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WIND TUNNEL TEST TO INVESTIGATE AERODYNAMIC HYSTERESIS PHENOMEN--ETC(U)
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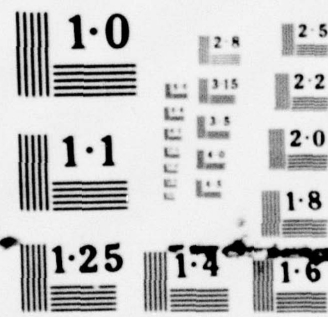

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AEDC-TSR-79-P27
May 15, 1979

LEVEL II

(2)

WIND TUNNEL TEST TO INVESTIGATE AERODYNAMIC HYSTERESIS PHENOMENA OF THE F-4 AND F-111 AIRCRAFT MODELS

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ARO, Inc., AEDC Division
A Sverdrup Corporation Company
Propulsion Wind Tunnel Facility
Arnold Air Force Station, Tennessee

Period Covered: March 27 - April 5, 1979

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AEDC/DOTR
Arnold AFS, Tennessee 37389

ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
ARNOLD AIR FORCE STATION, TENNESSEE

UNCLASSIFIED

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- Static aerodynamic characteristics
- Wing pressure distributions
- F-4 aircraft
- F-111 aircraft
- Flow visualization

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Wind tunnel tests were conducted to investigate aerodynamic hysteresis phenomena found in other investigations of the F-4 and F-111 aircraft models. A 1/20-scale model of the F-4C aircraft was used to obtain static force, moment and wing pressure data in pitch and sideslip over a Mach number range from 0.7 to 0.95. A 1/24-scale model of the F-111 aircraft was used to obtain static force and moment data for a Mach number range of 0.7 to 1.3. Data on the F-111 were obtained for wing sweep angles of 26 and 54 deg. In addition, tuft and oil flow visualization data were obtained for selected configurations.

CONTENTS

ILLUSTRATIONS

TABLES

NOMENCLATURE

A	Reference area; F-4, 1.325 ft^2, F-111, 0.91146 ft^2
AB	F-111 model base area, 0.03169 ft^2
ALFA, α	Model angle of attack measured between the relative wind vector and the reference waterline, deg
B	Wing span, F-4, 1.93 ft, F-111, 2.625 ft
BETA	Model sideslip angle, deg
BETA, β_M	Measured local wing surface flow angle in the yaw plane (Preston tube), deg
BL	Model buttline, in.
c	Local wing chord, in.
$\bar{c}$	Wing mean aerodynamic chord; F-4, 0.802 ft, F-111, 0.377 ft
℄	Model centerline
CA	Total axial-force coefficient, total axial force/Q.A
CAB	Base axial-force coefficient, -AB(PBA - P)/Q.A
CLL	Rolling-moment coefficient, rolling moment/Q.A.B
CLM	Total pitching-moment coefficient, pitching moment/Q.A.$\bar{c}$
CLN	Yawing-moment coefficient, yawing moment/Q.A.B
CN	Normal-force coefficient, normal force/Q.A
CP	Pressure coefficient
CY	Side-force coefficient, side force/Q.A
FS	Fuselage station, in.
M	Free-stream Mach number
P	Free-stream static pressure, psfa
PART	Run (data set) identification number
PBA	Average base pressure, psfa
PHIA	Model roll angle, deg

PT	Total pressure measured in the tunnel stilling chamber, psfa
PTi	Preston tube pressures, psfa (see Fig. 1c)
Q	Free-stream dynamic pressure, psf
WL	Model water line, in.
X/C	Fraction of wing chord measured from the leading edge
Y/C	Fraction of wing chord measured vertically from chord line
Λ	Wing leading-edge sweep, deg

1.0 INTRODUCTION

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Arnold Air Force Station, Tennessee, under Program Element 65807F. The Air Force project monitor was Mr. A. F. Money. The objective of the Flight Vehicle Motion Simulation project (P32F-30) is to provide a motion analysis and simulation capability at the AEDC and to stay abreast of and contribute to technology in three areas: (1) dynamic derivative estimation, (2) airframe flexibility effects, and (3) aerodynamic hysteresis. The wind tunnel test, reported on herein, was conducted in support of the hysteresis phase of the project under ARO Project No. P41C-A3 in the Aerodynamic Wind Tunnel (4T) from March 27 through April 5, 1979.

The test objectives were to obtain (1) force and wing pressure data on a 1/20-scale model of the F-4C aircraft and (2) force data on a 1/24-scale model of the F-111 aircraft with wing sweep angles of 26 and 54 deg in regions of aerodynamic hysteresis. The test was conducted in three phases: (1) wing pressure data for the F-4C model (the model was nonmetric during this phase), (2) force data for the F-4C model (pressure lines were disconnnected near the wing trailing edge), and (3) force data for the F-111 model. In addition, tuft and oil flow visualization data were obtained for selected configurations.

Requests data from these tests should be addressed to the Director of Test Engineering (AEDC/DOT), Arnold Air Force Station, Tennessee 37389. A copy of the final data is on file on microfilm at AEDC.

2.0 APPARATUS

2.1 TEST FACILITY

The Aerodynamic Wind Tunnel (4T) is closed-loop continous flow, variable-density tunnel in which the Mach number can be varied from 0.1 to 1.3 and can be set at discrete Mach numbers of 1.6 and 2.0 by placing nozzle inserts over the permanent sonic nozzle. At all Mach numbers, the stagnation pressure can be varied from 300 to 3,700 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. The model support system consists of a sector and sting attachment which has a pitch angle capability of -8 to 28 deg with respect to the tunnel centerline and a roll capability of -180 to 180 deg about the sting centerline. A more complete description of the tunnel may be found in the Test Facilities Handbook.[1]

2.2 TEST ARTICLES

Details of the 1/20-scale F-4C model are presented in Figure 1a. The left wing of the model was constructed with 74 static pressure orifices located at two spanwise stations as shown in Fig. 1b. Figure 1c presents an identification key as used in the tabulated wing pressure data. Tabulated locations of the wing static pressure orifices are given in Table 1. A Preston tube was located on the left wing upper surface as shown in Fig. 1c and detailed in Fig. 1d. Various simulated leading-edge slats which were tested with the basic wing are shown in Fig. 1e. A configuration identification free laminar-to-turbulent boundary layer transition was allowed on all model components.

Details of the 1/24-scale F-111 model are presented in Fig. 2a. For limited testing, the boundary layer was tripped by applying No. 150 glass beads as shown in Fig. 2b. Both aircraft models were tested without pylons or external stores. The models installed in the tunnel are shown in Fig. 3.

2.3 INSTRUMENTATION

A six-component, internal strain-gage balance was used to measure the aerodynamic forces and moments for each of the models tested; however, the force and moment data

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[1] Test Facilities Handbook (Tenth Edition). "Propulsion Wind Tunnel Facility, Vol. 4." Arnold Engineering Development Center, May 1974

obtained during Phase 1 must be used with caution because the model was non-metric due to external wing pressure tubes. Base pressures, total pressure at the exit plane of the flow through ducts, and one cavity pressure for the F-111 model were measured using orifice tubes connected to differential pressure transducers of the PWT 4T pressure system. During Phase 1, the PWT 4T pressure system was used to measure the pressure sensed at the wing orifices of the F-4 model. A camera was installed in the top or side wall of the tunnel to provide flow visualization data.

Electrical signals from the balances, pressure transducers, and standard tunnel instrumentation were processed by the PWT data acquisition system for online data reduction. The balance outputs were also recorded on an oscillograph for monitoring model-balance dynamics. Selected coefficients were also graphically displayed on a cathode ray tube plotter during the test for online evaluation of data.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS AND PROCEDURES

The nominal test conditions at which the test was conducted are listed in Table 3. Force and moment data were obtained while varying the model angle of attack or the sideslip angle at a constant Mach number and total stagnation pressure. All polars were run automatically (pitch-pause) utilizing online computer facilities which set the model pitch and roll angles to give the prescribed values of angle of attack and sideslip angle. Angle of attack was varied from -2 to 24 deg and angle of sideslip was varied from -12 to 12 deg. In addition to the force and moment data, selected configurations were examined using flow-visualization techniques. Fluorescent tufts were attached to the model or fluorescent oil was painted on the model surfaces, after which the test conditions were established and the model attitude was set. The model was then photographed using an ultraviolet flash. Two typical photographs obtained in this manner are presented in Fig. 4.

3.2 CORRECTIONS

The angle of attack and sideslip angle were corrected for sting and balance deflections caused by aerodynamic loads. Corrections for the components of model weight, normally termed static tares, were also applied to the data. Several of the model configurations were tested both upright and inverted to provide the data to correct for the tunnel flow angularity in the pitch plane.

3.3 DATA REDUCTION

The model aerodynamic forces and moments were reduced to coefficient form in the body and stability-axes systems. The model base pressure was measured and used to determine the base axial-force which was then used to determine the forebody coefficients for the F-111 model only. Moment reference points for the F-4 and F-111 models are given in Fig. 1a and 2a, respectively.

