AEDC-TSR-83-V16

C.2

PRESSURE MEASUREMENTS ON FIVE MINIATURE MACH/FLOW ANGULARITY PROBES AT MACH NUMBERS 1.76, 2.0, 3.0 AND 5.0

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Calspan Field Services, Inc.

May 1983

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

Pressure measurements were obtained on five miniature Mach/flow angularity probes which were developed at AEDC as part of an on-going probe development effort. These measurements will be correlated with Mach number and known flow angle in order to calibrate these probes. Secondary objectives were to test a hot-film anemometer and three pitot-acoustic probes for durability, and to examine the response of three ported dynamic pressure transducers located downstream of the tunnel test section.

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CONTENTS

		Page
	NOMENCLATURE	2
1.0	INTRODUCTION	4
2.0	APPARATUS	
	2.1 Test Facility	4
	2.2 Probe Rake	5
	2.3 Test Instrumentation	5
3.0	TEST DESCRIPTION	
	3.1 Test Conditions and Procedures	6
	3.2 Data Reduction	7
	3.3 Uncertainty of Measurements	8
4.0	DATA PACKAGE PRESENTATION	8
	REFERENCES	9

APPENDIXES

I. ILLUSTRATIONS

Figure		
1.	Tunnel A	11
2.	Probe Rake	12
3.	Probe Rake Details	13
4.	Installation Photograph	14
5.	Mach/Flow Angularity Probe	15
6.	Pitot Acoustic Probe	16
7.	Hot-Film Anemometer	17
8.	Dynamic Pressure Transducer Arrangement	18

II. TABLES

Table		
1.	Data Transmittal Summary	20
2.	Estimated Uncertainties	21
3.	Run Summary	24

III. SAMPLE DATA

SAMPLE		
1.	Tabulated Data	26
2.	Plotted Data	27

NOMENCLATURE

A	Slip flow coefficient (psi)
ALPI, ALPHI	Indicated angle of attack (deg)
ALPHT	Total angle of attack (deg)
DPSQP	Mach/Flow-Angularity probe nondimensional parameter, $[(DP13)^2 + (DP24)^2]^{0.5}/(2 \cdot P5)$
DP13	Differential pressure measurement of the probe in the pitch plane [P1-P3] (psid)
DP24	Differential pressure measurement in the yaw plane [P2-P4] (psid)
$\frac{dP_{(t)}}{dt}$	Derivative of the instantaneous transducer pressure with respect to time (psi/sec)
KNOM	Nominal stabilization coefficient, evaluated by an examination of the physical characteristics of the probes and pressure lines (1/psi)
KP(1-5)	Coefficients obtained by the pressure stabilization routine for Mach/Flow-Angularity pressures 1-5. (1/psi-sec)
M, MACH	Free-stream Mach number
MU	Dynamic viscosity ($lbf\text{-}sec/ft^2$)
P	Free-stream static pressure (psia)
PAVG	Average pressure value of the Mach/Flow-Angularity probe "static orifices" [(P1 + P2 + P3 + P4)/4] (psia)
PAVGP5	Ratio, PAVG/P5
P(1-5)	Pressure measurements for probe orifices 1-5 (psia)
P(1-5)F	Final transducer pressure measurement for orifices 1-5 (psia)

P_{eq}	Equilibrium transducer pressure as predicted by equilibrium pressure stabilization routine (psia)
P(1-5)I	First transducer pressure measurement for orifices 1-5 (psia)
$P_{(t)}$	Instantaneous transducer pressure (psia)
PHII	Indicated roll angle (deg)
PHIT	Total roll angle (deg)
PT	Stilling chamber pressure measurement (psia)
PT2	Pitot pressure downstream of normal shock (psia)
Q	Free-stream dynamic pressure (psia)
RE	Free-stream unit Reynolds number (ft^{-1})
RHO	Free-stream density (lbm/ft^3)
RUN	Data set identification number
T	Free-stream static temperature (^oR)
TDEL	Indication of delay time between data initiation and start of data recording (sec)
TDP	Free-stream flow frost point (^oF)
TNP(1-5)	Nominal time constant for the Mach/Flow-Angularity probe (sec)
TREC	Indication of elapsed time of data recording (sec)
TT	Tunnel stilling chamber temperature (°R or °F)
V	Free-stream velocity (ft/sec)

1.0 INTRODUCTION

The work reported herein was performed by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), under Program Element 65807F, Control Number 9R02, at the request of Director of Technology (DOT), AEDC. in support of technology project number DA12VW (Calspan project number V32B-AU). The AEDC/DOT project manager was Mr. M. K. Kingery. The results were obtained by Calspan Field Services, Inc./AEDC Division, operating contractor for the Aerospace Flight Dynamics testing effort at the AEDC, AFSC, Arnold Air Force Station, Tennessee. The test was performed in the von Karman Gas Dynamics Facility (VKF), in the Supersonic Wind Tunnel (A) on March 29, 1983 under the AEDC project number C960VA (Calspan Project Number V--A-2R).

The primary objective of the test was to obtain pressure measurements on five (5) Mach/Flow Angularity (MFA) probes so that these measurements can be correlated with Mach number and known flow angles to "calibrate" these probes for future flow-field probing techniques. Secondary objectives were to test three (3) pitot acoustic probes and one hot-film anemometer for durability and to investigate the response of three (3) ported dynamic pressure transducers mounted downstream of the tunnel test section.

The test was performed at Mach numbers 1.76, 2.0, 3.0, and 5.0 at unit Reynolds numbers of 0.92×10^6 to 4.2×10^6 per foot. The probes were tested over an angle-of-attack range of -4 to 11.6 deg and roll angles of -90 deg to 180 deg.

A summary of the test data transmitted to AEDC/DOT is presented in Table 1.

Inquiries to obtain copies of the test data should be directed to AEDC/DOT, Arnold Air Force Station, TN 37389. A microfilm copy has been retained at AEDC.

2.0 APPARATUS

2.1 TEST FACILITY

Tunnel A (Fig. 1) is a continuous, closed-circuit, variable density wind tunnel with an automatically driven flexible-plate-type nozzle and a 40- by 40-in. test section. The tunnel can be operated at Mach numbers from 1.5 to 6 at maximum stagnation pressures from 29 to 200 psia, respectively, and stagnation temperatures up to 750°R at Mach number 6. Minimum operating pressures range from about one-tenth to one-twentieth of the maximum at each Mach number. The tunnel is equipped with a model injection system which allows removal of the model from the test section while the tunnel remains in operation. A description of the tunnel and airflow calibration information may be found in the Test Facilities Handbook (Ref. 1).

2.2 PROBE RAKE

The Mach/Flow angularity probes, the pitot acoustic probes, and the hot film anemometer were supported in the test section by a probe rake which was designed and fabricated at AEDC. This rake was pitched or rolled to achieve the desired probe attitudes. The probe rake is shown in Fig. 2, with details presented in Fig. 3. Figure 4 shows the rake installed in the tunnel test section.

2.3 TEST INSTRUMENTATION

The measuring devices, recording devices, and calibration methods used for all measured parameters are listed in Table 2 along with the estimated measurement uncertainties.

