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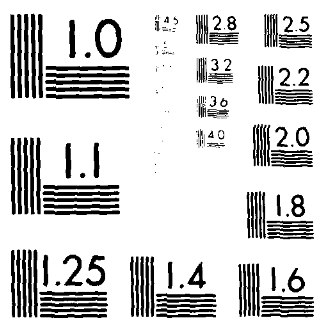

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MEMORANDUM REPORT ARBRL-MR-03079

SURFACE PRESSURE MEASUREMENTS ON A PROJECTILE SHAPE AT MACH 0.908

Lyle D. Kayser

February 1981

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

REPORT DOCUMENTATION PAGE

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Measurements of wall static pressures on a model shape with and without a boattail are reported. The model shape is similar to the M549 external geometry. Data were obtained at M = 0.908 at 10 longitudinal positions along the model. Measurements were made at 0, 1, 2.5, and 5.0 degrees angle of attack and at circumferential positions around the model in 10° increments.

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I. INTRODUCTION

A theorectical and experimental research program for providing the capability of predicting projectile aerodynamics has been underway in the Launch and Flight Division of BRL in recent years. Earlier efforts were predominately in the supersonic regime but more recently the efforts have been extended to the transonic regime. The predictive capability is to be achieved primarily by using modern finite-difference computational techniques. The objective of the experimental program is to obtain data for comparison to computations. The secant ogive-cylinder-boattail (Figure 1) shape was chosen because a substantial quantity of experimental and computational data already exist for this shape which is typical of modern, low drag shell. The shape has been simplified, with respect to conventional shell, by using a pointed nose and by eliminating the rotating band. Some examples of the data for this shape which have been reported are: (1) surface pressure measurements at supersonic speeds by Reklis[1]; (2) turbulent boundary layer measurements by Kayser and Sturek[2,3]; aerodynamic coefficient data by Nietubicz and Opalka[4]. A major motivation for obtaining the transonic

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1. *R. P. Reklis and W. B. Sturek, "Surface Pressure Measurements on Slender Bodies at Angle of Attack in Supersonic Flow," USA ARRADCOM, Ballistic Research Laboratory Memorandum Report No. 02876, November 1978, AD A064097.*

2. *L. D. Kayser and W. B. Sturek, "Experimental Measurements in the Turbulent Boundary Layer of a Yawed, Spinning Ogive-Cylinder Body of Revolution at M = 3.0. Part 1: Description of the Experiment and Data Analysis," USA ARRADCOM, Ballistic Research Laboratory Memorandum Report No. 02808, January 1978, AD A052301.*

3. *L. D. Kayser and W. B. Sturek, "Turbulent Boundary Layer Measurements on the Boattail Section of a Yawed, Spinning Projectile Shape at Mach 3.0," USA ARRADCOM, Ballistic Research Laboratory Memorandum Report No. 02880, November 1978, AD A052301.*

4. *C. J. Nietubicz and K. O. Opalka, "Supersonic Wind Tunnel Measurements of Static and Magnus Aerodynamic Coefficients for Projectile Shapes with Tangent and Secant Ogive Noses," USA ARRADCOM, Ballistic Research Laboratory Memorandum Report No. 02991, February 1980, AD 083297.*

pressure measurements was the research effort by Reklis[5] involving computation of transonic flow for projectiles at angle of attack.

II. EXPERIMENT

Surface pressure measurements were obtained for the secant-ogive-cylinder (SOC) model and the secant-ogive-cylinder with a 7° boattail (SOCBT) shown in Figure 1. Both models were 6 calibers long and identical in shape except that the SOC had a zero degree boattail angle. The model was instrumented with 10 pressure taps located along a single ray and positioned longitudinally at stations listed in Table 1. The tests were conducted in the Supersonic Wind Tunnel No. 2 of the Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, Maryland; this tunnel has an open jet test section with a nozzle exit size of 40.6 × 40.6 cm. Data were obtained at Mach 0.908 with a supply pressure and temperature of approximately one atmosphere and 328°K, respectively. These test conditions provide a Reynolds number of 4.5×10^6 based on model length. Data were recorded at 0, 1.0, 2.5, and 5.0 degrees angle of attack and the model was rolled from 0 to 180° in 10 degree increments to provide circumferential pressure distributions.

III. RESULTS

Surface pressure measurements for both configurations are presented in Tables 2 and 3. Pressure measurements are nondimensionalized by dividing by the free-stream static pressure. Data are tabulated so that pressure distributions can be conveniently obtained as a function of roll angle (PHI) or longitudinal position (Z/D).

Longitudinal pressure distributions for the windward and leeward sides of the model are shown in Figures 2 and 3. Figures 2a, b, and c compare pressure measurements on the SOC with the inviscid computations. At zero angle of attack agreement on the ogive is good. There are not enough experimental points to define the sharp expansion at the ogive cylinder junction but the one pressure measurement at Z/D = 3.13 does confirm the existence of the pressure drop. On the cylinder between Z/D of 3.5 to 5.0 the experimental pressures are higher by about 3%; this is interpreted as a boundary layer displacement thickness effect. Moving toward the base, the measured pressures drop below the inviscid computations. The base region, for the computations, is usually approximated by extending the model shape for one caliber; this

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5. *R. P. Reklis, W. B. Sturek and F. R. Bailey, "Computation of Transonic Flow Past Projectiles at Angle of Attack," USA ARRADCOM, Ballistic Research Laboratory Technical Report No. 02139, February 1979, AD A069106.*

technique has been used since numerous photographs seem to show a separated shear layer extending approximately parallel to the boattail surface. The inviscid flow was also computed assuming a one degree turn at the base. The effect of this one degree turn on the inviscid flow computation is shown in Figure 2a and gives better agreement with the experimental measurement. Figures 2b and 2c show the SOC pressure distribution at 2.5 and 5.0 degrees. The pressures on the ogive are slightly higher than the computed values; however, the difference in pressure from windward to leeward is approximately the same for both the computed and measured pressures. It is of interest to note that there is no difference in windward and leeward pressures on the cylinder for both the experimental data and the computational data.

Figures 3a, b, and c show the pressure distribution on the SOCBT. Again, there are not enough pressure taps to define the sharp pressure drop at the cylinder-boattail junction. The measured pressure at Z/D = 4.88 on the cylinder just before the junction shows a pressure drop which indicates that the flow anticipates the sharp expansion at the boattail. On the boattail, at angle of attack, the difference between experimental windward and leeward pressures is not as large as for the inviscid pressures; this is also believed to be a boundary layer displacement effect since addition of a thickening boundary layer on the boattail would decrease the turning angle and hence decrease the boattail effect. Also, it is seen both experimentally and computationally, that the leeward boattail pressures are larger than the windward pressures.

Figure 4 is a shadowgraph of the SOCBT. Although the picture is not too clear, the expansions and shock waves can be seen in the vicinity of the ogive-cylinder and cylinder-boattail junctions. Qualitatively the shock waves are seen to be at about the same longitudinal position as the sharp pressure rise as shown on the pressure plots.

Circumferential pressure distributions (Figure 5) are shown for three longitudinal stations on the SOCBT configuration at $\alpha = 5.0$ degree. The windward pressure is larger than the leeward pressure on the ogive and the reverse is true for the boattail. These pressure distributions illustrate why the pitching moment for boattailed configurations reach critical values at transonic velocities. Positive normal force on the ogive and the negative normal force on the boattail form a couple which results in a large positive pitching moment.

