FORCE AND PRESSURE TESTS ON A SEMI-SPAN DELTA WING AT SUPERSONIC SPEEDS

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ARO, Inc.

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NOTICES

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FOREWORD

The work reported herein was done at the request of the Air Force Office of Scientific Research (AFOSR) for Aerospace Research Associates (ARA), under Program Element 61445014/9781, Task 978101.

The results of tests presented were obtained by ARO, Inc. (a subsidiary of Sverdrup and Parcel, Inc.), contract operator of the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), Arnold Air Force Station, Tennessee, under Contract AF 40(600)-1200. The tests were conducted on May 6 and 7, 1965 under ARO Project No. VA0545, and the manuscript was submitted for publication on July 8, 1965.

This technical report has been reviewed and is approved.

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ABSTRACT

Static-force and pressure tests were conducted in the 40-in. supersonic tunnel of the von Kármán Gas Dynamics Facility on a 70-deg, blunt leading-edge, semi-span delta wing. The wing consisted of three sections, triangular forward and tip panels and a rectangular main panel. Tests were made with the forward panel deflected -2.5 deg and undeflected (flat wing). Force data on the total wing and pressure data on the tip panel were obtained at Mach numbers from 3 to 5; additional pressure data were obtained at Mach number 6. The angle-of-attack range was from -4 to 10 deg, and Reynolds number, based on the wing root chord, ranged from 9×10^6 at Mach number 3 to 18×10^6 at Mach number 6. Wing lift-to-drag ratio and tip panel pressure data are presented for the wing with the forward panel deflected and undeflected.

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NOMENCLATURE

L/D	Lift-to-drag ratio
M_∞	Free-stream Mach number
p	Model surface pressure, psia

p_o	Stilling chamber pressure, psia
p_∞	Free-stream static pressure, psia
Re	Reynolds number based on wing root chord
α	Wing angle of attack, deg

MODEL NOMENCLATURE

F	Forward wing panel
T	Tip wing panel
W	Main wing panel

SECTION I
INTRODUCTION

Static-force and pressure tests were conducted for Aerospace Research Association (ARA) on models of a 70-deg, blunt leading-edge, semi-span delta wing in the 40-in., supersonic tunnel (Gas Dynamic Wind Tunnel, Supersonic (A)), of the von Kármán Gas Dynamics Facility (VKF). The models were mounted on a sidewall pitch drive mechanism, and data were obtained with the wing surface flat and with the forward panel deflected -2.50 deg. Force tests had previously been conducted in VKF on these configurations (Ref. 1). In the current tests the angle-of-attack range was extended to determine the angle of attack for maximum L/D, and pressure distributions were obtained on the tip panel.

Data were obtained at Mach numbers 3.0, 4.0, 4.5, and 5.0 at angles of attack from -4 to 10 deg, and additional pressure data were obtained at Mach number 6.0 for the same angle-of-attack range. The dynamic pressure was constant at 2.6 psia, which corresponds to a Reynolds number range, based on the wing root chord, of 9×10^6 at $M_\infty = 3$ and 18×10^6 at $M_\infty = 6$.

SECTION II
APPARATUS

2.1 WIND TUNNEL

Tunnel A is a continuous, closed-circuit, variable density wind tunnel with an automatically driven flexible plate nozzle and a 40- by 40-in. test section. The tunnel operates at Mach numbers from 1.5 to 6 at maximum stagnation pressures from 29 to 200 psia, respectively, and stagnation temperatures up to 300°F ($M_\infty = 6$). Minimum operating pressures are about one-tenth of the maximum at each Mach number. A description of the tunnel and airflow calibration information may be found in Ref. 2.

2.2 MODELS AND MODEL SUPPORT

The models supplied by ARA (Fig. 1) were constant thickness (1.5-in.), semi-span delta wings having hemispherical leading edges, a sweep-back angle of 70 deg, and a root chord of 48 in. Each model consisted of two triangular sections and a rectangular section. Each of the two triangular panels, which comprised the forward and tip regions of the wing, had a root chord of 24 in. The surface area of each triangular panel was therefore 25 percent of the wing area, and the rectangular or main wing panel comprised 50 percent of the wing area. For the pressure tests the tip panel was instrumentated as shown in Fig. 1b.

A sectional view showing the sidewall-mounted angle-of-attack mechanism and the support for the three wing panels is presented in Fig. 2, and a tunnel installation photograph is presented in Fig. 3. Photographs of the two configurations tested are shown in Fig. 4. A description of the angle-of-attack mechanism is given in Ref. 1.

As shown in Fig. 2 the forward and tip wing panels were mounted on dummy balances which were in turn supported by the main wing balance through panel W. The forces and moments measured by the balance were therefore the aerodynamic loads on the total wing. The model was mounted in the same manner during the pressure phase of the tests.

Perfect alignment of the model panels could not be achieved because the weights of the solid steel panels caused deflection of the balances and support equipment. For example, in the case of configuration 1 the tip panel was slightly lower than the main panel, and a small longitudinal step existed on the wing surface. Alignment of the forward panel, accomplished by maintaining a smooth junction between the forward and main wing panels, resulted in an angular misalignment of these panels in pitch of -0.05 deg. Panel alignment was further affected by aerodynamic loading, which not only altered the initial deflections but also introduced a lateral step on the wing surface between the forward and main wing panels. Similar initial misalignment of the wing panels of configuration 2 was minimized in the manner described above, and in all cases the smoothest possible wing surface was maintained.

