
17.1	-0.396	.1213	17.3	0.045	.0332	14.6	-0.547	.0234
M = 0.65			M = 1.10			M = 1.90		
-01.0	-0.681	.0474	-00.7	-1.409	.0292	-00.7	-0.283	.0206
-01.9	-0.728	.0474	-01.5	-1.408	.0292	-01.6	-0.401	.0206
-03.9	-0.772	.0476	-03.6	-1.336	.0295	-03.4	-0.542	.0206
-01.0	-0.698	.0475	-00.6	-1.376	.0294	-00.7	-0.416	.0205
00.0	-0.677	.0477	00.2	-1.507	.0292	00.1	-0.486	.0204
01.9	-0.678	.0475	02.2	-1.662	.0293	01.9	-0.559	.0203
04.9	-0.760	.0475	05.3	-1.690	.0294	04.8	-0.897	.0203
07.9	-0.826	.0475	08.3	-1.703	.0296	07.7	-0.512	.0207
10.9	-0.714	.0477	11.3	-1.742	.0296	10.4	-0.549	.0207
13.9	-0.632	.0477	14.4	-1.193	.0301	13.1	-0.556	.0206
17.0	-0.628	.0477	17.4	-0.375	.0306	15.9	-0.606	.0206
M = 0.80			M = 1.20			M = 2.20		
-00.9	-0.755	.0394	-00.7	-1.176	.0276	-00.2	-0.587	.0188
-02.0	-0.872	.0394	-01.7	-1.101	.0277	-01.0	-0.431	.0186
-03.9	-0.867	.0394	-03.6	-0.898	.0279	-02.9	-0.499	.0187
-01.0	-0.789	.0394	-00.7	-1.176	.0276	-00.2	-0.449	.0187
00.0	-0.740	.0392	00.2	-1.216	.0276	00.7	-0.511	.0187
01.9	-0.814	.0393	02.1	-1.314	.0277	02.5	-0.397	.0186
05.0	-0.875	.0393	05.1	-0.842	.0280	05.4	-0.662	.0187
07.9	-0.876	.0394	08.0	-0.751	.0282	08.3	-0.525	.0187
10.9	-0.730	.0395	11.0	-0.788	.0285	11.4	-0.441	.0187
13.9	-0.710	.0398	13.7	-0.815	.0287	13.9	-0.476	.0190
17.0	-0.686	.0396	16.4	-0.762	.0289	16.7	-0.676	.0191
M = 0.90			M = 1.30					
-00.7	-1.100	.0350	-00.7	-1.046	.0263			
-01.7	-0.988	.0351	-01.7	-0.805	.0263			
-03.8	-1.056	.0351	-03.5	-0.787	.0264			
-00.8	-1.073	.0351	-00.7	-0.939	.0262			
00.1	-1.036	.0351	00.2	-1.083	.0264			
02.1	-1.101	.0351	02.0	-1.267	.0264			
05.0	-1.221	.0351	04.9	-0.691	.0266			
08.0	-1.164	.0354	07.7	-0.572	.0269			
11.1	-0.954	.0354	10.5	-0.657	.0270			
14.0	-0.940	.0357	13.3	-0.797	.0270			
17.0	-0.818	.0359	16.0	-0.811	.0272			

TABLE XIV (cont)

(f). Blunt cone with flat base; center of moments at 0.445d from model base.

α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K
M = 0.25			M = 1.00			M = 1.60		
-00.3	-0.373	.1314	00.0	-1.111	.0337	-00.3	-0.556	.0242
-01.4	-0.405	.1321	-01.2	-1.076	.0336	-01.6	-0.497	.0242
-03.3	-0.480	.1323	-03.3	-0.996	.0339	-03.4	-0.361	.0243
-03.3	-0.220	.1323	-00.1	-1.054	.0338	-00.4	-0.556	.0242
-00.3	-0.293	.1323	00.9	-1.082	.0335	00.6	-0.468	.0242
00.6	-0.360	.1321	03.1	-1.184	.0338	02.5	-0.668	.0242
02.6	-0.404	.1322	06.3	-0.897	.0337	05.6	-0.539	.0243
05.6	-0.187	.1320	09.5	-1.104	.0339	08.6	-0.271	.0245
08.6	-0.572	.1320	12.8	-1.943	.0344	11.6	-0.300	.0245
11.7	-0.259	.1322	11.7	-1.599	.0342	14.6	-0.303	.0246
14.7	-0.143	.1330	16.0	-2.698	.0357	17.5	-0.328	.0247
17.7	-0.160	.1321	18.9	-0.128	.0360			
			18.0	0.857	.0365			
M = 0.65			M = 1.10			M = 1.90		
-00.3	-0.553	.0519	-00.1	-1.085	.0310	-00.3	-0.252	.0219
-01.4	-0.581	.0518	-01.1	-1.109	.0310	-01.7	-0.330	.0219
-03.5	-0.621	.0518	-03.4	-1.023	.0311	-03.1	-0.326	.0219
-00.3	-0.514	.0520	-00.1	-1.207	.0310	-00.2	-0.295	.0219
00.5	-0.551	.0518	-11.4	-1.273	.0268	00.7	-0.210	.0219
02.6	-0.481	.0518	03.0	-1.192	.0309	02.7	-0.455	.0218
05.8	-0.654	.0519	06.3	-1.042	.0313	05.6	-0.269	.0219
08.8	-0.422	.0521	09.5	-1.280	.0314	08.7	-0.194	.0220
11.9	-0.762	.0521	12.8	-1.651	.0315	11.7	-0.265	.0220
15.0	-0.782	.0523	16.1	-1.718	.0327	14.7	-0.188	.0221
18.2	-0.753	.0525	18.9	0.098	.0335	17.5	-0.260	.0221
			17.2	-0.258	.0331			
			18.1	0.847	.0337			
M = 0.80			M = 1.20			M = 2.20		
-00.4	-0.688	.0428	-00.2	-0.920	.0289	00.3	-0.226	.0200
-01.4	-0.672	.0427	-01.2	-0.963	.0290	-00.6	-0.163	.0203
-03.5	-0.707	.0426	-03.4	-0.883	.0292	-02.8	-0.215	.0204
-00.4	-0.695	.0424	-00.1	-0.893	.0289	00.3	-0.296	.0203
00.5	-0.701	.0425	00.7	-1.013	.0289	01.2	-0.234	.0203
02.6	-0.666	.0424	02.9	-0.937	.0291	03.3	-0.246	.0203
05.8	-0.690	.0425	06.1	-0.623	.0294	06.2	-0.715	.0203
09.0	-0.699	.0426	09.3	-0.803	.0296	09.3	-0.118	.0203
12.1	-0.675	.0427	12.5	-0.669	.0298	12.3	-0.152	.0204
15.3	-0.689	.0429	15.7	-0.517	.0302	15.2	-0.190	.0204
17.6	-0.700	.0426	18.7	-0.485	.0305	18.2	-0.236	.0205
M = 0.90			M = 1.30					
-00.2	-0.700	.0372	-00.2	-0.775	.0274			
-01.2	-0.748	.0372	-01.3	-0.710	.0276			
-03.3	-0.842	.0373	-03.3	-0.637	.0277			
-00.2	-0.785	.0373	-00.2	-0.831	.0275			
00.7	-0.757	.0373	00.6	-0.876	.0275			
02.8	-0.909	.0371	02.8	-0.747	.0277			
06.0	-0.941	.0374	05.8	-0.544	.0279			
09.2	-0.754	.0375	09.0	-0.453	.0282			
12.4	-0.605	.0378	12.1	-0.480	.0283			
15.5	-0.549	.0379	15.1	-0.422	.0284			
18.7	-0.557	.0381	18.1	-0.460	.0285			

TABLE XIV (cont)
(g). Blunt cone with flat base; center of moments at
0.328d from model base.

α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K
M = 0.25			M = 1.00			M = 1.60		
00.1	-0.287	.1302	00.5	-0.999	.0324	00.2	-0.603	.0232
-00.7	-0.252	.1287	01.5	-1.040	.0323	-00.9	-0.735	.0232
-02.8	-0.292	.1303	04.0	-1.098	.0324	-03.0	-0.516	.0232
00.2	-0.183	.1300	00.5	-0.985	.0324	00.2	-0.628	.0232
01.2	-0.433	.1301	-00.5	-1.048	.0323	01.2	-0.499	.0232
03.2	-0.354	.1300	-02.9	-1.115	.0325	03.4	-0.783	.0232
06.3	-0.397	.1293	-06.2	-0.917	.0326	06.8	-0.327	.0234
09.2	-0.479	.1295	-09.6	-1.117	.0330	10.0	-0.318	.0236
12.4	-0.228	.1306	-13.1	-2.707	.0334	-06.1	-0.335	.0234
15.3	0.034	.1296	-14.2	-2.788	.0337	-09.3	-0.444	.0235
18.4	0.066	.1300	-10.7	-1.361	.0328	-12.6	-0.874	.0235
M = 0.65			M = 1.10			-13.5	-1.172	.0235
00.1	-0.456	.0506	00.6	-0.998	.0300	M = 1.90		
-00.8	-0.449	.0507	01.7	-1.115	.0301	00.3	-0.477	.0214
-02.9	-0.476	.0503	04.0	-1.205	.0301	-00.6	-0.533	.0213
00.1	-0.576	.0505	00.5	-1.079	.0301	-02.8	-0.419	.0212
01.2	-0.455	.0508	-02.9	-1.122	.0301	00.3	-0.433	.0213
03.3	-0.564	.0507	-00.9	-1.055	.0301	01.4	-0.428	.0213
06.7	-0.596	.0510	-06.2	-0.927	.0304	03.5	-0.570	.0213
09.8	-0.653	.0512	-09.7	-1.389	.0305	06.8	-0.303	.0213
12.0	-0.417	.0514	-13.1	-3.359	.0310	10.0	-0.251	.0214
M = 0.80			-14.5	2.638	.0313	13.2	-0.280	.0214
00.1	-0.464	.0404	-10.6	-1.804	.0305	M = 2.20		
01.2	-0.589	.0402	M = 1.20			00.8	-0.293	.0198
03.6	-0.536	.0404	00.5	-1.079	.0273	02.0	-0.206	.0198
06.9	-0.672	.0405	01.7	-0.983	.0274	03.9	-0.270	.0198
00.1	-0.546	.0405	03.9	-0.881	.0276	07.2	-0.305	.0198
-00.8	-0.451	.0405	-00.7	-1.072	.0274	10.3	-0.041	.0198
-03.0	-0.544	.0406	-02.9	-1.098	.0276	13.5	-0.015	.0198
-06.3	-0.680	.0406	-06.5	-0.728	.0279	16.6	-0.283	.0198
-09.5	-0.529	.0408	-09.8	-0.805	.0282	19.7	-0.215	.0199
-13.0	-0.510	.0410	-13.1	-1.195	.0286	00.9	-0.361	.0197
-13.9	-0.477	.0414	-14.1	-1.036	.0285	-02.1	-0.056	.0196
M = 0.90			00.6	-1.040	.0275			
00.3	-0.659	.0359	M = 1.30					
01.5	-0.707	.0358	00.3	-0.854	.0261			
03.8	-0.877	.0357	-00.8	-0.885	.0261			
00.4	-0.610	.0359	-02.8	-0.856	.0263			
-00.6	-0.708	.0359	00.2	-0.787	.0261			
-02.9	-0.732	.0358	01.3	-0.842	.0262			
-06.3	-0.806	.0360	03.7	-0.579	.0263			
-09.5	-0.867	.0360	-06.4	-0.495	.0266			
-12.9	-0.697	.0363	-09.6	-0.567	.0268			
-14.2	-0.862	.0365	-12.7	-0.811	.0269			
			-13.9	-0.870	.0269			

TABLE XIV (cont)

(h). Blunt cone with spherical base; center of moments at 0.562d from model base, center of spherical base at 0.562d.

α	$C_{m_q} + C_{m_d}$	K		α	$C_{m_q} + C_{m_d}$	K		α	$C_{m_q} + C_{m_d}$	K
M = 0.25				M = 1.00				M = 1.60		
-01.0	0.646	.1187		-00.8	-0.943	.0318		-00.9	-0.328	.0228
-02.0	0.803	.1180		-01.7	-1.024	.0316		-01.9	-0.445	.0229
-04.0	0.364	.1196		-03.7	-0.962	.0319		-03.6	-0.319	.0230
-00.8	0.730	.1188		-00.7	-1.004	.0317		-00.9	-0.280	.0229
00.0	0.608	.1187		00.1	-1.008	.0318		00.0	-0.328	.0229
02.0	0.572	.1193		02.1	-1.154	.0318		01.8	-0.364	.0229
05.0	-0.351	.1184		05.2	-1.411	.0316		04.5	-0.536	.0229
08.0	0.888	.1185		08.1	-1.300	.0319		07.4	-0.335	.0230
11.0	0.460	.1205		11.4	-1.725	.0319		10.2	-0.313	.0231
14.0	0.092	.1197		14.3	-3.048	.0330		12.8	-0.437	.0232
17.0	-0.171	.1196		17.1	-1.364	.0338		15.5	-0.506	.0232
M = 0.65				M = 1.10				M = 1.90		
-00.8	0.462	.0483		-00.7	-0.993	.0292		-00.7	-0.288	.0206
-01.9	0.310	.0483		-01.6	-1.024	.0293		-01.7	-0.076	.0206
-03.9	0.387	.0483		-03.7	-0.947	.0293		-03.6	-0.181	.0206
-00.9	0.501	.0483		-00.7	-1.043	.0293		-00.8	-0.268	.0206
00.0	0.462	.0483		00.2	-1.078	.0292		00.1	-0.230	.0206
01.9	0.595	.0481		02.1	-1.226	.0292		01.9	-0.274	.0205
04.9	0.615	.0481		05.2	-1.489	.0292		04.7	-0.463	.0205
07.9	0.710	.0481		08.1	-1.348	.0292		07.6	-0.316	.0205
10.9	0.158	.0478		11.3	-1.726	.0294		10.4	-0.452	.0206
13.8	-0.377	.0474		14.3	-1.793	.0299		13.1	-0.463	.0206
16.9	-0.565	.0473		17.3	-0.274	.0311		15.9	-0.457	.0206
M = 0.80				M = 1.20				M = 2.20		
-00.9	-0.176	.0400		-00.8	-0.785	.0276		-00.3	-0.159	.0190
-01.9	-0.145	.0399		-01.9	-0.711	.0277		-01.2	-0.229	.0190
-03.9	-0.023	.0401		-03.6	-0.673	.0277		-03.0	-0.042	.0190
-01.0	-0.203	.0400		-00.7	-0.753	.0277		-00.2	-0.191	.0189
00.0	-0.091	.0398		02.0	-0.791	.0276		00.6	-0.117	.0189
01.9	-0.011	.0399		05.1	-0.584	.0277		02.5	-0.304	.0189
04.9	0.007	.0399		00.1	-0.762	.0276		05.4	-0.562	.0189
07.9	-0.203	.0397		08.1	-0.747	.0279		08.2	-0.751	.0189
10.9	-0.480	.0395		10.8	-0.735	.0281		11.2	-0.325	.0190
13.8	-0.680	.0396		13.6	-0.671	.0284		13.9	-0.334	.0190
17.0	-0.729	.0393		16.3	-0.668	.0286		16.7	-0.539	.0190
M = 0.90				M = 1.30						
-00.8	-0.646	.0358		-00.8	-0.520	.0263				
-01.7	-0.699	.0357		-01.8	-0.506	.0264				
-03.7	-0.689	.0357		-03.6	-0.431	.0264				
-00.8	-0.666	.0358		-00.9	-0.554	.0264				
00.1	-0.683	.0357		00.0	-0.496	.0264				
02.0	-0.662	.0356		02.0	-0.748	.0263				
05.0	-0.844	.0356		04.7	-0.427	.0265				
08.1	-0.807	.0356		07.6	-0.510	.0266				
11.0	-0.813	.0357		10.5	-0.580	.0267				
13.9	-0.840	.0358		13.1	-0.586	.0267				
16.8	-0.913	.0357		15.8	-0.667	.0268				

TABLE XIV (cont)

(i). Blunt cone with spherical base; center of moments at 0.445d from model base, center of spherical base at 0.445d.

α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K	α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K
M = 0.25			M = 1.00			M = 1.60		
-00.4	0.400	.1299	00.0	-0.746	.0340	-00.3	-0.363	.0242
-03.3	0.290	.1293	-01.2	-0.760	.0342	-01.4	-0.297	.0242
-01.3	0.405	.1293	-03.3	-0.815	.0341	-03.3	-0.479	.0243
-00.3	0.367	.1315	-00.1	-0.793	.0341	-00.4	-0.352	.0242
00.5	0.510	.1300	00.8	-0.763	.0340	00.6	-0.355	.0242
02.6	0.396	.1293	03.0	-0.836	.0341	02.6	-0.361	.0242
05.6	0.001	.1277	06.3	-0.835	.0341	05.6	-0.519	.0242
08.6	0.516	.1314	09.5	-1.056	.0340	08.6	-0.296	.0243
11.7	0.140	.1305	13.0	-1.969	.0342	11.6	-0.405	.0244
14.7	0.009	.1290	15.9	-2.891	.0355	14.5	-0.326	.0245
17.9	-0.262	.1298	19.0	-0.190	.0359	17.5	-0.437	.0245
			18.0	-0.256	.0359			
M = 0.65			M = 1.10			M = 1.90		
-00.4	0.376	.0516	-00.1	-0.748	.0311	-00.1	-0.268	.0219
-01.4	0.426	.0513	-01.2	-0.767	.0311	-01.2	-0.256	.0219
-03.5	0.407	.0515	-03.2	-0.791	.0310	-03.1	-0.262	.0219
-00.4	0.370	.0513	-00.1	-0.740	.0310	-00.2	-0.285	.0219
00.5	0.408	.0514	00.7	-0.847	.0311	00.7	-0.304	.0219
02.6	0.389	.0512	03.1	-0.877	.0312	02.7	-0.324	.0219
05.7	0.283	.0512	06.3	-0.954	.0310	05.8	-0.455	.0218
08.9	0.104	.0511	09.5	-1.225	.0310	08.7	-0.273	.0218
12.0	-0.252	.0510	12.8	-1.430	.0311	11.6	-0.336	.0219
15.0	-0.259	.0510	16.1	-1.870	.0323	14.7	-0.373	.0219
18.2	-0.359	.0510	19.1	-0.167	.0328	17.6	-0.299	.0220
			17.9	-0.241	.0326			
M = 0.80			M = 1.20			M = 2.20		
-00.4	0.013	.0424	-00.2	-0.721	.0290	00.3	-0.351	.0203
-01.5	0.029	.0420	-01.3	-0.665	.0290	-00.7	-0.370	.0203
-03.5	0.080	.0422	-03.3	-0.636	.0291	-02.7	-0.294	.0203
-00.4	0.014	.0421	-00.2	-0.615	.0291	00.3	-0.328	.0203
00.5	0.032	.0421	00.7	-0.678	.0291	01.3	-0.296	.0203
02.6	0.033	.0421	03.0	-0.609	.0291	03.2	-0.291	.0203
05.8	0.001	.0418	06.1	-0.618	.0292	06.3	-0.286	.0203
08.9	-0.251	.0416	09.3	-0.698	.0293	09.3	-0.411	.0203
12.1	-0.400	.0418	12.6	-0.621	.0297	12.3	-0.259	.0203
15.3	-0.458	.0418	15.5	-0.405	.0300	15.2	-0.309	.0204
18.6	-0.461	.0418	18.4	-0.434	.0302	18.2	-0.308	.0204
M = 0.90			M = 1.30					
-00.2	-0.537	.0373	-00.3	-0.511	.0276			
-01.3	-0.564	.0373	-01.3	-0.599	.0276			
-03.3	-0.605	.0373	-03.3	-0.530	.0277			
-00.2	-0.528	.0374	-00.2	-0.546	.0276			
00.7	-0.527	.0373	00.6	-0.466	.0277			
02.8	-0.526	.0374	02.8	-0.496	.0277			
06.0	-0.578	.0376	05.8	-0.551	.0277			
09.2	-0.590	.0374	09.1	-0.488	.0279			
12.4	-0.618	.0374	12.1	-0.491	.0280			
15.5	-0.685	.0375	15.1	-0.472	.0281			
18.7	-0.651	.0377	18.1	-0.474	.0283			

TABLE XIV. (Concluded)

(j). Blunt cone with spherical base; center of moments
at 0.328d from model base, center of spherical base
at 0.328d.

α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K		α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K		α	$C_{m_q} + C_{m_{\dot{\alpha}}}$	K
M = 0.25				M = 1.00				M = 1.60		
00.1	0.002	.1315		00.5	-0.564	.0326		00.2	-0.266	.0232
-00.8	-0.034	.1315		01.7	-0.603	.0329		-00.8	-0.204	.0232
-02.8	-0.068	.1309		03.9	-0.722	.0327		-03.1	-0.349	.0232
00.1	0.040	.1315		00.5	-0.625	.0326		00.1	-0.198	.0232
01.1	-0.071	.1323		-00.6	-0.693	.0326		01.3	-0.218	.0232
03.1	0.035	.1317		-02.9	-0.697	.0328		03.3	-0.226	.0232
06.2	-0.073	.1315		-09.6	-1.114	.0325		06.8	-0.304	.0233
09.2	-0.139	.1301		-13.2	-2.413	.0330		10.1	-0.236	.0234
12.3	-0.114	.1317		-14.2	-3.494	.0333		13.3	-0.254	.0235
15.3	-0.111	.1309		-06.2	-0.763	.0326		16.5	-0.307	.0236
18.4	-0.178	.1295						19.7	-0.717	.0244
M = 0.65				M = 1.10				M = 1.90		
00.1	0.099	.0498		00.5	-0.610	.0299		00.3	-0.172	.0212
01.1	0.061	.0498		01.6	-0.644	.0299		-00.6	-0.162	.0212
03.3	-0.013	.0501		04.0	-0.755	.0298		-02.7	-0.016	.0211
06.6	-0.083	.0497		07.4	-0.972	.0299		00.3	-0.114	.0211
09.8	-0.191	.0498		11.1	-2.253	.0316		01.4	-0.214	.0211
00.0	0.098	.0498		00.4	-0.676	.0298		03.6	-0.090	.0210
-00.9	0.011	.0498		-00.5	-0.647	.0299		06.8	-0.247	.0211
-03.2	0.027	.0501		-02.9	-0.696	.0299		10.0	-0.042	.0212
-06.2	0.192	.0503		-06.4	-0.910	.0299		13.2	-0.132	.0212
-09.3	0.043	.0500		-09.7	-1.139	.0299		16.6	-0.175	.0213
-12.6	-0.157	.0500		-13.3	-2.956	.0305		19.5	-0.182	.0213
-13.6	-0.210	.0500		-10.8	-1.488	.0300				
M = 0.80				M = 1.20				M = 2.20		
00.1	-0.078	.0408		00.5	-0.642	.0276		01.0	-0.180	.0199
01.2	-0.092	.0408		-00.7	-0.672	.0276		-00.1	-0.280	.0199
03.4	-0.133	.0407		-03.0	-0.673	.0276		-02.3	-0.309	.0199
06.8	-0.181	.0406		00.3	-0.599	.0276		00.9	-0.152	.0199
00.1	-0.047	.0408		01.5	-0.597	.0276		02.0	-0.272	.0198
-01.1	-0.027	.0408		04.0	-0.596	.0277		04.1	-0.152	.0199
-02.9	-0.116	.0406		07.4	-0.655	.0278		07.1	-0.199	.0198
-06.4	-0.050	.0406		11.0	-1.351	.0294		10.5	-0.019	.0199
-09.6	-0.288	.0404		-06.3	-0.740	.0278		13.6	-0.076	.0199
-12.9	-0.354	.0403		-09.8	-0.738	.0280		16.7	-0.226	.0199
-13.8	-0.397	.0407		-13.2	-1.086	.0283		19.8	-0.128	.0200
				-14.1	-1.024	.0283				
M = 0.90				M = 1.30						
00.3	-0.358	.0358		00.2	-0.307	.0263				
01.5	-0.447	.0359		-00.8	-0.445	.0263				
03.8	-0.456	.0360		-03.1	-0.647	.0264				
07.2	-0.437	.0361		00.2	-0.461	.0264				
00.3	-0.453	.0360		01.4	-0.384	.0263				
-00.7	-0.452	.0359		03.7	-0.509	.0263				
-03.0	-0.496	.0360		07.1	-0.523	.0264				
-06.4	-0.560	.0361		10.6	-0.598	.0267				
-09.6	-0.642	.0360		14.1	-1.193	.0287				
-12.8	-0.617	.0361								
-13.9	-0.839	.0362								

TABLE XV
Static Stability Data for 12-1/2° Half-Angle
Sharp- and Blunt-Nose Cones.

(a). Sharp cone with flat base; center of moments at
0.677d from model base.

α	C_m	C_N	C_A	C_{p_b}		α	C_m	C_N	C_A	C_{p_b}
M = 0.25						M = 1.20				
-02.9	-.0172	-0.116	0.347	.3544		-02.8	-.0013	-0.091	0.602	.3790
-01.0	-.0129	-0.068	0.337	.3621		-00.7	.0009	-0.029	0.607	.3841
00.0	-.0088	-0.041	0.342	.3504		00.2	-.0015	0.003	0.607	.3885
02.9	-.0066	0.063	0.342	.3387		03.1	-.0015	0.099	0.600	.3800
05.9	.0178	0.142	0.330	.3544		06.1	-.0017	0.199	0.606	.3868
08.9	.0249	0.243	0.344	.3544		09.2	-.0020	0.303	0.617	.4087
12.0	.0207	0.362	0.322	.3662		12.2	.0004	0.401	0.622	.4265
14.9	.0130	0.470	0.309	.3811		15.1	.0034	0.498	0.627	.4519
18.0	.0058	0.603	0.309	.4158		18.1	.0063	0.604	0.638	.4870
M = 0.65						M = 1.30				
-03.0	-.0093	-0.095	0.365	.3493		-02.9	-.0019	-0.097	0.560	.3540
-00.9	-.0042	-0.037	0.365	.3494		-00.8	-.0010	-0.035	0.566	.3564
00.0	-.0039	-0.010	0.366	.3425		00.1	-.0015	-0.004	0.564	.3608
02.9	.0059	0.083	0.366	.3519		03.0	-.0039	0.097	0.561	.3514
05.7	.0111	0.170	0.367	.3600		06.1	-.0070	0.201	0.569	.3597
08.9	.0154	0.270	0.363	.3623		09.1	-.0085	0.303	0.578	.3784
11.9	.0214	0.361	0.356	.3745		12.0	-.0087	0.407	0.584	.3937
14.9	.0250	0.455	0.346	.3957		15.0	-.0082	0.513	0.593	.4182
17.9	.0321	0.549	0.337	.4226		18.1	-.0060	0.629	0.607	.4566
M = 0.80						M = 1.60				
-03.0	-.0061	-0.096	0.393	.3495		-02.9	.0011	-0.105	0.450	.2795
-01.0	-.0026	-0.036	0.391	.3491		-01.0	.0001	-0.047	0.456	.2798
00.0	-.0022	-0.005	0.391	.3512		00.0	.0001	-0.017	0.459	.2867
02.9	.0042	0.092	0.394	.3491		02.9	.0000	0.078	0.449	.2820
05.7	.0063	0.190	0.391	.3503		05.9	-.0020	0.176	0.454	.2820
08.9	.0105	0.289	0.386	.3606		09.0	-.0042	0.280	0.465	.2940
11.9	.0126	0.386	0.383	.3760		12.0	-.0063	0.386	0.472	.3072
14.9	.0169	0.483	0.374	.4040		14.9	-.0102	0.497	0.481	.3239
17.9	.0215	0.581	0.366	.4326		17.9	-.0141	0.624	0.489	.3474
M = 0.90						M = 1.90				
-02.8	-.0042	-0.089	0.442	.3497		-02.8	.0007	-0.092	0.386	.2251
-00.9	-.0031	-0.030	0.435	.3559		-00.7	-.0011	-0.030	0.398	.2302
00.1	-.0025	0.002	0.439	.3501		00.1	.0005	-0.002	0.401	.2379
03.0	.0016	0.097	0.444	.3469		03.1	-.0012	0.093	0.390	.2366
06.1	.0031	0.198	0.440	.3544		06.0	-.0025	0.191	0.392	.2332
09.1	.0051	0.297	0.430	.3694		09.2	-.0041	0.296	0.398	.2377
12.1	.0066	0.396	0.429	.3801		12.1	-.0063	0.405	0.403	.2486
15.0	.0077	0.496	0.420	.3989		15.0	-.0087	0.521	0.406	.2605
18.0	.0091	0.606	0.408	.4331		18.1	-.0113	0.649	0.410	.2695
M = 1.00						M = 2.20				
-02.7	-.0045	-0.080	0.719	.5214		-02.3	.0011	-0.082	0.337	.1931
-00.7	-.0031	-0.023	0.717	.5250		-00.2	.0018	-0.024	0.355	.1980
00.2	-.0036	0.012	0.719	.5258		00.7	.0009	0.009	0.350	.2042
03.1	-.0010	0.102	0.711	.5212		03.6	.0011	0.100	0.336	.2001
06.2	.0008	0.196	0.700	.5236		06.7	-.0016	0.201	0.336	.1952
09.2	.0021	0.293	0.705	.5305		09.8	-.0035	0.306	0.339	.1958
12.2	.0033	0.392	0.700	.5562		12.7	-.0062	0.413	0.343	.1999
15.2	.0042	0.494	0.701	.5886		15.6	-.0095	0.532	0.345	.2034
18.2	.0040	0.601	0.696	.6179		18.7	-.0145	0.672	0.354	.2074
M = 1.10										
-02.6	-.0046	-0.078	0.720	.3897						
-00.7	-.0038	-0.027	0.720	.3919						
00.3	-.0036	0.005	0.716	.3994						
03.2	.0007	0.092	0.713	.3942						
06.2	-.0012	0.184	0.708	.3887						
09.3	.0003	0.276	0.705	.3935						
12.3	.0003	0.368	0.702	.4055						
15.2	.0003	0.466	0.701	.4481						
18.3	.0001	0.566	0.697	.4802						

TABLE XV (cont)

(b). Sharp cone with spherical base; center of moments at 0.677d from model base, center of spherical base at 0.677d.

