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NASA Contractor Report 166018

(NASA-CR-166018) EXPERIMENTAL STUDY OF THE SEPARATING CONFLUENT BOUNDARY-LAYER. VOLUME 2: EXPERIMENTAL DATA Final Report (Lockheed-Georgia Co., Marietta.) 81 p HC A05/MF A01 CSCL 01A G3/02 N84-20481 Unclas 12874

Experimental Study of the Separating Confluent Boundary-Layer Volume II - Experimental Data

J. A. Braden
R. R. Whipkey
G. S. Jones
D. E. Lilley

LOCKHEED-GEORGIA COMPANY
A Division of Lockheed Corporation
Marietta, Georgia

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Langley Research Center
Hampton, Virginia 23665

FOREWORD

This document is submitted in accordance with the requirements of NASA Contract NASI-16028, "Experimental Studies of the Separating Confluent Boundary Layer." H. L. Morgan is the NASA-Langley Contract Monitor, and J. A. Braden is the Lockheed-Georgia Project Manager.

The technical descriptions and results from this experimental study are presented in two volumes; Volume I (NASA CR 3655) summarizes the test program and provides limited test results and comparative analysis. The bulk of the data, comprised of laser-velocimeter measurements and airfoil surface pressures, are contained in the present volume and its supplement in tabulated and plotted form.

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*Available as a Supplement to NASA CR-166018.

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1.0 INTRODUCTION

This report is a companion document to NASA CR 3655, "An Experimental Study of the Separating Confluent Boundary Layer, Volume I - Summary ." Volume I provides a detailed description of an experimental study of the separating confluent boundary layer on a two-dimensional, high-lift airfoil (NASA GAW-1). The primary instrumentation employed in the study was a two-dimensional laser-velocimeter system used in a "back-scatter" operational mode with limited data checks made with other, more conventional instruments. The present document, and its supplement, present the bulk of the data acquired in the program along with the necessary information to identify tabulated and plotted test results with corresponding airfoil configurations and test conditions.

Appendixes A, B, C, D, and E contain the LV-derived boundary-layer and wake data for approximately 30,000 combinations of airfoil geometric locations and configurations in the form of velocity vectors, turbulence intensities and Reynolds shear stresses. Tabulated surface-pressure data, corresponding to the LV-measurement conditions, are given in appendix E for both single- and multi-element configurations.

Due to the large volume of data contained in the appendixes, appendixes A, B, C, D, and E are included in a "Supplement to NASA CR

166018" which is available upon request. A request form is found at the back of this report.

2.0 LIST OF SYMBOLS

C_ℓ	section lift coefficient, $L/q_\infty C$
$C_{\ell_{max}}$	maximum section lift coefficient
C_p	pressure coefficient, $\Delta P/q_\infty$
C	chord length, in.
C_f	skin friction coefficient, τ_w/q
C_{ℓ_α}	section lift-curve slope
h,H	height, inches
L	section lift, pounds
g/c or G	gap-to-chord ratio
OH/C or OH	overhang-to-chord ratio
P	pressure, psf or psi
q_∞ or q_e	freestream dynamic pressure, psf
M_∞	freestream Mach number

RN_c	Reynolds number based on airfoil basic chord length
t/c	airfoil thickness ratio
U_∞ or U_e	freestream velocity, fps
U_{max}	velocity at edge of boundary-layer, fps
u,v	cartesian velocity components, fps
u',v'	turbulent velocity components, fps
$\bar{u}$, $\bar{v}$	mean velocity components, fps
x,y,z	cartesian coordinates, inches
α	angle-of-attack, degrees
ρ	mass density, slugs/cu. ft.
θ	boundary-layer momentum thickness, inches
δ	boundary-layer height, inches
δ^*	boundary-layer displacement thickness, inches

δ_f	flap deflection, degrees
δ_s	slat deflection, degrees
τ	shearing stress at wall, psf
ν	kinematic viscosity, sq. ft./sec.

Subscripts

max	maximum
min	minimum
∞,e	freestream condition
U, L	upper- or lower-surface, respectively
S	with reference to slat
M	with reference to main-element
F	with reference to flap
W	with reference to wake

R resultant, normally with respect to vector summation of velocity components

3.0 EXPERIMENTAL SUMMARY

3.1 Configuration Matrix

The various combinations of airfoil main-element, flap, and slat used to make up a selected test configuration are summarized in table I. A configuration code number, identifying the high-lift elements involved, appropriate-gap and overhang dimensions, and angle of attack are obtained directly from this chart. As an example, configuration B-2 represents a 30° trailing-edge flapped case with gap-to-chord and overhang-to-chord ratios of 0.04 and 0.0, respectively; the angle of attack is 7.94 degrees. The geometric definitions pertaining to a configuration are given in figure 1. All subsequent data sets contained in the appendixes and as corresponding to a given configuration are given by the configuration code number.

3.2 LV-Orientation

The spatial orientation of the LV-surveys is shown in figure 2. As indicated, the surveys were made perpendicular to the surfaces of the airfoil elements or perpendicular to chord-line extensions for freestream and wake positions.

4.0 EXPERIMENTAL PRESSURES

4.1 Pressure Distributions

Coordinates for the basic airfoil, flap and slat are given in figures 3 through 5 with the surface-pressure orifice locations shown in figure 6. Pressure distributions in coefficient form, $C_p=(P-P_s)/q_\infty$, for various chordwise positions are presented in figures 8 through 31. The identification notation shown on these figures corresponds to the configuration coding discussed in association with table I. For further data identification, table II provides a cross-reference of PRESSURE TEST-RUN-DATA Point number with the configuration code along with the appropriate geometries and angles of attack. With this information, the tabulated surface-pressure data, given in appendix E, can be readily identified.

4.2 Integrated Lift Data

The pressure distributions in 4.1 were integrated and presented in figures 32 to 35 as lift coefficient (C) versus angle of attack ( ) plots. These figures represent all of the configurations outlined in section 3.1 and in table II.

5.0 EXPERIMENTAL LV-DATA - COMPOSITE PLOTS

5.1 Composite Plots

The LV profile surveys of velocity vectors are summarized and shown in figures 36 to 60 for each test configuration. A run number identifies each survey which can be found individually in appendixes A, B, C, and D. These composite plots are intended for use as a run summary for the complete test. In some isolated instances, a run number is shown without a corresponding profile. This is done to simplify the plot and, in such cases, the position of the run number indicates the approximate location of the profile. The more exact location is defined in the tabulated data under that run number.

5.2 Individual Profiles

Each LV survey is identified by its run number in appendixes B and D. These individual survey plots are presented as velocity vectors, turbulence intensities, and Reynolds shear stresses. It should be noted that sliding scales are used to accommodate each plot. The LV surveys were made either perpendicular to the surface or chord-line extension as shown in section 3.2, figure 2. The LV-data acquired in wind-axes have been geometrically rotated to axes perpendicular and parallel to the surface or chord-line extension.

5.3 Tabulated LV Results

Appendixes A and C contain the tabulated data for all LV surveys shown in appendixes B and D. The headings show the run number and test number (ERF 027 for wing alone data and ERF 032 for flapped or slatted data). The letters (M,W,F,S) after GAW-1 in the title locate the survey position as being on the main element, wake, flap, or slat, respectively, at the given x/c location. For surveys made in the freestream directly upstream of the main-element or slat, the x/c-value carries a negative sign and a subscript of M (main) or S (slat), respectively. The translation angle is the angle relative to the test-section wind-axes at which the survey was run and is also the angle through which the LV wind-axes data have been geometrically rotated.

	CONFIGURATION	1	2	3	4	5	6
A	CLEAN AIRFOIL	$\alpha = 0°$	$\alpha = 4.20°$	$\alpha = 5.86°$	$\alpha = 11.72°$	$\alpha = 16.04°$	
B	FLAPPED $\delta_f = 30°$	$(G/C)_F = 0.04$ $(OH/C)_F = 0.0$			$(G/C)_F = 0.025$ $(OH/C)_F = 0.0$		
		$\alpha = 3.98°$	$\alpha = 7.94°$	$\alpha = 11.95°$	$\alpha = 4.13°$	$\alpha = 12.23°$	
C	FLAPPED $\delta_f = 40°$	$(G/C)_F = 0.015$ $(OH/C)_F = 0.025$			$(G/C)_F = 0.015$ $(OH/C)_F = 0.0$		
		$\alpha = 3.98°$	$\alpha = 7.99°$	$\alpha = 10°$	$\alpha = 3.97°$	$\alpha = 7.97°$	$\alpha = 11.05°$
D	SLATTED $\delta_S = 27°$	$(G/C)_S = 0.023$ $(OH/C)_S = 0.028$					
		$\alpha = 17.90°$	$\alpha = 21.48°$	$\alpha = 23.03°$			
E	FLAPPED & SLATTED $\delta_S = 42°$ $\delta_f = 30°$	$(\frac{G}{C})_S = 0.015$ $(\frac{OH}{C})_S = 0.015$ $(\frac{G}{C})_F = 0.025$ $(\frac{OH}{C})_F = 0.0$					
		$\alpha = 12.0°$	$\alpha = 14.06°$	$\alpha = 16.07°$			
F	FLAPPED & SLATTED $\delta_S = 42°$ $\delta_f = 40°$	$(\frac{G}{C})_S = 0.015$ $(\frac{OH}{C})_S = 0.015$ $(\frac{G}{C})_F = 0.015$ $(\frac{OH}{C})_F = 0.025$					
		$\alpha = 5.3°$	$\alpha = 9.5°$	$\alpha = 14.07°$			

CONFIGURATION	LV-TEST *	PRESS. TEST-RUN **
A-1 ➤ A-5	027	031-9
B-1 ➤ B-3	032	032-24
B-4 ➤ B-6	↓	032-25
C-1 ➤ C-3		032-29
C-4 ➤ C-6		032-65
D-1 ➤ D-3		032-58
E-1 ➤ E-3		032-40
F-1 ➤ F-3		032-59

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TABLE I. - CONFIGURATION MATRIX SELECTED FOR DETAILED LV-FLOW SURVEYS.

TABLE II. SURFACE-PRESSURE DATA IDENTIFICATION

GAW-1 AIRFOIL

TEST	RUN	PT.	CONFIG.	FLAP δ_F	FLAP G/C	FLAP OH/C	SLAT δ_S	SLAT G/C	SLAT OH/C	α (DEG)
31	9	3	A-1	—	—	—	—	—	—	0
		5	A-2	—	—	—	—	—	—	4.20
		6	A-3	—	—	—	—	—	—	5.86
		9	A-4	—	—	—	—	—	—	11.72
		14	A-5	—	—	—	—	—	—	16.04
32	24	3	B-1	30	0.04	0.0	—	—	—	3.98
		5	B-2				—	—	—	7.94
		8	B-3				—	—	—	11.95
	25	4	B-4		0.025	0.0	—	—	—	4.13
		9	B-5				—	—	—	12.23
32	29	5	C-1	40	0.015	0.025	—	—	—	3.98
		7	C-2				—	—	—	7.99
		8	C-3				—	—	—	10.
	65	21	C-4	40	0.015	0.0	—	—	—	3.97
		1	C-5				—	—	—	7.97
		7	C-6				—	—	—	11.05
32	58	11	D-1	—	—	—	27	0.023	0.028	17.90
		13	D-2	—	—	—				21.48
		14	D-3	—	—	—				23.03

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TABLE II (CONT'D). SURFACE-PRESSURE DATA IDENTIFICATION

GAW-1 AIRFOIL

TEST	RUN	PT.	CONFIG	FLAP δ_F	FLAP G/C	FLAP OH/C	SLAT δ_S	SLAT G/C	SLAT OH/C	α (DEG)
32	40	8	E-1	30	0.025	0.0	45	0.015	0.015	12.0
↓	↓	9	E-2	↓	↓	↓	↓	↓	↓	14.06
		10	E-3							16.07
32	59	6	F-1	40	0.015	0.025	45	0.015	0.015	5.3
↓	↓	8	F-2	↓	↓	↓	↓	↓	↓	9.5
		10	F-3							14.07

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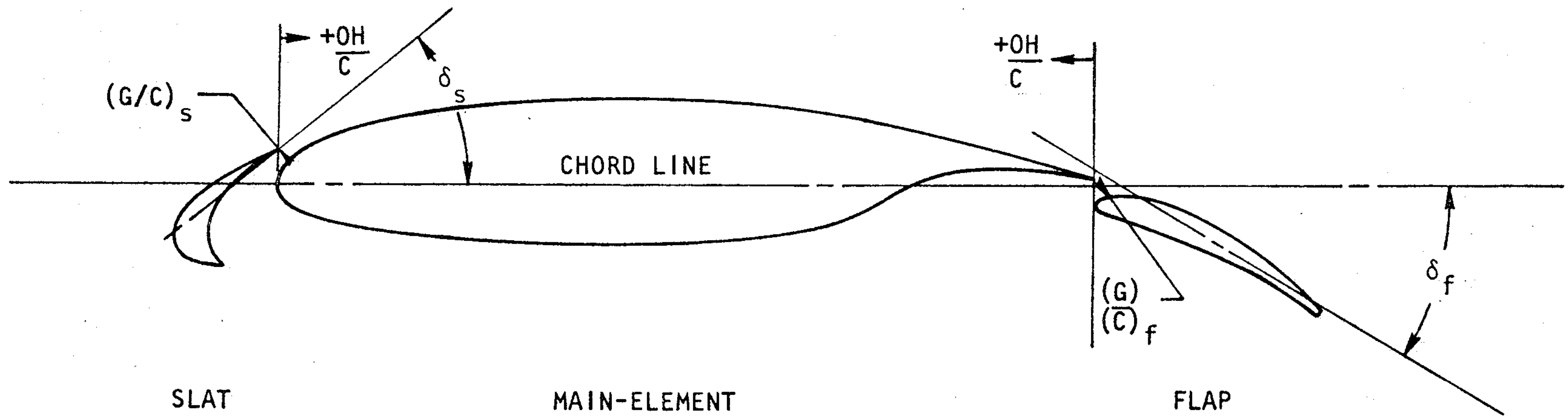