Generally, Mach/Flow angularity probes are used to measure the local stream total pressure, local Mach number, and local flow angle. A typical Mach/flow angularity probe is shown in Fig. 5. The probes are nominally 0.040 inches in diameter, made up of 5 individual pressure orifices of 0.006 inches ID. Probes this small minimize probe interference and improve the resolution of the measurement location while mapping complex flow fields. Mach/Flow angularity probes are calibrated to measure the two flow directional angles (ALPHT and PHIT) of the airstream with respect to the probe. Typically, pressure measurements in orifices 1 and 3 are in the vertical or pitch plane, and, orifices 2 and 4 are in the horizontal or yaw plane of the flow field.

These Mach/Flow angularity probes are the result of an on-going probe development effort. The goal of this effort is to develop a smaller, less intrusive MFA probe with extended structural life. The design approach was to fabricate the probes from single pieces of pre-stretched rods with 5 small holes drilled lengthwise through the rods in a cruciform pattern. Tensile stretching of the rods was performed after drilling to reduce further the diameter of the rods at a prescribed, controlled rate. Stretching was continued until the specimen fractured, whereupon the fractured tips were cut to orient the outer holes on 15-degree planes (see Fig. 5). Pressure tubes were then attached on the base to the orifices, and the probes were fit to probe bodies suitable for tunnel installation. Generally, the probes were stretched to the 0.040 in. diam from rods initially 0.2 in. in diameter. The holes were drilled 0.040 in. diam.

Three (3) pitot-acoustic probes, designed and fabricated at AEDC, were tested in order to investigate a new probe design. The pitot-acoustic probe, shown in Fig. 6, consists of a stainless steel cylindrical shell with a conical frustum tip (20 degree half angle) which houses a dynamic pressure sensor. As shown, the transducer was threaded into the stainless steel frustum probe tip and then a 0.015 inch thick RTV cap was placed over the 0.099 inch diameter sensor tip to protect it from the tunnel environment.

A hot-film anemometer probe (Fig. 7), designed and fabricated at AEDC, was mounted on the probe rake in order to determine its durability in supersonic flow. This probe consists of a 0.020-inch diameter glass rod ground to a slender double wedge at the leading edge. A thin platinum film was then deposited (painted) along the leading edge. Two strips of gold painted along the rod served to connect the film to wire leads from the anemometer instrumentation.

Four dynamic pressure transducers were located downstream of the tunnel test section and arranged as shown in Fig. 8. One transducer was flush mounted with the tunnel wall and the other three were located at distances of four, eight and sixteen inches from the orifice along a port. Dynamic signals from the transducers were recorded on analog tape. These recordings will be used to determine the effect of this porting concept on signal response. Such porting, if properly understood, may be used to isolate fragile transducers from harsh tunnel environments.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS AND PROCEDURES

A summary of the nominal test conditions at each Mach number is given below.

MACH	PT, psia	TT, °R	Q, psia	P, psia	RE x 10^{-6}/ft
1.76	14.76	546	5.92	2.73	4.11
2.00	16.66	546	5.96	2.13	4.21
3.01	26.90	541	4.57	0.72	4.16
5.04	86.99	621	2.79	0.16	3.92
5.04	68.20	620	2.19	0.12	3.05
5.04	60.51	620	1.94	0.11	2.74
5.04	50.71	620	1.63	0.09	2.30
5.04	30.92	613	1.00	0.06	1.42
5.04	20.17	613	0.65	0.04	0.92

The Tunnel A sidewall Mach number probe was used at each test condition to monitor deviations from the standard calibrated Mach numbers. When a deviation was measured, the free-stream conditions were corrected and the actual Mach number was printed on the data tabulations.

A test summary showing all configurations tested and variables for each is presented in Table 3.

In the VKF continuous flow wind tunnels (A, B, C), the model(in this case, the probe rake) is mounted on a sting support mechanism in an installation tank directly underneath the tunnel test section. The tank is separated from the tunnel by a pair of fairing doors and a safety door. When closed, the fairing doors, except for a slot for the pitch sector, cover the opening to the tank and the safety door seals the tunnel from the tank area. After the model is prepared for a data run, the personnel access door to the installation tank is closed, the tank is vented to the tunnel flow, the safety and fairing doors are opened, the model is injected into the airstream, and the fairing doors are closed. After the data are obtained, the model is retracted into the tank and the sequence is reversed, with the tank being vented to atmosphere to allow access to the model in preparation for the next run.

Rake attitude positioning and data recording were accomplished with the point-pause mode of operation, using the Model Attitude Control System (MACS). Rake pitch and roll requirements were entered into the controlling computer prior to the test. Rake positioning and data recording operations were performed automatically during the test by selecting the list of desired model attitudes and initiating the system.

Pressure data on the MFA probes were acquired by the Random Access Data System (RADS) from the Tunnel A Standard Pressure System. The data acquisition sequence was:

1. Inject the rake into the test section.

2. Pitch to desired rake attitude.

3. Delay a specified time to allow pressure to stabilize.

4. Acquire 20 to 40 data points (depending on pressure level) in order to establish a time history of the pressure readings.

5. Pitch to next probe attitude.

The data from the pitot acoustic probes, the hot film anemometer probe, and the dynamic pressure transducers were not acquired by the RADS but were recorded on FM tape.

3.2 DATA REDUCTION

Prior to each operating shift, and as required, the pressure transducers are all calibrated with a known pressure differential and their readings are recorded. A zero pressure differential is applied across each transducer and the zero readings are recorded. From these data, linear scale factors are calculated for each transducer for each range. MFA probe pressures are calculated from differential pressure readings using the calibrated scale factors, plus a reference pressure (near vacuum, ~ 50 μHg) which is measured with an absolute pressure transducer.

In order to optimize data acquisition time and improve the reliability of pressure readings, an equilibrium pressure stabilization routine was used. The routine requires as an input the time history of the pressure readings from a transducer. This routine then fits the time history as an exponential decay with a step input by adjusting the value of KP in the equation below and evaluates the final equilibrium value.

$$\frac{dP_{(t)}}{dt} = KP \; \{P_{eq}^{\;2} - P_{(t)}^{\;2} + A \; (P_{eq} - P_{(t)})\}, \text{ psi/sec}$$

References 2 and 3 give a further description of the equilibrium pressure stabilization routine.

In some cases the pressures are at equilibrium throughout the data record (essentially constant pressure, indicated by a value of KP less than 0.01 or greater than 3) and the pressures are simply defined as the average value of the recorded pressures.

Reduction of pitot acoustic probe, hot film anemometer probe, and dynamic pressure transducer data will consist of spectral analysis of their recorded signals. This effort will be performed and documented under technology project DA12VW, Aerodynamic Measurement Improvements.

3.3 UNCERTAINTY OF MEASUREMENTS

In general, instrumentation calibration and data uncertainty estimates were made using methods recognized by the National Bureau of Standards (NBS) (Ref. 4). Measurement uncertainty is a combination of bias and precision errors defined as:

$$U = \pm(B + t_{95}S)$$

where B is the bias limit, S is the sample standard deviation, and t_{95} is the 95th percentile point for the two-tailed Student's "t" distribution (95-percent confidence interval), which for sample sizes greater than 30 is equal to 2.

Estimates of the measured data maximum uncertainties for this test are given in Table 2. Propagation of the bias and precision errors of measured data through the calculated data was made in accordance with Ref. 4 and the results are given in Table 2b.

