AD-752 764

AERODYNAMIC DATA OBTAINED FROM FREE-FLIGHT MODEL FIRINGS OF TWO BLUNT-NOSED CONICAL CONFIGURATIONS AT HYPERSONIC VELOCITIES IN MIXTURES OF AIR, NITROGEN, AND CARBON DIOXIDE

Leonard E. Crogan

Naval Ordnance Laboratory

Prepared for:

National Aeronautics and Space Administration

29 September 1972

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

NOLTR 72-236

AD752764

AERODYNAMIC DATA OBTAINED FROM FREE-FLIGHT MODEL FIRINGS OF TWO BLUNT-NOSED CONICAL CONFIGURATIONS AT HYPERSONIC VELOCITIES IN MIXTURES OF AIR, NITROGEN, AND CARBON DIOXIDE

By
Leonard E. Crogan

29 SEPTEMBER 1972

NOL

NAVAL ORDNANCE LABORATORY, WHITE OAK, SILVER SPRING, MARYLAND

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED

NOLTR 72-236

59

R

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Ordnance Laboratory Silver Spring, Maryland 20910	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE
AERODYNAMIC DATA OBTAINED FROM FREE-FLIGHT MODEL FIRINGS OF TWO BLUNT-NOSED CONICAL CONFIGURATIONS AT HYPERSONIC VELOCITIES IN MIXTURES OF AIR, NITROGEN, AND CARBON DIOXIDE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Leonard E. Crogan

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
29 September 1972	66	1

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Task Number NOL 673 d.	9a. ORIGINATOR'S REPORT NUMBER(S) NOLTR 72-236 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	NASA Washington, D. C.

13. ABSTRACT

Two blunt-nosed conical configurations were investigated at hypersonic velocities to observe the effect of several gas mixtures on their drag and stability characteristics.

Details of illustrations in this document may be better studied on microfiche

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
drag stability blunt-nosed cones atmospheres other than air, drag, and stability hypervelocity drag and stability coefficients aerodynamic coefficients in foreign gases						

AERODYNAMIC DATA OBTAINED FROM FREE-FLIGHT MODEL FIRINGS OF TWO BLUNT-NOSED CONICAL CONFIGURATIONS AT HYPERSONIC VELOCITIES IN MIXTURES OF AIR, NITROGEN, AND CARBON DIOXIDE

Prepared by:
Leonard E. Crogan

ABSTRACT: Two blunt-nosed conical configurations were investigated at hypersonic velocities to observe the effect of several gas mixtures on their drag and stability characteristics.

NAVAL ORDNANCE LABORATORY
SILVER SPRING, MARYLAND

NOLTR 72-236 29 September 1972

Aerodynamic Data Obtained from Free-Flight Model Firings of Two Blunt-Nosed Conical Configurations at Hypersonic Velocities in Mixtures of Air, Nitrogen, and Carbon Dioxide

This report presents the results of firings made with models of blunt-nosed conical configurations in the Naval Ordnance Laboratory Pressurized Ballistics Range to determine their free-flight characteristics in different atmospheres of several gases.

The work reported herein was requested by NASA, Washington, D. C., for the Jet Propulsion Laboratory, Pasadena, California, under task number NOL 673.

ROBERT WILLIAMSON II
Captain, USN
Commander

A. E. Seigel
A. E. SEIGEL
By direction

5

CONTENTS

	Page
INTRODUCTION	1
MODEL DETAILS	1
DISCUSSION AND RESULTS	1
CONCLUSIONS	4

REFERENCES

(1) Murphy, C. H., "Data Reduction for the Free-Flight Spark Ranges," BRL Report No. 900, 1954

ILLUSTRATIONS

Figure	Title
1	NASA-JPL Configurations
2	V-1 Configuration with Its Sabot
3	Shadowgraph of V-1 Configuration, M = 16.4, P = 90.6 mm Hg, 85% CO_2, 14% N_2, 1% O_2
4	Shadowgraph of A-1 Configuration, M = 14.1, P = 89.9 mm Hg, 100% N_2
5	Instrumentation Location in the Pressurized Ballistics Range No. 3
6	Drag Coefficient as a Function of Mean Squared Yaw for the V-1 Configuration
7	Drag Coefficient Corrected to Zero Yaw as a Function of Mach Number for the V-1 Configuration
8	Slope of the Normal Force Coefficient as a Function of Mean Squared Yaw for the V-1 Configuration
9	Slope of the Normal Force Coefficient Corrected to Zero Yaw as a Function of Mach Number for the V-1 Configuration
10	Slope of the Pitching Moment Coefficient Corrected to a Common CG Location as a Function of Mean Squared Yaw for the V-1 Configuration
11	Slope of the Pitching Moment Coefficient Corrected to Zero Yaw and a Common CG Location as a Function of Mach Number for the V-1 Configuration
12	Slope of the Damping Moment Coefficient as a Function of Mean Squared Yaw for the V-1 Configuration
13	Slope of the Damping Moment Coefficient as a Function of Mach Number for the V-1 Configuration
14	Drag Coefficient as a Function of Mean Squared Yaw for the A-1 Configuration
15	Drag Coefficient Corrected to Zero Yaw as a Function of Mach Number for the A-1 Configuration
16	Slope of the Normal Force Coefficient as a Function of Mean Squared Yaw for the A-1 Configuration
17	Slope of the Normal Force Coefficient Corrected to Zero Yaw as a Function of Mach Number for the A-1 Configuration
18	Slope of the Pitching Moment Coefficient Corrected to a Common CG Location as a Function of Mean Squared Yaw for the A-1 Configuration
19	Slope of the Pitching Moment Coefficient Corrected to Zero Yaw and a Common CG Location as a Function of Mach Number for the A-1 Configuration
20	Slope of the Damping Moment Coefficient as a Function of Mean Squared Yaw for the A-1 Configuration
21	Slope of the Damping Moment Coefficient as a Function of Mach Number for the A-1 Configuration
22	Shadowgraph of V-1 Configuration, M = 16.3, P = 89 mm Hg, 79% CO_2, 19% N_2, 2% O_2

TABLES

Table	Title
I	Characteristics of the NOL Pressurized Ballistics Range
II	Mass Spectrometric Analyses
III	Gas Chromatography Analyses
IV	Drag and Stability Data Obtained for V-1 Configuration in a 100 Percent Nitrogen Atmosphere
V	Drag and Stability Data Obtained for V-1 Configuration in Air and in a 15 Percent Carbon Dioxide - 85 Percent Nitrogen Atmosphere
VI	Drag and Stability Data Obtained for V-1 Configuration in a 15 Percent Nitrogen - 85 Percent Carbon Dioxide Atmosphere
VII	Drag and Stability Data Obtained for A-1 Configuration in a 100 Percent Nitrogen Atmosphere
VIII	Drag and Stability Data Obtained for A-1 Configuration in a 5 Percent Carbon Dioxide - 95 Percent Nitrogen Atmosphere
IX	Drag and Stability Data Obtained for A-1 Configuration in a 15 Percent Carbon Dioxide - 85 Percent Nitrogen Atmosphere and in a 20 Percent Carbon Dioxide - 80 Percent Nitrogen Atmosphere
X	Drag and Stability Data Obtained for A-1 Configuration in an 85 Percent Carbon Dioxide - 15 Percent Nitrogen Atmosphere
XI	Drag and Stability Data Obtained for A-1 Configuration in Air

LIST OF SYMBOLS

$a = 299.22 \sqrt{\frac{\bar{\gamma} T}{M\ app.}}$	calculated speed of sound of gas mix in feet per second
$C_D = \frac{D_t}{qS}$	total drag coefficient based on the maximum body cross-sectional area (S) of the model
C_{M_α}	(slope of the pitching moment)/qSd = slope of the pitching moment coefficient referred to the CG of the model
$C_{M_q} + C_{M_{\dot{\alpha}}}$	(slope of yaw damping moment due to q)/ $\frac{d}{2V}$ qSd + (slope of yaw damping moment due to $\dot{\alpha}$)/ $\frac{d}{2V}$ qSd = slope of damping moment coefficient referred to CG of the model
C_{N_α}	(slope of normal force)/qS = slope of normal force coefficient
CG	center of gravity
CP	center of pressure
$\bar{C}_p = \Sigma \begin{pmatrix} \%\ gas \\ C_p\ of\ gas \end{pmatrix}$	specific heat of gas mix at constant pressure
$\bar{C}_v = \Sigma \begin{pmatrix} \%\ gas \\ C_v\ of\ gas \end{pmatrix}$	specific heat of gas mix at constant volume
d	maximum diameter of model in feet
D_t	component of the aerodynamic force directed along the trajectory
Exp. a_{down}	speed of sound measured experimentally downrange
Exp. a_{up}	speed of sound measured experimentally uprange
k_D, k_M, k_N	parameters used to correct to zero yaw the drag, pitching moment, and normal force coefficients, respectively
l	length of model

$M = \frac{V}{\alpha}$	Mach number (usually based on midrange value of V)
$M_{app.} = \Sigma$ (% gas) (molecular weight of gas)	apparent molecular weight of gas mix
P	range ambient pressure in pounds per square foot
P.E.	probable error based on accuracy of data fitting (P.E. swerve; swerve equation; P.E. yaw; and yaw equation)
$\bar{q} = \frac{\bar{\gamma} p M^2}{2}$	dynamic pressure in pounds per square foot
q	lateral component of angular velocity of model
$R_{e_d} = \frac{\bar{\rho} V d}{\bar{\mu}}$	Reynolds number based on maximum diameter (d) of model
$S = \frac{\pi d^2}{4}$	maximum cross-sectional area of model
T	temperature of gas mix in degrees Kelvin
V	velocity (usually a midrange value) in feet per second
α	angle of attack
$\dot{\alpha}$	rate of change of angle of attack with time
$\overline{\delta^2}$	mean squared yaw
$\bar{\mu} = \Sigma$ (% gas) (μ of gas)	coefficient of viscosity of gas mix in $\frac{\# \text{ sec}}{\text{ft}^2}$
$\bar{\rho} = \frac{\bar{\gamma} p}{\alpha^2}$	density of gas mix in slugs per cubic foot
$\bar{\gamma} = \frac{Cp}{Cv}$	

SUBSCRIPTS

CG	coefficient corrected to CG location of 0.337 caliber for the A-1 configuration and 0.474 caliber for the V-1 configuration measured from the base of the model
o	coefficient corrected to zero yaw
B	quantity measured in calibers from base of model (one caliber = one maximum diameter of model)

INTRODUCTION

Two blunt-nosed conical configurations were fired in the Naval Ordnance Laboratory (NOL) Pressurized Ballistics Range to determine the effect of several different gaseous atmospheres on the flight characteristics of the configurations. The cones were launched at velocities approximately 16,000 feet per second into an ambient pressure of 90 mm Hg. The tests were conducted in air, nitrogen, and several combinations of nitrogen and carbon dioxide.

MODEL DETAILS

Figure 1 is a sketch of the two configurations investigated. The base diameter of the actual models tested was 0.500 inch. Figure 2 shows the V-1 configuration with an exploded view of its sabot. Figures 3 and 4 are in-flight shadowgraph prints of the V-1 and A-1 configurations, respectively.

DISCUSSION AND RESULTS

The NOL Pressurized Ballistics Range is described in Table I. The models were launched with the 0.822-inch diameter, 375-caliber, two-stage light-gas gun. The tests were conducted in air, nitrogen, and several combinations of nitrogen and carbon dioxide. These combinations were:

15% N_2 - 85% CO_2

85% N_2 - 15% CO_2

95% N_2 - 5% CO_2

80% N_2 - 20% CO_2

Percentages throughout this report are given by volume. The composition of the atmosphere in the range was determined both by gas chromatograph measurements made at NOL and by mass spectrometer analyses conducted by the National Bureau of Standards. Gas samples were extracted from three points along the range facility immediately prior to launching each projectile. Gas chromatography analysis was conducted on samples for all three locations for every round to ascertain homogeneity of the gas mixture throughout the range tube. Samples for mass spectrometry were gathered only from the midrange location to act as a double check of the gas chromatography analysis. Mass spectrometry and gas chromatography analyses for each round are listed in Tables II and III, respectively.

In most cases, agreement between the two methods of analysis was within three percent by volume of the individual gas constituents.

Greater disagreements in the two methods of analysis were attributed to leakage of the bottled sample sent to the Bureau of Standards.

Speed-of-sound values were obtained both by experiment and calculation. The calculated values were determined by using measured values of the range temperature with gas composition values obtained by means of the gas chromatograph and/or the mass spectrometer. The experimental values for speed of sound were obtained at each end of the instrumented portion of the range. Each of the two units incorporated for this purpose consisted of a sound generator and pickup. The distance between the generator and pickup was known, and the time for the sound to travel this distance was obtained from oscilloscope traces. From these measurements, the speed of sound was determined. The calculated and experimental values of speed of sound for all rounds differed by less than one percent.

There are 27 spark shadowgraph stations in the Pressurized Ballistics Range spaced alternately five and eight feet apart. Analysis samples were taken from station numbers 2, 15, and 26. The experimental speed-of-sound instrumentation was located between station numbers 2 and 4 and station numbers 25 and 27. Figure 5 is a schematic of the system showing the location of the various instrumentation.

Nitrogen was injected directly into the range from storage bottles near the launcher end of the range for shots requiring 100 percent N_2 atmosphere. Shots requiring mixtures of N_2 and CO_2 utilized a mixing tank. The gases were injected into this tank in the desired proportions. After mixing, the gas was then admitted into the range proper.

The range was evacuated as low as possible (to approximately 3 mm Hg pressure) before the gases were injected. The gases were then admitted, until the desired range pressure was obtained (about 90 mm Hg). Oxygen contamination using this technique resulted in approximately one percent by volume, although early in the program, oxygen contamination was as high as three percent due to the then undetected leaks in the range tube.

The drag and stability coefficients for the models of the National Aeronautics and Space Administration (NASA) - Jet Propulsion Laboratory (JPL) configurations were obtained using data reduction techniques described in reference (1). Tables IV through XI list the drag and stability coefficients, both uncorrected and corrected to zero yaw, for both model configurations in the different atmospheres.

The slope of the pitching moment coefficient was adjusted to the required center-of-gravity locations for each configuration as shown in Figure 1. This was done as follows:

$$\frac{C_{M_{\alpha_1}}}{C_{N_\alpha}} = CP_N - CG_N$$

where

The subscript (1) indicates the coefficient is referred to the measured center of gravity (CG_N) of the model.

Then

$$\frac{C_{M_{\alpha_{CG}}}}{C_{N_\alpha}} = (CP_N - CG_N) + CG_N - X$$

where

The subscript (CG) indicates the coefficient is referred to the desired center of gravity, and X is the desired center of gravity expressed in calibers from the nose of the model (one caliber being the model's maximum diameter).