AVAILABLE RANGE OF VARIABLES

	G/C	OH/C	δ°
SLAT	.01 - .03	±.015	25→55
FLAP	.015 - .04	-.025	0→40

FIGURE 1 .-DEFINITION OF GEOMETRIC PARAMETERS ON GAW-1 HIGH-LIFT AIRFOIL

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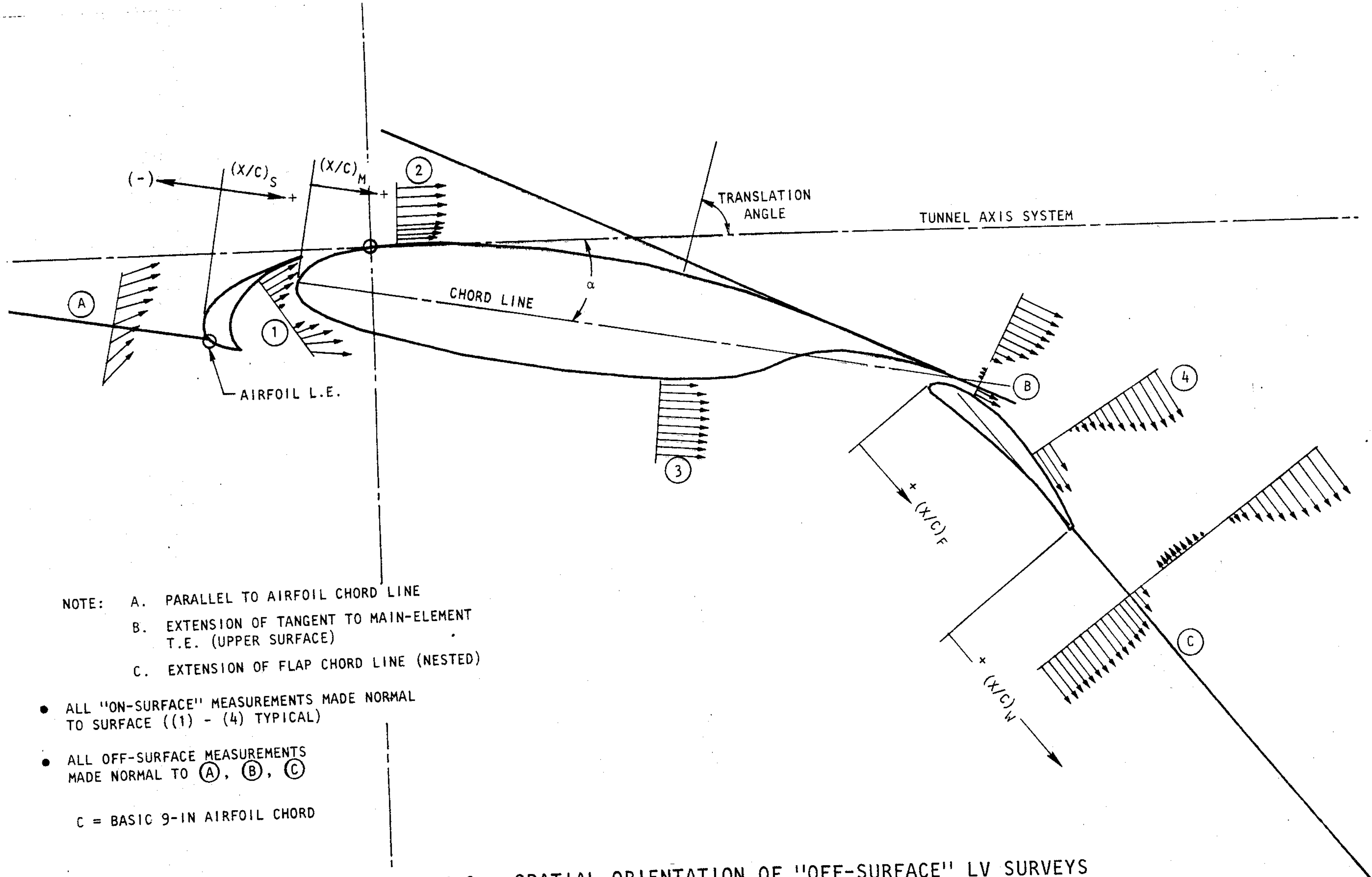

NOTE: A. PARALLEL TO AIRFOIL CHORD LINE
B. EXTENSION OF TANGENT TO MAIN-ELEMENT T.E. (UPPER SURFACE)
C. EXTENSION OF FLAP CHORD LINE (NESTED)

- ALL "ON-SURFACE" MEASUREMENTS MADE NORMAL TO SURFACE ((1) - (4) TYPICAL)
- ALL OFF-SURFACE MEASUREMENTS MADE NORMAL TO Ⓐ, Ⓑ, Ⓒ

C = BASIC 9-IN AIRFOIL CHORD

FIGURE 2. SPATIAL ORIENTATION OF "OFF-SURFACE" LV SURVEYS FOR WAKES AND FREE-STREAM ENTRY FLOWS

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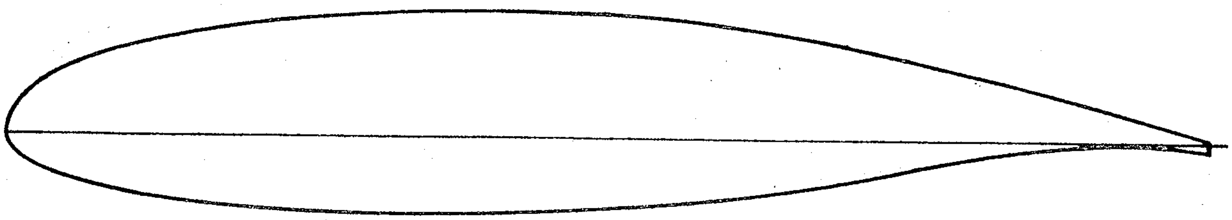

Upper Surface		Lower Surface	
X / c	Z / c	X / c	Z / c
0.00000	0.00000	0.00000	0.00000
.00200	.01300	.00200	-.00930
.00500	.02040	.00500	-.01380
.01250	.03070	.01250	-.02050
.22500	.04170	.02500	-.02690
.03750	.04965	.03750	-.03190
.05000	.05589	.05000	-.03580
.07500	.06551	.07500	-.04210
.10000	.07300	.10000	-.04700
.12500	.07900	.12500	-.05100
.15000	.08400	.15000	-.05430
.17500	.08840	.17500	-.05700
.20000	.09200	.20000	-.05930
.25000	.09770	.25000	-.06270
.30000	.10160	.30000	-.06450
.35000	.10400	.35000	-.06520
.40000	.10491	.40000	-.06490
.45000	.10445	.45000	-.06350
.50000	.10258	.50000	-.06100
.55000	.09910	.55000	-.05700
.57500	.09668	.57500	-.05400
.60000	.09371	.60000	-.05080
.62500	.09006	.62500	-.04690
.65000	.08599	.65000	-.04280
.67500	.08136	.67500	-.03840
.70000	.07634	.70000	-.03400
.72500	.07092	.72500	-.02940
.75000	.06513	.75000	-.02490
.77500	.05907	.77500	-.02040
.80000	.05286	.80000	-.01600
.82500	.04646	.82500	-.01200
.85000	.03988	.85000	-.00860
.87500	.03315	.87500	-.00580
.90000	.02639	.90000	-.00360
.92500	.01961	.92500	-.00250
.95000	.01287	.95000	-.00260
.97500	.00609	.97500	-.00400
1.00000	-.00070	1.00000	-.00800

FIGURE 3 GAW-1 AIRFOIL COORDINATES

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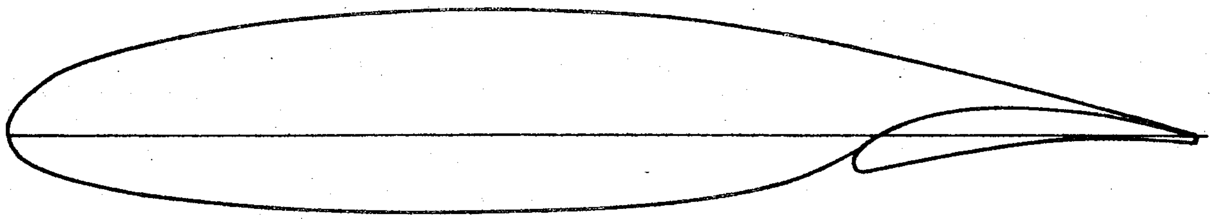

29% Fowler Flap Coordinates			
Upper Surface		Lower Surface	
X_f/c	Z_f/c	X_f/c	Z_f/c
0.00000	-.02350	0.00000	-.02350
.00030	-.02000	.00100	-.02700
.00200	-.01790	.00200	-.02880
.00400	-.01550	.00400	-.03000
.00800	-.01130	.00800	-.03100
.01200	-.00780	.01200	-.03040
.01800	-.00330	.02000	-.02880
.02300	.00000	.03000	-.02700
.02800	.00230	.05000	-.02350
.03800	.00700	.07000	-.01980
.04800	.01100	.09000	-.01600
.05800	.01410	.11000	-.01300
.06800	.01680	.13000	-.01000
.07800	.01900	.15000	-.00770
.08800	.02070	.17000	-.00580
.09800	.02180	.19000	-.00360
.10800	.02230	.21000	-.00270
.11800	.02280	.23000	-.00280
.12800	.02300	.25000	-.00350
.13800	.02340	.27000	-.00500
.14800	.02280	.29000	-.00800
.15800	.02230		
.16800	.02190		
.19000	.01980		
.21000	.01680		
.23000	.01380		
.25000	.00980		
.27000	.00590		
.29000	-.00070		

Nose Radius = .0075c

Nose Radius Location $(X_f/c, Z_f/c) = (.0075, -.0235)$

FIGURE 4 29% c FOWLER FLAP COORDINATES

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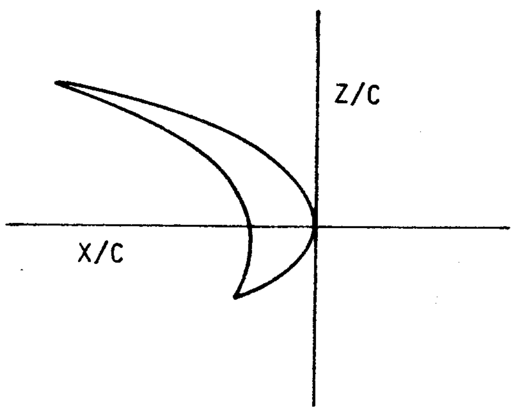
Upper Surface		Lower Surface	
X / C	Z / C	X / C	Z / C
0.00000	0.00000	0.00000	0.00000
.02000	.01300	.00200	-.00930
.00500	.02040	.00500	-.01380
.01250	.03070	.01250	-.02050
.02500	.04170	.02500	-.02690
.03750	.04965	.03750	-.03190
.05000	.05589	.04500	-.03440
.07500	.06551		
.10000	.07300		
.12500	.07900		
.14000	.08210		
.15000	.08400		



Cove Region	
X / C	Z / C
.04000	-.01600
.03900	.00000
.04500	.01850
.06000	.03800
.08000	.05510
.10000	.06640
.12000	.07500
.14000	.08110
.15000	.08350

FIGURE 5 15% LEADING-EDGE SLAT COORDINATES

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GAW-1 AIRFOIL

29% C FLAP

PRESSURE TAP LOCATIONS ON MODEL ℄

MAIN ELEMENT				FLAP	
X/C (TOP SURFACE		X/C (BOTTOM SURFACE)		X/C (TOP)	X/C (BOTTOM)
0	.70	0	.70	0	0
.0025	.75	.0025	.75	.015	.015
.0050	.80	.005	.80	.025	.025
.0075	.85	.0025	.85	.05	.05
.010	.90	.010	.90	.10	.10
.015	.925	.015	.95	.15	.15
.020	.95	.020		.25	.25
.025		.025		.275	.275
.050		.050		.29	.29
.075		.075			
.10		.10			
.15		.15			
.20		.20			
.25		.25			
.30		.30			
.35		.35			
.40		.40			
.45		.45			
.50		.50			
.55		.55			
.60		.60			
.65		.65			