α	C_m	C_N	C_A	C_{p_b}		α	C_m	C_N	C_A	C_{p_b}
M = 0.25						M = 1.20				
-02.9	.0095	-0.127	0.321	.3465		-02.8	.0009	-0.097	0.611	.3845
-01.0	.0052	-0.068	0.326	.3465		-00.7	.0000	-0.033	0.616	.3889
00.0	.0097	-0.048	0.335	.3465		00.2	.0007	0.001	0.615	.3959
02.9	.0198	0.055	0.340	.3426		03.2	.0038	0.099	0.609	.3833
05.9	.0247	0.144	0.330	.3504		06.2	.0028	0.199	0.624	.3969
09.0	.0438	0.223	0.333	.3585		09.2	.0031	0.298	0.635	.4223
12.0	.0556	0.296	0.337	.3662		12.2	.0043	0.395	0.641	.4353
15.0	.0672	0.380	0.335	.3898		15.1	.0068	0.494	0.644	.4554
18.0	.0925	0.461	0.338	.4182		18.2	.0082	0.604	0.650	.4840
M = 0.65						M = 1.50				
-03.0	-.0071	-0.091	0.362	.3627		-02.0	-.0011	-0.099	0.576	.3566
-01.0	-.0033	-0.033	0.364	.3581		-00.8	.0009	-0.035	0.581	.3684
00.0	-.0021	-0.003	0.365	.3552		00.1	.0009	-0.003	0.581	.3720
02.9	.0063	0.084	0.367	.3591		03.1	-.0011	0.098	0.574	.3581
05.9	.0121	0.175	0.365	.3652		06.1	-.0044	0.202	0.586	.3700
08.9	.0182	0.265	0.365	.3718		09.2	-.0065	0.306	0.598	.3920
11.9	.0269	0.350	0.361	.3912		12.1	-.0069	0.406	0.603	.4013
15.0	.0345	0.435	0.357	.4102		15.1	-.0053	0.512	0.610	.4235
17.8	.0476	0.509	0.347	.4263		18.1	-.0039	0.628	0.620	.4491
M = 0.80						M = 1.60				
-03.1	-.0023	-0.097	0.395	.3637		-02.9	.0070	-0.112	0.465	.2936
-01.0	.0009	-0.034	0.395	.3629		-01.0	.0061	-0.049	0.473	.2970
00.0	.0007	-0.002	0.397	.3552		00.0	.0074	-0.019	0.477	.3054
03.0	.0043	0.093	0.400	.3629		03.0	.0068	0.081	0.466	.2936
05.8	.0068	0.189	0.395	.3622		05.9	.0048	0.178	0.470	.2900
08.9	.0118	0.284	0.391	.3708		09.0	.0029	0.281	0.478	.2995
12.0	.0173	0.375	0.389	.3992		12.0	.0005	0.389	0.483	.3125
14.9	.0241	0.468	0.383	.4190		15.0	-.0023	0.501	0.492	.3315
17.8	.0326	0.555	0.274	.4441		18.1	-.0076	0.628	0.503	.3493
M = 0.90						M = 1.90				
-02.9	-.0024	-0.090	0.446	.3648		-02.9	.0012	-0.091	0.393	.2364
-00.7	-.0010	-0.027	0.444	.3657		-00.8	.0016	-0.030	0.406	.2434
00.2	.0007	0.010	0.442	.3600		00.1	.0014	-0.001	0.408	.2507
03.1	.0026	0.097	0.448	.3625		03.1	.0012	0.097	0.396	.2448
06.1	.0043	0.195	0.444	.3673		06.0	.0001	0.192	0.399	.2347
09.1	.0069	0.293	0.444	.3824		09.0	-.0029	0.298	0.403	.2413
12.0	.0095	0.387	0.442	.3995		12.1	-.0050	0.407	0.410	.2531
15.2	.0145	0.485	0.435	.4244		15.1	-.0085	0.524	0.418	.2599
18.0	.0183	0.584	0.420	.4477		18.1	-.0105	0.650	0.432	.2697
M = 1.00						M = 2.20				
-02.7	-.0053	-0.080	0.720	.5453		-02.3	.0103	-0.088	0.334	.1993
-00.7	-.0038	-0.023	0.725	.5353		-00.2	-.0022	-0.015	0.345	.2073
00.3	-.0032	0.016	0.726	.5386		00.6	-.0015	0.009	0.346	.2121
03.2	.0060	0.098	0.724	.5211		03.7	-.0018	0.105	0.331	.2025
06.1	.0078	0.191	0.721	.5352		06.7	-.0056	0.206	0.334	.1946
09.2	.0077	0.290	0.719	.5548		09.8	-.0097	0.310	0.339	.1919
12.2	.0085	0.387	0.715	.5683		12.7	-.0133	0.421	0.349	.2003
15.2	.0073	0.486	0.707	.5887		15.7	-.0165	0.540	0.361	.2051
18.2	.0076	0.593	0.701	.6210		18.8	-.0210	0.667	0.369	.2108
M = 1.10										
-02.7	-.0058	-0.080	0.725	.4035						
-00.6	-.0046	-0.024	0.722	.3840						
00.7	-.0049	0.005	0.722	.4023						
03.2	.0053	0.087	0.720	.3752						
06.3	.0051	0.180	0.722	.3986						
09.2	.0052	0.270	0.721	.4142						
12.3	.0046	0.363	0.718	.4305						
15.2	.0045	0.459	0.710	.4524						
18.3	.0034	0.558	0.702	.4738						

TABLE XV (cont)
(c). Blunt cone with flat base; center of moments
at 0.445d from model base.

α	C_m	C_N	C_A	C_{p_b}		α	C_m	C_N	C_A	C_{p_b}
M = 0.25						M = 1.20				
-03.0	-.0175	-0.100	0.299	.3346		-02.8	-.0085	-0.096	0.658	.3747
-01.0	-.0168	-0.041	0.318	.3189		-00.8	-.0045	-0.028	0.656	.3739
00.0	-.0084	-0.021	0.315	.3308		00.2	.0004	0.007	0.655	.3735
07.9	.0083	0.073	0.317	.3308		03.1	.0077	0.110	0.657	.3756
05.9	.0166	0.145	0.315	.3504		06.2	.0141	0.219	0.669	.3886
09.0	.0266	0.232	0.310	.3387		09.2	.0203	0.332	0.687	.4110
12.0	.0410	0.307	0.303	.3504		12.2	.0255	0.436	0.700	.4358
15.0	.0556	0.382	0.309	.3854		15.2	.0280	0.543	0.718	.4658
17.9	.0745	0.446	0.302	.4157		18.2	.0282	0.657	0.740	.5032
M = 0.65						M = 1.30				
-03.0	-.0103	-0.090	0.361	.3419		-02.8	-.0056	-0.100	0.651	.3491
-01.0	-.0049	-0.033	0.367	.3412		-00.7	-.0037	-0.032	0.648	.3496
00.0	-.0026	-0.003	0.367	.3425		00.1	-.0015	0.003	0.648	.3486
02.0	.0053	0.086	0.365	.3412		02.8	.0013	0.105	0.650	.3485
05.9	.0160	0.170	0.359	.3483		06.0	.0054	0.218	0.663	.3612
08.9	.0259	0.257	0.354	.3494		09.2	.0067	0.334	0.682	.3846
11.9	.0370	0.343	0.353	.3676		12.1	.0097	0.442	0.698	.4067
14.9	.0447	0.430	0.349	.3939		15.1	.0128	0.548	0.716	.4276
17.9	.0552	0.503	0.342	.4218		18.2	.0131	0.660	0.744	.4697
M = 0.80						M = 1.60				
-03.0	-.0097	-0.092	0.393	.3473		-02.9	.0007	-0.104	0.611	.2909
-01.0	-.0044	-0.031	0.397	.3443		-01.0	.0008	-0.045	0.612	.2861
-00.1	-.0026	-0.000	0.397	.3451		00.0	.0006	-0.011	0.613	.2873
02.9	.0072	0.094	0.394	.3499		02.9	.0015	0.087	0.612	.2873
05.9	.0173	0.189	0.390	.3485		05.9	.0000	0.190	0.618	.2919
08.9	.0256	0.285	0.389	.3592		09.0	.0003	0.292	0.630	.3004
11.9	.0360	0.376	0.389	.3804		12.0	-.0020	0.392	0.641	.3133
14.9	.0459	0.469	0.386	.4056		14.9	-.0038	0.493	0.658	.3321
18.0	.0567	0.563	0.384	.4374		17.9	-.0076	0.601	0.676	.3511
M = 0.90						M = 1.90				
-02.9	-.0079	-0.089	0.441	.3490		-02.8	-.0011	-0.080	0.572	.2346
-00.8	-.0043	-0.024	0.446	.3435		-00.8	-.0014	-0.024	0.574	.2342
00.1	.0006	0.008	0.447	.3511		00.1	-.0012	0.007	0.574	.2312
03.0	.0072	0.103	0.448	.3540		03.0	-.0026	0.095	0.576	.2382
06.1	.0163	0.202	0.450	.3630		06.0	-.0044	0.191	0.579	.2404
09.1	.0261	0.301	0.456	.3689		09.0	-.0048	0.282	0.583	.2435
12.1	.0360	0.401	0.452	.3905		12.1	-.0064	0.374	0.592	.2487
15.1	.0426	0.505	0.444	.4123		15.1	-.0083	0.470	0.604	.2621
18.1	.0492	0.610	0.426	.4443		18.1	-.0109	0.565	0.618	.2704
M = 1.00						M = 2.20				
-02.7	-.0110	-0.078	0.718	.5068		-02.3	.0003	-0.068	0.546	.1881
-00.7	-.0049	-0.019	0.723	.5164		-00.2	-.0017	-0.015	0.548	.1938
00.2	.0005	0.013	0.721	.4968		00.6	.0004	0.011	0.549	.1976
03.2	.0094	0.106	0.719	.5192		03.7	-.0022	0.094	0.543	.1986
06.2	.0200	0.199	0.715	.5300		06.7	-.0041	0.182	0.540	.2002
09.2	.0336	0.293	0.721	.5360		09.7	-.0050	0.268	0.543	.1971
12.2	.0463	0.392	0.716	.5570		12.7	-.0063	0.353	0.551	.1985
15.2	.0508	0.509	0.706	.5874		15.7	-.0090	0.444	0.565	.2024
18.3	.0490	0.644	0.704	.6212		18.7	-.0117	0.534	0.575	.2088
M = 1.10										
-02.7	-.0104	-0.080	0.719	.3773						
-00.7	-.0046	-0.023	0.716	.3805						
00.3	-.0014	0.010	0.718	.3773						
03.1	.0074	0.093	0.715	.3718						
06.2	.0184	0.183	0.716	.3819						
09.2	.0299	0.272	0.718	.3875						
12.3	.0427	0.367	0.711	.4084						
15.2	.0513	0.470	0.709	.4452						
18.3	.0445	0.601	0.718	.4973						

TABLE XV (cont)

(d). Blunt cone with spherical base; center of moments at 0.445d from model base, center of spherical base at 0.562d.

α	C_m	C_N	C_A	C_{p_b}		α	C_m	C_N	C_A	C_{p_b}
M = 0.25						M = 1.20				
-02.9	-.0031	-0.120	0.304	.3580		-02.7	-.0078	-0.099	0.662	.3842
-01.0	-.0071	-0.061	0.316	.3308		-00.8	-.0030	-0.032	0.657	.3794
00.0	-.0100	-0.035	0.323	.3426		00.3	.0006	0.005	0.654	.3785
02.2	.0165	0.049	0.336	.3426		03.2	.0080	0.114	0.661	.3854
06.0	.0265	0.115	0.339	.4088		06.2	.0140	0.222	0.676	.4011
08.9	.0225	0.230	0.321	.3695		09.2	.0199	0.332	0.693	.4223
12.0	.0319	0.328	0.319	.3811		15.1	.0271	0.550	0.723	.4743
15.0	.0385	0.422	0.327	.4205		18.2	.0259	0.662	0.737	.5023
17.9	.0331	0.528	0.339	.4438		12.1	.0237	0.441	0.705	.4442
M = 0.65						M = 1.30				
-03.1	-.0103	-0.088	0.364	.3552		-02.9	-.0051	-0.106	0.657	.3623
-01.0	-.0041	-0.035	0.367	.3522		-00.8	-.0030	-0.036	0.652	.3588
00.0	-.0019	-0.007	0.368	.3545		00.1	-.0011	0.001	0.651	.3543
02.9	.0070	0.083	0.369	.3545		03.1	.0019	0.111	0.658	.3602
05.9	.0175	0.170	0.366	.3681		06.0	.0042	0.222	0.671	.3715
08.9	.0267	0.261	0.365	.3847		09.2	.0059	0.336	0.688	.3891
11.9	.0341	0.348	0.363	.4067		12.2	.0082	0.446	0.699	.4090
14.9	.0421	0.434	0.357	.4272		15.1	.0113	0.553	0.716	.4300
17.9	.0483	0.519	0.353	.4521		18.1	.0106	0.667	0.741	.4665
M = 0.80						M = 1.60				
-03.0	-.0096	-0.090	0.394	.3612		-02.9	.0013	-0.108	0.612	.2881
-01.0	-.0046	-0.033	0.399	.3576		-00.9	.0017	-0.048	0.616	.2931
00.0	-.0011	-0.002	0.399	.3581		00.0	.0015	-0.013	0.617	.2931
02.9	.0079	0.093	0.397	.3594		02.9	.0022	0.084	0.614	.2943
05.9	.0167	0.190	0.396	.3684		05.9	.0016	0.186	0.623	.2981
08.9	.0261	0.287	0.396	.3869		09.0	.0004	0.289	0.629	.3100
12.0	.0339	0.387	0.401	.4043		12.0	-.0023	0.391	0.639	.3230
14.9	.0429	0.479	0.394	.4356		15.0	-.0046	0.494	0.654	.3359
17.9	.0509	0.578	0.392	.4660		18.0	-.0094	0.605	0.671	.3537
M = 0.90						M = 1.90				
-02.9	-.0095	-0.088	0.446	.3602		-02.9	.0008	-0.082	0.575	.2352
-00.8	-.0030	-0.026	0.445	.3577		-00.8	-.0015	-0.025	0.576	.2396
00.1	.0001	0.006	0.444	.3472		00.1	.0005	0.001	0.578	.2403
02.9	.0065	0.097	0.450	.3631		03.1	-.0021	0.095	0.579	.2429
06.1	.0160	0.204	0.455	.3809		06.1	-.0040	0.187	0.578	.2415
09.1	.0258	0.303	0.456	.4017		09.1	-.0047	0.281	0.581	.2473
12.1	.0342	0.405	0.457	.4214		12.1	-.0069	0.376	0.590	.2508
15.1	.0414	0.512	0.451	.4362		15.1	-.0108	0.474	0.601	.2576
18.1	.0465	0.622	0.435	.4645		18.2	-.0133	0.571	0.615	.2739
M = 1.00						M = 2.20				
-02.7	-.0099	-0.079	0.713	.5191		-02.2	.0001	-0.068	0.540	.1949
-00.7	-.0039	-0.022	0.713	.5232		-00.2	.0004	-0.017	0.542	.1976
00.3	.0005	0.014	0.712	.5199		00.8	.0009	0.014	0.543	.2007
03.1	.0095	0.102	0.703	.5199		03.6	-.0017	0.099	0.538	.1992
06.2	.0210	0.200	0.725	.5482		06.7	-.0035	0.180	0.538	.1971
09.2	.0334	0.296	0.724	.5637		09.7	-.0053	0.269	0.539	.1976
12.3	.0430	0.400	0.716	.5771		12.7	-.0078	0.356	0.547	.1976
15.3	.0478	0.523	0.709	.6151		15.7	-.0102	0.445	0.558	.1992
18.2	.0449	0.654	0.707	.6380		18.7	-.0146	0.541	0.571	.2056
M = 1.10										
-02.8	-.0111	-0.079	0.717	.3823						
-00.7	-.0041	-0.025	0.698	.3715						
00.3	.0005	0.007	0.715	.3757						
03.2	.0086	0.093	0.713	.3877						
06.2	.0177	0.186	0.721	.4062						
09.3	.0304	0.280	0.717	.4296						
12.3	.0405	0.370	0.716	.4368						
15.2	.0487	0.479	0.712	.4672						
18.2	.0416	0.607	0.715	.4968						

TABLE XV (cont)

(e). Blunt cone with spherical base; center of moments at 0.445d from model base, center of spherical base at 0.445d.

α	C_m	C_N	C_A	C_{p_b}		α	C_m	C_N	C_A	C_{p_b}
M = 0.25						M = 1.20				
-02.9	-.0114	-0.090	0.343	.3308		-02.6	-.0082	-0.097	0.667	.3851
-01.0	-.0056	-0.048	0.344	.3346		-00.7	-.0026	-0.028	0.659	.3800
00.0	-.0032	-0.028	0.350	.3346		00.2	.0018	0.005	0.657	.3802
02.9	.0181	0.062	0.346	.3346		03.3	.0087	0.115	0.664	.3818
05.9	.0169	0.134	0.365	.3943		09.2	.0208	0.330	0.695	.4175
09.0	.0239	0.246	0.337	.3585		12.2	.0244	0.437	0.707	.4378
12.0	.0317	0.330	0.337	.3869		15.2	.0260	0.551	0.723	.4667
15.0	.0382	0.423	0.337	.4110		18.2	.0256	0.660	0.738	.4902
17.9	.0421	0.512	0.344	.4473						
M = 0.65						M = 1.30				
-02.9	-.0101	-0.087	0.374	.3561		-02.9	-.0054	-0.102	0.662	.3670
-01.0	-.0039	-0.034	0.376	.3577		-00.7	-.0032	-0.033	0.657	.3569
00.0	.0004	-0.006	0.376	.3584		00.1	-.0011	0.001	0.656	.3548
02.9	.0091	0.081	0.376	.3616		03.0	.0028	0.108	0.660	.3571
05.9	.0174	0.169	0.371	.3668		06.1	.0046	0.221	0.673	.3700
09.0	.0268	0.261	0.374	.3788		09.2	.0062	0.334	0.692	.3864
11.9	.0356	0.341	0.373	.4015		12.0	.0085	0.443	0.700	.4048
14.9	.0430	0.432	0.364	.4219		15.1	.0111	0.552	0.716	.4285
17.9	.0507	0.510	0.358	.4536		18.1	.0100	0.663	0.739	.4602
M = 0.80						M = 1.60				
-03.0	-.0088	-0.090	0.425	.3615		-02.9	.0020	-0.108	0.615	.2899
-01.0	-.0036	-0.032	0.406	.3581		-01.0	.0018	-0.047	0.619	.2900
00.0	.0002	-0.002	0.407	.3564		00.0	.0015	-0.013	0.618	.2912
02.9	.0101	0.090	0.402	.3616		02.9	.0018	0.085	0.616	.2926
05.9	.0184	0.190	0.423	.3634		05.9	.0016	0.187	0.624	.2950
08.9	.0266	0.284	0.401	.3804		09.0	.0001	0.287	0.628	.3046
11.9	.0348	0.380	0.400	.4013		12.0	-.0023	0.391	0.641	.3151
14.9	.0421	0.479	0.400	.4285		15.0	-.0055	0.493	0.653	.3281
17.9	.0505	0.569	0.393	.4504		17.9	-.0088	0.595	0.666	.3412
M = 0.90						M = 1.90				
-02.8	-.0092	-0.086	0.453	.3604		-02.8	-.0012	-0.080	0.580	.2374
-00.8	-.0036	-0.024	0.455	.3591		-00.8	.0003	-0.026	0.581	.2374
00.1	.0005	0.009	0.454	.3558		00.1	.0007	0.006	0.582	.2404
03.1	.0099	0.101	0.453	.3558		03.1	-.0015	0.094	0.583	.2424
06.0	.0172	0.202	0.453	.3697		06.1	-.0034	0.187	0.582	.2427
09.1	.0264	0.302	0.460	.3887		09.0	-.0048	0.280	0.581	.2432
12.1	.0339	0.402	0.452	.4166		12.1	-.0064	0.375	0.591	.2497
15.0	.0413	0.505	0.450	.4338		15.0	-.0097	0.467	0.600	.2513
18.1	.0469	0.621	0.439	.4593		18.1	-.0133	0.566	0.616	.2610
M = 1.00						M = 2.20				
-02.7	-.0103	-0.077	0.723	.5182		-02.1	.0007	-0.070	0.544	.1913
-00.7	-.0021	-0.021	0.720	.5069		-00.1	.0006	-0.012	0.545	.1929
00.2	.0007	0.012	0.719	.5123		00.8	.0008	0.014	0.545	.1977
03.2	.0106	0.106	0.717	.5182		03.7	.0008	0.094	0.542	.1994
06.2	.0216	0.199	0.723	.5347		06.7	-.0019	0.180	0.536	.1968
09.2	.0332	0.294	0.726	.5561		09.7	-.0049	0.267	0.537	.1919
12.2	.0446	0.395	0.721	.5757		12.8	-.0072	0.354	0.548	.1945
15.2	.0478	0.517	0.707	.5954		15.7	-.0111	0.445	0.561	.1993
18.2	.0453	0.652	0.709	.6361		18.6	-.0151	0.535	0.570	.2029
M = 1.10										
-02.6	-.0098	-0.079	0.721	.3806						
-00.8	-.0036	-0.025	0.717	.3875						
00.4	.0003	0.009	0.720	.3668						
03.2	.0098	0.093	0.717	.3901						
06.2	.0194	0.185	0.726	.3965						
09.3	.0301	0.278	0.725	.4174						
12.3	.0419	0.371	0.715	.4322						
15.2	.0464	0.476	0.714	.4532						
18.3	.0408	0.607	0.717	.4970						

TABLE XV. (Concluded)

(f). Blunt cone with spherical base; center of moments at 0.445d from model base, center of spherical base at 0.323d.

α	C_m	C_N	C_A	C_{p_b}		α	C_m	C_N	C_A	C_{p_b}
M = 0.25						M = 1.20				
-02.8	-.0050	-0.139	0.342	.3506		-02.7	-.0061	-0.105	0.669	.3898
-01.0	.0065	-0.102	0.340	.3385		-00.7	-.0016	-0.035	0.661	.3813
00.0	.0090	-0.082	0.347	.3385		00.2	.0012	0.000	0.659	.3777
02.9	.0167	0.002	0.341	.3426		03.2	.0085	0.113	0.667	.3832
06.0	.0331	0.080	0.377	.4371		06.2	.0148	0.220	0.678	.4003
09.0	.0347	0.211	0.341	.3780		09.2	.0202	0.333	0.693	.4219
12.0	.0411	0.305	0.330	.3854		12.2	.0253	0.440	0.708	.4430
15.0	.0453	0.404	0.315	.4182		15.1	.0273	0.549	0.719	.4680
17.9	.0473	0.510	0.336	.4421		18.2	.0261	0.666	0.739	.5045
M = 0.65						M = 1.30				
-03.0	-.0078	-0.095	0.372	.3613		-02.9	-.0052	-0.106	0.663	.3597
-01.0	-.0025	-0.042	0.375	.3591		-00.9	-.0032	-0.038	0.658	.3563
00.0	.0010	-0.012	0.373	.3568		00.1	.0008	-0.002	0.658	.3540
02.9	.0119	0.076	0.374	.3652		03.1	.0032	0.107	0.663	.3598
05.9	.0209	0.162	0.368	.3736		06.1	.0041	0.223	0.675	.3715
08.9	.0289	0.255	0.371	.3855		09.1	.0074	0.336	0.688	.3879
11.9	.0370	0.343	0.369	.4053		12.2	.0099	0.446	0.699	.4043
14.9	.0446	0.431	0.364	.4333		15.1	.0116	0.555	0.716	.4275
17.9	.0510	0.515	0.355	.4585		18.1	.0105	0.669	0.742	.4638
M = 0.80						M = 1.60				
-03.0	-.0078	-0.097	0.404	.3646		-03.0	.0024	-0.114	0.617	.2888
-01.0	-.0019	-0.039	0.407	.3625		-01.0	.0016	-0.049	0.620	.2891
00.0	.0010	-0.007	0.409	.3628		00.0	.0018	-0.015	0.622	.2704
02.9	.0105	0.086	0.406	.3694		02.9	.0032	0.082	0.620	.2954
05.9	.0187	0.186	0.404	.3800		05.9	.0025	0.185	0.625	.2977
09.0	.0271	0.284	0.403	.3999		09.0	.0013	0.287	0.629	.3061
11.9	.0350	0.382	0.404	.4158		12.0	-.0016	0.393	0.639	.3179
14.9	.0428	0.482	0.401	.4415		15.0	-.0049	0.496	0.653	.3320
17.9	.0501	0.574	0.392	.4614		17.9	-.0087	0.604	0.670	.3451
M = 0.90						M = 1.90				
-02.9	-.0078	-0.093	0.454	.3656		-02.8	.0005	-0.083	0.585	.2382
-00.8	-.0019	-0.030	0.452	.3611		-00.8	.0005	-0.028	0.584	.2381
00.1	.0010	0.002	0.454	.3537		00.0	.0001	-0.001	0.588	.2422
03.1	.0090	0.100	0.457	.3758		03.1	.0000	0.090	0.585	.2451
06.1	.0179	0.202	0.462	.3951		06.1	-.0016	0.187	0.582	.2458
09.2	.0264	0.306	0.465	.4030		09.2	-.0039	0.281	0.585	.2450
12.1	.0342	0.405	0.463	.4283		12.1	-.0062	0.377	0.593	.2486
15.1	.0411	0.513	0.459	.4594		15.1	-.0106	0.476	0.604	.2552
18.1	.0471	0.623	0.438	.4698		18.1	-.0134	0.573	0.617	.2642
M = 1.00						M = 2.20				
-02.7	-.0096	-0.083	0.727	.5245		-02.2	.0007	-0.070	0.544	.1721
-00.7	-.0026	-0.023	0.718	.5290		-00.1	.0009	-0.020	0.551	.1943
00.3	.0012	0.010	0.716	.5141		00.7	.0011	0.009	0.549	.1985
03.2	.0114	0.101	0.724	.5296		03.7	.0004	0.091	0.544	.1985
06.1	.0212	0.197	0.722	.5620		06.7	-.0016	0.177	0.536	.1979
09.2	.0331	0.297	0.730	.5730		09.8	-.0039	0.267	0.541	.1943
12.2	.0446	0.395	0.717	.5852		12.7	-.0069	0.357	0.549	.1978
15.2	.0478	0.519	0.730	.6305		15.6	-.0108	0.451	0.563	.2010
18.1	.0454	0.654	0.711	.6448		18.7	-.0151	0.546	0.574	.2058
M = 1.10										
-02.6	-.0098	-0.084	0.723	.3981						
-00.7	-.0033	-0.029	0.719	.3838						
00.2	.0003	0.002	0.718	.3904						
03.2	.0097	0.091	0.722	.3868						
06.1	.0189	0.181	0.733	.4141						
09.3	.0304	0.278	0.726	.4301						
12.3	.0415	0.373	0.717	.4440						
15.2	.0498	0.481	0.728	.4894						
18.3	.0413	0.613	0.720	.5051

(a) BASIC CONFIGURATION

Figure 141. Sketches of $12\frac{1}{2}^\circ$ Half-Angle Blunt-Nose Cone Models Having a Flat Base, Variation in Base Radius, and Modifications to the Base Surface.

(a) SHORT BASE RADIUS
(BASIC CONFIGURATION)

(c) LONG BASE RADIUS

(b) MEDIUM BASE RADIUS

(d) FLAT BASE

(b) VARIATION OF BASE RADIUS

Figure 141. (Continued)

CROSS SECTION OF BASES SHOWN

(a) STEP OUT BASE

(c) OUTER FENCE

(b) STEP IN BASE

(d) INNER FENCE

(C) BASES WITH STEPS AND FENCES

Figure 141. (Concluded)

Figure 142. Variation of Reynolds Number with Mach Number Associated with Experimental Tests of $12\text{-}1\frac{1}{2}^\circ$ Half-Angle Blunt-Nose Cone Models.

Figure 143. Variation of Static Characteristics with Angle of Attack for a 12-1/2° Half-Angle Blunt-Nose Cone; Basic Configuration.

TABLE XV (cont)

(b). Sharp cone with spherical base; center of moments at 0.677d from model base, center of spherical base at 0.677d.

