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**STATIC STABILITY AND DRAG CHARACTERISTICS  
OF THE ALL-ALTITUDE SPIN-PROJECTED  
MUNITION (ASP) AT MACH NUMBERS  
FROM 0.50 TO 1.20**

D. K. Smith

ARO, Inc.

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## FOREWORD

The work reported herein was sponsored by the Air Force Armament Laboratory (DLGD/Glen Phillips), Armament Development and Test Center, Air Force Systems Command (AFSC), under Program Element 64602F, Project 2586.

The test results presented were obtained by ARO, Inc. (a subsidiary of Sverdrup & Parcel and Associates, Inc.), contract operator of the Arnold Engineering Development Center (AEDC), AFSC, Arnold Air Force Station, Tennessee, under Contract F40600-72-C-0003. The test was conducted on August 17, 1971, under ARO Project No. PC0160. The manuscript was submitted for publication on October 4, 1971.

This technical report has been reviewed and is approved.

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Colonel, USAF  
Director of Test

**ABSTRACT**

Force and moment data were obtained with a 0.25-scale model of the All-Altitude Spin-Projected Munition (ASP) at Mach numbers from 0.50 to 1.20 to determine the effects of fins and fins with tip plates on the static stability and drag of the ASP munition. Five configurations, comprised of three different tip plates on the fins, the fins alone, and the body without fins, were tested.

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## NOMENCLATURE

$A_b$	Base area, 0.0873 ft <sup>2</sup>
ASP-B	Body alone configuration
ASP-BT	Body and fin configuration
ASP-BTP-1	Body and fin with tip plates no. 1 configuration
ASP-BTP-2	Body and fin with tip plates no. 2 configuration
ASP-BTP-3	Body and fin with tip plates no. 3 configuration
$C_A$	Axial-force coefficient, measured axial force/ $q_\infty S$ (see Fig. 4)
$C_{A,b}$	Base axial-force coefficient. $(p_\infty - p_b)A_b/q_\infty S$

$C_{A,F}$	Forebody axial-force coefficient, $C_A - C_{A,b}$
$C_D$	Forebody drag coefficient, $C_{A,F} \cos a + C_N \sin a$
$C_m$	Pitching-moment coefficient, measured pitching moment/ $q_\infty Sd$ , moment reference at MS 11.70
$C_N$	Normal-force coefficient, measured normal force/ $q_\infty S$
$d$	Model body diameter, 0.333 ft
$M_\infty$	Free-stream Mach number
MS	Model station, in. (see Fig. 2)
$p_b$	Model base pressure, psfa
$p_\infty$	Free-stream static pressure, psfa
$q_\infty$	Free-stream dynamic pressure, psf
Re	Free-stream Reynolds number, $ft^{-1}$
S	Model body reference area, 0.0873 $ft^2$
$a$	Model angle of attack, deg

## SECTION I INTRODUCTION

Wind tunnel tests were conducted to determine the static stability and drag of the Aerojet All-Altitude Spin-Projected Munition (ASP). The tests were conducted in the Aerodynamic Wind Tunnel (4T) of the AEDC Propulsion Wind Tunnel Facility (PWT) over a Mach number range from 0.50 to 1.20 and at Reynolds numbers per foot from  $3.35 \times 10^6$  to  $5.00 \times 10^6$ . Force and moment data were obtained with the 0.25-scale model of the ASP without fins, with fins, and with fins and three different tip plates over an angle-of-attack range from -6 to 20 deg.

## SECTION II APPARATUS

### 2.1 TEST FACILITY

Tunnel 4T is a closed-loop, continuous flow, variable density tunnel in which the Mach number can be varied from 0.1 to 1.3. At all Mach numbers, the stagnation pressure can be varied from 300 to 3700 psfa. The test section is 4 ft square and 12.5 ft long with perforated, variable porosity (0.5- to 10-percent-open) walls. It is completely enclosed in a plenum chamber from which the air can be evacuated, allowing part of the tunnel airflow to be removed through the perforated walls of the test section. A more thorough description of the tunnel may be found in the Test Facilities Handbook.<sup>1</sup> A sketch of the test section wall details and the location of the test model in the test section is shown in Fig. 1, Appendix.

### 2.2 TEST ARTICLES

The test article was a 0.25-scale model of the ASP munition with and without fins and three different tip plates. Details and dimensions of the ASP model, fins, and tip plates are given in Fig. 2. Photographs of the model, fins, and tip plates are shown in Fig. 3.

### 2.3 INSTRUMENTATION

A six-component, moment-type, internal strain-gage balance was used to obtain the force and moment data. Two base pressure measurements were made with pressure transducers connected to two orifices located on the sting flush with the base of the ASP model.

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<sup>1</sup>Test Facilities Handbook (Ninth Edition). "Propulsion Wind Tunnel Facility, Vol. 4." Arnold Engineering Development Center, July 1971.

## SECTION III TEST DESCRIPTION

### 3.1 TEST CONDITIONS AND PROCEDURES

Force and moment data were obtained on the various configurations of the ASP munition model. The Mach numbers at which the tests were conducted were 0.50, 0.80, 0.90, 0.95, 1.10, and 1.20 at free-stream dynamic pressures of 380, 835, 875, 920, 1050, and 1090 psf, respectively. The Reynolds number per foot was held at  $5.0 \times 10^6$  for all Mach numbers except  $M_\infty = 0.50$ , at which the Reynolds number per foot was  $3.35 \times 10^6$ . The total temperature varied from 110 to 130°F. The tunnel conditions were held constant at the prescribed Mach number and Reynolds number while the angle of attack was varied from -6 to 20 deg. Data were recorded at 2-deg increments of angle of attack. The orientation of the force and moment coefficients is shown in Fig. 4.

### 3.2 CORRECTIONS

Balance and sting deflections caused by aerodynamic loads on the model were accounted for in the data reduction to determine the angle of attack. Model tare corrections were made to calculate the net aerodynamic forces on the model. A model base drag correction was made to obtain the forebody drag coefficient.

### 3.3 PRECISION OF MEASUREMENTS

The precision of the data which can be attributed to the errors of the balance measurements and in setting the tunnel conditions was determined for a confidence level of 95 percent and is presented below for the set of conditions that produced the largest errors.

