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**EXPANSION-SIDE FLOW FIELD PRESSURE TESTS
OF A 75-DEG DELTA WING AT MACH NUMBER 10**



C. J. Spurlin

ARO, Inc.

March 1967

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Per Letter dtd 6-11-68 - William D. Cole, STINFD Officer, Directorate of Test.

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EXPANSION-SIDE FLOW FIELD PRESSURE TESTS
OF A 75-DEG DELTA WING AT MACH NUMBER 10

*1. Triangular wing -- Pressure distribution
" " -- Leading edge*

2

C. J. Spurlin
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1-1

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Per Letter dtd 6-11-68, William O. Cole, STINFO OFFICER, Directorate of Test

FOREWORD

The work reported herein was done at the request of the Aerospace Research Laboratories (ARL), Office of Aerospace Research (OAR), Air Force Systems Command (AFSC), under Program Element 61445014, Project 7064.

The results of tests presented herein were obtained by ARO, Inc. (a subsidiary of Sverdrup & Parcel and Associates, Inc.), contract operator of the Arnold Engineering Development Center (AEDC), AFSC, Arnold Air Force Station, Tennessee, under Contract AF40(600)-1200. The tests were conducted on November 15 and December 6, 1966, under ARO Project No. VC0754, and the manuscript was submitted for publication on February 1, 1967.

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This technical report has been reviewed and is approved.

James N. McCready
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AF Representative, VKF
Directorate of Test

Leonard T. Glaser
Colonel, USAF
Director of Test

ABSTRACT

Leeward surface pressures, oil flow photographs, and flow field pressure surveys were obtained at a nominal Mach number of 10 for a 75-deg sharp leading-edge delta wing. Tests were conducted at free-stream unit Reynolds numbers of 0.73×10^6 and $1.46 \times 10^6 \text{ ft}^{-1}$, angles of attack from 0 to 21 deg, and zero sideslip angle. Selected results are presented to illustrate the quality and types of data obtained. (AFR 310-2, Statement 2)

CONTENTS

	<u>Page</u>
ABSTRACT.	iii
NOMENCLATURE.	vi
I. INTRODUCTION	1
II. APPARATUS	
2.1 Model	1
2.2 Wind Tunnel	1
2.3 Instrumentation.	2
III. PROCEDURE.	2
IV. RESULTS AND DISCUSSION	3

TABLE

I. Test Summary	2
---------------------------	---

APPENDIX

Illustrations

Figure

1. Model Photograph	7
2. Model Details	8
3. Oil Flow Photograph (Leeward Surface), $\alpha = 13$ deg, $Re_{\infty} = 0.73 \times 10^6 \text{ ft}^{-1}$	9
4. Centerline Pressure Distributions	10
5. Spanwise Pressure Distributions (Station 4)	11
6. Typical Pressure Probe Flow Field Surveys, $\alpha = 13$ deg, $Re_{\infty} = 0.73 \times 10^6 \text{ ft}^{-1}$	12

NOMENCLATURE

ℓ	Model length, 7.00 in.
M_∞	Free-stream Mach number
p	Model surface pressure, psia
P_0	Tunnel stilling chamber pressure, psia
P_0'	Pressure downstream of a normal shock, psia
P_p	Probe total pressure, psia
P_∞	Free-stream static pressure, psia
q_∞	Free-stream dynamic pressure, psia
Re_∞	Free-stream unit Reynolds number, ft^{-1}
s	Distance along pressure orifice ray measured from and normal to leading edge, in.
s_n	Length of pressure orifice ray measured from the leading edge to the model centerline, in.
T_0	Tunnel stilling chamber temperature, °R
x	Model surface distance measured downstream from model nose, in.
y	Vertical coordinate measured upward from model surface in the model centerline plane (see Fig. 2), in.
α	Model angle of attack, deg

SECTION I INTRODUCTION

The objective of these tests was to obtain leeward surface pressure distributions, oil flow photographs, and flow field pressure surveys for a sharp leading-edge, 75-deg delta wing. These data were obtained for ARL to supplement an investigation of delta wing expansion-side flow fields.