α	C_m	C_N	C_A	C_{p_b}		α	C_m	C_N	C_A	C_{p_b}
M = 0.25						M = 1.20				
-02.9	.0095	-0.127	0.321	.3465		-02.8	.0009	-0.097	0.611	.3845
-01.0	.0052	-0.068	0.326	.3465		-00.7	.0000	-0.033	0.616	.3889
03.0	.0097	-0.048	0.335	.3465		00.2	.0007	0.001	0.615	.3959
02.9	.0198	0.055	0.340	.3426		03.2	.0038	0.099	0.609	.3833
05.9	.0247	0.144	0.330	.3504		06.2	.0028	0.199	0.624	.3969
09.0	.0438	0.223	0.333	.3585		09.2	.0031	0.298	0.635	.4223
17.0	.0556	0.296	0.337	.3662		12.2	.0043	0.395	0.641	.4353
15.0	.0672	0.380	0.335	.3898		15.1	.0068	0.494	0.644	.4554
18.0	.0925	0.461	0.338	.4182		18.2	.0082	0.604	0.650	.4840
M = 0.65						M = 1.30				
-03.0	-.0071	-0.091	0.362	.3627		-02.0	-.0011	-0.099	0.576	.3566
-01.0	-.0033	-0.033	0.364	.3581		-00.8	.0009	-0.035	0.581	.3684
00.0	-.0021	-0.003	0.365	.3552		00.1	.0009	-0.003	0.581	.3720
02.9	.0063	0.084	0.367	.3591		03.1	-.0011	0.098	0.574	.3581
05.9	.0121	0.175	0.365	.3652		06.1	-.0044	0.202	0.586	.3700
08.9	.0182	0.265	0.365	.3718		09.2	-.0065	0.306	0.598	.3920
11.9	.0269	0.350	0.361	.3912		12.1	-.0069	0.406	0.603	.4013
15.0	.0345	0.435	0.357	.4102		15.1	-.0053	0.512	0.610	.4235
17.8	.0476	0.509	0.347	.4263		18.1	-.0039	0.628	0.620	.4491
M = 0.80						M = 1.60				
-03.1	-.0023	-0.097	0.395	.3637		-02.9	.0070	-0.112	0.465	.2936
-01.0	.0009	-0.034	0.395	.3629		-01.0	.0061	-0.049	0.473	.2970
00.0	.0007	-0.002	0.397	.3552		00.0	.0074	-0.019	0.477	.3054
03.0	.0043	0.093	0.400	.3629		03.0	.0068	0.081	0.466	.2936
05.8	.0068	0.189	0.395	.3622		05.9	.0048	0.178	0.470	.2900
08.9	.0118	0.284	0.391	.3708		09.0	.0029	0.281	0.478	.2995
12.0	.0173	0.375	0.389	.3992		12.0	.0005	0.389	0.483	.3125
14.9	.0241	0.468	0.383	.4190		15.0	-.0023	0.501	0.497	.3315
17.8	.0326	0.555	0.374	.4441		18.1	-.0076	0.628	0.505	.3493
M = 0.90						M = 1.90				
-02.9	-.0024	-0.090	0.446	.3648		-02.9	.0012	-0.091	0.393	.2364
-00.7	-.0010	-0.027	0.444	.3637		-00.8	.0016	-0.030	0.406	.2434
00.2	.0007	0.010	0.442	.3608		00.1	.0014	-0.001	0.408	.2507
03.1	.0026	0.097	0.448	.3625		03.1	.0012	0.097	0.396	.2448
06.1	.0043	0.195	0.444	.3673		06.0	.0001	0.192	0.399	.2347
09.1	.0069	0.293	0.444	.3824		09.0	-.0029	0.298	0.403	.2413
12.0	.0095	0.387	0.442	.3995		12.1	-.0050	0.407	0.410	.2531
15.2	.0145	0.485	0.435	.4244		15.1	-.0085	0.524	0.418	.2599
18.0	.0183	0.584	0.420	.4477		18.1	-.0105	0.650	0.432	.2697
M = 1.00						M = 2.20				
-02.7	-.0053	-0.080	0.720	.5453		-02.3	.0103	-0.088	0.334	.1993
-00.7	-.0038	-0.023	0.725	.5353		-00.2	-.0022	-0.015	0.345	.2073
00.3	-.0032	0.016	0.726	.5386		00.6	-.0015	0.009	0.346	.2121
03.2	.0060	0.098	0.724	.5211		03.7	-.0018	0.105	0.331	.2025
06.1	.0078	0.191	0.721	.5352		06.7	-.0056	0.206	0.334	.1946
09.2	.0077	0.290	0.719	.5548		09.8	-.0097	0.310	0.339	.1919
12.4	.0005	0.387	0.715	.5683		12.7	-.0133	0.421	0.349	.2003
15.2	.0073	0.486	0.707	.5887		15.7	.0165	0.540	0.361	.2051
18.2	.0076	0.593	0.701	.6218		18.6	-.0210	0.667	0.369	.2108
M = 1.10										
-02.7	-.0058	-0.080	0.725	.4035						
-00.6	-.0046	-0.024	0.722	.3840						
00.2	-.0049	0.005	0.727	.4023						
03.2	.0053	0.087	0.720	.3752						
06.3	.0051	0.180	0.722	.3986						
09.2	.0052	0.270	0.721	.4142						
12.3	.0046	0.363	0.718	.4305						
15.2	.0045	0.459	0.710	.4524						
18.3	.0034	0.558	0.702	.4738

(b) MEDIUM RADIUS

Figure 144. (Continued)

(c) LONG RADIUS

Figure 144. (Continued)

(d) FLAT BASE

Figure 144. (Continued)

(e) STEP OUT BASE

Figure 144. (Continued)

(f) STEP IN BASE

Figure 144. (Continued)

(q) OUTER FENCE

Figure 144. (Continued)

(h) INNER FENCE

Figure 144. (Concluded)

Figure 145. Variation of Static Stability Derivatives at Zero Angle of Attack with Mach Number for a $12\frac{1}{2}^\circ$ Half-Angle Blunt-Nose Cone; Basic Configuration.

Figure 146. Variation of Damping in Pitch with Mach Number for a $12\text{-}1/2^\circ$ Half-Angle Blunt-Nose Cone Having a Flat Base, Various Base Radii, and Modifications to the Base Surface. $\alpha = 0^\circ$.

Figure 147. Variation of Damping in Pitch with Mach Number for a $12\text{-}1/2^\circ$ Half-Angle Blunt-Nose Cone Having a Flat Base, Various Base Radii, and Modifications to the Base Surface. $\alpha = 15^\circ$.

Figure 148. Sketch Showing Dimensions of a 12-1/2° Half-Angle Sharp Cone Model Used in an Experimental Pressure Test.

Figure 149. Spanwise Variation of the Pressure Coefficient on The Lower Forward and Aft Surface of a $12\text{-}1/2^\circ$ Half-Angle Cone at Three Angles of Attack.

Figure 149. (Continued)

(c) $M = 5.08$, $Re = 3.3 \times 10^6$

Figure 149. (Continued)

(d) $M = 8.08$, $Re = 2.0 \times 10^6$

Figure 149. (Concluded)

Figure 150. Spanwise Variation of the Pressure Coefficient on the Lower Forward Surface of 12-1/2° Half-Angle Cone at Three Angles of Yaw.

Figure 150. (Concluded)

Figure 151. Spanwise Variation of the Pressure Coefficient on the Upper Forward Surface of a $12\frac{1}{2}^\circ$ Half-Angle Cone at Three Angles of Attack.

Figure 151. (Concluded)

Figure 152. Sketch Showing Dimensions of Two 15° Half-Angle Sharp Cone Models.

Figure 153. Comparison of Experimental and Theoretical Total Drag Coefficient Variation with Free-Stream Reynolds Number on the Fore Portion of a 15° Half-Angle Cone.

Figure 154. Viscous Drag Coefficient ($C_D - C_{D_i}$) for a 15° Half-Angle Cone Versus Free-Stream Reynolds Number.

Figure 155. Variation of Measured Cone Pressure Coefficient (C_{p_c}) with Free-Stream Reynolds Number for a 15° Half-Angle Cone.

Figure 156. Variation of Measured Force Coefficient (C_F) with Free-Stream Reynolds Number for a 15° Half-Angle Cone.

TABLE XVI
Force and Pressure Test Data for 15° Half-Angle Sharp-Nose Cones.

	1	2	3	4	5	6	7
		Model Length L inches	Flow Rate lb/hr	Stagnation Pressure P _o microns	Stagnation Temperature T _o °R	Free-Stream Pressure P ₁ microns	Free-Stream Temperature T ₁ °R
Run Number	Nozzle Number						
413	6	2	30	2,021	525.0	189.0	266.8
			24	1,614	525.6	153.3	268.3
			18	1,220	526.8	121.5	272.5
			12	823	527.1	88.6	278.8
			5.2	368	527.6	49.3	297.0
421	6	1	30	2,000	537.5	187.0	273.1
			24	1,583	538.2	150.4	274.7
			18	1,209	537.5	120.4	278.0
			12	813	536.7	87.5	283.9
			5.2	367	535.0	49.1	301.2
414	8	2	26	23,770	537.3	133.6	122.3
			20	18,033	537.3	109.2	124.9
			14	13,069	535.8	89.2	128.8
			10.3	9,947	535.1	73.5	131.7
			5.2	5,045	535.1	50.8	143.8
422	8	1	26	24,150	538.2	135.6	122.4
			20	18,140	539.6	109.6	125.3
			14	13,290	538.5	88.9	128.8
			10.3	9,912	538.9	72.6	132.3
			5.2	5,093	538.2	50.2	143.8

TABLE XVI (cont)

	8	9	10	11	12	13	14
Run Number	Free-Stream Mach Number M_1	Free-Stream Dynamic Pressure q_1 microns	Free-Stream Reynolds Number R_1 (based on L)	Measured Force F mg	Force Coefficient C_F	Cone Pressure p_c microns	Cone Pressure Coefficient C_{pc}
413	2.20	640.3	1591	956	0.2022	329.4	0.5144
	2.19	514.7	1274	863	0.2271	271.8	0.5281
	2.16	396.8	975	764	0.2607	215.5	0.5412
	2.11	276.1	673	647	0.3173	157.5	0.5704
	1.97	134.0	320	490	0.4552	83.1	0.6204
421	2.20	633.6	762	316	0.2702	314.1	0.5384
	2.19	504.9	604	291	0.3122	287.6	0.5694
	2.16	393.2	469	265	0.3651	222.0	0.5646
	2.11	272.6	324	228	0.4531	161.0	0.5904
	1.97	133.4	156	165	0.6700	90.2	0.6762
414	4.12	1587	7029	1671	0.1426	385.5	0.2429
	4.06	1262	5468	1493	0.1602	314.8	0.2494
	3.97	986.0	4147	1314	0.1805	251.3	0.2549
	3.91	788.3	3238	1182	0.2031	205.3	0.2604
	3.69	483.6	1829	976	0.2733	131.6	0.2721
422	4.12	1612	3568	539	0.1811	432.6	0.2684
	4.06	1268	2739	498	0.2127	350.8	0.2767
	3.99	989.1	2074	447	0.2448	275.7	0.2787
	3.92	781.2	1595	400	0.2774	223.0	0.2855
	3.70	482.3	908	323	0.3628	145.8	0.3023

TABLE XVI (cont)

RUN NUMBER	15 TOTAL DRAG	16 TOTAL DRAG COEFFICIENT	17 INVISCID DRAG COEFFICIENT	18 VISCOUS DRAG COEFFICIENT	19 CONE PRESSURE (INVISCID)	20 CONE TEMPERATURE (INVISCID)
	D	C_D	C_{Di}	$C_D - C_{Di}$	P_{ci}	T_{ci}
	mg				microns	°R
413	1994	0.4217	0.1948	0.2269	313.7	309.0
	1739	0.4576	0.1951	0.2625	253.7	310.4
	1459	0.4979	0.1961	0.3018	199.3	314.5
	1156	0.5670	0.1982	0.3688	143.3	320.5
	740	0.7479	0.2061	0.5418	76.9	337.4
421	601	0.5138	0.1948	0.3190	310.4	316.2
	545	0.5847	0.1951	0.3893	248.9	317.8
	453	0.6241	0.1961	0.4280	197.5	320.8
	364	0.7233	0.1982	0.5251	141.5	326.3
	241	0.9786	0.2061	0.7725	76.6	342.2
414	3533	0.3015	0.1610	0.1405	389.1	170.2
	3013	0.3233	0.1612	0.1621	312.6	172.7
	2512	0.3450	0.1624	0.1826	249.3	176.5
	2156	0.3704	0.1627	0.2077	201.8	179.4
	1573	0.4405	0.1646	0.2759	130.4	191.3
422	1088	0.3656	0.1609	0.2047	395.0	170.4
	944	0.4033	0.1614	0.2419	314.3	173.4
	792	0.4338	0.1623	0.2715	249.4	176.7
	678	0.4701	0.1626	0.3075	199.6	180.3
	500	0.5616	0.1643	0.3973	129.5	191.5

TABLE XVI (cont)

RUN NUMBER	21 CONE MACH NUMBER (INVISCID)	22 CONE DYNAMIC PRESSURE (INVISCID)	23 CONE REYNOLDS NUMBER	24 CONE BOUNDARY- LAYER KNUDSEN NUMBER	25 SHEAR-DRAG COEFFICIENT (THEORETICAL)	26 TANGENT-CONE PRESSURE PARAMETER
	M_{ci}	q_{ci} microns	R_{ci}	K_{ci}	C_{Df}	f
413	1.87	769.9	1830	0.0657	0.1547	4.08
	1.86	616.0	1463	0.0730	0.1723	4.06
	1.84	472.3	1114	0.0827	0.1965	3.97
	1.80	324.1	763	0.0976	0.2346	3.82
	1.68	152.0	356	0.1335	0.3331	3.45
421	1.87	761.8	877	0.0948	0.2235	4.08
	1.86	604.4	694	0.1060	0.2502	4.06
	1.84	468.1	537	0.1191	0.2831	3.97
	1.80	320.0	367	0.1407	0.3382	3.82
	1.68	151.3	174	0.1911	0.4765	3.45
414	3.28	2932	9575	0.0503	0.0986	12.40
	3.24	2301	7417	0.0565	0.1108	12.14
	3.19	1773	5643	0.0636	0.1255	11.72
	3.15	1399	4393	0.0712	0.1406	11.43
	3.00	818.8	2446	0.0908	0.1808	10.35
422	3.28	2979	4856	0.0707	0.1385	12.41
	3.24	2317	3716	0.0798	0.1568	12.15
	3.19	1782	2822	0.0902	0.1778	11.75
	3.15	1389	2159	0.1018	0.2017	11.45
	3.00	818.6	1218	0.1292	0.2567	10.43

TABLE XVI (Concluded)

RUN NUMBER	27	28	29	30
	VISCOUS PRESSURE-DRAG COEFFICIENT (THEORETICAL)	VISCOUS DRAG COEFFICIENT (THEORETICAL)	TOTAL DRAG COEFFICIENT (THEORETICAL)	CONE PRESSURE COEFFICIENT (THEORETICAL)
	$C_{Dp}' - C_{Di}$	$C_D' - C_{Di}$	C_D'	C_{pc}'
413	0.0370	0.1917	0.3865	0.5177
	0.0414	0.2137	0.4038	0.5240
	0.0471	0.2436	0.4397	0.5377
	0.0562	0.2903	0.4690	0.5612
	0.0800	0.4131	0.6192	0.6342
421	0.0535	0.2770	0.4718	0.5300
	0.0600	0.3102	0.5053	0.5380
	0.0678	0.3509	0.5470	0.5532
	0.0810	0.4192	0.6174	0.5799
	0.1144	0.5909	0.7970	0.6600
414	0.0283	0.1269	0.2879	0.2664
	0.0319	0.1427	0.3039	0.2714
	0.0359	0.1614	0.3238	0.2797
	0.0402	0.1808	0.3435	0.2862
	0.0511	0.2319	0.3965	0.3079
422	0.0398	0.1783	0.3392	0.2749
	0.0450	0.2018	0.3632	0.2817
	0.0507	0.2285	0.3908	0.2901
	0.0573	0.2590	0.4216	0.2985
	0.0727	0.3294	0.4937	0.3230

TABLE XVII
Experimental Force and Pressure Data for 15° Half-Angle
Cones Corrected to Mach Number of 2 and 4.

RUN NUMBER	1 MODEL LENGTH	2 FREE-STREAM MACH NUMBER	3 FREE-STREAM REYNOLDS NO.	4 STAGNATION TEMPERATURE	5 STAGNATION PRESSURE	6 FREE-STREAM TEMPERATURE	7 FREE-STREAM PRESSURE
	<u>L</u> <u>inches</u>	<u>M₁</u>	<u>R₁</u>	<u>T₀</u> <u>°R</u>	<u>p₀</u> <u>microns</u>	<u>T₁</u> <u>°R</u>	<u>p₁</u> <u>microns</u>
413	2	2	1591 1274 975 673 320	530	1868 1495 1145 789 375	294.4	238.7 191.1 146.3 100.9 48.0
421	1	2	762 604 469 324 156	530	1789 1419 1102 760 366	294.4	228.6 181.3 140.8 97.2 46.8
414	2	4	7029 5468 4147 3238 1829	530	21,990 17,100 12,970 10,130 5,721	126.2	144.9 112.7 85.5 66.8 37.7
422	1	4	3568 2739 2074 1595 908	530	22,320 17,130 12,980 9,979 5,683	126.2	147.1 112.9 85.5 65.8 37.5

TABLE XVII (cont)

RUN NUMBER	8	9	10	11	12	13	14
	FREE-STREAM DYNAMIC PRESSURE	CONE TEMPERATURE (INVISCID)	CONE PRESSURE (INVISCID)	CONE MACH NUMBER (INVISCID)	CONE REYNOLDS NUMBER	INVISCID DRAG COEFFICIENT	SHEAR-DRAG COEFFICIENT (THEORETICAL)
	q_1 microns	T_{ci} °R	P_{ci} microns	M_{ci}	R_{ci}	C_{Di}	C'_{Df}
413	668.4	335.2	374.8	1.71	1780	0.2036	0.1501
	535.1		300.0		1425		0.1678
	409.6		229.7		1091		0.1917
	282.5		158.4		752		0.2309
	134.3		75.3		358		0.3349
421	640.1	335.2	358.9	1.71	852	0.2036	0.2169
	507.6		284.6		676		0.2436
	394.2		221.1		525		0.2764
	272.1		152.6		362		0.3327
	131.2		73.5		175		0.4793
414	1623	173.4	407.6	3.20	9532	0.1619	0.0968
	1262		317.0		7413		0.1098
	957.5		240.5		5624		0.1261
	747.6		187.8		4392		0.1427
	422.2		106.1		2481		0.1898
422	1648	173.4	413.8	3.20	4839	0.1619	0.1359
	1264		317.6		3714		0.1551
	957.7		240.5		2812		0.1783
	736.5		185.0		2163		0.2033
	419.4		105.3		1231		0.2695

TABLE XVII (Concluded)

RUN NUMBER	15 TANGENT-CONE PRESSURE PARAMETER	16 VISCOUS PRESSURE-DRAG COEFFICIENT (THEORETICAL)	17 VISCOUS DRAG COEFFICIENT (THEORETICAL)	18 TOTAL DRAG COEFFICIENT (THEORETICAL)	19 VISCOUS DRAG COEFFICIENT	20 TOTAL DRAG COEFFICIENT
	f	$C'_{Dp} - C_{Di}$	$C'_D - C_{Di}$	C'_D	$C_D - C_{Di}$	C_D
413	3.53	0.0360	0.1861	0.3597	0.2213	0.4249
		0.0402	0.2080	0.4116	0.2568	0.4604
		0.0460	0.2377	0.4413	0.2959	0.4995
		0.0553	0.2862	0.4898	0.3642	0.5678
		0.0802	0.4151	0.6187	0.5438	0.7474
421	3.53	0.0520	0.2689	0.4725	0.3109	0.5145
		0.0584	0.3020	0.5056	0.3811	0.5847
		0.0663	0.3427	0.5463	0.4198	0.6234
		0.0798	0.4125	0.6161	0.5184	0.7220
		0.1149	0.5942	0.7978	0.7758	0.9794
414	11.8	0.0277	0.1245	0.2864	0.1381	0.3000
		0.0314	0.1412	0.3021	0.1606	0.3225
		0.0362	0.1622	0.3241	0.1834	0.3453
		0.0409	0.1836	0.3455	0.2105	0.3724
		0.0544	0.2442	0.4061	0.2882	0.4501
422	11.8	0.0389	0.1748	0.3367	0.2012	0.3631
		0.0444	0.1995	0.3614	0.2396	0.4015
		0.0511	0.2294	0.3913	0.2724	0.4343
		0.0582	0.2615	0.4234	0.3100	0.4719
		0.0772	0.3467	0.5086	0.4146	0.5765

THERMOCOUPLE LOCATIONS:

$X' = 1.50; 1.75; 2.00; 2.50; 3.00; 3.50; 4.00; 5.00; 6.00$

PRESSURE-TUBE LOCATIONS:

$X' = 1.50; 1.75; 2.00; 3.00; 4.00; 5.00; 6.00$

CHROMEL-ALUMEL
THERMOCOUPLES

0.040-I.D.
PRESSURE TUBES

$t = 0.030 \pm 0.001$

THERMOCOUPLE LOCATIONS:

$X' = 1.00; 1.50; 2.00; 2.50; 3.00; 3.50; 4.00; 5.00; 6.00$

PRESSURE-TUBE LOCATIONS:

$X' = 0.50; 1.00; 1.50; 2.00; 3.00; 4.00; 5.00; 6.00$

CHROMEL-ALUMEL
THERMOCOUPLES

0.040-I.D.
PRESSURE TUBES

X'	t
1	0.037
1.5	.034
2.0	.028
2.5	.028
3.0	.028
3.5	.029
4.0	.030
5.0	.030
6.0	.031

ALL DIMENSIONS ARE IN INCHES. MATERIAL IS 347 STAINLESS STEEL.

Figure 157. Sketch Showing Pressure Orifice and Thermocouple Locations on 15° Half-Angle Sharp- and Blunt-Nose Cone Models.

Figure 158. Heat-Transfer and Pressure Distributions on the Stagnation Line of 15° Half-Angle Sharp- and Blunt-Nose Cones at Various Angles of Attack. $M = 6$.

Figure 158. (Continued)

Figure 158. (Continued)

Figure 158. (Continued)

(e) $\alpha = 90^\circ$

Figure 158. (Concluded)

Figure 159. Heat Transfer and Pressure Distributions at an Angle of Attack of 0° for a 15° Half-Angle Sharp- and Blunt-Nose Cone. $M = 6$.

Figure 160. Pressure Coefficient on the Stagnation Line Versus Angle of Attack for a 15° Half-Angle Sharp- and Blunt-Nose Cone. $M = 6$. $Re_\infty = 6 \times 10^6$.

Figure 161. Circumferential Pressure Distributions at Various Angles of Attack for a 15° Half-Angle Sharp- and Blunt-Nose Cone. $M = 6$. $Re_\infty = 6 \times 10^6$

DIMENSIONS ARE IN INCHES

PRESSURE ORIFICE LOCATIONS	
ORIFICE	X, in.
1	0.503
2	0.800
3	1.097
4	1.362
5	1.658

Figure 162. Sketch Showing Pressure Orifice Locations on a 15° Half-Angle Conical Forebody.

Figure 163. Total Drag, Base Drag, and Forebody Pressure-Drag Coefficients and Typical Pressure Distributions Over the Conical Portion of a 15° Half-Angle Cone-Cylinder Model.

Figure 164. Comparison of Experimental and Theoretical Skin-Friction Coefficient Variation with Reynolds Number for a 15° Half-Angle Conical Forebody. $M = 2.41$.

Figure 165. Variation of Reynolds Number for Transition with Stagnation Pressure for a 10° Cone.

ALL DIMENSIONS ARE IN INCHES

Figure 166. Sketch Showing Dimensions and Pressure Orifice Locations of a 15° Half-Angle Sharp Cone.

Figure 167. Variation of Experimental and Theoretical Surface and Base Static Pressure Ratios with Mach Number for a 15° Half-Angle Sharp Cone Having a Flat Base.

Figure 167. (Concluded)

Figure 168. Average Surface and Base Pressure Ratios along with Theory, Versus Mach Number for a 15° Half-Angle Sharp Cone Having a Flat Base.

(b)

Figure 168. (Concluded)

Figure 169. Forward Surface and Center Base Pressure Ratios, along with the Averaged Pressure Ratio, Versus Mach Number for a 15° Half-Angle Sharp Cone Having a Flat Base.

Figure 170. Variation of Reynolds Number with Mach Number Associated with the Experimental Testing of a 15° Half-Angle Sharp Cone Having a Flat Base.

(a)

Figure 171. Variation of the Stability Derivatives C_{N_α} , C_{N_q} , and $C_{N_{\dot{\alpha}}}$ with Mach Number for a 10° Half-Angle Sharp Cone.

(b)

Figure 171. (Continued)

(c)

Figure 171. (Concluded)

(a)

Figure 172. Variation of the Stability Derivatives $C_{N\alpha}$, C_{Nq} , and $C_{N\dot{\alpha}}$ with Mach Number for a 20° Half-Angle Sharp Cone.

(b)

Figure 172.. (Continued)

(c)

Figure 172. (Concluded)

Figure 173. Sketch Showing Dimensions of 20° Half-Angle Sharp- and Blunt-Nose Cone Models Having Flat Bases.

Figure 174. Damping-In-Pitch Derivatives Versus Angle of Attack for a Sharp- and a Blunt-Nose 20° Half-Angle Cone. $M = 8$.

S = BASE AREA, 41.70 in.²

l = LENGTH FROM APEX TO BASE, 10.00 in.

ALL DIMENSIONS
IN INCHES

Figure 175. Sketches of 20° Half-Angle Sharp- and Blunt-Nose Cone Models Having a Flat Base.

Figure 176. Pitching-Moment, Axial Force, and Normal Force Coefficients Versus Angle of Attack for 20° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base. $M = 8$.

Figure 177. Variation of Lift and Drag Coefficients and Lift-Drag Ratio Versus Angle of Attack for 20° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base. $M = 8.0$.

Figure 178. Comparison of Experimental and Theoretical Values of Pitching-Moment and Normal Force Coefficients Versus Angle of Attack for 20° Half-Angle Sharp- and Blunt-Nose Cones Having a Flat Base. $M = 8.0$.

Figure 179. Subsonic Laminar Skin-Friction Correction Factor for Slender Cones (Half-Angles Less than 20°). $\alpha = 0^\circ$.

Figure 180. Subsonic Turbulent Skin-Friction Correction Factor for Slender Cones (Half-Angles Less than 20°). $\alpha = 0^\circ$.

(a)

Figure 181. Relations Between Free-Stream Conditions and Conditions at the Surface of Sharp Cones (Shock Attached, $M_1 \geq 1$) Versus Cone Half-Angle. $\alpha = 0^\circ$.

(b)

Figure 181. (Continued)

Figure 181. (Concluded)

Figure 182. Sonic Wave Drag of Cones. $\alpha = 0^\circ$.

Figure 183. Comparison of Theoretical Transonic and Supersonic Wave Drag of Thick Pointed Cone Cylinders with Cone Half-Angles of 20° to 35° with Some Experimental Data.

Figure 184. Wave Drag of Hemispheres. $\alpha = 0^\circ$.

Figure 185. Wave Drag of Slender Pointed Cones.

Figure 186. Regions of Applicability of Rules for Cone Wave Drag.

Figure 187. Stagnation Pressure Coefficient Across a Normal Shock.

Figure 188. Slope of the Normal Force Coefficient Curve for Various Cone Half-Angles and Free-Stream Mach Numbers.

Figure 188. (Concluded)

TABLE XVIII

Summary Results for the Minimum Free-Stream Mach Number
Solution for Cones of Half-Angles Ranging from 2.5° to 30°.

θ_s	M_{∞}	S_2/R	η/α	M_2^*	M_{w2}^*	$\left(\frac{dC_N}{d\alpha}\right)_{\alpha=0}$	$\frac{\alpha_\ell}{\alpha}$
2.5	1.0121844	0	.00217694	- .08727873	2.0015645	1.9792220	2.0015561
5.0	1.0383341	.00000004	.01230054	- .17468360	2.0045502	1.9377305	2.0045418
7.5	1.0735583	.00000168	.03650328	- .26192168	2.0068113	1.8847211	2.0068029
10.0	1.1159051	.00002551	.08055267	- .34849606	2.0069071	1.8259721	2.0068987
12.5	1.1643198	.00021161	.14640315	- .43387247	2.0039620	1.7653417	2.0039536
15.0	1.2182190	.00112638	.23047873	- .51775257	1.9973856	1.7053838	1.9973772
17.5	1.2773745	.00426192	.32567982	- .60040503	1.9865672	1.6474358	1.9865589
20.0	1.3419094	.01239809	.42489989	- .68287429	1.9707283	1.5917219	1.9707200
22.5	1.4123337	.02949805	.52313389	- .76692255	1.9490311	1.5376674	1.9490229
25.0	1.4895953	.06020902	.61769493	- .85476984	1.9208169	1.4843004	1.9208088
27.5	1.5751393	.10929058	.70754538	- .94880773	1.8857868	1.4305861	1.8857789
30.0	1.6710795	.18124500	.79257648	-1.0514337	1.8439785	1.3756264	1.8439708

TABLE XIX

Computed Values of the Initial Slope of the Normal Force
Coefficient for Cones of Half-Angles Ranging from 2.5° to 30°.