<u><math>\delta C_N</math></u>	<u><math>\delta C_m</math></u>	<u><math>\delta C_D</math></u>	<u><math>\delta q_\infty</math></u>
$\pm 0.045$	$\pm 0.075$	$\pm 0.024$	$\pm 10$

The error in setting Mach number is within  $\pm 0.005$ . The Mach number variation in the portion of the test section occupied by the model is no greater than  $\pm 0.002$  for Mach numbers up to 0.95 and  $\pm 0.01$  for Mach numbers greater than 1.0. The uncertainty in setting the angle of attack is  $\pm 0.1$  deg.

## SECTION IV RESULTS AND DISCUSSION

The objective of this investigation was to obtain aerodynamic force and moment data to determine the static stability and drag of various configurations of the ASP. The aerodynamic coefficient data are presented in Fig. 5 and were machine plotted and faired with straight lines. The normal-force, pitching-moment, and drag coefficients are essentially the same for all finned configurations for a given Mach number. (See Nomenclature for

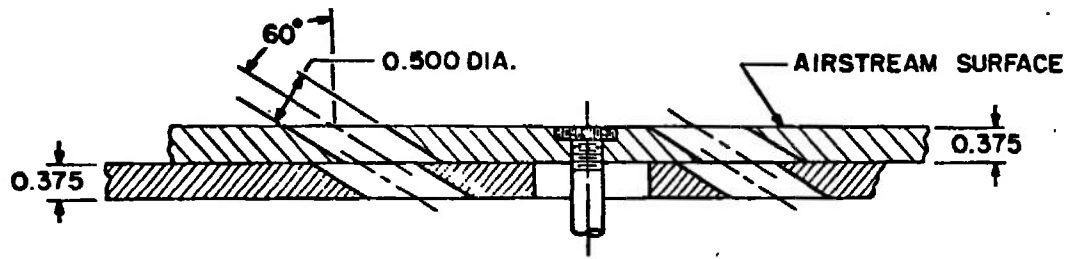
definition of configurations.) For the body alone configuration, the normal-force and drag coefficients were lower than for the other configurations, and the pitching-moment coefficient showed an unstable configuration as expected. The data thus showed that the tip plates, either 1, 2, or 3, have little effect in changing the aerodynamic characteristics of the model.

## **SECTION V CONCLUSIONS**

Based on the results of the test to determine the static stability and drag characteristics of the ASP for various configurations, the following conclusions are made:

1. The body alone (ASP-B) configuration is unstable, whereas the configuration with fins is stable.
2. The addition of tip plates to the fins had little effect in changing the aerodynamic characteristics of the body with fins.

**APPENDIX  
ILLUSTRATIONS**



TYPICAL PERFORATED WALL CROSS SECTION

ALL DIMENSIONS AND TUNNEL STATIONS IN INCHES

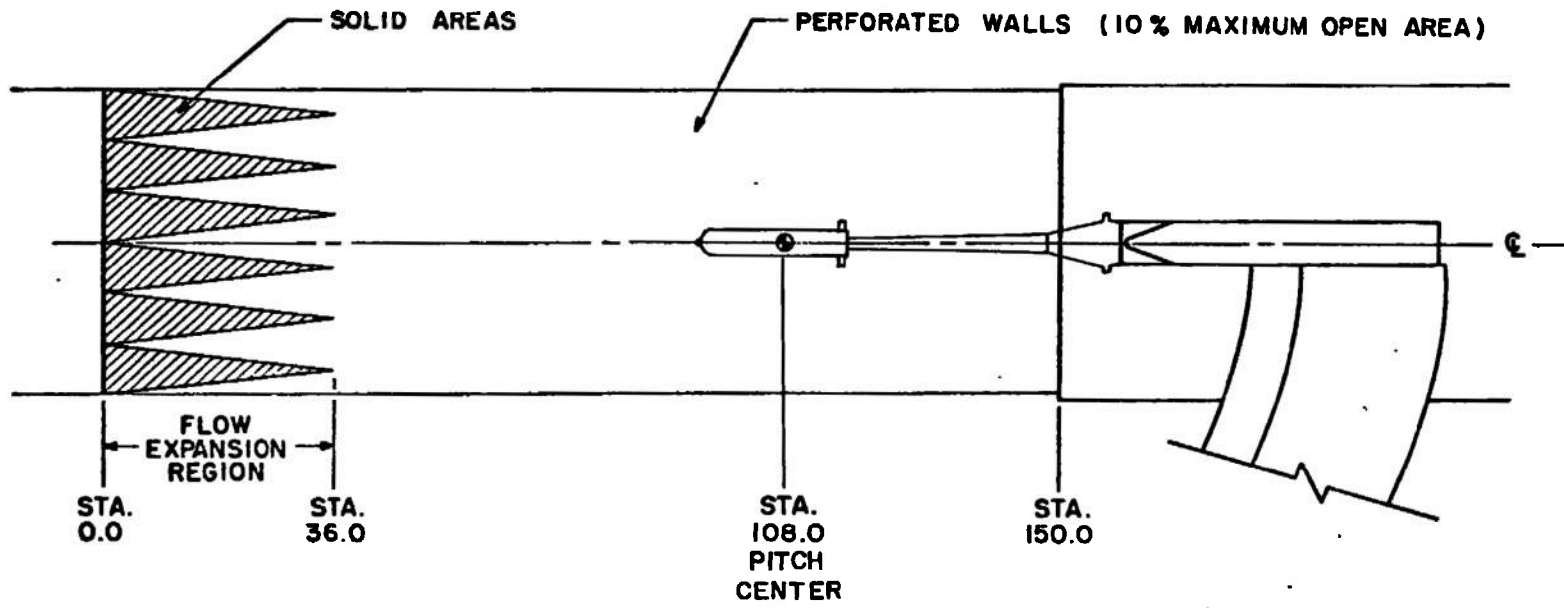
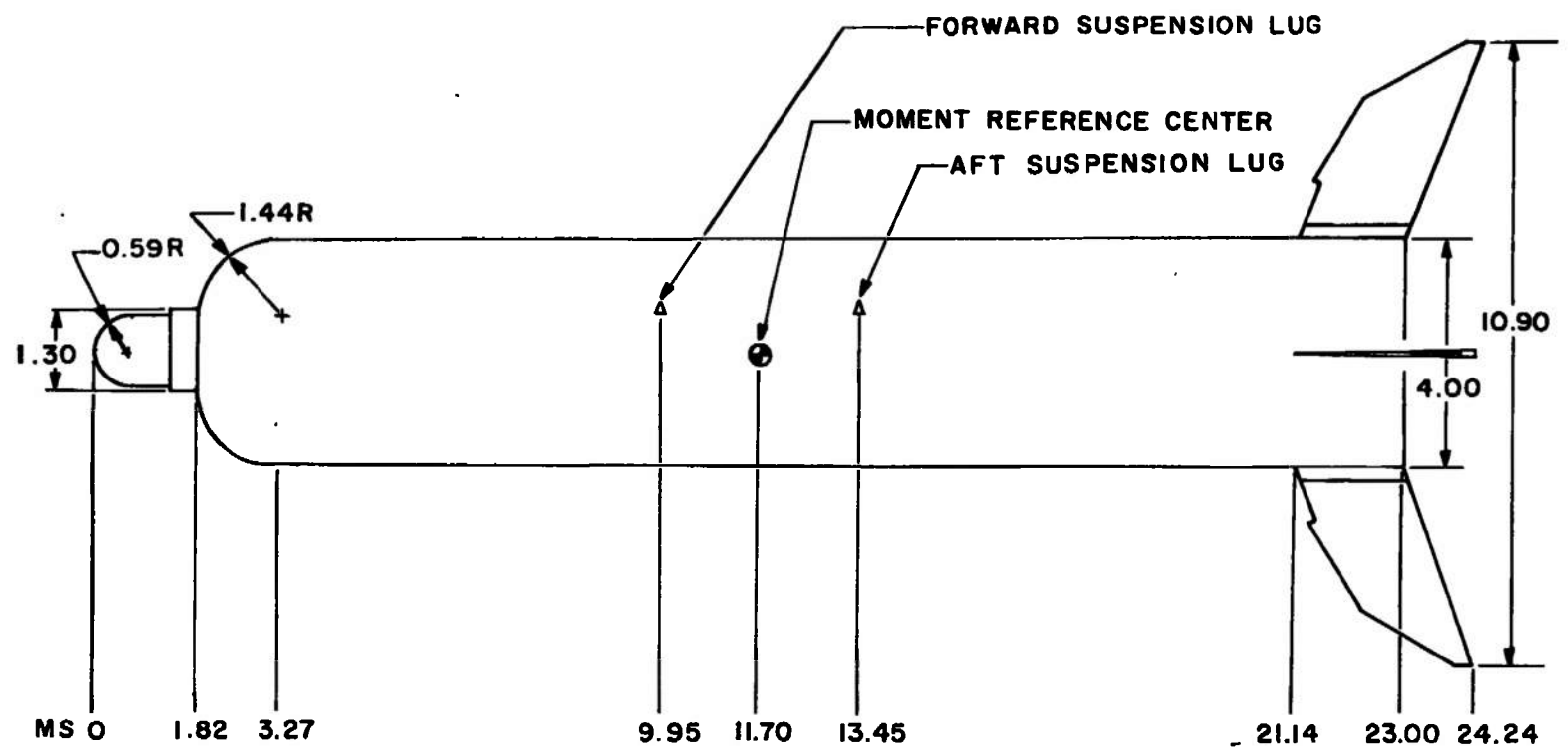