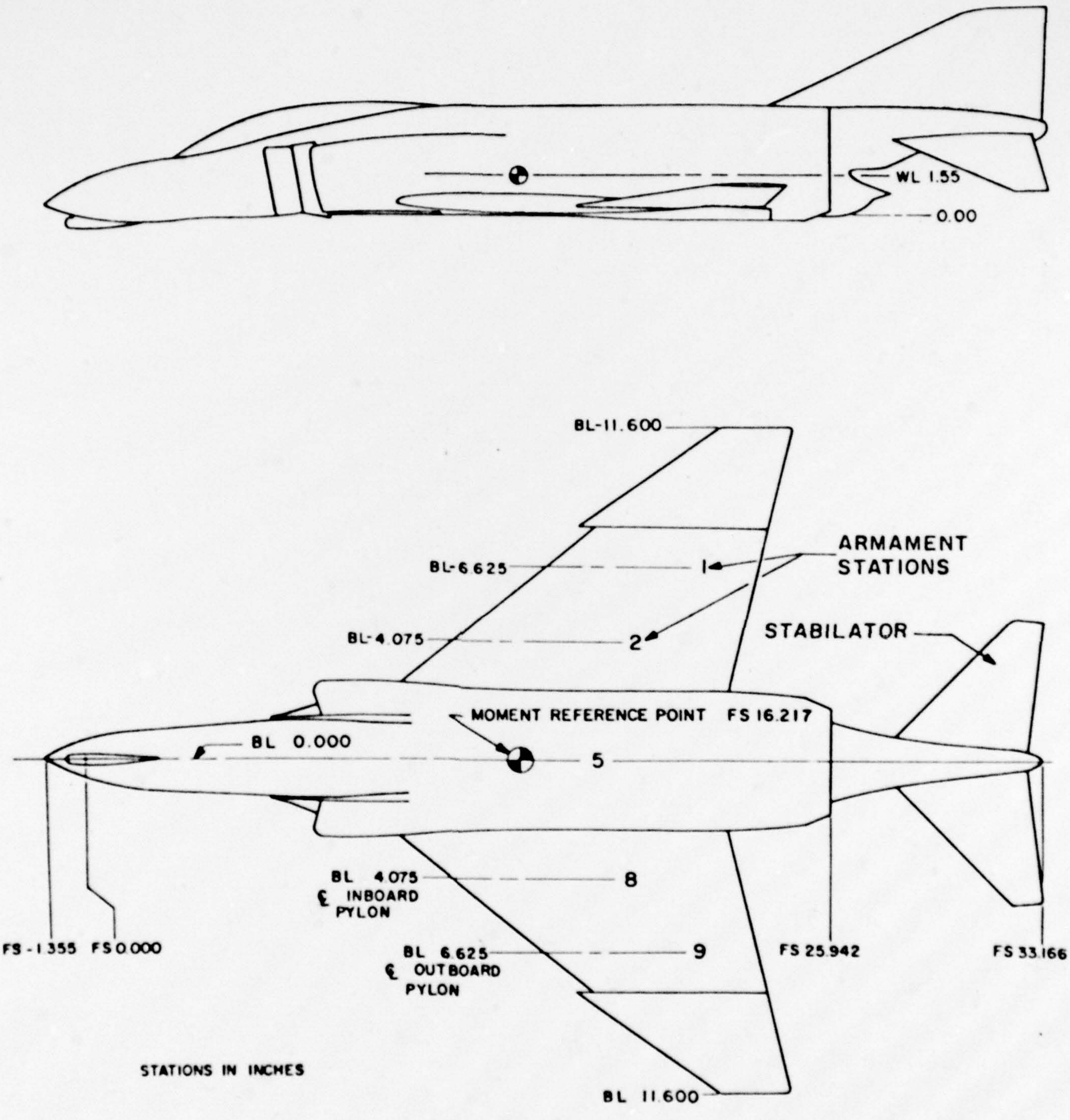
3.4 UNCERTAINTY/PRECISION OF MEASUREMENTS

The data uncertainties determined for a 95-percent confidence level are presented in Table 4. The aerodynamic coefficient uncertainties include the uncertainties of the Mach number and dynamic pressure along with the uncertainty contribution associated with the particular balance, transducers, and data acquisition system.

The precision in setting and maintaining a specific Mach number was ±0.005. The Mach number variation in the test section occupied by the model was no greater than ±0.005 for Mach numbers up to 0.95 and ±0.01 for Mach numbers greater than 1.0. The uncertainty in the model angle of attack and roll angle was 0.1 deg and ±0.30 deg, respectively.

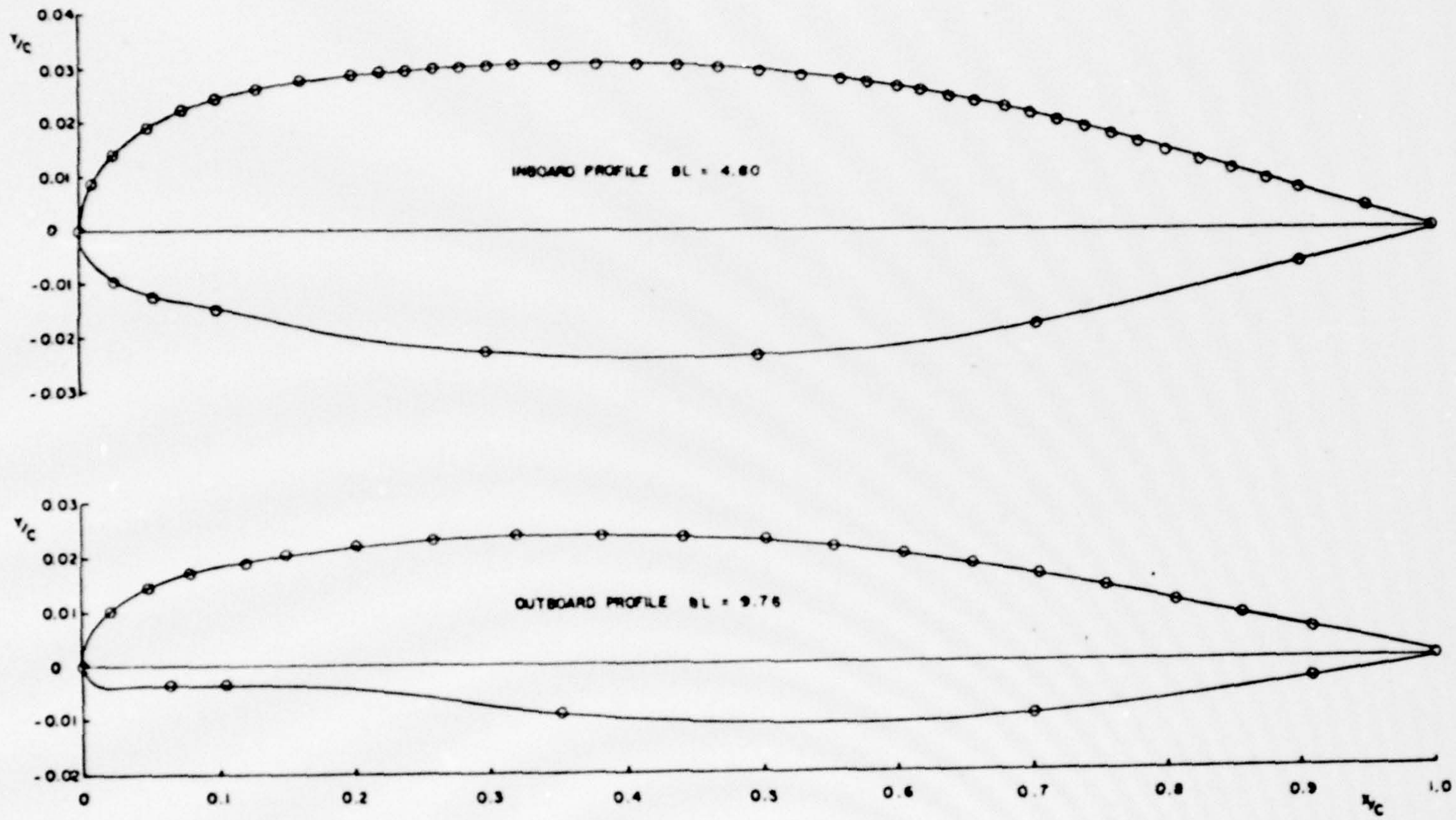
4.0 DATA PACKAGE PRESENTATION

The final data package contained tabulated data, flow visualization photographs, and installation photographs. A part number summary of the data is presented in Table 5. A sample of the point-by-point test data for Phase I is shown in Table 6a. An example of the summary test data is shown in Table 6b. All data parameters used herein are defined in the nomenclature of this report. The nomenclature for the parameters appearing in the tabulated data is presented in Table 7.