Therefore

$$C_{M_{\alpha_{CG}}} = C_{N_\alpha} (CP_N - X)$$

The coefficients were corrected to zero yaw by using the following equations.

$$C_{D_o} = C_D - k_D \bar{\gamma}^2$$

$$C_{M_{\alpha_{CG_o}}} = C_{M_{\alpha_{CG}}} - k_M \bar{\gamma}^2$$

$$C_{N_{\alpha_o}} = C_{N_\alpha} - k_N \bar{\gamma}^2.$$

Values for k_D, k_M, and k_N were obtained by using the data of a particular configuration within a specific gas mixture.

Although there are variations in center-of-gravity locations, the slopes of the damping moment coefficient were not corrected to a particular center-of-gravity location, since the scatter in coefficient at any one center-of-gravity location was greater than the variation caused by the difference in the center-of-gravity location. It was also because of the scatter in the slope of the damping moment coefficient that no trend with $\bar{\delta}^2$ could be observed, and, therefore, these coefficients were not corrected to zero yaw.

The aerodynamic coefficients and derivatives are also presented in graphical form as a function of both Mach number and mean squared yaw in Figures 6 through 21.

Several interesting phenomena were observed during the course of this program. Turbulent disturbances were observed both on the model and in the wake of both configurations during tests in atmospheres high in CO_2 content. Figure 22 is a good example of these phenomena. An explanation of these phenomena could be that the turbulent disturbances seen are pressure gradients caused by the release of energy during the dissociation of the high concentration of carbon dioxide gas at the elevated temperatures encountered at the program conditions.

It was also noted that the magnitude of the visible radiation greatly increased for atmospheres of ten percent CO_2 and less.

CONCLUSIONS

At the conditions investigated, only one derivative for one configuration displayed any definite effect of different gas mixtures. This was the slope of the normal force coefficient for configuration V-1. The absolute value of the coefficient in an atmosphere of high nitrogen concentration was lower than that in an atmosphere of high carbon dioxide concentration. This is shown in Figure 9.

TABLE I

CHARACTERISTICS OF THE NOL PRESSURIZED BALLISTICS RANGE

Length	285-foot tube 189-foot usable length for drag and stability measurements
Cross Section	3-foot-diameter where 14-inch x 17-inch shadowgraphs of model and wake are made
Pressure	6 atmospheres absolute to 4/1000 of an atmosphere (123,000-foot altitude)
Temperature	75 degrees F ambient
Maximum Projectile Size	2 inches in a powder gun 1 inch in the two-stage gas gun
Velocity Range	1,000 - 24,000 feet per second dependent upon gun, projectile size, and charge
Launchers	Two-Stage Light-Gas Guns: .822 inch x 375 cal .788 inch x 240 cal 1.261 inches x 230 cal 1.000 inch x 400 cal Powder Guns: 76 mm - 40 mm x 144 inches long 57 mm x 72 inches long 50 mm x 60 inches long
Photographic Spark Stations	27 shadowgraph stations, 2 high-sensitivity double-pass schlieren stations
X-ray stations	2
Additional Capabilities	Controlled-temperature section (80 degrees F - 850 degrees F); gas chromatograph; 3 spectrophotometers for radiation studies Specially instrumented 21-foot section for continuous coverage wake photographs
Luminosity Stations	5

TABLE II

MASS SPECTROMETRIC ANALYSES

Round No.	% Dry Air*	% N_2	% CO_2	% H_2O
4848	30.0	68.4	1.2	0.4
4849	14.7	84.8	—	0.4
4850	14.5	85.1	—	0.4
4851	18.3	81.4	—	0.3
4852	38.0	8.7	52.9	0.4
4853	48.8	7.2	43.7	0.3
4854	12.4	87.4	—	0.2
4855	10.8	89.0	—	0.3
4856	7.0	92.7	—	0.3
4857	7.1	92.7	—	0.2
4858	29.8	8.8	61.2	0.2
4864	11.0	88.8	—	0.2
4865	85.3	14.6	—	0.1
4866	24.1	9.9	65.6	0.3
4870	7.0	11.6	81.2	0.2
4871	1.9	98.0	—	0.1
4872	88.0	1.7	9.9	0.4
4873	7.6	14.6	77.6	0.2
4874	9.6	9.1	81.1	0.2
4875	7.3	11.0	81.6	0.1
4876	13.1	13.2	73.4	0.2
4877	1.3	98.5	—	0.2
4878	32.9	10.8	55.6	0.7
4884	2.3	93.1	4.4	0.1
4887	2.7	90.6	6.7	—
4889	6.9	14.4	78.8	—
4890	4.0	90.0	6.0	—
4894	8.2	11.4	80.3	0.1
4895	1.0	98.8	—	0.2
4896	1.5	98.5	—	—
4902	13.5	86.3	—	0.1
4904	3.6	76.1	20.2	—
4905	4.2	81.1	14.7	—
4906	1.7	84.0	14.2	—
4907	1.2	85.2	13.5	—
4908	3.1	83.1	13.8	—
4909	2.6	83.6	13.8	—
4911	55.6	38.2	6.0	0.2

*Nitrogen 78.03 mole percent
Oxygen 20.99 mole percent
Argon 0.94 mole percent
Carbon Dioxide 0.03 mole percent

TABLE III

GAS CHROMATOGRAPHY ANALYSES

Round No.	Location	% N_2	% O_2	% CO_2
4848	downrange	94.7	3.3	2.0
	midrange	96.7	2.9	0.4
	uprange	97.0	3.0	
4849	downrange	95.1	4.2	0.7
	midrange	96.8	2.6	0.6
	uprange	98.2	1.6	0.2
4850	downrange	95.5	3.4	1.1
	midrange	96.6	2.5	0.9
	uprange	97.9	1.8	0.3
4851	downrange	99.5	0.5	
	midrange	96.1	3.1	0.8
	uprange	99.2	0.8	
4852	downrange	13.4	1.2	85.4
	midrange	33.2	8.5	58.3
	uprange	21.4	4.2	74.4
4854	downrange	98.3	1.4	0.3
	midrange	96.6	2.5	0.9
	uprange	98.1	1.4	0.5
4856	downrange	98.7	1.0	0.3
	midrange	97.7	1.6	0.7
	uprange	98.2	1.1	0.7
4857	downrange	98.8	0.9	0.3
	midrange	97.6	1.6	0.8
	uprange	98.2	1.4	0.4
4858	downrange	14.8	2.0	83.2
	midrange	24.8	5.2	70.0
	uprange	22.1	4.4	73.5
4864	downrange	98.6	1.1	0.3
	midrange	96.7	2.6	0.7
	uprange	97.5	1.9	0.6
4865	downrange	98.3	1.1	0.6
	midrange	97.5	1.5	1.0
	uprange	96.9	2.2	0.9

TABLE III (Cont.)

Round No.	Location	% N_2	% O_2	% CO_2
4866	downrange	16.6	2.2	81.2
	midrange	24.8	5.1	70.1
	uprange	21.5	3.9	74.6
4870	downrange	16.8	1.4	81.8
	midrange	22.9	4.1	73.0
	uprange	14.9	1.4	83.7
4871	downrange	99.2	0.5	0.3
	midrange	99.6	0.3	0.1
	uprange	99.6	0.4	
4872	downrange	16.9	1.6	81.5
	midrange	16.5	1.6	81.9
	uprange	17.4	2.0	80.6
4873	downrange	18.5	1.6	79.9
	midrange	19.2	1.7	79.1
	uprange	19.3	1.9	78.8
4874	downrange	14.4	1.3	84.3
	midrange	14.0	1.3	84.7
	uprange	15.4	1.6	83.0
4875	downrange	14.9	1.4	83.7
	midrange	14.9	1.5	83.6
	uprange	15.9	1.8	82.3
4876	downrange	20.6	2.7	76.7
	midrange	20.5	2.6	76.9
	uprange	20.9	2.7	76.4
4877	downrange	99.3	0.4	0.3
	midrange	99.7	0.3	
	uprange	99.6	0.4	
4878	downrange	13.8	0.9	85.3
	midrange	13.6	1.1	85.3
	uprange	14.3	1.2	84.5
4879		air		
4882		air		
4884	downrange	96.0	0.5	3.5
	midrange	95.4	0.7	3.9
	uprange	95.2	0.7	4.1
4887	downrange	93.4	0.6	6.0
	midrange	92.9	0.7	6.4
	uprange	92.8	0.8	6.4

TABLE III (Cont.)

Round No.	Location	% N_2	% O_2	% CO_2
4888		air		
4889	downrange	16.8	1.2	82.0
	midrange	17.7	1.5	80.8
	uprange	18.5	1.8	79.7
4891		air		
4894	downrange	15.1	1.6	83.3
	midrange	15.3	1.7	83.0
	uprange	16.5	1.9	81.6
4895	downrange	99.7	0.3	
	midrange	99.7	0.3	
	uprange	99.7	0.3	
4896	downrange	99.5	0.5	
	midrange	99.6	0.4	
	uprange	99.6	0.4	
4902	downrange	99.4	0.6	
	midrange	99.6	0.4	
	uprange	99.6	0.4	
4903		air		
4904	downrange	78.4	0.6	21.0
	midrange	79.0	0.9	20.1
	uprange	78.3	1.0	20.7
4905	downrange	85.1	1.1	13.8
	midrange	84.1	1.1	14.8
	uprange	84.4	1.5	14.1
4906	downrange	85.6	0.2	14.2
	midrange	85.8	0.3	13.9
	uprange	85.4	0.4	14.2
4908	downrange	84.7	0.5	14.8
	midrange	84.9	0.7	14.4
	uprange	84.2	0.6	15.2
4909	downrange	86.7	0.8	12.5
	midrange	85.4	0.6	14.0
	uprange	85.4	0.7	13.9
4911	downrange	85.9	0.2	13.9
	midrange	85.1	0.5	14.4
	uprange	85.4	0.6	14.0

TABLE IV

DRAG AND STABILITY DATA OBTAINED FOR V-1 CONFIGURATION IN A 100 PERCENT NITROGEN ATMOSPHERE

Round	4848	4877	4871	4895	4896
M	12.38	13.76	13.41	12.70	13.60
P (in Hg)	3.39	3.56	3.53	3.54	3.52
$\overline{\delta^2}$ (deg^2)	58	81	11	137	52
$Re_d \times 10^{-6}$	0.410	0.477	0.462	0.438	0.466
C_D	0.370	0.3809	0.3522	0.4101	0.3521
$\pm$P.E.	0.001	0.0005	0.0006	0.0006	0.0007
C_{D_o}	0.336	0.3339	0.3458	0.3306	0.3219
P.E. yaw (deg)	1.1	0.6		1.1	0.6
P.E. swerve (in)	0.02	0.02		0.04	0.02
C_{M_α}/deg	-0.00188	-0.00216	-0.0026	-0.00215	-0.00182
$\pm$P.E.	0.00004	0.00002	0.0001	0.00003	0.00002
$C_{M_{\alpha_{CG}}}$/deg	-0.00191	-0.00214		-0.00313	-0.00202
$C_{M_{\alpha_{CG_o}}}$/deg	-0.00181	-0.00201		-0.00290	-0.00193
C_{N_α}/deg	-0.021	-0.021		-0.023	-0.021
$\pm$P.E.	0.001	0.001		0.002	0.001
$C_{N_{\alpha_o}}$/deg	-0.020	-0.019		-0.020	-0.020
$C_{M_q} + C_{M_{\dot\alpha}}$	-0.7	-0.6		-0.6	0

TABLE IV (Cont.)

Round	4848	4877	4871	4895	4896
±P.E.	1.2	0.5		0.8	0.7
(CP-CG) Cal.	0.091	0.104		0.130	0.088
CG_B (in)	0.237	0.238	0.240	0.234	0.233
l (in)	0.576	0.575	0.575	0.575	0.575
d (in)	0.500	0.500	0.500	0.500	0.500
a (ft/sec)	1146	1151	1150	1151	1151
Exp. a_{up} (ft/sec)	1154	1148	1149	1149	1146
Exp. a_{down} (ft/sec)		1149	1151	1150	1150
Stations Used	8-27	3-37	5-27	3-27	3-27
Location of Sample Used for Reduction	midrange	midrange & Bureau of Standards	midrange & Bureau of Standards	midrange & Bureau of Standards	midrange & Bureau of Standards

TABLE V

DRAG AND STABILITY DATA OBTAINED FOR V-1 CONFIGURATION IN AIR AND IN A 15 PERCENT CARBON DIOXIDE - 85 PERCENT NITROGEN ATMOSPHERE

Round	4908	4840
M	14.67	14.22
P (in Hg)	3.52	3.91
$\overline{\delta^2}$ (deg^2)	190	19
$Re_d \times 10^{-6}$	0.534	0.533
C_D	0.441	0.3409
$\pm$P.E.	0.001	0.0008
C_{D_o}	0.331	0.3299
P.E. yaw (deg)	1.0	
P.E. swerve (in)	0.02	-0.0019
C_{M_α}/deg	-0.00242	
$\pm$P.E.	0.00002	
$C_{M_{\alpha_{CG}}}$/deg	-0.00255	
$C_{M_{\alpha_{CG_o}}}$/deg	-0.00223	
C_{N_α}/deg	-0.023	
$\pm$P.E.	0.001	
$C_{M_q} + C_{M_{\dot{\alpha}}}$	-0.3	

TABLE V (Cont.)

Round	4908	4840
$\pm$P.E.	0.5	
(CP-CG) Cal	0.103	
CG_B (in)	0.233	0.240
l (in)	0.575	0.575
d (in)	0.500	0.500
a (ft/sec)	1099	1134
Exp. a_{up} (ft/sec)	1091	
Exp. a_{down} (ft/sec)	1100	
Stations Used	6-27	5-27
Location of Sample Used for Reduction	midrange & Bureau of Standards	air

TABLE VI

DRAG AND STABILITY DATA OBTAINED FOR V-1 CONFIGURATION IN A 15 PERCENT NITROGEN - 85 PERCENT CARBON DIOXIDE ATMOSPHERE

Round	4875	4872	4873	4873	4874	4874
M	17.59	16.30	16.27	16.21	16.56	16.41
P (in Hg)	3.54	3.53	3.51	3.51	3.57	3.57
$\overline{\delta^2}$ (deg^2)	12	126	95	95	12	12
$Re_d \times 10^{-6}$	0.828	0.665	0.749	0.743	0.786	0.771
C_D	0.349	0.4146	0.3889	0.3909	0.3254	0.3298
$\pm$P.E.	0.003	0.0004	0.0002	0.0002	0.0004	0.0004
C_{D_o}	0.342	0.3415	0.3338	0.3358	0.3184	0.3228
P.E. yaw (deg)		0.9	1.2	1.2	0.7	0.7
P.E. swerve (in)		0.02	0.01	0.01	0.02	0.02
C_{M_α}/deg	-0.0034	-0.00265	-0.00261	-0.00264	-0.00312	-0.00316
$\pm$P.E.		0.00002	0.00004	0.00004	0.00006	0.00006
$C_{M_{\alpha_{CG}}}$/deg		-0.00261	-0.00267		-0.00305	
$C_{M_{\alpha_{CG_o}}}$/deg		-0.00240	-0.00251		-0.00303	
C_{N_α}/deg		-0.0261	-0.025	-0.025	-0.025	-0.025

TABLE VI (Cont.)