2.3 INSTRUMENTATION AND TECHNIQUES

Total wing force measurements were made with a six-component, force-type, strain-gage balance supplied and calibrated by VKF. After the test a range of static loadings was applied to the balance which simulated the range of model loadings obtained during the test. These static loadings were applied in combinations to the balance components of interest. Listed below are the balance design loads and the range of static loadings applied to each component. The range of uncertainties listed here corresponds to the differences between the applied loads and the values calculated by the balance equations used in the final data reduction.

Balance Component	Design Load	Range of Static Loadings	Range of Uncertainties
Normal force, lb	1200	75 to 250	±0.30 to ±1.40
Pitching moment, in.-lb	800	320 to 560	±0.10 to ±1.30
Side force, lb	100	25 to 50	±0.02 to ±0.35
Yawing moment, in.-lb	3000	75 to 420	±0.25 to ±1.50
Rolling moment, in.-lb	3400	600 to 2000	±1.00 to ±5.00
Axial force, lb	1200	10 to 50	±0.20 to ±2.50

Model surface pressures were measured with the standard pressure-scanning system of Tunnel A. This system utilizes 15-psid transducers referenced to a near vacuum. These transducers are calibrated for ranges of 15, 5, and 1 psia, and the precision of the system is estimated to be within 0.2 percent of full scale of the range being used.

The angle of attack is considered to be correct to within ±0.1 deg, and the centerline flow uniformity is within ±0.5 percent in Mach number.

Data on both configurations were obtained at the test conditions listed below.

M_∞	p_o, psia	Re x 10^{-6}/in.
3.0	15.0	0.18
4.0	35.0	0.25
4.5	53.0	0.30
5.0	80.0	0.30
6.0	157.0	0.37

SECTION III
RESULTS AND DISCUSSIONS

Since the primary objective of the force tests was to determine the angle of attack for maximum L/D, only these results are presented.

Force and moment data were obtained on these configurations in previous tests and are available (up to α = 6 deg) in Ref. 1.

In Fig. 5 the variation of L/D with angle of attack at M_∞ = 3 and 5 is given for both configurations. The data show that deflecting the forward panel -2.5 deg decreased L/D near zero angle of attack but had no significant effect at the higher angles of attack (α > 6 deg).

Figure 6 presents the variations with Mach number of maximum L/D and the angle of attack at $(L/D)_{max}$. In general for both configurations $(L/D)_{max}$ decreased and the angle of attack at $(L/D)_{max}$ increased with increased Mach number. Deflecting the forward panel had no appreciable effect on $(L/D)_{max}$ or on the angle of attack at $(L/D)_{max}$ over the Mach number range.

In Figs. 7a and b pressure distributions on the bottom surface and along the leading edge of the tip panel are shown for angles of attack of 6 and 10 deg for M_∞ = 3 and 5. As can be seen there were no significant effects of deflecting the forward flap -2.5 deg.

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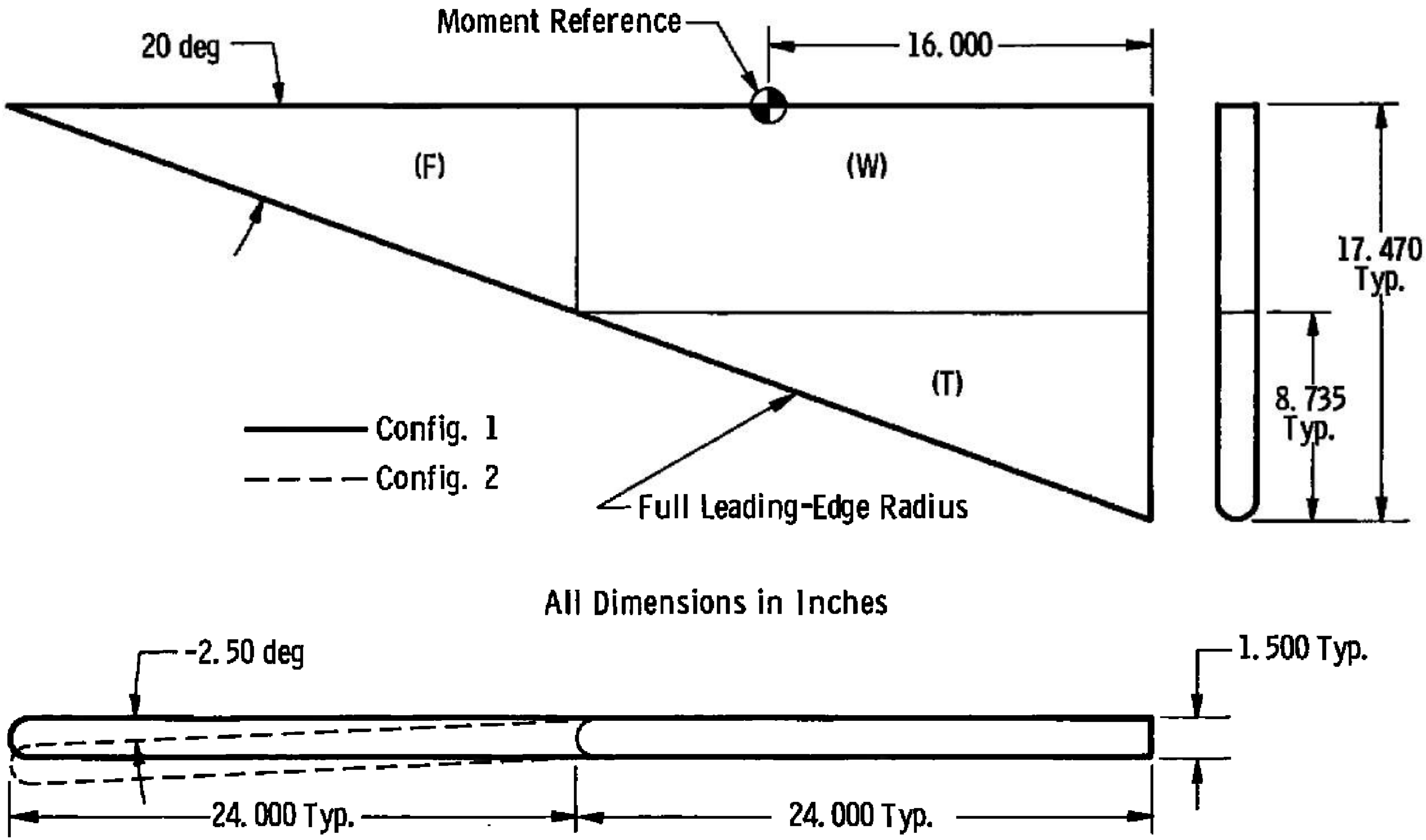
1. Coats, Jack D. and Morgan, L. A. "Force Tests on Flat, Cambered, and Twisted Wings at Mach Numbers 3, 4, and 6." AEDC-TN-61-147 (AD326853), November 1961.