Values of $\left(\frac{dC_N}{d\alpha}\right)_{\alpha=0}$

$\frac{\theta_B}{M_\infty}$	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0
1.5	1.9770483	1.9336127	1.8821566	1.8280992	1.7735619	1.7187816	1.6630926	1.6057182	1.5462941	1.4852936		
1.75	1.9731742	1.9258447	1.8737533	1.8224578	1.7730646	1.7243971	1.6746400	1.6223425	1.5666956	1.5075064	1.4451701	1.3808820
2.0	1.9690287	1.9180672	1.8661051	1.8183423	1.7742540	1.7310117	1.6859216	1.6372641	1.5842135	1.5265736	1.4645815	1.3988695
2.5	1.9602967	1.9036740	1.8548454	1.8161039	1.7820973	1.7472553	1.7083329	1.6638860	1.6134668	1.5571606	1.4953496	1.4285279
3.0	1.9514206	1.8917127	1.8493550	1.8202950	1.7941549	1.7645092	1.7287097	1.6859461	1.6362061	1.5798551	1.5174588	1.4497109
3.5	1.9426977	1.8826075	1.8447600	1.8282076	1.8074148	1.7806466	1.7461812	1.7037859	1.6537994	1.5968132	1.5335317	1.4647351
4.0	1.9343213	1.8763907	1.8516843	1.8377630	1.8203259	1.7949749	1.7608321	1.7181330	1.6674853	1.6096523	1.5454397	1.4756774
4.5	1.9264473	1.8728601	1.8568202	1.8477350	1.8322685	1.8074272	1.7730368	1.7296967	1.6782310	1.6195188	1.5544309	1.4838272
5.0	1.9191785	1.8715909	1.8632046	1.8574765	1.8430453	1.8181556	1.7832011	1.7390731	1.6867491	1.6272149	1.5613461	1.4900257
6.0	1.9066985	1.8741557	1.8772933	1.8752450	1.8611884	1.8352940	1.7988073	1.7530357	1.6991506	1.6381839	1.5710540	1.4986224
7.0	1.8972025	1.8808308	1.8911403	1.8902959	1.8754007	1.8479983	1.8098978	1.7626404	1.7074620	1.6453960	1.5773421	1.5041237
8.0	1.8906735	1.8893943	1.9037986	1.9027991	1.8865235	1.8575153	1.8179511	1.7694507	1.7132534	1.6503536	1.5816157	1.5078364
10.0	1.8854155	1.9075860	1.9248544	1.9216225	1.9022129	1.8703588	1.8284727	1.7781460	1.7205191	1.6564935	1.5868584	1.5123524
12.0	1.8876297	1.9243231	1.9408134	1.9345246	1.9122898	1.8782443	1.8347389	1.7832191	1.7246910	1.6599792	1.5898124	1.5148790
15.0	1.8980460	1.9449893	1.9576949	1.9470431	1.9215589	1.8852675	1.8402027	1.7875704	1.7282369	1.6629184	1.5922831	1.5169846
20.0	1.9201707	1.9690214	1.9743436	1.9583547	1.9295376	1.8911343	1.8446777	1.7910947	1.7310758	1.6652577	1.5942431	1.5186494

Figure 189. Sketch Showing General Cone Nomenclature for Sharp- and Blunt-Nose Cones Having Spherical Segment Bases.

Figure 190. Newtonian Drag Coefficient Versus Cone Half-Angle for Blunt-Nosed Cones Having Spherical Bases.

Figure 191. Variation of the Expression (W/R_b^2) Versus Cone Half-Angle for Various Sharp- and Blunt-Nose Cones Having Spherical Bases.

Figure 192. Variation of Fineness Ratio Versus Cone Half-Angle for Several Sharp- and Blunt-Nose Cones Having Spherical Bases.

HEMISPHERE

Figure 193. Sketch of a Hemisphere and of a 30° Half-Angle Blunt Cone Model.

Figure 194. Variation of the Total Drag Coefficient with Mach Number for a Hemisphere and a 30° Half-Angle Blunt-Nose Cone.

DIMENSIONS IN INCHES UNLESS OTHERWISE NOTED.

Figure 195. Sketch of Two Blunt-Nosed Cone Models Having Cone Half-Angles of 14.5° and 32° .

Figure 196. Effect of Change in Reynolds Number on the Aerodynamic Characteristics of a 14.5° Half-Angle Blunt-Nose Cone.

(b) $M = 2.06$

Figure 196. (Concluded)

(a) $M = 4.50$

Figure 197. Effect of Change in Reynolds Number on the Aerodynamic Characteristics of a 32° Half-Angle Blunt-Nose Cone.

Figure 197. (Concluded)

Figure 198. Aerodynamic Characteristics of a 14.5° Half-Angle Blunt-Nose Cone in Pitch for Several Mach Numbers. $R = 2.9 \times 10^6$ to 3.9×10^6 .

Figure 199. Aerodynamic Characteristics of a 32° Half-Angle Blunt-Nose Cone in Pitch for Several Mach Numbers. $R = 2.9 \times 10^6$ to 3.9×10^6 .

Figure 200. Summary of Stability and Axial-Force Characteristics of a 14.5° and a 32° Half-Angle Blunt-Nose Cone.

Figure 201. Effect of Angle of Attack on the Center-of-Pressure Location of a 14.5° and a 32° Half-Angle Blunt-Nose Cone.

Figure 202. Schematic Diagram Showing General Cone Geometry for Several Blunt-Nose Cones.

Figure 203. Cone Surface Pressure and Mach Number and the Drag Coefficient Along the Surface of Several Blunt-Nose Cones at Various Mach Numbers,
 (a) Bluntness, $\delta = 0.5$; $M_{\infty} = 3$.

Figure 203 (a). (Continued)

Figure 203 (a). (Concluded)

Figure 203 (b). Bluntness, $\delta = 0.5$; $M_\infty = 4$.

Figure 203 (b). (Continued)

Figure 203 (b). (Concluded)

Figure 203 (c). Bluntness, $\delta = 0.5$; $M_\infty = 6$.

Figure 203 (c). (Continued)

Figure 203 (c). (Concluded)

Figure 203 (d). Bluntness, $\delta = 0.5$; $M_\infty = \infty$.

Figure 203 (d). (Continued)

Figure 203 (d). (Concluded)

Figure 203 (e). Bluntness, $\delta = 1.0$; $M_\infty = 3$.

Figure 203 (e). (Continued)

Figure 203 (e). (Concluded)

Figure 203 (f). Bluntness, $\delta = 1.0$; $M_\infty = 4$.

Figure 203 (f). (Continued)

Figure 203 (f). (Concluded)

Figure 203 (g). Blurtness, $\delta = 1.0$; $M_\infty = 6$.

Figure 203 (g). (Continued)

Figure 203 (g). (Concluded)

Figure 203 (h). Bluntness, $\delta = 1.0$; $M_{\infty} = 10$.

Figure 203 (h). (Continued)

Figure 203 (h). (Concluded)

Figure 203 (i). Bluntness, $\delta = 1.0$; $M_\infty = \infty$.

Figure 203 (i). (Continued)

Figure 203 (i). (Concluded)

Figure 203 (j). Bluntness, $\delta = 1.5$; $M_\infty = 4$.

Figure 203 (j). (Continued)

Figure 203 (j). (Concluded)

Figure 203 (k). Bluntness, $\delta = 1.5$; $M_\infty = 6$.

Figure 203 (k). (Continued)

Figure 203 (k). (Concluded)

Figure 203 (1). Bluntness, $\delta = 1.5$; $M_\infty = \infty$.

Figure 2(3) (1). (Continued)

Figure 203 (1). (Concluded)

Figure 204. Family of Shock Waves for Several Blunt-Nose Cones at Various Mach Numbers.
 (a). Bluntness, $\delta = 0.5$; $M_\infty = 3$.

Figure 204 (b). Bluntness, $\delta = 0.5$; $M_{\infty} = 4$.

Figure 204 (c). Bluntness, $\delta = 0.5$; $M_\infty = 6$.

Figure 204 (d). Bluntness, $\delta = 0.5$; $M_\infty = \infty$.

Figure 204 (ϵ). Bluntness, $\delta = 1.0$; $M_\infty = 3$ and 4.

Figure 204 (f). Bluntness, $\delta = 1.0$; $M_\infty = 6$ and 10.

Figure 204 (g). Bluntness, $\delta = 1.0$; $M_\infty = \infty$.

Figure 204 (h). Bluntness, $\delta = 1.5$; $M_\infty = 4, 6$, and ∞ .

Figure 205. Schematic Diagram of Supersonic Flow About a Non-lifting Cone.

Figure 206. Variation of Cone Half-Angle with Free-Stream Mach Number Showing Range of Applicability of Cone Solution for $\omega - \delta \ll 1$.

Figure 207. Variation of Flow Inclination Angle with Ray Angle for a 5° Half-Angle Cone Operating at Mach Numbers of 1.5058, 4.8602, and 13.196.

Figure 208. Variation of Flow Inclination Angle with Ray Angle for a 10° Half-Angle Cone Operating at Mach Numbers of 1.5957, 5.4223, and 15.146.

Figure 209. Variation of Flow Inclination Angle with Ray Angle for a 20° Half-Angle Cone Operating at Mach Numbers of 1.4672, 5.5457, and 9.5928.

Figure 210. Variation of Flow Inclination Angle with Ray Angle for a 40° Half-Angle Cone Operating at Mach Numbers of 2.0242, 5.8336, and 13.101.

Figure 211. Variation of the Ratio of Local Velocity to Limiting Velocity with Ray Angle for a 5° Half-Angle Cone Operating at Mach Numbers of 1.5058, 4.8602, and 13.196.

Figure 212. Variation of the Ratio of Local Velocity to Limiting Velocity with Ray Angle for a 10° Half-Angle Cone Operating at Mach Numbers of 1.5957, 5.4223, and 15.146.

Figure 213. Variation of the Ratio of Local Velocity to Limiting Velocity with Ray Angle for a 20° Half-Angle Cone Operating at Mach Numbers of 1.4672, 5.5457, and 9.5928.

Figure 214. Variation of the Ratio of Local Velocity to Limiting Velocity with Ray Angle for a 40° Half-Angle Cone Operating at Mach Numbers 2.0242, 5.8336, and 13.101.

Figure 215. Variation of Pressure Coefficient with Free-Stream Mach Number for 5°, 10°, 20°, and 40° Half-Angle Cones.

Figure 216. Variation of Local Mach Number Along Ogives Corresponding to Four Values of the Similarity Parameter, K , for a Free-Stream Mach Number of 6.

Figure 217. Variation of Pressure Coefficient Along Ogives Corresponding to Four Values of the Similarity Parameter, K , for a Free-Stream Mach Number of 6.

(c) $K=1.5$

(d) $K=2$

Figure 217. (Concluded)

Figure 218. Schematic Showing Cone Body-Axis System.

ALL LINEAR DIMENSIONS IN INCHES

Figure 219. Sketch Showing Dimensions of 30°, 35°, and 40° Half-Angle Blunt-Nose Cone Models.

(a) CONFIGURATION 1.

Figure 220. Longitudinal Characteristics of a 30° , 35° , and 40° Half-Angle Blunt-Nose Cone Through a Wide Angle of Attack Range. $M = 24.5$.

(b) CONFIGURATION 2.

Figure 220. (Continued)

(c) CONFIGURATION 3.

Figure 220. (Concluded)

Figure 221. Variation of the Lift Coefficient with Angle of Attack for a 30°, 35°, and 40° Half-Angle Blunt-Nose Cone. $M = 24.5$.

Figure 222. Variation of the Drag Coefficient with Angle of Attack for a 30° , 35° , and 40° Half-Angle Blunt-Nose Cone. $M = 24.5$.

Figure 223. Variation of the Lift-Drag Ratio with Angle of Attack for a 30°, 35°, and 40° Half-Angle Blunt-Nose Cone. $M = 24.5$.

Figure 224. Variation of the Pitching-Moment Coefficient with Angle of Attack for a 30°, 35°, and 40° Half-Angle Blunt-Nose Cone. $M = 24.5$.

Figure 225. Vertical Center-of-Gravity Offset Required to Trim at Various Lift Coefficients and Lift-Drag Ratios. $\frac{x_{cg}}{D} = 0.288$. $M = 24.5$.

(a) C_L , C_D , AND L/D .

Figure 226. Longitudinal Stability and Performance Characteristics of a 35° Half-Angle Blunt-Nose Cone as Determined From Experiments in Nitrogen and Helium and by Modified Newtonian Theory. $M = 18$ and 24.5 .

(b) C_N, C_A , AND C_m

Figure 226. (Concluded)

Figure 227. The Longitudinal Stability of a 35° Half-Angle Blunt-Nose Cone at Mach Numbers of 18 and 24.5.

DIMENSIONS ARE IN INCHES

Figure 228. Sketches of Several Sharp-Nose Cone Models. (a). $\theta_s = 5^\circ$.

DIMENSIONS ARE IN INCHES

Figure 228. (b). $\theta_s = 10^\circ$.

DIMENSIONS ARE IN INCHES

Figure 228. (c). $\theta_s = 15^\circ$.

DIMENSIONS ARE IN INCHES

Figure 228. (d). $\theta_s = 20^\circ$.

DIMENSIONS ARE IN INCHES

Figure 228. (e). $\theta_s = 30^\circ$.

DIMENSIONS ARE IN INCHES

Figure 228. (f). $\theta_s = 45^\circ$.

Figure 229. Variation of Longitudinal Force Coefficients with Angle of Attack for a 5° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.

Figure 230. Variation of Longitudinal Force Coefficients with Angle of Attack for a 10° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.

Figure 231. Variation of Longitudinal Force Coefficients with Angle of Attack for a 15° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.

Figure 232. Variation of Longitudinal Force Coefficients with Angle of Attack for a 20° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.

Figure 233. Variation of Longitudinal Force Coefficients with Angle of Attack for a 30° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.

Figure 234. Variation of Longitudinal Force Coefficients with Angle of Attack for a 45° Half-Angle Sharp-Nose Cone Having a Flat Base. $M_\infty = 6.83$.

Figure 235. Variation of Lift-Curve Slope with Cone Half-Angle for Right Circular Cones. $M_\infty = 6.83$.

Figure 236. Variation of Maximum Lift Coefficient and the Angle of Attack at Which it Occurs with Cone Half-Angle for Right Circular Cones. $M_\infty = 6.83$.

Figure 237. Variation of Maximum Lift-Drag Ratio and the Angle of Attack at Which it Occurs with Cone Half-Angle for Right Circular Cones. $M_\infty = 6.83$.

Figure 238. Variation of Lift Coefficient at the Point of Maximum Lift-Drag Ratio and Lift-Drag Ratio at the Point of Maximum Lift Coefficient with Cone Half-Angle for Right Circular Cones. $M = 6.83$.

Figure 239. Variation of the Increments of Angle of Attack and Lift Coefficient Between $(L/D)_{\max}$ and $C_{L,\max}$ with Cone Half-Angle for Right Circular Cones. $M_\infty = 6.83$.

Figure 240. Sketch Showing Several Sharp- and Blunt-Nose Cones Having Various Cone Half-Angles and Nose Bluntness Ratios.

TABLE XX
Characteristic Air Properties Associated with Scaled-Model
Testing of Several Sharp- and Blunt-Nose Cones.

Wind Tunnel Test Facility	M	P (P _{sia})	T _t (°F)	R _n /in. × 10 ⁻⁶
14 x 14 Transonic	0.5	22	120	0.352
	0.7			0.436
	0.85			0.489
	0.95			0.510
	1.15			0.535
	1.25			0.535
	1.43	22		0.513
	1.93	28	120	0.590
14 x 14 Supersonic	2.74	30	120	0.402
	2.99	45	120	0.551
	3.48	75	140	0.657
	4.00	105	140	0.717
	4.45	105	180	0.551
	4.96	105	200	0.402
7 x 7 Supersonic	1.58	14.5	90	0.350
	1.99			0.306
	2.44			0.246
	2.99			0.187
	3.26			0.162
	3.60			0.137
	3.89			0.117
	4.39	14.5	90	0.094

D Base diameter
 r_n Nose radius
 L Length of body
 d Diameter at tangent station
 θ_s Cone half-angle

CONFIG.	TUNNEL		DIAMETER OF MODELS		
	14 x 14-inch		3.00 inch		
	7 x 7-inch		1.50 inch		
	θ_s	d/D	r_n/D	a/A	L/D
A-1	10°	0	0	0	2.836
A-2	10°	0.2	0.102	0.04	2.352
A-3	10°	0.4	0.203	0.16	1.869
A-4	10°	0.6	0.305	0.36	1.386
A-5	10°	0.8	0.406	0.64	0.903
B-1	13.32°	0	0	0	2.112
B-2	13.32°	0.2	0.103	0.04	1.768
B-3	13.32°	0.4	0.206	0.16	1.425
B-4	13.32°	0.6	0.308	0.36	1.082
B-5	13.32°	0.8	0.411	0.64	0.739
C-1	25°	0	0	0	1.077
C-2	25°	0.2	0.110	0.04	0.922
C-3	25°	0.4	0.221	0.16	0.771
C-4	25°	0.6	0.331	0.36	0.620
C-5	25°	0.8	0.441	0.64	0.469
D-1	50°	0	0	0	0.420
D-2	50°	0.2	0.156	0.04	0.372
D-3	50°	0.4	0.311	0.16	0.325
D-4	50°	0.6	0.467	0.36	0.277
D-5	50°	0.8	0.622	0.64	0.230

Figure 241. Nomenclature and Model Characteristics for Several Sharp- and Blunt-Nose Cone Models Having Various Cone Half-Angles and Nose Bluntness Ratios.

Figure 242. Variation of Normal Force Coefficient Slope with Mach Number for Various Sharp- and Blunt-Nose Cones. (a). $d/D = 0$.

Figure 242. (b). $d/D = 0.4$.

Figure 242. (c). $d/D = 0.8$.

Figure 243. Variation of Normal Force Coefficient Slope with Cone Half-Angle and Bluntness. (a). $M = 0.68$.

Figure 243. (b). $M = 0.94$.

Figure 243. (c). $M = 1.05$.

Figure 243. (d). $M = 1.30$.

Figure 243. (e). $M = 1.50$.

Figure 243. (f). $M = 1.97$.

Figure 243. (g). $M = 2.75$.

Figure 243. (h). $M = 4.0$.

Figure 244. Variation of Center-of-Pressure with Mach Number for Various Sharp- and Blunt-Nose Cones. (a). $d/D = 0$.

Figure 244. (b). $d/D = 0.4$.

Figure 244. (c). $d/D = 0.8$.

Figure 245. Variation of Center-of-Pressure with Cone Half-Angle and Bluntness. (a). $M = 0.68$.

Figure 245. (b). $M = 0.94$.

Figure 245. (c). $M = 1.05$.

Figure 245. (d). $M = 1.50$.

Figure 245. (e). $M = 1.97$.

Figure 245. (f). $M = 2.75$.

Figure 245. (g). $M = 4.0$.

Figure 246. Variation of Foredrag Coefficient with Mach Number for Various Sharp- and Blunt-Nose Cones. (a). $d/D = 0$.

Figure 246. (b). $d/D = 0.4$.

Figure 246. (c) $d/D = 0.8$.

Figure 247. Variation of Foredrag Coefficient with Cone Half-Angle and Bluntness. (a). $M = 0.68$.

Figure 247. (b). $M = 0.94$.

Figure 247. (c). $M = 1.05$.

Figure 247. (d). $M = 1.50$.

Figure 247. (e). $M = 1.97$.

Figure 247. (f). $M = 2.75$.

Figure 247. (g). $M = 4.0$.

Figure 248. Relationship Between Geometric Parameters of Sharp and Spherically Blunted Cones. (a). θ_s vs. L/D .

Figure 248. (b). θ_s vs. d/D .

Figure 249. Hypersonic Newtonian Normal Force Coefficient Slope for Cones of Varying Geometry.

Figure 250. Hypersonic Newtonian Centers-of-Pressure for Cones of Varying Geometry.

Figure 251. Hypersonic Newtonian Wave Drag for Cones of Varying Geometry.

Figure 252. Axis System with Positive Directions of Forces, Moments, and Angles Indicated by Arrows.

Figure 253. Comparison of Predicted Values of C_A and $C_{N\alpha}$ of a Series of Sharp Circular Cones with Cone Half-Angle with the Use of Newtonian and Exact Theories.

Figure 254. Comparison of Experimental Results with Theoretical Results of the Variation in the Longitudinal Characteristics of a Series of Sharp-Nose, Circular Conic Bodies with Angle of Attack at $M = 6.7$.

Figure 255. Comparison of Experimental Results with Theoretical Results of Variations in the Longitudinal Characteristics of a Series of Blunt-Nose Circular Conic Bodies with Angle of Attack for $M = 9.6$ and $h/R = 0.2$.

Figure 256. Comparison of Experimental Results with Theoretical Results of the Variations in $C_{L,max}$ and $(L/D)_{max}$ for a Series of Circular Conic Bodies with Varying Cone Half-Angle.

Figure 257. Comparison of Experimental Results with Theoretical Results of the Variations in the Longitudinal Stability Derivatives of a Series of Circular Conic Bodies with Varying Cone Half-Angle.

TABLE XXI
Aerodynamic Characteristics of Circular Cone Bodies Having
Half-Angles Ranging from 2.5° to 90°.

(a) C_N , $M = 6.83$, $\beta = 0^\circ$.

α , deg θ , deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0348	.0346	.0343	.0338	.0326	.0308	.0287	.0262	.0234	.0205
2.0	.0696	.0692	.0686	.0677	.0651	.0616	.0573	.0523	.0468	.0409
4.0	.1433	.1381	.1368	.1350	.1299	.1229	.1143	.1044	.0934	.0817
6.0	.2368	.2070	.2044	.2016	.1940	.1836	.1708	.1559	.1395	.1220
8.0	.3525	.2824	.2710	.2673	.2572	.2434	.2264	.2067	.1850	.1618
10.0	.4900	.3674	.3396	.3317	.3191	.3020	.2809	.2565	.2295	.2007
12.0	.6488	.4621	.4131	.3958	.3795	.3592	.3341	.3051	.2729	.2387
15.0	.9253	.6217	.5333	.4966	.4665	.4415	.4107	.3750	.3355	.2934
20.0	1.4802	.9307	.7585	.6790	.6065	.5676	.5280	.4821	.4313	.3772
25.0	2.1379	1.2852	1.0097	.8768	.7483	.6810	.6292	.5745	.5140	.4495
30.0	2.8785	1.6747	1.2794	1.0846	.8906	.7879	.7147	.6495	.5211	.5082
35.0	3.6795	2.0871	1.5595	1.2963	1.0300	.8877	.7891	.7074	.6305	.5514
40.0	4.5164	2.5102	1.8415	1.5057	1.1626	.9784	.8526	.7521	.6629	.5779
45.0	5.3640	2.9309	2.1170	1.7064	1.2845	1.0575	.9042	.7845	.6820	.5885
50.0	6.1964	3.3366	2.3776	1.8923	1.3921	1.1229	.9426	.8045	.6890	.5870
55.0	6.9883	3.7148	2.6152	2.0578	1.4822	1.1727	.9671	.8118	.6846	.5749
60.0	7.7157	4.0542	2.8228	2.1979	1.5521	1.2056	.9770	.8065	.6693	.5535
65.0	8.3565	4.3444	2.9941	2.3084	1.5996	1.2204	.9721	.7891	.6440	.5238
70.0	8.8913	4.5765	3.1237	2.3857	1.6234	1.2169	.9526	.7600	.6096	.4871
75.0	9.3036	4.7435	3.2078	2.4278	1.6227	1.1951	.9192	.7203	.5672	.4445
80.0	9.5811	4.8404	3.2438	2.4331	1.5976	1.1558	.8729	.6713	.5182	.3977
85.0	9.7153	4.8642	3.2307	2.4017	1.5488	1.1001	.8151	.6144	.4642	.3479
α , deg θ , deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	.0174	.0144	.0115	.0087	.0062	.0041	.0023	.0011	.0003	.0000
2.0	.0349	.0288	.0229	.0174	.0125	.0087	.0043	.0021	.0005	.0000
4.0	.0696	.0575	.0458	.0348	.0249	.0163	.0093	.0042	.0011	.0000
6.0	.1040	.0859	.0684	.0520	.0371	.0243	.0139	.0063	.0016	.0000
8.0	.1378	.1139	.0907	.0689	.0492	.0322	.0185	.0083	.0021	.0000
10.0	.1710	.1413	.1125	.0855	.0611	.0400	.0229	.0103	.0026	.0000
12.0	.2034	.1681	.1338	.1017	.0726	.0476	.0272	.0123	.0031	.0000
15.0	.2500	.2066	.1645	.1250	.0893	.0585	.0335	.0151	.0038	.0000
20.0	.3214	.2656	.2115	.1607	.1148	.0752	.0431	.0194	.0049	.0000
25.0	.3830	.3165	.2520	.1915	.1368	.0896	.0513	.0231	.0058	.0000
30.0	.4330	.3578	.2849	.2165	.1547	.1013	.0580	.0261	.0066	.0000
35.0	.4698	.3893	.3091	.2349	.1678	.1099	.0629	.0283	.0071	.0000
40.0	.4924	.4069	.3240	.2462	.1759	.1152	.0660	.0297	.0075	.0000
45.0	.5000	.4132	.3290	.2500	.1786	.1170	.0670	.0302	.0076	.0000
50.0	.4938	.4069	.3240	.2462	.1759	.1152	.0660	.0297	.0075	.0000
55.0	.4775	.3895	.3091	.2349	.1678	.1099	.0629	.0283	.0071	.0000
60.0	.4529	.3644	.2860	.2165	.1547	.1013	.0580	.0261	.0066	.0000
65.0	.4216	.3336	.2577	.1924	.1368	.0896	.0513	.0231	.0058	.0000
70.0	.3849	.2988	.2262	.1656	.1156	.0752	.0431	.0194	.0049	.0000
75.0	.3442	.2614	.1933	.1378	.0935	.0592	.0335	.0151	.0039	.0000
80.0	.3009	.2228	.1601	.1104	.0721	.0436	.0235	.0103	.0026	.0000
85.0	.2564	.1843	.1279	.0846	.0524	.0296	.0146	.0057	.0013	.0000

TABLE XXI (cont)

(a) $C_N \quad \beta = 2^\circ$

θ_s α , deg deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0348	.0346	.0343	.0338	.0325	.0308	.0286	.0261	.0234	.0205
2.0	.0696	.0691	.0685	.0676	.0650	.0615	.0572	.0523	.0468	.0409
4.0	.1461	.1379	.1366	.1348	.1297	.1227	.1142	.1043	.0933	.0816
6.0	.2409	.2073	.2041	.2014	.1937	.1834	.1706	.1557	.1393	.1219
8.0	.3571	.2835	.2708	.2670	.2569	.2431	.2261	.2065	.1847	.1616
10.0	.4947	.3688	.3398	.3313	.3187	.3016	.2806	.2562	.2292	.2005
12.0	.6535	.4637	.4135	.3956	.3790	.3587	.3337	.3047	.2726	.2304
15.0	.9298	.6234	.5339	.4966	.4659	.4410	.4102	.3745	.3351	.2931
20.0	1.4842	.9322	.7592	.6791	.6061	.5669	.5273	.4815	.4308	.3767
25.0	2.1411	1.2864	1.0102	.8768	.7479	.6803	.6285	.5738	.5134	.4490
30.0	2.8809	1.6754	1.2796	1.0845	.8902	.7873	.7139	.6487	.5804	.5076
35.0	3.6809	2.0875	1.5594	1.2960	1.0295	.8871	.7884	.7066	.6298	.5508
40.0	4.5168	2.5100	1.8412	1.5052	1.1620	.9776	.8519	.7513	.6621	.5772
45.0	5.3634	2.9303	2.1163	1.7057	1.2838	1.0567	.9034	.7838	.6812	.5878
50.0	6.1947	3.3354	2.3766	1.8914	1.3913	1.1221	.9419	.8037	.6883	.5863
55.0	6.9857	3.7132	2.6140	2.0567	1.4813	1.1719	.9663	.8110	.6839	.5743
60.0	7.7122	4.0522	2.8213	2.1967	1.5511	1.2047	.9762	.8058	.6687	.5530
65.0	8.3523	4.3420	2.9923	2.3070	1.5986	1.2195	.9713	.7834	.6435	.5233
70.0	8.8863	4.5738	3.1218	2.3843	1.6223	1.2160	.9519	.7594	.6091	.4866
75.0	9.2982	4.7407	3.2058	2.4262	1.6217	1.1943	.9185	.7198	.5667	.4442
80.0	9.5754	4.8375	3.2418	2.4316	1.5966	1.1550	.8723	.6708	.5178	.3973
85.0	9.7094	4.8612	3.2287	2.4002	1.5478	1.0993	.8145	.6139	.4638	.3476

θ_s α , deg deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	.0174	.0144	.0115	.0027	.0062	.0041	.0023	.0011	.0003	.0000
2.0	.0348	.0288	.0229	.0174	.0124	.0082	.0047	.0021	.0005	.0000
4.0	.0695	.0574	.0457	.0348	.0248	.0163	.0093	.0042	.0011	.0000
6.0	.1038	.0858	.0683	.0519	.0371	.0243	.0139	.0063	.0016	.0000
8.0	.1377	.1137	.0906	.0688	.0492	.0322	.0184	.0083	.0021	.0000
10.0	.1708	.1411	.1124	.0854	.0610	.0400	.0229	.0103	.0026	.0000
12.0	.2031	.1678	.1336	.1016	.0726	.0475	.0272	.0122	.0031	.0000
15.0	.2497	.2063	.1643	.1248	.0892	.0584	.0335	.0151	.0039	.0000
20.0	.3210	.2653	.2112	.1605	.1147	.0751	.0430	.0194	.0049	.0000
25.0	.3826	.3161	.2517	.1913	.1367	.0895	.0513	.0231	.0058	.0000
30.0	.4325	.3574	.2846	.2162	.1545	.1012	.0579	.0261	.0066	.0000
35.0	.4693	.3878	.3088	.2346	.1676	.1098	.0629	.0283	.0071	.0000
40.0	.4918	.4064	.3236	.2459	.1757	.1151	.0659	.0297	.0075	.0000
45.0	.4994	.4127	.3286	.2497	.1794	.1168	.0669	.0301	.0076	.0000
50.0	.4933	.4064	.3236	.2459	.1757	.1151	.0659	.0297	.0075	.0000
55.0	.4770	.3890	.3088	.2346	.1676	.1098	.0629	.0283	.0071	.0000
60.0	.4525	.3640	.2856	.2162	.1545	.1012	.0579	.0261	.0066	.0000
65.0	.4212	.3333	.2574	.1922	.1367	.0895	.0513	.0231	.0058	.0000
70.0	.3845	.2985	.2260	.1654	.1154	.0751	.0430	.0194	.0049	.0000
75.0	.3439	.2612	.1931	.1376	.0934	.0591	.0335	.0151	.0038	.0000
80.0	.3006	.2226	.1599	.1103	.0720	.0435	.0234	.0103	.0026	.0000
85.0	.2562	.1841	.1278	.0845	.0524	.0296	.0146	.0057	.0013	.0000