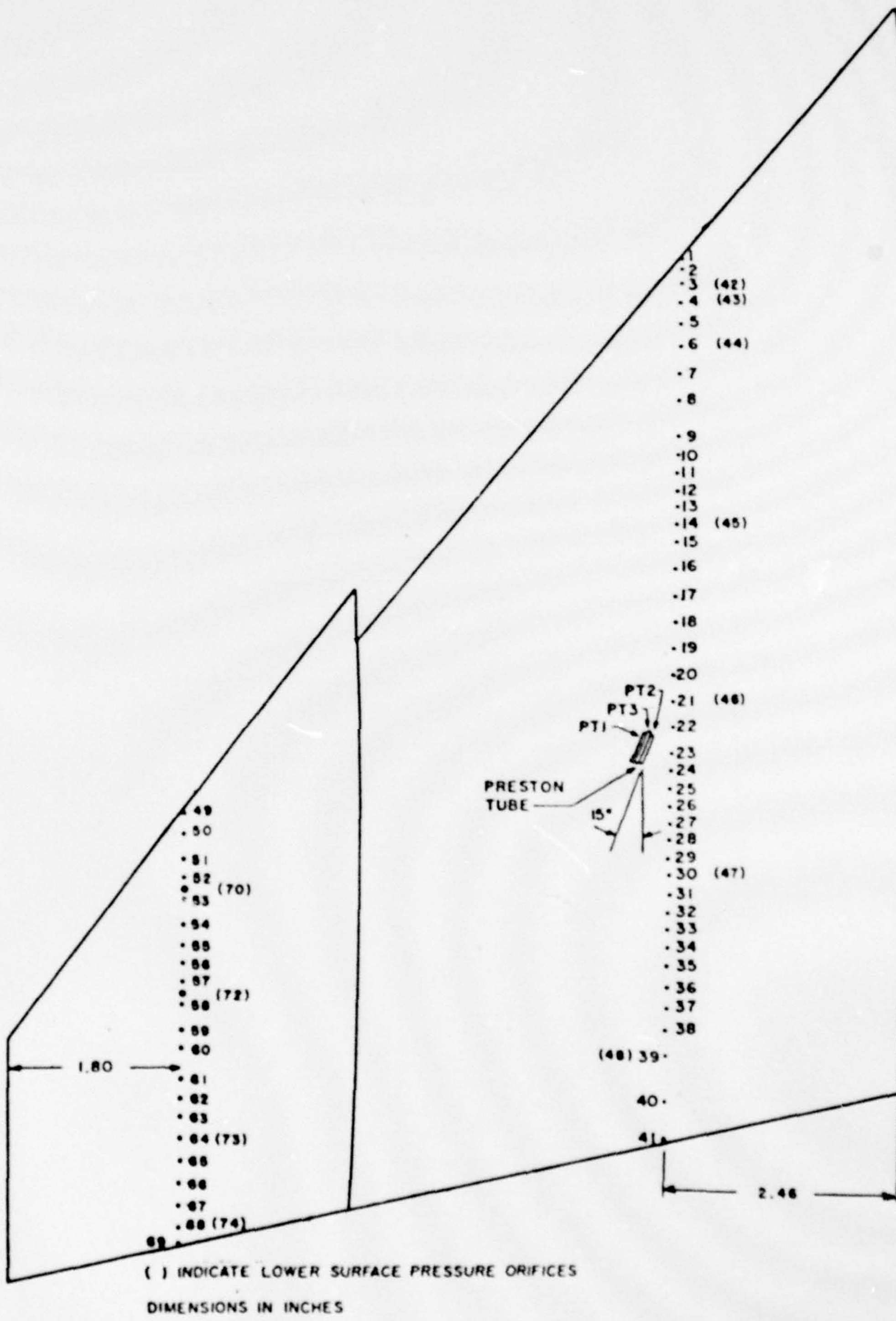
a. General arrangement drawing

Figure 1. Details and Dimensions of the F-4C Model



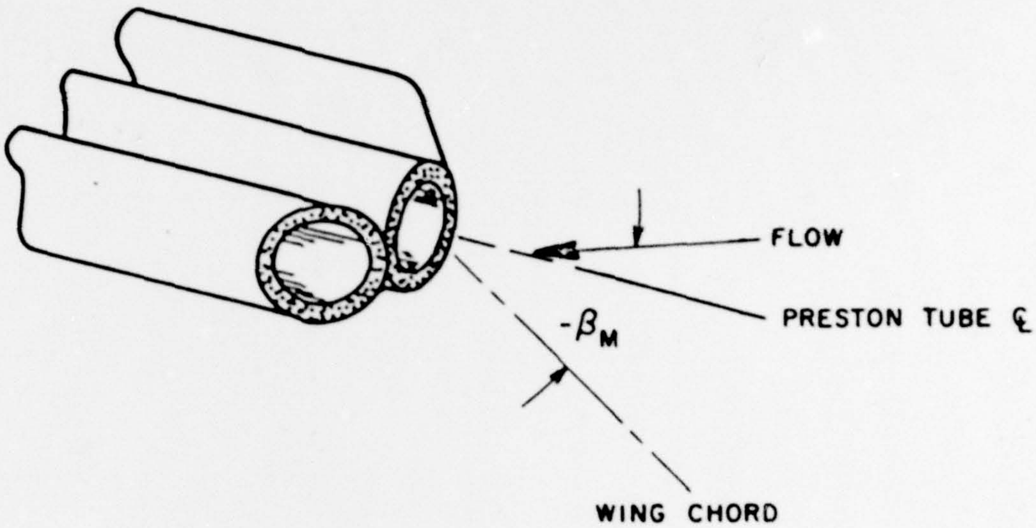
b. Wing cross-section of pressure orifice locations