4.0 DATA PACKAGE PRESENTATION

The data package consists of one volume containing tabulated and plotted pressure data, as well as a nomenclature list, and a detailed run schedule. Appendix III contains examples of the data presented in the data package. Sample 1 shows typical tabulated data and Sample 2 shows typical plotted data.

REFERENCES

1. Test Facilities Handbook (Eleventh Edition) "von Karman Gas Dynamics Facility, Vol. 3," Arnold Engineering Development Center, Revised, April 1981.

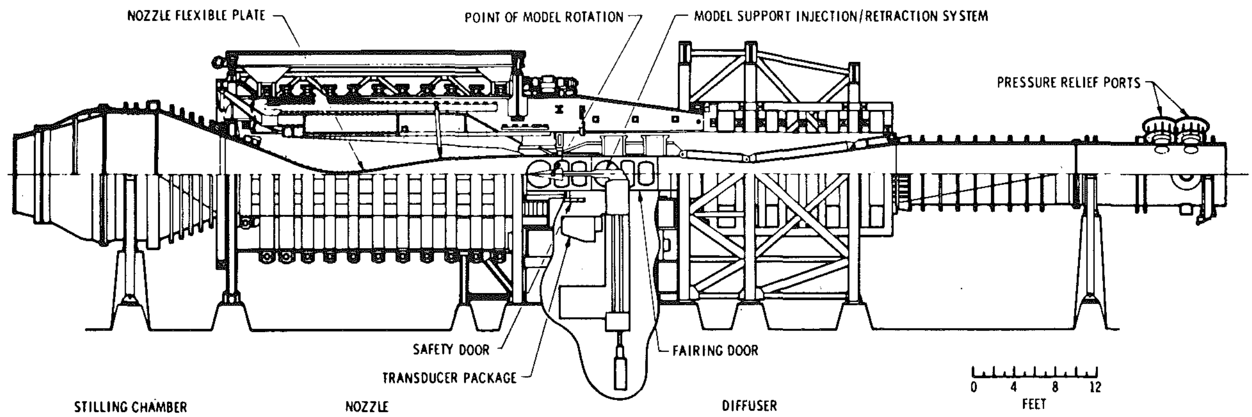
2. Carver, D. B. "Heat-Transfer, Surface-Pressure, and Flow-Field Survey Tests on a Blunt Biconic Model at Mach Number 10 - Phase V," AEDC-TSR-79-V36, June 1979.

3. Brown, David L. "Predicting Equilibrium Pressures from Transient Pressure Data," Aerospace Research Laboratories, ARL 65-7, January 1965.

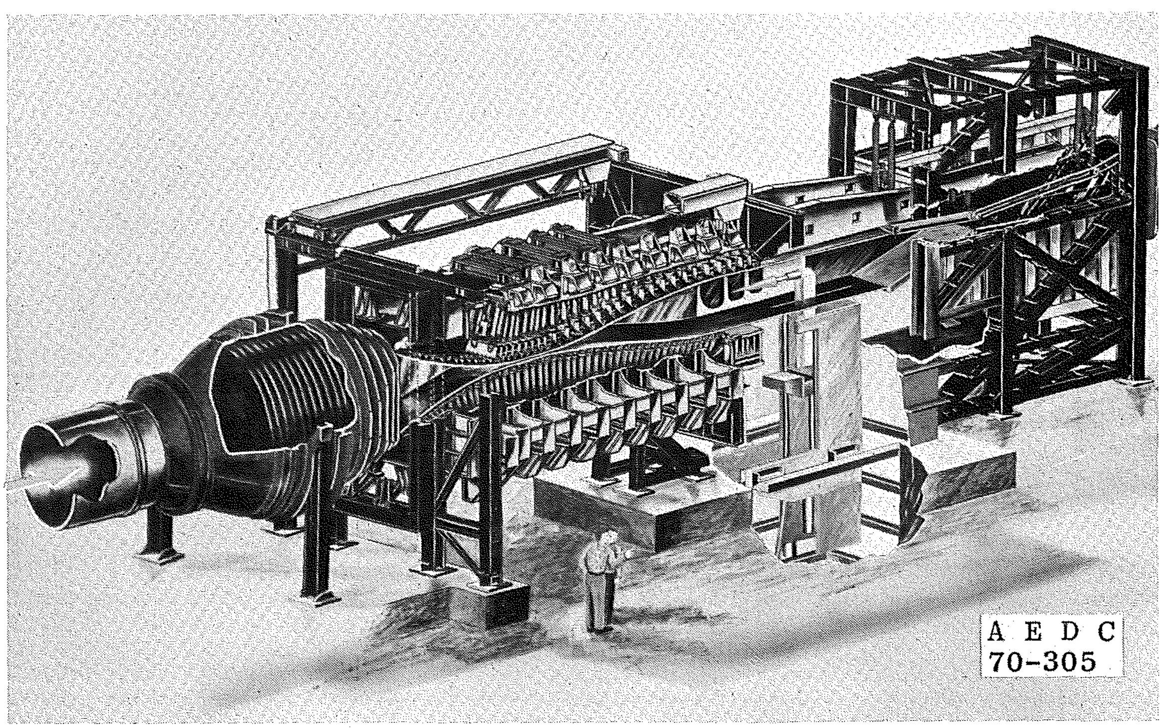
4. Abernethy, R. B. et. al. and Thompson, J. W. "Handbook Uncertainty in Gas Turbine Measurements," AEDC-TR-73-5 (AD755356), February 1973.