IV. SUMMARY

Surface pressure measurements were obtained on a projectile shape at a Mach number of 0.908. These experimental data compliment available supersonic data for the same configurations. The experimental results have been valuable in evaluating computational codes; however, more pressure taps are needed to define the pressure distribution more completely. The existance of mixed subsonic-supersonic flow on the model at a free-stream Mach number of 0.908 illustrates the basic features of the flow at transonic velocities but data for a wide range of transonic Mach numbers are needed.

REFERENCES

1. R. P. Reklis and W. B. Sturek, "Surface Pressure Measurements on Slender Bodies at Angle of Attack in Supersonic Flow," USA ARRADCOM, Ballistic Research Laboratory Memorandum Report No. 02876, November 1978, AD A064097.

2. L. D. Kayser and W. B. Sturek, "Experimental Measurements in the Turbulent Boundary Layer of a Yawed, Spinning Ogive-Cyinder Body of Revolution at M = 3.0. Part 1: Description of the Experiment and Data Analysis," USA ARRADCOM, Ballistic Research Laboratory Memorandum Report No. 02808, January 1978, AD A052301.

3. L. D. Kayser and W. B. Sturek, "Turbulent Boundary Layer Measurements on the Boattail Section of a Yawed, Spinning Projectile Shape at Mach 3.0," USA ARRADCOM, Ballistic Research Laboratory Memorandum Report No. 02880, November 1978, AD A065355.

4. C. J. Nietubicz and K. O. Opalka, "Supersonic Wind Tunnel Measurements of Static and Magnus Aerodynamic Coefficients for Projectile Shapes with Tangent and Secant Ogive Noses," USA ARRADCOM, Ballistic Research Laboratory Memorandum Report No. 02991, February 1980, AD A083297.

5. R. P. Reklis, W. B. Sturek and F. R. Bailey, "Computation of Transonic Flow Past Projectiles at Angle of Attack," USA ARRADCOM, Ballistic Research Laboratory Technical Report No. 02139, February 1979, AD A069106.