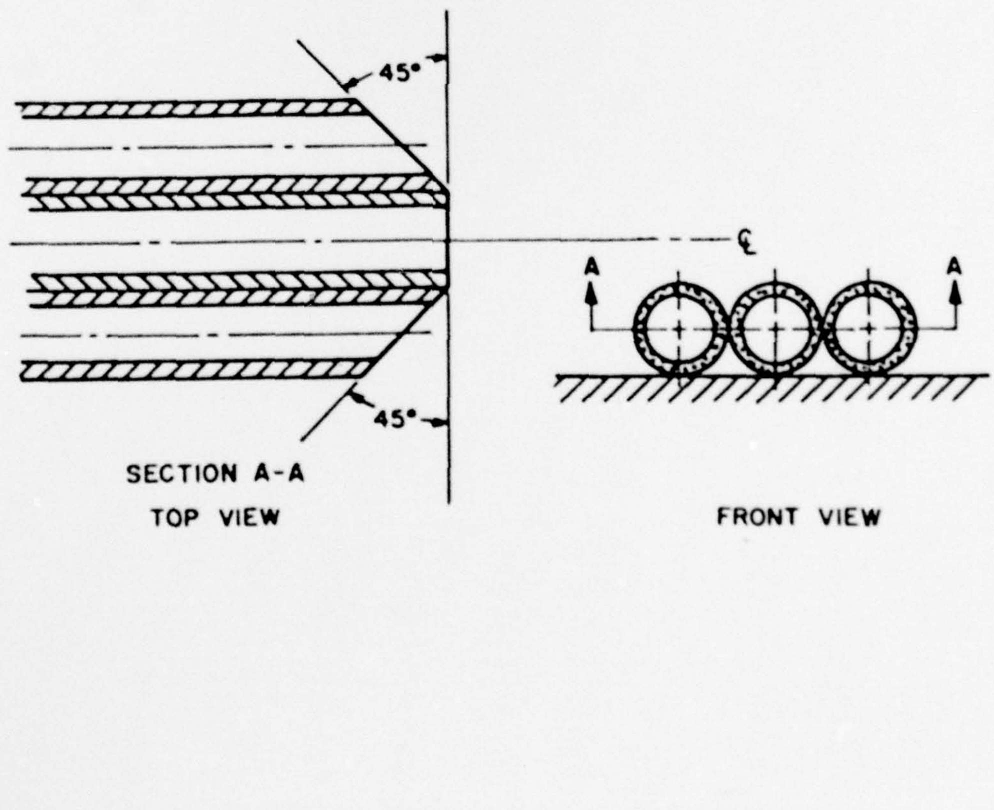
Figure 1. Continued



c. Identification of wing pressure orifices

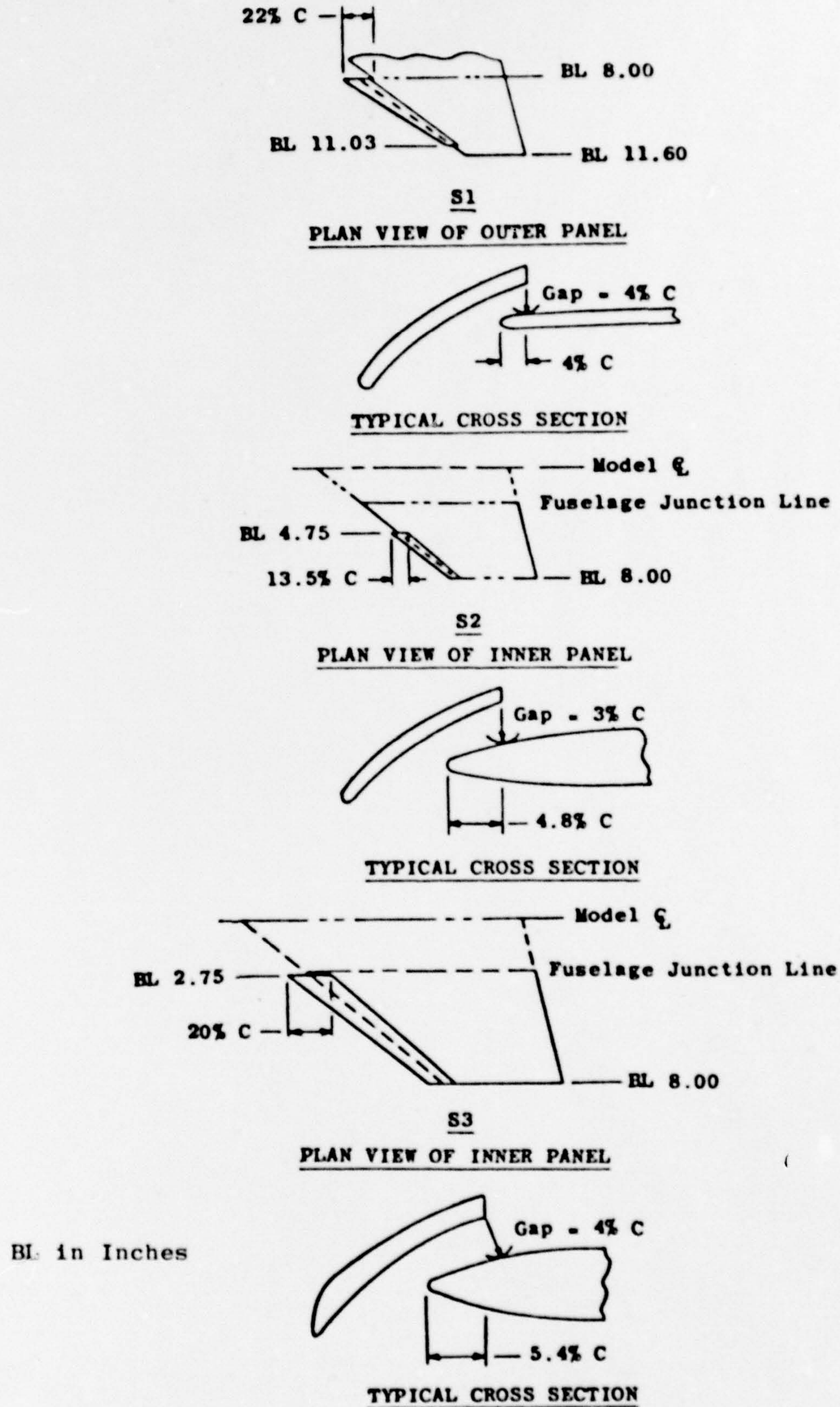
Figure 1. Continued





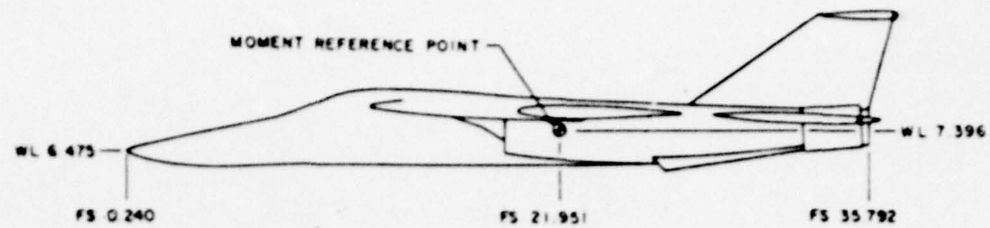
d. Preston tube details

Figure 1. Continued

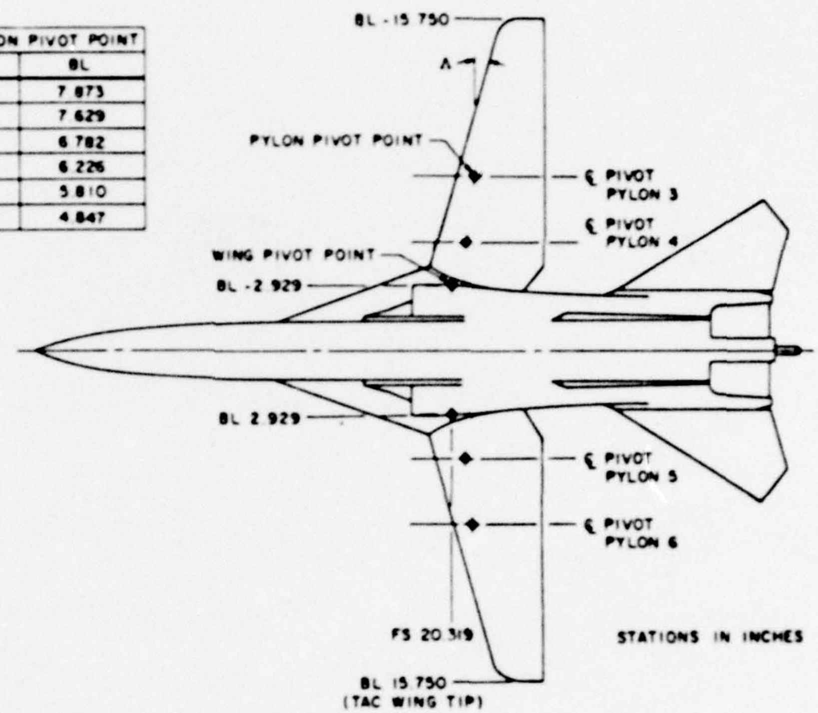


e. Simulated leading-edge slats

Figure 1. Concluded

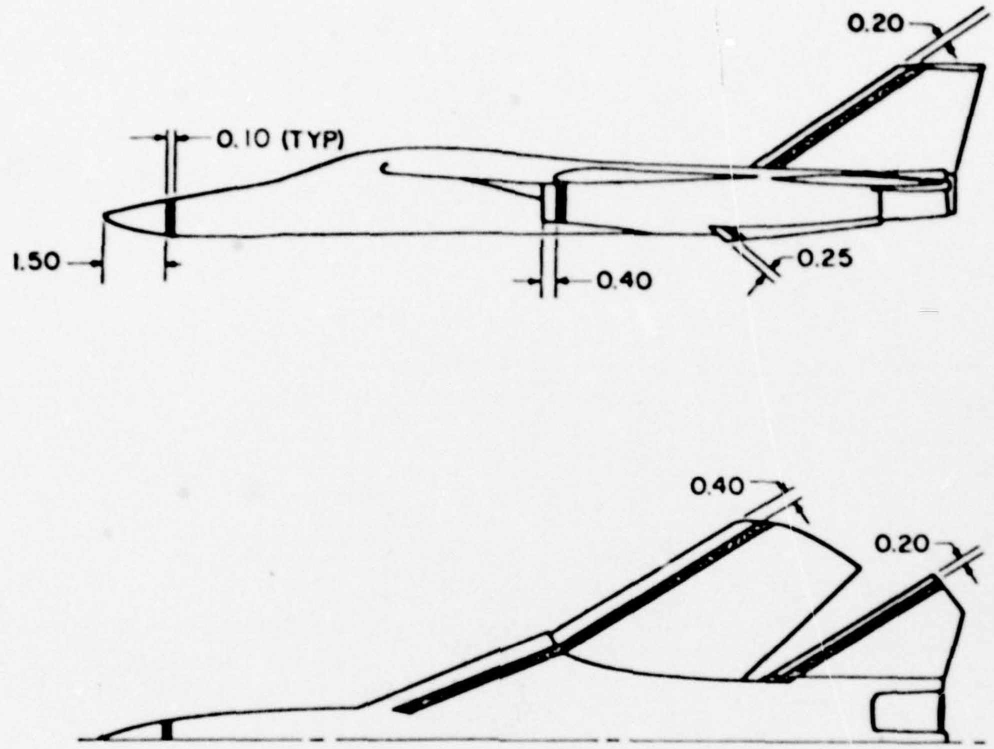


Λ	INBD PYLON PIVOT POINT		OUTBD PYLON PIVOT POINT	
	FS	BL	FS	BL
16 (Ref)	20.962	4.913	21.291	7.873
26	21.297	4.771	22.135	7.629
45	21.843	4.352	23.566	6.782
54	22.047	4.096	24.129	6.226
60	22.160	3.910	24.452	5.810
72.5	22.238	3.488	24.978	4.847