TABLE XXI (cont)

(a) C_N $\beta = 5^\circ$

θ_s α , deg deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0375	.0344	.0340	.0336	.0323	.0306	.0284	.0260	.0232	.0203
2.0	.0762	.0687	.0680	.0671	.0646	.0611	.0569	.0519	.0465	.0406
4.0	.1609	.1380	.1358	.1340	.1289	.1220	.1134	.1036	.0927	.0810
6.0	.2609	.2106	.2028	.2001	.1925	.1822	.1695	.1547	.1385	.1211
8.0	.3795	.2895	.2704	.2653	.2552	.2415	.2247	.2052	.1836	.1605
10.0	.5182	.3765	.3411	.3295	.3167	.2997	.2788	.2546	.2278	.1992
12.0	.6772	.4721	.4159	.3947	.3766	.3564	.3316	.3027	.2709	.2369
15.0	.9528	.6321	.5372	.4967	.4630	.4382	.4076	.3722	.3330	.2912
20.0	1.5045	.9401	.7624	.6797	.6037	.5633	.5240	.4784	.4280	.3743
25.0	2.1577	1.2926	1.0126	.8771	.7457	.6768	.6245	.5702	.5101	.4461
30.0	2.8929	1.6795	1.2807	1.0839	.8878	.7838	.7099	.6446	.5767	.5043
35.0	3.6880	2.0891	1.5590	1.2945	1.0266	.8834	.7843	.7024	.6258	.5472
40.0	4.5187	2.5090	1.8391	1.5025	1.1585	.9738	.8478	.7472	.6581	.5735
45.0	5.3599	2.9267	2.1126	1.7019	1.2798	1.0526	.8993	.7797	.6773	.5843
50.0	6.1860	3.3293	2.3713	1.8865	1.3867	1.1177	.9377	.7997	.6846	.5829
55.0	6.9719	3.7048	2.6072	2.0509	1.4763	1.1674	.9621	.8072	.6804	.5712
60.0	7.6939	4.0416	2.8133	2.1900	1.5457	1.2001	.9721	.8022	.6654	.5501
65.0	8.3298	4.3295	2.9832	2.2996	1.5930	1.2149	.9673	.7849	.6404	.5207
70.0	8.8605	4.5599	3.1119	2.3764	1.6166	1.2115	.9481	.7562	.6064	.4843
75.0	9.2697	4.7257	3.1954	2.4181	1.6160	1.1899	.9150	.7169	.5644	.4422
80.0	9.5451	4.8219	3.2312	2.4235	1.5911	1.1509	.8690	.6682	.5158	.3957
85.0	9.6783	4.8455	3.2182	2.3923	1.5427	1.0956	.8117	.6118	.4622	.3464

θ_s α , deg deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	.0173	.0143	.0114	.0087	.0062	.0041	.0023	.0010	.0003	.0000
2.0	.0346	.0286	.0228	.0173	.0124	.0081	.0046	.0021	.0005	.0000
4.0	.0691	.0571	.0454	.0345	.0247	.0162	.0093	.0042	.0010	.0000
6.0	.1032	.0853	.0679	.0516	.0369	.0241	.0138	.0062	.0016	.0000
8.0	.1368	.1130	.0900	.0684	.0489	.0320	.0183	.0082	.0021	.0000
10.0	.1697	.1402	.1117	.0849	.0606	.0397	.0227	.0102	.0026	.0000
12.0	.2018	.1668	.1328	.1009	.0721	.0472	.0270	.0122	.0031	.0000
15.0	.2481	.2050	.1632	.1241	.0886	.0580	.0332	.0150	.0038	.0000
20.0	.3190	.2636	.2099	.1595	.1139	.0746	.0427	.0192	.0048	.0000
25.0	.3801	.3141	.2501	.1901	.1358	.0889	.0509	.0229	.0058	.0000
30.0	.4297	.3551	.2827	.2149	.1535	.1005	.0576	.0259	.0065	.0000
35.0	.4663	.3853	.3068	.2331	.1666	.1091	.0625	.0281	.0071	.0000
40.0	.4887	.4038	.3215	.2443	.1746	.1143	.0655	.0295	.0074	.0000
45.0	.4962	.4100	.3265	.2481	.1772	.1161	.0665	.0299	.0075	.0000
50.0	.4902	.4038	.3215	.2443	.1746	.1143	.0655	.0295	.0074	.0000
55.0	.4742	.3866	.3068	.2331	.1666	.1091	.0625	.0281	.0071	.0000
60.0	.4499	.3618	.2839	.2149	.1535	.1005	.0576	.0259	.0065	.0000
65.0	.4190	.3314	.2559	.1910	.1358	.0889	.0509	.0229	.0058	.0000
70.0	.3826	.2969	.2248	.1644	.1147	.0746	.0427	.0192	.0048	.0000
75.0	.3423	.2599	.1921	.1369	.0929	.0587	.0332	.0150	.0038	.0000
80.0	.2994	.2216	.1592	.1098	.0716	.0433	.0233	.0102	.0026	.0000
85.0	.2553	.1834	.1272	.0842	.0522	.0295	.0145	.0056	.0013	.0000

TABLE XXI (cont)

(a) $C_N \quad \beta = 15^\circ$

θ_s α, deg deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0603	.0405	.0348	.0323	.0304	.0288	.0267	.0244	.0218	.0191
2.0	.1212	.0812	.0696	.0647	.0607	.0575	.0535	.0488	.0437	.0382
4.0	.2461	.1640	.1398	.1296	.1212	.1147	.1067	.0974	.0871	.0762
6.0	.3782	.2497	.2114	.1949	.1811	.1713	.1593	.1455	.1302	.1138
8.0	.5204	.3395	.2848	.2608	.2403	.2271	.2112	.1929	.1726	.1509
10.0	.6743	.4344	.3607	.3277	.2988	.2818	.2621	.2393	.2141	.1873
12.0	.8429	.5351	.4395	.3959	.3567	.3351	.3117	.2846	.2546	.2227
15.0	1.1224	.6979	.5637	.5009	.4427	.4120	.3832	.3499	.3130	.2738
20.0	1.6625	1.0008	.7872	.6842	.5849	.5329	.4926	.4498	.4024	.3519
25.0	2.2892	1.3403	1.0296	.8771	.7260	.6461	.5886	.5360	.4796	.4194
30.0	2.9878	1.7090	1.2863	1.0763	.8648	.7521	.6734	.6068	.5422	.4742
35.0	3.7403	2.0974	1.5511	1.2775	.9990	.8498	.7473	.6642	.5887	.5145
40.0	4.5247	2.4945	1.8166	1.4754	1.1257	.9377	.8100	.7092	.6213	.5394
45.0	5.3779	2.8888	2.0753	1.6644	1.2416	1.0140	.8608	.7422	.6415	.5510
50.0	6.0963	3.2685	2.3196	1.8392	1.3435	1.0769	.8987	.7629	.6501	.5514
55.0	6.8363	3.6223	2.5422	1.9945	1.4288	1.1247	.9231	.7714	.6477	.5418
60.0	7.5161	3.9396	2.7366	2.1260	1.4948	1.1564	.9335	.7677	.6348	.5231
65.0	8.1147	4.2108	2.8968	2.2295	1.5399	1.1711	.9298	.7524	.6122	.4964
70.0	8.6141	4.4278	3.0182	2.3021	1.5625	1.1684	.9123	.7261	.5809	.4629
75.0	8.9993	4.5839	3.0949	2.3416	1.5623	1.1485	.8816	.6896	.5419	.4238
80.0	9.2584	4.6745	3.1307	2.3468	1.5391	1.1120	.8388	.6442	.4966	.3805
85.0	9.3838	4.6968	3.1186	2.3176	1.4937	1.0602	.7850	.5913	.4464	.3343
θ_s α, deg deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	.0163	.0135	.0107	.0081	.0058	.0038	.0022	.0010	.0002	.0000
2.0	.0325	.0269	.0214	.0163	.0116	.0076	.0044	.0020	.0005	.0000
4.0	.0649	.0537	.0427	.0325	.0232	.0152	.0087	.0039	.0010	.0000
6.0	.0970	.0801	.0638	.0485	.0346	.0227	.0130	.0058	.0015	.0000
8.0	.1286	.1063	.0846	.0643	.0459	.0301	.0172	.0078	.0020	.0000
10.0	.1596	.1318	.1050	.0798	.0570	.0373	.0214	.0096	.0024	.0000
12.0	.1897	.1568	.1248	.0949	.0678	.0444	.0254	.0114	.0029	.0000
15.0	.2333	.1927	.1536	.1166	.0833	.0546	.0312	.0141	.0035	.0000
20.0	.2999	.2478	.1973	.1499	.1071	.0702	.0402	.0181	.0046	.0000
25.0	.3574	.2953	.2351	.1787	.1277	.0836	.0479	.0216	.0054	.0000
30.0	.4040	.3339	.2658	.2020	.1443	.0945	.0541	.0244	.0061	.0000
35.0	.4384	.3622	.2884	.2192	.1566	.1026	.0587	.0264	.0067	.0000
40.0	.4594	.3796	.3023	.2297	.1641	.1075	.0616	.0277	.0070	.0000
45.0	.4666	.3855	.3070	.2333	.1666	.1091	.0625	.0281	.0071	.0000
50.0	.4621	.3797	.3023	.2297	.1641	.1075	.0616	.0277	.0070	.0000
55.0	.4482	.3643	.2885	.2192	.1566	.1026	.0587	.0264	.0067	.0000
60.0	.4265	.3419	.2675	.2020	.1443	.0945	.0541	.0244	.0061	.0000
65.0	.3983	.3141	.2418	.1800	.1277	.0836	.0479	.0216	.0054	.0000
70.0	.3648	.2824	.2131	.1555	.1082	.0702	.0402	.0181	.0046	.0000
75.0	.3274	.2480	.1829	.1300	.0879	.0554	.0313	.0141	.0035	.0000
80.0	.2874	.2124	.1523	.1048	.0682	.0411	.0220	.0096	.0024	.0000
85.0	.2462	.1767	.1224	.0809	.0500	.0282	.0138	.0053	.0012	.0000

TABLE XXI (cont)

(b) $C_A \quad \beta = 0^\circ$

θ_s α , deg deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0041	.0155	.0344	.0606	.1342	.2342	.3574	.5001	.6580	.8263
2.0	.0050	.0164	.0352	.0614	.1349	.2347	.3578	.5003	.6580	.8261
4.0	.0084	.0199	.0387	.0647	.1379	.2371	.3595	.5012	.6580	.8252
6.0	.0133	.0250	.0444	.0702	.1427	.2410	.3623	.5027	.6581	.8237
8.0	.0193	.0333	.0524	.0779	.1495	.2465	.3662	.5048	.6582	.8217
10.0	.0265	.0420	.0622	.0877	.1581	.2535	.3712	.5075	.6584	.8191
12.0	.0348	.0518	.0732	.0994	.1685	.2620	.3773	.5108	.6585	.8160
15.0	.0491	.0685	.0917	.1191	.1875	.2774	.3883	.5167	.6589	.8103
20.0	.0779	.1006	.1267	.1561	.2256	.3099	.4115	.5292	.6595	.7983
25.0	.1120	.1375	.1657	.1968	.2671	.3482	.4401	.5447	.6603	.7836
30.0	.1502	.1778	.2076	.2396	.3097	.3873	.4716	.5625	.6612	.7665
35.0	.1915	.2204	.2510	.2832	.3517	.4248	.5015	.5807	.6623	.7475
40.0	.2346	.2640	.2945	.3261	.3915	.4589	.5272	.5951	.6619	.7274
45.0	.2782	.3072	.3369	.3670	.4278	.4884	.5474	.6038	.6565	.7051
50.0	.3210	.3488	.3768	.4046	.4595	.5121	.5611	.6056	.6446	.6778
55.0	.3616	.3874	.4129	.4379	.4855	.5291	.5676	.6000	.6258	.6446
60.0	.3988	.4219	.4443	.4657	.5050	.5389	.5664	.5869	.6000	.6056
65.0	.4315	.4513	.4699	.4872	.5174	.5410	.5575	.5664	.5676	.5611
70.0	.4587	.4746	.4890	.5018	.5222	.5355	.5410	.5389	.5291	.5121
75.0	.4796	.4911	.5009	.5089	.5194	.5222	.5174	.5050	.4855	.4595
80.0	.4935	.5004	.5054	.5085	.5089	.5018	.4872	.4657	.4379	.4046
85.0	.5001	.5021	.5022	.5004	.4911	.4746	.4513	.4219	.3874	.3488
θ_s α , deg deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	.9998	1.1734	1.3417	1.4996	1.6423	1.7655	1.8655	1.9391	1.9842	1.9994
2.0	.9994	1.1727	1.3408	1.4985	1.6410	1.7640	1.8638	1.9374	1.9824	1.9976
4.0	.9976	1.1699	1.3371	1.4939	1.6357	1.7580	1.8573	1.9304	1.9752	1.9903
6.0	.9945	1.1653	1.3310	1.4863	1.6268	1.7480	1.8464	1.9188	1.9632	1.9781
8.0	.9903	1.1589	1.3224	1.4758	1.6144	1.7341	1.8312	1.9027	1.9465	1.9613
10.0	.9849	1.1507	1.3115	1.4623	1.5986	1.7163	1.8118	1.8821	1.9252	1.9397
12.0	.9784	1.1408	1.2982	1.4460	1.5795	1.6948	1.7883	1.8571	1.8993	1.9135
15.0	.9665	1.1227	1.2742	1.4163	1.5447	1.6556	1.7455	1.8118	1.8524	1.8660
20.0	.9415	1.0847	1.2235	1.3538	1.4715	1.5731	1.6556	1.7163	1.7535	1.7660
25.0	.9107	1.0378	1.1611	1.2767	1.3813	1.4715	1.5447	1.5986	1.6317	1.6428
30.0	.8750	.9835	1.0888	1.1875	1.2767	1.3538	1.4163	1.4623	1.4905	1.5000
35.0	.8355	.9235	1.0087	1.0888	1.1611	1.2235	1.2742	1.3115	1.3343	1.3420
40.0	.7934	.8594	.9235	.9835	1.0378	1.0847	1.1227	1.1507	1.1679	1.1736
45.0	.7500	.7934	.8355	.8750	.9107	.9415	.9665	.9849	.9962	1.0000
50.0	.7051	.7274	.7475	.7665	.7836	.7983	.8103	.8191	.8245	.8264
55.0	.6565	.6619	.6623	.6612	.6603	.6595	.6589	.6584	.6581	.6580
60.0	.6038	.5951	.5807	.5625	.5447	.5292	.5167	.5075	.5019	.5000
65.0	.5474	.5272	.5015	.4716	.4401	.4115	.3883	.3712	.3607	.3572
70.0	.4884	.4589	.4248	.3873	.3482	.3099	.2774	.2535	.2389	.2340
75.0	.4278	.3915	.3517	.3097	.2671	.2256	.1875	.1581	.1400	.1340
80.0	.3670	.3261	.2832	.2396	.1968	.1561	.1191	.0877	.0672	.0603
85.0	.3072	.2640	.2204	.1778	.1375	.1006	.0685	.0420	.0226	.0152

TABLE XXI (cont)

(b) $C_A \beta = 2^\circ$

θ α , deg deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0053	.0167	.0355	.0617	.1352	.2349	.3579	.5004	.6580	.8260
2.0	.0062	.0176	.0364	.0625	.1359	.2355	.3583	.5006	.6580	.8258
4.0	.0095	.0211	.0398	.0658	.1388	.2379	.3600	.5015	.6581	.8249
6.0	.0142	.0269	.0456	.0713	.1437	.2418	.3628	.5030	.6581	.8234
8.0	.0201	.0343	.0536	.0790	.1504	.2473	.3668	.5051	.6582	.8214
10.0	.0272	.0429	.0633	.0888	.1590	.2543	.3718	.5078	.6584	.8183
12.0	.0355	.0527	.0742	.1004	.1694	.2628	.3778	.5111	.6586	.8157
15.0	.0498	.0692	.0925	.1200	.1884	.2782	.3888	.5170	.6589	.8100
20.0	.0785	.1013	.1274	.1569	.2263	.3106	.4120	.5295	.6595	.7981
25.0	.1125	.1380	.1663	.1974	.2677	.3487	.4406	.5449	.6603	.7833
30.0	.1507	.1783	.2081	.2401	.3102	.3878	.4720	.5627	.6612	.7663
35.0	.1920	.2208	.2514	.2836	.3521	.4252	.5017	.5809	.6623	.7474
40.0	.2350	.2644	.2949	.3264	.3918	.4592	.5274	.5952	.6618	.7272
45.0	.2785	.3075	.3372	.3672	.4281	.4886	.5475	.6038	.6546	.7049
50.0	.3212	.3490	.3770	.4048	.4597	.5122	.5612	.6056	.6446	.6777
55.0	.3618	.3876	.4131	.4380	.4856	.5292	.5676	.6000	.6257	.6445
60.0	.3989	.4221	.4444	.4658	.5051	.5389	.5664	.5869	.5999	.6054
65.0	.4316	.4514	.4700	.4872	.5174	.5410	.5575	.5663	.5675	.5610
70.0	.4588	.4746	.4890	.5018	.5222	.5354	.5410	.5388	.5290	.5119
75.0	.4797	.4911	.5009	.5089	.5194	.5222	.5173	.5049	.4854	.4594
80.0	.4936	.5004	.5054	.5084	.5089	.5017	.4871	.4656	.4378	.4046
85.0	.5001	.5021	.5022	.5004	.4911	.4746	.4513	.4219	.3874	.3488

θ α , deg deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	.9992	1.1725	1.3405	1.4981	1.6406	1.7635	1.8633	1.9368	1.9818	1.9970
2.0	.9988	1.1718	1.3396	1.4970	1.6392	1.7620	1.8616	1.9350	1.9800	1.9951
4.0	.9970	1.1690	1.3359	1.4924	1.6339	1.7560	1.8551	1.9281	1.9728	1.9878
6.0	.9939	1.1644	1.3297	1.4848	1.6250	1.7460	1.8442	1.9165	1.9608	1.9757
8.0	.9897	1.1580	1.3212	1.4743	1.6127	1.7321	1.8290	1.9004	1.9441	1.9589
10.0	.9843	1.1498	1.3103	1.4608	1.5969	1.7144	1.8097	1.8799	1.9229	1.9373
12.0	.9778	1.1399	1.2970	1.4445	1.5778	1.6928	1.7862	1.8549	1.8970	1.9112
15.0	.9659	1.1218	1.2730	1.4148	1.5430	1.6537	1.7435	1.8096	1.8501	1.8638
20.0	.9470	1.0839	1.2224	1.3524	1.4699	1.5714	1.6536	1.7143	1.7514	1.7639
25.0	.9102	1.0371	1.1601	1.2755	1.3798	1.4699	1.5429	1.5967	1.6297	1.6408
30.0	.8745	.9828	1.0878	1.1864	1.2754	1.3523	1.4146	1.4606	1.4887	1.4982
35.0	.8351	.9228	1.0079	1.0877	1.1599	1.2222	1.2727	1.3099	1.3327	1.3404
40.0	.7931	.8589	.9227	.9826	1.0368	1.0835	1.1214	1.1494	1.1665	1.1722
45.0	.7497	.7929	.8349	.8742	.9098	.9405	.9654	.9838	.9950	.9988
50.0	.7048	.7270	.7470	.7658	.7828	.7975	.8094	.8182	.8235	.8253
55.0	.6562	.6615	.6619	.6607	.6597	.6588	.6581	.6576	.6573	.6572
60.0	.6035	.5948	.5804	.5621	.5442	.5287	.5162	.5070	.5013	.4994
65.0	.5472	.5270	.5012	.4714	.4398	.4112	.3879	.3708	.3603	.3568
70.0	.4882	.4588	.4246	.3871	.3479	.3096	.2772	.2533	.2386	.2337
75.0	.4277	.3913	.3515	.3096	.2670	.2254	.1874	.1579	.1399	.1338
80.0	.3669	.3260	.2831	.2395	.1967	.1560	.1190	.0877	.0671	.0602
85.0	.3072	.2640	.2204	.1778	.1374	.1006	.0684	.0420	.0226	.0152

TABLE XXI (cont)

(b) $C_A \beta = 5^\circ$

$\alpha, \deg$ $\theta_s, \deg$	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0109	.0229	.0416	.0675	.1403	.2391	.3609	.5020	.6581	.8245
2.0	.0117	.0238	.0424	.0683	.1410	.2397	.3613	.5022	.6581	.8242
4.0	.0144	.0272	.0459	.0716	.1439	.2420	.3630	.5031	.6581	.8234
6.0	.0187	.0325	.0516	.0771	.1487	.2459	.3658	.5046	.6582	.8219
8.0	.0243	.0394	.0593	.0847	.1554	.2514	.3697	.5067	.6583	.8199
10.0	.0312	.0476	.0685	.0944	.1640	.2583	.3746	.5094	.6585	.8174
12.0	.0392	.0571	.0791	.1056	.1743	.2667	.3807	.5126	.6586	.8143
15.0	.0533	.0732	.0969	.1246	.1931	.2820	.3916	.5185	.6589	.8086
20.0	.0817	.1048	.1311	.1607	.2303	.3142	.4146	.5309	.6596	.7967
25.0	.1154	.1411	.1695	.2007	.2710	.3518	.4430	.5462	.6604	.7821
30.0	.1532	.1809	.2108	.2429	.3129	.3902	.4740	.5639	.6613	.7651
35.0	.1942	.2231	.2537	.2859	.3542	.4270	.5032	.5817	.6623	.7463
40.0	.2369	.2663	.2968	.3282	.3935	.4606	.5284	.5957	.6617	.7263
45.0	.2801	.3091	.3387	.3687	.4293	.4896	.5482	.6040	.6561	.7040
50.0	.3225	.3503	.3781	.4059	.4606	.5128	.5615	.6055	.6441	.6767
55.0	.3628	.3885	.4140	.4388	.4862	.5295	.5676	.5997	.6252	.6435
60.0	.3997	.4227	.4450	.4663	.5054	.5390	.5663	.5865	.5993	.6045
65.0	.4321	.4518	.4703	.4876	.5176	.5410	.5573	.5659	.5668	.5602
70.0	.4591	.4749	.4892	.5019	.5223	.5353	.5407	.5384	.5284	.5113
75.0	.4798	.4913	.5010	.5090	.5193	.5220	.5171	.5046	.4850	.4589
80.0	.4936	.5004	.5054	.5084	.5088	.5016	.4869	.4654	.4375	.4042
85.0	.5001	.5021	.5022	.5003	.4910	.4745	.4511	.4218	.3872	.3486
$\alpha, \deg$ $\theta_s, \deg$	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	.9961	1.1676	1.3340	1.4901	1.6312	1.7530	1.8518	1.9246	1.9692	1.9842
2.0	.9956	1.1670	1.3331	1.4890	1.6299	1.7515	1.8502	1.9229	1.9674	1.9824
4.0	.9938	1.1642	1.3294	1.4845	1.6246	1.7456	1.8437	1.9160	1.9602	1.9751
6.0	.9908	1.1596	1.3233	1.4770	1.6158	1.7356	1.8329	1.9045	1.9483	1.9631
8.0	.9866	1.1533	1.3149	1.4665	1.6035	1.7218	1.8178	1.8885	1.9318	1.9464
10.0	.9812	1.1451	1.3040	1.4531	1.5879	1.7042	1.7985	1.8680	1.9106	1.9250
12.0	.9748	1.1352	1.2909	1.4369	1.5689	1.6828	1.7752	1.8433	1.8850	1.8990
15.0	.9630	1.1173	1.2670	1.4074	1.5343	1.6439	1.7328	1.7982	1.8383	1.8519
20.0	.9382	1.0796	1.2167	1.3454	1.4617	1.5621	1.6435	1.7035	1.7403	1.7526
25.0	.9076	1.0331	1.1548	1.2689	1.3721	1.4612	1.5335	1.5867	1.6193	1.6303
30.0	.8722	.9792	1.0830	1.1804	1.2684	1.3444	1.4060	1.4514	1.4792	1.4886
35.0	.8330	.9196	1.0036	1.0824	1.1536	1.2151	1.2650	1.3017	1.3242	1.3318
40.0	.7912	.8560	.9189	.9780	1.0313	1.0773	1.1147	1.1422	1.1591	1.1647
45.0	.7481	.7905	.8317	.8703	.9051	.9352	.9597	.9777	.9887	.9924
50.0	.7034	.7250	.7444	.7625	.7790	.7932	.8047	.8131	.8183	.8201
55.0	.6549	.6599	.6597	.6581	.6566	.6554	.6544	.6536	.6531	.6530
60.0	.6024	.5934	.5787	.5601	.5419	.5261	.5133	.5039	.4981	.4962
65.0	.5463	.5258	.4999	.4699	.4381	.4093	.3859	.3686	.3581	.3545
70.0	.4874	.4579	.4236	.3860	.3468	.3084	.2758	.2518	.2371	.2322
75.0	.4271	.3907	.3508	.3088	.2662	.2247	.1866	.1571	.1390	.1330
80.0	.3665	.3256	.2826	.2391	.1963	.1556	.1186	.0873	.0668	.0598
85.0	.3070	.2638	.2202	.1776	.1373	.1004	.0683	.0419	.0225	.0151

TABLE XXI (cont)

(b) $C_A \quad \beta = 15^\circ$

θ_s α, deg deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0492	.0686	.0919	.1193	.1877	.2776	.3884	.5168	.6589	.8102
2.0	.0492	.0692	.0925	.1200	.1884	.2782	.3888	.5170	.6589	.8100
4.0	.0518	.0715	.0950	.1227	.1911	.2804	.3904	.5179	.6589	.8092
6.0	.0551	.0753	.0992	.1270	.1956	.2841	.3930	.5193	.6590	.8079
8.0	.0597	.0804	.1048	.1330	.2017	.2892	.3967	.5213	.6591	.8060
10.0	.0655	.0869	.1118	.1405	.2094	.2957	.4014	.5238	.6592	.8036
12.0	.0725	.0946	.1202	.1493	.2185	.3036	.4070	.5268	.6594	.8006
15.0	.0849	.1083	.1349	.1647	.2344	.3180	.4173	.5324	.6597	.7953
20.0	.1108	.1360	.1642	.1952	.2655	.3467	.4390	.5440	.6603	.7842
25.0	.1416	.1687	.1983	.2301	.3004	.3788	.4648	.5584	.6610	.7704
30.0	.1766	.2051	.2355	.2677	.3369	.4118	.4912	.5745	.6619	.7544
35.0	.2147	.2439	.2746	.3065	.3735	.4437	.5160	.5891	.6625	.7368
40.0	.2545	.2838	.3140	.3450	.4085	.4730	.5372	.5998	.6602	.7178
45.0	.2948	.3235	.3526	.3819	.4406	.4982	.5535	.6053	.6527	.6953
50.0	.3344	.3617	.3889	.4159	.4686	.5183	.5640	.6046	.6393	.6677
55.0	.3720	.3972	.4219	.4460	.4915	.5325	.5680	.5972	.6195	.6346
60.0	.4066	.4290	.4506	.4711	.5084	.5400	.5651	.5830	.5933	.5961
65.0	.4369	.4560	.4739	.4904	.5188	.5406	.5551	.5619	.5610	.5525
70.0	.4621	.4774	.4911	.5032	.5223	.5340	.5381	.5344	.5232	.5048
75.0	.4814	.4924	.5017	.5092	.5186	.5204	.5145	.5011	.4807	.4538
80.0	.4942	.5007	.5054	.5081	.5079	.5001	.4849	.4628	.4345	.4008
85.0	.5002	.5020	.5019	.5000	.4904	.4735	.4500	.4204	.3857	.3469
θ_s α, deg deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	.9864	1.1225	1.2739	1.4159	1.5443	1.6551	1.7450	1.8112	1.8518	1.8655
2.0	.9659	1.1218	1.2730	1.4148	1.5430	1.6537	1.7435	1.8096	1.8501	1.8638
4.0	.9642	1.1193	1.2696	1.4106	1.5381	1.6481	1.7373	1.8031	1.8434	1.8569
6.0	.9614	1.1150	1.2638	1.4035	1.5298	1.6388	1.7272	1.7923	1.8322	1.8456
8.0	.9575	1.1090	1.2559	1.3937	1.5182	1.6258	1.7130	1.7773	1.8166	1.8299
10.0	.9524	1.1013	1.2457	1.3811	1.5035	1.6092	1.6949	1.7581	1.7967	1.8098
12.0	.9465	1.0920	1.2333	1.3659	1.4857	1.5891	1.6730	1.7348	1.7726	1.7854
15.0	.9353	1.0752	1.2108	1.3381	1.4532	1.5525	1.6331	1.6924	1.7288	1.7410
20.0	.9119	1.0397	1.1636	1.2798	1.3849	1.4756	1.5492	1.6034	1.6366	1.6477
25.0	.8832	.9960	1.1053	1.2080	1.3007	1.3808	1.4457	1.4936	1.5229	1.5327
30.0	.8499	.9453	1.0379	1.1247	1.2032	1.2709	1.3259	1.3664	1.3912	1.3995
35.0	.8130	.8893	.9632	1.0326	1.0953	1.1494	1.1933	1.2256	1.2455	1.2521
40.0	.7733	.8295	.8836	.9344	.9803	1.0199	1.0520	1.0757	1.0901	1.0950
45.0	.7331	.7679	.8016	.8331	.8617	.8863	.9062	.9210	.9300	.9330
50.0	.6898	.7062	.7195	.7319	.7430	.7527	.7605	.7663	.7698	.7710
55.0	.6426	.6439	.6399	.6337	.6280	.6232	.6192	.6163	.6145	.6139
60.0	.5914	.5800	.5627	.5415	.5201	.5016	.4866	.4756	.4688	.4665
65.0	.5369	.5142	.4873	.4559	.4226	.3918	.3668	.3484	.3371	.3333
70.0	.4799	.4491	.4142	.3759	.3360	.2969	.2633	.2386	.2234	.2183
75.0	.4214	.3845	.3443	.3020	.2592	.2176	.1794	.1495	.1312	.1250
80.0	.3628	.3217	.2786	.2351	.1923	.1518	.1151	.0839	.0632	.0563
85.0	.3052	.2620	.2184	.1752	.1356	.0990	.0670	.0408	.0216	.0142