Tests were conducted in the von Kármán Gas Dynamics Facility (VKF) 50-in. hypersonic tunnel (Gas Dynamic Wind Tunnel, Hypersonic (C)) at a nominal Mach number of 10, free-stream unit Reynolds numbers of 0.73×10^6 and $1.46 \times 10^6 \text{ ft}^{-1}$, angles of attack from 0 to 21 deg, and zero sideslip angle.

SECTION II APPARATUS

2.1 MODEL

A photograph and details of the model furnished by ARL are shown in Figs. 1 and 2, respectively. The model was instrumented with twenty 0.062-in. -diam pressure orifices and had four thermocouples embedded in the upper surface to monitor model temperature. The leading-edge thickness was approximately 0.001 in.

2.2 WIND TUNNEL

Tunnel C is a continuous, closed-circuit, variable density wind tunnel with an axisymmetric contoured nozzle and a 50-in. -diam test section. The tunnel operates at a nominal Mach number of 10 at stagnation conditions from 200 to 2000 psia at 1900°R. The model may be injected into the tunnel for a test run and then retracted for model cooling or model changes without interrupting the tunnel flow. A description of the tunnel may be found in the Test Facilities Handbook*.

*Test Facilities Handbook (6th Edition). "von Kármán Gas Dynamics Facility, Vol. 4." Arnold Engineering Development Center, November 1966.

2.3 INSTRUMENTATION

Model pressures were measured with 1-psid transducers and probe pressures with a 15-psid transducer. A vacuum reference was used for all transducers. From repeat calibrations, the estimated measurement precision of the 1-psid transducers was ± 0.001 psia or ± 0.5 percent, whichever was greater. The estimated precision of the 15-psid transducer was ± 0.003 psia or ± 1.0 percent, whichever was greater.

Schlieren photographs were obtained during all tests, and oil flow photographs were obtained at selected angles of attack. Figure 3 shows a typical oil flow photograph.

SECTION III PROCEDURE

A summary of surface pressure, oil flow, and flow field pressure survey tests is presented in Table I. The tests were conducted at the following conditions:

M_∞	p_{O_2} , psia	T_{O_2} , °R	$Re_\infty \times 10^{-6} \text{ ft}^{-1}$	p_∞ , psia	p'_{O_2} , psia
10.17	600	1900	0.73	0.013	1.64
10.21	1200	1900	1.46	0.025	3.28

TABLE I
TEST SUMMARY

Data	$Re_\infty \times 10^{-6} \text{ ft}^{-1}$	α , deg	Station
Surface Pressure	0.73	0, 5, 7, 9, 11, 13, 15, 17, 19, 21	
↓	1.46	0, 11, 13, 15, 17	
Oil Flow	0.73	11, 13, 15, 17	
Flow Field Pressure Survey	0.73	11, 13, 15, 17	2, 3, 5

Oil flow photographs were obtained by covering the model's upper surface with a thin layer of silicone oil-titanium dioxide mixture and injecting the model into the wind tunnel test section. After the model surface flow patterns were established (about 30 sec), the model was removed from the test section and photographed.