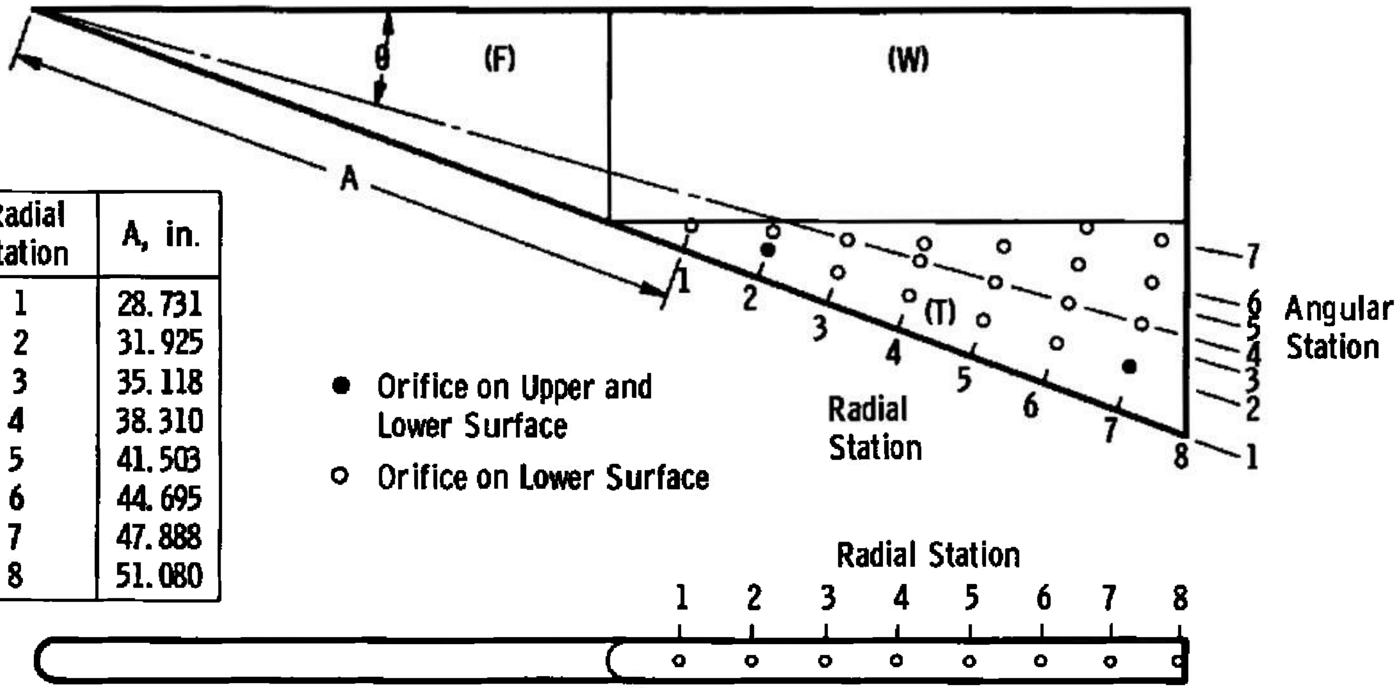
2. Test Facilities Handbook (Fifth Edition). "von Kármán Gas Dynamics Facility, Vol. 4." Arnold Engineering Development Center, July 1963.



a. Force Model

Fig. 1 Model Details

Angular Station	θ, deg
1	20.000
2	17.841
3	16.761
4	15.681
5	14.601
6	13.522
7	11.362