TABLE XXI (cont)

(c) $C_Y \beta = 2^\circ$

α, deg θ, deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	-.0696	-.0692	-.0686	-.0676	-.0651	-.0616	-.0573	-.0523	-.0468	-.0409
2.0	-.0697	-.0692	-.0685	-.0676	-.0650	-.0616	-.0573	-.0523	-.0468	-.0409
4.0	-.0731	-.0691	-.0684	-.0675	-.0649	-.0614	-.0572	-.0522	-.0467	-.0408
6.0	-.0805	-.0693	-.0682	-.0673	-.0647	-.0613	-.0570	-.0520	-.0466	-.0407
8.0	-.0896	-.0711	-.0679	-.0670	-.0645	-.0610	-.0567	-.0518	-.0464	-.0405
10.0	-.0995	-.0742	-.0683	-.0666	-.0641	-.0607	-.0564	-.0515	-.0461	-.0403
12.0	-.1098	-.0779	-.0695	-.0664	-.0637	-.0603	-.0560	-.0512	-.0458	-.0400
15.0	-.1255	-.0841	-.0720	-.0670	-.0629	-.0595	-.0553	-.0505	-.0452	-.0395
20.0	-.1515	-.0952	-.0775	-.0693	-.0619	-.0579	-.0538	-.0492	-.0440	-.0385
25.0	-.1769	-.1063	-.0835	-.0725	-.0618	-.0562	-.0519	-.0474	-.0424	-.0371
30.0	-.2012	-.1170	-.0894	-.0757	-.0622	-.0550	-.0499	-.0453	-.0405	-.0355
35.0	-.2241	-.1271	-.0949	-.0789	-.0627	-.0540	-.0480	-.0430	-.0383	-.0335
40.0	-.2454	-.1364	-.1000	-.0818	-.0631	-.0531	-.0463	-.0408	-.0360	-.0314
45.0	-.2649	-.1447	-.1045	-.0842	-.0634	-.0522	-.0446	-.0387	-.0336	-.0290
50.0	-.2824	-.1520	-.1083	-.0862	-.0634	-.0512	-.0429	-.0366	-.0314	-.0267
55.0	-.2978	-.1583	-.1114	-.0877	-.0631	-.0500	-.0412	-.0346	-.0292	-.0245
60.0	-.3110	-.1634	-.1138	-.0886	-.0625	-.0486	-.0394	-.0325	-.0270	-.0223
65.0	-.3218	-.1673	-.1153	-.0889	-.0616	-.0470	-.0374	-.0304	-.0248	-.0202
70.0	-.3302	-.1700	-.1160	-.0886	-.0603	-.0452	-.0354	-.0282	-.0226	-.0181
75.0	-.3362	-.1714	-.1159	-.0877	-.0586	-.0437	-.0332	-.0260	-.0205	-.0161
80.0	-.3395	-.1715	-.1150	-.0862	-.0566	-.0410	-.0309	-.0238	-.0184	-.0141
85.0	-.3404	-.1704	-.1132	-.0841	-.0543	-.0385	-.0286	-.0215	-.0163	-.0122
α, deg θ, deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	-.0349	-.0288	-.0229	-.0174	-.0125	-.0082	-.0047	-.0021	-.0005	-.0000
2.0	-.0349	-.0288	-.0229	-.0174	-.0125	-.0082	-.0047	-.0021	-.0005	-.0000
4.0	-.0348	-.0288	-.0229	-.0174	-.0124	-.0081	-.0047	-.0021	-.0005	-.0000
6.0	-.0347	-.0287	-.0228	-.0173	-.0124	-.0081	-.0046	-.0021	-.0005	-.0000
8.0	-.0345	-.0285	-.0227	-.0173	-.0123	-.0081	-.0046	-.0021	-.0005	-.0000
10.0	-.0343	-.0284	-.0226	-.0172	-.0123	-.0080	-.0046	-.0021	-.0005	-.0000
12.0	-.0341	-.0282	-.0224	-.0171	-.0122	-.0080	-.0046	-.0021	-.0005	-.0000
15.0	-.0337	-.0278	-.0222	-.0168	-.0120	-.0079	-.0045	-.0020	-.0005	-.0000
20.0	-.0328	-.0271	-.0216	-.0164	-.0117	-.0077	-.0044	-.0020	-.0005	-.0000
25.0	-.0316	-.0261	-.0208	-.0158	-.0113	-.0074	-.0042	-.0019	-.0005	-.0000
30.0	-.0302	-.0250	-.0199	-.0151	-.0108	-.0071	-.0040	-.0018	-.0005	-.0000
35.0	-.0286	-.0236	-.0188	-.0143	-.0102	-.0067	-.0038	-.0017	-.0004	-.0000
40.0	-.0267	-.0221	-.0176	-.0134	-.0095	-.0063	-.0036	-.0016	-.0004	-.0000
45.0	-.0247	-.0204	-.0162	-.0123	-.0086	-.0058	-.0033	-.0015	-.0004	-.0000
50.0	-.0225	-.0185	-.0148	-.0112	-.0080	-.0052	-.0030	-.0014	-.0003	-.0000
55.0	-.0203	-.0166	-.0132	-.0100	-.0071	-.0047	-.0027	-.0012	-.0003	-.0000
60.0	-.0182	-.0147	-.0115	-.0087	-.0062	-.0041	-.0023	-.0011	-.0003	-.0000
65.0	-.0162	-.0128	-.0099	-.0074	-.0053	-.0034	-.0020	-.0009	-.0002	-.0000
70.0	-.0143	-.0111	-.0084	-.0061	-.0043	-.0028	-.0016	-.0007	-.0002	-.0000
75.0	-.0124	-.0094	-.0070	-.0050	-.0034	-.0021	-.0012	-.0005	-.0001	-.0000
80.0	-.0107	-.0079	-.0057	-.0039	-.0026	-.0015	-.0008	-.0004	-.0001	-.0000
85.0	-.0090	-.0065	-.0045	-.0030	-.0018	-.0010	-.0005	-.0002	-.0000	-.0000

TABLE XXI (cont)

(c) $C_Y \quad \beta = 5^\circ$

θ a, deg deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	-.1882	-.1723	-.1707	-.1684	-.1620	-.1533	-.1426	-.1302	-.1165	-.1019
2.0	-.1910	-.1723	-.1706	-.1683	-.1619	-.1532	-.1425	-.1302	-.1164	-.1018
4.0	-.2019	-.1731	-.1703	-.1680	-.1616	-.1530	-.1423	-.1299	-.1162	-.1017
6.0	-.2183	-.1763	-.1698	-.1675	-.1611	-.1525	-.1419	-.1295	-.1159	-.1013
8.0	-.2386	-.1820	-.1700	-.1668	-.1604	-.1518	-.1412	-.1290	-.1154	-.1009
10.0	-.2611	-.1897	-.1718	-.1660	-.1596	-.1510	-.1405	-.1283	-.1147	-.1004
12.0	-.2853	-.1987	-.1750	-.1661	-.1585	-.1500	-.1395	-.1274	-.1140	-.0997
15.0	-.3221	-.2137	-.1816	-.1679	-.1565	-.1481	-.1378	-.1258	-.1125	-.0984
20.0	-.3848	-.2405	-.1950	-.1739	-.1544	-.1441	-.1340	-.1224	-.1095	-.0958
25.0	-.4467	-.2676	-.2096	-.1816	-.1544	-.1401	-.1293	-.1180	-.1056	-.0924
30.0	-.5062	-.2939	-.2241	-.1897	-.1553	-.1371	-.1242	-.1128	-.1009	-.0892
35.0	-.5625	-.3186	-.2378	-.1975	-.1566	-.1348	-.1196	-.1071	-.0954	-.0835
40.0	-.6150	-.3415	-.2503	-.2045	-.1577	-.1325	-.1154	-.1017	-.0896	-.0781
45.0	-.6632	-.3621	-.2614	-.2106	-.1583	-.1302	-.1113	-.0965	-.0838	-.0723
50.0	-.7065	-.3802	-.2708	-.2155	-.1584	-.1277	-.1071	-.0913	-.0782	-.0666
55.0	-.7446	-.3957	-.2785	-.2190	-.1577	-.1247	-.1028	-.0862	-.0727	-.0610
60.0	-.7773	-.4083	-.2842	-.2212	-.1562	-.1212	-.0982	-.0810	-.0672	-.0556
65.0	-.8041	-.4179	-.2880	-.2220	-.1538	-.1173	-.0934	-.0758	-.0618	-.0503
70.0	-.8249	-.4245	-.2897	-.2213	-.1505	-.1128	-.0883	-.0704	-.0565	-.0451
75.0	-.8396	-.4280	-.2894	-.2190	-.1464	-.1078	-.0829	-.0649	-.0511	-.0401
80.0	-.8480	-.4284	-.2871	-.2153	-.1413	-.1022	-.0772	-.0594	-.0458	-.0352
85.0	-.8500	-.4255	-.2826	-.2101	-.1355	-.0962	-.0713	-.0537	-.0406	-.0304

θ a, deg deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	-.0861	-.0717	-.0571	-.0434	-.0310	-.0203	-.0116	-.0052	-.0013	-.0000
2.0	-.0863	-.0717	-.0571	-.0434	-.0310	-.0203	-.0116	-.0052	-.0013	-.0000
4.0	-.0863	-.0716	-.0570	-.0433	-.0309	-.0203	-.0116	-.0052	-.0013	-.0000
6.0	-.0863	-.0714	-.0568	-.0432	-.0308	-.0202	-.0116	-.0052	-.0013	-.0000
8.0	-.0860	-.0710	-.0566	-.0430	-.0307	-.0201	-.0115	-.0052	-.0013	-.0000
10.0	-.0855	-.0707	-.0563	-.0428	-.0305	-.0200	-.0115	-.0052	-.0013	-.0000
12.0	-.0849	-.0702	-.0559	-.0425	-.0303	-.0199	-.0114	-.0051	-.0013	-.0000
15.0	-.0839	-.0693	-.0552	-.0419	-.0300	-.0196	-.0112	-.0051	-.0013	-.0000
20.0	-.0816	-.0674	-.0537	-.0408	-.0291	-.0191	-.0109	-.0049	-.0012	-.0000
25.0	-.0787	-.0650	-.0518	-.0393	-.0281	-.0184	-.0105	-.0047	-.0012	-.0000
30.0	-.0752	-.0621	-.0495	-.0376	-.0269	-.0176	-.0101	-.0045	-.0011	-.0000
35.0	-.0711	-.0588	-.0468	-.0356	-.0254	-.0166	-.0095	-.0043	-.0011	-.0000
40.0	-.0665	-.0550	-.0438	-.0333	-.0238	-.0156	-.0089	-.0040	-.0010	-.0000
45.0	-.0614	-.0507	-.0404	-.0307	-.0219	-.0144	-.0082	-.0037	-.0009	-.0000
50.0	-.0560	-.0461	-.0367	-.0279	-.0199	-.0131	-.0075	-.0034	-.0008	-.0000
55.0	-.0506	-.0413	-.0328	-.0249	-.0178	-.0117	-.0067	-.0030	-.0008	-.0000
60.0	-.0455	-.0366	-.0287	-.0217	-.0155	-.0102	-.0058	-.0026	-.0007	-.0000
65.0	-.0404	-.0320	-.0247	-.0184	-.0131	-.0086	-.0049	-.0022	-.0006	-.0000
70.0	-.0356	-.0276	-.0209	-.0153	-.0107	-.0069	-.0040	-.0018	-.0005	-.0000
75.0	-.0310	-.0235	-.0174	-.0124	-.0084	-.0053	-.0030	-.0014	-.0003	-.0000
80.0	-.0266	-.0197	-.0141	-.0098	-.0064	-.0038	-.0021	-.0009	-.0002	-.0000
85.0	-.0224	-.0161	-.0112	-.0074	-.0046	-.0026	-.0013	-.0005	-.0001	-.0000

TABLE XXI (cont)

(c) $C_Y \quad \beta = 15^\circ$

$\alpha, \deg$ θ_s deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	-.9265	-.6222	-.5335	-.4966	-.4664	-.4414	-.4106	-.3749	-.3355	-.2934
2.0	-.9304	-.6238	-.5342	-.4969	-.4662	-.4412	-.4104	-.3748	-.3353	-.2932
4.0	-.9454	-.6300	-.5371	-.4978	-.4654	-.4404	-.4097	-.3741	-.3347	-.2927
6.0	-.9696	-.6401	-.5418	-.4996	-.4641	-.4391	-.4084	-.3729	-.3337	-.2918
8.0	-1.0019	-.6537	-.5484	-.5022	-.4626	-.4372	-.4067	-.3714	-.3322	-.2906
10.0	-1.0412	-.6703	-.5566	-.5057	-.4611	-.4348	-.4045	-.3693	-.3304	-.2890
12.0	-1.0862	-.6896	-.5664	-.5102	-.4597	-.4319	-.4017	-.3668	-.3282	-.2870
15.0	-1.1620	-.7225	-.5836	-.5186	-.4584	-.4265	-.3967	-.3622	-.3241	-.2834
20.0	-1.3024	-.7841	-.6167	-.5360	-.4582	-.4175	-.3859	-.3524	-.3153	-.2757
25.0	-1.4513	-.8498	-.6528	-.5561	-.4603	-.4097	-.3732	-.3399	-.3041	-.2659
30.0	-1.6012	-.9158	-.6894	-.5768	-.4634	-.4030	-.3608	-.3252	-.2906	-.2541
35.0	-1.7473	-.9798	-.7246	-.5968	-.4667	-.3970	-.3491	-.3103	-.2750	-.2403
40.0	-1.8861	-1.0398	-.7573	-.6150	-.4693	-.3909	-.3377	-.2957	-.2590	-.2249
45.0	-2.0152	-1.0947	-.7864	-.6307	-.4705	-.3842	-.3262	-.2812	-.2431	-.2088
50.0	-2.1324	-1.1433	-.8114	-.6433	-.4699	-.3767	-.3144	-.2668	-.2274	-.1929
55.0	-2.2363	-1.1849	-.8316	-.6524	-.4674	-.3679	-.3019	-.2523	-.2119	-.1772
60.0	-2.3255	-1.2189	-.8467	-.6578	-.4625	-.3578	-.2888	-.2375	-.1964	-.1618
65.0	-2.3991	-1.2449	-.8564	-.6592	-.4553	-.3462	-.2749	-.2225	-.1810	-.1468
70.0	-2.4563	-1.2626	-.8606	-.6564	-.4456	-.3332	-.2601	-.2070	-.1656	-.1320
75.0	-2.4964	-1.2716	-.8591	-.6496	-.4334	-.3186	-.2446	-.1913	-.1503	-.1176
80.0	-2.5191	-1.2718	-.8518	-.6385	-.4188	-.3026	-.2282	-.1753	-.1351	-.1035
85.0	-2.5240	-1.2633	-.8388	-.6234	-.4018	-.2852	-.2112	-.1590	-.1201	-.0899
$\alpha, \deg$ θ_s deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	-.2500	-.2066	-.1645	-.1250	-.0893	-.0585	-.0335	-.0151	-.0038	-.0000
2.0	-.2498	-.2065	-.1644	-.1249	-.0892	-.0585	-.0335	-.0151	-.0038	-.0000
4.0	-.2494	-.2061	-.1641	-.1247	-.0891	-.0583	-.0334	-.0150	-.0038	-.0000
6.0	-.2486	-.2055	-.1636	-.1243	-.0888	-.0582	-.0333	-.0150	-.0038	-.0000
8.0	-.2476	-.2046	-.1629	-.1238	-.0884	-.0579	-.0332	-.0149	-.0038	-.0000
10.0	-.2462	-.2034	-.1620	-.1231	-.0879	-.0576	-.0330	-.0148	-.0037	-.0000
12.0	-.2445	-.2021	-.1609	-.1223	-.0874	-.0572	-.0328	-.0147	-.0037	-.0000
15.0	-.2415	-.1995	-.1589	-.1207	-.0863	-.0565	-.0324	-.0146	-.0037	-.0000
20.0	-.2349	-.1941	-.1546	-.1175	-.0839	-.0550	-.0315	-.0142	-.0036	-.0000
25.0	-.2266	-.1872	-.1491	-.1133	-.0809	-.0530	-.0304	-.0137	-.0034	-.0000
30.0	-.2165	-.1789	-.1425	-.1083	-.0773	-.0507	-.0290	-.0131	-.0033	-.0000
35.0	-.2048	-.1692	-.1347	-.1024	-.0732	-.0479	-.0274	-.0124	-.0031	-.0000
40.0	-.1915	-.1583	-.1260	-.0958	-.0684	-.0448	-.0257	-.0115	-.0029	-.0000
45.0	-.1768	-.1461	-.1163	-.0884	-.0631	-.0414	-.0237	-.0107	-.0027	-.0000
50.0	-.1616	-.1328	-.1057	-.0803	-.0574	-.0376	-.0215	-.0097	-.0024	-.0000
55.0	-.1466	-.1192	-.0944	-.0717	-.0512	-.0335	-.0192	-.0086	-.0022	-.0000
60.0	-.1320	-.1058	-.0828	-.0625	-.0447	-.0292	-.0167	-.0075	-.0019	-.0000
65.0	-.1177	-.0929	-.0713	-.0532	-.0377	-.0247	-.0142	-.0064	-.0016	-.0000
70.0	-.1040	-.0805	-.0608	-.0443	-.0308	-.0200	-.0115	-.0052	-.0013	-.0000
75.0	-.0908	-.0688	-.0507	-.0361	-.0244	-.0154	-.0087	-.0039	-.0010	-.0000
80.0	-.0782	-.0578	-.0414	-.0285	-.0186	-.0112	-.0060	-.0026	-.0007	-.0000
85.0	-.0662	-.0475	-.0329	-.0218	-.0135	-.0076	-.0037	-.0014	-.0003	-.0000

TABLE XXI (cont)

(d) $C_L \beta = 0^\circ$

θ_s α , deg deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0348	.0344	.0337	.0328	.0302	.0267	.0224	.0174	.0119	.0061
2.0	.0674	.0686	.0673	.0655	.0603	.0534	.0448	.0348	.0238	.0121
4.0	.1424	.1364	.1338	.1301	.1199	.1061	.0890	.0692	.0473	.0239
6.0	.2341	.2032	.1986	.1932	.1780	.1574	.1320	.1025	.0700	.0352
8.0	.3463	.2750	.2611	.2539	.2339	.2067	.1732	.1345	.0915	.0458
10.0	.4780	.3545	.3236	.3114	.2868	.2534	.2122	.1645	.1117	.0554
12.0	.6274	.4412	.3888	.3665	.3362	.2968	.2483	.1922	.1300	.0638
15.0	.8810	.5828	.4914	.4488	.4021	.3547	.2962	.2285	.1535	.0737
20.0	1.3643	.8401	.6695	.5846	.4922	.4274	.3554	.2720	.1797	.0814
25.0	1.8903	1.1067	.8450	.7114	.5653	.4701	.3843	.2905	.1868	.0763
30.0	2.4178	1.3614	1.0041	.8195	.6165	.4887	.3831	.2812	.1726	.0569
35.0	2.9342	1.5833	1.1335	.8995	.6421	.4835	.3588	.2464	.1367	.0229
40.0	3.3590	1.7532	1.2214	.9439	.6390	.4545	.3143	.1936	.0824	-.0249
45.0	3.5962	1.8552	1.2587	.9471	.6058	.4024	.2522	.1278	.0180	-.0824
50.0	3.7371	1.8775	1.2397	.9064	.5428	.3295	.1761	.0532	-.0510	-.1419
55.0	3.7122	1.8134	1.1618	.8216	.4525	.2392	.0698	-.0259	-.1200	-.1983
60.0	3.5125	1.6617	1.0267	.6957	.3387	.1361	-.0020	-.1050	-.1850	-.2477
65.0	3.1405	1.4270	.8395	.5340	.2071	.0254	-.0945	-.1799	-.2422	-.2872
70.0	2.6099	1.1193	.6089	.3445	.0645	-.0870	-.1826	-.2464	-.2887	-.3146
75.0	1.9447	.7533	.3464	.1368	-.0817	-.1951	-.2519	-.3014	-.3222	-.3288
80.0	1.1777	.3478	.0656	-.0782	-.2238	-.2934	-.3282	-.3420	-.3412	-.3294
85.0	.3486	-.0762	-.2187	-.2891	-.3543	-.3769	-.3785	-.3668	-.3455	-.3172
θ_s α , deg deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	-.0000	-.0061	-.0119	-.0174	-.0224	-.0267	-.0302	-.0328	-.0344	-.0349
2.0	-.0000	-.0121	-.0239	-.0349	-.0448	-.0534	-.0604	-.0655	-.0687	-.0697
4.0	-.0002	-.0242	-.0476	-.0695	-.0893	-.1064	-.1203	-.1305	-.1367	-.1388
6.0	-.0006	-.0364	-.0711	-.1037	-.1331	-.1585	-.1791	-.1943	-.2036	-.2068
8.0	-.0013	-.0485	-.0942	-.1372	-.1759	-.2094	-.2366	-.2566	-.2688	-.2730
10.0	-.0026	-.0607	-.1169	-.1697	-.2174	-.2586	-.2920	-.3167	-.3317	-.3368
12.0	-.0045	-.0728	-.1390	-.2012	-.2573	-.3058	-.3451	-.3741	-.3919	-.3976
15.0	-.0087	-.0910	-.1709	-.2458	-.3135	-.3720	-.4194	-.4544	-.4758	-.4830
20.0	-.0200	-.1214	-.2198	-.3120	-.3954	-.4674	-.5258	-.5688	-.5952	-.6040
25.0	-.0377	-.1517	-.2623	-.3660	-.4598	-.5407	-.6063	-.6547	-.6843	-.6943
30.0	-.0625	-.1819	-.2976	-.4062	-.5044	-.5892	-.6579	-.7085	-.7396	-.7500
35.0	-.0944	-.2116	-.3254	-.4321	-.5285	-.6117	-.6723	-.7290	-.7595	-.7698
40.0	-.1328	-.2407	-.3454	-.4436	-.5324	-.6020	-.6511	-.7019	-.7450	-.7544
45.0	-.1768	-.2689	-.3582	-.4419	-.5177	-.5830	-.6361	-.6751	-.6990	-.7071
50.0	-.2227	-.2957	-.3644	-.4289	-.4872	-.5375	-.5783	-.6084	-.6268	-.6330
55.0	-.2639	-.3188	-.3652	-.4069	-.4446	-.4772	-.5036	-.5231	-.5350	-.5390
60.0	-.2964	-.3332	-.3599	-.3789	-.3943	-.4077	-.4185	-.4265	-.4314	-.4330
65.0	-.3180	-.3368	-.3456	-.3461	-.3411	-.3351	-.3302	-.3267	-.3245	-.3237
70.0	-.3273	-.3291	-.3218	-.3073	-.2876	-.2655	-.2460	-.2316	-.2228	-.2198
75.0	-.3242	-.3105	-.2897	-.2635	-.2338	-.2026	-.1724	-.1488	-.1343	-.1294
80.0	-.3091	-.2824	-.2511	-.2169	-.1813	-.1462	-.1132	-.0846	-.0657	-.0594
85.0	-.2837	-.2469	-.2084	-.1698	-.1324	-.0977	-.0669	-.0414	-.0224	-.0151

TABLE XXI (cont)

(e) C_D $\beta = 0^\circ$

α, deg θ, deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	.0047	.0161	.0350	.0612	.1348	.2347	.3578	.5005	.6583	.8265
2.0	.0074	.0188	.0376	.0637	.1371	.2368	.3596	.5018	.6592	.8270
4.0	.0184	.0295	.0481	.0740	.1466	.2451	.3666	.5073	.6630	.8289
6.0	.0379	.0473	.0656	.0909	.1622	.2589	.3782	.5163	.6691	.8320
8.0	.0682	.0723	.0897	.1144	.1838	.2780	.3941	.5287	.6774	.8362
10.0	.1112	.1052	.1202	.1440	.2111	.3021	.4144	.5444	.6882	.8415
12.0	.1689	.1468	.1576	.1795	.2437	.3310	.4385	.5631	.7009	.8478
15.0	.2869	.2270	.2266	.2435	.3019	.3823	.4814	.5962	.7232	.8586
20.0	.5795	.4129	.3785	.3789	.4194	.4853	.5673	.6622	.7673	.8792
25.0	1.0050	.6677	.5769	.5489	.5583	.6034	.6648	.7364	.8157	.9001
30.0	1.5694	.9913	.8195	.7498	.7135	.7294	.7658	.8119	.8632	.9179
35.0	2.2674	1.3777	1.1001	.9755	.8789	.8572	.8634	.8814	.9042	.9286
40.0	3.0829	1.8158	1.4093	1.2176	1.0472	.9805	.9519	.9393	.9331	.9287
45.0	3.9897	2.2897	1.7352	1.4661	1.2108	1.0931	1.0264	.9817	.9464	.9148
50.0	4.9530	2.7802	2.0635	1.7097	1.3618	1.1893	1.0828	1.0055	.9422	.8854
55.0	5.9319	3.2652	2.3791	1.9368	1.4926	1.2641	1.1177	1.0091	.9197	.8407
60.0	6.8814	3.7220	2.6668	2.1363	1.5967	1.3135	1.1293	.9919	.8797	.7821
65.0	7.7560	4.1280	2.9121	2.2980	1.6684	1.3347	1.1166	.9545	.8236	.7119
70.0	8.5119	4.4628	3.1025	2.4135	1.7041	1.3267	1.0802	.8985	.7538	.6328
75.0	9.1107	4.7090	3.2281	2.4768	1.7019	1.2894	1.0218	.8265	.6735	.5483
80.0	9.5213	4.8538	3.2823	2.4845	1.6617	1.2254	.9442	.7419	.5864	.4619
85.0	9.7220	4.8895	3.2622	2.4362	1.5857	1.1372	.8513	.6488	.4962	.3770
α, deg θ, deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	1.0000	1.1735	1.3417	1.4995	1.6422	1.7653	1.8652	1.9388	1.9839	1.9991
2.0	1.0000	1.1730	1.3408	1.4982	1.6404	1.7632	1.8629	1.9363	1.9812	1.9963
4.0	1.0000	1.1711	1.3370	1.4927	1.6334	1.7549	1.8534	1.9260	1.9704	1.9854
6.0	1.0000	1.1679	1.3308	1.4836	1.6218	1.7410	1.8377	1.9090	1.9526	1.9673
8.0	.9999	1.1635	1.3221	1.4710	1.6056	1.7217	1.8159	1.8853	1.9279	1.9422
10.0	.9997	1.1578	1.3111	1.4549	1.5850	1.6972	1.7882	1.8553	1.8964	1.9102
12.0	.9993	1.1508	1.2977	1.4355	1.5601	1.6676	1.7548	1.8191	1.8585	1.8717
15.0	.9983	1.1379	1.2733	1.4004	1.5152	1.6143	1.6947	1.7539	1.7902	1.8024
20.0	.9947	1.1101	1.2221	1.3271	1.4220	1.5040	1.5705	1.6194	1.6494	1.6595
25.0	.9872	1.0744	1.1588	1.2381	1.3097	1.3715	1.4217	1.4586	1.4813	1.4889
30.0	.9743	1.0307	1.0854	1.1367	1.1830	1.2231	1.2555	1.2795	1.2941	1.2990
35.0	.9539	.9792	1.0036	1.0266	1.0474	1.0653	1.0798	1.0905	1.0971	1.0993
40.0	.9243	.9199	.9157	.9117	.9081	.9050	.9024	.9006	.8994	.8991
45.0	.8839	.8532	.8234	.7955	.7703	.7485	.7308	.7178	.7098	.7071
50.0	.8315	.7793	.7287	.6813	.6384	.6014	.5714	.5493	.5357	.5312
55.0	.7677	.6987	.6331	.5717	.5162	.4683	.4295	.4008	.3833	.3774
60.0	.6941	.6131	.5380	.4687	.4063	.3524	.3086	.2764	.2566	.2500
65.0	.6135	.5252	.4454	.3737	.3100	.2551	.2106	.1778	.1577	.1510
70.0	.5287	.4378	.3579	.2881	.2277	.1766	.1354	.1049	.0863	.0800
75.0	.4432	.3538	.2777	.2132	.1594	.1155	.0809	.0555	.0399	.0347
80.0	.3600	.2760	.2068	.1503	.1052	.0700	.0438	.0254	.0142	.0105
85.0	.2822	.2066	.1466	.0998	.0642	.0383	.0205	.0093	.0033	.0013