Round	4875	4872	4873	4873	4874	4874
±P.E.		0.0009	0.002	0.002	0.006	0.006
$C_{N_{\alpha_o}}$/deg		-0.0251	-0.024	-0.024	-0.025	-0.025
$C_{M_q} + C_{M_{\dot{\alpha}}}$		+0.2	-1.5	-1.5	-2.1	-2.1
±P.E.		0.4	0.8	0.8	1.1	1.1
(CP-CG) Cal		0.102	0.104	0.104	0.126	0.126
CG_B (in)	0.238	0.238	0.236	0.236	0.239	0.239
l (in)	0.576	0.574	0.575	0.575	0.575	0.575
d (in)	0.501	0.500	0.501	0.501	0.500	0.500
a (ft/sec)	914	918.1	924.2	927.6	912.1	920
Exp. a_{up} (ft/sec)	916.4	920.4	925.1	925.1	917.8	917.8
Exp. a_{down} (ft/sec)	915.5	920.9	924.1	924.1	917.3	917.3
Stations Used	17-27	3-24	2-27	2-27	2-27	2-27
Location of Sample Used for Reduction	midrange & Bureau Standards	midrange	midrange	Bureau of Standards	midrange	Bureau of Standards

TABLE VII

DRAG AND STABILITY OBTAINED FOR A-1 CONFIGURATION
IN a 100 PERCENT NITROGEN ATMOSPHERE

Round	4849	4849	4850	4850	4864	4864
M	12.34	12.30	12.27	12.24	13.40	13.38
P (in Hg)	3.58	3.58	3.87	3.87	3.62	3.62
$\overline{\delta^2}$ (deg^2)	12	12	264	264	367	367
$Re_d \times 10^{-6}$	0.430	0.427	0.460	0.457	0.471	0.470
C_D	0.7080	0.7127	0.730	0.735	0.7652	0.7663
$\pm$P.E.	0.0009	0.0009	0.002	0.002	0.0005	0.0005
C_{D_o}	0.7068	0.7115	0.704	0.709		
P.E. yaw (deg)			1.1	1.1	1.4	1.4
P.E. swerve (in)			0.02	0.02	0.01	0.01
C_{M_α}/deg	-0.0007	-0.0007	-0.00089	-0.00090	-0.00130	-0.00130
$\pm$P.E.	0.0002	0.0002	0.00001	0.00001	0.00002	0.00002
$C_{M_{\alpha CG}}$/deg	-0.0007	-0.0007	-0.00096	-0.00068	-0.00132	
$C_{M_{\alpha CG_o}}$/deg			-0.00038		-0.00051	

TABLE VII (Cont.)

Round	4849	4849	4850	4850	4864	4864
C_{N_α}/deg			-0.0171	-0.0172	-0.0176	-0.0176
±P.E.			0.0005	0.0005	0.0003	0.0003
$C_{N_{\alpha_o}}$/deg			-0.0152	-0.0153		
$C_{M_q} + C_{M_{\dot\alpha}}$			-0.3	-0.3	-0.4	-0.4
±P.E.			0.5	0.5	0.7	0.7
(CP-CG) Cal			0.052	0.052	0.079	0.079
CG_B (in)	0.170	0.170	0.166	0.166	0.170	0.170
l (in)	0.410	0.410	0.410	0.410	0.409	0.409
d (in)	0.499	0.499	0.498	0.498	0.498	0.498
a (ft/sec)	1146	1149	1146	1149	1147	1149
Exp. a_{up} (ft/sec)	1150	1150	1153	1153	1147	1147
Exp. a_{down} (ft/sec)	1149	1149	1155	1155	1151	1151
Stations Used	5-27	5-27	5-26	5-26	2-27	2-27
Location of Sample Used for Reduction	midrange	Bureau of Standards	midrange	Bureau of Standards	uprange	Bureau of Standards

TABLE VII

(Continued)

Round	4865	4902	4851	4854	4856	4857
M	13.13	13.88	12.28	12.16	13.84	13.10
P (in Hg)	3.61	3.50	3.80	3.58	3.54	3.53
$\overline{\delta^2}$ (deg^2)	233	38	74	7	32	74
$Re_d \times 10^{-6}$	0.464	0.471	0.451	0.434	0.477	0.451
C_D	0.7468	0.722	0.710	0.712	0.720	0.707
$\pm$P.E.	0.0002	0.001	0.002	0.002	0.002	0.002
C_{D_o}	0.7240	0.718	0.703	0.711	0.717	0.700
P.E. yaw (deg)	1.4					
P.E. swerve (in)	0.01					
C_{M_α}/deg	-0.00096	-0.0007	-0.0009	-0.0007	-0.0008	
$\pm$P.E.	0.00001		0.0003			
$C_{M_{\alpha_{CG}}}$/deg	-0.00085	-0.0007	-0.0008	-0.0007	-0.0008	
$C_{M_{\alpha_{CG_o}}}$/deg	-0.00034					

TABLE VII (Cont.)

Round	4865	4902	4851	4854	4856	4857
C_{N_α}/deg	-0.0180					
±P.E.	0.0005					
$C_{N_{\alpha_o}}$/deg	-0.0163					
$C_{M_q} + C_{M_{\dot\alpha}}$	-0.1					
±P.E.	0.8					
(CP-CG) Cal	0.053					
CG_B (in)	0.171	0.165	0.165	0.166	0.172	0.166
l (in)	0.411	0.410	0.410	0.410	0.408	0.409
d (in)	0.499	0.498	0.498	0.500	0.499	0.500
a (ft/sec)	1142	1151	1146	1146	1148	1148
Exp. a_{up} (ft/sec)	1151	1151	1159	1149	1146	1145
Exp. a_{down} (ft/sec)	1149	1152	1156	1146	1148	1148
Stations Used	8-27	6-27	16-27	11-27	14-27	8-24
Location of Sample Used for Reduction	midrange	midrange	midrange & Bureau of Standards	midrange & Bureau of Standards	midrange & Bureau of Standards	midrange & Bureau of Standards

TABLE VIII

DRAG AND STABILITY DATA OBTAINED FOR A-1 CONFIGURATION IN A 5 PERCENT CARBON DIOXIDE - 95 PERCENT NITROGEN ATMOSPHERE

Round	4884	4887
M	13.60	13.48
P (in Hg)	3.54	3.53
$\overline{\delta^2}$ (deg^2)	234	45
$Re_d \times 10^{-6}$	0.474	0.473
C_D	0.7387	0.7142
$\pm$P.E.	0.0007	0.0007
C_{D_o}	0.7158	0.7098
P.E. yaw (deg)	2.4	0.4
P.E. swerve (in)	0.03	0.02
C_{M_α}/deg	-0.00074	-0.000348
$\pm$P.E.	0.00007	0.000007
$C_{M_{\alpha_{CG}}}$/deg	-0.00093	-0.000480
$C_{M_{\alpha_{CG_o}}}$/deg	-0.00042	-0.000381
C_{N_α}/deg	-0.0183	-0.016
$\pm$P.E.	0.0008	0.002
$C_{N_{\alpha_o}}$/deg	-0.0166	-0.016

TABLE VIII (Cont.)

Round	4884	4887
$C_{M_q} + C_{M_{\dot{\alpha}}}$		-2.6
$\pm$P.E.		0.4
(CP-CG) Cal	0.041	0.021
CG_B (in)	0.163	0.163
l (in)	0.410	0.407
d (in)	0.498	0.497
a (ft/sec)	1136	1126
Exp. a_{up} (ft/sec)	1129	1124
Exp. a_{down} (ft/sec)	1132	1124
Stations Used	2-27	2-27
Location of Sample Used for Reduction	midrange & Bureau of Standards	midrange & Bureau of Standards

TABLE IX

DRAG AND STABILITY DATA OBTAINED FOR A-1 CONFIGURATION IN A 15 PERCENT CARBON DIOXIDE - 85 PERCENT NITROGEN ATMOSPHERE AND IN A 20 PERCENT CARBON DIOXIDE - 80 PERCENT NITROGEN ATMOSPHERE

Round	4906	4909	4911	4905	4904
M	14.40	14.18	14.49	14.29	14.46
P (in Hg)	3.54	3.56	3.54	3.50	3.50
$\overline{\delta^2}$ (deg^2)	22	44	87	30	16
$Re_d \times 10^{-6}$	0.519	0.518	0.526	0.516	0.532
C_D	0.7271	0.6988	0.7196	0.7244	0.736
±P.E.	0.0008	0.0005	0.0005	0.0006	0.001
C_{D_o}	0.7249	0.6945	0.7111	0.7215	0.734
P.E. yaw (deg)			1.4	1.2	0.6
P.E. swerve (in)			0.02	0.01	0.02
C_{M_α}/deg	-0.00030	-0.00027	-0.00051	-0.00052	-0.00032
±P.E.			0.00002	0.00003	0.00002
$C_{M_{\alpha_{CG}}}$/deg	-0.00026	-0.00019	-0.00056	-0.00076	-0.00048

TABLE IX (Cont.)

Round	4906	4909	4911	4905	4904
$C_{M_{\alpha_{CG_o}}}$/deg			-0.00037	-0.00069	-0.00044
C_{N_α}/deg			-0.0175	-0.0173	-0.0167
$\pm$P.E.			0.0004	0.0007	0.0009
$C_{N_{\alpha_o}}$/deg			-0.0169	-0.0171	-0.0166
$C_{M_q} + C_{M_{\dot{\alpha}}}$			-1.7		-1
$\pm$P.E.			0.7		1
(CP-CG) Cal			0.027	0.030	0.019
CG_B (in)	0.162	0.159	0.165	0.161	0.163
l (in)	0.409	0.407	0.410	0.409	0.409
d (in)	0.495	0.498	0.497	0.498	0.498
a (ft/sec)	1101	1101	1100	1097	1080
Exp. a_{up} (ft/sec)	1095	1094	1098	1095	1075
Exp. a_{down} (ft/sec)	1096	1095	1099	1097	1078
Stations Used	6-27	2-27	3-27	3-27	3-27
Location of Sample Used for Reduction	midrange & Bureau Standards	midrange & Bureau Standards	midrange	midrange & Bureau Standards	midrange & Bureau Standards

TABLE X

DRAG AND STABILITY DATA OBTAINED FOR A-1 CONFIGURATION IN A 85 PERCENT CARBON DIOXIDE - 15 PERCENT NITROGEN ATMOSPHERE

Round	4889	4894	4878	4876	4876
M	16.16	17.44	17.21	16.68	16.54
P (in Hg)	3.57	3.53	3.51	3.52	3.52
$\overline{\delta^2}$ (deg^2)	63	41	114	98.5	98.5
$Re_d \times 10^{-6}$	0.758	0.813	0.802	0.755	0.741
C_D	0.7142	0.6960	0.7154	0.7068	0.7171
$\pm$P.E.	0.0004	0.0006	0.0004	0.0003	0.0003
C_{D_o}	0.7080	0.6920	0.7042	0.6971	0.7074
P.E. yaw (deg)		1.0	0.9	0.8	0.8
P.E. swerve (in)		0.02	0.02	0.02	0.02
C_{M_α}/deg	-0.00029	-0.00021	-0.000444	-0.000329	-0.000333
$\pm$P.E.		0.00001	0.000007	0.000005	0.000005
$C_{M_{\alpha CG}}$/deg	-0.00011	-0.00029	-0.000603	-0.000554	-0.000057

TABLE X (Cont.)

Round	4889	4894	4878	4876	4876
$C_{M_{\alpha CG_o}}$/deg		-0.00020	-0.000352	-0.000337	
C_{N_α}/deg		-0.0145	-0.0163	-0.0168	-0.0170
±P.E.		0.0003	0.0002	0.0003	0.0003
$C_{N_{\alpha_o}}$/deg		-0.0142	-0.0155	-0.0161	-0.0163
$C_{M_q} + C_{M_{\dot\alpha}}$		+0.4	+0.3	+0.8	+0.8
±P.E.		0.6	0.3	0.2	0.2
(CP-CG) Cal		0.014	0.027	0.019	0.019
CG_B (in)	0.166	0.165	0.163	0.161	0.161
l (in)	0.407	0.409	0.408	0.409	0.409
d (in)	0.499	0.499	0.498	0.498	0.498
a (ft/sec)	920.1	915.6	911	928.8	936.2
Exp. a_{up} (ft/sec)	922.5	919.1	913.5	934.8	934.8
Exp. a_{down} (ft/sec)	921.8		914.6	933.9	933.9
Stations Used	2-27	3-27	2-26	2-27	2-27
Location of Sample Used for Reduction	midrange & Bureau of Standards	midrange & Bureau of Standards	midrange	midrange	Bureau of Standards

TABLE XI

DRAG AND STABILITY DATA OBTAINED FOR A-1 CONFIGURATION IN AIR

Round	4903	4879	4882	4888	4891
M	13.80	13.67	13.49	13.80	13.92
P (in Hg)	3.51	3.37	3.49	3.54	3.48
$\overline{\delta^2}$ (deg^2)	41	120	127	51	46
$Re_d \times 10^{-6}$	0.460	0.439	0.448	0.465	0.462
C_D	0.7127	0.7211	0.7237	0.7102	0.7021
$\pm$P.E.	0.0005	0.0005	0.0005	0.0005	0.0005
C_{D_o}	0.7087	0.7093	0.7113	0.7052	0.6976
P.E. yaw (deg)	0.8	1.0	1.3	0.6	0.8
P.E. swerve (in)	0.02	0.01	0.02	0.02	0.02
C_{M_α}/deg	-0.00033	-0.00054	-0.00062	-0.000429	-0.00035
$\pm$P.E.	0.00001	0.00001	0.00001	0.000008	0.00001
$C_{M_{\alpha_{CG}}}$/deg	-0.00060	-0.00066	-0.00073	-0.000551	-0.00047

TABLE XI (Cont.)