Fig. 1 Schematic of Tunnel Test Section Showing Model Location

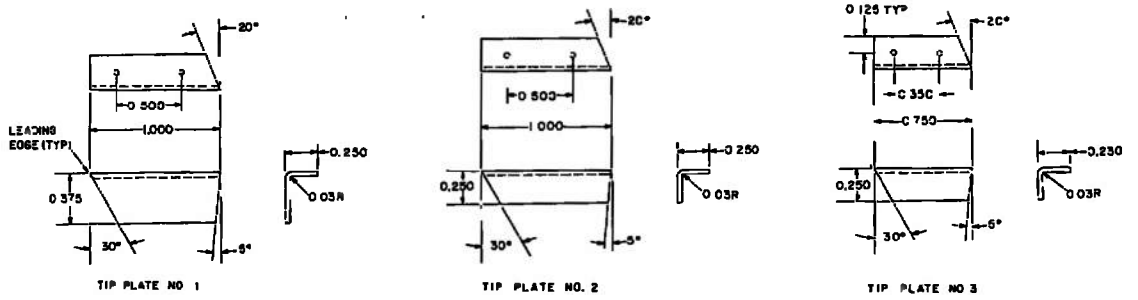
7



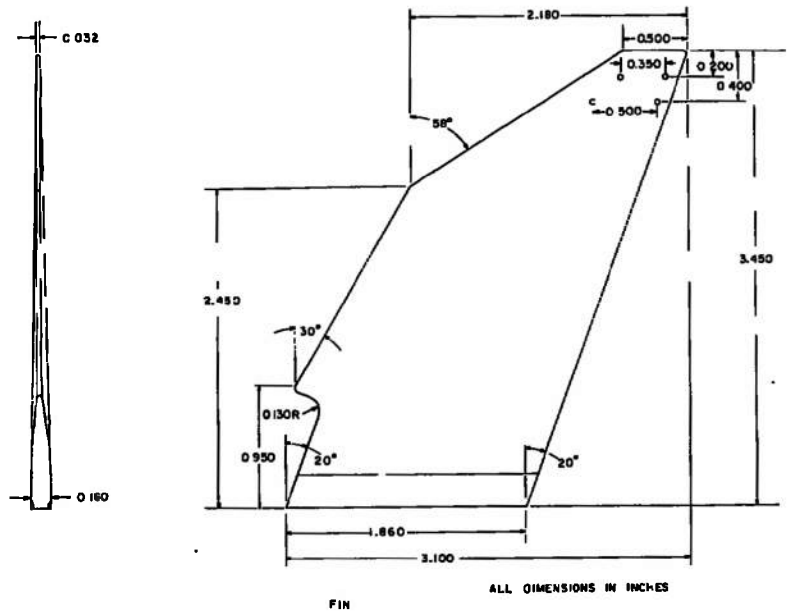
ALL DIMENSIONS IN INCHES

a. ASP Test Model with Fins  