a. General arrangement drawing

Figure 2. Details and Dimensions of the F-111 Model

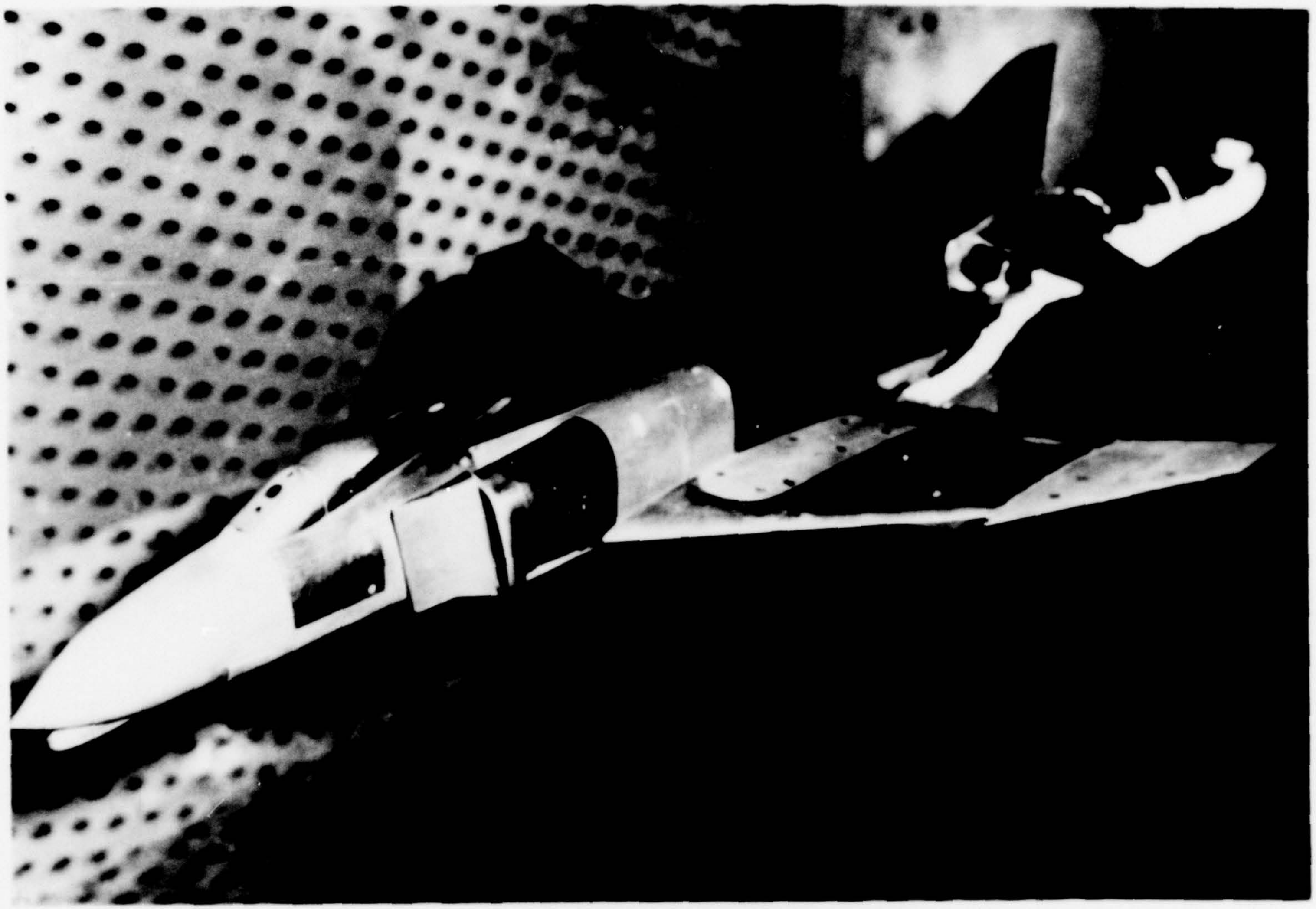


DIMENSIONS IN INCHES
#150 GLASS BEADS

NOTE:
TRANSITION STRIP USED ONLY
FOR LIMITED TESTING

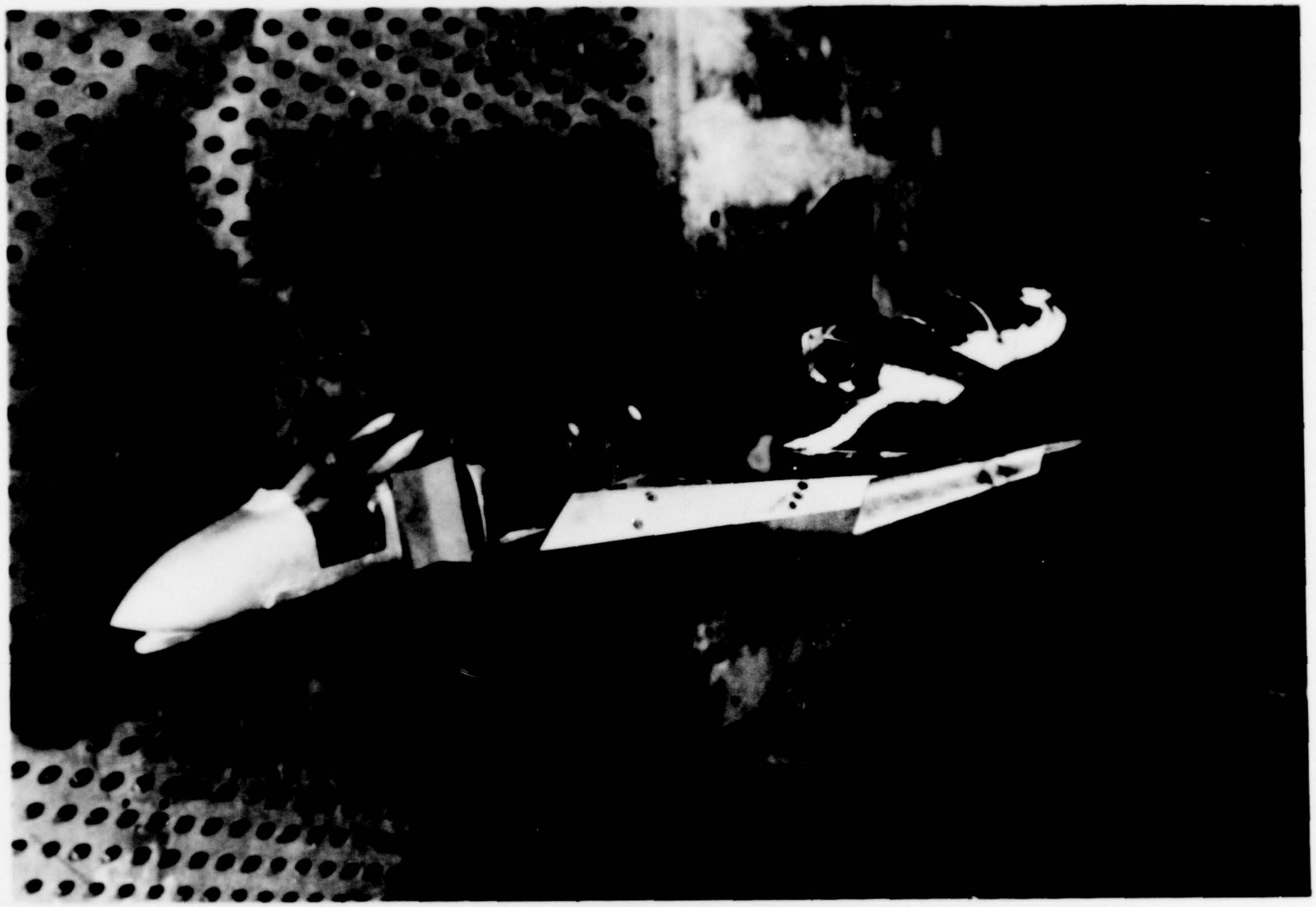
b. Boundary layer transition strip location

Figure 2. Concluded



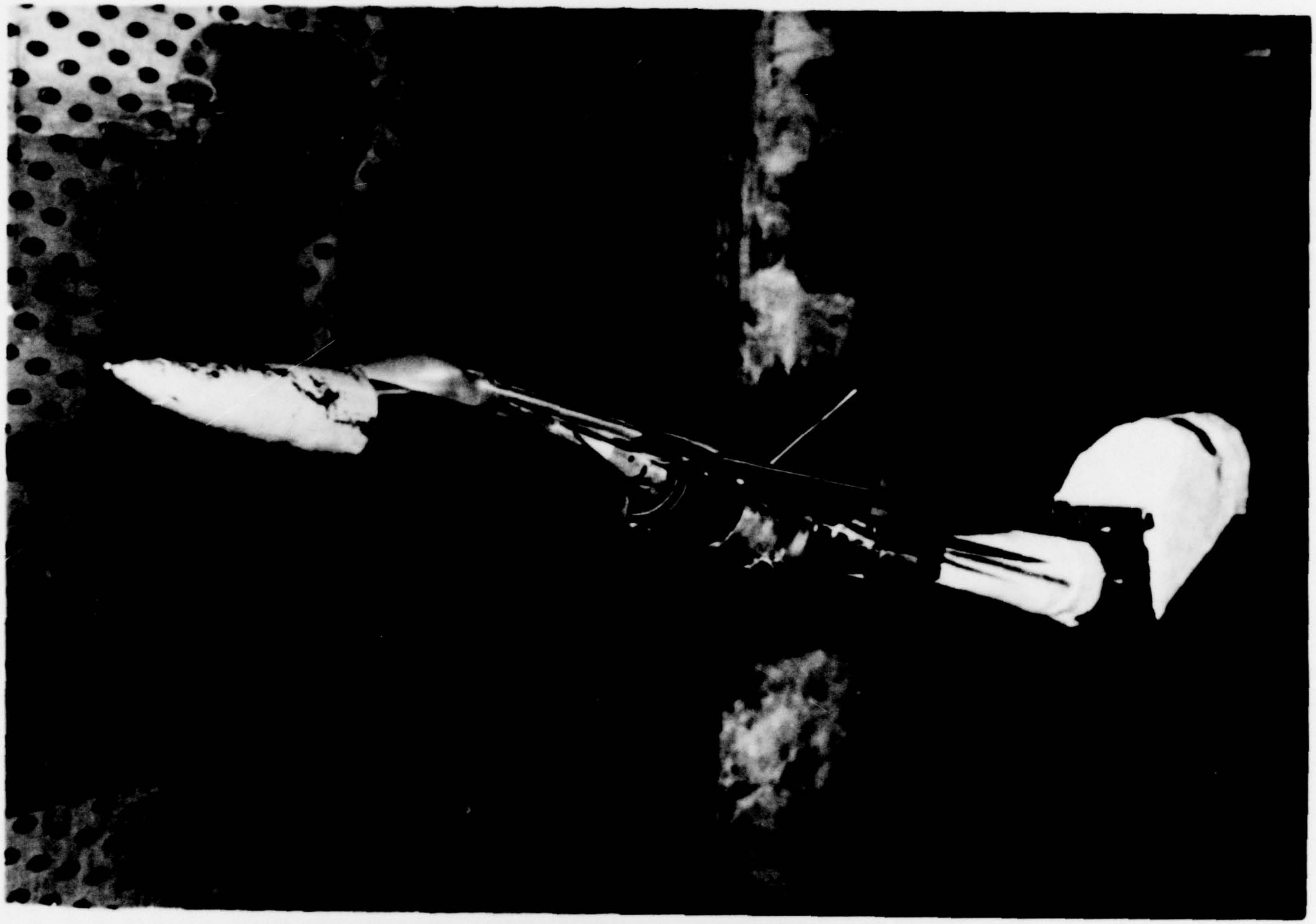
a. F-4C - Configuration 1

Figure 3. Model Installation in Tunnel 4T



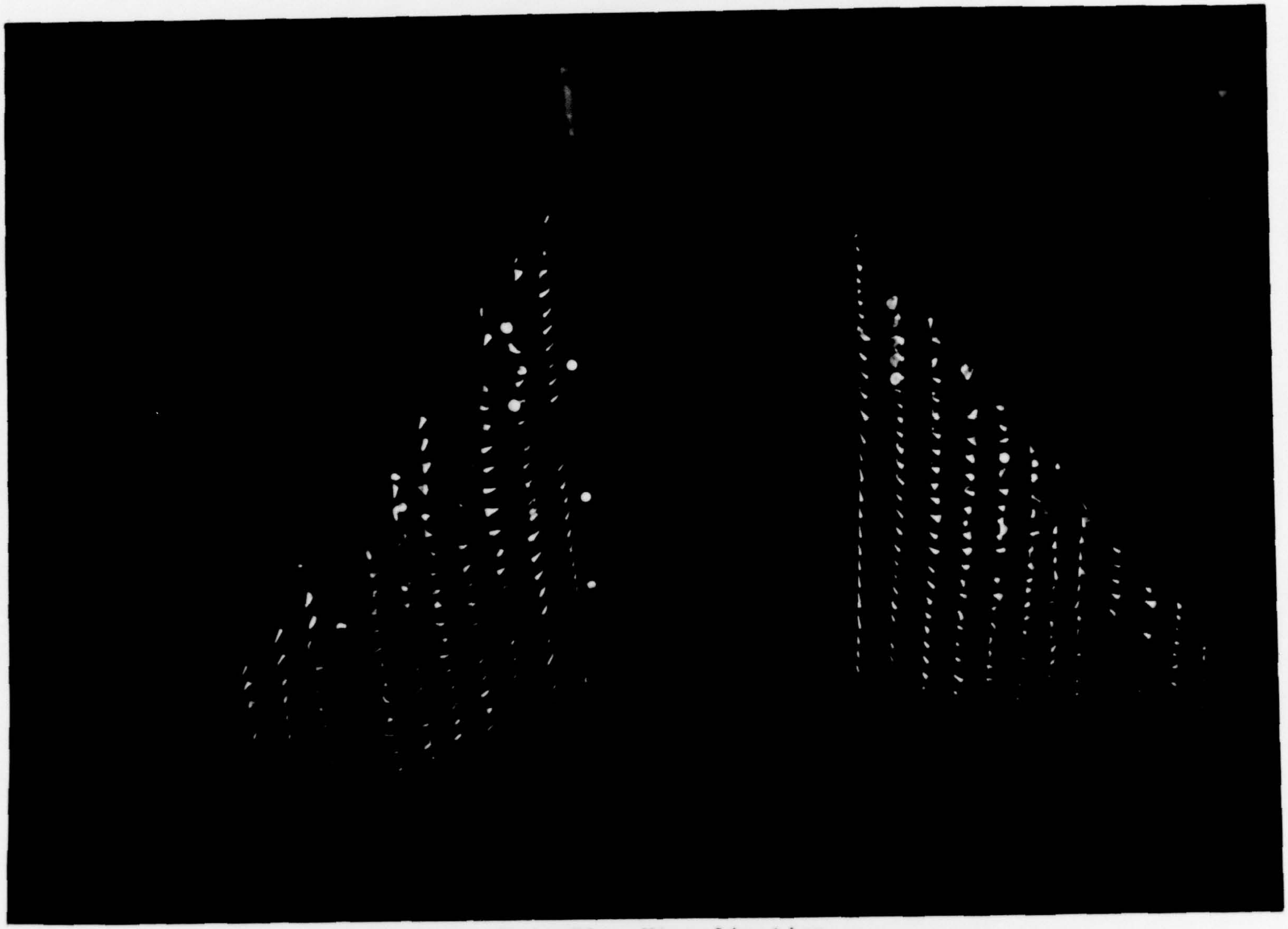
b. F-4C - Configuration 2

Figure 3. Continued



c. F-111 - Configuration 7

Figure 3. Concluded



a. Tuft Flow Visualization

Figure 4. Typical Flow Visualization Results; $M = 0.9$, $\alpha = 15$ deg, $\beta = 2$ deg (Increasing β)