Round	4903	4879	4882	4888	4891
$C_{M_{\alpha CG_o}}$/deg	-0.00051	-0.00040	-0.00045	-0.000439	-0.00037
C_{N_α}/deg	-0.0154	-0.0161	-0.0174	-0.0162	-0.0168
$\pm$P.E.	0.0003	0.0003	0.0005	0.0003	0.0005
$C_{N_{\alpha_o}}$/deg	-0.0151	-0.0152	-0.0165	-0.0158	-0.0165
$C_{M_q} + C_{M_{\dot{\alpha}}}$	+2.3	0	+0.4	-0.9	-1.7
$\pm$P.E.	0.9	0.5	0.5	0.4	0.5
(CP-CG) Cal	0.022	0.033	0.036	0.026	0.021
CG_B (in)	0.159	0.164	0.165	0.164	0.165
l (in)	0.409	0.410	0.410	0.410	0.410
d (in)	0.497	0.498	0.498	0.499	0.500
a (ft/sec)	1136	1136	1136	1136	1135
Exp. a_{up} (ft/sec)	1133	1130	1129	1132	1131
Exp. a_{down} (ft/sec)	1134	1131	1131	1132	1131
Stations Used	3-27	5-27	3-27	3-27	3-27
Location of Sample Used for Reduction	air	air	air	air	air