Fig. 2 Details and Dimensions of the Test Articles

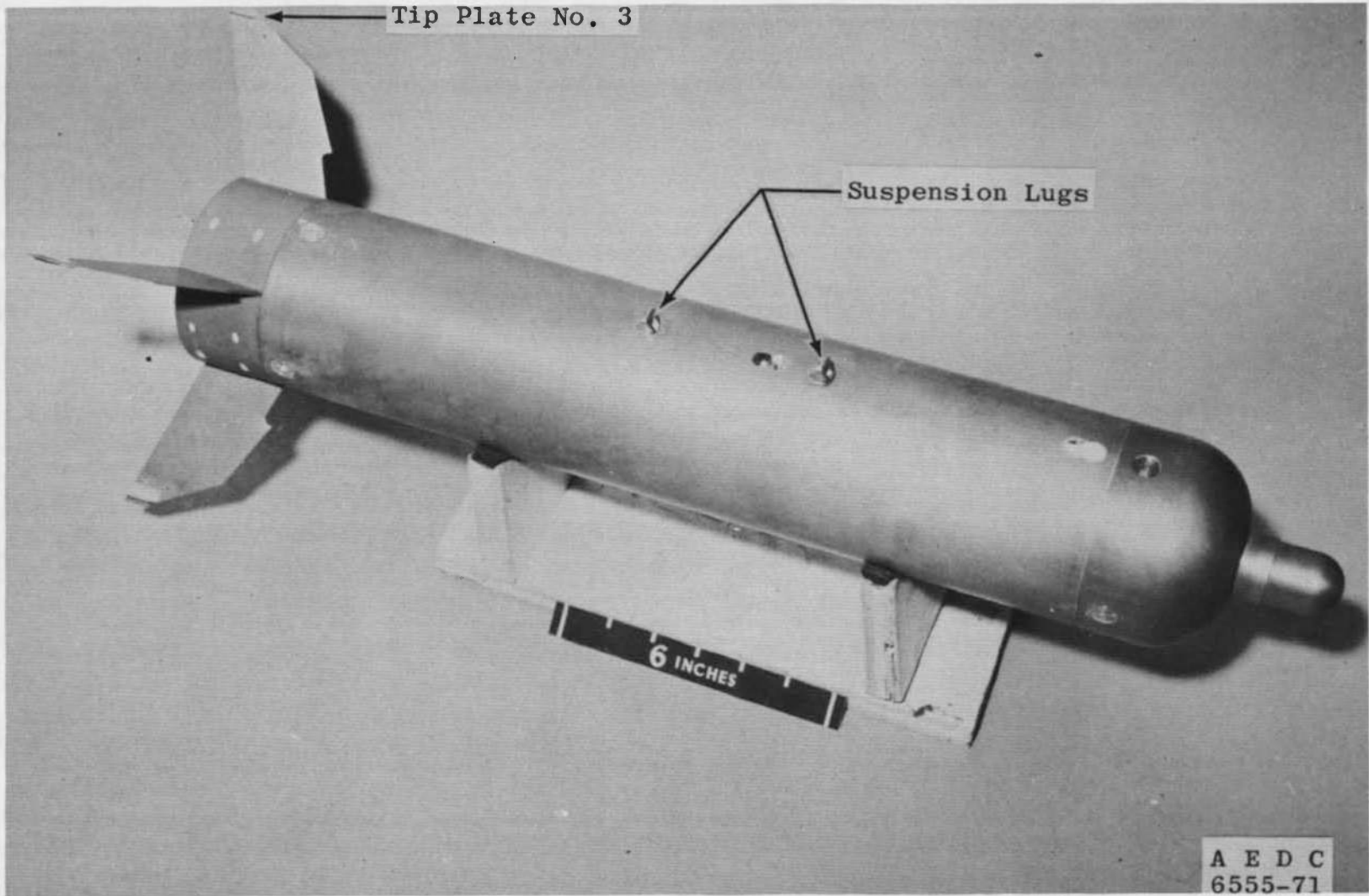
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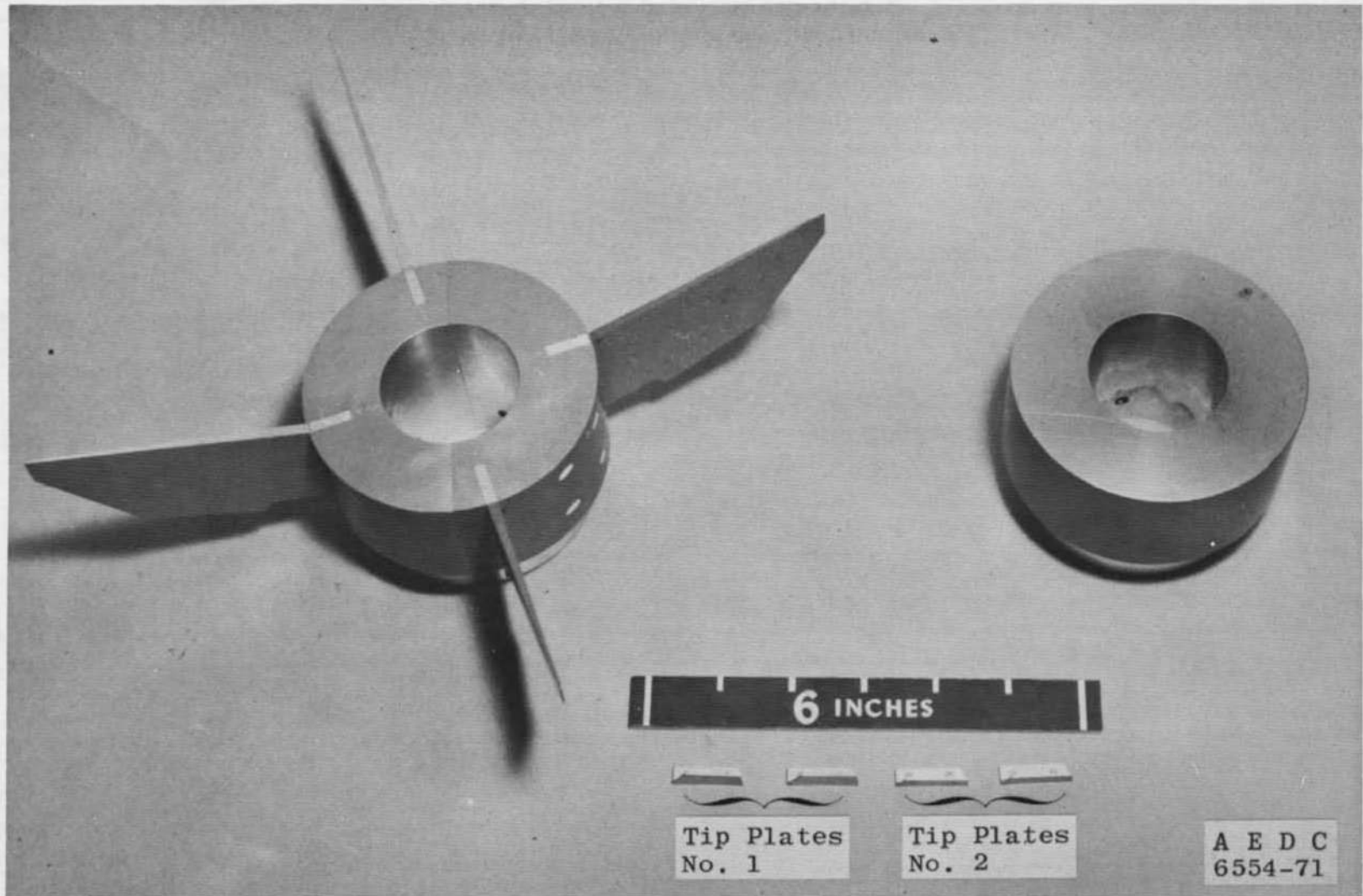
NOTE TWO TIP PLATES PER FIN