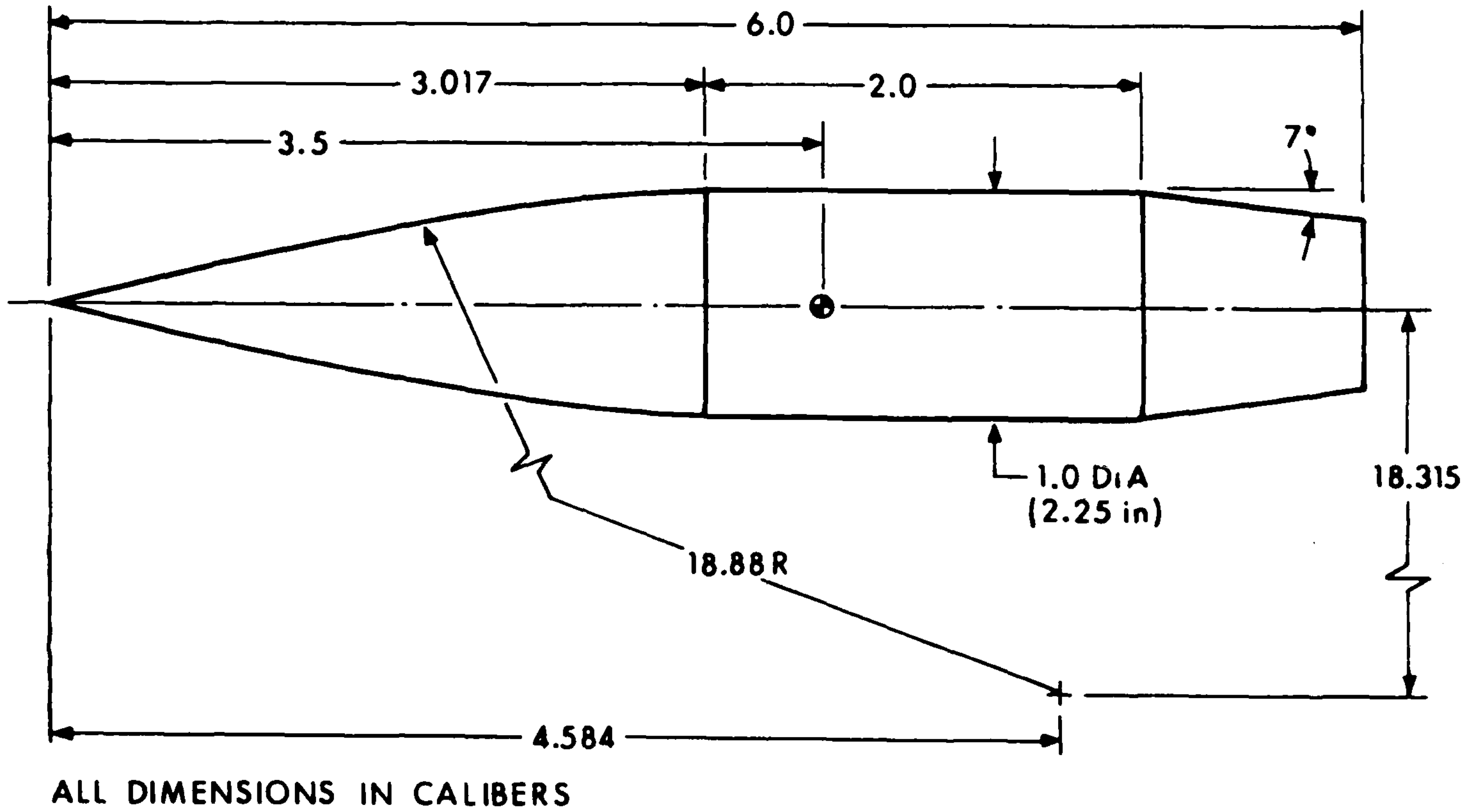

Figure 1. Model Geometry

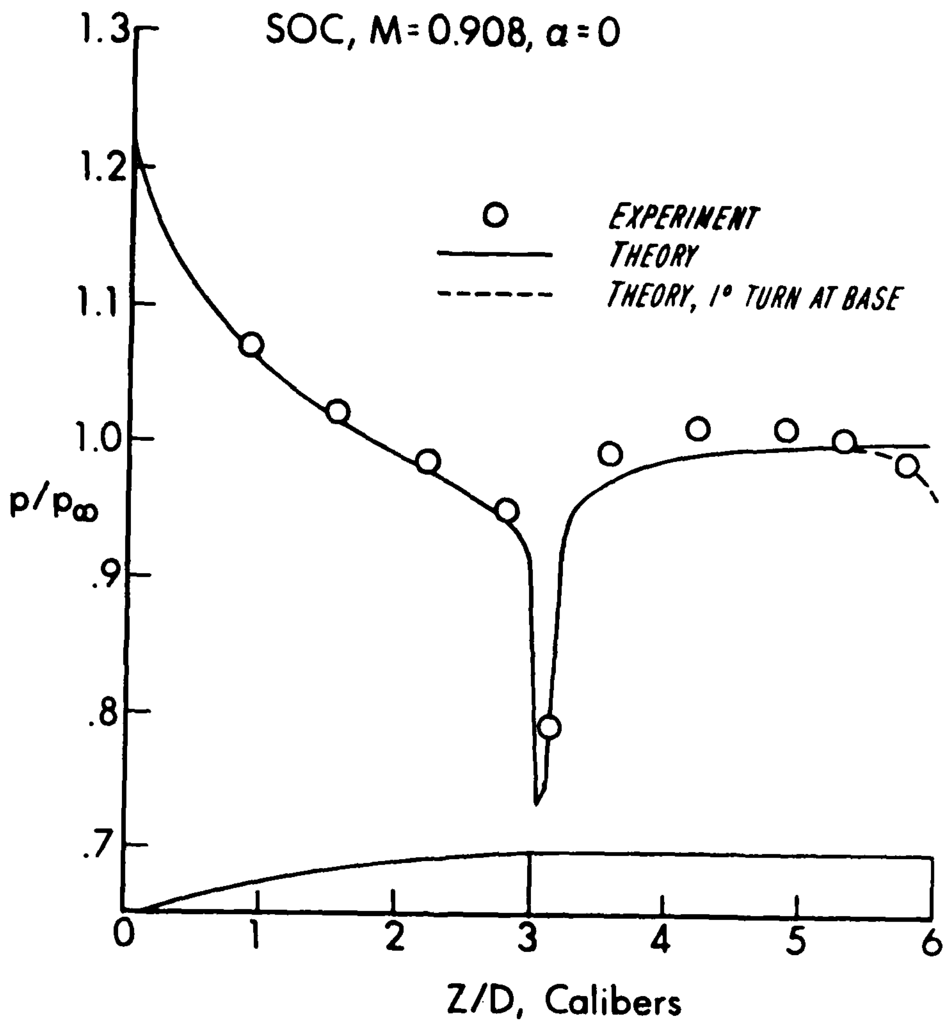

Figure 2. SOC Pressure Distribution

a. $\alpha = 0$

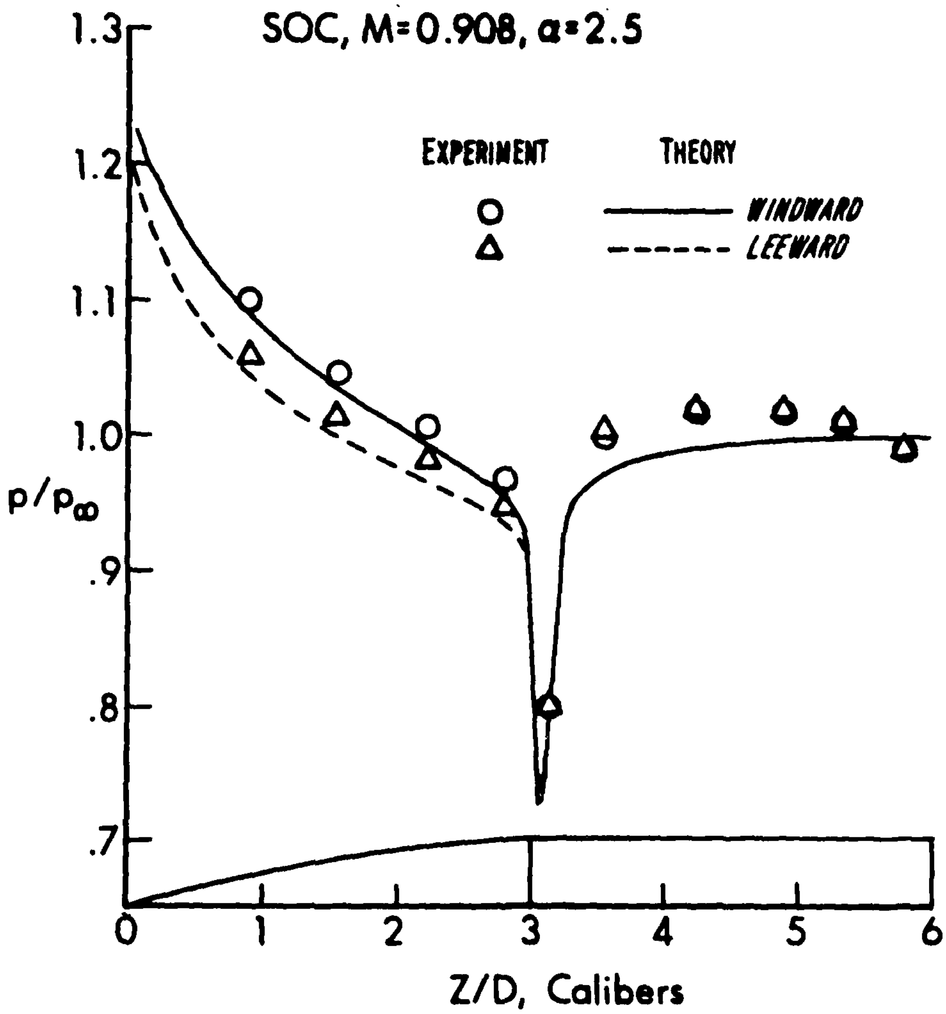

Figure 2. (Cont'd)

b. α = 2.5

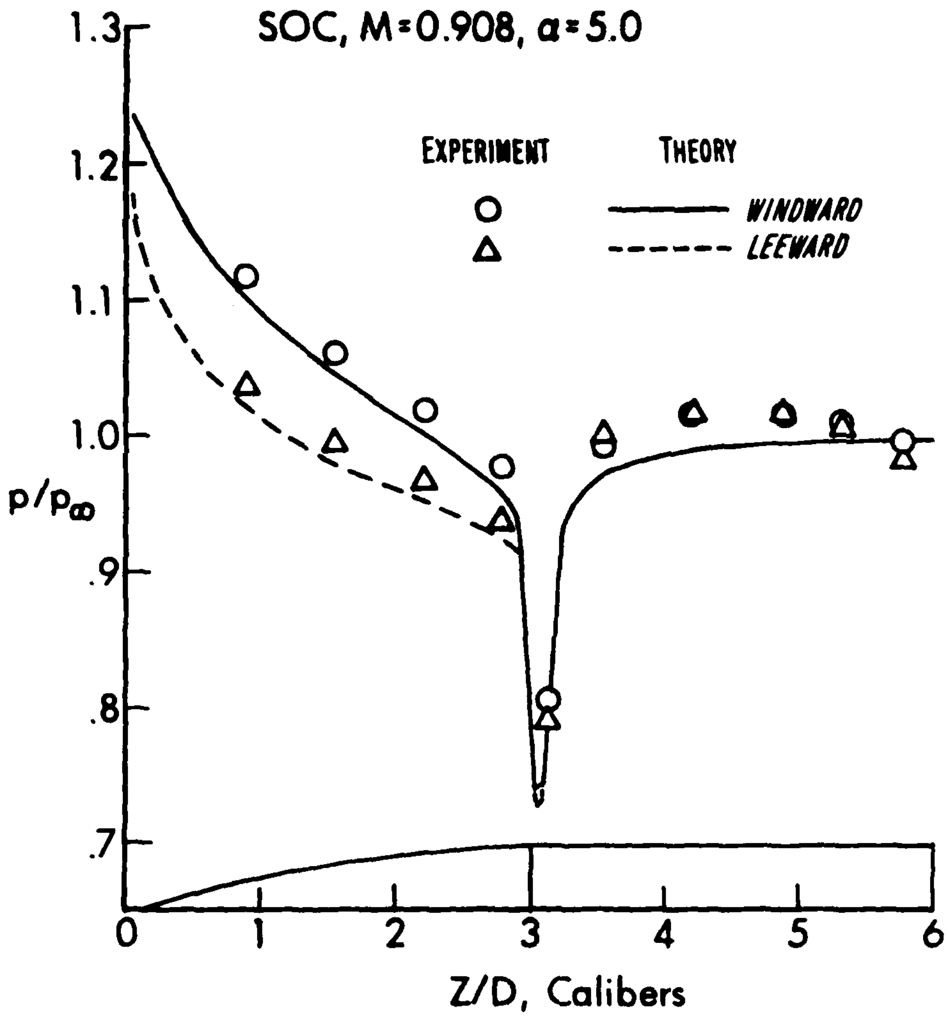

Figure 2. (Cont'd)