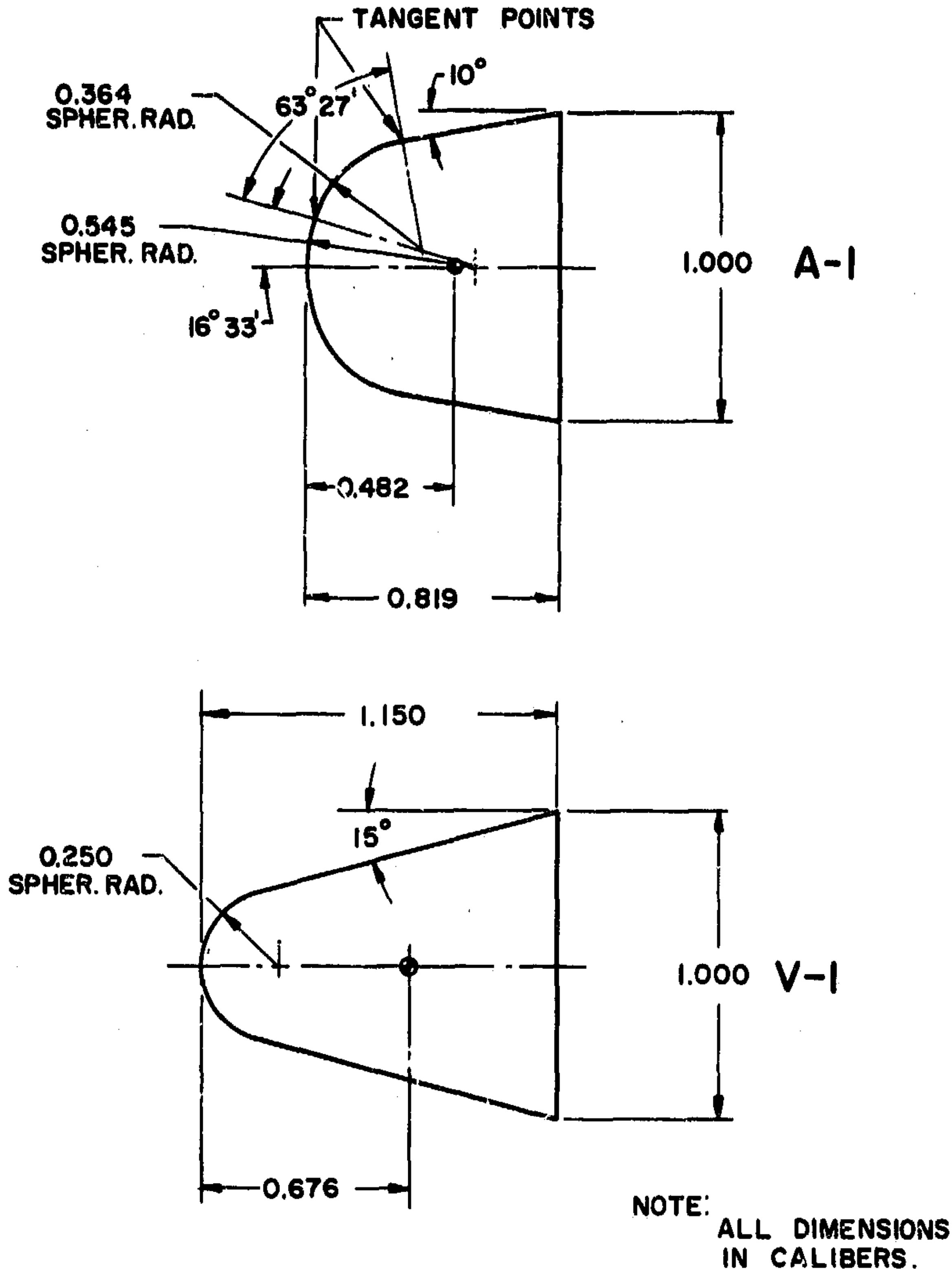

FIGURE I NASA-JPL CONFIGURATIONS

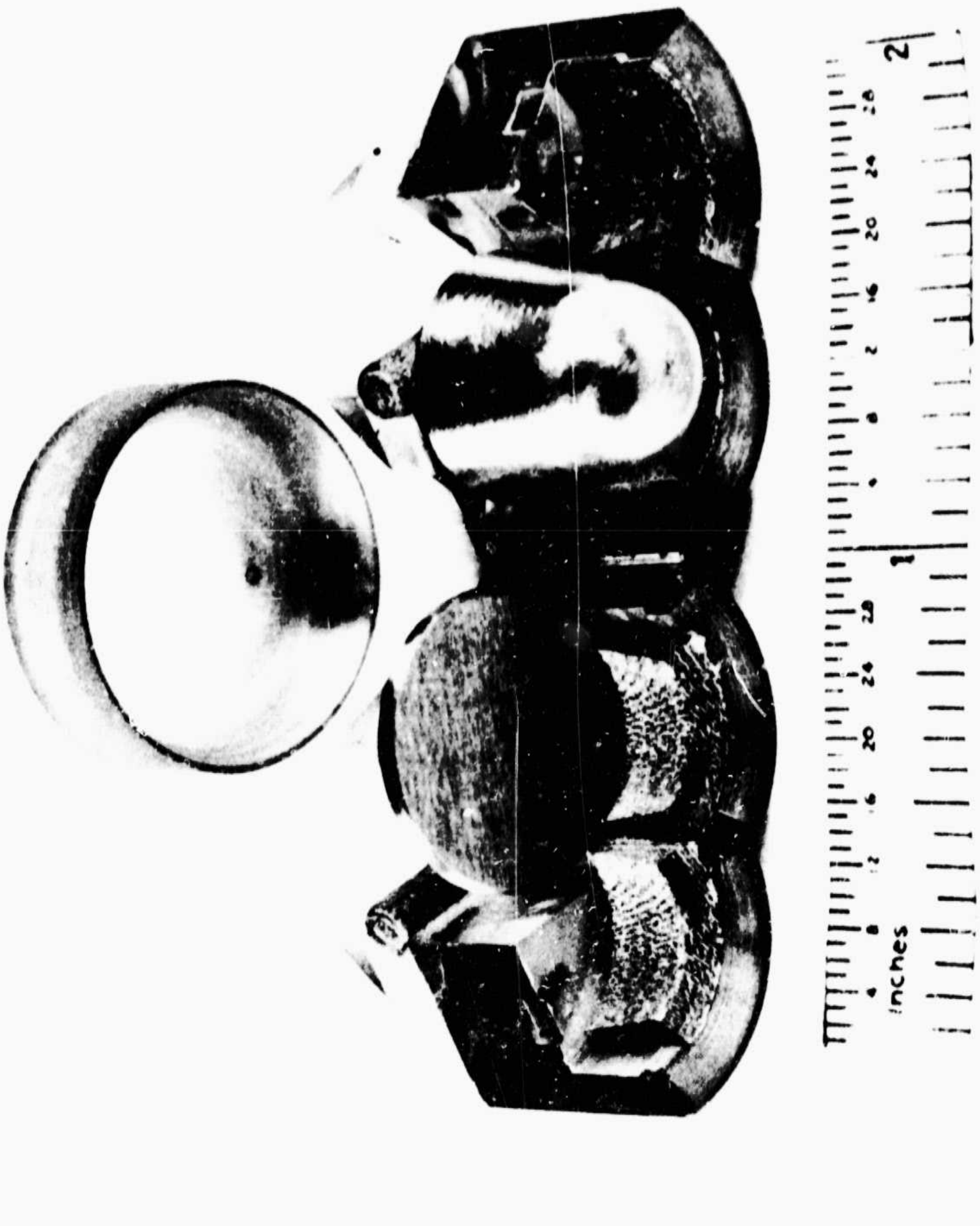

FIG. 2 V-1 CONFIGURATION WITH ITS SABOT

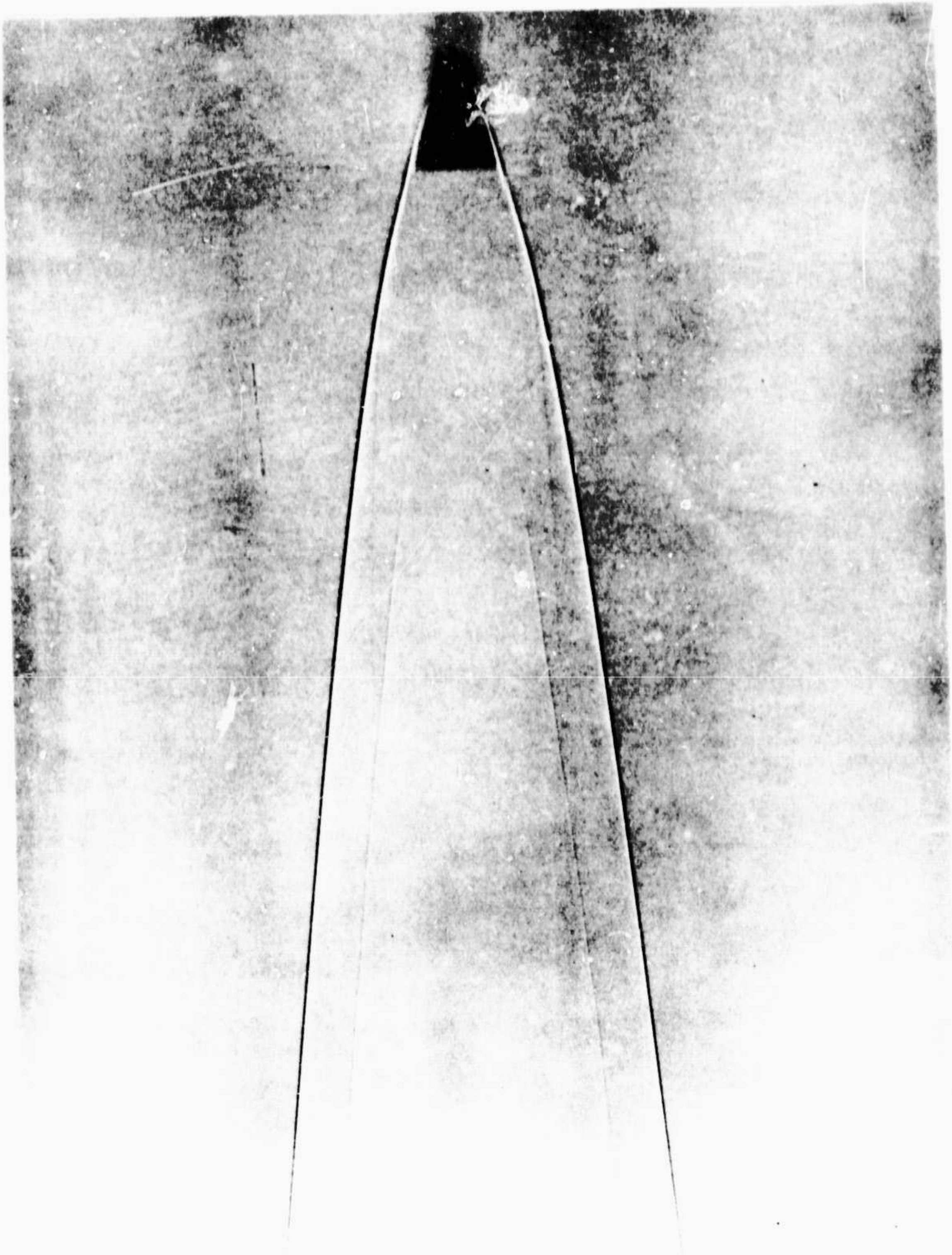

FIG. 3 SHADOWGRAPH OF V-1 CONFIGURATION, M 16.4, P 90.5 mm Hg, 85% CO_2, 14% N_2, 1% O_2

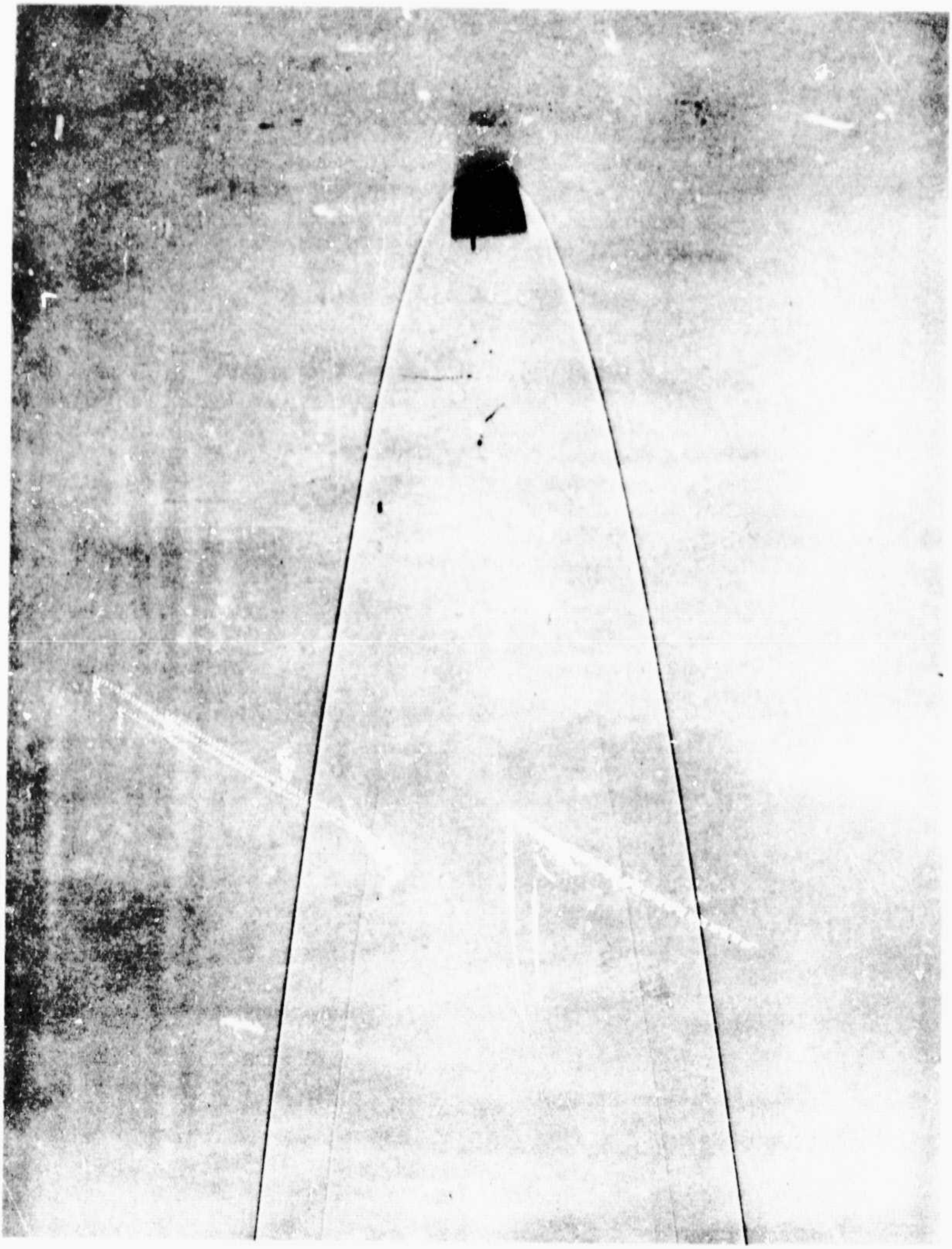

FIG. 4 SHADOWGRAPH OF A-1 CONFIGURATION, M 14.1, P 84.9 mm Hg, 100% N_2

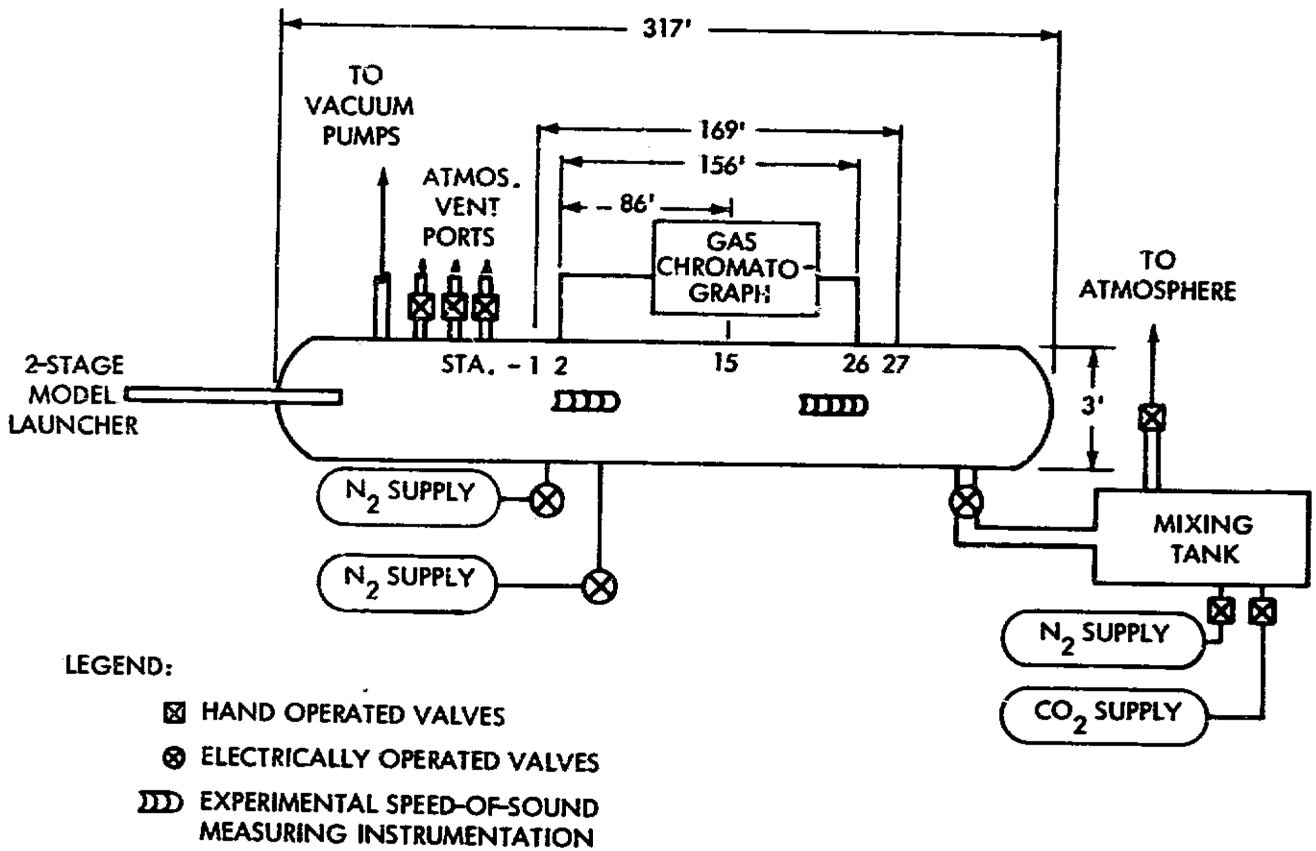

FIG. 5 INSTRUMENTATION LOCATION IN THE PRESSURIZED BALLISTICS RANGE NO. 3

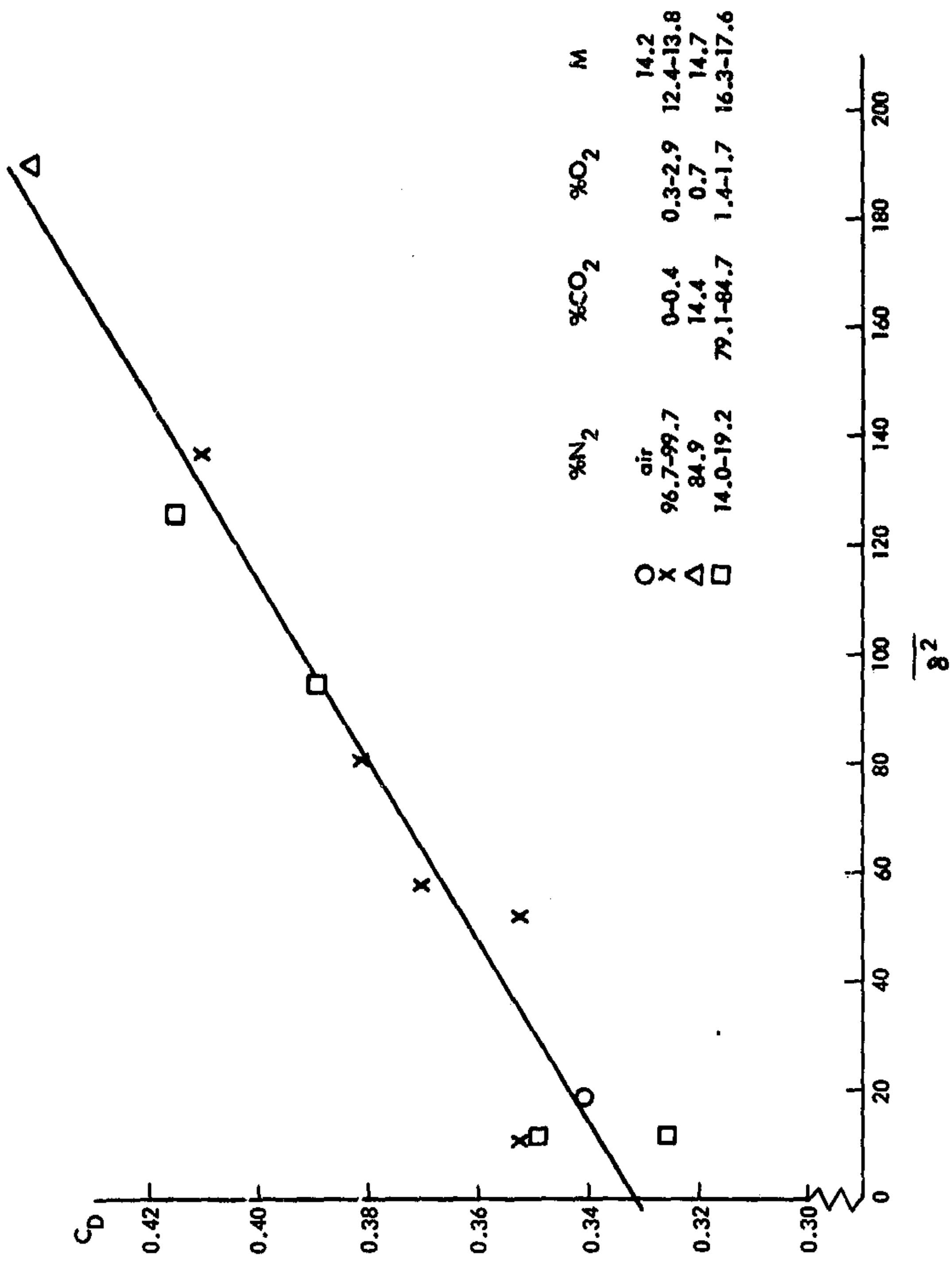

FIG. 6 DRAG COEFFICIENT AS A FUNCTION OF MEAN SQUARED YAW FOR THE V-1 CONFIGURATION

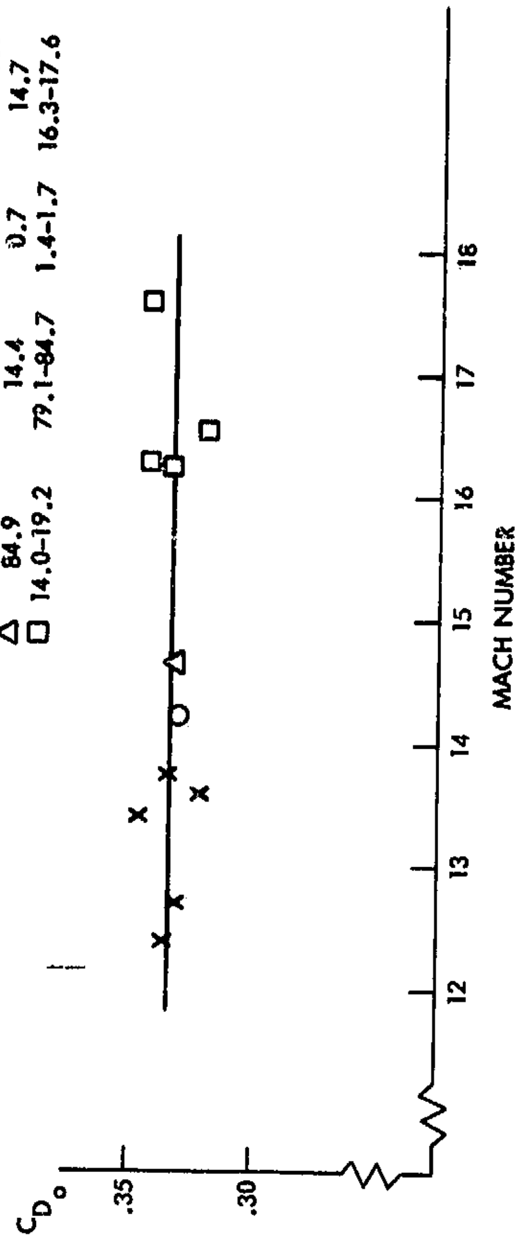

FIG. 7 DRAG COEFFICIENT CORRECTED TO ZERO YAW AS A FUNCTION OF MACH NUMBER FOR THE V-1 CONFIGURATION