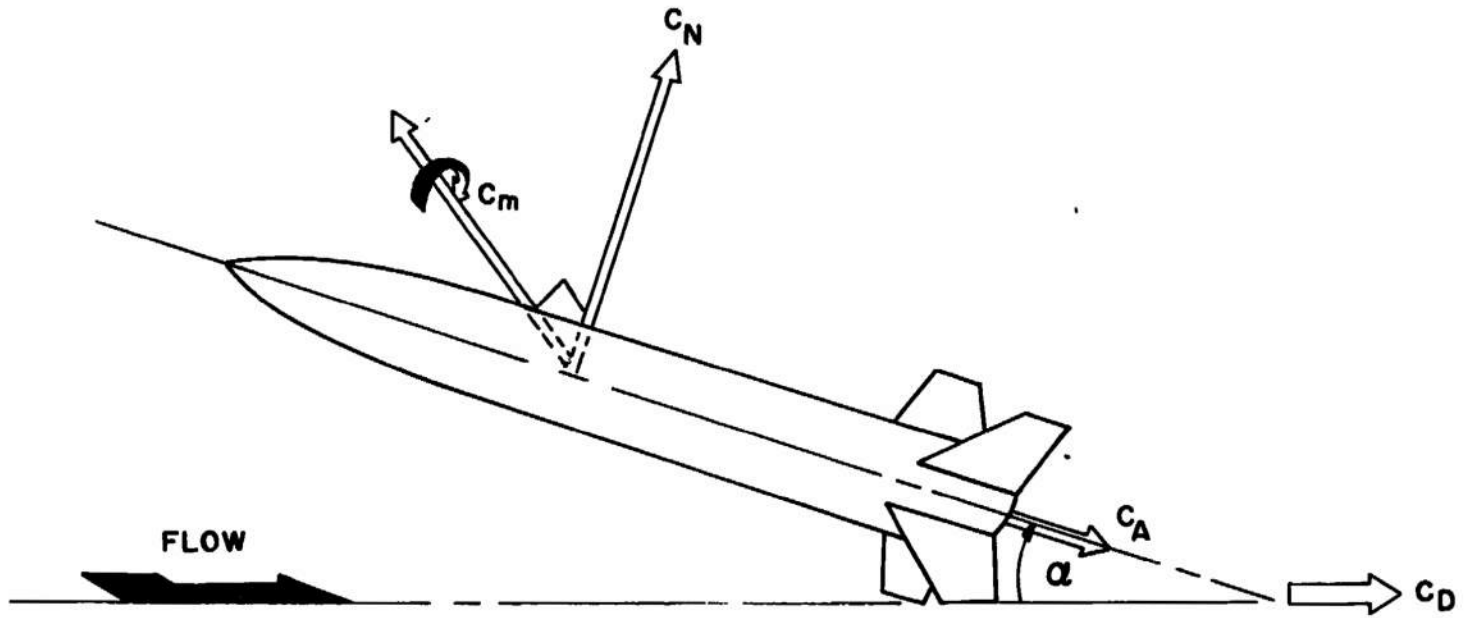
b. Fin and Tip Plates  
Fig. 2 Concluded



a. ASP Test Model with Fins and Tip Plates No. 3  
Fig. 3 Photographs of the Test Articles



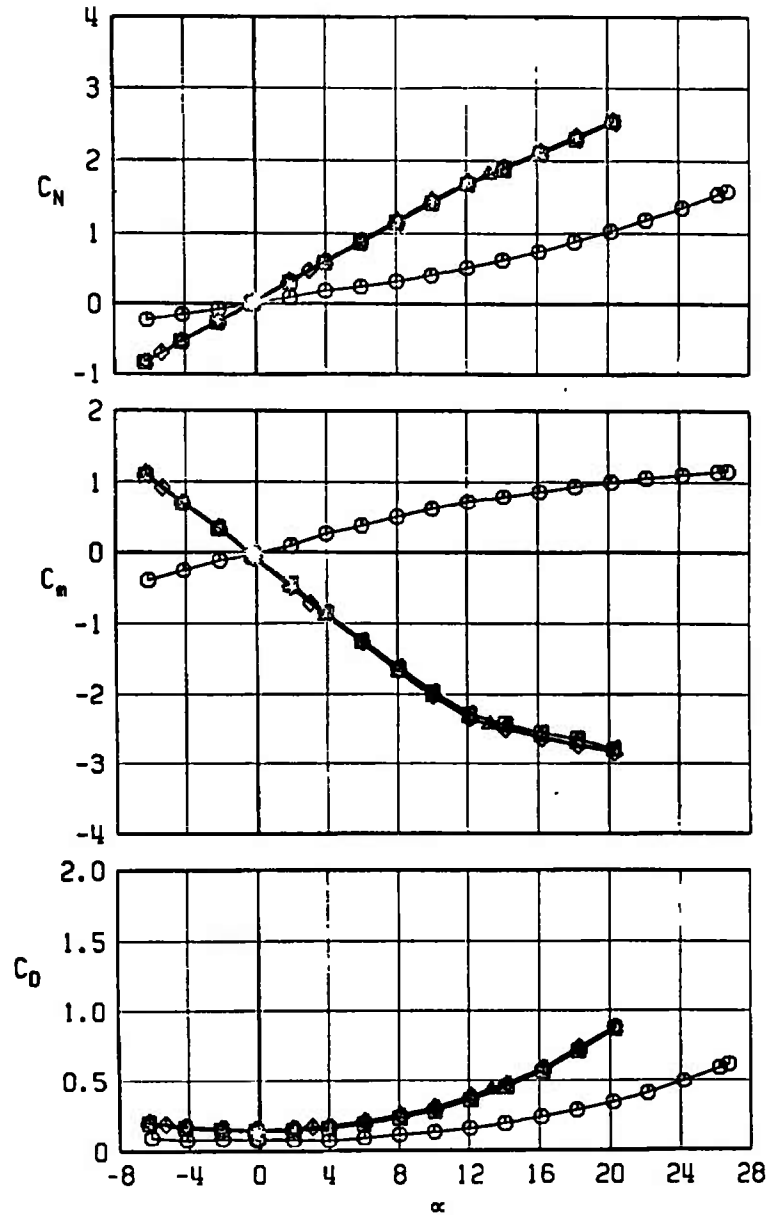
b. Tail with Fins, Tail without Fins, and Tip Plates No. 1 and 2  
Fig. 3 Concluded



ARROWS INDICATE POSITIVE DIRECTION  
OF ANGLES, FORCES AND MOMENTS.