APPENDIX I

ILLUSTRATIONS



a. Tunnel assembly



b. Tunnel test section
Fig. 1 Tunnel A

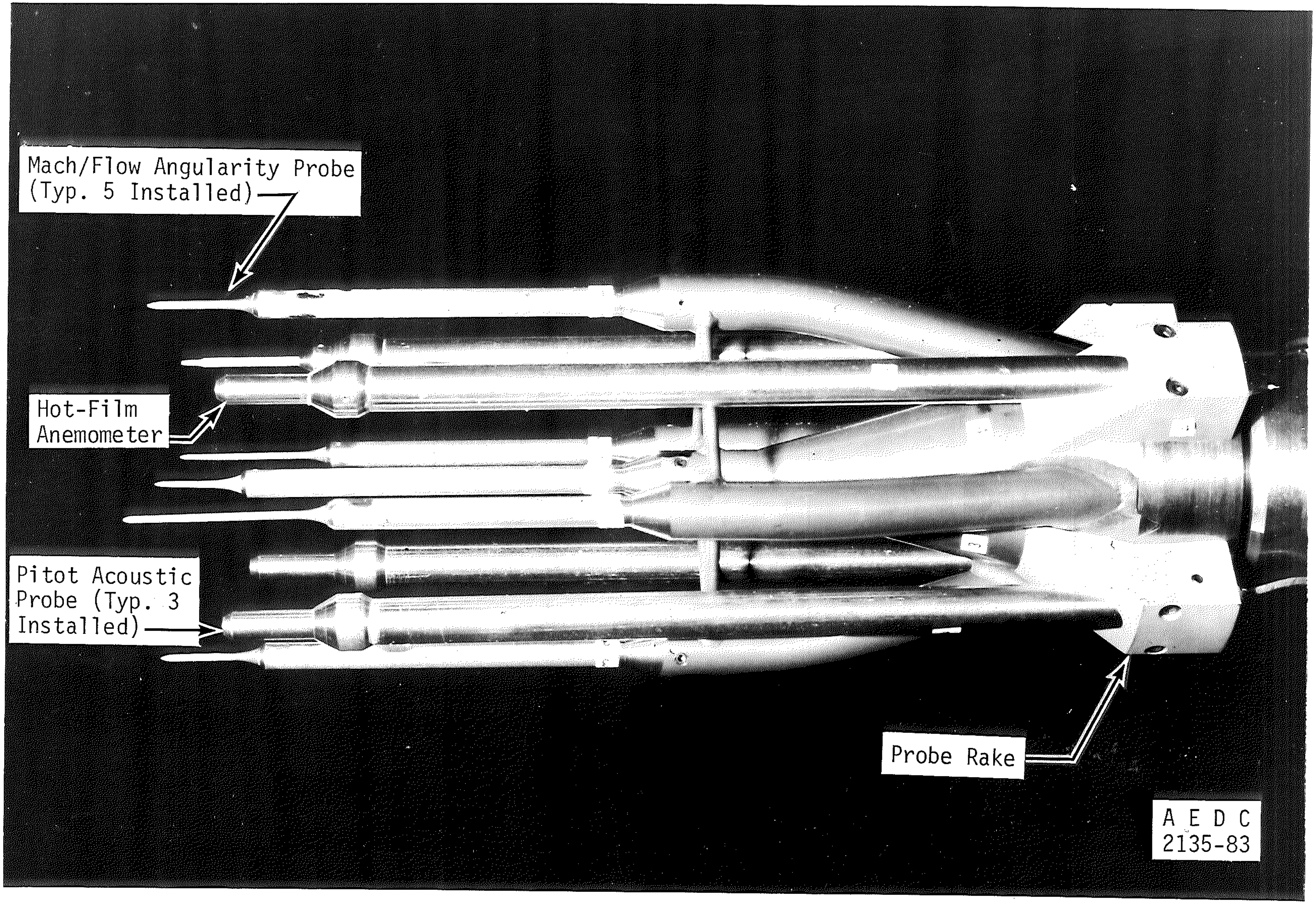
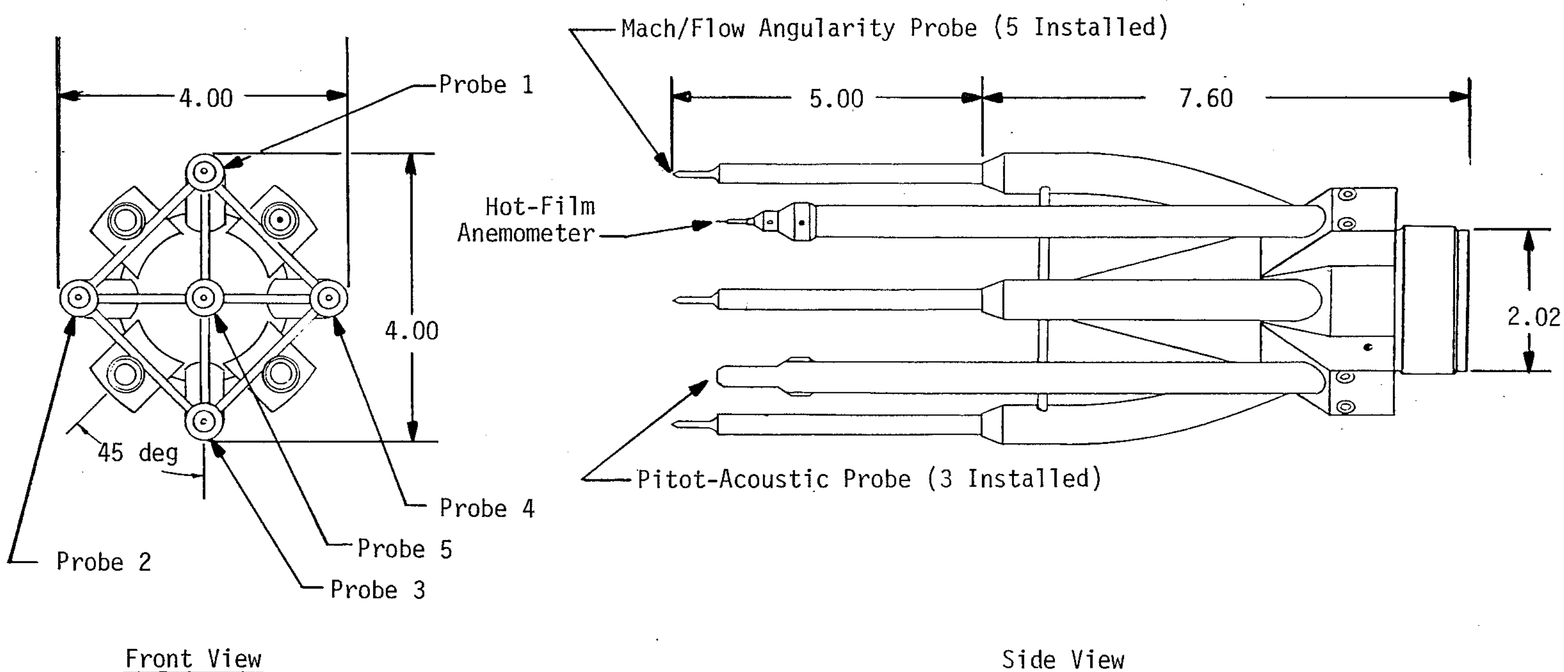


Figure 2. Probe Rake



All dimensions in inches unless otherwise specified.