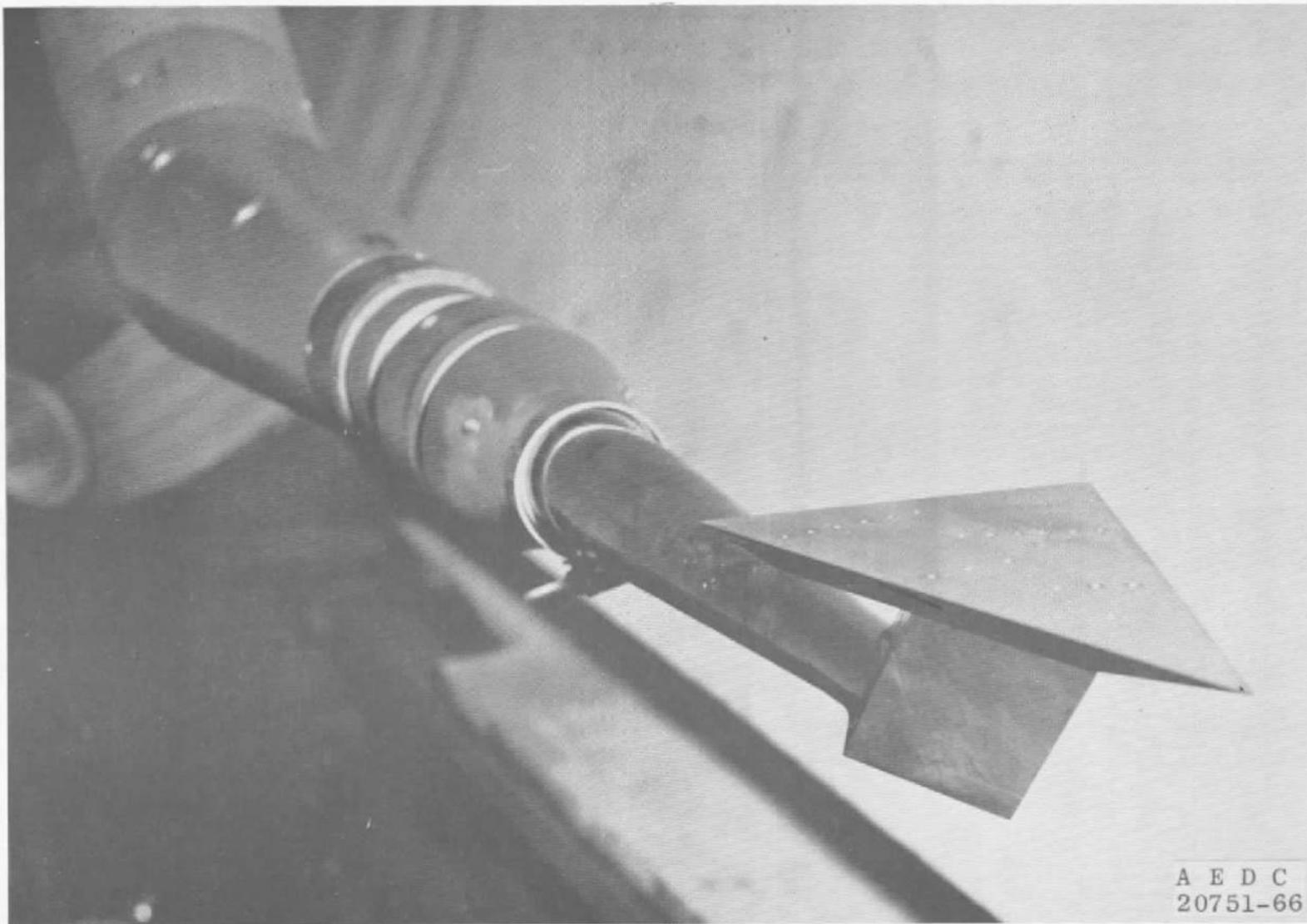
Flow field pressure surveys were made with a total pressure probe aligned parallel to the model centerline and upper surface. The probe was positioned vertically relative to the tunnel centerline with a remotely controlled probe drive system.

SECTION IV RESULTS AND DISCUSSION

Figures 4 and 5 show the centerline and spanwise model surface pressure distributions for several angles of attack. Within the precision of the data, there was no Reynolds number effect at $\alpha = 0$ and 13 deg.

Typical pressure probe flow field surveys at model stations 2, 3, and 5 for an angle of attack of 13 deg are shown in Fig. 6. The probe total pressures at the model surface and the model surface pressures (indicated by the solid symbols at $y = 0$) differed less than 0.005 psia. Failure of the probe to indicate p'_0 in the free stream ($p_p/p'_0 = 1$) was attributed to the probe angle of attack ($\alpha = 13$ deg in this case).