Fig. 4 Force and Moment Coefficient Orientation

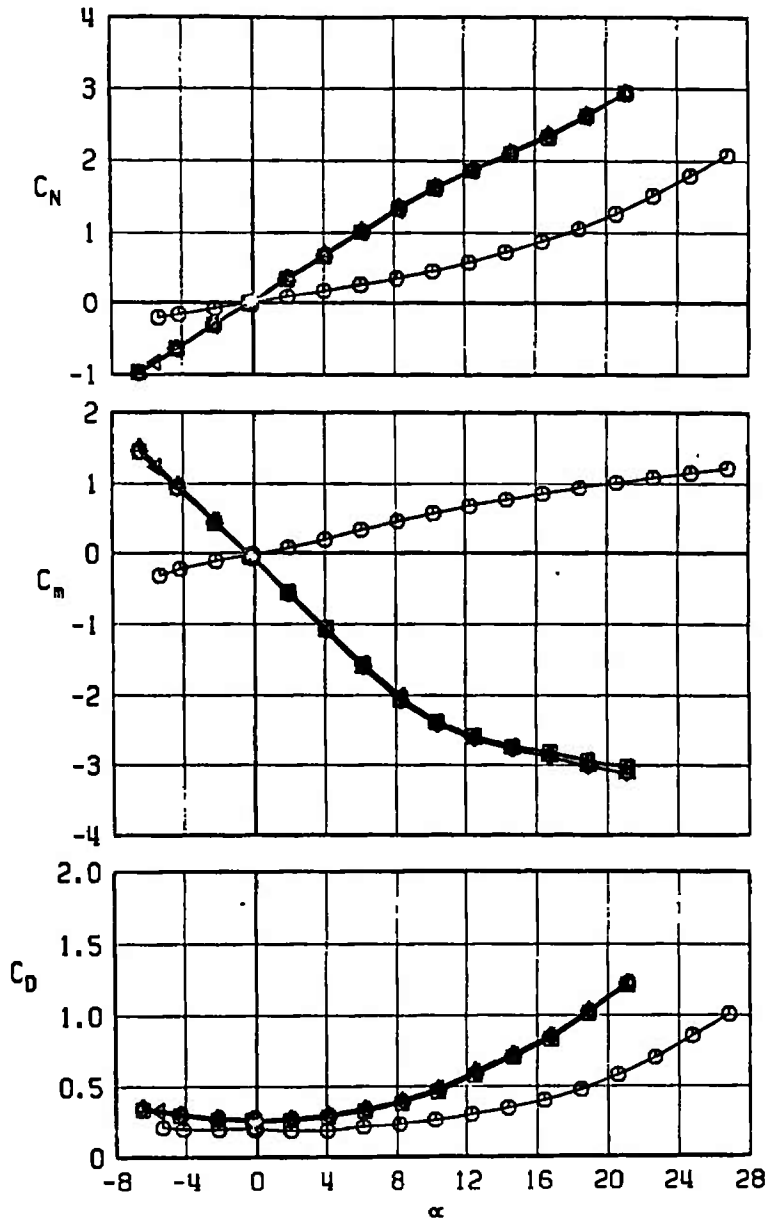
SYMBOL	$M_\infty$	$P_E \times 10^{-6}$	CONFIG
○	0.50	3.35	ASP-B
□	0.50	3.35	ASP-BT
△	0.50	3.35	ASP-BTP-1
◇	0.50	3.35	ASP-BTP-2
◁	0.50	3.35	ASP-BTP-3



a.  $M_\infty = 0.50$

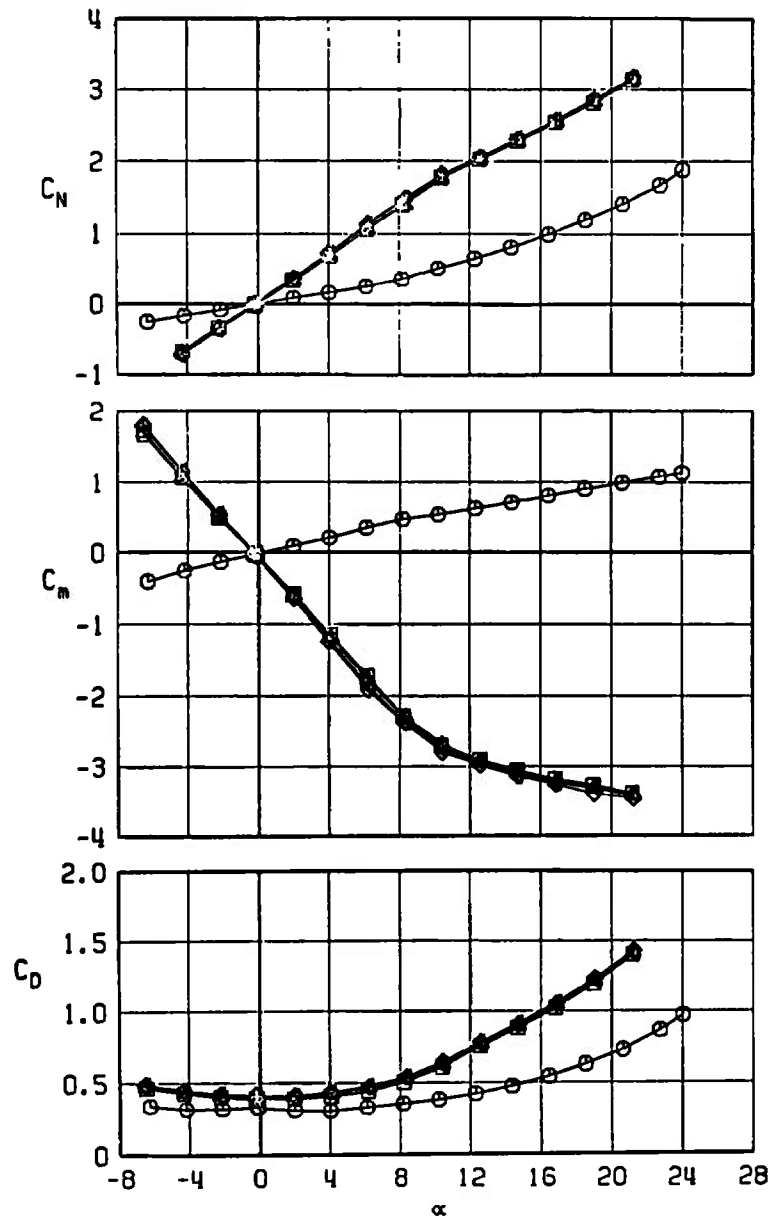
Fig. 5 Variation of the Normal-Force, Pitching-Moment, and Drag Coefficients with Angle of Attack for the Different Configurations