FIGURE 6 GAW-1 CHORDWISE SURFACE PRESSURE PORT LOCATIONS - MAIN ELEMENT AND FLAP

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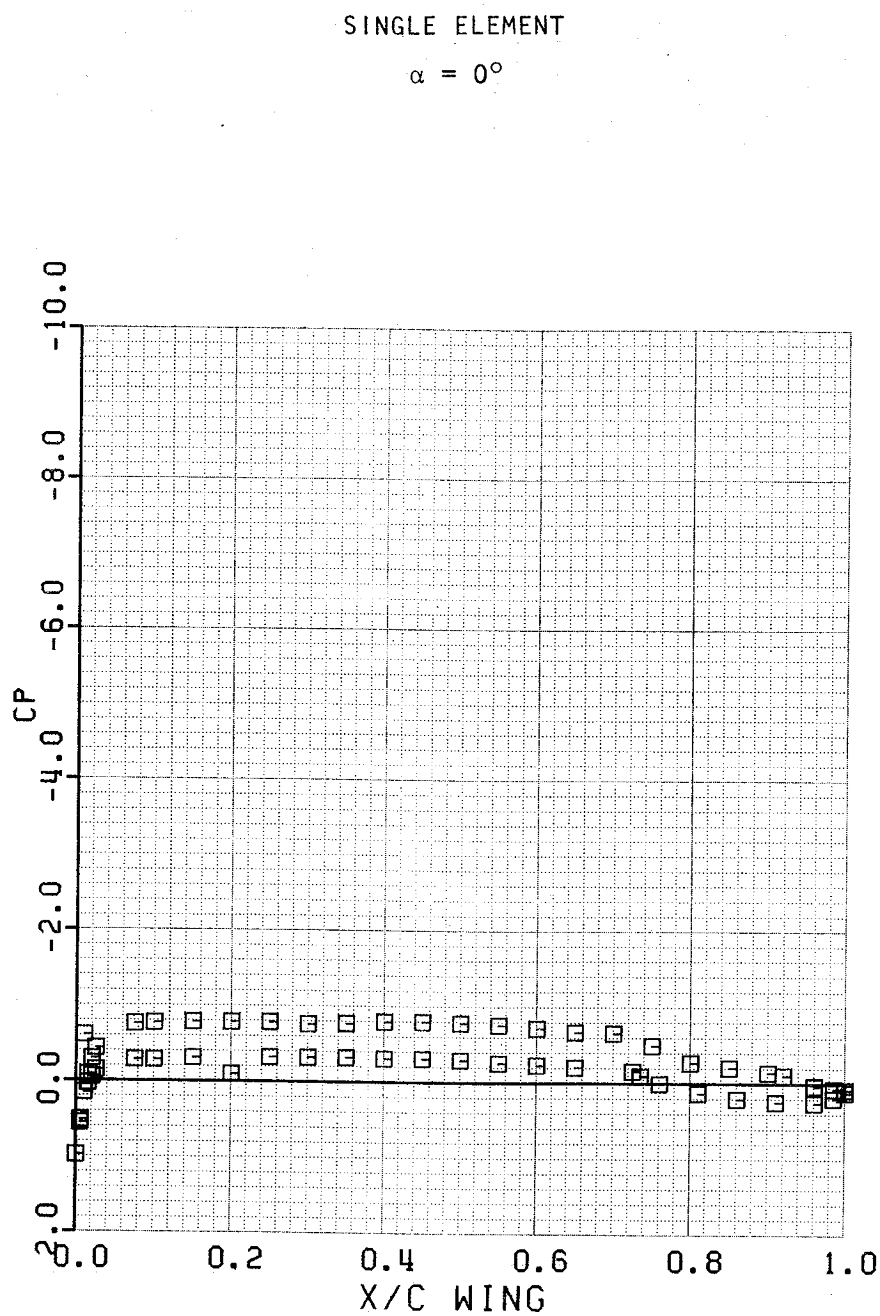

FIGURE 7 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. A-1

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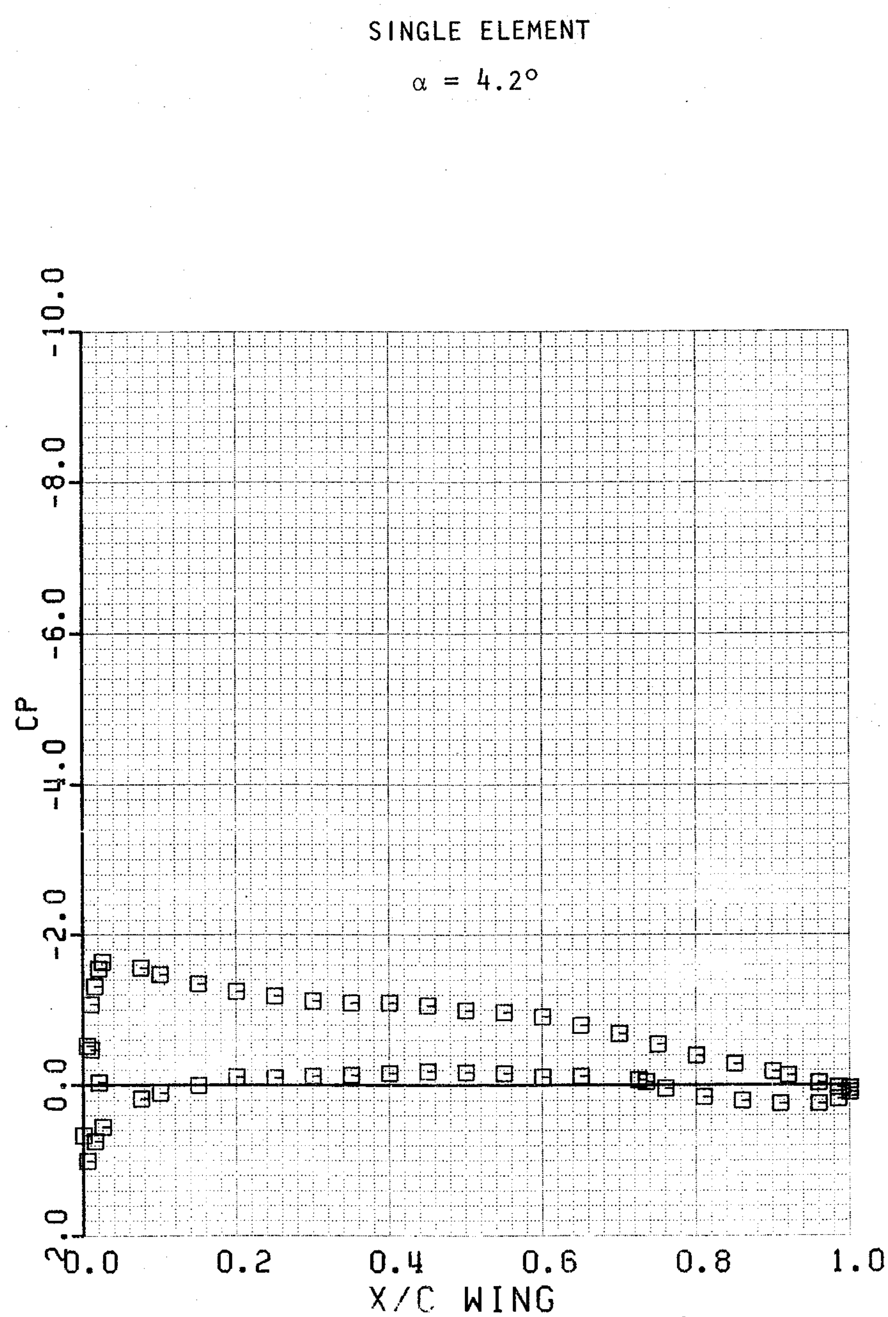

FIGURE 8 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. A-2

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SINGLE ELEMENT
$\alpha = 5.86°$

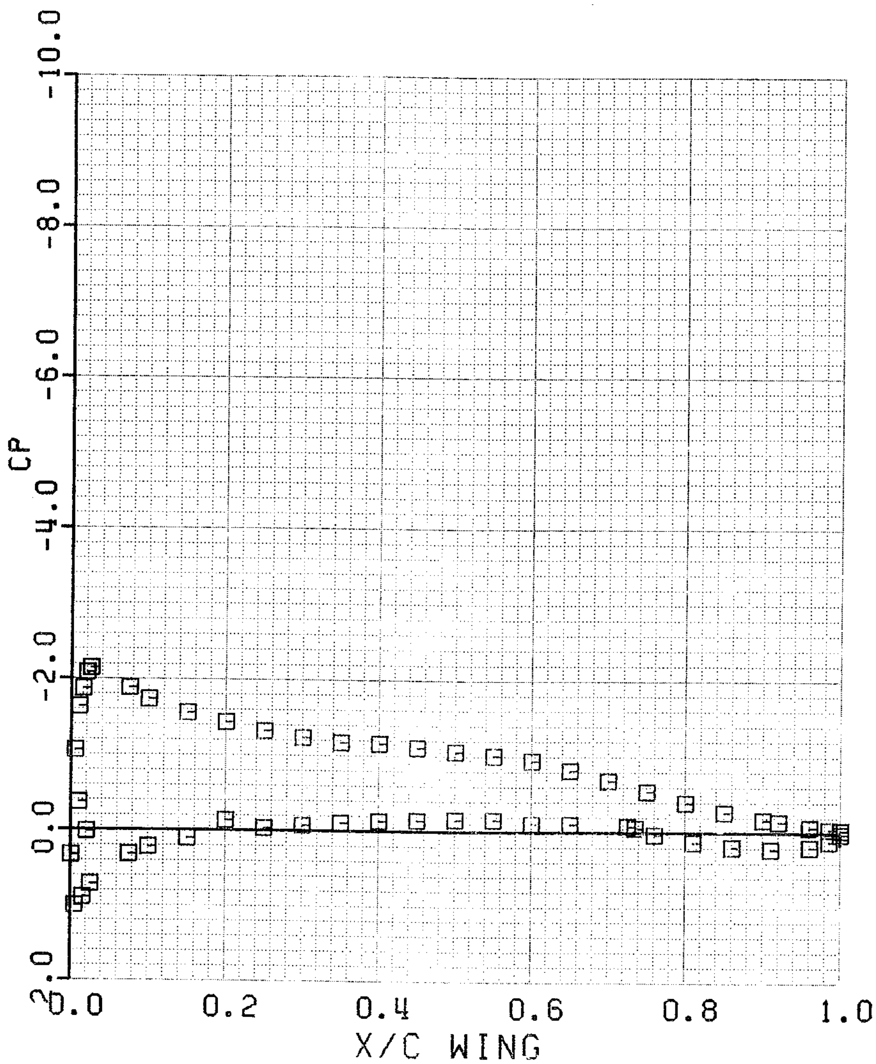

FIGURE 9 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. A-3

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SINGLE ELEMENT AIRFOIL

$\alpha = 11.72°$

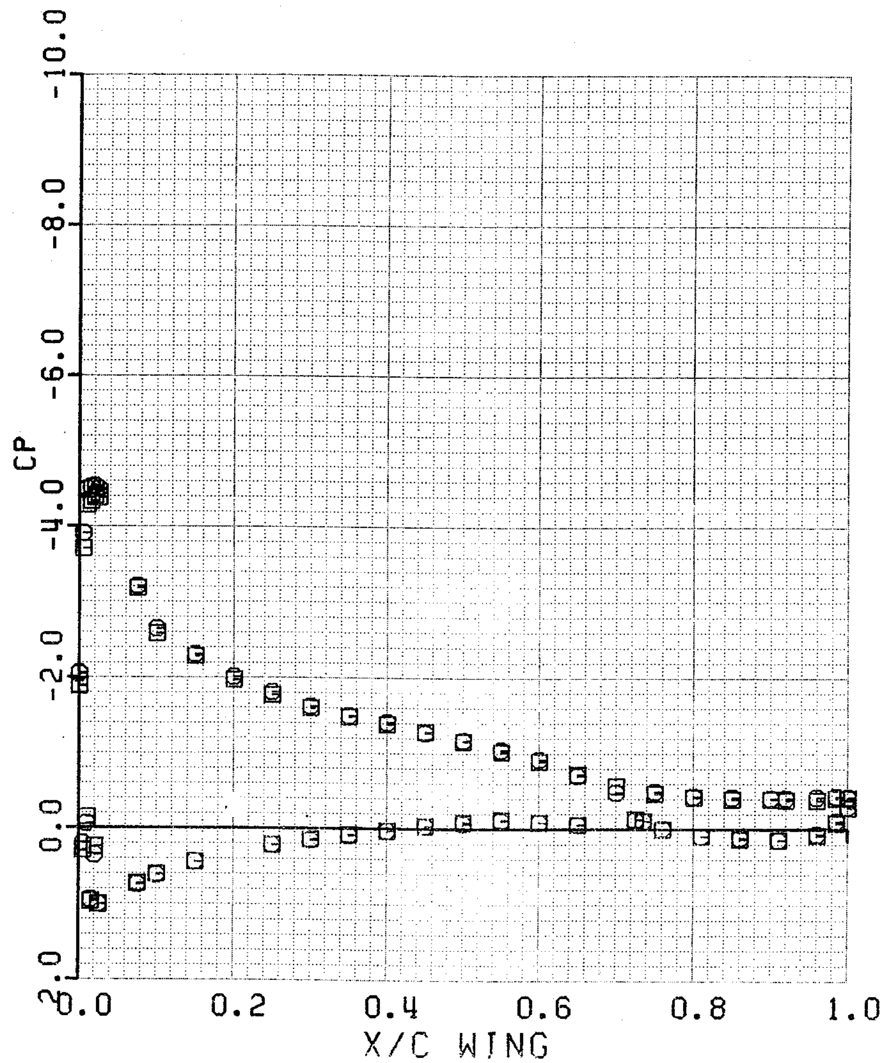

FIGURE 10 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS - PRESSURE DISTRIBUTION, CONFIG. A-4

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SINGLE ELEMENT
$\alpha = 16.04°$