TABLE XXI (Concluded)

(f) $L/D \quad \beta = 0^\circ$

θ_s α, deg deg	2.5	5.0	7.5	10.0	15.0	20.0	25.0	30.0	35.0	40.0
1.0	7.3707	2.1351	.9640	.5360	.2242	.1139	.0627	-.0349	.0181	-.0073
2.0	9.3249	3.6519	1.7897	1.0271	.4400	.2254	.1245	-.0694	.0361	-.0146
4.0	7.7319	4.6181	2.7788	1.7588	.8181	.4327	.2427	-.1363	.0713	-.0288
6.0	6.1692	4.2949	3.0293	2.1245	1.0974	.6079	.3490	-.1986	.1045	-.0424
8.0	5.0808	3.8049	2.9121	2.2198	1.2725	.7436	.4395	-.2543	.1351	-.0548
10.0	4.2994	3.3705	2.6914	2.1627	1.3588	.8387	.5121	-.3022	.1623	-.0659
12.0	3.7149	3.0059	2.4683	2.0418	1.3792	.8969	.5664	-.3413	.1855	-.0753
15.0	3.0704	2.5670	2.1686	1.8429	1.3321	.9278	.6153	-.3832	.2123	-.0858
20.0	2.3543	2.0549	1.7490	1.5429	1.1750	.8806	.6265	-.4108	.2343	-.0926
25.0	1.8809	1.6574	1.4648	1.2962	1.0125	.7791	.5780	-.3945	.2290	-.0847
30.0	1.5406	1.3733	1.2254	1.0929	.8640	.6700	.5003	-.3464	.2000	-.0620
35.0	1.2809	1.1492	1.0304	.9221	.7305	.5641	.4156	-.2795	.1511	-.0247
40.0	1.0733	.9656	.8666	.7752	.6102	.4635	.3301	-.2061	.0883	-.0268
45.0	.9014	.8102	.7254	.6460	.5003	.3681	.2457	-.1302	.0190	-.0901
50.0	.7546	.6753	.6008	.5302	.3986	.2771	.1626	-.0529	-.0541	-.1603
55.0	.6258	.5554	.4883	.4242	.3031	.1893	.0803	-.0257	-.1305	-.2359
60.0	.5104	.4464	.3850	.3256	.2121	.1036	-.0018	-.1059	-.2103	-.3167
65.0	.4069	.3457	.2883	.2324	.1241	.0191	-.0846	-.1884	-.2941	-.4034
70.0	.3066	.2508	.1963	.1427	.0378	-.0655	-.1690	-.2743	-.3830	-.4971
75.0	.2134	.1600	.1073	.0552	-.0480	-.1513	-.2563	-.3646	-.4783	-.5996
80.0	.1237	.0716	.0200	-.0315	-.1347	-.2395	-.3476	-.4610	-.5819	-.7132
85.0	.0359	-.0156	-.0670	-.1187	-.2234	-.3314	-.4446	-.5653	-.6964	-.8413
θ_s α, deg deg	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
1.0	-.0800	-.0052	-.0089	-.0116	-.0137	-.0151	-.0162	-.0169	-.0173	-.0175
2.0	-.0800	-.0103	-.0178	-.0233	-.0273	-.0303	-.0324	-.0338	-.0347	-.0349
4.0	-.0802	-.0207	-.0356	-.0466	-.0547	-.0606	-.0649	-.0677	-.0694	-.0699
6.0	-.0806	-.0311	-.0534	-.0699	-.0821	-.0911	-.0975	-.1018	-.1043	-.1051
8.0	-.0813	-.0417	-.0713	-.0932	-.1096	-.1216	-.1303	-.1361	-.1394	-.1405
10.0	-.0826	-.0524	-.0892	-.1167	-.1372	-.1524	-.1633	-.1707	-.1749	-.1763
12.0	-.0845	-.0633	-.1071	-.1401	-.1650	-.1834	-.1967	-.2057	-.2109	-.2126
15.0	-.0887	-.0800	-.1342	-.1755	-.2069	-.2304	-.2475	-.2591	-.2658	-.2679
20.0	-.0901	-.1094	-.1798	-.2351	-.2781	-.3108	-.3348	-.3512	-.3608	-.3640
25.0	-.0982	-.1412	-.2263	-.2956	-.3510	-.3942	-.4265	-.4488	-.4620	-.4663
30.0	-.0942	-.1765	-.2742	-.3574	-.4264	-.4817	-.5240	-.5538	-.5715	-.5774
35.0	-.0989	-.2161	-.3242	-.4209	-.5046	-.5742	-.6290	-.6685	-.6923	-.7002
40.0	-.1437	-.2617	-.3772	-.4866	-.5882	-.6729	-.7437	-.7961	-.8282	-.8391
45.0	-.2000	-.3151	-.4350	-.5556	-.6721	-.7790	-.8704	-.9406	-.9849	-1.0000
50.0	-.2678	-.3794	-.5001	-.6295	-.7631	-.8938	-1.0121	-1.1074	-1.1700	-1.1918
55.0	-.3437	-.4563	-.5768	-.7117	-.8613	-1.0189	-1.1726	-1.3049	-1.3957	-1.4281
60.0	-.4270	-.5434	-.6690	-.8083	-.9706	-1.1570	-1.3561	-1.5431	-1.6808	-1.7321
65.0	-.5183	-.6414	-.7758	-.9262	-1.1002	-1.3134	-1.5680	-1.8371	-2.0572	-2.1445
70.0	-.6190	-.7517	-.8991	-1.0669	-1.2633	-1.5029	-1.8173	-2.2074	-2.5820	-2.7475
75.0	-.7314	-.8775	-1.0431	-1.2356	-1.4663	-1.7536	-2.1321	-2.6820	-3.3644	-3.7321
80.0	-.8587	-1.0232	-1.2141	-1.4420	-1.7237	-2.0874	-2.5854	-3.3322	-4.6199	-5.6713
85.0	-1.0053	-1.1954	-1.4220	-1.7015	-2.0613	-2.5503	-3.2671	-4.4443	-6.8230	-11.4301

LIST OF REFERENCES

1. Aeronutronic, A division of Ford Motor Company: Experimental Investigation of the Aerodynamic Characteristics of 9 deg. Half-Angle Cones with Varying Degrees of Bluntness at Mach Number 9. AERON-U-1638, April, 1962.
2. Ames Research Staff: Equations, Tables, and Charts for Compressible Flow, NACA Report 1135, 1953.
3. Amick, James L.: Pressure Measurements on Sharp and Blunt 5°- and 15°-Half-Angle Cones at Mach Number 3.86 and Angles of Attack to 100°. NASA TN D-753, 1961.
4. Armstrong, William O.: Hypersonic Aerodynamic Characteristics of Several Series of Lifting Bodies Applicable to Re-entry Vehicle Design. NASA TMX-536, 1961.
5. Beltran, Alfred A.: Aerodynamics of Cones and Protuberances. Lockheed Missiles and Space Division, Lockheed Aircraft Corporation. Special Bibliography 3-30-61-1 SB-61-28, May 1961.
6. Berger, S. A.: Hypersonic Flow Over Cones. Princeton University Department of Aeronautical Engineering Report 523 (AFOSR TN 60-1214) September 1960.
7. Bertram, M. H.: Tip-Bluntness Effects on Cone Pressure at $M = 6.85$. J. Aero. Sci., Vol. 23, No. 9, pp 898-900, September 1956.
8. Bertram, Mitchel H., and Blackstock, Thomas A.: Some Simple Solutions to the Problem of Predicting Boundary-Layer Self-Induced Pressures. NASA TN D-798, 1961.
9. Bertram, Mitchel H., and Henderson, Arthur, Jr.: Effects of Boundary-Layer Displacement and Leading-Edge Bluntness on Pressure Distribution, Skin Friction, and Heat Transfer of Bodies at Hypersonic Speeds. NACA TN 4301, 1958.
10. Blick, Edward F.: (Lockheed Missiles and Space Company, Sunnyvale, California) Similarity Rule Estimation Methods for Cones. AIAA Journal, Vol. 1, No. 10, pp 2415-2416, October 1963.
11. Blick, Edward F.: (Lockheed Missiles and Space Company, Sunnyvale, California) Aerodynamic Coefficients in the Slip and Transition Regime. AIAA Journal, Vol. 1, No. 11, pp 2656-2658, November 1963.
12. Braun, Willis H.: Turbulent Boundary Layer on a Yawed Cone in a Supersonic Stream. NASA TR R-7, 1959. (Supersedes NACA TN 4208.)
13. Briggs, Benjamin R.: The Numerical Calculation of Flow Past Conical Bodies Supporting Elliptic Conical Shock Waves at Finite Angles of Incidence. NASA TN D-340, November 1960.
14. Brooks, Cuyler W., Jr., and Trescot, Charles D., Jr.: Transonic Investigations of the Effects of Nose Bluntness, Fineness Ratio, Cone Angle, and Base Shape on the Static Aerodynamic Characteristics of Short, Blunt Cones at Angles of Attack to 180°. NASA TN D-1926, August 1963.
15. Buford, W.: Comparison of the Theoretical Aerodynamic Characteristics of a Series of Cones with the Results Found by Supersonic Wind Tunnel Experiments. SSWTL Memorandum to Director, BRL 23, 1948.

LIST OF REFERENCES (CONTINUED)

16. Buford, W. E., and Shatunoff, S.: The Effects of Fineness Ratio and Mach Number on the Normal Force and Center of Pressure of Conical and Ogival Head Bodies. BRL Memorandum Report No. 760, February 1954.
17. Bulakh, B. M.: On the Nonsymmetric Hypersonic Flow Around a Circular Cone. Jour. App. Math. and Mechs. Vol. 26, No. 5, pp 1473-1479, March 1963 (Translation).
18. Burke, A. F. and Curtis, J. H.: Blunt-Cone Pressure Distributions at Hypersonic Mach Numbers. J. Aerospace Sci. Vol. 29, pp 237, 238, February 1962.
19. Carter, Howard S., and Bressette, Walter E.: Heat-Transfer and Pressure Distribution on Six Blunt Noses at a Mach Number of 2. NACA RM L57C18 April 18, 1957. Declassified January 12, 1961.
20. Centolozzi, F. T.: Characteristics of a 40-Degree Cone for Measuring Mach Numbers, Total Pressure, and Flow Angles at Supersonic Speeds. NACA TN 3967, May 1957.
21. Chapman, D. R.: An Analysis of Base Pressure at Supersonic Velocities and Comparison with Experiment. NACA TN 2137, July 1950. (Superseded by NACA Rpt. 1051, 1951).
22. Chapman, D. R.: An Analysis of Base Pressure at Supersonic Velocities and Comparison with Experiment. NACA Report 1051, 1951. (Supersedes NACA TN 2137).
23. Chapman, D. R.: Base Pressure on Wings and Bodies with Turbulent Boundary Layers. NACA Conference on Aerodynamic Design Problems of Supersonic Guided Missiles, October 1951.
24. Chapman, Gary T., and Jackson, Charles T., Jr.: Measurement of Heat Transfer to Bodies of Revolution in Free Flight by Use of a Catcher Calorimeter. NASA TN D-1890, July 1963.
25. Charters, A. C., and Turetsky, R. A.: Determination of Base Pressure from Free-Flight Data. RRI Report 653, 1948.
26. Cheng, H. K.: Hypersonic Flow with Combined Leading-Edge Bluntness and Boundary-Layer Displacement Effect. Cornell Aeronautical Lab. Report No. AF-1285-A-4, August 1960.
27. Cheng, H. K. et al.: Boundary-Layer Displacement and Leading-Edge Bluntness Effects in High Temperature Hypersonic Flow. IAS Paper No. 60-38, presented January 25-27, 1960. Also, Jour. of Aero-Space Sci., Vol. 28, No. 5, pp 353-381, May 1961.
28. Cheng-Ting Hsu: Nonuniform Deceleration of a Slender Cone in Supersonic, Transonic, and Subsonic Flight. ARS Jour., Vol. 31, pp 1289-1291, September 1961.
29. Chernyi, G. G.: Flow Around a Thin Blunt Cone at High Supersonic Speeds. Soviet Phys., Doklady 115, pp 263-265, 1957.
30. Chuskin, P. I., and Shulishnina, N. P.: Tables of Supersonic Flow About Blunted Cones. Academy of Sciences USSR (Moscow), 1961. Translated and Edited by J. F. Springfield, Research and Advanced Development Division AVCO Corporation, Wilmington, Massachusetts, September 14, 1962.

LIST OF REFERENCES (CONTINUED)

31. Clippinger, R. F., Giese, J. H., and Carter, W. C.: Tables of Supersonic Flows About Cone Cylinders. Pt. I: Surface Data. Rep. No. 729, Ballistic Res. Labs., Aberdeen Proving Ground (Maryland), July 1950. (Proj. TB3-0108H of Res. and Dev. Div., Ord. Dept.)
32. Cohen, C. B. and Reshotko, Eli: The Compressible Laminar Boundary Layer with Heat Transfer and Arbitrary Pressure Gradient. NACA TN 3326, 1955.
33. Cohen, Clarence B., and Reshotko, Eli: Similar Solutions for the Compressible Laminar Boundary Layers with Heat Transfer and Pressure Gradient. NACA Report 1293, 1956.
34. Cohen, Clarence B., and Reshotko, Eli: The Compressible Laminar Boundary Layer with Heat Transfer and Arbitrary Pressure Gradient. NACA Report 1294, 1956.
35. Coltrane, Lucille C.: Stability Investigation of a Blunt Cone and a Blunt Cylinder with a Square Base at Mach Numbers from 0.64 to 2.14. NACA RML58G24, September 17, 1958.
36. Coltrane, Lucille C.: Stability Investigation of a Blunted Cone and a Blunted Ogive with a Flared Cylinder Afterbody at Mach Numbers from 0.30 to 2.85. NASA TN D-1506, October 1962. (Supersedes NASA TMX-199).
37. Compton, D. L.: Free-Flight Measurements of Drag and Static Stability for a Blunt-Nosed 10° Half-Angle Cone at Mach Number 15. NASA TMX-507, April 1961.
38. Conti, Raul J.: Laminar Heat-Transfer and Pressure Measurements at a Mach Number of 6 on Sharp and Blunt 15° Half-Angle Cones at Angles of Attack Up to 90°. NASA TN D-962, October 1961.
39. Cooper, Ralph D. and Robinson, Raymond A.: An Investigation of the Aerodynamic Characteristics of a Series of Cone-Cylinder Configurations at a Mach Number of 6.86. NACA RM L51J09, 1951.
40. Cope, W. G.: The Effect of Reynolds Number on the Base Pressure of Projectiles. National Physical Laboratory (Great Britain), Engineering Division, Report 63/44, January 1945.
41. Crocco, L., and Lees, L.: A Mixing Theory for the Interaction Between Dissipative Flows and Nearly Isentropic Streams. Jour. of Aero. Sci., Vol. 19, No. 10, 1952.
42. Cronvich, L. L.: Results of Experimental Studies of Pressure Distributions on Cones at Supersonic Velocities, NAVORD Report 1651, 1950.
43. Czarnecki, K. R., and Jackson, M. W.: Effects of Cone Angle, Mach Number, and Nose Blunting on Transition at Supersonic Speeds. NASA TN D-634, January 1961.
44. Dennis, David H., and Cunningham, Bernard E.: Forces and Moments on Pointed and Blunt-Nosed Bodies of Revolution at Mach Numbers from 2.75 to 5.00. NACA RM A52E22 August 8, 1952.
45. Dickey, R. R.: Forces and Moments on Sphere-Cone Bodies in Newtonian Flow. NASA TN D-1203, December 1961.
46. Dorrance, William H.: Nonsteady Supersonic Flow About Pointed Bodies of Revolution. Jour. Aero. Sci., Vol. 18, No. 8, pp 505-511, August 1951.

LIST OF REFERENCES (CONTINUED)

47. Dorrance, William H., and Romig, Mary F.: The Effect of Blunting a Cone on Conical Surface Reynolds Number and Laminar Flow Heat Transfer at Hypersonic Mach Numbers. Rep. No. ZA-7-015, Convair, March 11, 1955.
48. Drake, R. M., and Maslach, G. J.: Heat Transfer from Right Circular Cones to a Rarefied Gas Flow in Supersonic Flow. University of California Eng. Projects Report HE-150-91, April 1952.
49. Dye, F. E.: Pressure Distribution Tests for Conical Flow Research. Consolidated Vultee OAL Report 160, 1950.
50. Eggers, A. J., Jr., Dennis, David H., and Resnikoff, Meyer M.: Bodies of Revolution for Minimum Drag at High Supersonic Airspeeds. NACA RM A51K27, February 25, 1952. (See NACA Report 1306, 1957 also).
51. Eggers, A. J., Jr., and Savin, Raymond C.: Approximate Methods for Calculating the Flow about Nonlifting Bodies of Revolution at High Supersonic Airspeeds. NACA TN 2579, December 1951.
52. Ehret, D. M.: Accuracy of Approximate Methods for Predicting Pressures on Pointed Non-lifting Bodies of Revolution in Supersonic Flow. NACA TN 2764, August 1952.
53. Erickson, Wayne D.: Study of Pressure Distributions on Simple Sharp-Nosed Models at Mach Numbers from 16 to 18 in Helium Flow. NACA TN 4113, 1957.
- 53A. Felix, A. Richard: Force Tests of a Related Family of Twenty Nose Cones for a Range of Mach Numbers from 0.47 to 1.93. ABMA Report DA-TN-42-58, July 1958.
54. Ferrari, C.: Determination of the Pressure Exerted on Solid Bodies of Revolution with Pointed Noses Placed Obliquely in a Stream of Compressible Fluid at Supersonic Velocity. R.T.P. Translation No. 1105, British Ministry of Aircraft Production. (From Atti R. Accad. Sci. Torino, Vol. 72, pp 140-163, November-December 1936.)
55. Ferrari, Carlo: The Determination of the Projectile of Minimum Wave Resistance. Reale Academia della Science de Torino Atti, 1939. (Issued as British, M. A. P. RTP Tr. 1180.)
56. Ferri, A.: Supersonic-Tunnel Tests of Projectiles in Germany and Italy, NACA ACR No. L5H08, October, 1945.
57. Ferri, Antonio: The Methods of Characteristics for the Determination of Supersonic Flow-Over Bodies of Revolution at Small Angles of Attack. NACA TN 1809, 1949.
58. Ferri, Antonio: Supersonic Flow Around Circular Cones at Angles of Attack. NACA TN 2236, 1950. (Superseded by NACA Rep. 1045, 1951.)
59. Ferri, Antonio: The Method of Characteristics for the Determination of Supersonic Flow Over Bodies of Revolution at Small Angles of Attack. NACA Report 1044, 1951.
60. Ferri, Antonio: Supersonic Flow Around Circular Cones at Angles of Attack. NACA Report No. 1045, 1951. (Supersedes NACA TN 2236).
61. Ferri, Antonio: The Linearized Characteristics Method and Its Application to Practical Non-Linear Supersonic Problems. NACA Report 1102, 1952. (Supersedes NACA TN 2515).
62. Ferri, A., and Pallone, A.: Note on the Flow on the Rear Part of Blunt Bodies in Hypersonic Flow. WADC TN 56-294, July 1956.

LIST OF REFERENCES (CONTINUED)

63. Fisher, Lewis R., Keith, Arvid L., Jr., and DiCamillo, Joseph R.: Aerodynamic Characteristics of Some Families of Blunt Bodies at Transonic Speeds. NASA MEMO 10-28-58L, November 1958.
64. Fisher, Lewis R. and DiCamillo, Joseph R.: Investigation of Several Blunt Bodies to Determine Transonic Aerodynamic Characteristics Including Effects of Spinning and of Extendible Afterbody Flaps and Some Measurements of Unsteady Base Pressures. NASA Memo 1-21-59L, 1959.
65. Fisher, Lewis R.: Equations and Charts for Determining the Hypersonic Stability Derivatives of Combinations of Cone Frustums Computed by Newtonian Impact Theory. NASA TN D-149, 1959.
66. Fletcher, Herman S., and Wolhart, Walter D.: Damping in Pitch and Static Stability of a Group of Blunt-Nose and Cone-Cylinder-Flare Models at a Mach Number of 6.83. NASA MEMO 5-6-59L, 1959.
67. Fletcher, Herman S., and Wolhart, Walter D.: Damping in Pitch and Static Stability of Supersonic Impact Nose Cones, Short Blunt Subsonic Impact Nose Cones, and Manned Re-Entry Capsules at Mach Numbers from 1.93 to 3.05. NASA TMX-347, November 1960.
68. Fletcher, Herman S.: Damping in Pitch and Static Stability of Blunt Cone-Cylinder-Flare Models and Manned Re-Entry Capsule Models for Various Angles of Attack at a Mach Number of 2.91. NASA TMX-539 July 1961.
69. Freed, Aubyn: Newtonian Drag Coefficients and Weights for Blunted Cone Spheres at Small Angles of Attack. Mass. Inst. of Tech., Lincoln Lab., Lexington. AFESD TDR 62-81 (Rept. No. 22G-5), March 30, 1962.
70. Gabeaud, A.: Base Pressures at Supersonic Velocities. Readers' Forum. Jour. of Aero. Sci., Vol. 16, No. 10, p 638, October 1949.
71. Gabeaud, A.: Base Pressures at Supersonic Velocities. Readers' Forum. Jour. of Aero. Sci., Vol. 17, No. 8, p 525, August 1950.
72. Gendtner, W. J.: Sharp and Blunted Cone Force Coefficients and Centers of Pressure from Wind Tunnel Tests at Mach Numbers from 0.50 to 4.06. Convair Report ZA-7-017, June 1955.
73. General Applied Sciences Laboratories, Inc., Westbury, New York: Pressure Distribution on a Blunted 15 Degrees Circular Cone. Technical Report No. 136; Data Report, No. 5134-1, February 1960, (Contract AF 33 (616) 6692).
74. General Electric Company. Private Communications from H. Ridyard to Clark H. Lewis, VKF, ARO, Inc. referenced in AEDC-TN-61-81, August 1961.
75. Göthert, B.: Plane and Three-Dimensional Flow at High Subsonic Speeds. NACA TM 1105, October, 1946.
76. Gray, J. Don: Drag and Stability Derivatives of Missile Components According to the Modified Newtonian Theory. AEDC-TN-60-191, November 1960.
77. Greenberg, R. A.: A Correlation of Nose-Bluntness-Induced Pressure on Cylindrical and Conical Afterbodies at Hypersonic Speeds. Jour. Aero. Sci. Vol. 29, pp 359-360, March 1962.

LIST OF REFERENCES (CONTINUED)

78. Griffith, B. J. and Wolny, W.: Sharp and Blunt Cone Force Tests at M of Approximately 17 and Various Reynolds Numbers. AEDC TDR 62-67, March 1962.
79. Grimminger, G., Williams, E. P., and Young, G. B. W.: Lift on Inclined Bodies of Revolution in Hypersonic Flow. Jour. Aero. Sci., Vol. 17, No. 11, pp 675-690, November 1950.
80. Grimes, James H., Jr., (Research and Advanced Development Division, AVCO Corporation,) and Casey, John J. (Fluidyne Engineering Corporation): Dynamic Stability Testing with Ablation at Mach 14 in a Long Duration Wind Tunnel. Fluidyne Engineering Corporation binding. (Paper presented at AIAA Aerodynamic Testing Conference, Washington, D. C., March 9-10, 1964).
81. Grisby, C. E., and Ogburn, E. L.: Investigation of Reynolds Number Effects for a Series of Cone-Cylinder Bodies at Mach Numbers 1.62, 1.93, and 2.41. NACA RML53H21, October 1953.
82. Haack, W.: Projectile Forms of Minimum Wave Resistance. Douglas Aircraft Company, Inc., Report 288, 1946. (Translation).
83. Hall, James R. and Speegle, Katherine C.: Limited Heat-Transfer, Drag, and Stability Results from an Investigation at Mach Numbers up to 9 of a Large Rocket-Propelled 10° Cone. NACA RML57E08.
84. Hammitt, A. G. and Murthy, K. R. A.: Approximate Solutions for Supersonic Flow Over Wedges and Cones. Princeton University, Forrestal Research Center Report No. 449, April 1959.
85. Hantzsche, W., and Wendt, H.: The Laminar Boundary Layer of a Circular Cone in Supersonic Flow at Zero Angle of Attack. (Die Laminare Grenzschicht bei einem mit Überschallgeschwindigkeit Angeströmten nichtangestellten Kreiskegel. Jahrbuch der Deutschen Luftfahrtforschung, Pt. I, pp 76-77, 1941) Translated by Ronald Kay, ed. by M. W. Rubesin. Engr. Res. Proj., Univ. Calif., Berkely, Calif., May 1, 1947.
86. Hantzsche, W., and Wendt, H.: Cones in Supersonic Flow. RAND T-8, January 5, 1948.
87. Harris, Pamela: Separation of Shock Wave from the Nose of a 40° Cone. BRL 651, 1947.
88. Hart, Roger G.: Flight Investigation of the Drag of Round-Nosed Bodies of Revolution at Mach Numbers from 0.6 to 1.5 Using Rocket-Propelled Test Vehicles. NACA RML51E25, 1951.
89. Henderson, Arthur Jr., and Johnston, Patrick J.: Fluid-Dynamic Properties of Some Simple Sharp and Blunt-Nosed Shapes at Mach Numbers from 16 to 24 in Helium Flow, NASA MEMO 5-8-59L, June 1959.
90. Henderson, A. Jr., and Braswell, D. O.: Charts for Conical and Two-Dimensional Oblique-Shock Flow Parameters in Helium at Mach Numbers from About 1 to 100. NASA TN D-819, June 1961.
91. Hertzberg, A. and Wittliff, C. E.: Studying Hypersonic Flight in the Shock Tunnel. IAS Paper No. 60-67, presented June 28-July 1, 1960.
92. Hodges, A. J.: The Drag Coefficient of Very High Velocity Spheres. New Mexico School of Mines, Research and Devel. Div., Socorro, New Mexico, October 1949.
93. Holt, Maurice and Blackie, John: Experiments on Circular Cones at Yaw in Supersonic Flow. Jour. of Aero. Sci., Vol. 23, No. 10, pp 931-936, October 1956.
94. Intrieri, Peter F.: Free-Flight Measurements of the Static and Dynamic Stability and Drag of a 10° Blunted Cone at Mach Numbers 3.5 and 8.5. NASA TN D-1299, 1962.

LIST OF REFERENCES (CONTINUED)

95. Ipsen, D. C.: Cone Drag in a Rarefied Gas Flow. University of California Eng. Projects. Report HE-150-114, August 10, 1953.
96. Ipsen, D. C.: Experiments on Cone Drag in a Rarefied Air Flow. Jet Propulsion, pp 1076-1077, December 1956.
97. Isenberg, I. S.: The Method of Characteristics in Compressible Flow. Part 1 (Steady Supersonic Flow), Tech. Report F-TR-1173A-ND, USAF, Air Materiel Command, Wright Field, Technical Intelligence (Brown University, Graduate Division of Applied Mathematics, A-9-M II/1), December 1947.
98. Iversen, James D.: Base and Surface Pressure Variation with Mach Number on a Right Circular Cone. SCTM 202-56-51, September 12, 1956.
99. Jackson, Charlie M., Jr. and Harris, Roy V., Jr.: Investigation at a Mach Number of 1.99 of Two Series of Blunted Delta Planform Models with Several Cross-Sectional Shapes for Angles of Attack from 0° to 90°. NASA TMX-543, 1961.
100. Jacobs, W. F.: A Simplified Approximate Method for the Calculation of the Pressure Around Conical Bodies of Arbitrary Shape in Supersonic and Hypersonic Flow. Jour. of Aero. Sci., Vol. 28, pp 978-988, December 1961.
101. Jenkins, B. Z.: Real Gas Flow Field Properties Around Blunt Cones, Volume I. Army Missile Command RF-TR-63-18, August 19, 1963.
102. Johnston, Patrick J. and Snyder, Curtis D.: Static Longitudinal Stability and Performance of Several Ballistic Spacecraft Configurations in Helium at a Mach Number of 24.5. NASA TN D-1379, August 1962.
103. Jones, J. H. and Deitering, J. S.: Force and Pressure Tests on a Blunt Cone at Mach Numbers from 2 to 5. AEDC TN 61-164, December 1961.
104. Jones, J. H. and Deitering, J. S.: Force and Pressure Tests on a Blunt Cone at Mach Number 8. AEDC TDR 62-33, February 1962.
105. Julius, Jerome D.: Measurements of Pressure and Local Heat Transfer on a 20° Cone at Angles of Attack up to 20° for a Mach Number of 4.95. NASA TN D-179, December 1959.
106. Katz, Jerome R.: Pressure and Wave Drag Coefficients for Hemispheres, Hemisphere-Cones, and Hemisphere-Ogives. Naval Ordnance Test Station, Inyokern (China Lake). NAVORD Rep. 5849, March 21, 1958.
107. Kavanau, L.: Base Pressure Studies in Rarified Supersonic Flows. Jour. of Aero. Sci., Vol. 23, No. 3, p 193, March 1956.
108. Kehlet, Alan B.: Some Effects of Reynolds Number on the Stability of a Series of Flared-Body and Blunted-Cone Models at Mach Numbers from 1.62 to 6.86. NACA RML57J29, January 7, 1958.