c. α = 5.0

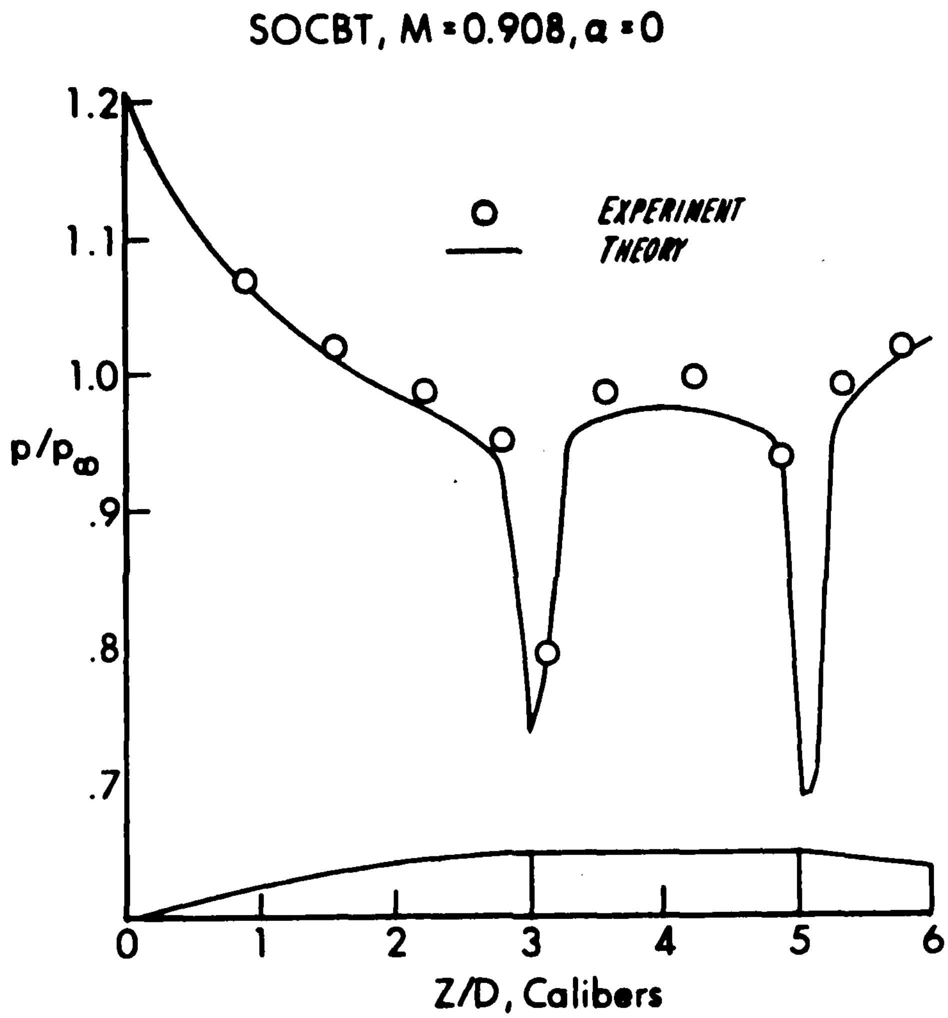

Figure 3. SOCBT Pressure Distribution

a. $\alpha = 0$

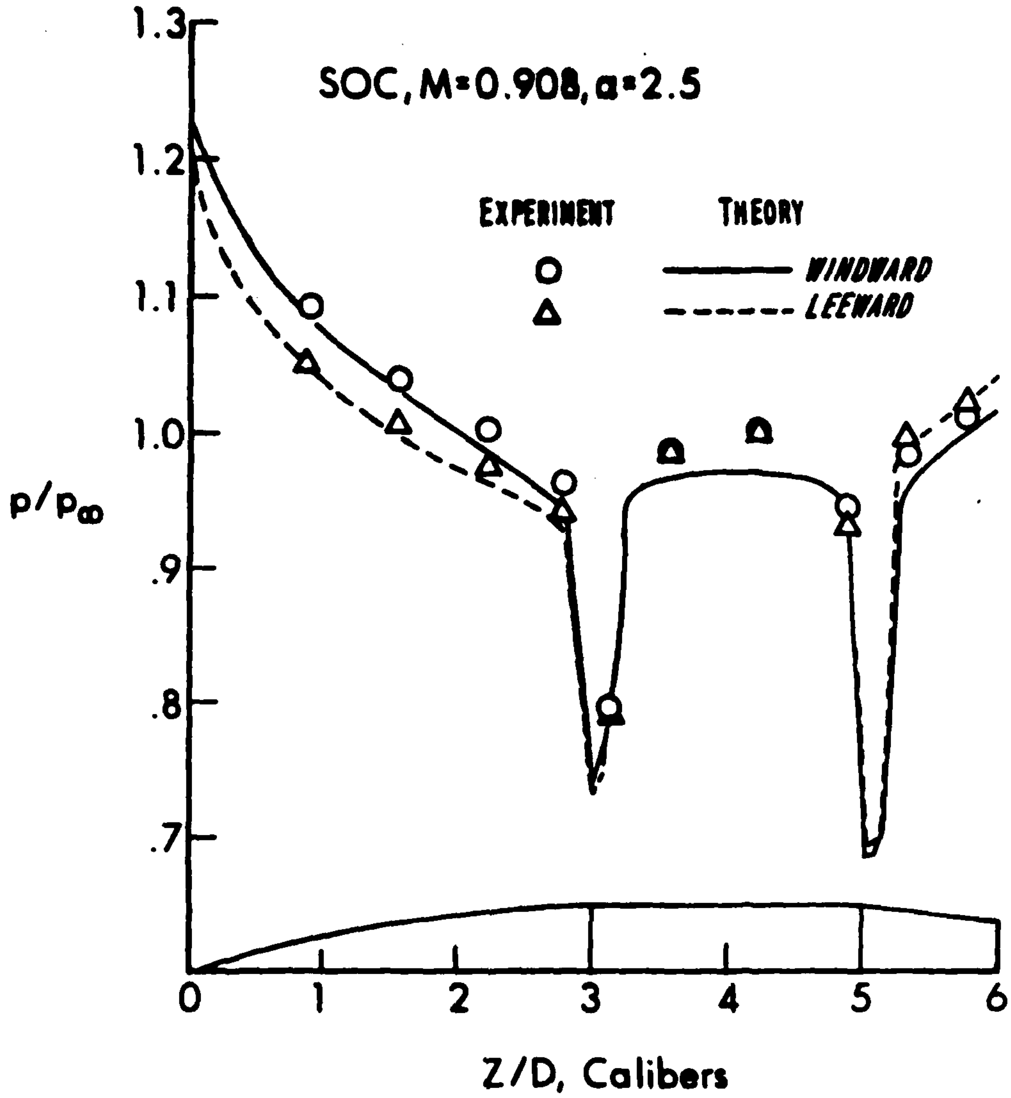

Figure 3. (Cont'd)