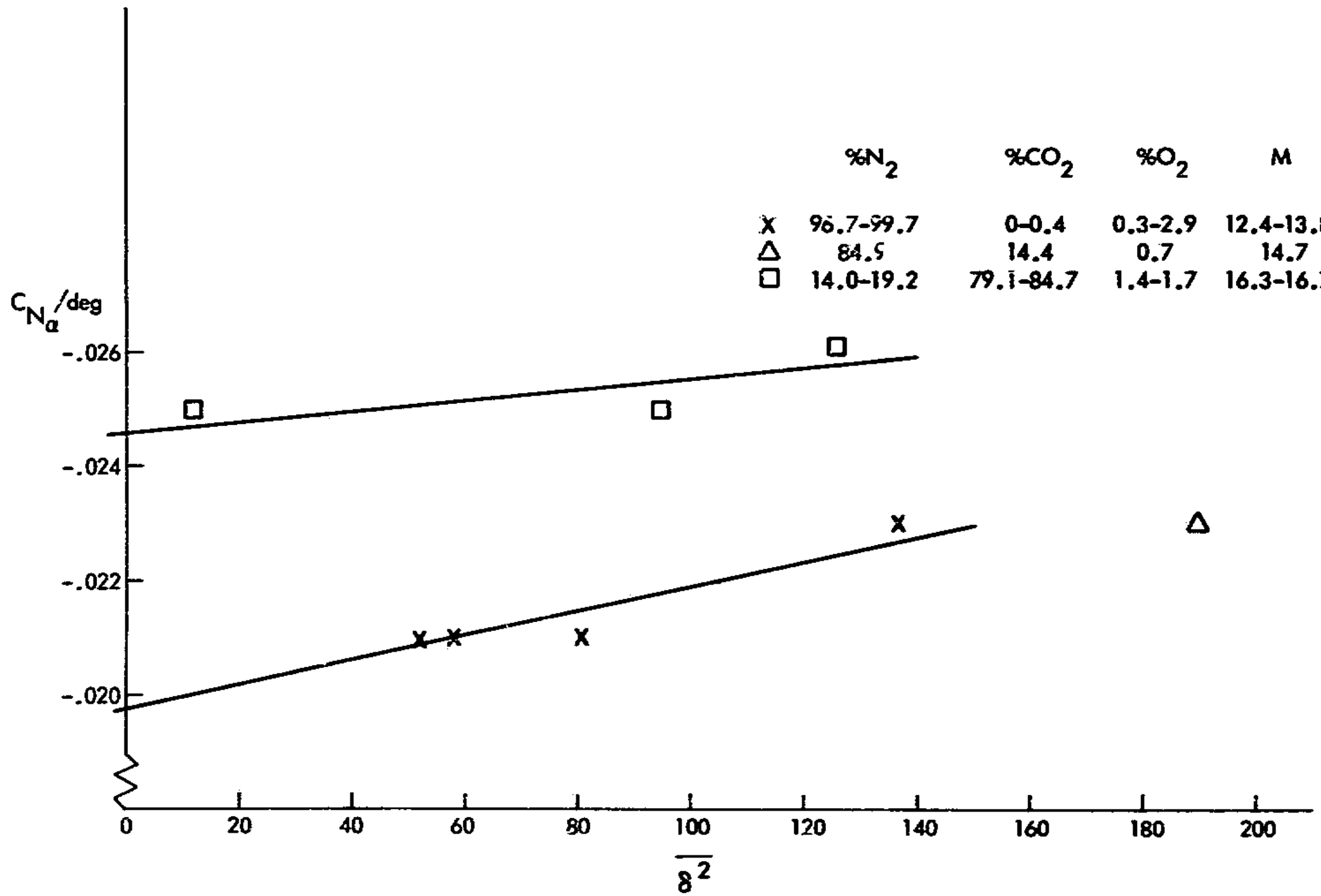

FIG. 8 SLOPE OF THE NORMAL FORCE COEFFICIENT AS A FUNCTION OF MEAN SQUARED YAW FOR THE V-1 CONFIGURATION

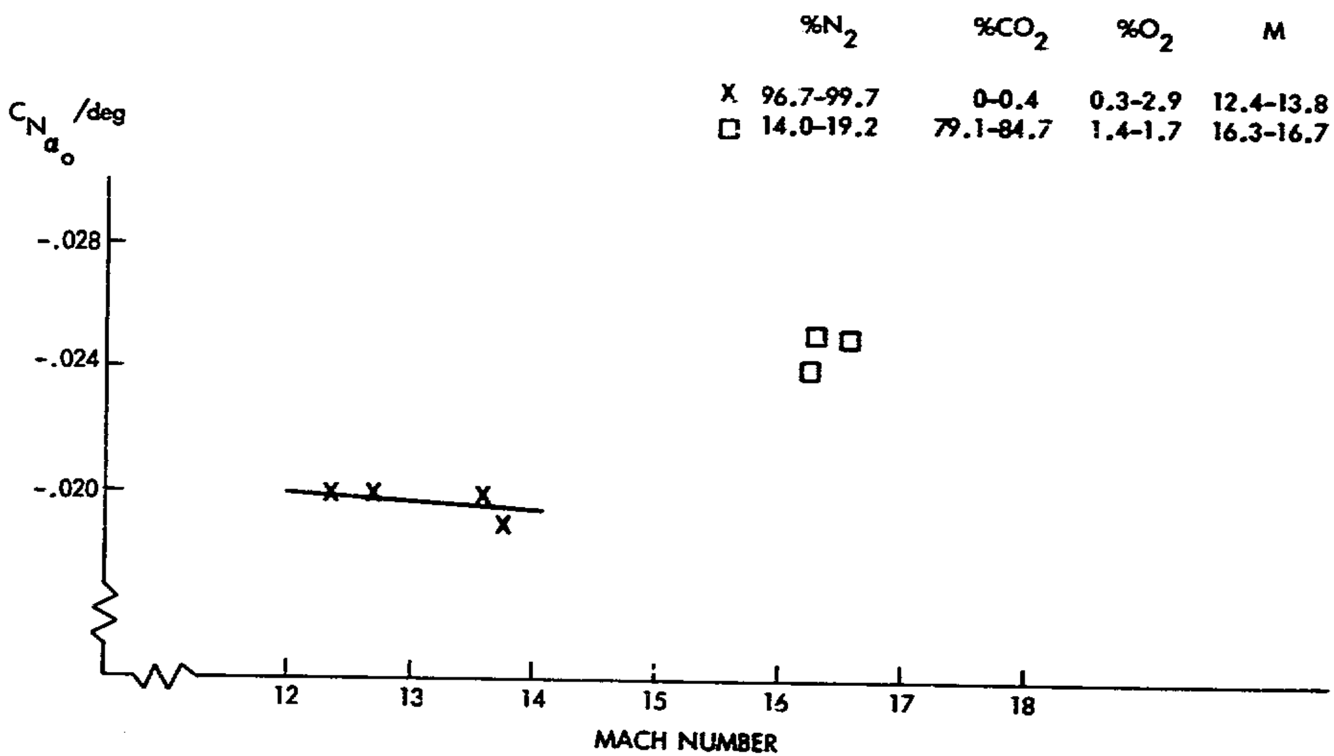

FIG. 9 SLOPE OF THE NORMAL FORCE COEFFICIENT CORRECTED TO ZERO YAW AS A FUNCTION OF MACH NUMBER FOR THE V-1 CONFIGURATION

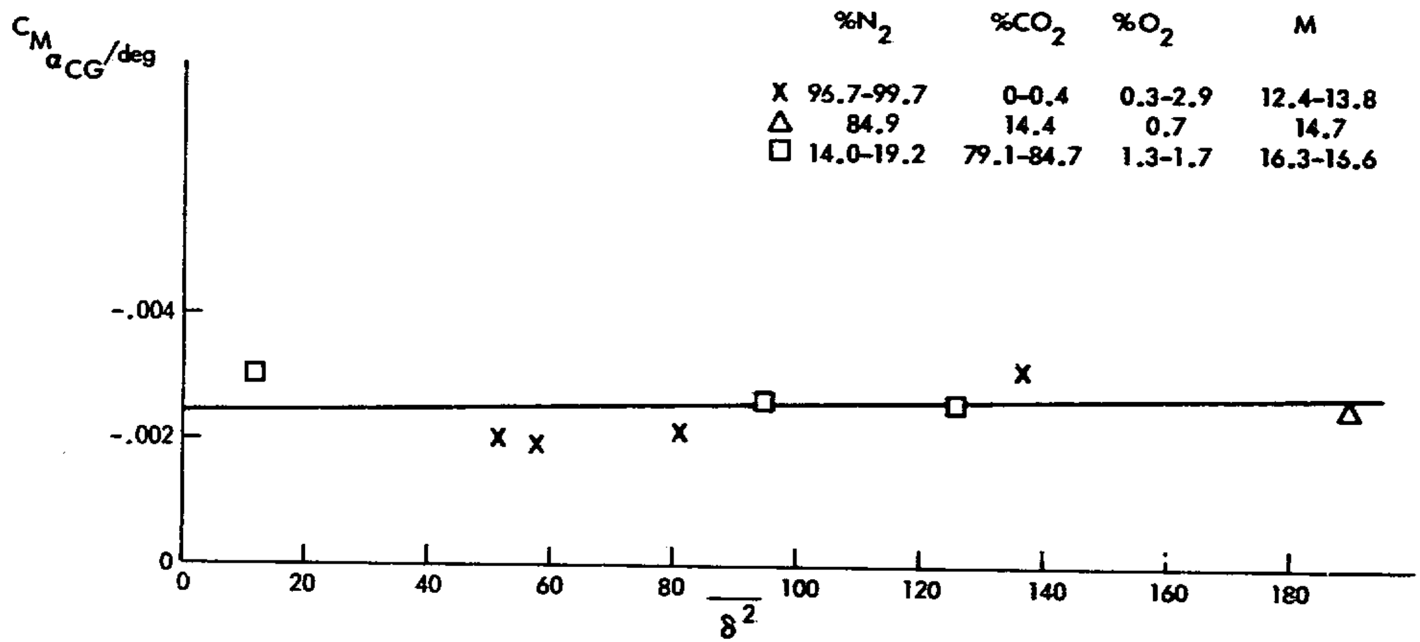

FIG. 10 SLOPE OF THE PITCHING MOMENT COEFFICIENT CORRECTED TO A COMMON CG LOCATION AS A FUNCTION OF MEAN SQUARED YAW FOR THE V-1 CONFIGURATION

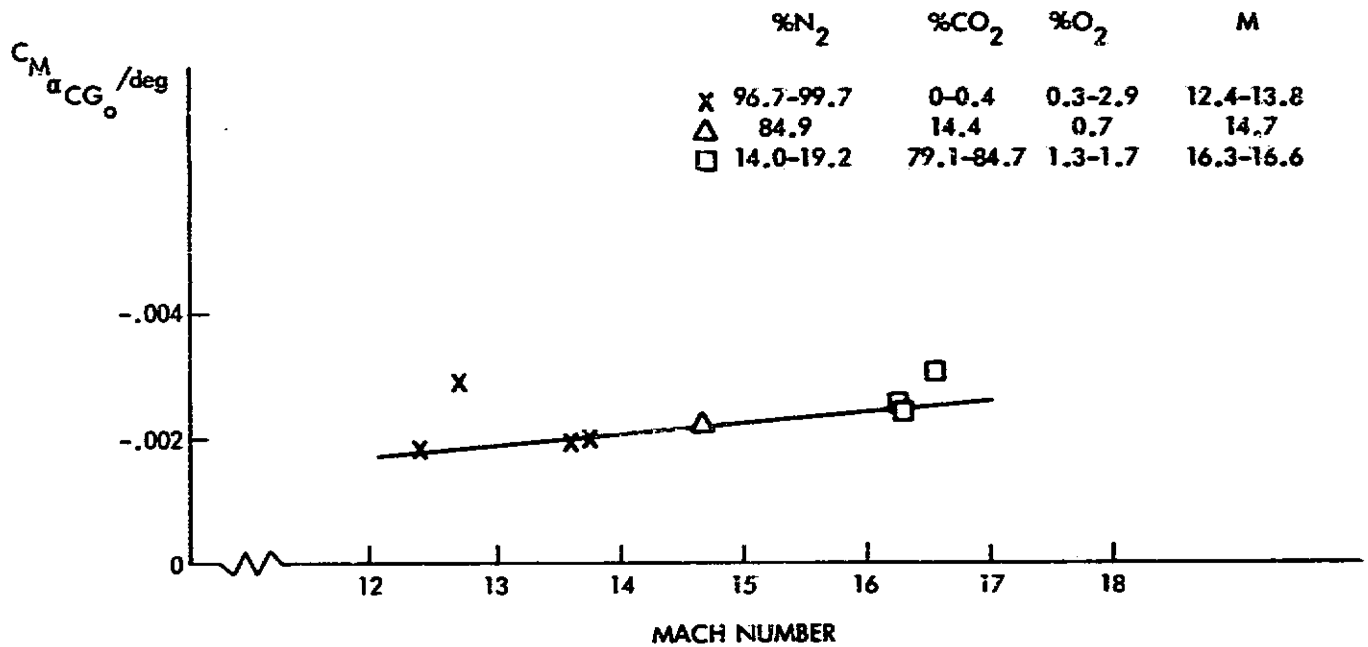

FIG. 11 SLOPE OF THE PITCHING MOMENT COEFFICIENT CORRECTED TO ZERO YAW AND A COMMON CG LOCATION AS A FUNCTION OF MACH NUMBER FOR THE V-1 CONFIGURATION