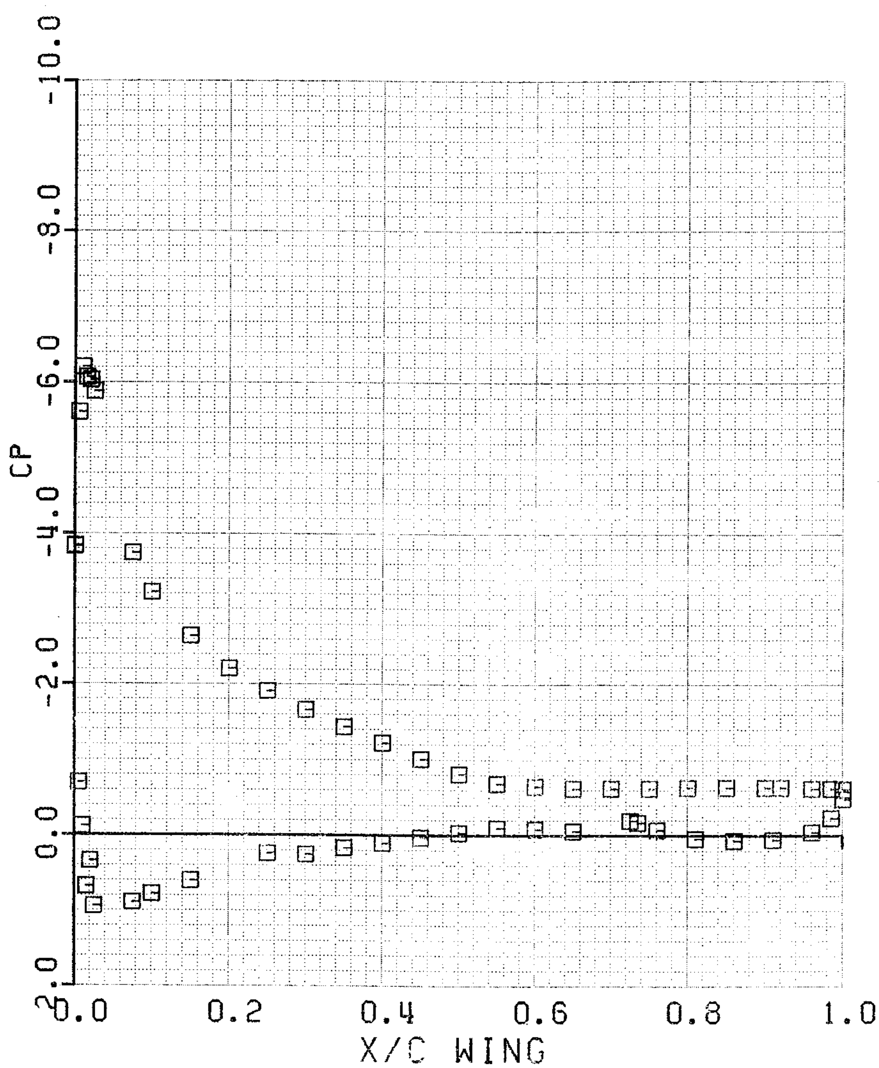

FIGURE 11 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. A-5

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δ_f	G/C	OH/C
30°	0.040	0.00

$\alpha = 3.98°$

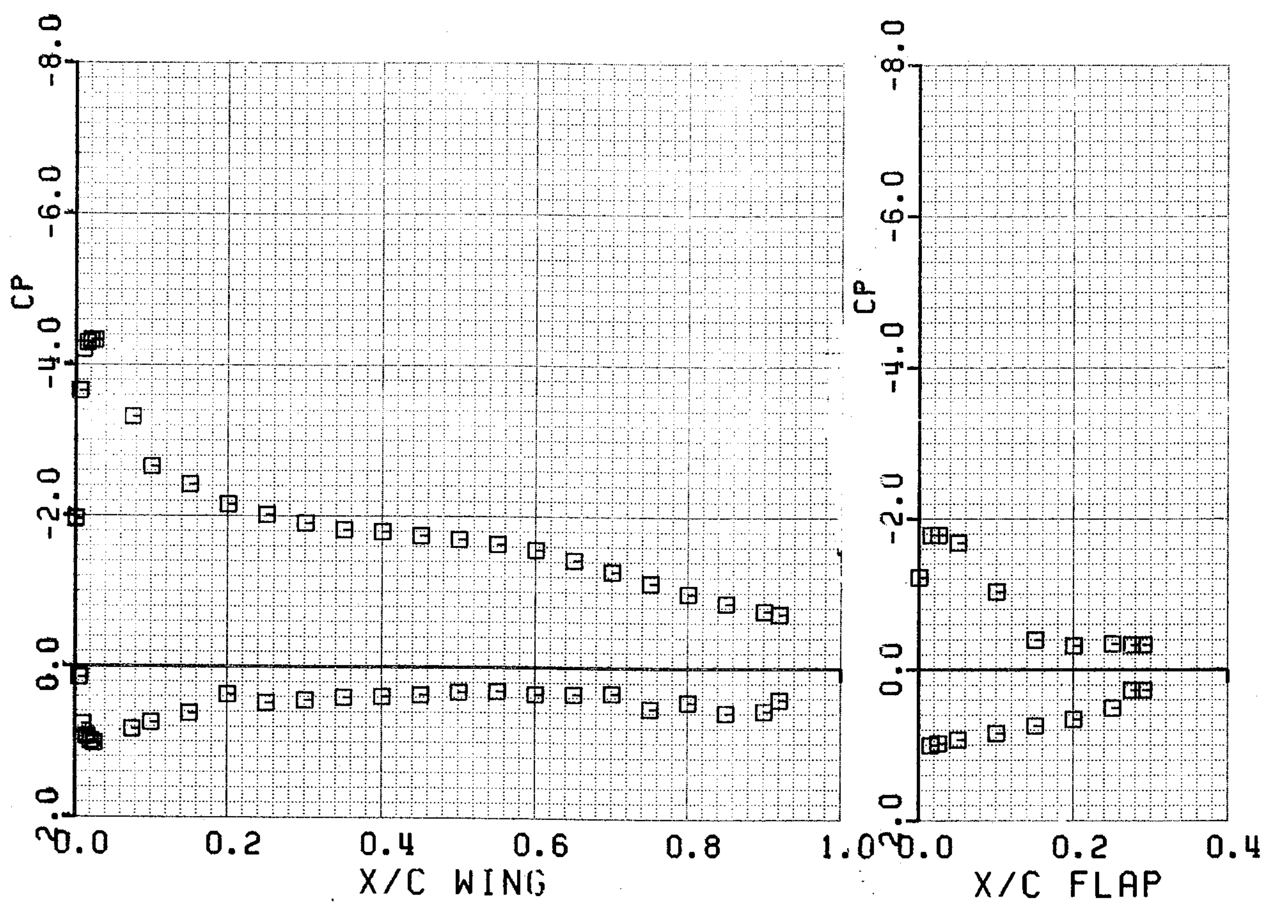

FIGURE 12 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-
PRESSURE DISTRIBUTION, CONFIG. B-1

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δ_f	G/C	OH/C
30°	0.040	0.00

$\alpha = 7.94°$

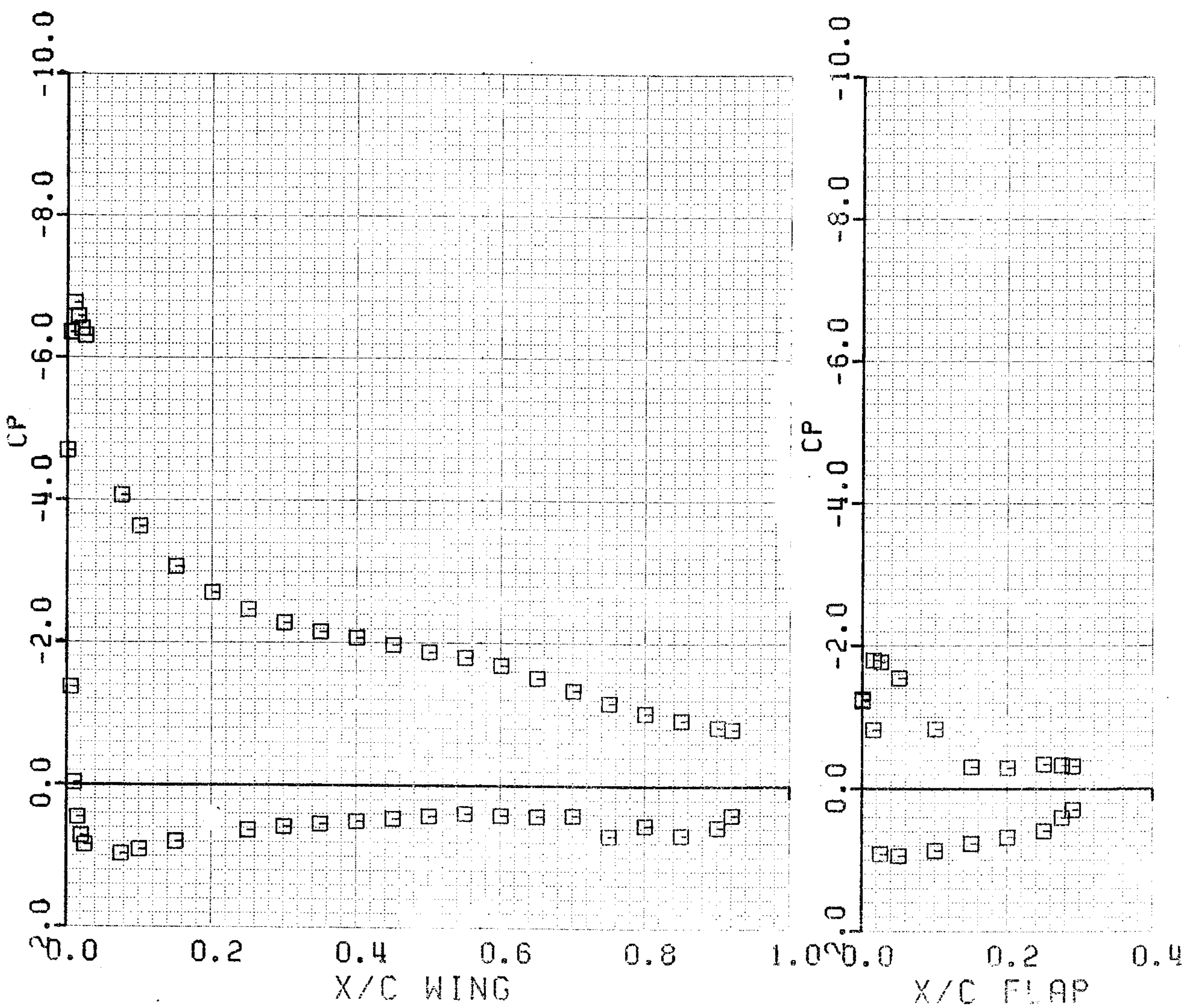

FIGURE 13 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-
PRESSURE DISTRIBUTION, CONFIG. B-2

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δ_f	G/C	OH/C
30°	0.040	0.00

α - 11.95°

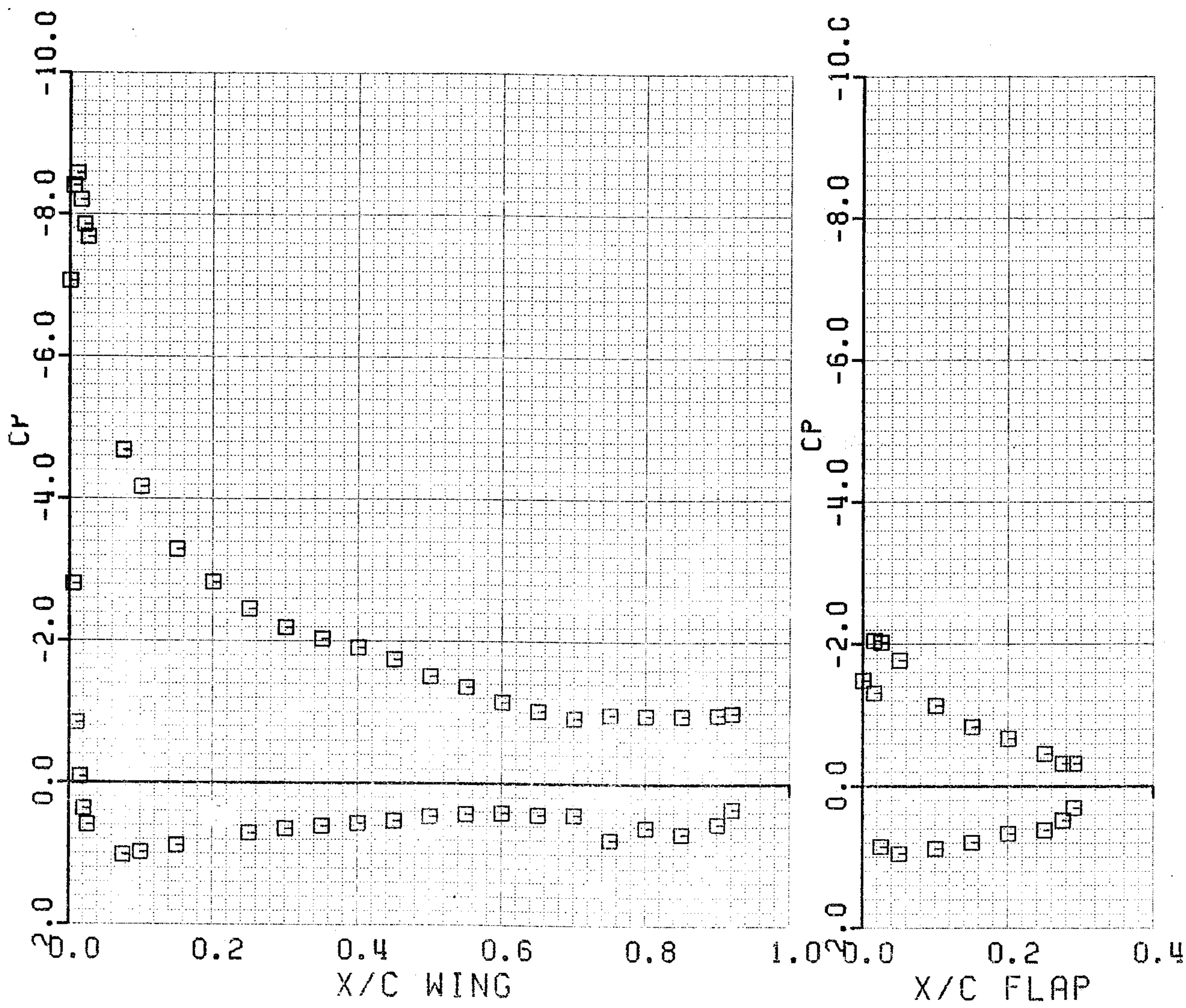

FIGURE 14 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-
PRESSURE DISTRIBUTION, CONFIG. B-3