b. $\alpha = 2.5$

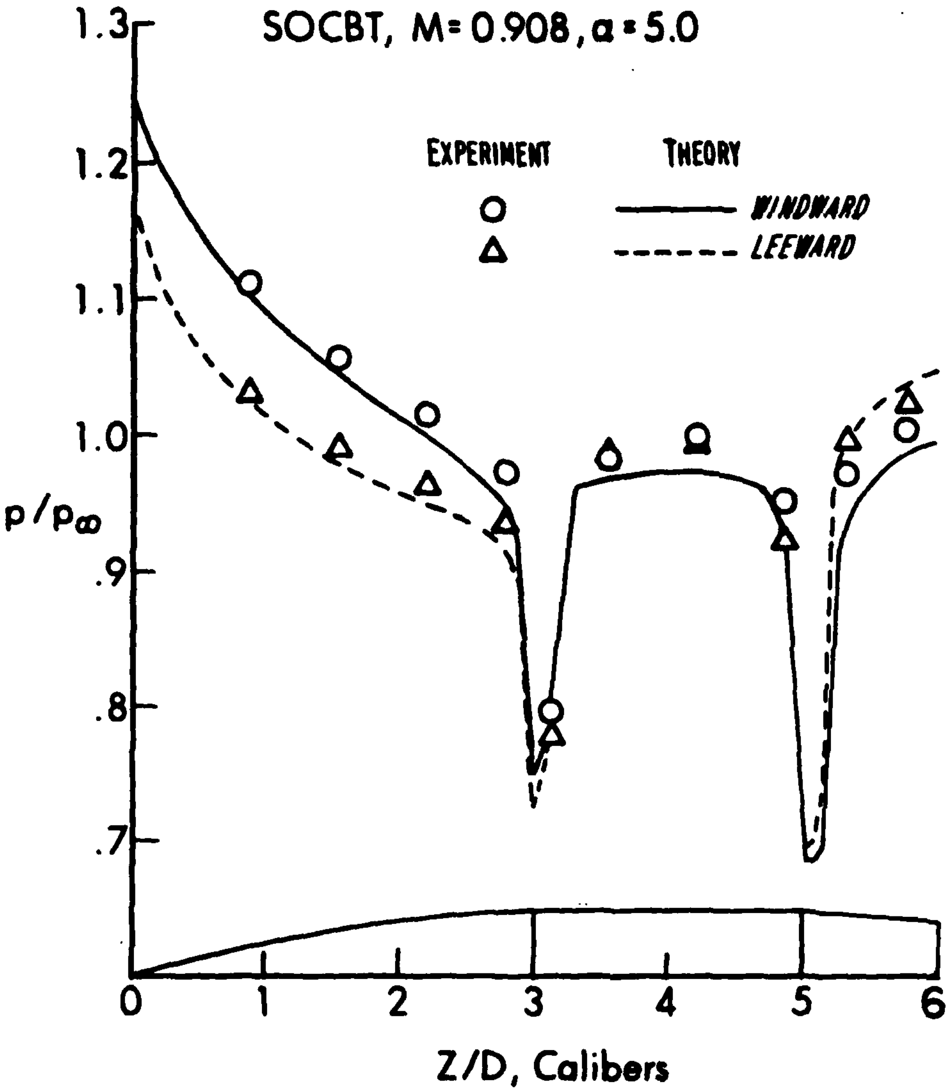

Figure 3. (Cont'd)