SYMBOL	$M_\infty$	$R_\epsilon \times 10^{-6}$	CONFIG
○	0.80	5.0	ASP-B
□	0.80	5.0	ASP-8T
△	0.80	5.0	ASP-BTP-1.
◇	0.80	5.0	ASP-BTP-2
◁	0.80	5.0	ASP-BTP-3



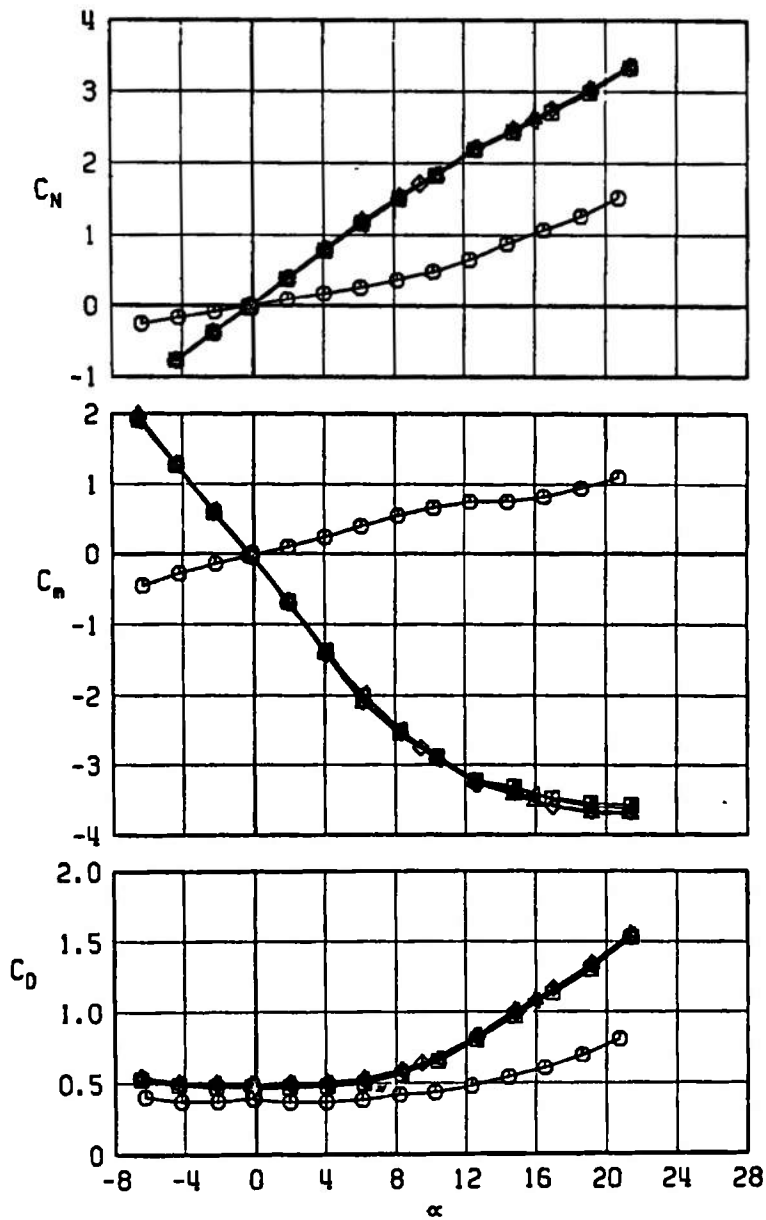
b.  $M_\infty = 0.80$   
 Fig. 5 Continued

SYMBOL	$M_\infty$	$R_\infty \times 10^{-6}$	CONFIG
○	0.90	5.0	ASP-B
□	0.90	5.0	ASP-BT
△	0.90	5.0	ASP-BTP-1
◇	0.90	5.0	ASP-BTP-2
◀	0.90	5.0	ASP-BTP-3