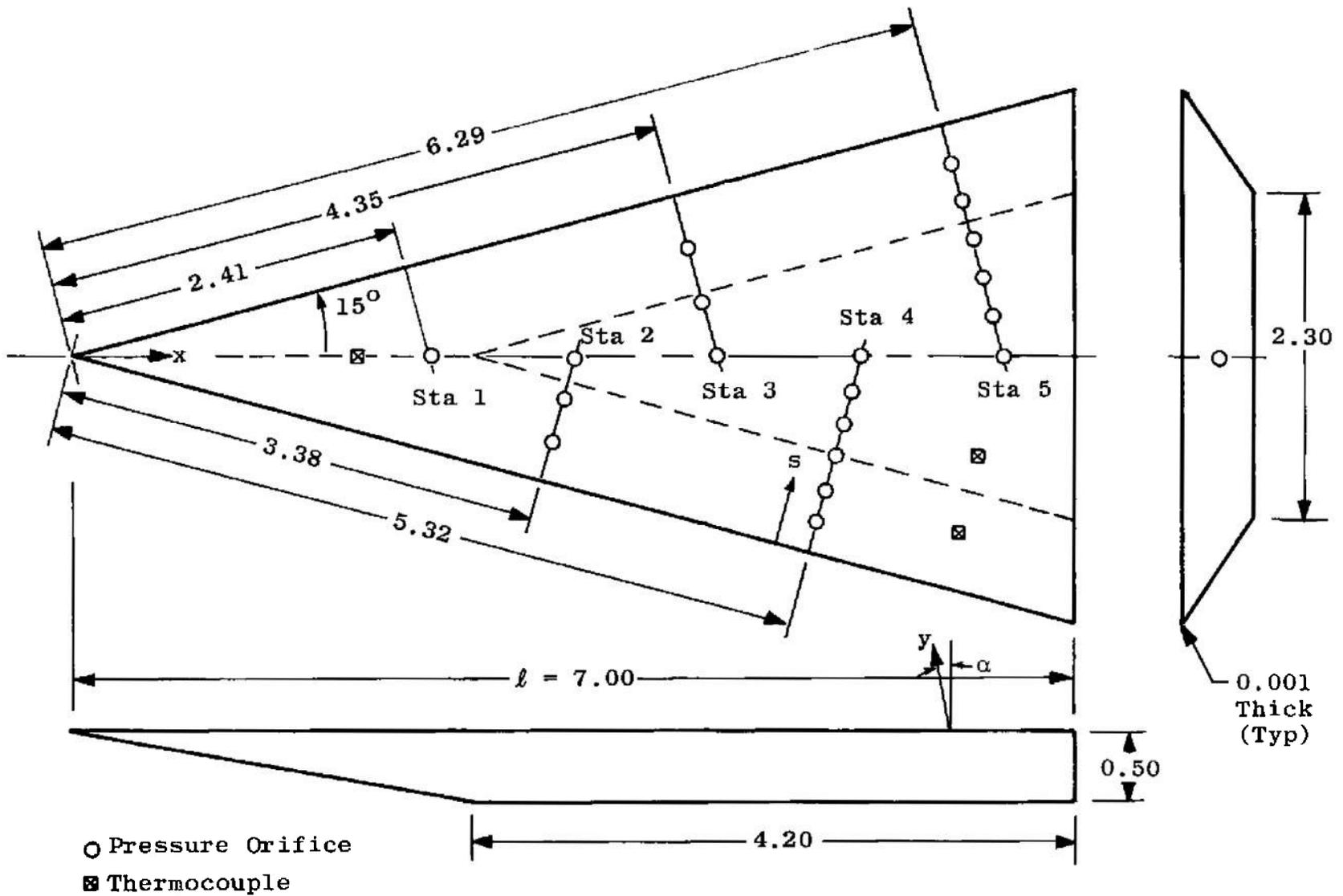
**APPENDIX
ILLUSTRATIONS**



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Fig. 1 Model Photograph

8



○ Pressure Orifice
⊠ Thermocouple