c. α = 5.0

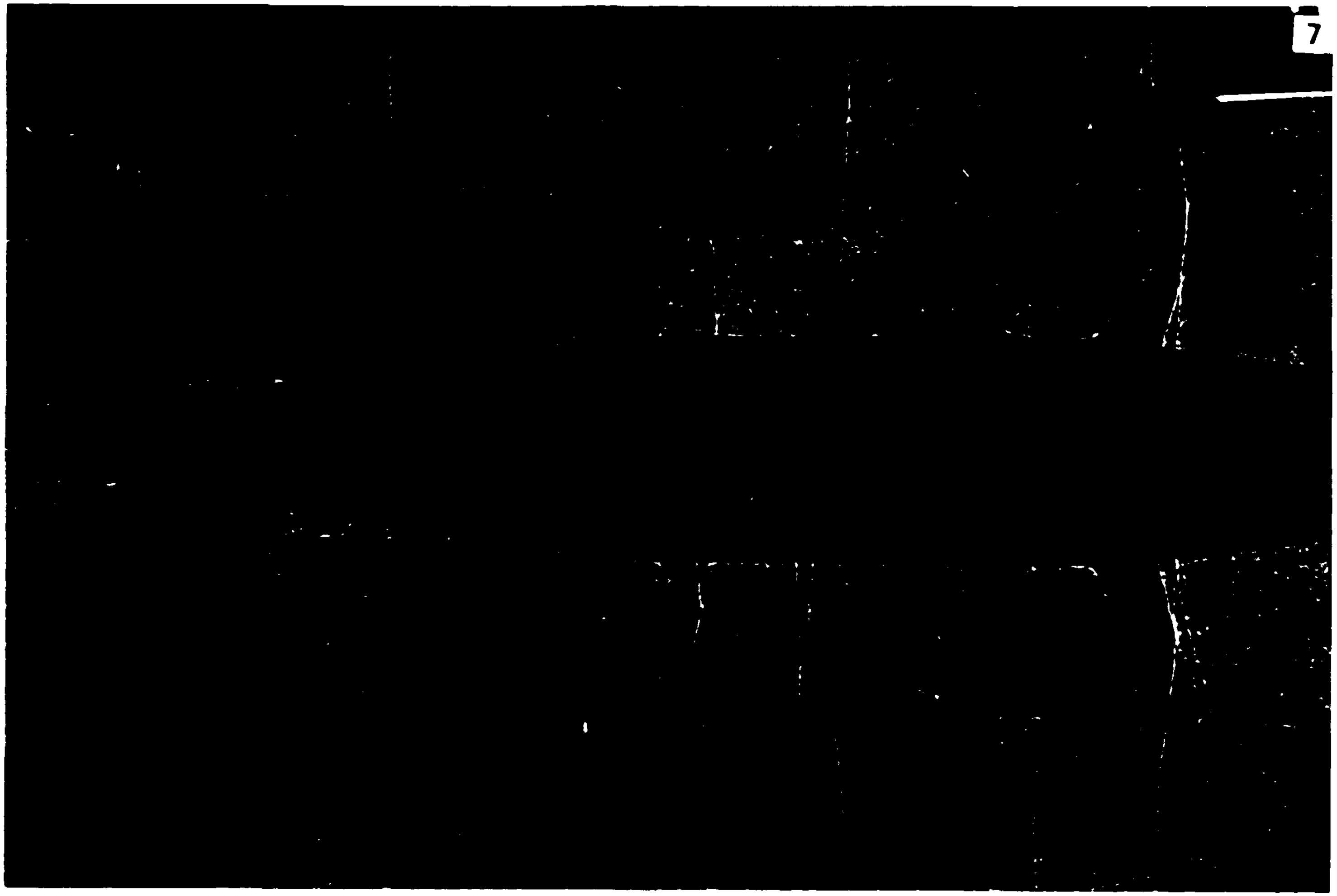

Figure 4. SOCBT Shadowgraph, $\alpha = 0$

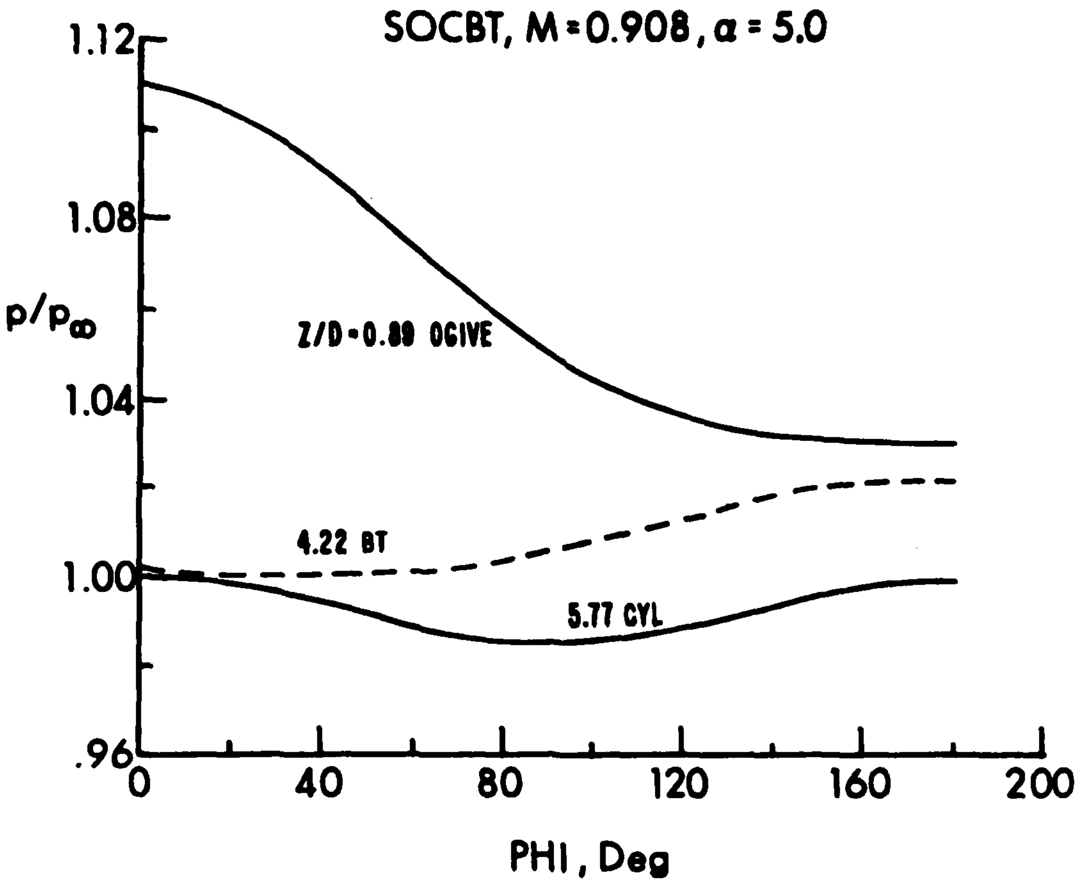

Figure 5. Circumferential Pressure Distribution, SOCBT

Tap	Distance from Nose (Calibers)
1	.89
2	1.56
3	2.22
4	2.79
5	3.13
6	3.56
7	4.22
8	4.88
9	5.32
10	5.77

Table 1. Pressure Tap Locations

SECANT-OGIVE CYLINDER

M=0.91 ALPHA=0.00 PS=59.9 KPA TO=325 K REL=4.45X10**6

PHI	P1/PS	P2/PS	P3/PS	P4/PS	P5/PS	P6/PS	P7/PS	P8/PS	P9/PS	P10/PS
0.	1.075	1.028	.993	.956	.799	.998	1.016	1.017	1.008	.994
10.	1.075	1.027	.992	.955	.799	.997	1.016	1.017	1.008	.994
20.	1.075	1.028	.992	.956	.799	.997	1.016	1.017	1.008	.994
30.	1.074	1.027	.992	.956	.800	.998	1.017	1.017	1.009	.994
40.	1.073	1.027	.992	.955	.799	.997	1.016	1.017	1.008	.994
50.	1.073	1.027	.992	.955	.800	.997	1.017	1.017	1.008	.994
60.	1.073	1.026	.991	.955	.800	.997	1.016	1.017	1.008	.994
70.	1.071	1.025	.989	.954	.798	.995	1.015	1.015	1.006	.992
80.	1.071	1.025	.990	.954	.799	.996	1.016	1.015	1.007	.992
90.	1.070	1.025	.989	.954	.799	.995	1.015	1.015	1.007	.992
100.	1.070	1.024	.989	.954	.798	.995	1.014	1.014	1.006	.991
110.	1.069	1.023	.988	.952	.796	.994	1.013	1.013	1.005	.989
120.	1.070	1.024	.989	.953	.798	.994	1.014	1.014	1.006	.991
130.	1.069	1.023	.988	.952	.795	.994	1.013	1.013	1.005	.989
140.	1.069	1.023	.986	.952	.795	.994	1.013	1.013	1.005	.989
149.	1.068	1.022	.986	.951	.793	.993	1.011	1.011	1.003	.987
160.	1.068	1.022	.986	.951	.793	.993	1.011	1.011	1.003	.987
170.	1.069	1.022	.986	.951	.792	.993	1.012	1.012	1.003	.987
180.	1.069	1.021	.986	.951	.791	.993	1.011	1.011	1.003	.986
Z/D=	0.89	1.56	2.22	2.79	3.13	3.56	4.22	4.86	5.32	5.77

Table 2. SOC Pressure Distribution

a. $\alpha = 0$

SECANT-OGIVE CYLINDER

M=0.91 ALPHA=1.00 PS=59.9 KPA TO=325 K REL=4.45X10**6

PHI	P1/PS	P2/PS	P3/PS	P4/PS	P5/PS	P6/PS	P7/PS	P8/PS	P9/PS	P10/PS
0.	1.084	1.033	.997	.959	.801	.996	1.015	1.015	1.008	.994
10.	1.083	1.033	.996	.959	.801	.996	1.015	1.015	1.007	.994
20.	1.082	1.033	.996	.959	.801	.996	1.015	1.016	1.008	.994
30.	1.081	1.031	.995	.958	.801	.996	1.015	1.015	1.007	.994
40.	1.079	1.030	.994	.957	.800	.995	1.014	1.015	1.007	.993
50.	1.077	1.029	.993	.956	.800	.995	1.015	1.015	1.007	.993
60.	1.076	1.028	.993	.956	.801	.995	1.015	1.015	1.007	.993
70.	1.074	1.027	.992	.955	.801	.996	1.015	1.015	1.007	.993
80.	1.072	1.026	.991	.955	.802	.996	1.015	1.016	1.007	.993
90.	1.072	1.026	.991	.955	.803	.997	1.016	1.017	1.008	.993
100.	1.070	1.024	.989	.953	.802	.996	1.016	1.016	1.007	.992
110.	1.069	1.023	.989	.953	.802	.997	1.016	1.016	1.008	.992
120.	1.068	1.022	.988	.952	.802	.997	1.016	1.016	1.008	.992
130.	1.067	1.021	.988	.952	.802	.997	1.016	1.016	1.008	.991
140.	1.066	1.021	.987	.951	.802	.998	1.015	1.016	1.008	.991
150.	1.066	1.020	.987	.951	.802	.998	1.016	1.016	1.008	.991
159.	1.066	1.020	.986	.951	.802	.998	1.017	1.017	1.008	.992
170.	1.066	1.020	.986	.951	.801	.998	1.017	1.017	1.008	.991
180.	1.066	1.020	.986	.951	.801	.998	1.017	1.016	1.008	.991
Z/D=	0.89	1.56	2.22	2.79	3.13	3.56	4.22	4.68	5.32	5.77