Radial Station	A, in.
1	28.731
2	31.925
3	35.118
4	38.310
5	41.503
6	44.695
7	47.888
8	51.080

b. Pressure Model

Fig. 1 Concluded

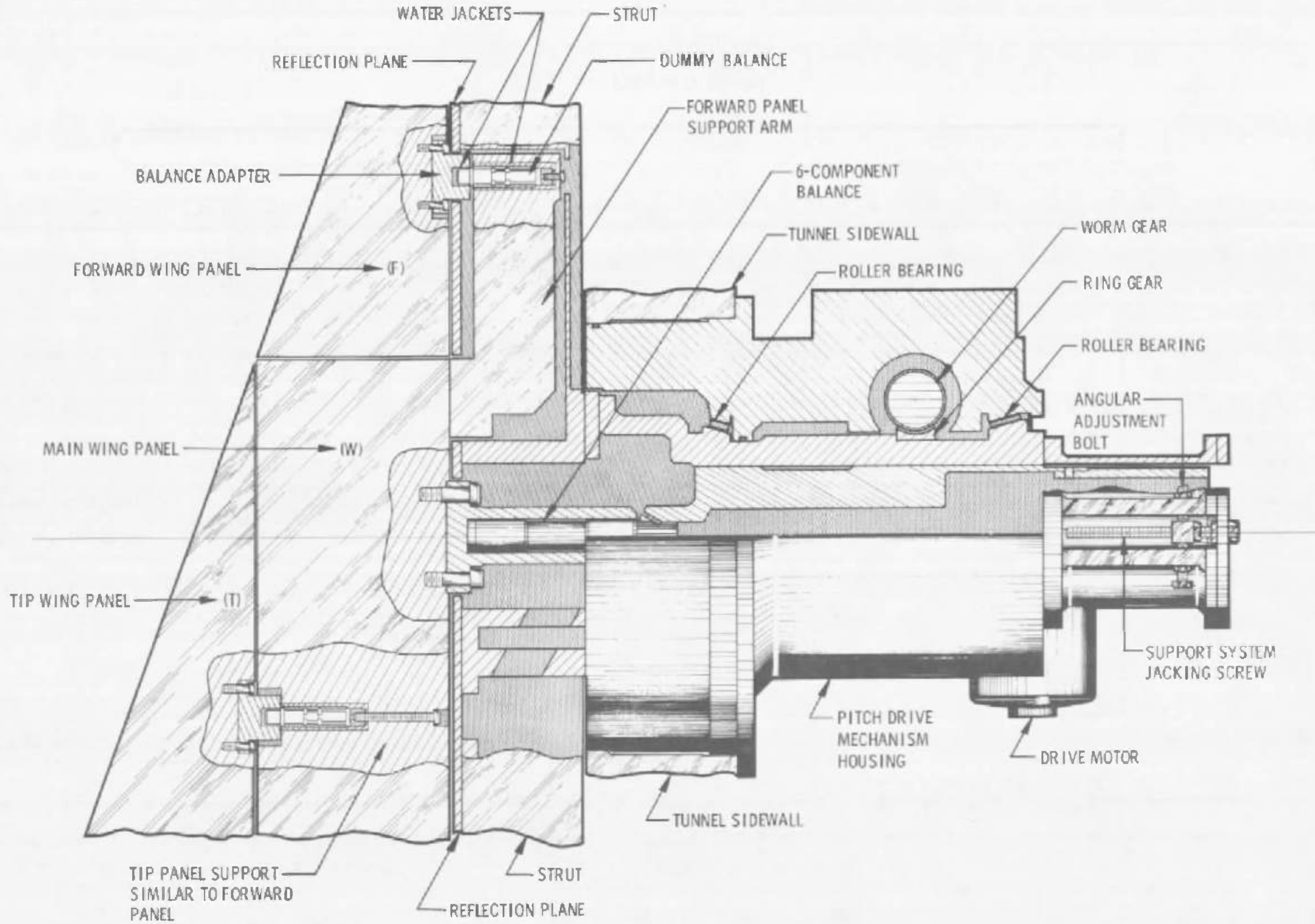


Fig. 2 General Arrangement of the Sidewall Angle-of-Attack Mechanism and Model Support Details