All Dimensions in Inches

Fig. 2 Model Details

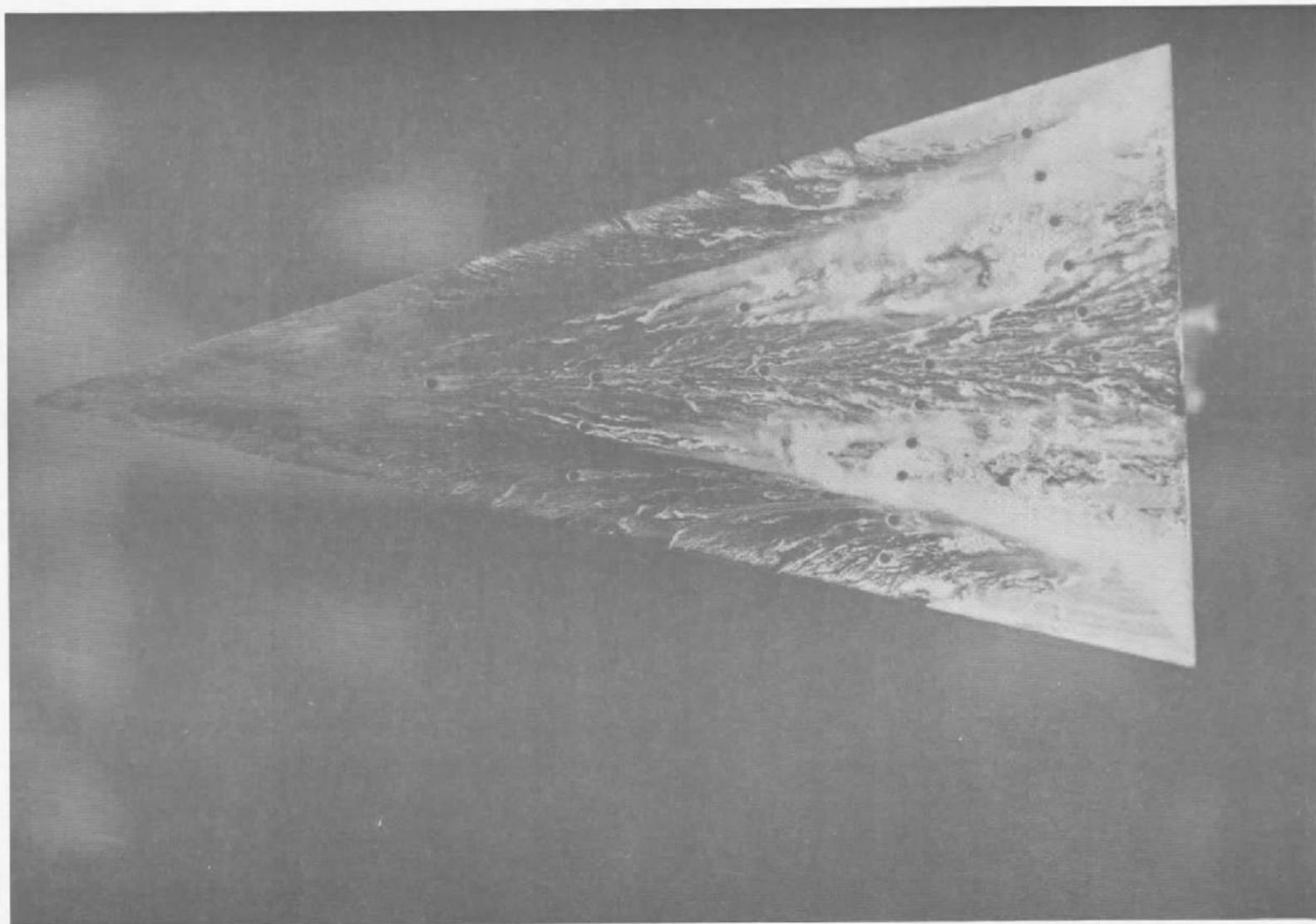


Fig. 3 Oil Flow Photograph (Leeward Surface), $\alpha = 13$ deg, $Re_{\infty} = 0.73 \times 10^6$ ft $^{-1}$