Table 2. (Cont'd)

b. $\alpha = 1.0$

SECANT-OGIVE CYLINDER

M=0.91 ALPHA=2.50 PS=59.9 KPA TO=325 K REL=4.45X10**6

PHI	P1/PS	P2/PS	P3/PS	P4/PS	P5/PS	P6/PS	P7/PS	P8/PS	P9/PS	P10/PS
-0.	1.095	1.042	1.004	.965	.798	.994	1.014	1.014	1.007	.993
10.	1.094	1.041	1.003	.964	.798	.994	1.013	1.014	1.006	.993
20.	1.092	1.040	1.002	.963	.797	.993	1.013	1.014	1.006	.993
30.	1.089	1.037	1.000	.962	.796	.992	1.013	1.013	1.006	.992
40.	1.086	1.035	.998	.960	.794	.992	1.012	1.013	1.005	.992
50.	1.082	1.031	.995	.957	.793	.991	1.011	1.011	1.004	.990
60.	1.077	1.028	.992	.955	.791	.990	1.010	1.011	1.003	.989
70.	1.074	1.026	.990	.953	.792	.991	1.011	1.011	1.004	.989
80.	1.071	1.023	.988	.952	.791	.992	1.011	1.012	1.004	.989
90.	1.067	1.020	.986	.950	.791	.992	1.011	1.011	1.003	.988
100.	1.063	1.017	.983	.948	.789	.993	1.010	1.011	1.003	.987
110.	1.062	1.016	.983	.948	.792	.994	1.013	1.012	1.004	.986
120.	1.059	1.014	.981	.946	.792	.995	1.013	1.012	1.004	.987
130.	1.057	1.012	.980	.945	.793	.996	1.014	1.013	1.005	.987
140.	1.055	1.011	.979	.945	.794	.998	1.014	1.014	1.005	.987
149.	1.054	1.010	.978	.944	.796	.999	1.015	1.014	1.006	.987
160.	1.054	1.011	.978	.945	.797	1.000	1.016	1.016	1.006	.988
170.	1.054	1.010	.978	.944	.798	1.001	1.016	1.015	1.007	.988
180.	1.054	1.010	.978	.944	.798	1.001	1.016	1.015	1.006	.987
L/D=	0.89	1.56	2.22	2.79	3.13	3.56	4.22	4.88	5.32	5.77

Table 2. (Cont'd)

c. $\alpha = 2.5$

SECANT-OGIVE CYLINDER

M=0.91 ALPHA=5.00 PS=59.9 KPA TO=325 K REL=4.45X10**6

PHI	P1/PS	P2/PS	P3/PS	P4/PS	P5/PS	P6/PS	P7/PS	P8/PS	P9/PS	P10/PS
-0.	1.118	1.061	1.020	.978	.806	.993	1.016	1.017	1.009	.996
10.	1.116	1.059	1.019	.977	.805	.992	1.016	1.016	1.009	.995
20.	1.111	1.055	1.015	.973	.802	.990	1.014	1.014	1.007	.993
30.	1.105	1.050	1.010	.969	.799	.987	1.011	1.012	1.004	.991
40.	1.097	1.043	1.004	.964	.795	.985	1.008	1.009	1.002	.988
50.	1.089	1.036	.998	.959	.791	.982	1.006	1.007	.999	.985
60.	1.080	1.029	.992	.954	.782	.980	1.004	1.004	.997	.982
70.	1.072	1.022	.986	.951	.772	.979	1.002	1.003	.995	.980
80.	1.064	1.015	.981	.948	.763	.980	1.002	1.002	.994	.978
90.	1.056	1.009	.977	.945	.754	.980	1.001	1.001	.994	.977
100.	1.051	1.004	.974	.943	.751	.982	1.002	1.002	.995	.977
110.	1.045	1.001	.972	.941	.753	.985	1.004	1.004	.996	.977
120.	1.041	.997	.969	.938	.755	.987	1.005	1.005	.997	.977
130.	1.039	.996	.968	.938	.768	.991	1.008	1.008	1.000	.978
140.	1.038	.996	.968	.938	.779	.995	1.011	1.010	1.002	.980
150.	1.036	.995	.967	.937	.783	.997	1.012	1.012	1.003	.980
160.	1.036	.994	.967	.937	.789	1.000	1.015	1.013	1.005	.982
170.	1.036	.995	.967	.937	.790	1.001	1.017	1.015	1.006	.983
180.	1.036	.995	.967	.937	.791	1.002	1.017	1.016	1.006	.983
X/D=	0.89	1.56	2.22	2.79	3.13	3.56	4.22	4.88	5.32	5.77

Table 2. (Cont'd)

d. $\alpha = 5.0$

SECANT-OGIVE CYLINDER BOATTAIL

M=0.91 ALPHA=0.00 PS=59.9 KPA TO=325 K REL=4.45X10**6

PHI	P1/PS	P2/PS	P3/PS	P4/PS	P5/PS	P6/PS	P7/PS	P8/PS	P9/PS	P10/PS
-0.	1.071	1.024	.989	.953	.798	.989	1.002	.940	.994	1.020
10.	1.071	1.024	.989	.952	.798	.989	1.002	.939	.994	1.020
20.	1.070	1.023	.988	.952	.797	.988	1.001	.939	.994	1.020
30.	1.070	1.023	.989	.952	.798	.989	1.002	.939	.994	1.021
40.	1.069	1.023	.988	.952	.798	.989	1.002	.939	.994	1.021
50.	1.069	1.023	.989	.952	.798	.989	1.002	.939	.994	1.021
60.	1.069	1.023	.989	.952	.798	.989	1.002	.939	.995	1.021
70.	1.069	1.023	.989	.952	.797	.989	1.003	.939	.995	1.022
80.	1.069	1.023	.990	.953	.797	.989	1.003	.940	.996	1.022
90.	1.067	1.022	.988	.952	.796	.988	1.002	.939	.994	1.021
100.	1.067	1.022	.988	.952	.796	.988	1.002	.939	.994	1.021
110.	1.068	1.022	.989	.953	.797	.986	1.003	.940	.995	1.021
120.	1.068	1.022	.988	.952	.796	.988	1.002	.939	.994	1.021
130.	1.068	1.021	.988	.952	.795	.987	1.002	.939	.994	1.020
140.	1.067	1.020	.987	.951	.794	.987	1.001	.938	.993	1.019
150.	1.067	1.021	.987	.951	.794	.987	1.001	.938	.993	1.020
160.	1.067	1.020	.986	.950	.793	.987	1.001	.938	.992	1.019
170.	1.067	1.020	.986	.951	.793	.987	1.001	.938	.992	1.019
180.	1.067	1.020	.985	.950	.792	.986	1.000	.937	.991	1.018
X/D=	0.89	1.56	2.22	2.79	3.13	3.56	4.22	4.88	5.32	5.77