b. Oil-Flow

Figure 4. Concluded

Table 1. Tabulated Locations of Wing Static Pressure Orifices

Inboard Upper Surface

NO.	X/C	Y/C	NO.	X/C	Y/C	NO.	X/C	Y/C
1	0	0	14	0.2998	0.03050	28	0.6610	0.02369
2	0.00997	0.00883	15	0.3199	0.03067	29	0.6822	0.02255
3	0.0255	0.01406	16	0.3509	0.03081	30	0.7013	0.02145
4	0.0501	0.01908	17	0.3811	0.03077	31	0.7204	0.02029
5	0.0755	0.02230	18	0.4104	0.03065	32	0.7410	0.01888
6	0.0999	0.02436	19	0.4405	0.02038	33	0.7613	0.01745
7	0.1291	0.02585	20	0.4708	0.02995	34	0.7810	0.01604
8	0.1611	0.02731	21	0.5007	0.02914	35	0.8006	0.01465
9	0.2004	0.02866	22	0.5308	0.02868	36	0.8259	0.01283
10	0.2212	0.02919	23	0.5611	0.02781	37	0.8514	0.01100
11	0.2409	0.02962	24	0.5812	0.02714	38	0.8760	0.00925
12	0.2606	0.02997	25	0.6019	0.02637	39	0.9010	0.00747
13	0.2801	0.03027	26	0.6204	0.02562	40	0.9506	0.00399
			27	0.6415	0.02465	41	1.0000	0.00042

Inboard Lower Surface

1	0	0	4	0.0986	0.01442	7	0.7035	0.01796
2	0.0232	0.00934	5	0.2995	0.02259	8	0.9013	0.00633
3	0.0528	0.01214	6	0.4983	0.02377	9	1.0000	0.00042

Outboard Upper Surface

1	0	0	8	0.2584	0.02294	15	0.6552	0.01825
2	0.0211	0.01016	9	0.3199	0.02350	16	0.7056	0.01621
3	0.0482	0.01432	10	0.3826	0.02356	17	0.7559	0.01377
4	0.0787	0.01684	11	0.4420	0.02308	18	0.8061	0.01092
5	0.1192	0.01888	12	0.5024	0.02235	19	0.8564	0.00695
6	0.1489	0.02022	13	0.5532	0.02132	20	0.9083	0.00569
7	0.2001	0.02178	14	0.6055	0.01992	21	1.0000	0.00085

Outboard Lower Surface

1	0	0	3	0.1055	0.00340	5	0.7056	0.00952
2	0.0627	0.00360	4	0.3525	0.00886	6	0.9083	0.00360
						7	1.0000	0.00085

Table 2. Model Configuration Nomenclature

Configuration No.	Configuration
1.	Baseline F-4C model
2.	F-4C with S_1, S_2, and S_3
3.	F-4C with S_3
4.	F-4C with S_2
5.	F-4C with S_1 and S_2
6.	F-4C with S_1
7.	F-111 with boundary layer transition strip, Λ = 54 deg
8.	F-111 clean, Λ = 54 deg
9.	F-111 clean, Λ = 26 deg

Table 3. Summary of Nominal Test Conditions

M	PT psfa	Q psf	R x 10^{-6} 1/ft
0.70	1200	295	2.18
0.80		352	2.32
0.85		378	2.37
0.90		402	2.42
0.95		424	2.51
1.10		476	2.50
1.20		500	2.52
1.30		513	2.50

Table 4. Data Uncertainties

a. F-4 Model

M	± ΔCN	± ΔCY	± ΔCA	± ΔCLM	± ΔCLN	± ΔCLL	± ΔCP
0.70	0.03	0.008	0.004	0.009	0.002	0.001	0.018 + 0.005 CP
0.80	0.02	0.007	0.003	0.007			0.015 + 0.004 CP
0.85		↓		↓			0.013 + 0.003 CP
0.90		0.006		0.006	↓		0.012 + 0.003 CP
0.95	↓	↓	↓	↓	0.001	↓	↓

Table 4. Concluded

b. F-111 Model

M	$\pm\Delta$CN	$\pm\Delta$CY	$\pm\Delta$CA	$\pm\Delta$CLM	$\pm\Delta$CLN	$\pm\Delta$CLL	$\pm\Delta$CP
0.70	0.02	0.005	0.003	0.007	0.001	0.001	0.018 + 0.005 CP
0.80	↓	0.004	↓	0.006			0.015 + 0.004 CP
0.90	0.01	0.003	0.002	0.005			0.012 + 0.003 CP
0.95				↓			↓
1.10				0.004			0.010 + 0.002 CP
1.20							0.009 + 0.002 CP
1.30	↓	↓	↓	↓	↓	↓	↓

Table 5. Test Program Part Number Summary

PHASE	CONFIG	ALFA	BETA	PHIA	M				
					0.70	0.80	0.85	0.90	0.95
1	1	V	0	0/180	65/66	70/71	73/74	25/26	89/90
		V	↓	0	67/68	72	82	28	92
		5	V					34	
		10						35	
		15			69	81/88		32/33	93
		20						49	
	↓	15	↓					50 → 63[1]	
	2	V	0	0		108	106	98	105
	↓	15	V			109	107	99	100
	3	V	0	0				114	
	↓	15	V					115	
	4	V	0	0				122[2]	
	↓	15	V					121[2]	
	6	V	0	0				126[2]	
↓	↓	15	V					127	

V - Variable
1 - Time Dependence/Model Movement Studies
2 - Flow-Visualization

Table 5. Continued

PHASE	CONFIG	ALFA	BETA	PHIA	M 0.70	M 0.80	M 0.85	M 0.90	M 0.95
2	1	V	0	0	153	155	157	135	159
		5	V					137	
		10						138	
		15			154	156	158	136	160
		20						139	
		15						140 → 152[1]	
								167[2]/168[2]	
								185[2]/187[2]/193[2]	
	2	V	0	0				180	
		15	V					178[2]/179[2]	

V - Variable
1 - Time Dependence/Model Movement Studies
2 - Flow Visualization

Table 5. Concluded

PHASE	CONFIG	ALFA	BETA	PHIA	M						
					0.70	0.80	0.90	0.95	1.10	1.20	1.30
3	7	V	0	0					240	244	248
		↓	↓	180					239	245	249
		15	V	90					241	246	250
	↓	↓	↓	-90						247	251
	8	V	0	180	266			265	264	260	259
		15	V	90					263	262	257
				-90						261	258
	↓	↓	↓							270[2]	
	9	V	0	0	275	277	278	282			
		↓	↓	180	274	276	279	283			
		15	V	90							
				-90			280	281			
↓	↓	↓	↓	↓				287→289[2]			

V - Variable
2 - Flow Visualization

DATE. 5- 3-79 PROJECT NO. P41C-A3C
ARO, INC.
AEDC DIVISION
A SVERDRUP CORPORATION COMPANY
PROPULSION WIND TUNNEL
ARNOLD AIR FORCE STATION, TENNESSEE

Table 8. Format for Tabulated Data

a. Phase 1 point-by-point

PART	POINT	PROJECT	TEST	DATE	DAY	HR MN SC	MB	DM	SCHED	MODE	ERCODE	PROS DATE	WIND-OFF	AEDC PROPULSION WIND TUNNEL
50	7	P41C-A3C	TC604	3/29/78	88	14:42: 6	0.900	0.005	B	10	0	05-03-79	60/ 1	TRANSONIC 4T

M	PT	Q	P	RX10-6	ALFI	PHII	TTA-1	TTB-2	PTA-1	PTB-2	PCA-1	PCB-2	PE	TPR	WA	POR	SCX100	PM	TDP
0.900	1199.9	402.4	709.2	2.454	10.36	-0.4	82.7	83.0	1199.9	1200.5	716.4	716.8	942.3	1.273	0.00	4.99	0.139	1097.	-1.6

AERODYNAMIC HYSTERESIS PHASE 1
CONFIGURATION 1 SWEEP 51.4

BODY AXIS (BALANCE BRIDGED) — BASE PRESSURES — EXIT PRESSURES

ALFA	BETA	PHIA	CN	CLM	CY	CLN	CLL	CA	CAF	CPB1	CPB2	CPB3	CPE1	CPE2
9.99	0.02	0.1	0.6994	-0.0822	0.0014	-0.0023	-0.0005	0.0279	0.0279	0.0567	0.2391	0.0759	1.0994	1.0887

STABILITY AXIS (BALANCE BRIDGED)

CLS	CLM	CY	CLNS	CLLS	CD	CDF	PB1	PB2	PB3	PE1	PE2
0.6839	-0.0822	0.0014	-0.0022	-0.0009	0.1489	0.1489	732.0	805.4	739.7	1151.6	1147.3