Figure 3. Probe Rake Details

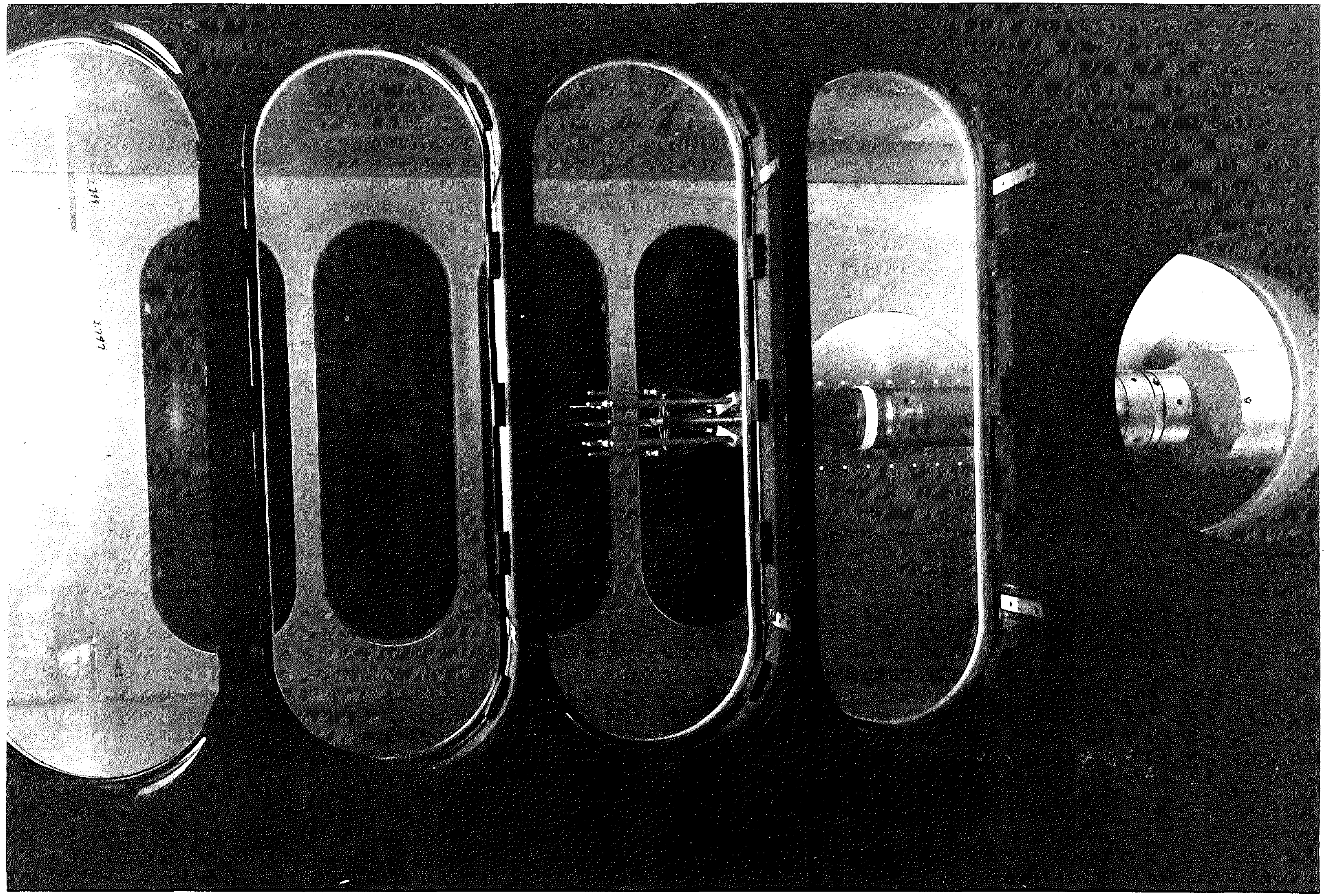


Figure 4. Installation Photograph

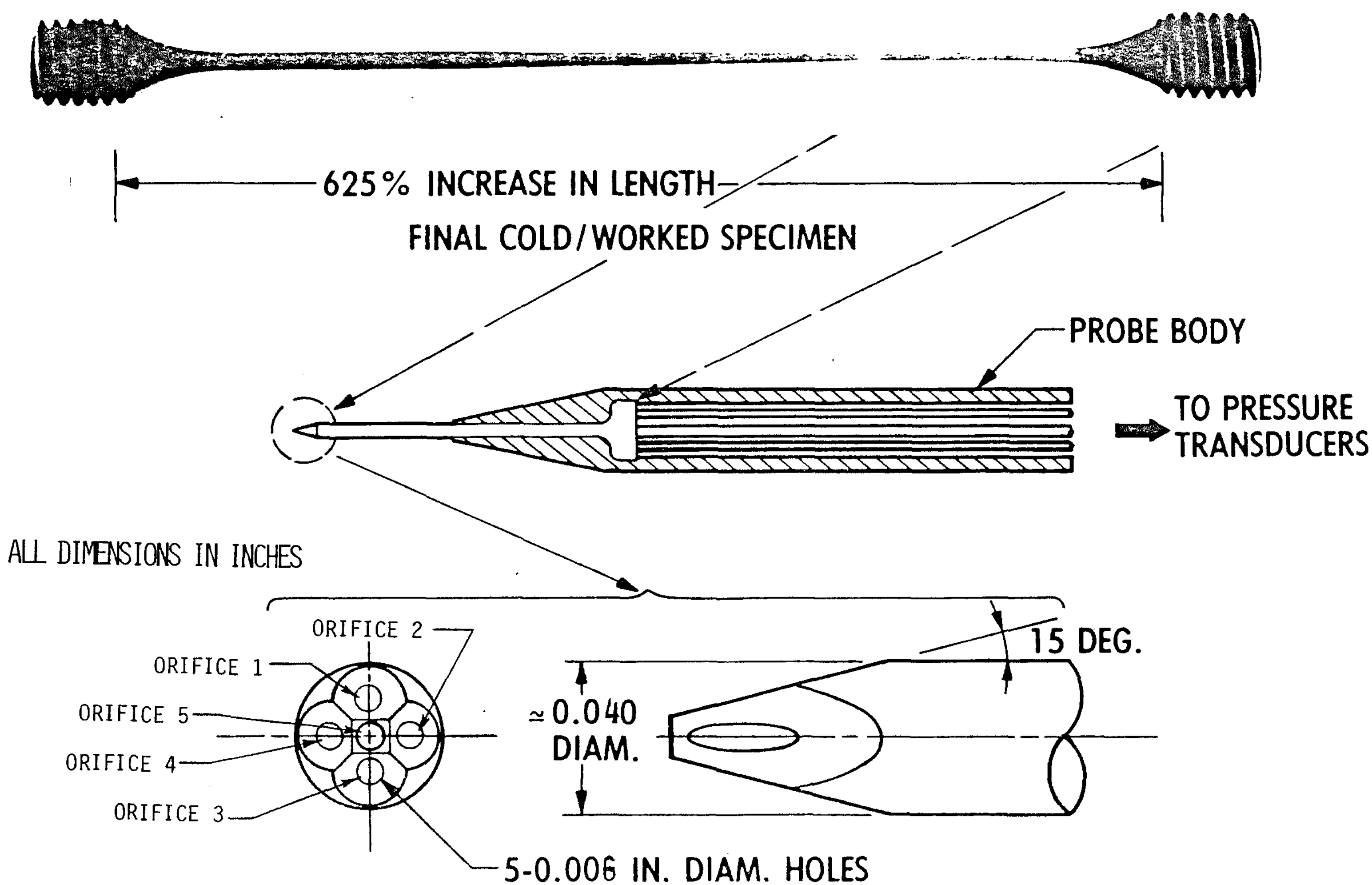
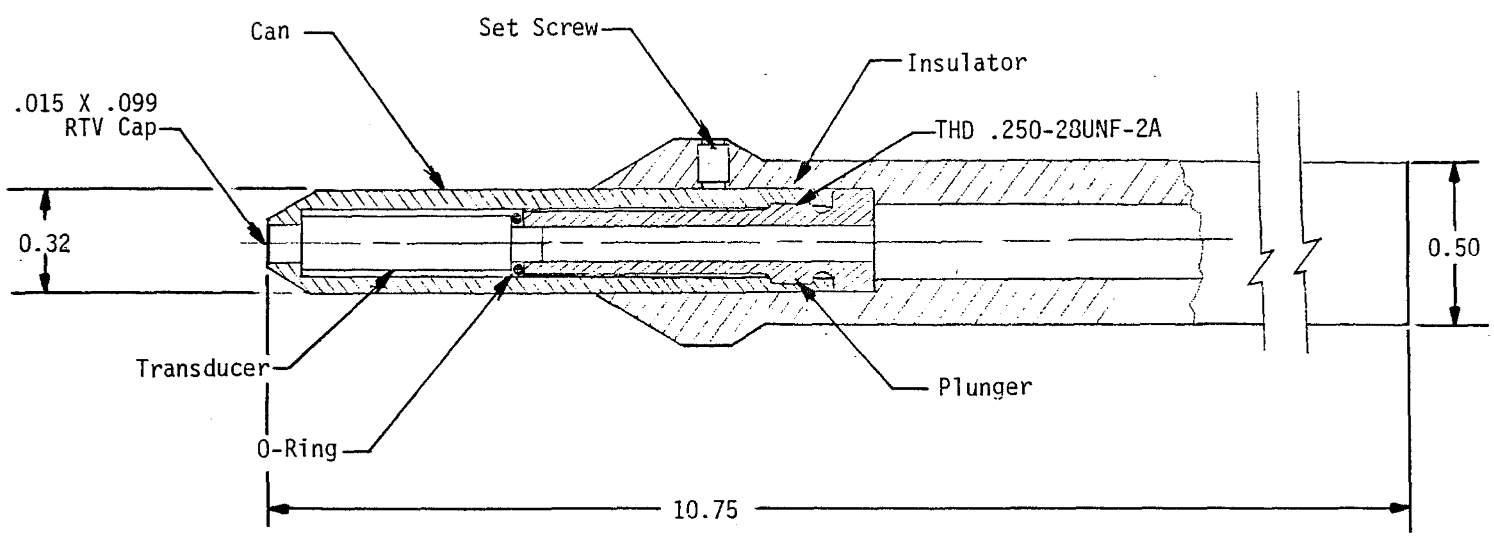