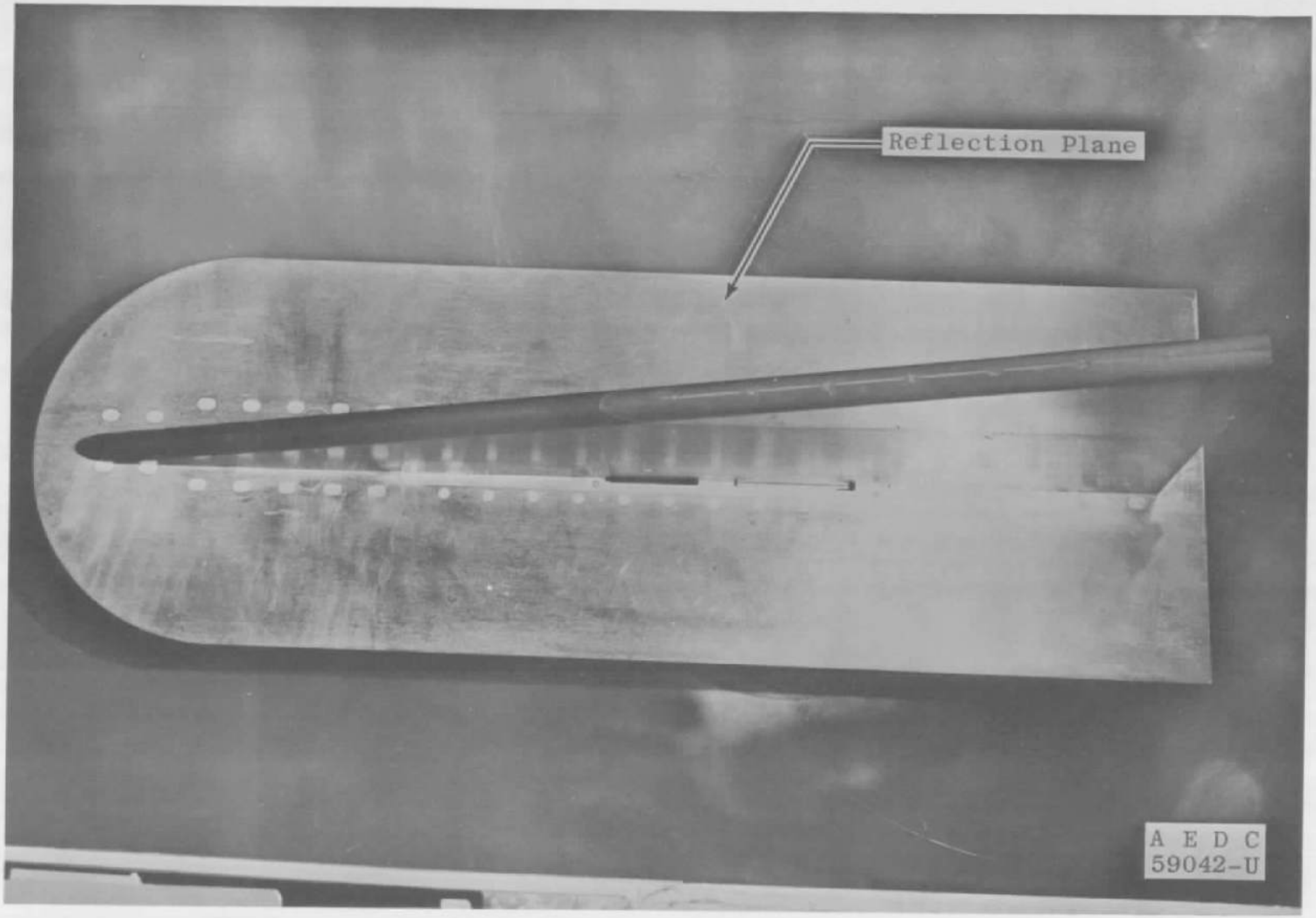


Fig. 3 Installation Photograph

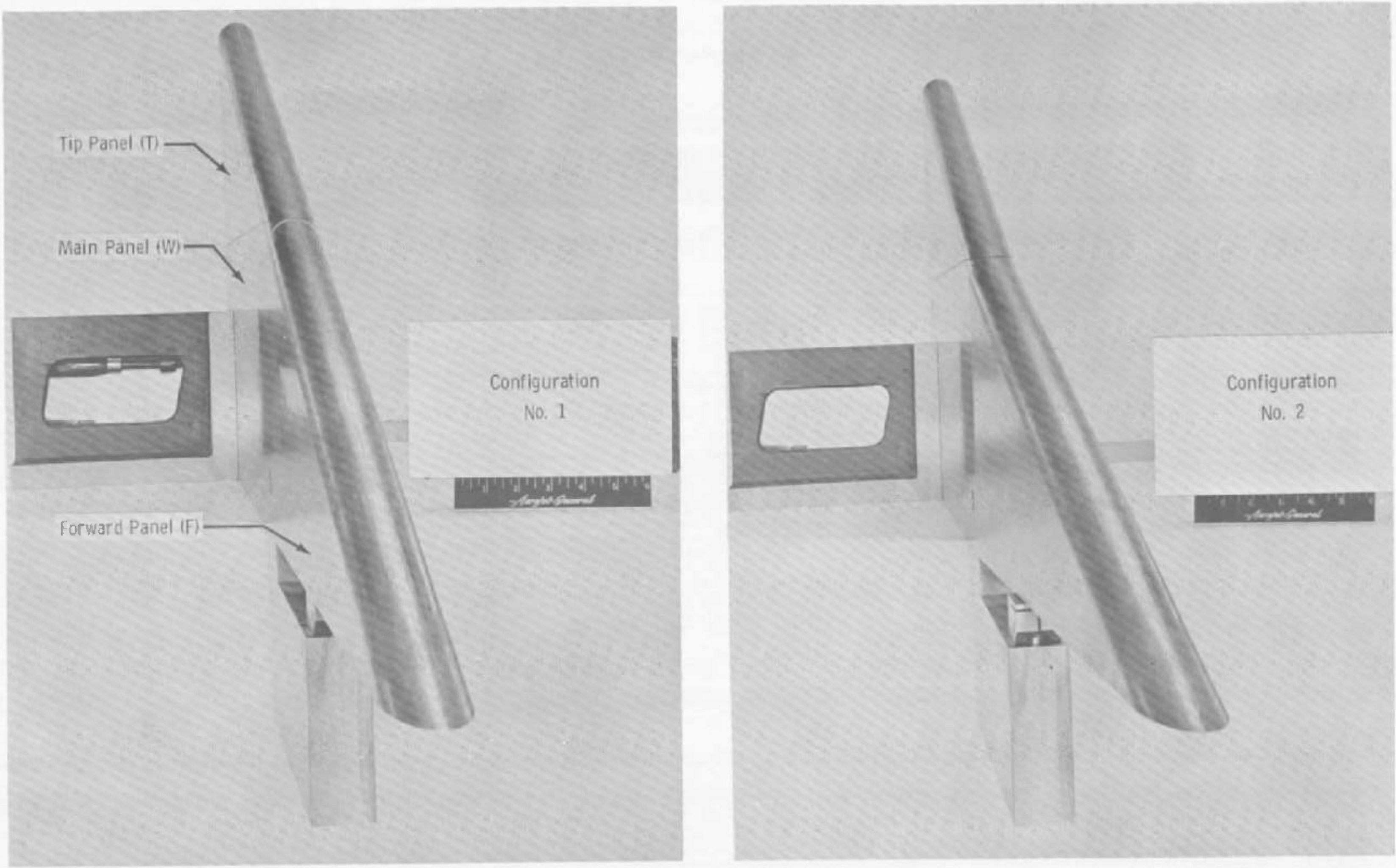


Fig. 4 Model Photographs