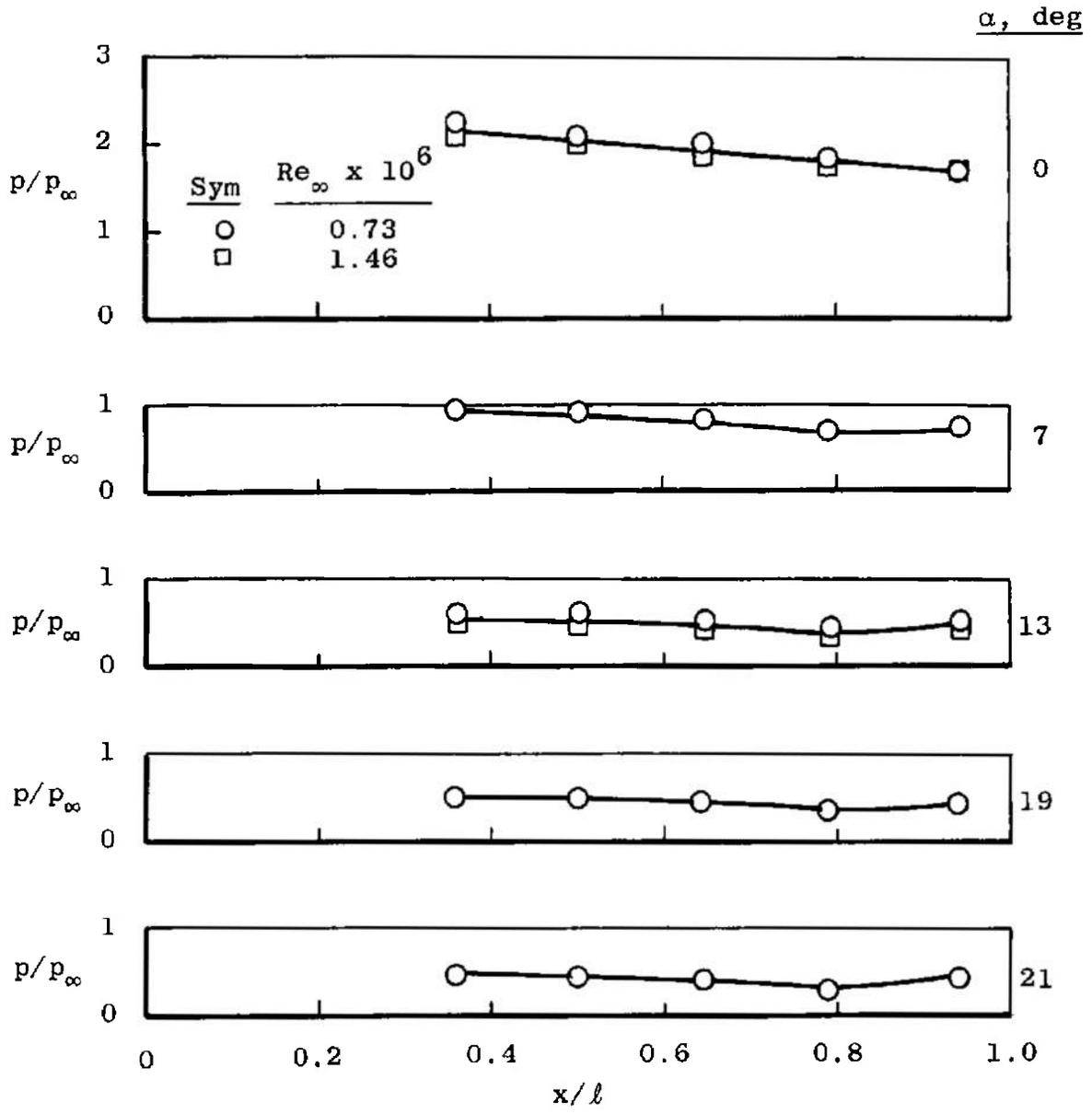


Fig. 4 Centerline Pressure Distributions