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δ_f	G/C	OH/C
30°	0.025	0.0

$\alpha = 4.13°$

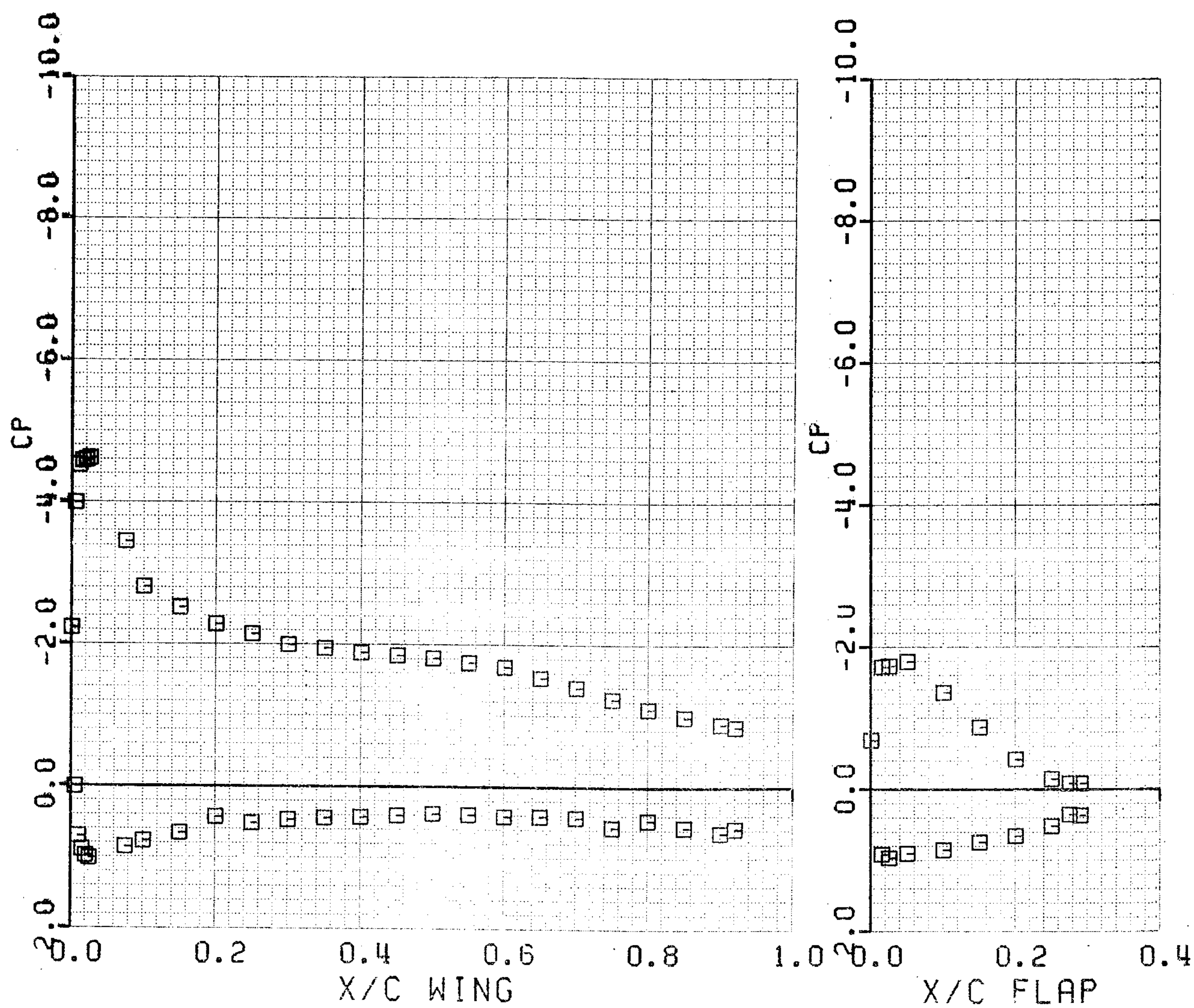

FIGURE 15 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-
PRESSURE DISTRIBUTION, CONFIG. B-4

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δ_f	G/C	OH/C
30°	0.025	0.0

$\alpha = 12.23°$

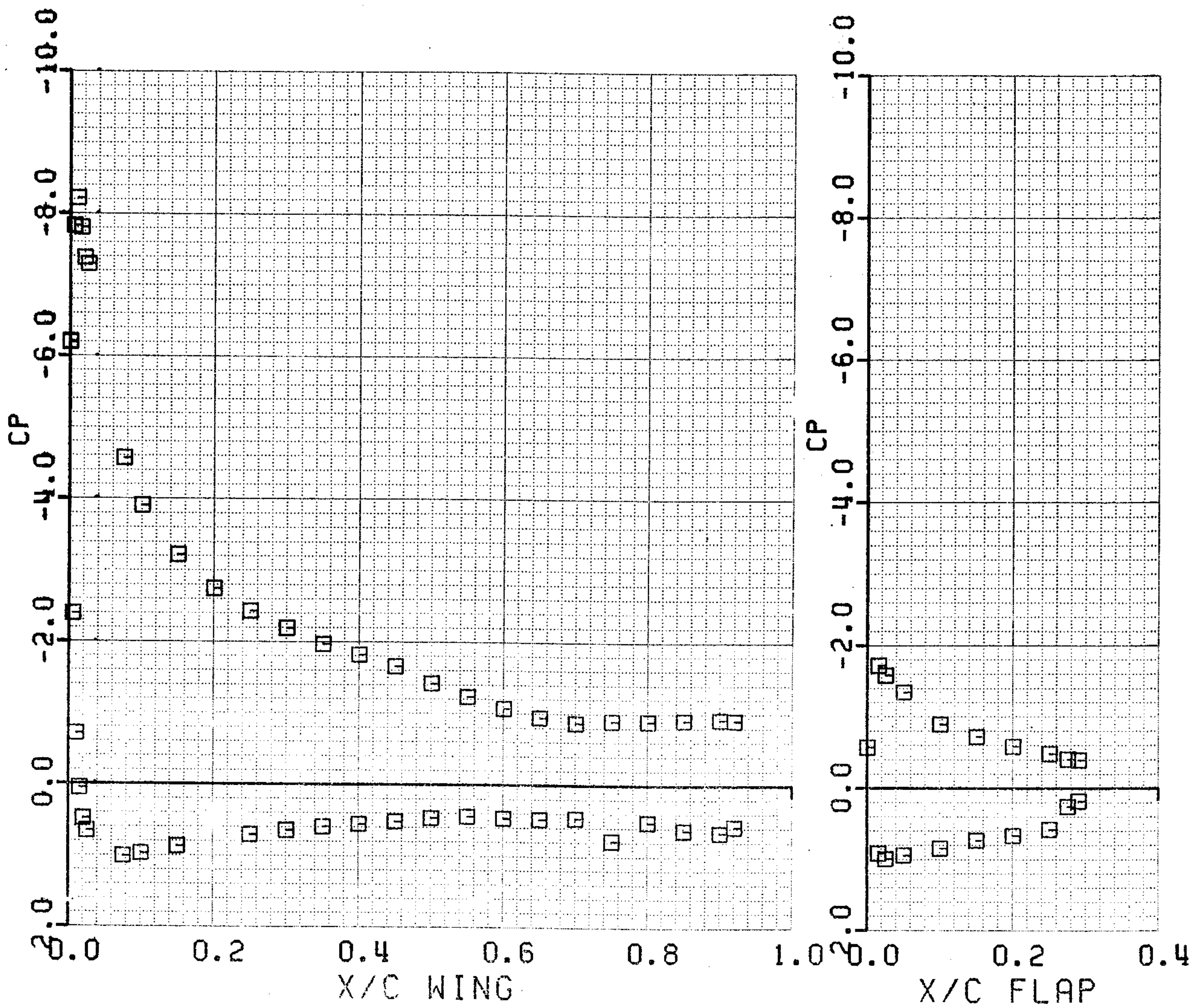

FIGURE 16 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. B-5

ORIGINAL PAGE IS
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δ_f	G/C	OH/C
40°	0.015	0.025

$\alpha = 3.98°$

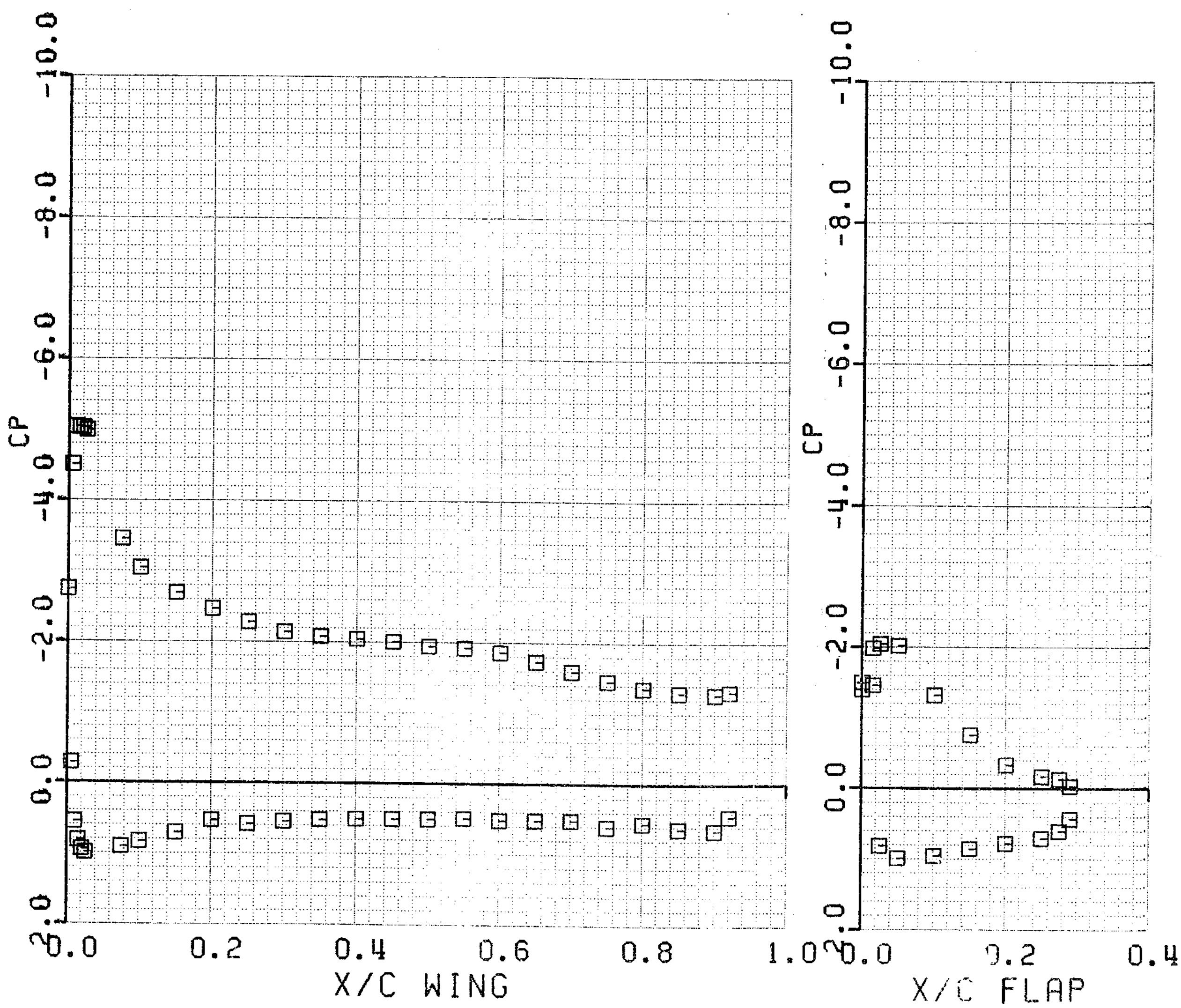

FIGURE 17 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. C-1

ORIGINAL PAGE IS
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δ_f	G/C	OH/C
40°	0.015	0.025