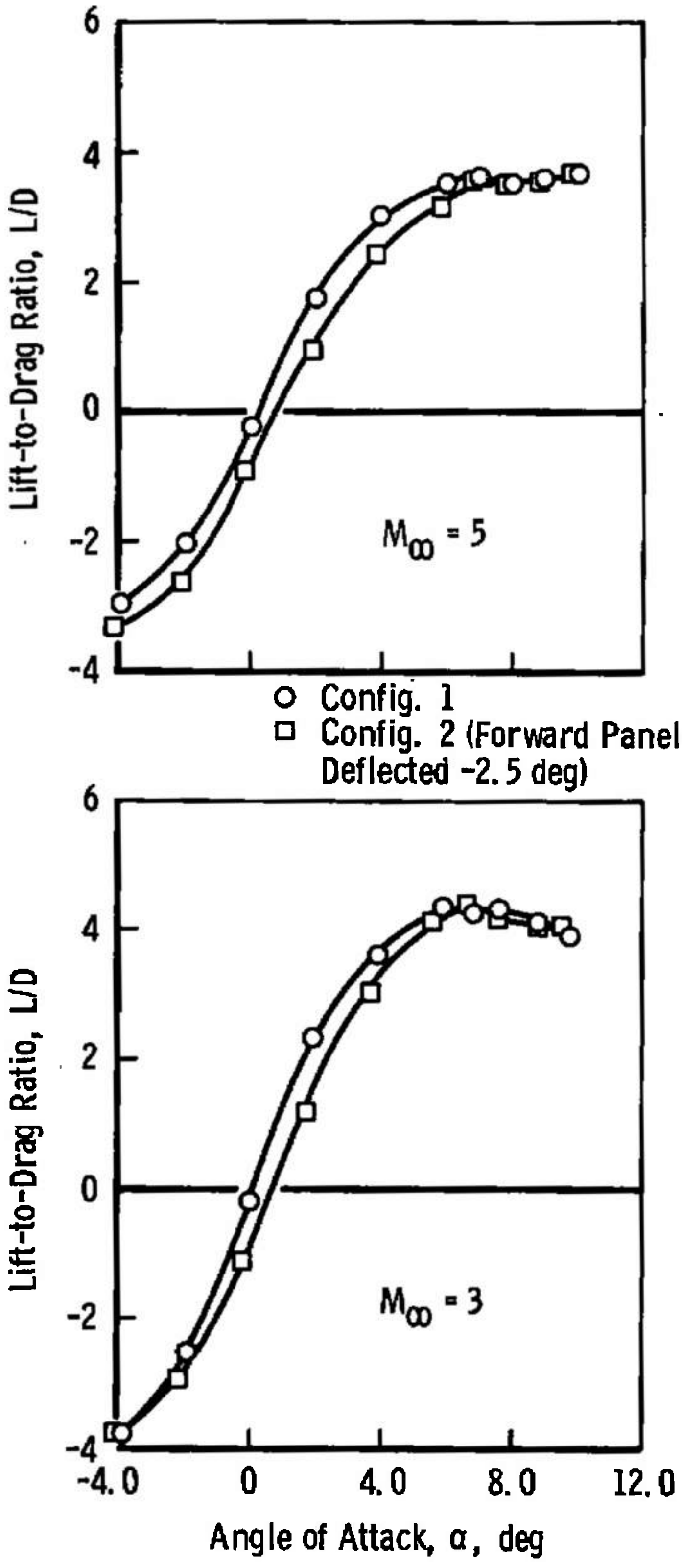


Fig. 5 Variation of L/D with Angle of Attack at M_∞ = 3 and 5

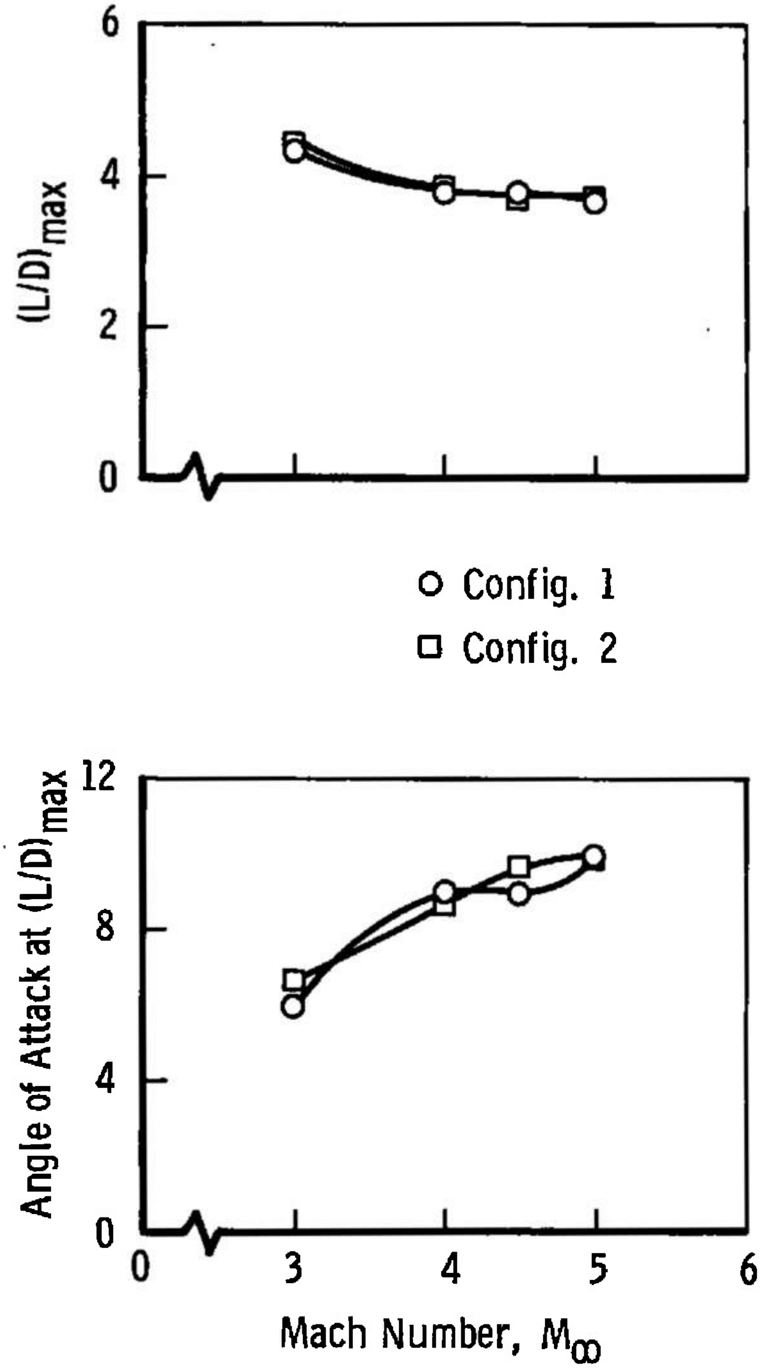
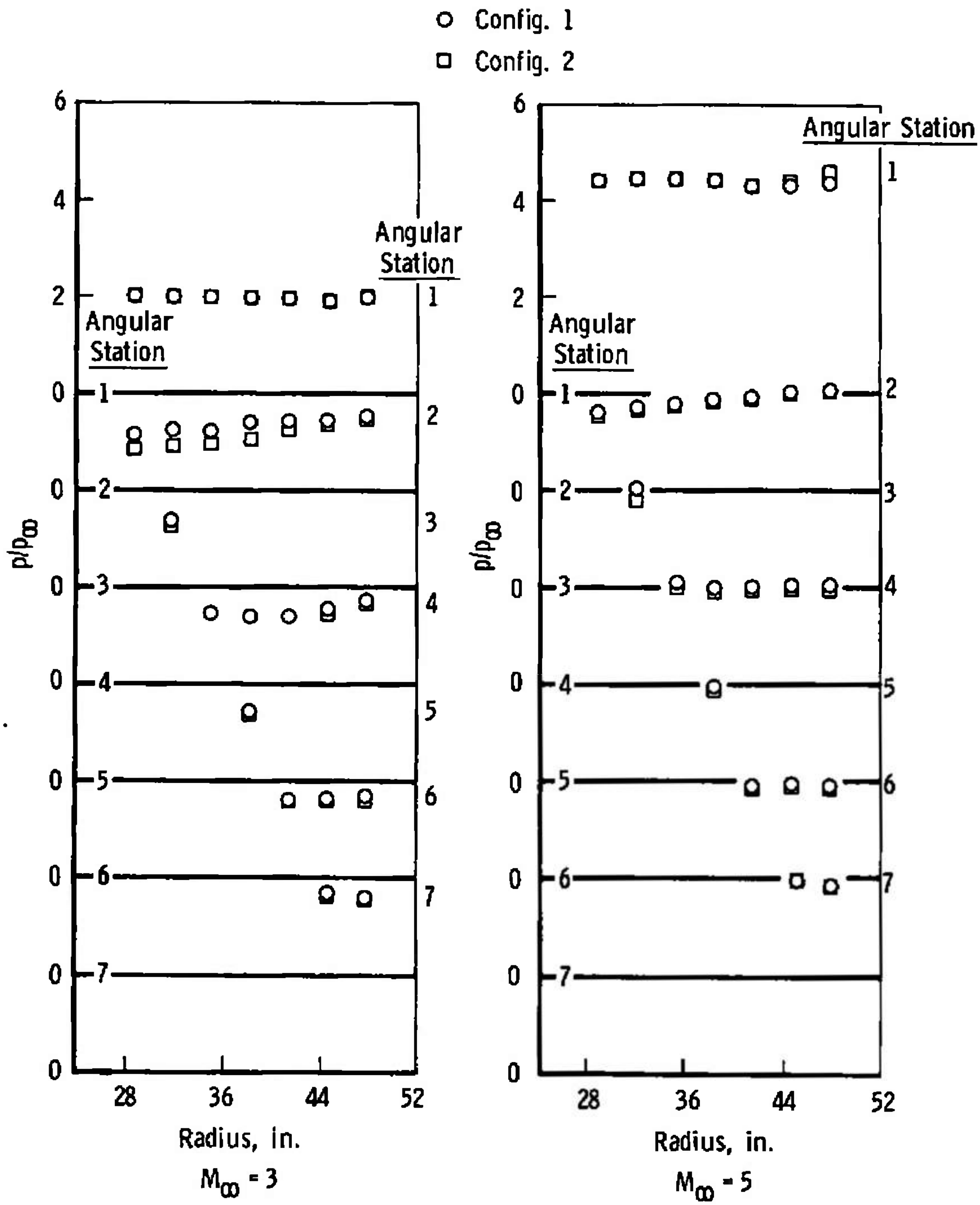