BALANCE READINGS (BALANCE BRIDGED) — GROSS FORCES

RNN1	RNN1	RFA	RML	RNN2	RNN2	FNG	MMG	FYG	MNG	FAG	MLG	PCAV
-847	-79	435	-123	1059	-66	314.6	20.9	3.6	-26.2	21.8	-7.0	0.0

NET FORCES AND TRANSFERED MOMENTS — STATIC TARES

FN	MM	FY	MN	FA	ML	ALFO	FNST	MMST	FYST	MNST	FAST	MLST
373.1	-421.7	0.8	-28.4	10.8	-6.3	-0.09	-58.4	-110.7	-0.4	-0.1	11.0	3.3

SLOPE	T-OUT	FLAG1	TREQ1	LCS1	NLCS1	NCNS1	FLAG2	TREQ2	LCS2	NLCS2	NCNS2
2.0	30	0	18	70	42	0	0	22	46	48	0

	INBOARD-UPPER						LOWER			OUTBOARD-UPPER			LOWER	
	X/C	CP		X/C	CP		X/C	CP		X/C	CP		X/C	CP
CP 1	0.0	-0.4686	CP22	0.530	-0.4571	CP42	0.025	0.0	CP49	0.0	-0.4069	CP70	0.050	0.2598
CP 2	0.010	-0.5876	CP23	0.560	-0.3806	CP43	0.050	0.3221	CP50	0.020	-0.7971	CP71	0.100	0.0
CP 3	0.025	-0.9094	CP24	0.580	-0.4820	CP44	0.100	0.2635	CP51	0.050	-0.8338	CP72	0.350	0.0
CP 4	0.050	-1.0843	CP25	0.600	0.0	CP45	0.300	0.1780	CP52	0.080	-0.8739	CP73	0.700	0.0020
CP 5	0.075	-1.0319	CP26	0.620	-0.3975	CP46	0.500	-0.0054	CP53	0.120	-0.8130	CP74	0.900	-0.1291
CP 6	0.100	0.0	CP27	0.640	-0.3888	CP47	0.700	0.0224	CP54	0.150	0.0			
CP 7	0.130	-0.9221	CP28	0.660	-0.3719	CP48	0.900	-0.0245	CP55	0.200	-0.6820			
CP 8	0.160	-0.9643	CP29	0.680	-0.3461				CP56	0.260	-0.6408			
CP 9	0.200	-0.9357	CP30	0.700	-0.3167				CP57	0.320	-0.6244			
CP10	0.220	-0.9280	CP31	0.720	-0.2879				CP58	0.380	-0.5931			
CP11	0.240	-0.9104	CP32	0.740	-0.1585				CP59	0.440	-0.5719			
CP12	0.250	-0.8835	CP33	0.760	-0.2245				CP60	0.500	-0.5389			
CP13	0.240	-0.8560	CP34	0.780	0.0				CP61	0.550	-0.4984			
CP14	0.300	0.0	CP35	0.800	-0.2072				CP62	0.600	0.0			
CP15	0.320	-0.7916	CP36	0.825	-0.1999				CP63	0.650	-0.4830			
CP16	0.350	-0.7337	CP37	0.850	-0.2049				CP64	0.700	-0.4601			
CP17	0.380	-0.6785	CP38	0.875	-0.1597				CP65	0.750	-0.3948			
CP18	0.410	-0.6524	CP39	0.900	-0.1316				CP66	0.800	-0.4129			
CP19	0.440	-0.3809	CP40	0.950	-0.1058				CP67	0.850	-0.2675			
CP20	0.470	-0.5483	CP41	1.000	0.0523				CP68	0.900	-0.3736			
CP21	0.500	-0.9124							CP69	1.000	0.0			

PRESTON TUBE — TUNNEL CONDITIONS

PT1	PT2	PT3	BETAM	PCBL1	PCBL2	PTBL1	PTBL2
521.1	854.9	882.7	16.21	712.1	713.0	1197.2	1196.9

DATE. 4-20-79 PROJECT NO. PWIT-A30
ARO, INC.
AEDC DIVISION
A SVERDRUP CORPORATION COMPANY
PROPULSION WIND TUNNEL
ARNOLD AIR FORCE STATION, TENNESSEE

Table 6. Continued

b. Summary data

PART	POINT	PROJECT	TEST	DATE	DAY	HR MN SC	MN	DM	SCHED	MODE	ERCODE	PROS DATE	WIND-OFF	AEDC PROPULSION WIND TUNNEL
250	5	PWIT-A30	TC66A	4/ 5/78	95	18147135	1.300	0.005	8	10	0	04-20-79	237/ 3	TRANSONIC 4T

M	PT	Q	P	RTT-6	ALFI	PHII	TTA-1	TTB-2	PTA-1	PTB-2	PCA-1	PCB-2	PE	TPR	WA	POR	SCX100	PM	TOP
1.299	1292.9	513.5	434.8	2.495	0.31	90.0	101.4	100.8	1202.9	1203.7	446.0	445.5	803.8	1.497	0.00	6.22	0.110	1031.	-7.2

AERODYNAMIC HYSTERESIS PHASE 3
CONFIGURATION 7 SWEEP 56.0

SUMMARY 1 BODY AXIS

POINT	ALFA	BETA	PHIA	CN	CY	CA	CLL	CLM	CLN	CAF	CPB1	CPB2	CPB3	CPCAV
5	14.90	0.15	90.0	1.1009	-0.0056	0.0386	-0.0519	-0.5754	-0.0024	0.0287	-0.2870	-0.2872	0.0	-0.1032
8	14.90	-1.92	90.0	1.0963	0.0213	0.0392	0.0016	-0.5699	-0.0008	0.0295	-0.2854	-0.2760	0.0	-0.1044
11	14.91	-3.90	90.1	1.0934	0.0561	0.0454	0.0060	-0.5638	-0.0018	0.0355	-0.2979	-0.2733	0.0	-0.1059
13	14.91	-5.81	90.0	1.0973	0.0902	0.0467	0.0108	-0.5557	-0.0031	0.0367	-0.3027	-0.2733	0.0	-0.1119
16	14.91	-7.96	90.0	1.0817	0.1265	0.0475	0.0172	-0.5472	-0.0033	0.0372	-0.3176	-0.2737	0.0	-0.1191
17	14.89	-6.02	89.9	1.0856	0.0843	0.0442	0.0119	-0.5539	-0.0003	0.0341	-0.3093	-0.2717	0.0	-0.1139
18	14.90	-4.05	90.0	1.0904	0.0453	0.0425	0.0067	-0.5609	0.0017	0.0325	-0.3022	-0.2689	0.0	-0.1080
19	14.89	-1.99	89.9	1.0950	0.0116	0.0405	0.0020	-0.5675	0.0024	0.0307	-0.2938	-0.2729	0.0	-0.1067
20	14.89	-0.00	89.9	1.0942	-0.0275	0.0443	-0.0011	-0.5647	0.0043	0.0345	-0.2891	-0.2776	0.0	-0.1028
21	14.89	2.01	89.9	1.0941	-0.0591	0.0320	-0.0066	-0.5703	0.0046	0.0222	-0.2837	-0.2786	0.0	-0.0977
23	14.89	4.00	90.0	1.0906	-0.0906	0.0318	-0.0092	-0.5681	0.0045	0.0219	-0.2778	-0.2881	0.0	-0.1090
24	14.89	6.01	90.0	1.0815	-0.1288	0.0383	-0.0140	-0.5624	0.0066	0.0283	-0.2795	-0.2960	0.0	-0.1167
25	14.91	8.03	89.9	1.0730	-0.1597	0.0400	-0.0202	-0.5574	0.0062	0.0248	-0.2803	-0.3039	0.0	-0.1205
26	14.91	9.98	89.9	1.0661	-0.1925	0.0465	-0.0258	-0.5541	0.0064	0.0361	-0.2849	-0.3139	0.0	-0.1339
27	14.87	8.01	90.1	1.0726	-0.1472	0.0411	-0.0206	-0.5568	0.0029	0.0309	-0.2800	-0.3102	0.0	-0.1238
28	14.89	6.08	90.1	1.0811	-0.1086	0.0409	-0.0149	-0.5605	0.0008	0.0308	-0.2775	-0.3044	0.0	-0.1173
29	14.88	4.05	90.1	1.0909	-0.0696	0.0364	-0.0100	-0.5656	-0.0015	0.0264	-0.2767	-0.2989	0.0	-0.1118
30	14.89	2.09	90.0	1.0948	-0.0361	0.0380	-0.0050	-0.5690	-0.0022	0.0281	-0.2781	-0.2894	0.0	-0.1017
31	14.90	0.04	90.0	1.0950	-0.0047	0.0417	-0.0017	-0.5687	-0.0022	0.0319	-0.2824	-0.2845	0.0	-0.0986
32	14.90	-1.98	90.1	1.0938	0.0217	0.0441	0.0016	-0.5649	-0.0007	0.0342	-0.2844	-0.2795	0.0	-0.1021
33	14.92	-3.91	90.2	1.0918	0.0537	0.0459	0.0060	-0.5592	-0.0012	0.0360	-0.2968	-0.2750	0.0	-0.1072
34	14.91	-5.89	90.1	1.0862	0.0888	0.0485	0.0111	-0.5528	-0.0022	0.0385	-0.3024	-0.2722	0.0	-0.1098
35	14.92	-7.92	90.1	1.0808	0.1263	0.0504	0.0171	-0.5462	-0.0035	0.0402	-0.3127	-0.2740	0.0	-0.1180

DATE. 4-20-79 PROJECT NO. P41T-A30
ARO, INC.
AEDC DIVISION
A SVERDRUP CORPORATION COMPANY
PROPULSION WIND TUNNEL
ARNOLD AIR FORCE STATION, TENNESSEE