Figure 5. Mach/Flow Angularity Probe



All Dimensions in Inches

Figure 6. Pitot Acoustic Probe

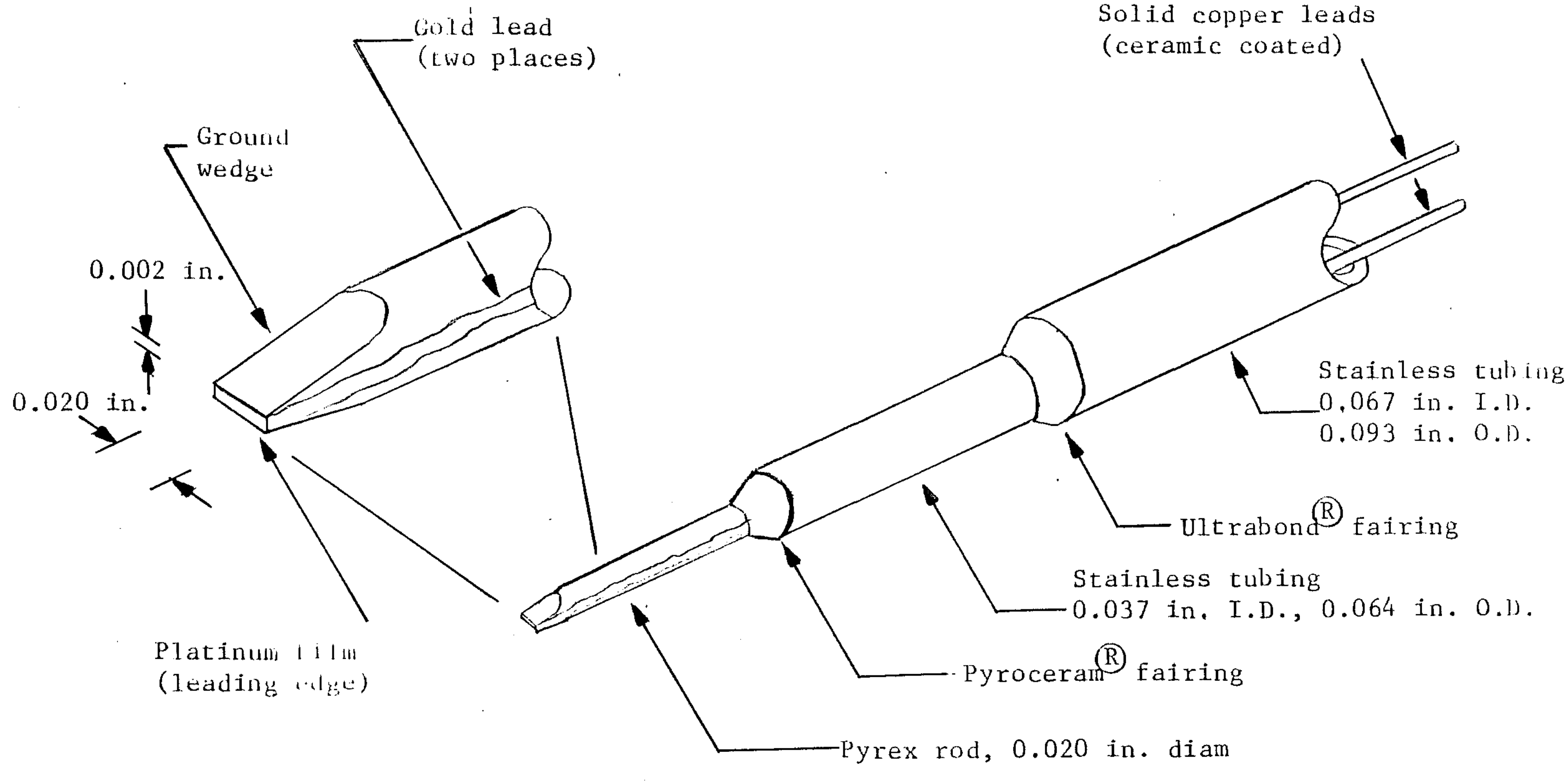
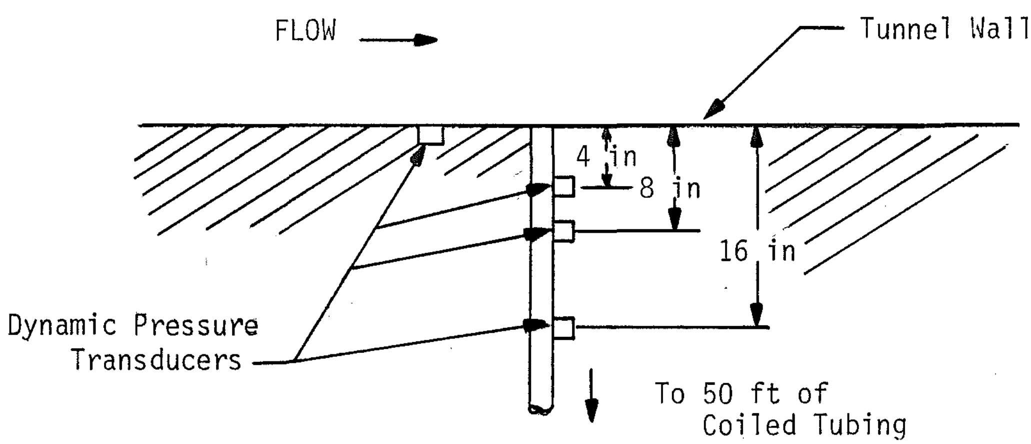


Figure 7. Hot-Film Anemometer



NOTE: Transducers were installed ≈ 108 inches aft of STA 0.00 (Roll Hub)