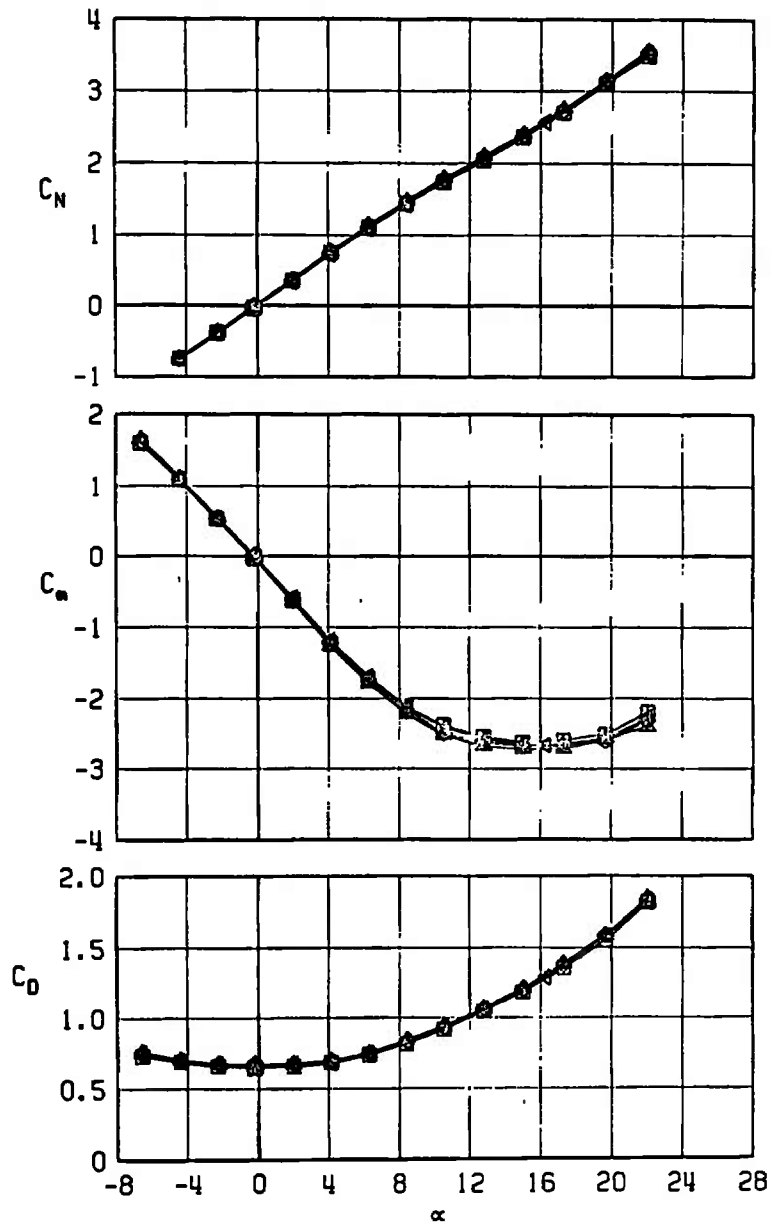
c.  $M_\infty = 0.90$   
 Fig. 5 Continued

SYMBOL	$M_\infty$	$R_e \times 10^{-5}$	CONFIG
○	0.95	5.0	ASP-B
□	0.95	5.0	ASP-BT
△	0.95	5.0	ASP-BTP-1
◇	0.95	5.0	ASP-BTP-2
◀	0.95	5.0	ASP-BTP-3



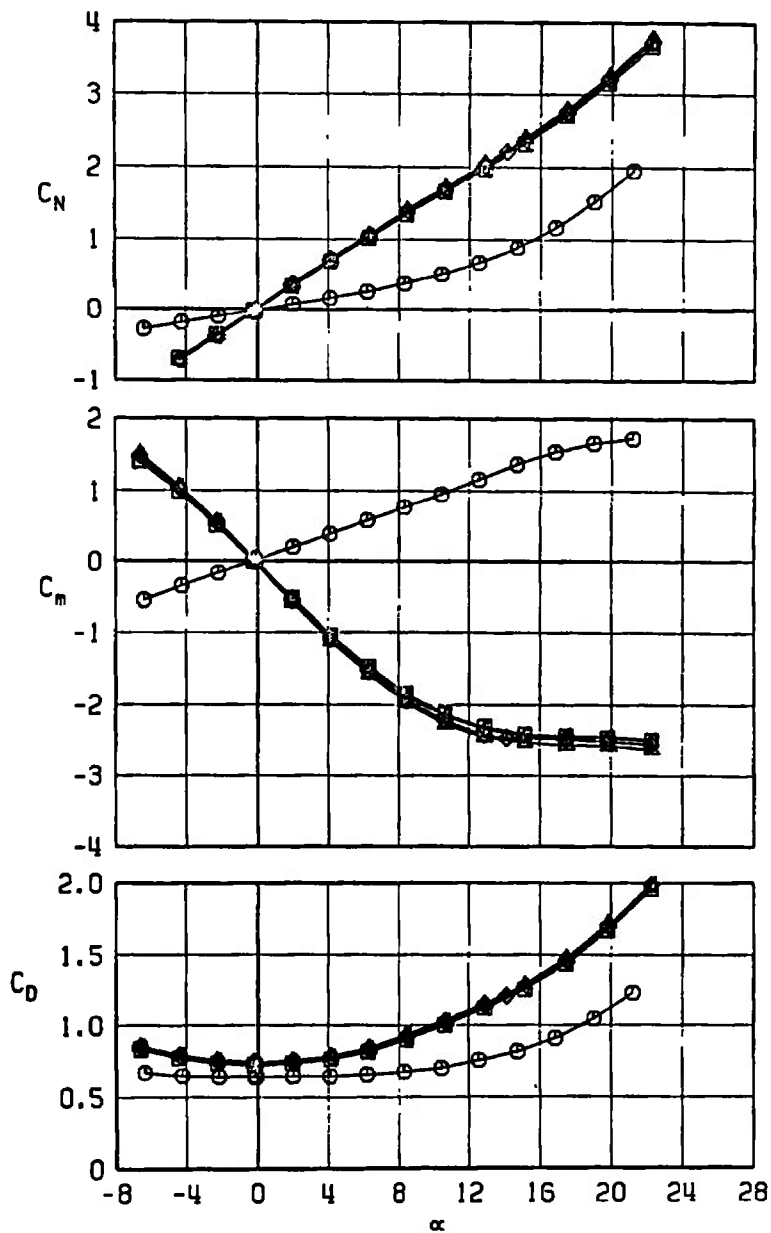
d.  $M_\infty = 0.95$   
 Fig. 5 Continued

SYMBOL	$M_\infty$	$R_e \times 10^{-6}$	CONFIG
□	1.10	5.0	ASP-BT
△	1.10	5.0	ASP-BTP-1
◇	1.10	5.0	ASP-BTP-2
◁	1.10	5.0	ASP-BTP-3



e.  $M_\infty = 1.10$   
 Fig. 5 Continued

SYMBOL	$M_\infty$	$R_e \times 10^{-6}$	CONFIG
○	1.20	5.0	ASP-8
□	1.20	5.0	ASP-8T
△	1.20	5.0	ASP-8TP-1
◇	1.20	5.0	ASP-8TP-2
◀	1.20	5.0	ASP-8TP-3



f.  $M_\infty = 1.20$   
 Fig. 5 Concluded

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13. ABSTRACT  
Force and moment data were obtained with a 0.25-scale model of the All-Altitude Spin-Projected Munition (ASP) at Mach numbers from 0.50 to 1.20 to determine the effects of fins and fins with tip plates on the static stability and drag of the ASP munition. Five configurations, comprised of three different tip plates on the fins, the fins alone, and the body without fins, were tested.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
aerodynamic forces						
fins						
static stability						
aerodynamic drag						
spin stabilized ammunition						