Table 6. Concluded

b. Concluded

PART	POINT	PROJECT	TEST	DATE	DAY	HR MN SC	MN	DM	SCHED	MODE	ERCODE	PROS DATE	WIND-OFF	AEDC PROPULSION WIND TUNNEL
250	5	P41T-A30	TC604	4/ 5/78	95	18:47:35	1.300	0.005	H	10	0	04-20-79	237/ 3	TRANSONIC 4T

M	PT	Q	P	HA10-6	ALFI	PHII	TTA-1	TTB-2	PTA-1	PTB-2	PCA-1	PCB-2	PE	TPR	WA	POR	SCX100	PM	TDP
1.299	1202.9	513.5	434.9	2.495	0.31	90.0	101.4	100.8	1202.9	1203.7	446.0	445.5	803.8	1.497	0.00	8.22	0.110	1031.	-7.2

AERODYNAMIC HYSTERESIS PHASE 3
CONFIGURATION 7 SWEEP 54.0

SUMMARY 2 STABILITY AXIS

POINT	ALFA	BETA	PHIA	CL	CY	CDS	CLLS	CLM	CLNW	COF	COH	CPE1	CPE2
5	14.90	0.15	90.0	1.0539	-0.0056	0.3203	-0.0025	-0.5754	-0.0018	0.3107	0.0096	1.2700	1.3079
8	14.90	-1.92	90.0	1.0494	0.0213	0.3198	0.0013	-0.5699	-0.0012	0.3103	0.0094	1.2926	1.3105
11	14.91	-3.90	90.1	1.0449	0.0561	0.3251	0.0053	-0.5638	-0.0033	0.3155	0.0096	1.3179	1.2161
13	14.91	-5.81	90.0	1.0387	0.0902	0.3249	0.0097	-0.5557	-0.0058	0.3152	0.0097	1.3299	1.1061
16	14.91	-7.96	90.0	1.0331	0.1265	0.3242	0.0158	-0.5472	-0.0077	0.3142	0.0099	1.3345	0.9611
17	14.89	-6.02	89.9	1.0378	0.0843	0.3217	0.0114	-0.5539	-0.0034	0.3119	0.0098	1.3293	1.0899
18	14.90	-4.05	90.0	1.0424	0.0453	0.3214	0.0070	-0.5609	-0.0001	0.3118	0.0096	1.3169	1.2007
19	14.89	-1.99	89.9	1.0478	0.0116	0.3206	0.0026	-0.5675	0.0018	0.3111	0.0095	1.2937	1.3089
20	14.89	-0.00	89.9	1.0461	-0.0275	0.3241	0.0000	-0.5697	0.0044	0.3146	0.0095	1.2669	1.3100
21	14.89	2.01	89.9	1.0491	-0.0591	0.3121	-0.0031	-0.5703	0.0054	0.3027	0.0094	1.2894	1.3222
23	14.89	4.00	90.0	1.0458	-0.0906	0.3110	-0.0077	-0.5681	0.0067	0.3015	0.0095	1.2162	1.3403
24	14.89	6.01	90.0	1.0353	-0.1288	0.3150	-0.0119	-0.5624	0.0100	0.3053	0.0097	1.0910	1.3423
25	14.91	8.03	89.9	1.0266	-0.1597	0.3147	-0.0179	-0.5574	0.0111	0.3049	0.0098	0.9666	1.3482
26	14.91	9.98	89.9	1.0182	-0.1925	0.3193	-0.0232	-0.5541	0.0128	0.3093	0.0101	0.8245	1.3499
27	14.87	8.01	90.1	1.0263	-0.1472	0.3150	-0.0192	-0.5568	0.0081	0.3051	0.0099	0.9662	1.3467
28	14.89	6.08	90.1	1.0343	-0.1086	0.3173	-0.0162	-0.5605	0.0046	0.3075	0.0098	1.0847	1.3412
29	14.88	4.05	90.1	1.0450	-0.0696	0.3154	-0.0101	-0.5656	0.0012	0.3058	0.0097	1.2107	1.3353
30	14.89	2.09	90.0	1.0482	-0.0361	0.3181	-0.0054	-0.5690	-0.0008	0.3085	0.0095	1.2853	1.3212
31	14.90	0.04	90.0	1.0485	-0.0047	0.3221	-0.0022	-0.5687	-0.0017	0.3126	0.0095	1.2730	1.3082
32	14.90	-1.98	90.1	1.0457	0.0217	0.3239	0.0014	-0.5649	-0.0011	0.3144	0.0095	1.2921	1.3071
33	14.92	-3.91	90.2	1.0432	0.0537	0.3254	0.0055	-0.5592	-0.0027	0.3158	0.0096	1.3159	1.2149
34	14.91	-5.89	90.1	1.0372	0.0888	0.3264	0.0102	-0.5528	-0.0050	0.3167	0.0097	1.3288	1.1016
35	14.92	-7.92	90.1	1.0314	0.1263	0.3270	0.0156	-0.5462	-0.0078	0.3171	0.0099	1.3352	0.9649

Table 7. Tabulated Data Nomenclature

Test Data	Identification and Wind Tunnel Parameters
PART	Run (data set) identification number
POINT	Data point number
PROJECT	Project number
TEST	Test number
DATE	Date of data acquisition
DAY	Day (of year) of data acquisition
HR	Hour of data acquisition
MN	Minute of data acquisition
SC	Second of data acquisition
MB	Set point Mach number
DM	Mach number tolerance
SCHED	Tunnel wall porosity schedule
MODE	Data acquisition mode
ERCODE	Error code
PROS DATE	Date of data processing
WIND OFF	Wind-off part and point number
M	Free-stream Mach number
PT	Free-stream stagnation pressure, psfa
Q	Free-stream dynamic pressure, psf
P	Free-stream static pressure, psfa
RX10-6	Free-stream unit Reynolds number x 10^{-6}, 10^6/ft
ALFI	Pitch sector indicated pitch angle, deg
PHII	Pitch sector indicated roll angle, deg
TTA-X	Total temperature measured in the tunnel stilling chamber - A system, °F
TTB-X	Total temperature measured in the tunnel stilling chamber - B system, °F

Table 7. Continued

PTA-X	Total pressure measured in the tunnel stilling chamber - A system, psfa
PTB-X	Total pressure measured in the tunnel stilling chamber - B system, psfa
PCA-X	Tunnel plenum chamber pressure - A system, psfa
PCB-X	Tunnel plenum chamber pressure - B system, psfa
PE	Tunnel diffuser pressure, psfa
TPR	Tunnel pressure ratio, PT/PE
WA	Test section wall angle, deg
POR	Average tunnel wall porosity , percent of wall area open to test section plenum
SCX100	Tunnel specific humidity x 100, lb/lb x 10^{-2}
PM	Hygrometer mixture pressure, psfa
TDP	Hygrometer dew point temperature, °F

Note: The suffixed "X's" with TT, PT, and PC indicate the primary system and the program checks on system agreement. The suffixed nomenclature is as follows:

X = 1	Primary system
X = 2	Secondary system
X = 0	Delete checks on system agreement

Body Axes Coefficients/Base Pressures/Exit Pressures

ALFA	Model angle of attack measured between the relative wind vector and the reference water line, deg
BETA	Model sideslip angle, deg
PHIA	Model roll angle, positive right wing down, deg
CN	Normal-force coefficient
CLM	Pitching-moment coefficient
CY	Side-force coefficient
CLN	Yawing-moment coefficient

Table 7. Continued

CLL	Rolling-moment coefficient
CA	Total axial-force coefficient
CAF	Forebody axial-force coefficient, CA-CAB
CPB_i	Base pressure coefficient
CPE_i	Flow-thru duct total exit pressure coefficients
<u>Stability Axes</u>	
CLS	Lift coefficient
CLM	Pitching-moment coefficient
CY	Side-force coefficient
CLNW	Yawing-moment coefficient
CLLS	Rolling-moment coefficient
CD	Total drag coefficient
CDB	Base drag coefficient
CDF	Forebody drag coefficient, CD-CDB
PB_i	Base pressure, psfa
PE_i	Flow thru duct total exit pressure, psfa
<u>Balance Readings/Gross Forces</u>	
RMM1	Balance forward pitching moment gage reading
RMN1	Balance forward yawing moment reading
RFA	Balance axial force gage reading
RML	Balance rolling moment gage reading
RMM2	Balance aft pitching moment gage reading
RMN2	Balance aft yawing moment gage reading
FNG	Gross normal force, lb
MMG	Gross pitching moment, in.-lb
FYG	Gross side force, lb

Table 7. Continued

MNG	Gross yawing moment, in.-lb
FAG	Gross axial force, lb
MLG	Gross rolling moment, in.-lb
PCAV	Cavity pressure, psfa

Net Forces and Transferred Moments/Static Tares

FN	Net normal force, lb
MM	Net transferred pitching moment, in.-lb
FY	Net side force, lb
MN	Net transferred yawing moment, in.-lb
FA	Net total axial force, lb
ML	Net rolling moment, in.-lb
ALFO	Flow correction angle in pitch, deg
FNST	Normal force tare, lb
MMST	Pitching moment tare, in.-lb
FYST	Side force tare, lb
MNST	Yawing moment tare, in.-lb
FAST	Axial force tare, lb
MLST	Rolling moment tare, in.-lb

4T Pressure System Information

SLOPE	Pressure settling slope criteria, psf/sec
T-OUT	Time out criteria, sec
FLAGi	Indicator if pressure settling criteria was settled at time of data acquisition (i = 1, loop 1; i = 2, loop 2)
TREQi	Time required for settling
LCSi	Last channel to settle
NLCSi	Next to last channel to settle

Table 7. Concluded

NCNSi	Number of channels not settled at time of data acquisition

<u>Phase 1 Pressures - Wing/Preston Tube/Tunnel Conditions</u>

X/C	Fraction of wing chord measured from the leading edge
CPi	Wing pressure coefficient
PTi	Preston tube pressures, psfa
BETAM	Measured local wing surface flow angle in the yaw plane (Preston tube), deg
PCBLi	Tunnel plenum chamber pressure during data cycle - B system, psfa
PTBLi	Total pressure measured in the tunnel stilling chamber during data cycle - B system, psfa