α = 7.99°

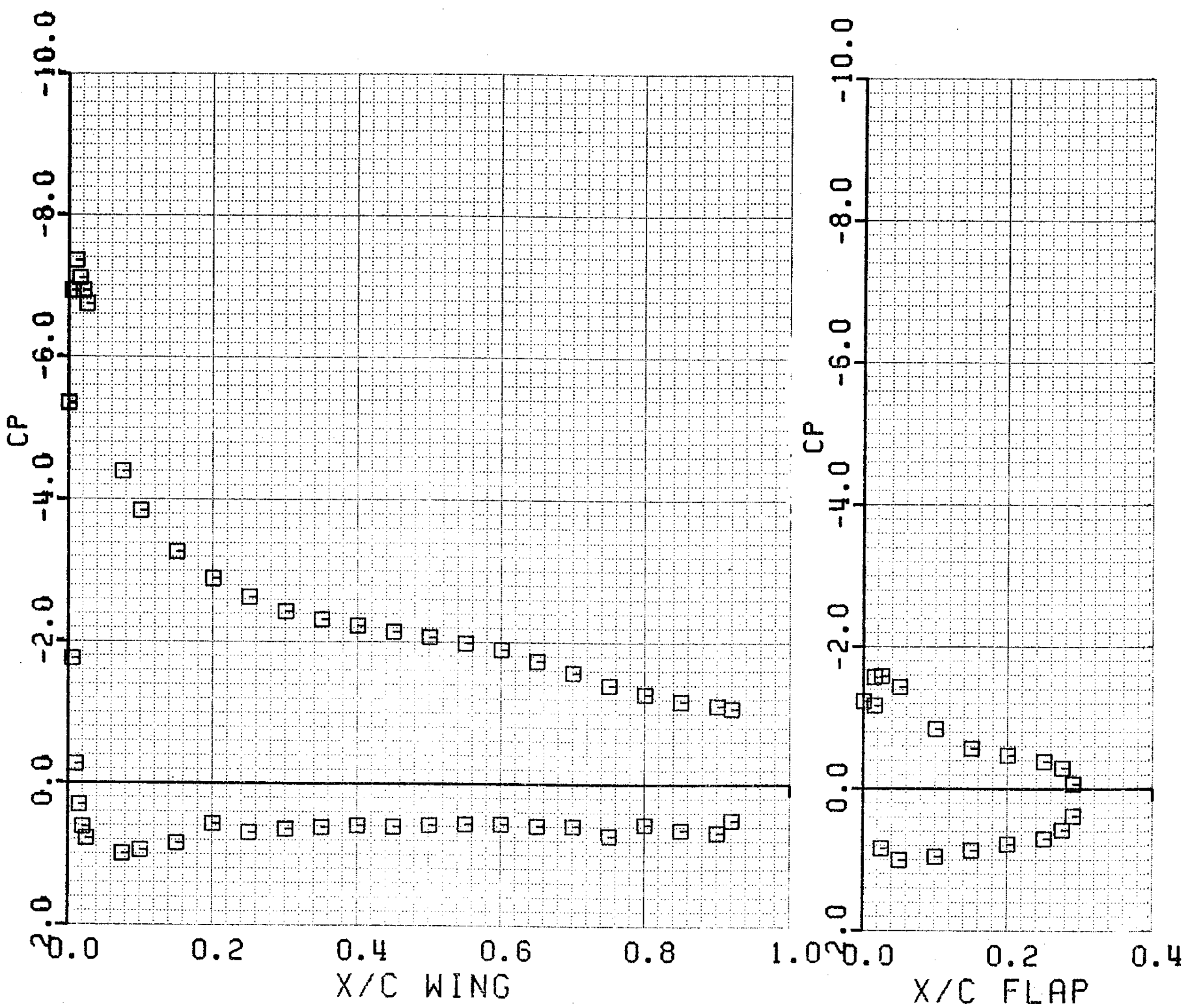

FIGURE 18 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. C-2

ORIGINAL PAGE IS
OF POOR QUALITY

δ_f	G/C	OH/C
40°	0.015	0.025

$\alpha = 10°$

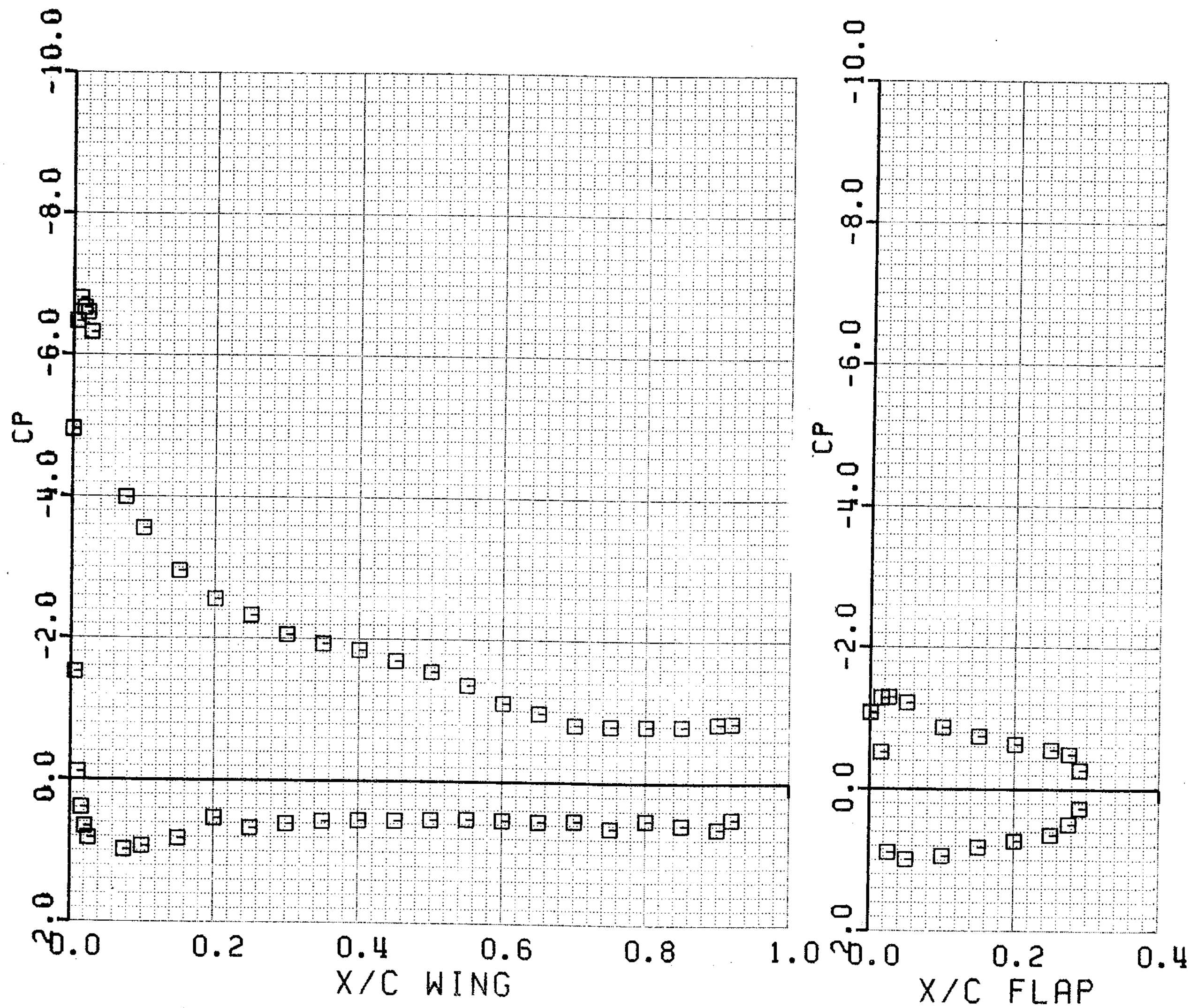

FIGURE 19 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS - PRESSURE DISTRIBUTION, CONFIG. C-3

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OF POOR QUALITY

δ_f	$(G/C)_f$	$(OH/C)_f$
40°	0.015	0.0

$\alpha = 3.97°$

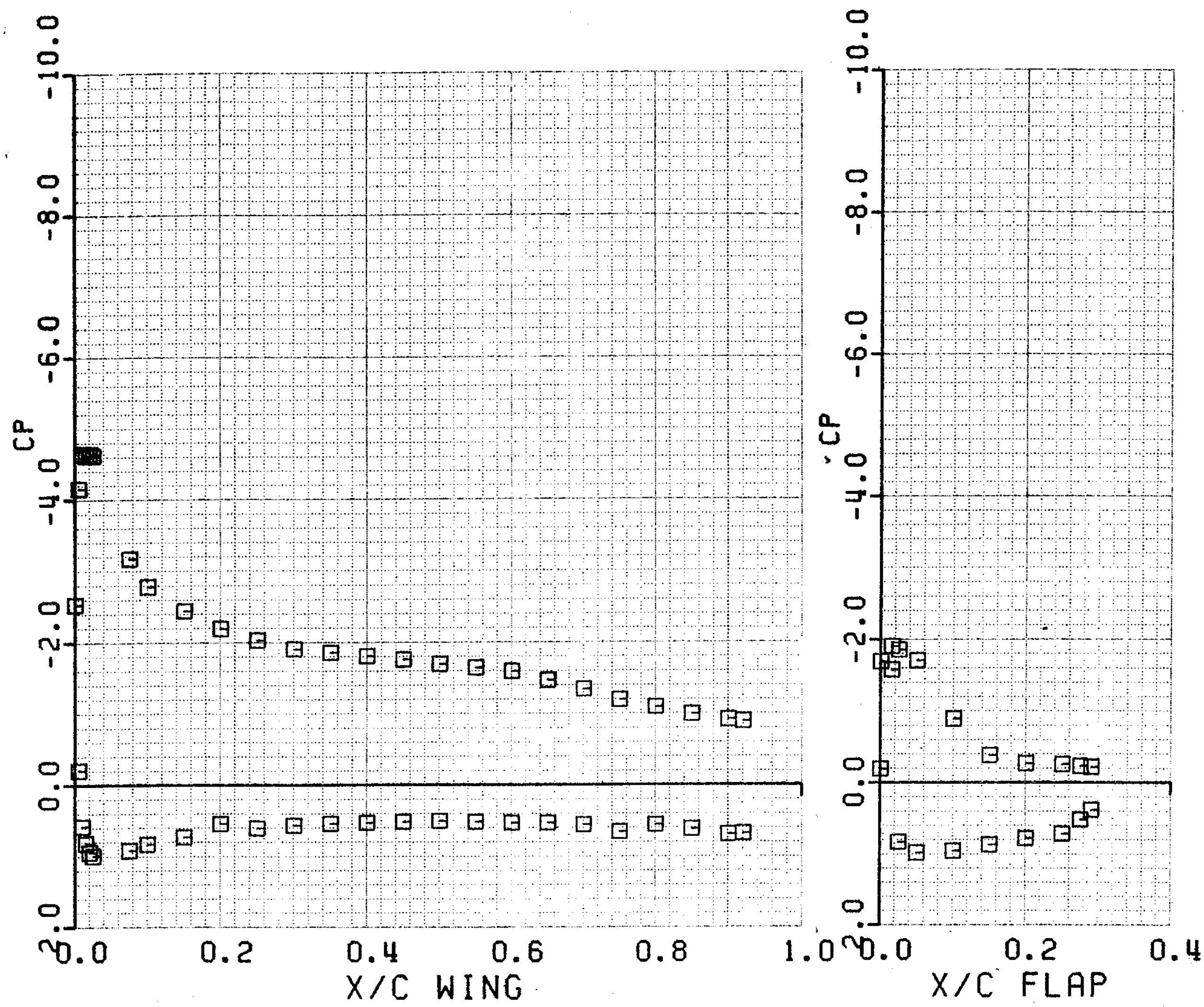

FIGURE 20. GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. C-4

ORIGINAL PAGE IS
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δ_f	$(G/C)_f$	$(OH/C)_f$
40°	0.015	0.0