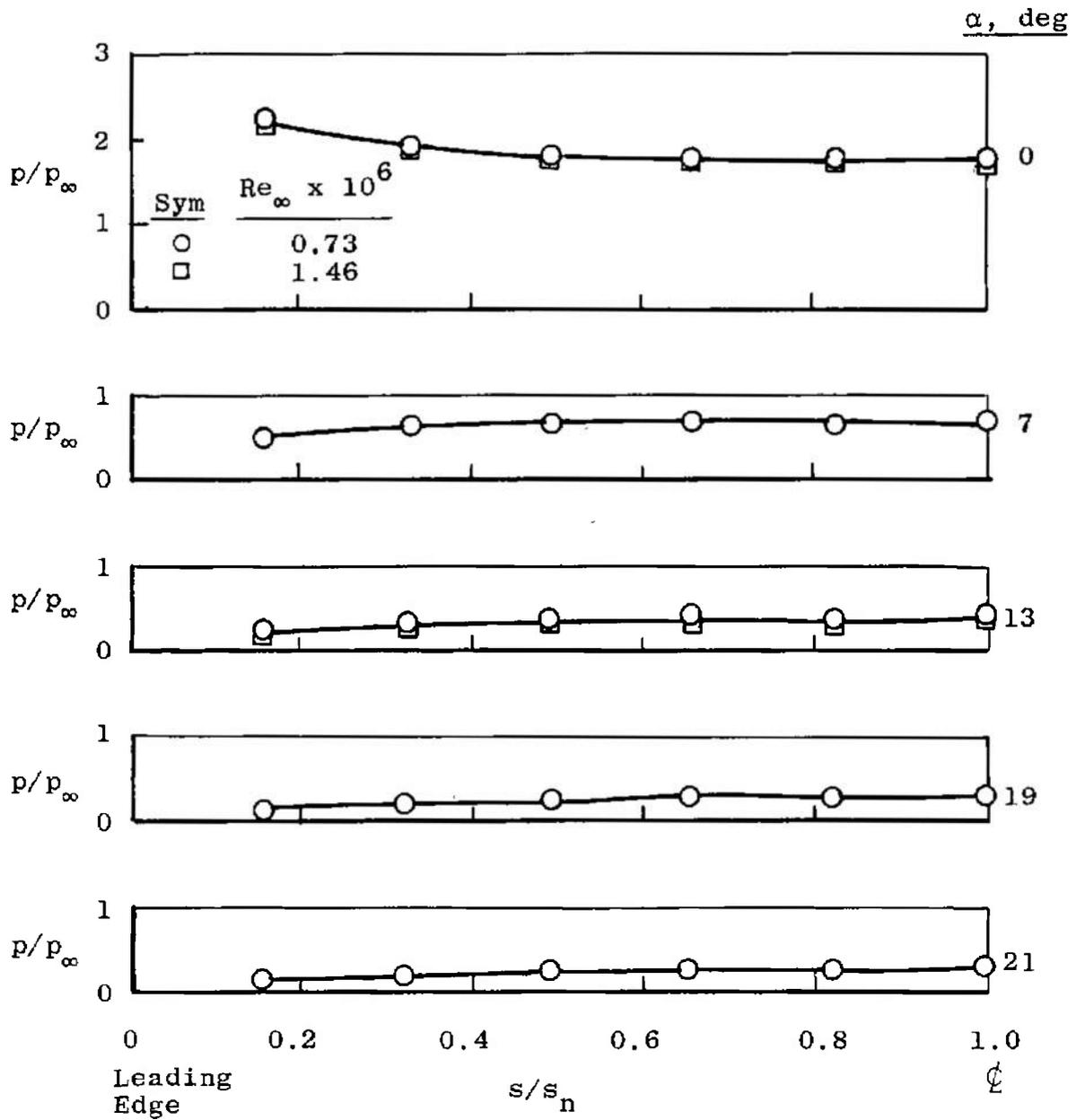


Fig. 5 Spanwise Pressure Distributions (Station 4)