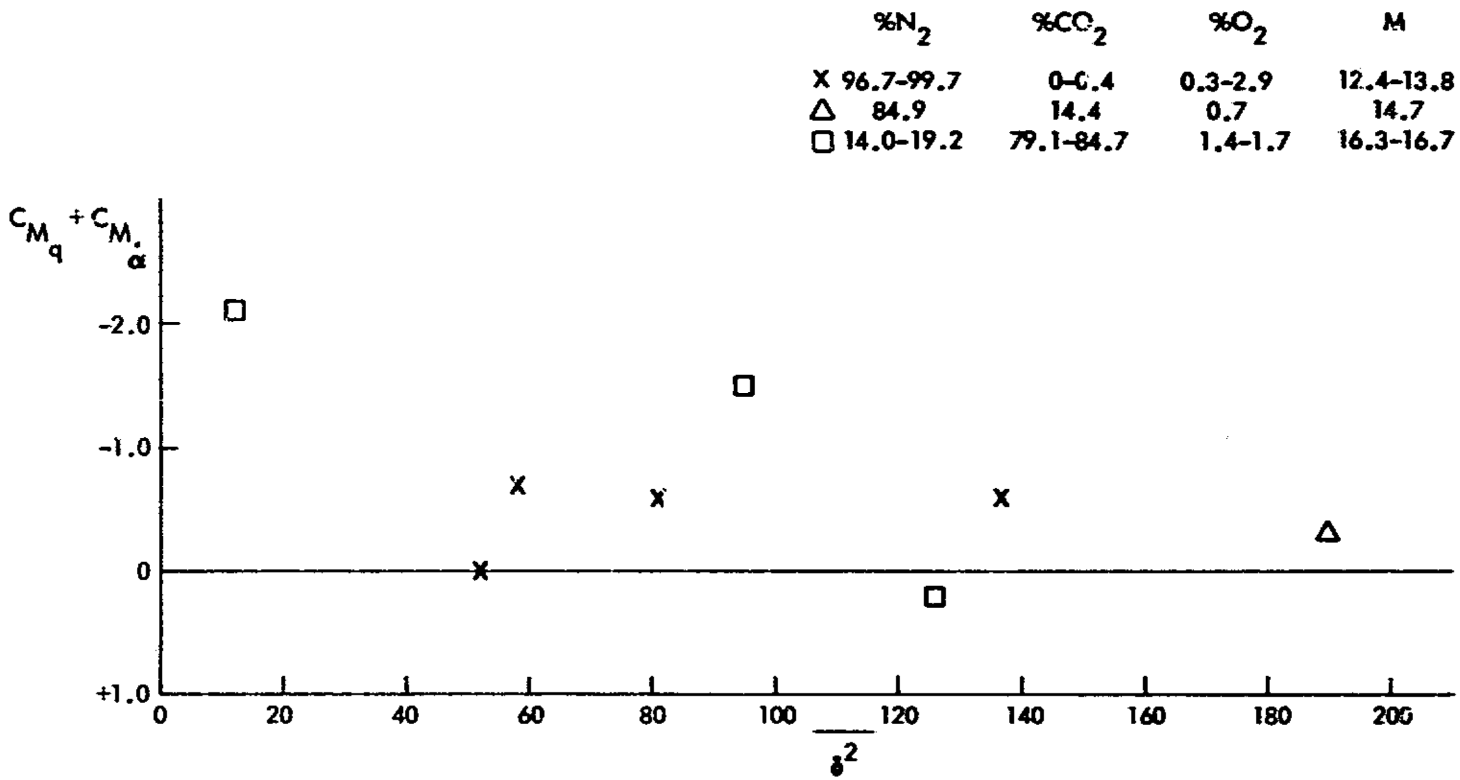

FIG. 12 SLOPE OF THE DAMPING MOMENT COEFFICIENT AS A FUNCTION OF MEAN SQUARED YAW FOR THE V-1 CONFIGURATION

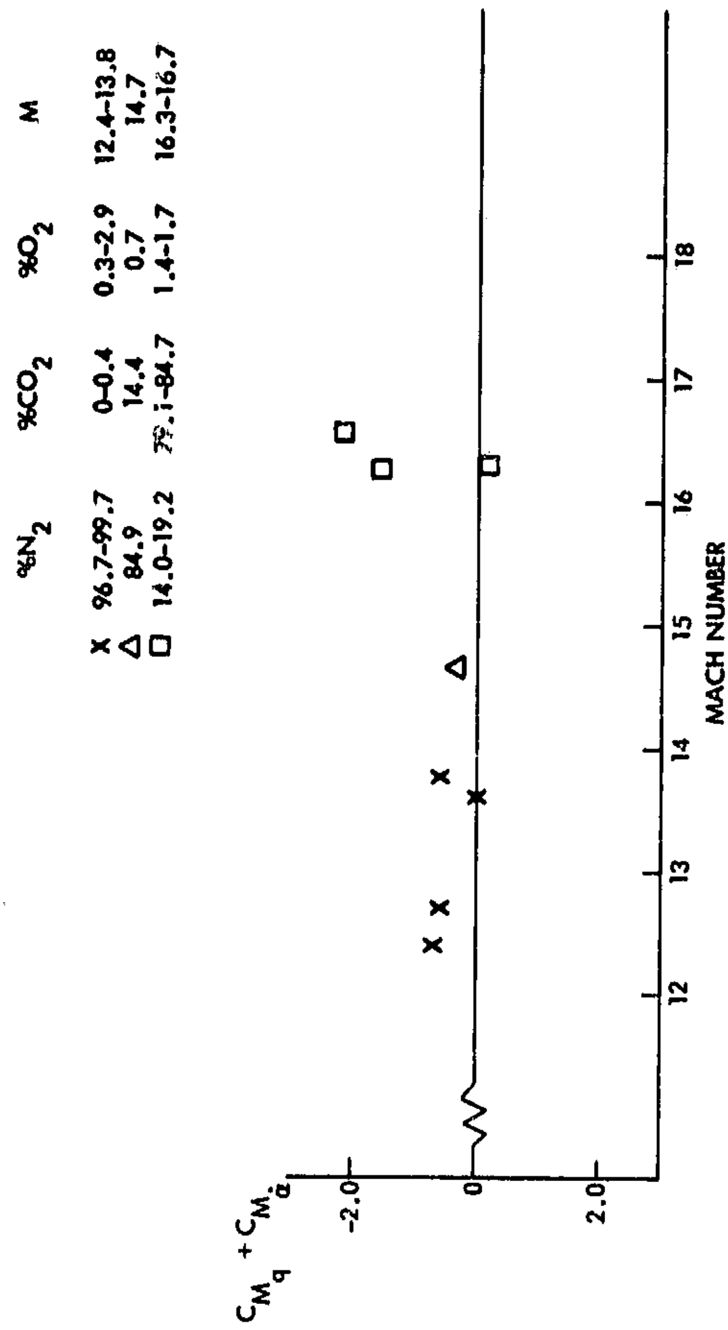

FIG. 13 SLOPE OF THE DAMPING MOMENT COEFFICIENT AS A FUNCTION OF MACH NUMBER FOR THE V-1 CONFIGURATION

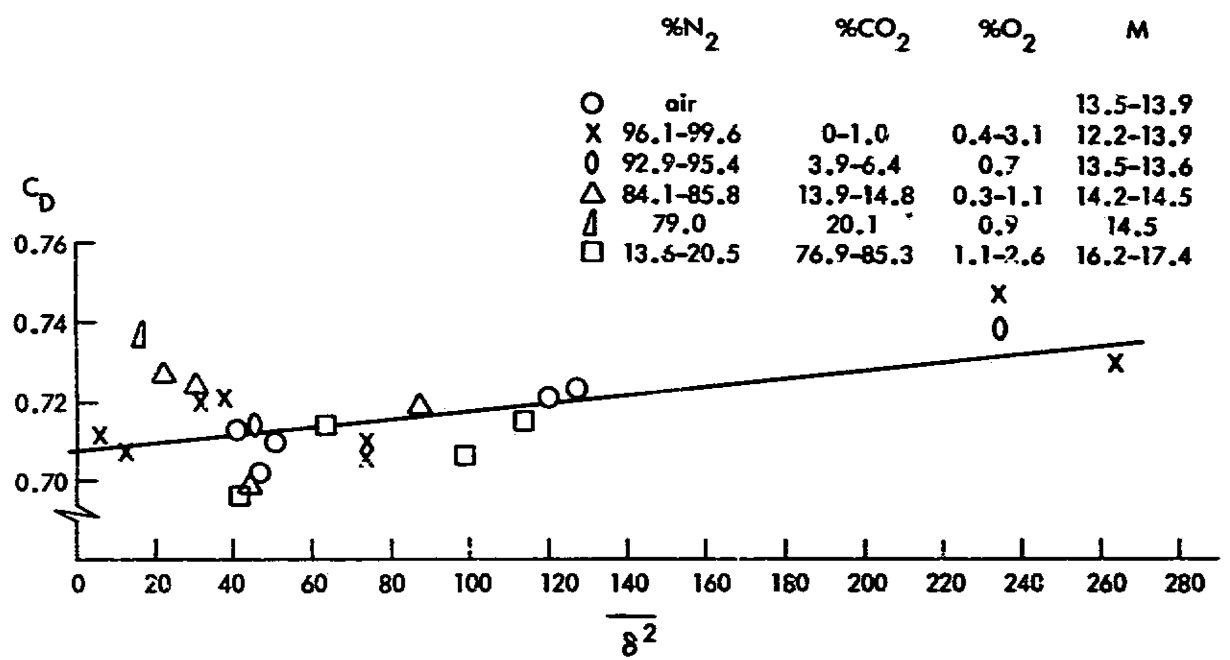

FIG. 14 DRAG COEFFICIENT AS A FUNCTION OF MEAN SQUARED YAW FOR THE A-1 CONFIGURATION

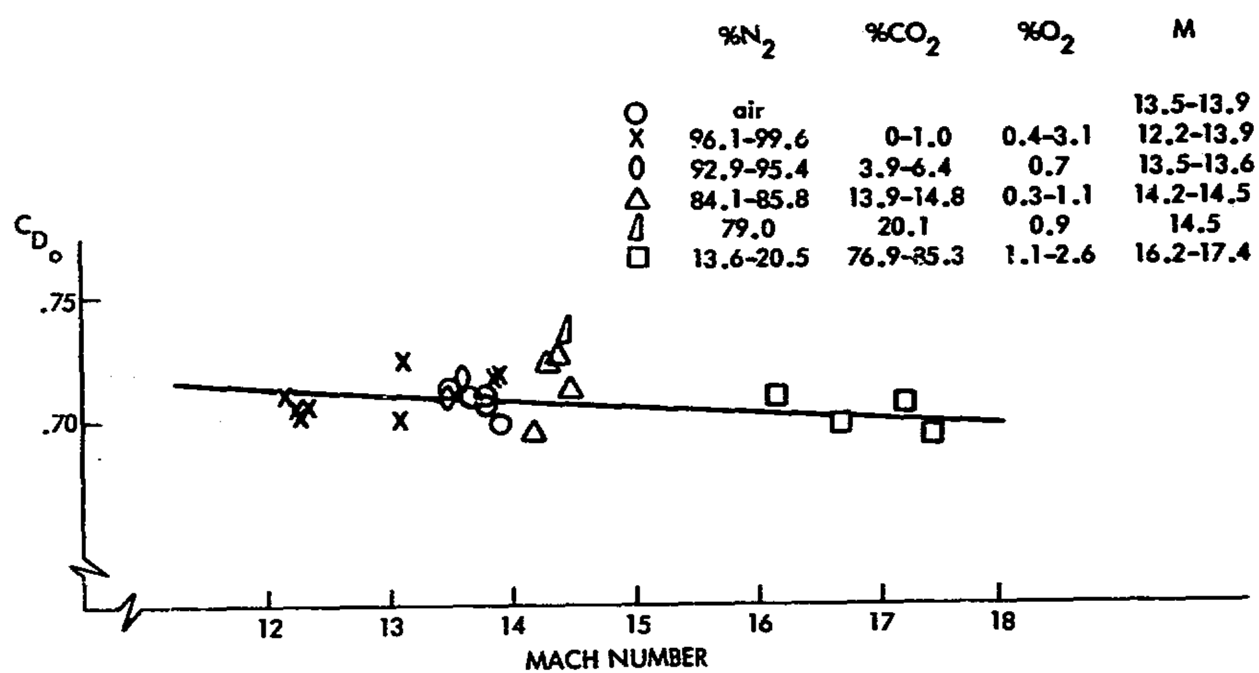

FIG. 15 DRAG COEFFICIENT CORRECTED TO ZERO YAW AS A FUNCTION OF MACH NUMBER FOR THE A-1 CONFIGURATION

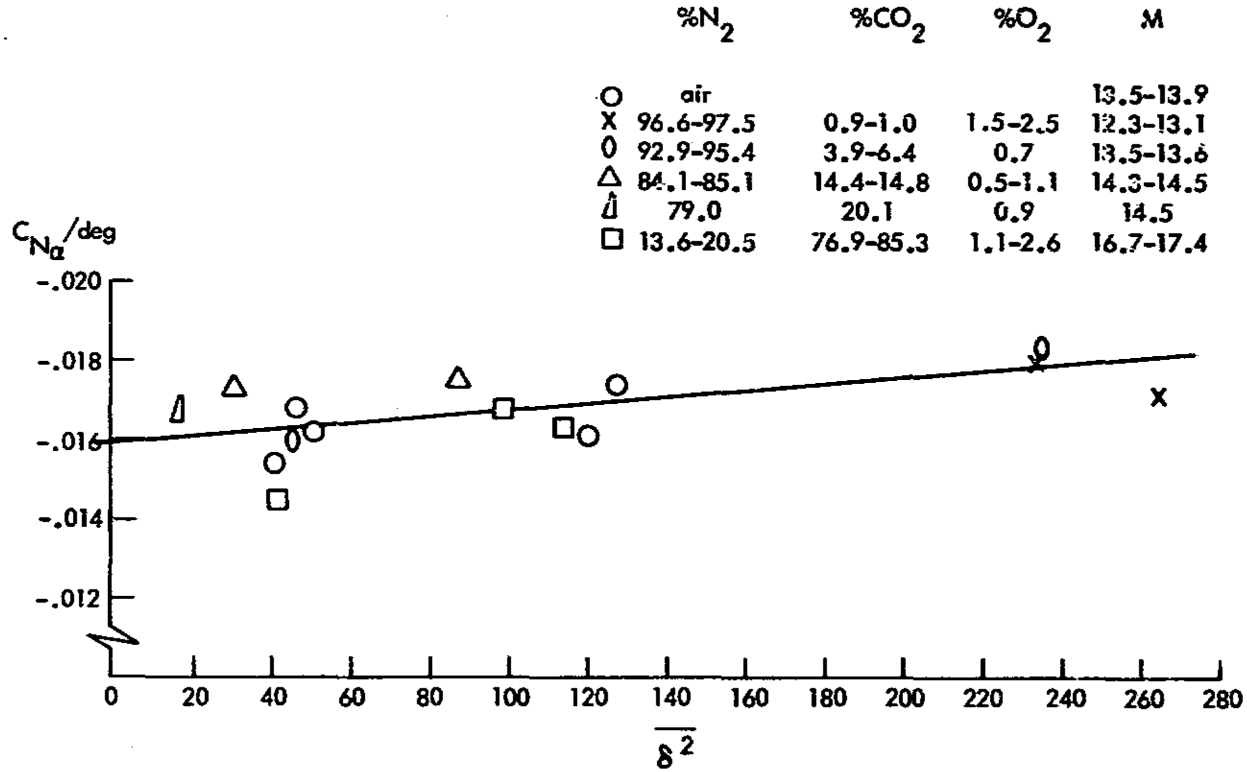

FIG. 16 SLOPE OF THE NORMAL FORCE COEFFICIENT AS A FUNCTION OF MEAN SQUARED YAW FOR THE A-1 CONFIGURATION

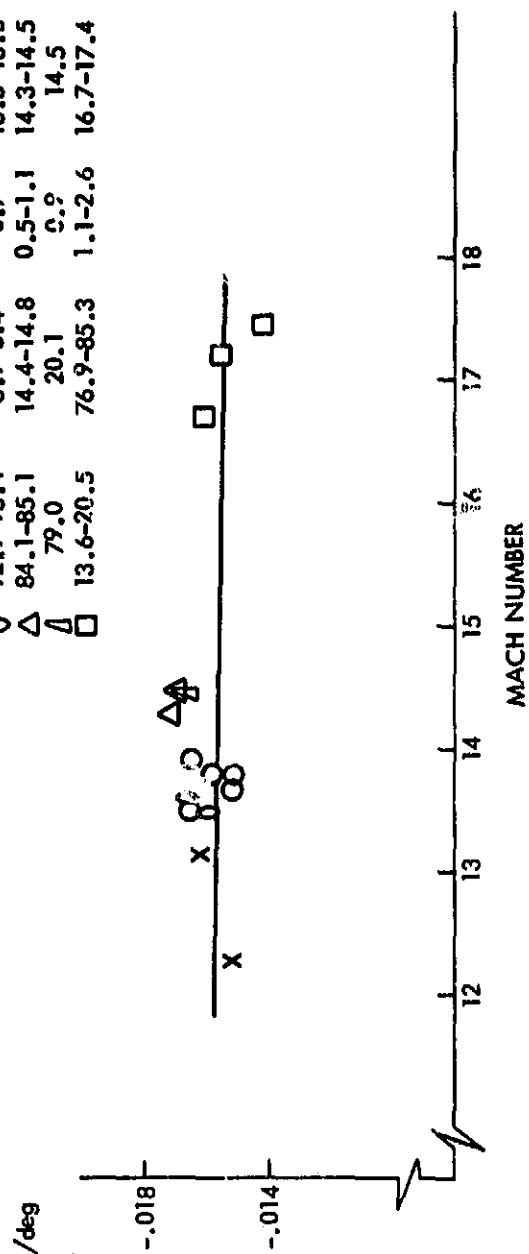

FIG. 17 SLOPE OF THE NORMAL FORCE COEFFICIENT CORRECTED TO ZERO YAW AS A FUNCTION OF MACH NUMBER FOR THE A-1 CONFIGURATION

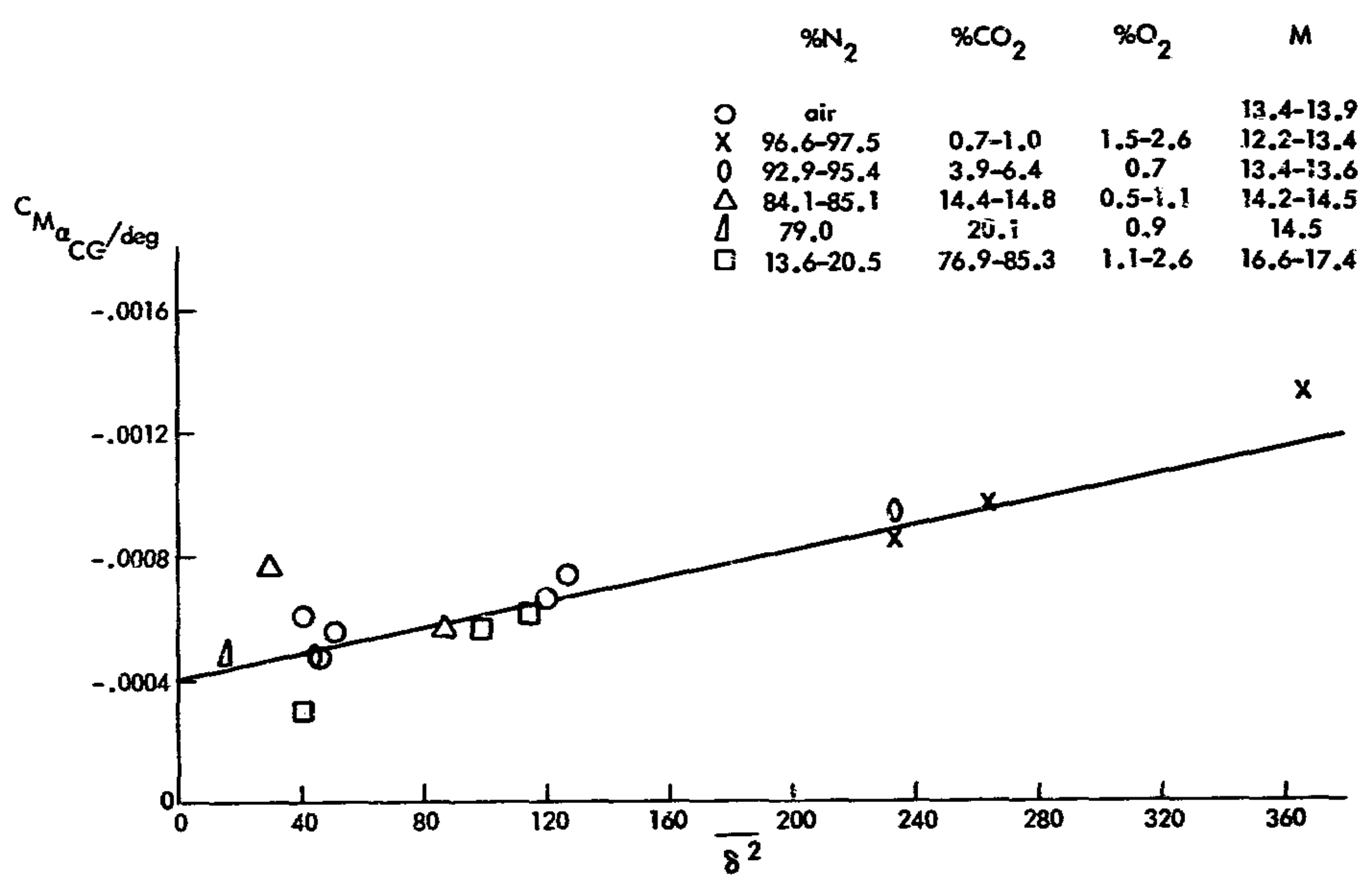

FIG. 18 SLOPE OF THE PITCHING MOMENT COEFFICIENT CORRECTED TO A COMMON CG LOCATION AS A FUNCTION OF MEAN SQUARED YAW FOR THE A-1 CONFIGURATION