$\alpha = 7.97°$

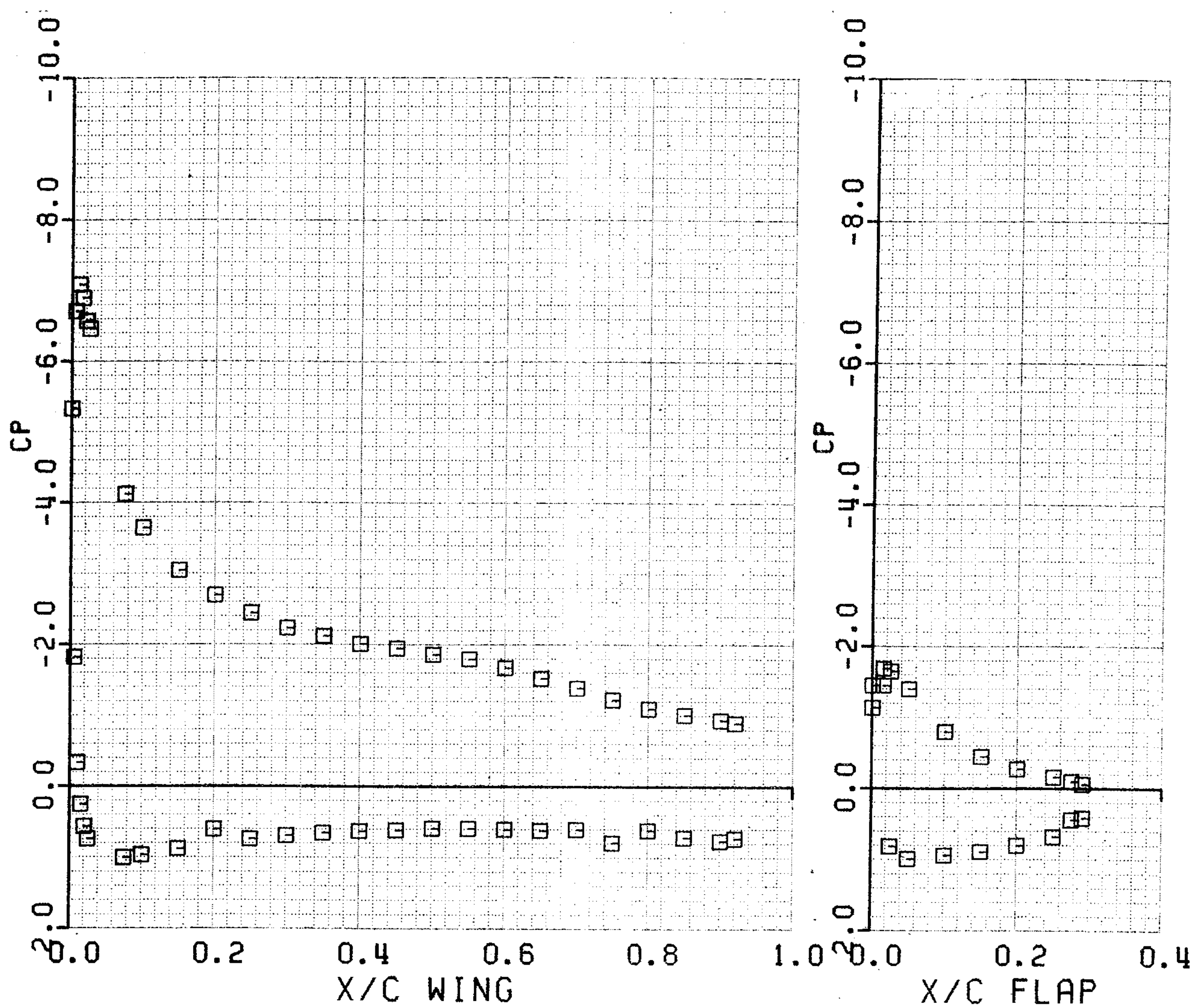

FIGURE 21. GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. C-5

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δ_f	$(G/C)_f$	$(OH/C)_f$
40°	0.015	0.0

α = 11.05°

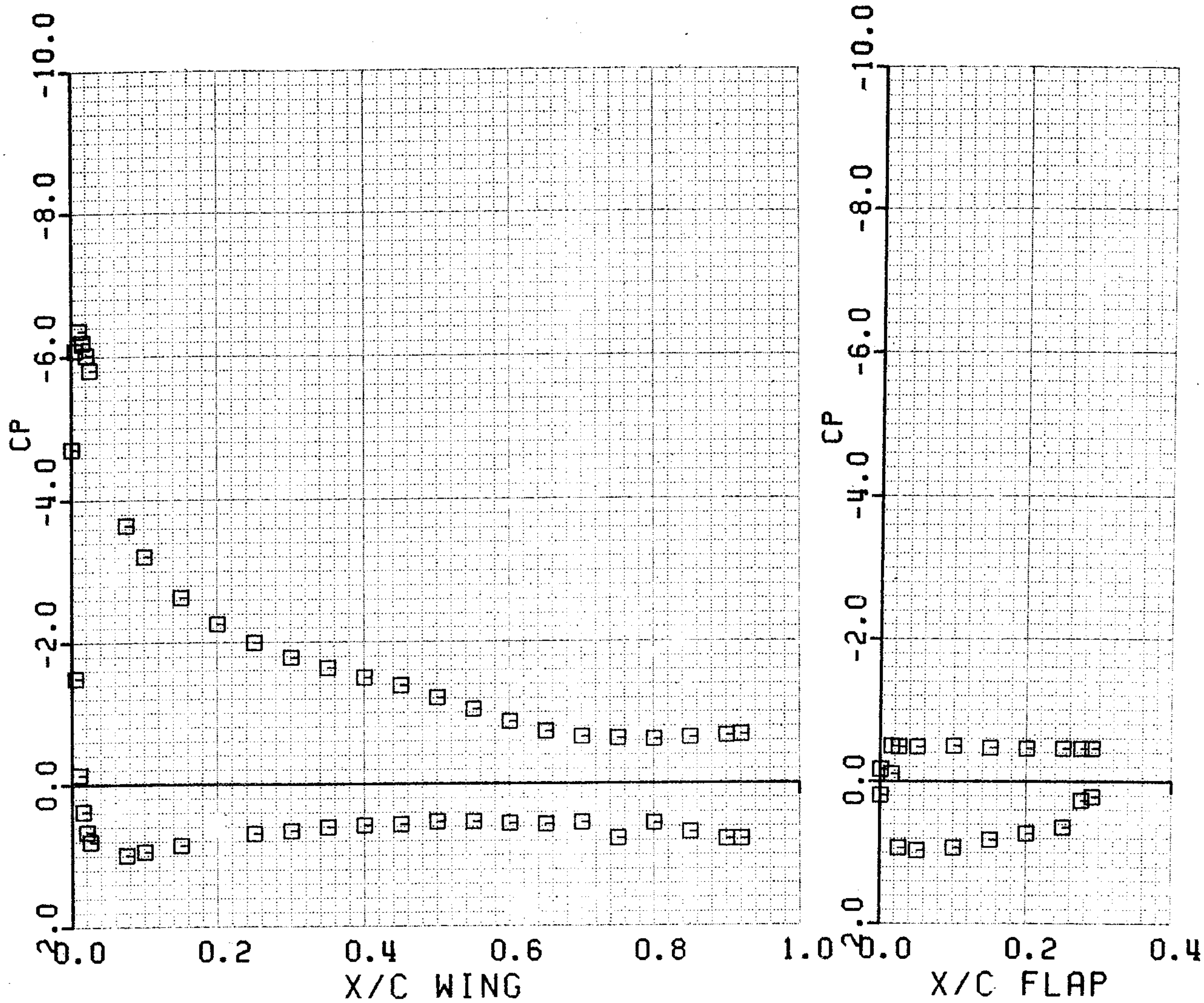

FIGURE 22. GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. C-6

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δ_s	G/C	OH/C
27°	0.023	0.028

$\alpha = 17.90°$

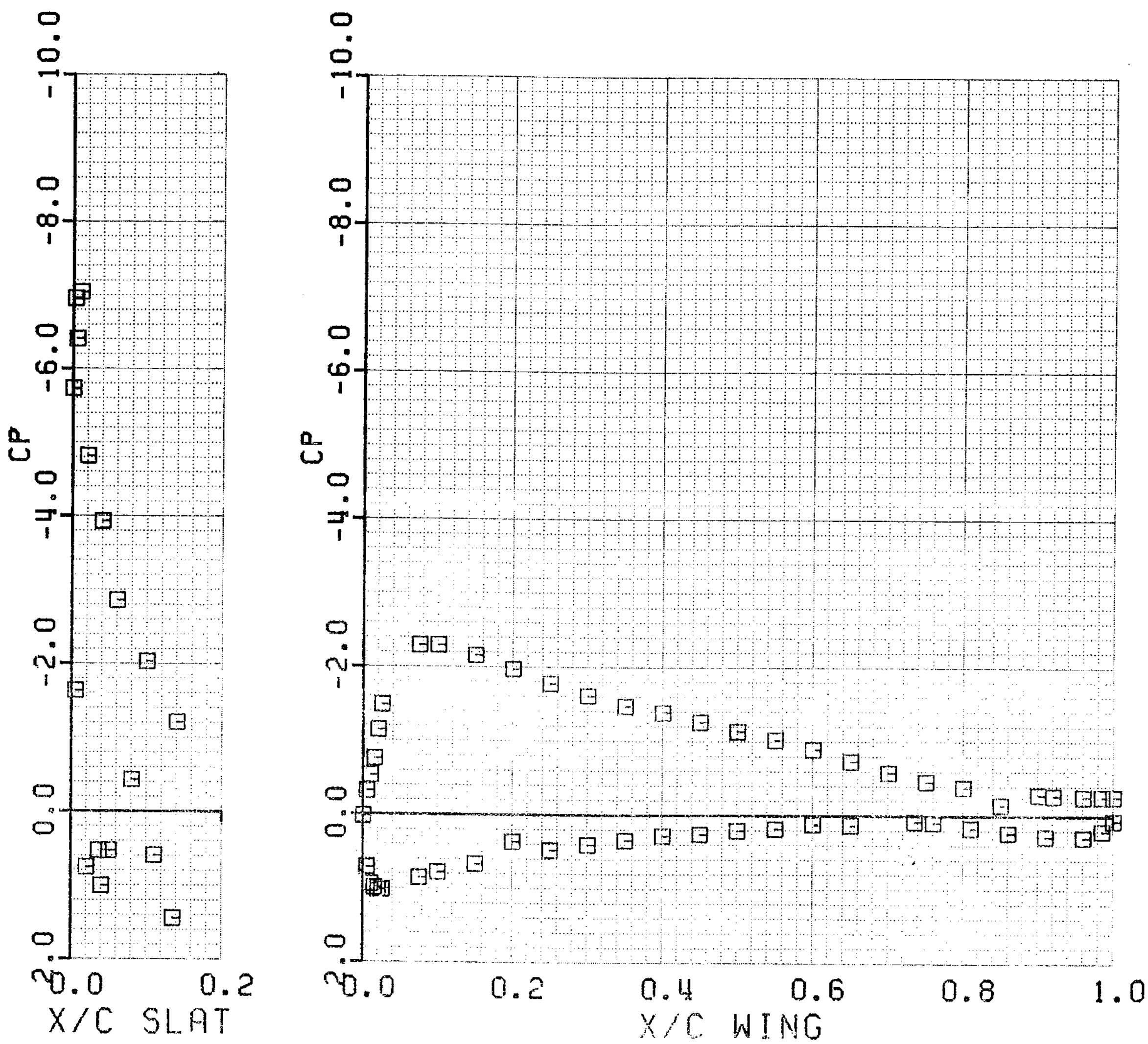

FIGURE 23 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. D-1

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δ_s	G/C	OH/C
27°	0.023	0.028

$\alpha = 21.48°$

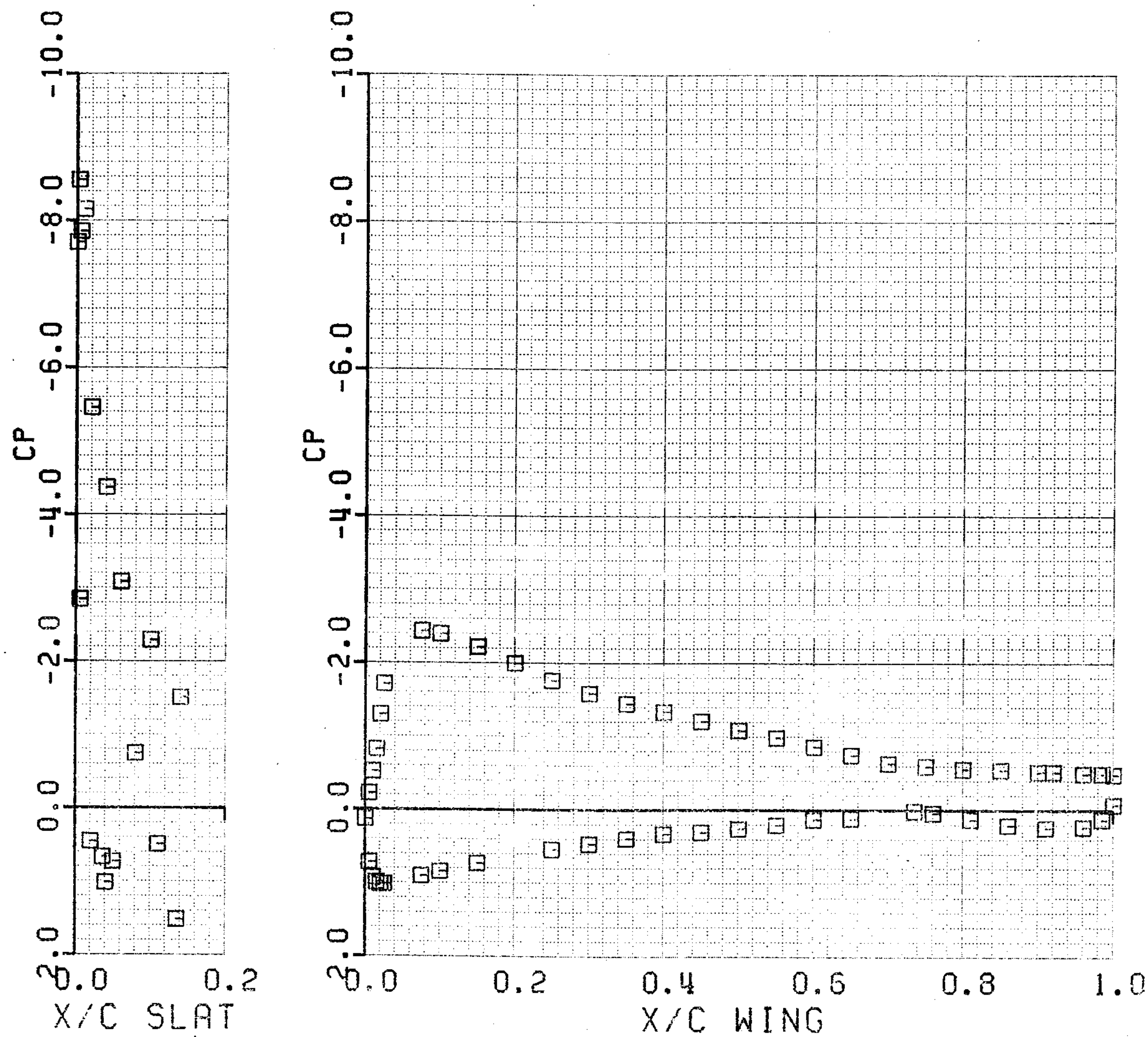

FIGURE 24 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-
PRESSURE DISTRIBUTION, CONFIG. D-2.