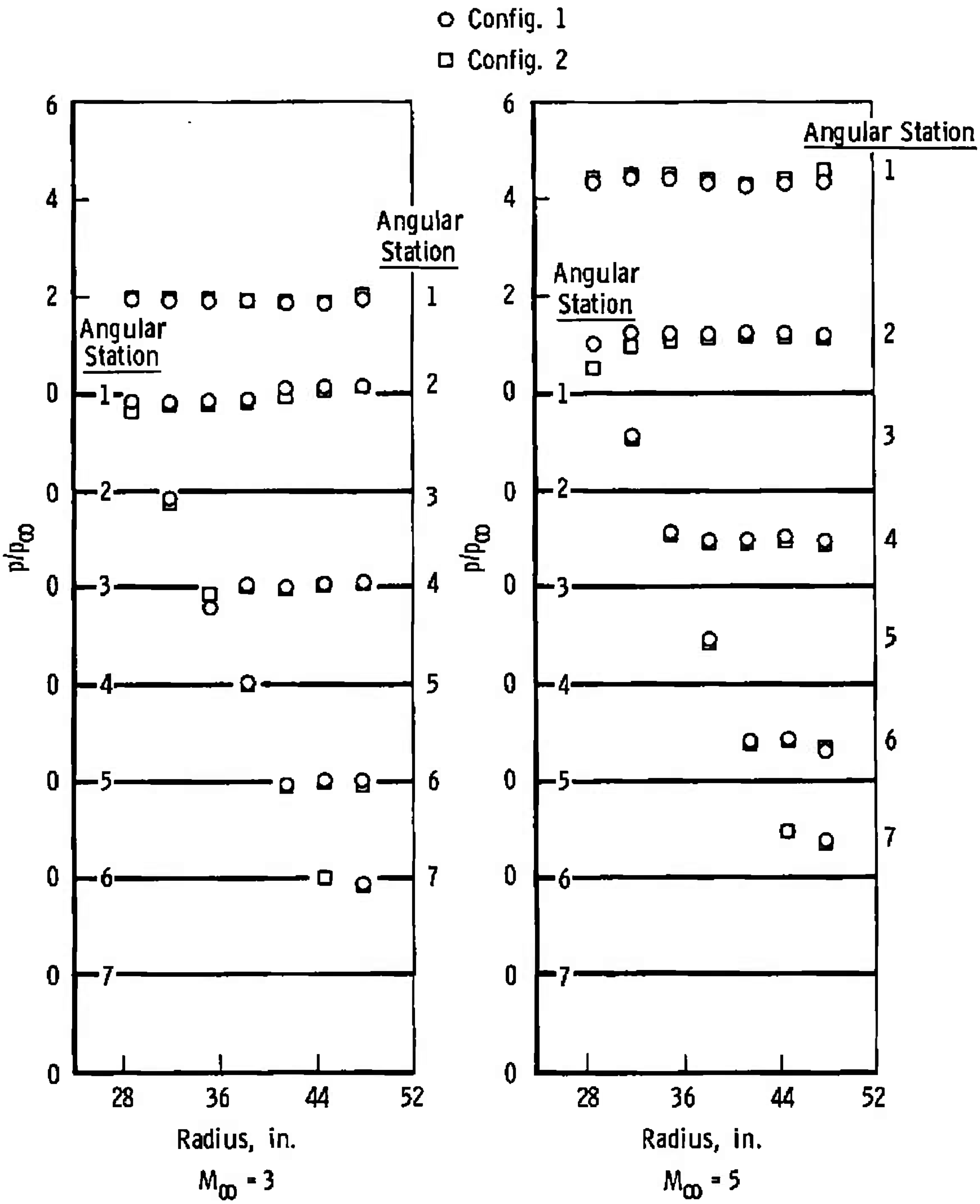


Fig. 6 Variation of $(L/D)_{max}$ and Angle of Attack at $(L/D)_{max}$ with Mach Number



a. α = 6 deg

Fig. 7 Pressure Distribution over Tip Panel for M_∞ = 3 and 5



b. α = 10 deg

Fig. 7 Concluded

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