Figure 8. Dynamic Pressure Transducer Arrangement

APPENDIX II

TABLES

TABLE 1. Data Transmittal Summary

The following items were transmitted to the Sponsor:

Sponsor

AEDC/DOT
Attn: Mr. M. K. Kingery
Arnold AFS, TN 37389

Item	No. of Copies
Test Summary Report	1
Final Tabulated and Plotted Data, 1 volume	1

PROJECT NUMBER C9..VP TESTING COMPLETED 3/27/83 TABLE COMPLETED 5/5/83	MEASUREMENT UNCERTAINTY TABLE 2 Estimated Uncertainties a. Basic Measurements SHEET NO. 1 OF 3	DATA QUALITY CERTIFIED: ORIGINATOR M. T. Byers DATE 5/5/83 CHECKED BY T. Buchanan DATE 5-..-83

Parameter Designation	STEADY-STATE ESTIMATED MEASUREMENT* Precision Index (S)			Bias (B)		Uncertainty $\pm(B + t_{95}S)$		Range	Type of Measuring Device	Type of Recording Device	Method of System Calibration
	Percent of Reading	Unit of Measurement	Degree of Freedom	Percent of Reading	Unit of Measurement	Percent of Reading	Unit of Measurement				
PT, psia		0.002 0.007 0.017	>30 >30 >30	0.2 0.2 0.2		±(0.2% + 0.004) ±(0.2% + 0.014) ±(0.2% + 0.034)		5.5 to 15 15 to 60 60 to 150	Bell & Howell Variable Capacitance Pressure Transducer	Digital Data Acquisition System (RADS) and Analog to Digital Converter	End to End Calibration Using Multiple Pressure Levels Measured with a Secondary Standard Traceable to N.B.S.
TT, deg F		1	>30		2		±4	70 to 300	Chromel®-Alumel® Thermocouple	Doric Digital Thermometer and RADS	Thermocouple Verification of NBS Conformity and Voltage Substitution Calibration
P1--P5, psia	Note 1	0.002	>30	0.15		±(0.15% + 0.004)		0 to 15	Bell & Howell Variable Capacitance Pressure Transducer	Digital Data Acquisition System and Analog to Digital Converter	End to End Calibration Using Multiple Pressure Levels Measured with a Secondary Standard Traceable to NBS
ALPI, deg		0.025	>30		0		±0.05	-12 to 20	Potentiometer		Heidenhain Rotary Encoder RD 700 Resolution - 0.0006 deg, Overall Accuracy - 0.001 deg
PHII, deg		0.15	>30		0		±0.30	-180 to +180			

*Thompson, J. W. and Abernethy, R. B. et al. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5 (AD 755356), February 1973.

NOTE: 1. Precision index includes considerations for equilibrium pressure stabilization technique (see Section 3.2); Precision index of transducer is 0.0015 psi.

TABLE 2. Continued

b. Calculated Parameters

Parameter Designation	STEADY-STATE ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Precision Index (S) Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty $\pm(B + t_{95}S)$ Percent of Reading	Uncertainty $\pm(B + t_{95}S)$ Unit of Measurement	Test Conditions Mach	Range
MACH		0.01			0.00		0.02	1.76	1.76-5.04
		0.01			0.00		0.02	2.00	
		0.01			0.00		0.02	3.01	
		0.01			0.00		0.03	5.04	
P		0.033			0.005		0.071	1.76	0.04-2.73
		0.027			0.002		0.058	2.00	
		0.009			0.003		0.019	3.01	
		0.002			0.000		0.004	5.04	
T		4.09			7.84		16.02	1.76	101-337
		3.69			7.05		14.43	2.00	
		2.46			4.75		9.67	3.01	
		0.77			1.27		2.81	5.04	
RE, $ft^{-1}x10^{-6}$		0.07			0.13		0.27	1.76	0.9-4.2
		0.07			0.14		0.28	2.00	
		0.08			0.15		0.31	3.01	
		0.04			0.07		0.16	5.04	
Q		0.02			0.01		0.05	1.76	0.6-5.9
		0.03			0.01		0.07	2.00	
		0.03			0.01		0.07	3.01	
		0.03			0.01		0.06	5.04	
V		10.20			18.40		38.80	1.76	1580-2500
		10.60			19.80		41.00	2.00	
		12.80			25.30		50.90	3.01	
		7.80			15.50		31.10	5.04	
PT2		0.05			0.03		0.13	1.76	1.2-12.2
		0.06			0.02		0.15	2.00	
		0.06			0.02		0.14	3.01	
		0.05			0.01		0.11	5.04	
$RHOx10^3$		0.32			0.51		1.15	1.76	0.9-21.8
		0.29			0.44		1.02	2.00	
		0.15			0.25		0.56	3.01	
		0.05			0.05		0.16	5.04	
$MUx10^8$		0.55			1.07		2.18	1.76	0.1-26.2
		0.52			1.00		2.05	2.00	
		0.20			0.38		0.78	3.01	
		0.06			0.10		0.23	5.04	

*Abernethy, R. B. et al. and Thompson, J. W. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5 (AD 755356), February 1973.

TABLE 2. Concluded

b. Concluded

Parameter Designation	STEADY-STATE ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Precision Index (S) Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty ±(B + t_{95}S) Percent of Reading	Uncertainty ±(B + t_{95}S) Unit of Measurement	Range
$\frac{P(1-5)}{P_5}$		0.0008	>30		0.0018		0.0034	0.1 to 0.5
$\frac{DP13}{P5}$, $\frac{DP24}{P5}$		0.0011	>30		0.0025		0.0047	-0.3 to 0.3
DPSQP		0.0006	>30		0.0013		0.0025	0.0 to 0.2
PAVGP5		0.0004	>30		0.0009		0.0017	0.1 to 0.4
ALPHT								
Probe 1		1.2	>30		0.0		2.4	0.0 to 14.0
Probe 2		1.2	>30		0.0		2.4	0.0 to 14.0
Probe 3		1.2	>30		0.0		2.4	0.0 to 14.0
Probe 4		1.3	>30		0.0		2.6	0.0 to 14.0
Probe 5		1.3	>30		0.0		2.6	0.0 to 14.0
PHIT								
Probe 1		5.0	>30		0.0		10.0	-90 to 180.0
Probe 2		6.0	>30		0.0		12.0	-90 to 180.0
Probe 3		8.0	>30		0.0		16.0	-90 to 180.0
Probe 4		7.0	>30		0.0		14.0	-90 to 180.0
Probe 5		6.0	>30		0.0		12.0	-90 to 180.0

*Abernethy, R. B. et al. and Thompson, J. W. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5 (AD 755356), February 1973.