Table 3. SOCBT Pressure Distribution

a. $\alpha = 0$

SECANT-OGIVE CYLINDER BOATTAIL

M=0.91 ALPHA=1.00 PS=59.9 KPA TO=325 K REL=4.45X10**6

PHI	P1/PS	P2/PS	P3/PS	P4/PS	P5/PS	P6/PS	P7/PS	P8/PS	P9/PS	P10/PS
-0.	1.079	1.030	.995	.957	.799	.988	1.002	.942	.991	1.018
10.	1.078	1.029	.994	.956	.799	.988	1.001	.942	.991	1.017
20.	1.077	1.028	.993	.956	.798	.988	1.001	.942	.991	1.018
30.	1.076	1.028	.993	.955	.798	.988	1.001	.942	.991	1.018
40.	1.075	1.026	.992	.954	.797	.988	1.001	.941	.992	1.018
50.	1.073	1.026	.991	.954	.798	.988	1.001	.941	.993	1.019
60.	1.072	1.025	.991	.953	.798	.988	1.001	.941	.993	1.020
70.	1.071	1.024	.990	.953	.798	.989	1.001	.940	.994	1.020
80.	1.069	1.023	.989	.952	.798	.989	1.002	.940	.994	1.020
90.	1.067	1.021	.988	.951	.797	.988	1.001	.939	.994	1.020
100.	1.066	1.021	.988	.951	.798	.989	1.002	.939	.995	1.021
110.	1.065	1.019	.987	.950	.797	.989	1.001	.938	.995	1.021
120.	1.063	1.018	.985	.949	.797	.988	1.001	.938	.995	1.021
130.	1.063	1.017	.985	.949	.797	.988	1.001	.937	.996	1.021
140.	1.062	1.017	.984	.949	.797	.989	1.001	.937	.996	1.022
150.	1.061	1.016	.983	.948	.797	.989	1.001	.936	.996	1.021
160.	1.061	1.016	.983	.948	.797	.989	1.002	.936	.996	1.022
170.	1.061	1.015	.982	.947	.797	.989	1.002	.936	.996	1.021
180.	1.061	1.016	.982	.947	.796	.989	1.002	.936	.995	1.021
Z/D=	0.89	1.56	2.22	2.79	3.13	3.56	4.22	4.88	5.32	5.77

Table 3. (Cont'd)

b. $\alpha = 1.0$

SECANT-OGIVE CYLINDER BOATTAIL

M=0.91 ALPHA=2.50 PS=59.9 KPA TO=325 K REL=4.45X10**6

PHI	P1/PS	P2/PS	P3/PS	P4/PS	P5/PS	P6/PS	P7/PS	P8/PS	P9/PS	P10/PS
-0.	1.091	1.039	1.002	.963	.798	.987	1.001	.946	.985	1.012
10.	1.089	1.038	1.001	.962	.798	.987	1.001	.946	.985	1.013
20.	1.088	1.037	1.000	.961	.797	.986	1.001	.945	.986	1.013
30.	1.085	1.034	.998	.959	.795	.985	1.000	.944	.986	1.013
40.	1.082	1.032	.996	.958	.795	.985	.999	.943	.986	1.013
50.	1.079	1.029	.994	.956	.795	.985	.999	.942	.987	1.014
60.	1.074	1.026	.991	.953	.793	.984	.997	.939	.988	1.014
70.	1.071	1.023	.989	.951	.794	.984	.998	.938	.989	1.015
80.	1.067	1.021	.986	.950	.793	.985	.998	.938	.990	1.016
90.	1.064	1.016	.985	.948	.793	.985	.998	.937	.992	1.018
100.	1.061	1.015	.982	.946	.793	.986	.998	.936	.993	1.018
110.	1.059	1.013	.981	.945	.792	.986	.998	.935	.994	1.019
120.	1.056	1.012	.980	.944	.793	.987	.999	.935	.996	1.021
130.	1.053	1.009	.978	.943	.793	.987	.999	.933	.996	1.021
140.	1.052	1.008	.977	.943	.794	.988	1.000	.933	.997	1.022
150.	1.051	1.007	.976	.942	.794	.989	1.000	.933	.998	1.023
160.	1.050	1.006	.976	.942	.793	.990	1.000	.932	.998	1.022
170.	1.049	1.006	.974	.942	.791	.990	1.000	.931	.997	1.022
180.	1.050	1.006	.975	.942	.788	.990	1.001	.931	.997	1.022
Z/D=	0.89	1.56	2.22	2.79	3.13	3.56	4.22	4.88	5.32	5.77

Table 3. (Cont'd)

c. $\alpha = 2.5$

SECANT-OGIVE CYLINDER BOATTAIL

M=0.91 ALPHA=5.00 PS=59.9 KPA TO=325 K RE_=4.45X10**6

PHI	P1/PS	P2/PS	P3/PS	P4/PS	P5/PS	P6/PS	P7/PS	P8/PS	P9/PS	P10/PS
-0.	1.111	1.056	1.015	.973	.797	.985	1.001	.952	.973	1.003
10.	1.108	1.053	1.013	.971	.794	.983	.999	.950	.972	1.001
20.	1.105	1.050	1.010	.969	.796	.981	.999	.949	.973	1.001
30.	1.098	1.045	1.005	.965	.792	.979	.996	.946	.972	1.000
40.	1.092	1.039	1.001	.960	.791	.977	.994	.944	.974	1.001
50.	1.083	1.032	.994	.955	.785	.974	.992	.940	.975	1.001
60.	1.075	1.025	.988	.952	.776	.972	.989	.936	.975	1.001
70.	1.067	1.017	.983	.947	.764	.972	.987	.932	.977	1.002
80.	1.059	1.011	.978	.944	.753	.972	.986	.929	.979	1.004
90.	1.051	1.005	.973	.942	.742	.972	.985	.926	.981	1.006
100.	1.045	1.000	.970	.939	.739	.974	.986	.925	.984	1.008
110.	1.040	.996	.967	.937	.741	.976	.987	.923	.987	1.011
120.	1.037	.994	.966	.935	.752	.978	.989	.922	.989	1.014
130.	1.034	.992	.964	.934	.764	.982	.991	.922	.991	1.016
140.	1.032	.991	.963	.934	.772	.985	.994	.922	.993	1.018
150.	1.031	.990	.963	.934	.778	.988	.996	.922	.995	1.019
160.	1.031	.990	.963	.934	.779	.990	.998	.923	.996	1.021
170.	1.031	.990	.963	.935	.781	.991	1.000	.924	.998	1.023
180.	1.031	.990	.963	.935	.779	.991	.999	.923	.997	1.022
Z/D=	0.89	1.56	2.22	2.79	3.13	3.56	4.22	4.88	5.32	5.77

Table 3. (Cont'd)

d. α = 5.0

LIST OF SYMBOLS

ALPHA, α	model angle of attack, degree
M	Mach number
PHI	circumferential position on model, $\phi = 0$ on wind side
PN, p	surface pressure, N = 1, 2, ...
PS, p_{∞}	free-stream static pressure, kPa
REL	Reynolds number based on model length
SOC	model, 3 caliber secant ogive with 3 caliber cylinder
SOCBT	model, 3 caliber secant ogive, 2 caliber cylinder, and 1 caliber boattail
TO	tunnel stagnation temperature, °K
Z/D	longitudinal position along model axis, calibers

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