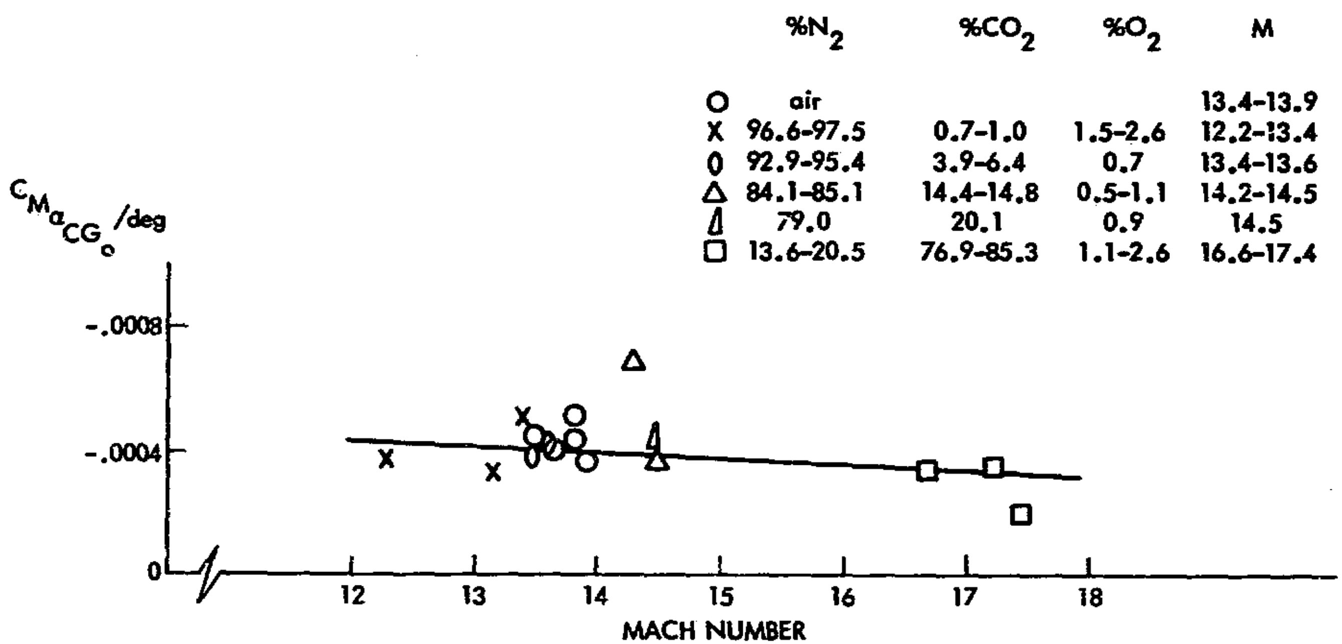

FIG. 19 SLOPE OF THE PITCHING MOMENT COEFFICIENT CORRECTED TO ZERO YAW AND A COMMON CG LOCATION AS A FUNCTION OF MACH NUMBER FOR THE A-1 CONFIGURATION

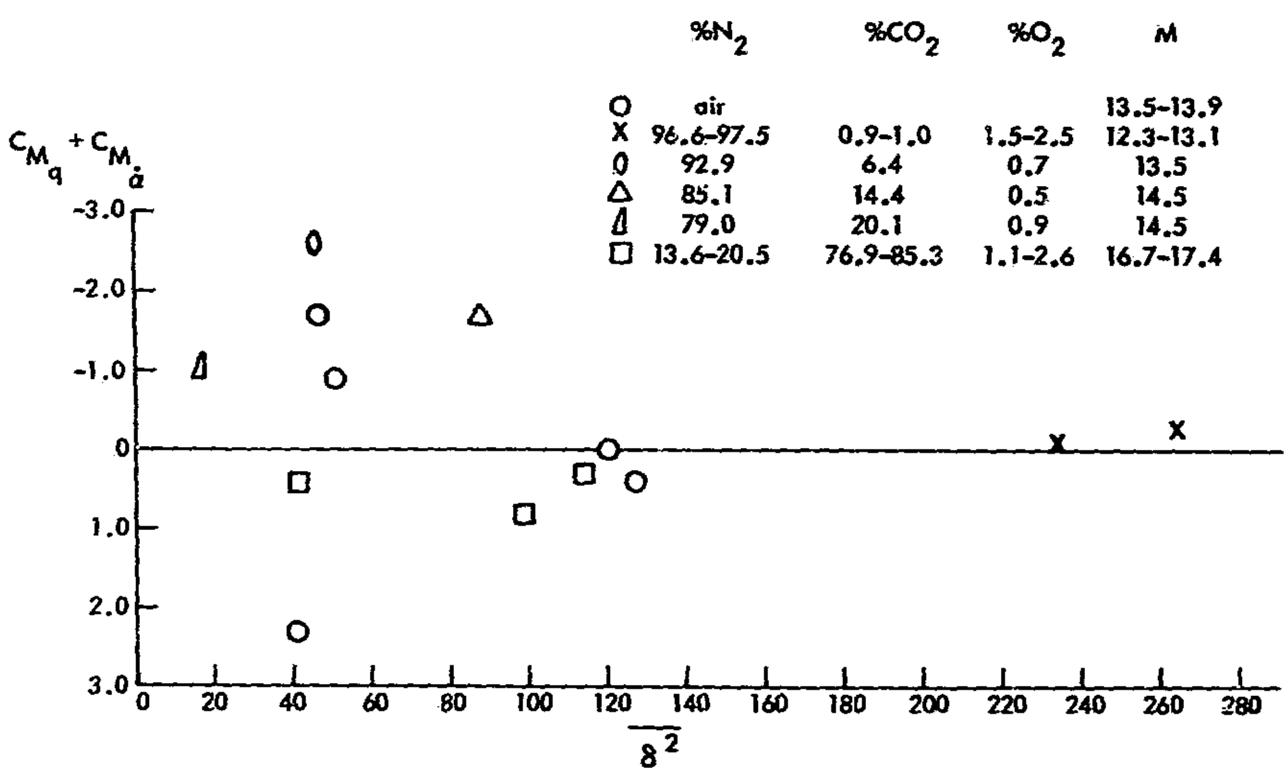

FIG. 20 SLOPE OF THE DAMPING MOMENT COEFFICIENT AS A FUNCTION OF MEAN SQUARED YAW FOR THE A-1 CONFIGURATION

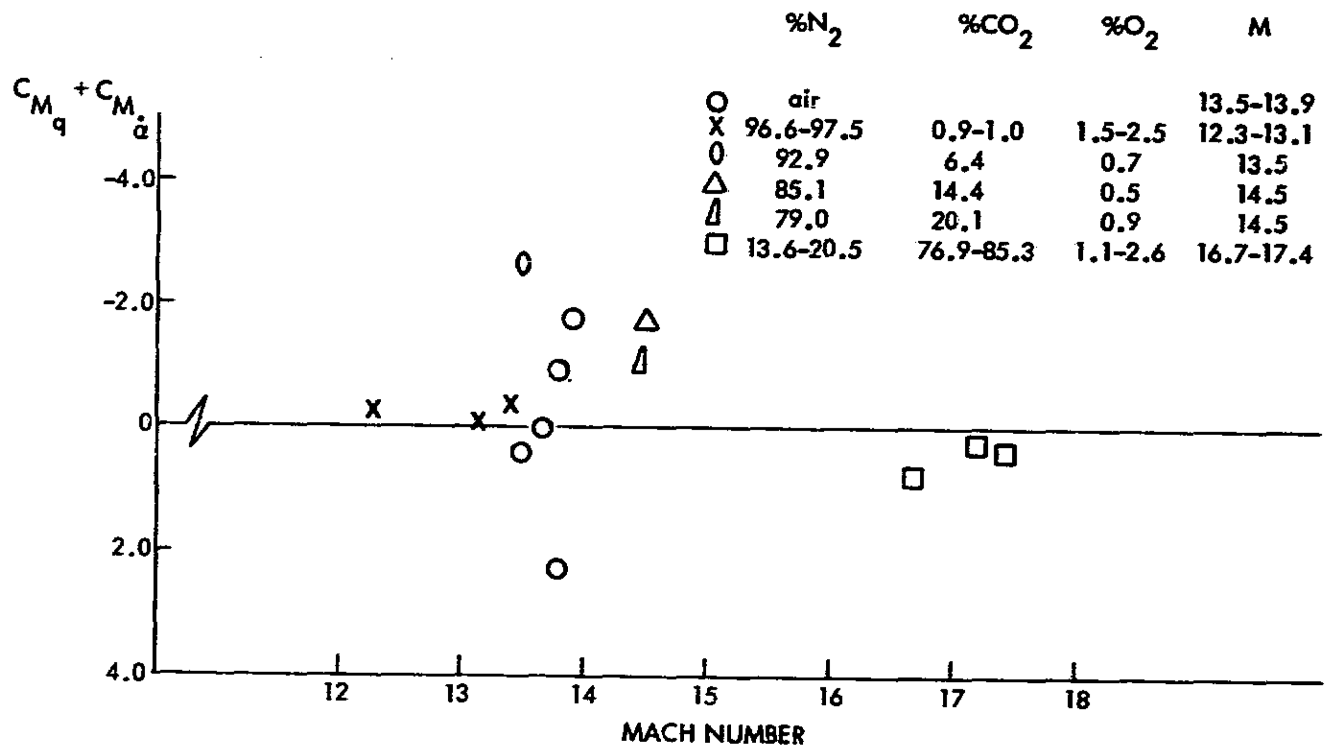

FIG. 21 SLOPE OF THE DAMPING MOMENT COEFFICIENT AS A FUNCTION OF MACH NUMBER FOR THE A-1 CONFIGURATION

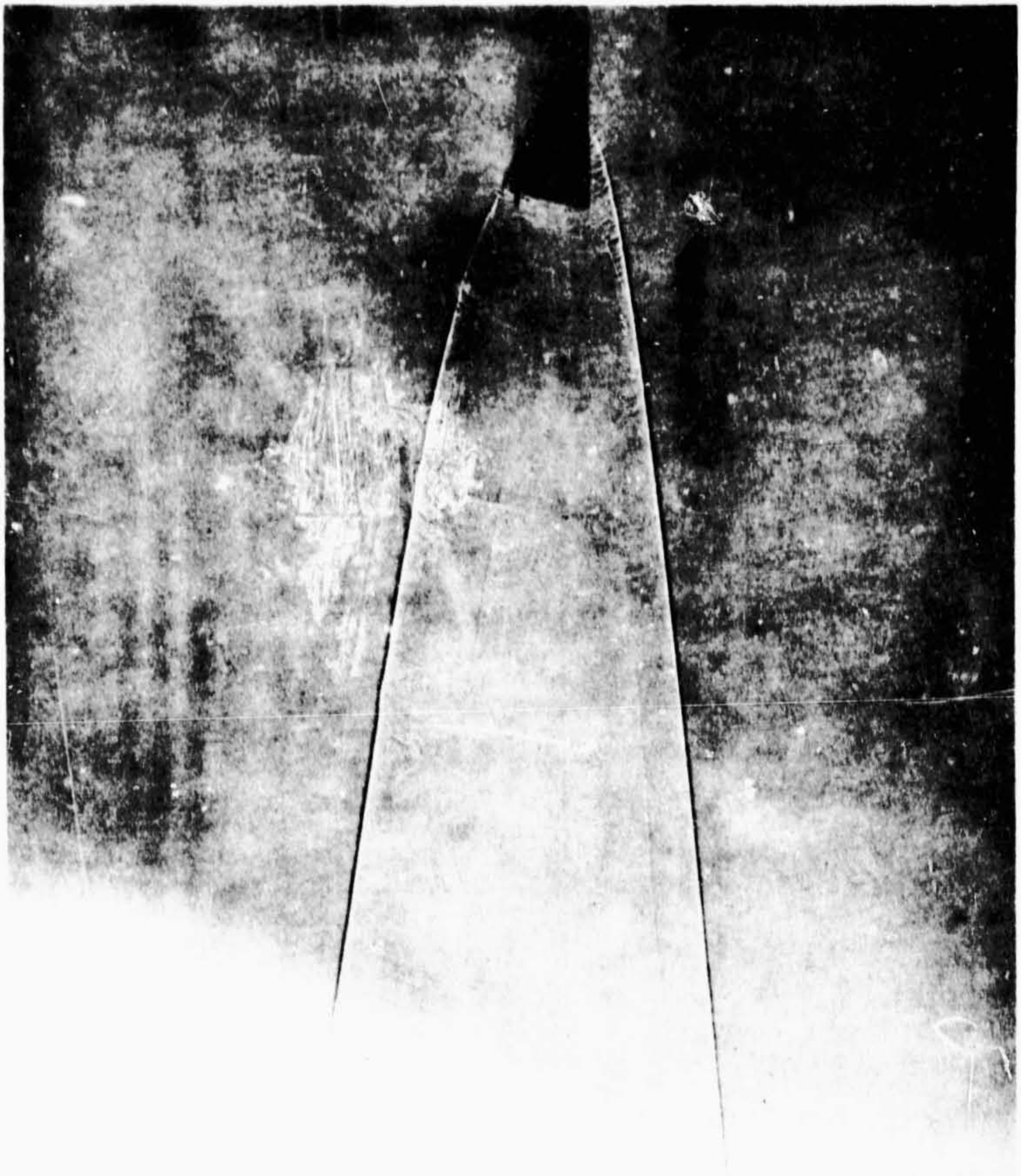

FIG. 22 SHADOWGRAPH OF V-1 CONFIGURATION, M=16.3, P=89 mm Hg, 79% CO_2, 19% N_2, 2% O_2