TABLE 3. Run Summary

RUN	MACH	$REx10^{-6}/ft$	ALPHI(deg)	PHII(deg)
6-16	3.0	4.2	-4 to 11.6	0
26-36	1.75	4.1	-4 to 11.6	0
37-55	1.75	4.1	4	-90 to 180
56,57,58	1.75	4.1	-4 to +4	90
60-78	2.0	4.2	10	-90 to 180
79-87	2.0	4.2	-4 to 11.6	90
88-98	2.0	4.2	-4 to 11.6	0
99-117	2.0	4.2	10	-90 to 180
118-129	5.0	3.9	-4 to 11.6	0
130-148	5.0	3.9	10	-90 to 180
149-151	5.0	3.9	-1 to 1	0
152	5.0	3.1	0	0
153	5.0	2.7	0	0
154	5.0	2.3	0	0
155	5.0	1.4	0	0
156	5.0	0.9	0	0

APPENDIX III

SAMPLE DATA

ARVIN/CALSPAN FIELD SERVICES,INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
MEASUREMENTS IMPROVEMENTS TEST

DATE COMPUTED 20-APR-83
DATE RECORDED 29-MAR-83
TIME RECORDED 12:26:23
TIME COMPUTED 10:47
PROJECT NO V A-2R

RUN 60
PAGE 1

ALPI 10.02 KNOM 0.03
PHII-90.01 A 0.160

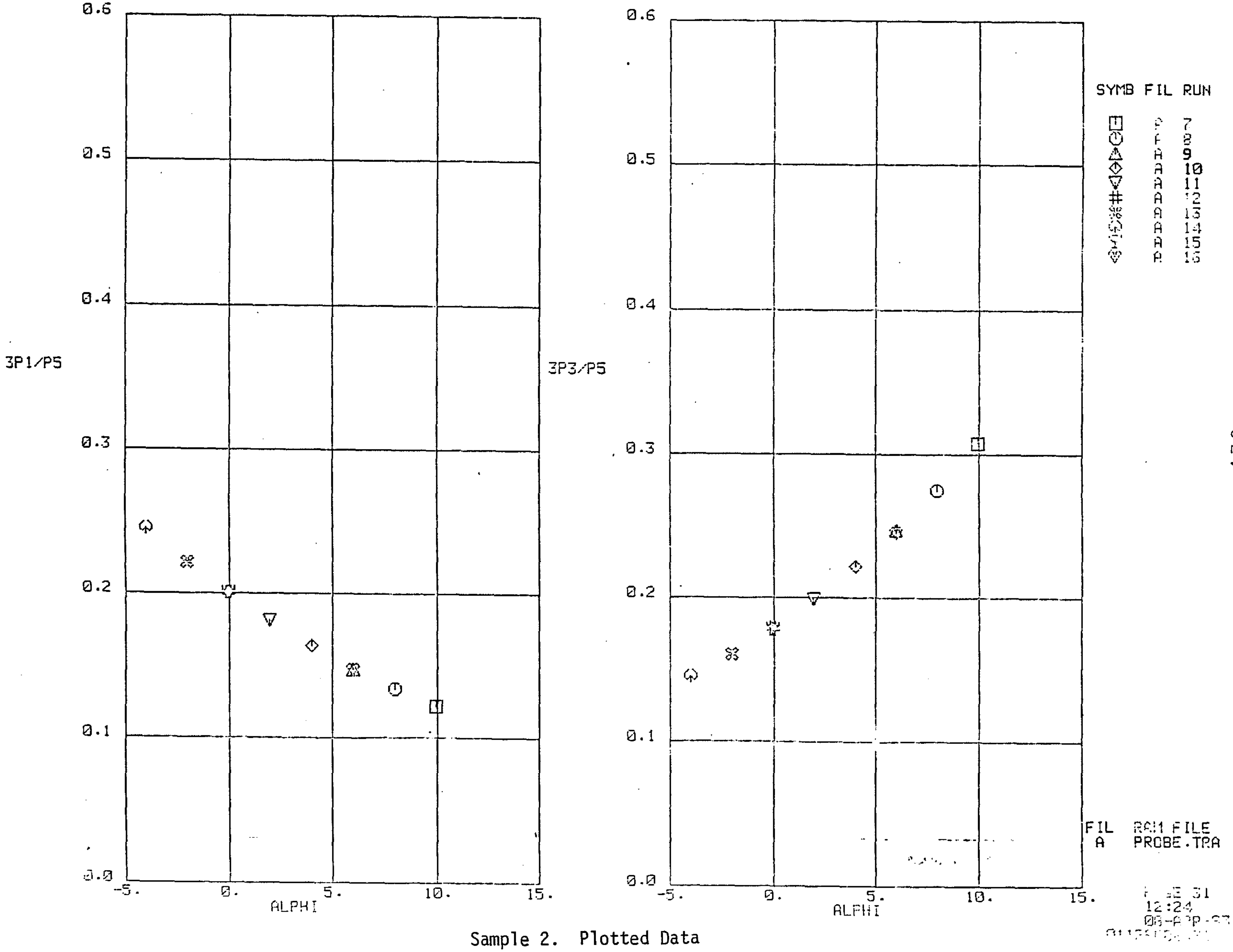
M	2.000	TT	545.67	Q	0.596E+01	RHO	0.189E-01	TREC	27.50
RE	0.421E+07	T	0.303E+03	V	0.1707E+04	MU	0.239E-06	TDEL	10.00
PT	16.643	P	0.213E+01	PT2	0.120E+02	TDP	-26.		

PROBE	P1	P2	P3	P4	P5	TNP1	TNP2	TNP3	TNP4	TNP5	KP1	KP2	KP3	KP4	KP5
1	3.963	2.617	3.754	5.859	11.994	4.125	6.186	4.348	2.805	1.380	0.016	0.016	0.004	0.002	0.002
2	4.265	2.892	4.218	5.247	11.994	3.832	5.603	3.878	3.129	1.381	0.008	-0.000	-0.000	0.007	0.002
3	3.861	2.655	4.053	4.955	12.010	4.234	6.092	4.032	3.310	1.378	0.012	0.007	0.018	0.006	0.002
4	3.766	2.528	3.853	5.040	11.915	4.336	6.394	4.238	3.255	1.390	0.014	0.021	0.025	0.005	0.002
5	3.906	2.666	4.609	5.517	12.012	4.184	6.062	3.553	2.977	1.379	0.016	0.017	0.015	0.009	0.003

PROBE	ALPHT	PHIT	P1I /P1F	P2I /P2F	P3I /P3F	P4I /P4F	P5I /P5F	P1F /P1	P2F /P2	P3F /P3	P4F /P4	P5F /P5
1	9.74	85.91	0.997	0.997	1.001	0.999	0.999	0.999	0.999	1.000	1.000	1.000
2	10.55	94.29	0.997	0.998	1.000	0.998	0.999	1.001	1.001	1.000	1.000	1.000
3	12.04	86.68	0.991	0.999	1.009	0.999	0.999	0.999	1.000	1.000	1.000	1.000
4	11.02	89.99	0.995	1.004	1.003	0.999	0.999	0.999	1.000	1.000	1.000	1.000
5	11.82	91.43	0.996	1.019	1.019	0.997	0.999	0.999	1.001	1.000	1.000	1.000

PROBE	P1/P5	P2/P5	P3/P5	P4/P5	DP13 /P5	DP24 /P5	PAVGP5	DPSQP
1	0.330	0.218	0.313	0.488	0.017	-0.270	0.338	0.135
2	0.356	0.241	0.352	0.437	0.004	-0.196	0.346	0.098
3	0.322	0.221	0.337	0.413	-0.016	-0.191	0.323	0.096
4	0.316	0.212	0.323	0.423	-0.007	-0.211	0.319	0.105
5	0.325	0.222	0.384	0.459	-0.058	-0.237	0.348	0.122

Sample 1. Tabulated Data



Sample 2. Plotted Data

27

478