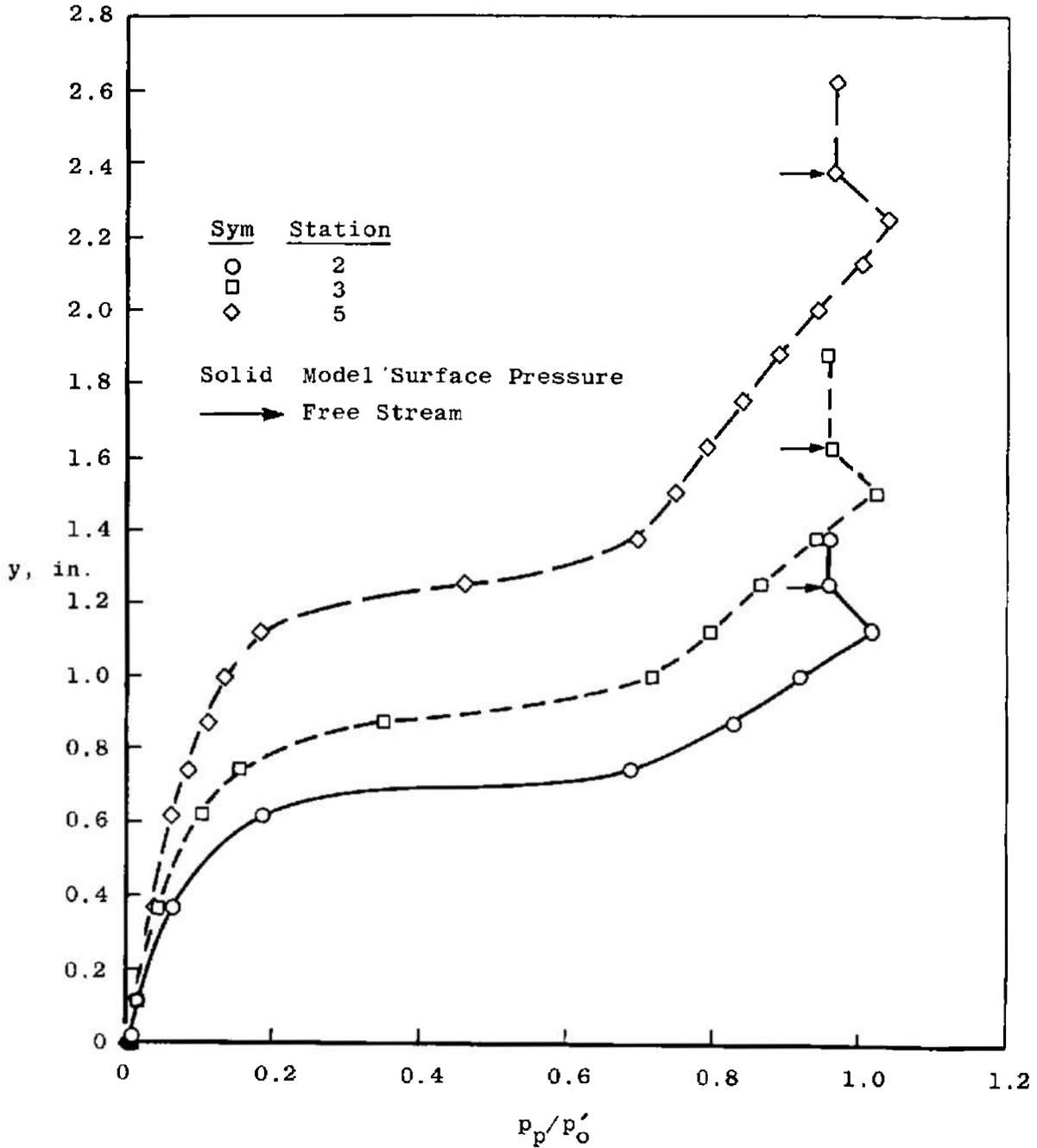


Fig. 6 Typical Pressure Probe Flow Field Surveys, $\alpha = 13$ deg, $Re_\infty = 0.73 \times 10^6 \text{ ft}^{-1}$

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