LIST OF REFERENCES (CONTINUED)

109. Keyes, J. Wayne: Longitudinal Aerodynamic Characteristics of Blunted Cones at Mach Numbers of 3.5, 4.2, and 6.0. NASA TN D-2201, February 1964.
110. King, H. H.: Hypersonic Flow Over a Slender Cone with Gas Injection. University of California, Berkeley, Tech. Report HE-150-205, November 5, 1962.
111. King, Hartley H., and Talbot, Lawrence (University of California, Berkeley, California): Effect of Mass Injection on the Drag of a Slender Cone in Hypersonic Flow. AIAA Jour., Vol. 2, No. 5, pp 836-844, May 1964.
112. Korst, H. H., Page, R. H., Childs, M. E.: A Theory for Base Pressures in Transonic and Supersonic Flow. University of Illinois, M. E. Technical Note 392-2.
113. Kurzweg, H. H.: Interrelationship Between Boundary-Layer and Base Pressure. Jour. of Aero. Sci., Vol. 18, No. 11, 1951.
114. Langelo, V. A., and Lengyel, A.: Aerodynamic Coefficients of a Pointed Cone at Angles of Attack in a Rarefied Gas Flow. General Electric Technical Information Series Report No. R58SD229, May 1958. (See also Rarefied Gas Dynamics, Pergamon Press, New York, pp 329-351, 1960.)
115. Large, E.: Nose Shape for Minimum Drag in Hypersonic Flow. Jour. of Aero. Sci., Vol. 29, No. 1, pp 98-99, January 1962.
116. Lees, Lester: Hypersonic Flow. Fifth International Aeronautical Conference, Los Angeles, California, June 20-23, 1955, Inst. Aero. Sci., Inc., pp 241-276, 1955.
117. Lees, Lester: Recent Developments in Hypersonic Flow. Jet Propulsion, Vol. 27, No. 11, pp 1162-1178, November 1957.
118. Lehnert, R., and Schermerhorn, V. L.: Wake Investigation on Sharp and Blunt Nose Cones at Supersonic Speeds. NAVORD Rep. 5668, U. S. Naval Ord. Lab., White Oak, Maryland, January 28, 1958.
119. Letko, William: Experimental Investigation at a Mach Number of 3.11 of the Lift, Drag, and Pitching-Moment Characteristics of a Number of Blunt, Low-Fineness-Ratio Bodies. NASA MEMO 1-18-59L, 1959.
120. Levensteins, Zigurds J.: Hypersonic Wake Characteristics Behind Spheres and Cones. (Cone Half-Angle = 6.3°, 8°, 10°, 12.5°.) AIAA Jour., Vol. 1, No. 12, pp 2848-2850, December 1963.
121. Lewis, C. H.: Pressure Distribution and Shock Shape over Blunted Slender Cones at Mach Numbers from 16 to 19. Arnold Eng. Dev. Center, TN-61-81, August 1961.
122. Liccini, L. L.: Hypersonic Tunnel No. 4 Results IX: The Development of a Water-Cooled Strain-Gage Balance (Including Sting Effects) and its Application to a Study of Normal Force and Pitching Moments of a Cone and Cone-Cylinder at Mach Numbers 5 to 8. NAVORD Report 4334, U. S. Naval Ord. Lab., White Oak, Md., August 20, 1956.
123. Lighthill, M. J.: Supersonic Flow Past Bodies of Revolution. R & M No. 2003, British A.R.C., 1945.

LIST OF REFERENCES (CONTINUED)

124. Lighthill, M. J.: Supersonic Flow Past Slender Pointed Bodies of Revolution at Yaw: Quarterly Journal of Mechanics and Applied Mathematics, Vol. 1, Part 1, March 1948.
125. Lin, T. S., Schaaf, S. A., and Sherman, F. S.: Boundary Layer Effect on the Surface Pressure of an Infinite Cone in Supersonic Flow. University of California Eng. Projects Report HE-150-80, March 1951.
126. Linnell, R. D.: A Note on Cone Base Pressures in Hypersonic Flow. Jour. of Aero. Sci., Vol. 24, No. 5, p. 390, May 1957.
127. Love, E. S.: Base Pressure at Supersonic Speeds on Two-Dimensional Airfoils and on Bodies of Revolution with and without Fins Having Turbulent Boundary Layers. NACA TN 3819, January 1957.
128. Lubliner, J., Oliver, R. E., and Morgan, A. J. A.: Low-To-High Speed Drag Compilations for Rocket Test Sled Components. NAVORD Report 5635. Investigation made by AER, Inc., Pasadena, California, August 7, 1957.
129. Lukasiewicz, J., Jackson, R. and Whitfield, Jack D.: Status of Development of Hotshot Tunnels at the AEDC. Paper presented at the AGARD Meeting on "High Temperature Aspects of Hypersonic Flow," Training Center for Experimental Aerodynamics, Rhode-Saint-Genese, Belgium, April 3-6, 1962.
130. Lukasiewicz, J., Whitfield, Jack D., and Jackson, R.: Aerodynamic Testing at Mach Numbers 15 to 20. Hypersonic Flow Research, Vol. 7, Progress in Astronautics and Rocketry, pp 473-512, Academic Press, 1962.
131. Lyons, W. C., Jr., Brady, J. J., and Levensteins, Z. J.: Hypersonic Drag, Stability, and Wake Data for Cones and Spheres. (U. S. Naval Ord. Lab., Silver Spring, Md.) AIAA Aerospace Sciences Meeting, New York, N. Y., Preprint 64-44, January 20-22, 1964.
132. Machell, Reginald M. and O'Bryant, William T.: An Experimental Investigation of the Flow Over Blunt-Nosed Cones at a Mach Number of 5.8. GARCIT MEMO. No. 32 (Contract No. DA-04-495-Ord-19), June 15, 1956. (See also Jour. of Aero. Sci., Vol. 23, No. 11, pp 1054-1055.)
133. Mangler, W.: Compressible Boundary Layers on Bodies of Revolution. Interrogation Report, ATI No. 28063, MAP-VG 83-4.7.T, Translation, June 1946.
134. Margolis, Kenneth: Theoretical Evaluation of the Pressures, Forces, and Moments at Hypersonic Speeds Acting on Arbitrary Bodies of Revolution Undergoing Separate and Combined Angle-of-Attack and Pitching Motions. NASA TN D-652, 1961.
135. Marks, Alma S.: Normal Force, Pitching Moment, and Center of Pressure of Several Spherically Blunted Cones at Mach Numbers of 1.50, 2.18, and 4.04. US AOMC-ARGMA-OML Report 6R8F, April, 1958.
136. Marson, G. B., Keates, R. E., and Socha, W.: An Experimental Investigation of the Pressure Distribution on Five Bodies of Revolution at Mach Numbers of 2.45 and 3.19. College of Aeronautics, Cranfield, England, Report 79, April, 1954.

LIST OF REFERENCES (CONTINUED)

137. Maslach, G. J. and Talbot, L.: Low-Density Aerodynamic Characteristics of a Cone at Angle of Attack, University of California Technical Report HE-150-172, October 30, 1959.
138. Merz, G. H., and Pritts, O. R.: Static Force Tests at Mach 8 of Sharp and Blunt 20-Deg. Half-Angle Cones and a Blunt 70-Degree Swept Delta Wing. AEDC-TDR-62-187, October 1962.
139. Messing, Wesley E., Rabb, Leonard, and Disher, John H.: Preliminary Drag and Heat-Transfer Data Obtained from Air-Launched Cone-Cylinder Test Vehicle Over Mach Number Range from 1.5 to 5.18, NACA RM E53104, November 16, 1953, Declassified February 8, 1960.
140. Miles, J. W.: On the Sonic Drag of a Slender Body. Jour. of Aero. Sci., Vol. 23, No. 2, pp 146-154, February 1956.
141. Monaghan, R. J.: An Approximate Solution of the Compressible Laminar Boundary Layer on a Flat Plate. Tech. Note No. Aero 2025, Sup. 96, R.A.E. (British), 1949.
142. Monta, William J., Howard, Paul W., and Czarnecki, E. R.: Effect of Nose Bluntness in Transition for a Cone and a Hollow Cylinder at Mach Numbers 1.41 and 2.01. NASA TN D-717, April 1961.
143. Munk, Max M., and Crown, J. Conrad: The Head Shock Wave. Naval Ordnance Lab. Memo. 9773, 1948.
144. Munson, Albert G.: A Preliminary Experimental Investigation of the Flow Over Simple Bodies of Revolution at $M = 18.4$ in Helium. GALCIT Memo No. 35 (Contract No. DA-04-495-Ord-19) December 15, 1956.
145. Murphy, C. H.: On the Stability Criteria of the Kelly-McShane Linearized Theory of Yawing Motion. BRL Report 853, 1953.
146. Murphy, C. H., and Schmidt, L. E.: The Effect of Varying Length on the Aerodynamic Characteristics of Bodies of Revolution in Supersonic Flight. BRL Report 876, 1953.
147. Neal, Luther, Jr.: Aerodynamic Characteristics at a Mach Number of 6.77 of a 9° Cone Configuration, with and without Spherical Afterbodies, at Angles of Attack up to 180° with Various Degrees of Nose Blunting. NASA TN D-1606, March 1961.
148. Nelson, Robert L.: The Motions of Rolling Symmetrical Missiles Referred to a Body-Axis System. NACA TN 3737, 1956.
149. Newton, Isaac: Principia-Motte's Translation Revised. University of California Press, pp 333, 657-661, 1946.
150. Nichols, James H.: Determination of Optimum Operating Parameters for the PWT 16-ft Transonic Circuit Utilizing One-Percent Bodies of Revolution. AEDC-TN-59-100, September 1959.
151. No Author Name: Notes and Tables for Use in the Analysis of Supersonic Flow. NACA TN 1428, December 1947.
152. No Author Name: The NBS-NACA Tables of Thermal Properties of Gases (Table 2.39), December 1950.
153. No Author Name: Pressure Distribution on a Blunted 15° Circular Cone. Gen. Appl. Sci. Labs., Inc., TR 136, February 1960.

LIST OF REFERENCES (CONTINUED)

154. No Author Name: Aerodynamic Characteristics of Spherically Blunted Cones at Mach Numbers from 0.5 to 5.0. George C. Marshall Space Flight Center Report MTP-AERO-61-38, May 2, 1961.
155. Nucci, Louis M.: The External-Shock-Drag of Supersonic Inlets Having Subsonic Entrance Flow. NACA RML50G14a, 1950.
156. Oliver, R. E.: An Experimental Investigation of Flow Over Simple Blunt Bodies at a Nominal Mach Number of 5.8. Guggenheim Aeronautical Laboratory, California Institute of Technology, Wind Tunnel Memo. No. 26, June 1955.
157. Pasiuk, Lionel: Supersonic Aerodynamic Heat Transfer and Pressure Distributions on a Sphere-Cone Model at High Angles of Yaw. Naval Ordnance Lab., White Oak, Md., Rept. No. NOLTR 62-35, July 1962.
158. Penland, Jim A.: Aerodynamic Characteristics of a Circular Cylinder at Mach Number 6.86 and Angles of Attack up to 90°. NACA TN 3861, 1957. (Supersedes NACA RM L54A14.)
159. Penland, Jim A.: Aerodynamic Force Characteristics of a Series of Lifting Cone and Cone-Cylinder Configurations at a Mach Number of 6.83 and Angles of Attack up to 130°. NASA TN D-840, June 1961.
160. Perkins, E. W., Jorgensen, L. H., and Sommer, S. C.: Investigation of the Drag of Various Axially Symmetric Nose Shapes of Fineness Ratio 3 for Mach Numbers from 1.24 to 7.4. NACA TN 1386. (Supersedes NACA RM A52H28 and NACA RM A52B13.)
161. Persh, J., and Lee, R.: A Method for Calculating Turbulent Boundary-Layer Development in Supersonic and Hypersonic Nozzles Including the Effects of Heat Transfer. NAVORD Report 4200, 1956.
162. Persh, J., and Lee, R.: Table of Turbulent Boundary-Layer Parameters. NAVORD Report 4282, 1956.
163. Persh, J.: A Procedure for Calculating the Boundary-Layer Development in the Region of Transition from Laminar to Turbulent Flow. NAVORD Report 4438, 1957.
164. Peterson, Victor L.: Motions of a Short 10° Blunted Cone Entering a Martian Atmosphere at Arbitrary Angles of Attack and Arbitrary Pitching Rates. NASA TN D-1326, 1962.
165. Potter, J. L.: New Experimental Investigations of Friction Drag and Boundary Layer Transition on Bodies of Revolution at Supersonic Speeds. NAVORD Report 2371, U. S. Naval Ord. Lab., White Oak, Md., April 24, 1952.
166. Powers, S. A., and O'Neill, J. B.: (Northrop Corp., Hawthorne, Calif.) Determination of Hypersonic Flow Fields by the Method of Characteristics. AIAA Journal, Vol. 1, pp 1693-1694, July 1963.
167. Pritchard, E. Brian: (Virginia Polytechnic Institute). The Stability of Several Missile Nose Configurations in Hypersonic Flow. Institute of the Aeronautical Sciences 1959 First Award Papers. IAS Student Branch Paper Competition, pp 120-147.
168. Probstein, R. F.: Interacting Hypersonic Laminar Boundary Layer Flow Over a Cone. Tech. Report AF 2798/1 (Contract AF33(616) - 2798), Div. Eng., Brown Univ., March 1955.
169. Rainey, Robert W.: Working Charts for Rapid Prediction of Force and Pressure Coefficients on Arbitrary Bodies of Revolution by Use of Newtonian Concepts. NASA TN D-176, 1959.

LIST OF REFERENCES (CONTINUED)

170. Randall, R. E., Bell, D. R., and Burk, J. L.: Pressure Distribution Tests of Several Sharp Leading Edge Wings, Bodies, and Body-Wing Combinations at Mach 5 and 8. AEDC-TN-60-173, September 1960.
171. Reller, J. O., Jr., and Hamaker, F. M.: An Experimental Investigation of Base Pressure Characteristics of Nonlifting Bodies of Revolution at Mach Numbers from 2.73 to 4.98. NACA TN 3393, March 1955. (Formerly NACA RMA52E20).
172. Replaced by reference 53A.
173. Roberts, Richard C., and Riley, James D.: A Guide to the Use of the M. I. T. Cone Tables. Jour. of Aero. Sci., Vol. 21, No. 5, p 336.
174. Rogers, R. H.: The Transition to Turbulence in a Boundary Layer on a Blunt Cone in Supersonic Flow. Jour. of Aero. Sci., Vol. 29, pp 501-502, April 1962.
175. Rossow, Vernon J.: Applicability of the Hypersonic Similarity Rule to Pressure Distributions which Include the Effects of Rotation for Bodies of Revolution at Zero Angle of Attack. NACA TN 2399, 1951.
176. Rott, N., and Crabtree, L. F.: Simplified Boundary-Layer Calculations for Bodies of Revolution and for Yawed Wings. Jour. of Aero. Sci., Vol. 19, No. 8, pp 553-565, August 1952.
177. Sacks, Alvin H.: Aerodynamic Forces, Moments, and Stability Derivatives for Slender Wings and Bodies of General Cross Section. NACA TN 3283, 1954.
178. Schaaf, S. A., Hurlbut, F. C. and Talbot, L.: Pressure Distributions on Blunt-Nosed Cones in Hypersonic Low Density Flow. California University, Berkeley, California, Bell Aircraft Report No. D143-978-010; ARDC TR-57-120, 30 April 1957. (Sub-Contract to Bell Aircraft Corp., Contract AF 18 (600) 1607) (See also Jet Propulsion, Vol. 28, pp 832-834, December 1958.)
179. Schmidt, L. E.: The Dynamic Properties of Pure Cones and Cone Cylinders. BRL-MR-759, January 1954.
180. Sears, William R.: On Projectiles of Minimum Wave Drag. Quart. App. Math., Vol. IV, No. 4, pp 361-366, January 1947.
181. Sedney, R., and Gerber, N.: (Ballistic Research Laboratories, Aberdeen Proving Ground, Md.) Nonequilibrium Flow over a Cone. AIAA Jour., Vol. 1, No. 11, pp 2482-2486, November 1963.
182. Seiff, Alvin, Sommer, Simon C., and Canning, Thomas N.: Some Experiments at High Supersonic Speeds on the Aerodynamic and Boundary-Layer Transition Characteristics of High-Drag Bodies of Revolution. NACA RM A56IO5, 1957.
183. Seiff, Alvin, and Whiting, Ellis E.: A Correlation Study of the Bow-Wave Profiles of Blunt Bodies, NASA TN D-1148, February 1962.

LIST OF REFERENCES (CONTINUED)

184. Sewall, J. L., Hess, R. W., and Watkins, C. E.: Analytical and Experimental Investigation of Flutter and Divergence of Spring-Mounted Cone Configurations at Supersonic Speeds. NASA TN D-1021, April 1962.
185. Shantz, I.: Cone Static Stability Investigation at Mach Numbers 1.56 through 4.24. NAVORD Report 3584, December 7, 1953.
186. Shaw, D. S., Fuller, D. E., and Babb, C. D.: Effects of Nose Bluntness, Fineness Ratio, Cone Angle, and Model Base on the Static Aerodynamic Characteristics of Blunt Bodies at Mach Numbers of 1.57, 1.80, and 2.16 and Angles of Attack up to 180°. NASA TN D-1781, May 1963.
187. Short, Barbara J., Whiting, Ellis E., Kruse, Robert L., and Malcom, Gerald N.: A Comparison of the Hypersonic Static Stability Characteristics of Blunt- and Pointed-Nosed Slender Entry Vehicles. NASA TMX-850, October 1963.
188. Simon, Wayne E., and Walter, Louise A.: (Martin Marietta Corp., Martin Co., Denver, Colorado) Approximation for Supersonic Flow Over Cones. AIAA Jour., Vol. 1, pp 1696-1698, July 1963.
189. Sims, Joseph L.: Supersonic Flow Around Right Circular Cones--Tables for Zero Angle of Attack, ABMA Report DA-TR-11-60.
190. Sims, Joseph L.: Supersonic Flow Around Right Circular Cones Tables for Small Angle of Attack. ABMA Report-DA-TR-19-60, April 27, 1960.
191. Solomon, G. E.: Transonic Flow Past Cone Cylinders, NACA TN 3213, September 1954.
192. Sommer, Simon C., and Stark, James A.: The Effect of Bluntness on the Drag of Spherical-Tipped Truncated Cones of Fineness Ratio 3 at Mach Numbers 1.2 to 7.4. NACA RMA52B13, April 25, 1952.
193. Speegle, K. C., Charvin, L. T., and Heberlig, J. C.: Heat Transfer for Mach Numbers up to 2.2 and Pressure Distributions for Mach Numbers up to 4.7 from Flight Investigation of a Flat-Face-Cone and a Hemisphere-Cone. NACA RM L58B18, May 8, 1958.
194. Spring, D. J.: The Static Stability and Drag of Three Blunted-Cone Re-Entry Bodies at Mach Numbers 15 and 18. AMC-RF-TR-63-17, July 1963.
195. Staff of the Computing Section, Center of Analysis (Under Direction of Zdeněk Kopál): Tables of Supersonic Flow Around Cones. Tech. Report No. 1, M. I. T., 1947.
196. Staff of the Computing Section, Center of Analysis (Under Direction of Zdeněk Kopál): Tables of Supersonic Flow Around Yawing Cones. Tech. Report No. 3, M. I. T., 1947.
197. Staff of the Computing Section, Center of Analysis (Under Direction of Zdeněk Kopál): Tables of Supersonic Flow Around Cones of Large Yaw. Tech. Report No. 5, M. I. T., 1949.
198. Stetson, K.: Preliminary Ablation Results for Sharp Cones. RAD-TM-63-18, April 1963.
199. Stivers, L. S., Jr., and Levy, L. L., Jr.: Longitudinal Force and Moment Data at Mach Numbers from 0.60 to 1.40 for a Family of Elliptic Cones with Various Semiapex Angles. NASA TN D-1149, December 1961.

LIST OF REFERENCES (CONTINUED)

200. Stocker, P. M., and Mauger, F. F.: Supersonic Flow Past Cones of General Cross-Section. Jour. Fluid Mech., Vol. 13, Part 3, pp 383-399, July 1962. (Armament Research and Development Establishment, War Office, Sevenoaks, Kent.)
201. Stone, A. H.: On Supersonic Flow Past a Slightly Yawing Cone. Jour. Math. and Phys., Vol. 27, No. 1, pp 67-81, April 1948.
202. Stone, A. H.: On Supersonic Flow Past a Slightly Yawing Cone. Jour. Math. and Phys., Vol. 30, 1952.
203. Strike, W. T., Jr., and Norton, B. B., Jr.: Flow Properties of an Unyawed 10-Deg Cone for $Y = 1.28$ to 1.40 at Mach Numbers of 1.5 to 8 . AEDC-TN-60-178, October 1960.
204. Syvertson, C. A., and McDevitt, J. B.: Effects of Mass Addition on the Stability of Slender Cones at Hypersonic Speeds. ARS Jour., April 1963.
205. Talbot, L.: Viscosity Corrections to Cone Probes in Rarefied Supersonic Flow at a Nominal Mach Number of 4. Univ. of Calif. Eng. Projects Report HE-150-113.
206. Talbot, L.: Viscosity Corrections to Cone Probes in Rarefied Supersonic Flow at a Nominal Mach Number of 4. NACA TN 3219, November 1954.
207. Talbot, L., Koga, T., and Sherman, P. M.: Hypersonic Viscous Flow Over Slender Cones. Jour. Aerospace Sci., Vol. 26, No. 11, pp 723-730, November 1959.
208. Taylor, G. I., and Maccoll, J. W.: The Air Pressure on a Cone Moving at High Speeds. Proc. Roy. Soc. (London), Ser. A, Vol. 139, No. 838, pp 278-311, February 1, 1933.
209. Tobak, Murray, and Wehrend, William R.: Stability Derivatives of Cones at Supersonic Speeds. NACA TN 3788, 1956.
210. Traugott, S. C.: Some Features of Supersonic and Hypersonic Flow About Blunted Cones. Jour. of Aero. Sci., Vol. 29, No. 4, pp 389-399, April 1962.
211. Treon, Stuart L.: Static Aerodynamic Characteristics of Short Blunt Cones with Various Nose and Base Cone Angles at Mach Numbers from 0.6 to 5.5 and Angles of Attack to 180° . NASA TN D-1327, 1962.
212. Tsien, Hsue-Shen: Supersonic Flow Over an Inclined Body of Revolution. Jour. of Aero. Sci., Vol. 5, No. 12, pp 480-483, October 1938.
213. Tsien, Hsue-Shen: Similarity Laws of Hypersonic Flows. Jour. of Math. and Phys., Vol. 25, No. 3, pp 252-259, October 1946.
214. Turner, Kenneth L., and Shaw, David S.: Wind-Tunnel Investigation at Mach Numbers from 1.60 to 4.50 of the Static-Stability Characteristics of Two Nonlifting Vehicles Suitable for Re-Entry. NASA MEMO 3-2-59L, 1959.
215. Vaglio-Laurin, R. and Trella, M.: A Study of Flow Fields about Some Typical Blunt-Nosed Slender Bodies. Polytechnic Institute of Brooklyn, PIBAL Report No. 623, December 1960.

LIST OF REFERENCES (CONTINUED)

216. Van Driest, E. R.: Turbulent Boundary Layer on a Cone in a Supersonic Flow at Zero Angle of Attack. Jour. of Aero. Sci., Vol. 19, No. 1, pp 55-57, 72, January 1952.
217. Van Dyke, Milton D.: A Study of Second-Order Supersonic-Flow Theory. NACA TN 2200, 1951.
218. Van Dyke, Milton D.: First-Order and Second-Order Theory of Supersonic Flow Past Bodies of Revolution. Jour. of Aero. Sci., Vol. 18, No. 3, pp 161-178, 216, March 1951.
219. Van Dyke, Milton D., Young, George B. W., and Siska, Charles: Proper Use of the M. I. T. Tables for Supersonic Flow Past Inclined Cones. Jour. of Aero. Sci., Vol. 18, No. 5, p 355.
220. von Kármán, Theodore, and Moore, Norton B.: Resistance of Slender Bodies Moving with Supersonic Velocities, with Special Reference to Projectiles. A. S. M. E., Vol. 54, No. 23, pp 303-310, December 15, 1932.
221. von Kármán, Theo.: The Problem of Resistance in Compressible Fluids. GALCIT Pub. No. 75, 1936. (From R. Acad. D'Italia, Vol. XIV, Roma, 1936.)
222. Wagner, Richard D., Jr., and Watson, Ralph: Induced Pressures and Shock Shapes on Blunt Cones in Hypersonic Flow. NASA TN D-2182, March 1964.
223. Wagner, Richard D., Jr., and Watson, Ralph: Reynolds Number Effects on the Induced Pressures of Cylindrical Bodies with Different Nose Shapes and Nose Drag Coefficients in Helium at a Mach Number of 24. NASA TR R-182, November 1963.
224. Ward, L. K., and Urban, R. H.: Dynamic Stability Tests of Three Re-Entry Configurations at Mach 8. AEDC TDR-62-11, January 1962.
225. Wehrend, William R., Jr., and Reese, David E., Jr.: Wind-Tunnel Tests of the Static and Dynamic Stability Characteristics of Four Ballistic Re-Entry Bodies. NASA TMX-369, 1960.
226. Wehrend, William R., Jr.: Wind-Tunnel Investigation of the Static and Dynamic Stability Characteristics of a 10° Semivertex Angle Blunted Cone. NASA TN D-1202, 1962.
227. Wehrend, William R., Jr.: An Experimental Evaluation of Aerodynamic Damping Moments of Cones with Different Centers of Rotation. NASA TN D-1768, March 1963.
228. Wehrend, William R., Jr.: A Wind-Tunnel Investigation of the Effect of Changes in Base Contour on the Damping in Pitch of a Blunted Cone. NASA TN D-2062, November 1963.
229. Wells, William R., and Armstrong, William O.: Tables of Aerodynamic Coefficients Obtained from Developed Newtonian Expressions for Complete and Partial Conic and Spheric Bodies at Combined Angles of Attack and Sideslip with Some Comparisons with Hypersonic Experimental Data. NASA TR R-127, 1962.
230. Whitfield, Jack D., and Potter, J. Leith: On Base Pressures at High Reynolds Numbers and Hypersonic Mach Numbers. AEDC-TN-60-61, March 1960.
231. Whitfield, Jack D., and Norfleet, Glenn D.: Source Flow Effects in Conical Hypervelocity Nozzles. AEDC-TDR-62-116, June 1962.

LIST OF REFERENCES (CONCLUDED)

232. Whitfield, J. D., and Wolney, W.: Hypersonic Static Stability of Blunt Slender Cones. AEDC-TDR-62-166, August 1962.
233. Whitfield, Jack D., and Wolney, W.: (ARO Inc. Arnold Air Force Station, Tenn.) Correlation of Hypersonic Static-Stability Data from Blunt Slender Cones. AIAA Jour., Vol. 1, No. 2, pp 486-487, February 1963.
234. Whitfield, Jack D., and Griffith, B. J.: Viscous Effects on Zero-Lift Drag of Slender Blunt Cones. AEDC-TDR-63-35.
235. Wilkinson, D. B., and Harrington, S. A. (Cornell Aeronautical Lab., Buffalo, N. Y.): Hypersonic Force, Pressure, and Heat Transfer Investigations of Sharp and Blunt Slender Cones, Cornell Aeronautical Lab., Report No. AF-1560-A-5, December 1962; AEDC-TDR-63-177, August 1963.
236. Wolny, William: Blunt Cone Force Tests at $M = 20$. AEDC-TDR-62-43, March 1962.
237. Wood, C. J.: Hypersonic Flow Over Spiked Cones. Jour. Fluid Mech., Vol. 12, Part 4, pp 614-624, April 1962.
238. Wood, Nigel B: Nose Bluntness Effects on Cone Pressure and Shock Shape at $M = 8.5$ to 12.9 . The War Office, Royal Armament Research and Development Establishment, Fort Halstead, England. AIAA Jour., Vol. 1, pp 1929-1930, August 1963.
239. Wu, T. Y.: Exact Solution for the Potential Flow About a Single Wedge. Appendix I of "The Hydroelastic Problem for the Knife Edges at the Entrance Section of the HME Water Brake Intake Ducts," by A. J. A. Morgan, AER, Inc. Design Memo. No. 502, January 10, 1956.
240. Yoshihara, H.: On the Flow Over a Cone-Cylinder Body at Mach Number One. WADC TR 52-295, Dayton, Ohio, 1952.
241. Young, G. B. W.: An Elucidation of Stone's Solution for a Slightly Yawing Supersonic Cone. Rand Corporation Research Memo. RM 48, July 20, 1948.
242. Young, G. B. W., and Siska, C. P.: Supersonic Flow Around Cones at Large Yaw. Jour. of Aero. Sci., Vol. 19, No. 2, p 111.
243. Zakkay, Victor, and Krause, Egon: (Polytechnic Institute of Brooklyn, Freeport, N. Y.) Boundary Conditions at the Outer Edge of the Boundary Layer on Blunted Conical Bodies. AIAA Jour., Vol. 1, pp 1671-1672, July 1963.
244. Zakkay, V.: Preliminary Experimental Investigation of the Flow About a Blunt Body with Flow-Separation Spikes at $M_{\infty} = 7.9$. Polytechnic Institute, Department Aerospace Eng. and Appl. Mech., Brooklyn, New York. PIBAL Report 631, AFOSR 219, February 1961.
245. Zumwalt, Glen W. and Tang, Homer H.: Pressures Exerted--On a Blunt-Based Cone Flying at Zero Yaw Angle at High Mach Numbers Before and After Encountering a Blast Wave. School of Mechanical Engineering, Oklahoma State University, Stillwater, Oklahoma. March 1963.

No. of copies	Distribution
165	Aero-Thermodynamics Standard Distribution
325	USAEC Division of Technical Information Extension
75	Clearinghouse, U. S. Department of Commerce

Issued by
Technical Information Division
Sandia Corporation
Albuquerque, New Mexico