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δ_s	G/C	OH/C
27°	0.023	0.028

$\alpha = 23.03°$

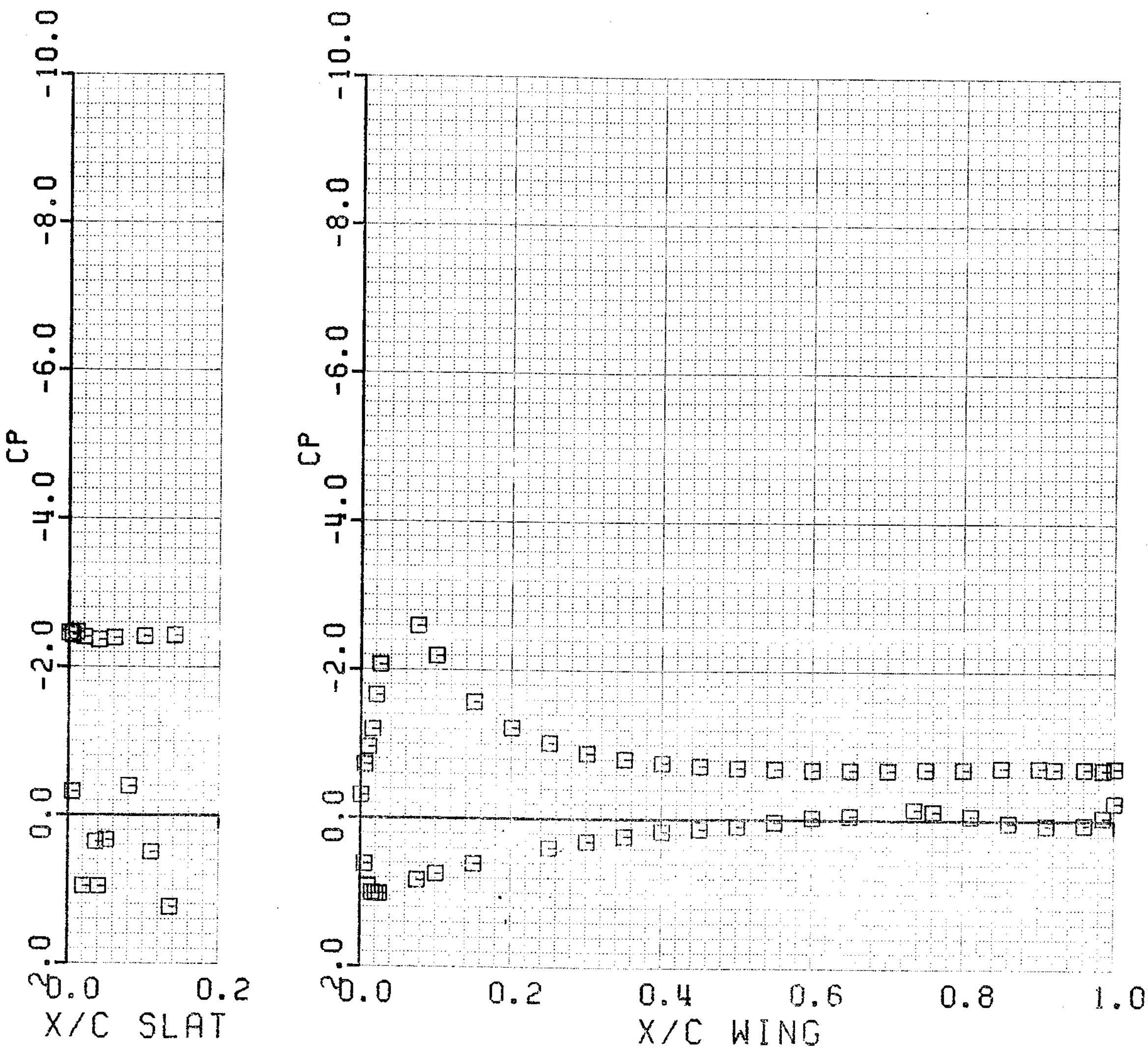

FIGURE 25 GAW-1 AIRFOIL CONFIGURATION for LV-SURVEYS-
PRESSURE DISTRIBUTION, CONFIG. D-3

δ_f	G/C	OH/C	δ_s	G/C	OH/C
30°	0.025	0.0	42°	0.015	0.015

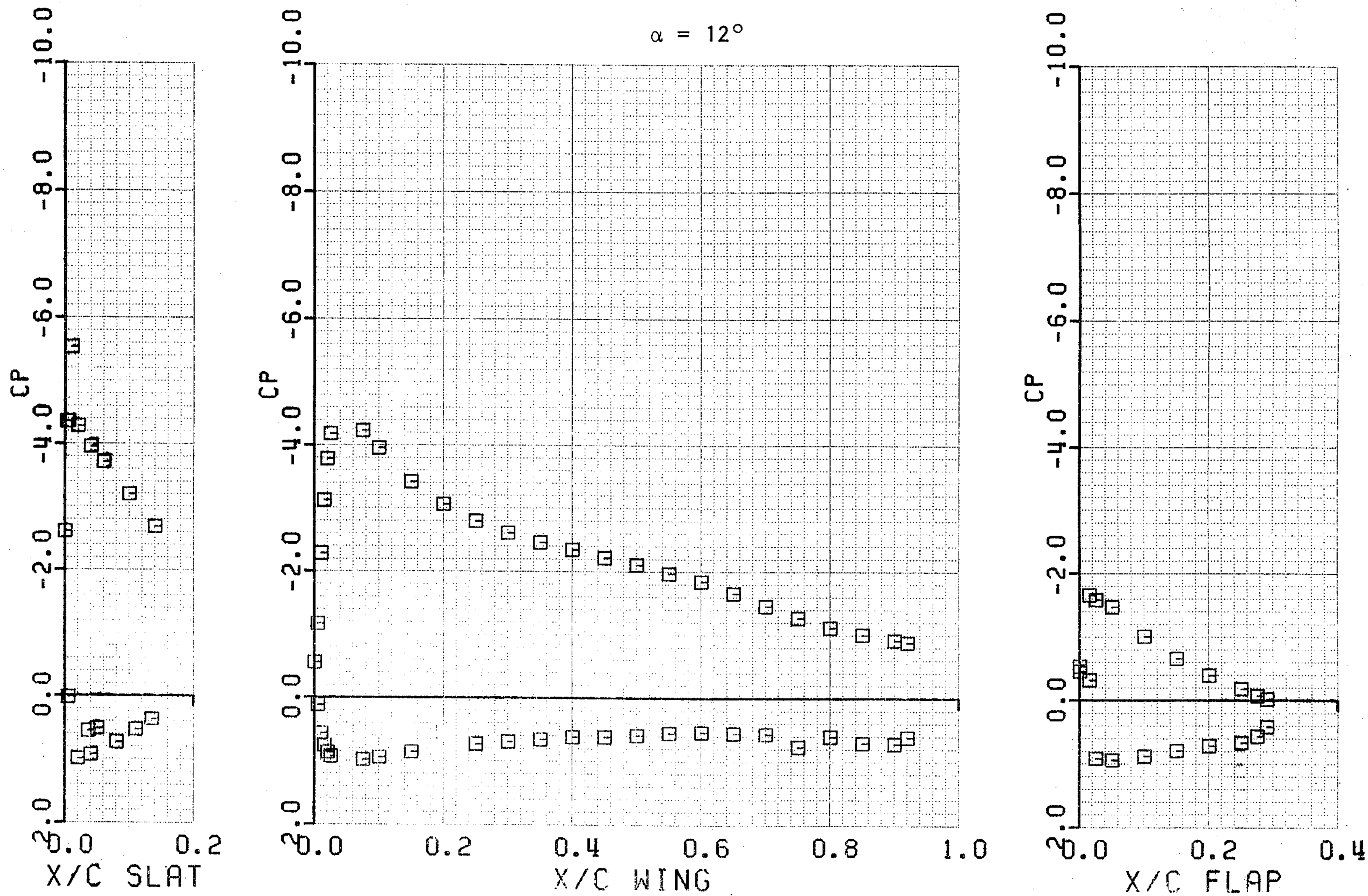

FIGURE 26 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. E-1

ORIGINAL PAGE IS OF POOR QUALITY

δ_f	G/C	OH/C	δ_s	G/C	OH/C
30°	0.025	0.0	42°	0.015	0.015

$\alpha = 14.06°$

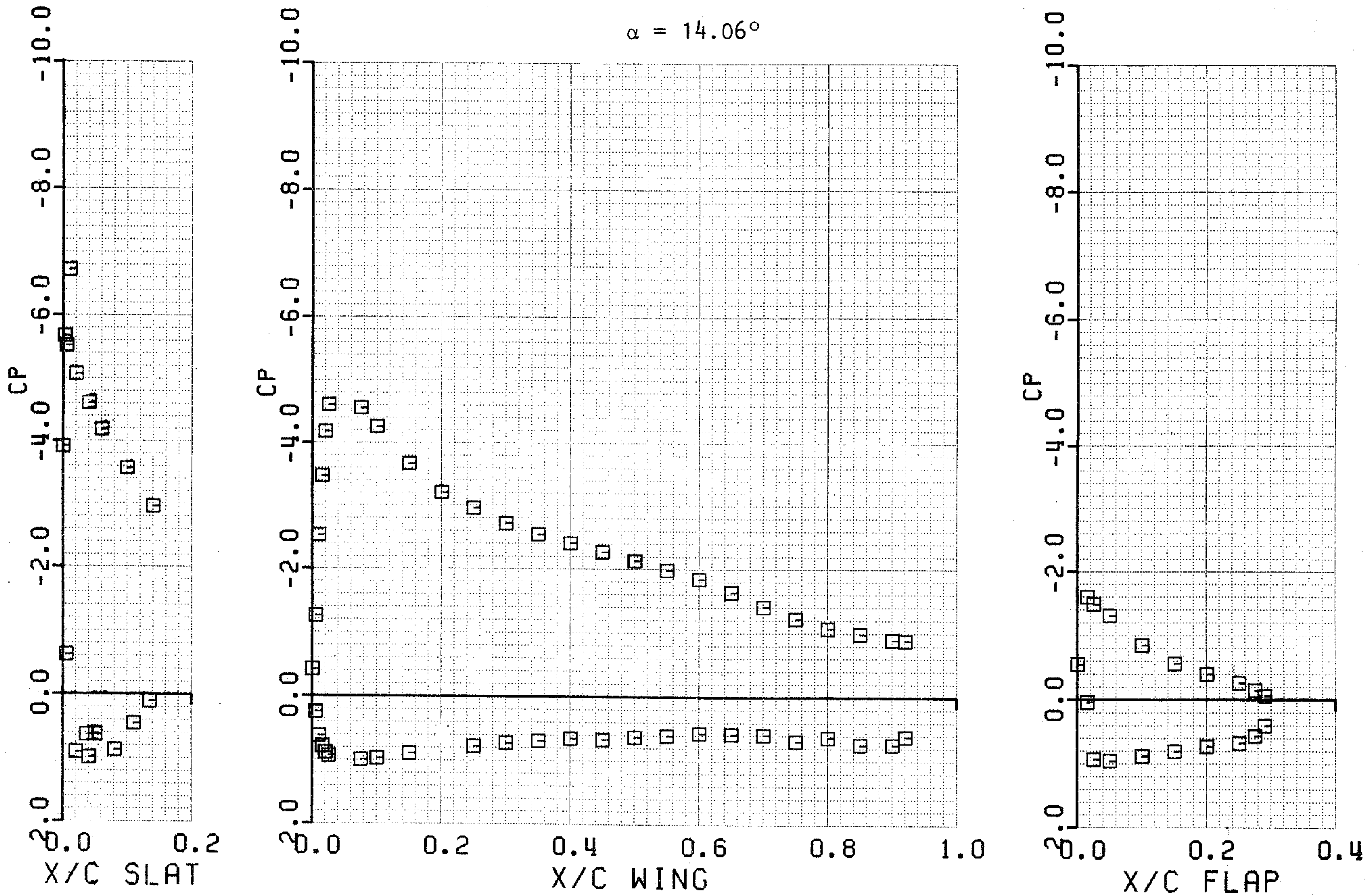

FIGURE 27 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-PRESSURE DISTRIBUTION, CONFIG. E-2

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δ_f	G/C	OH/C	δ_s	G/C	OH/C
30°	0.025	0.0	42°	0.015	0.015

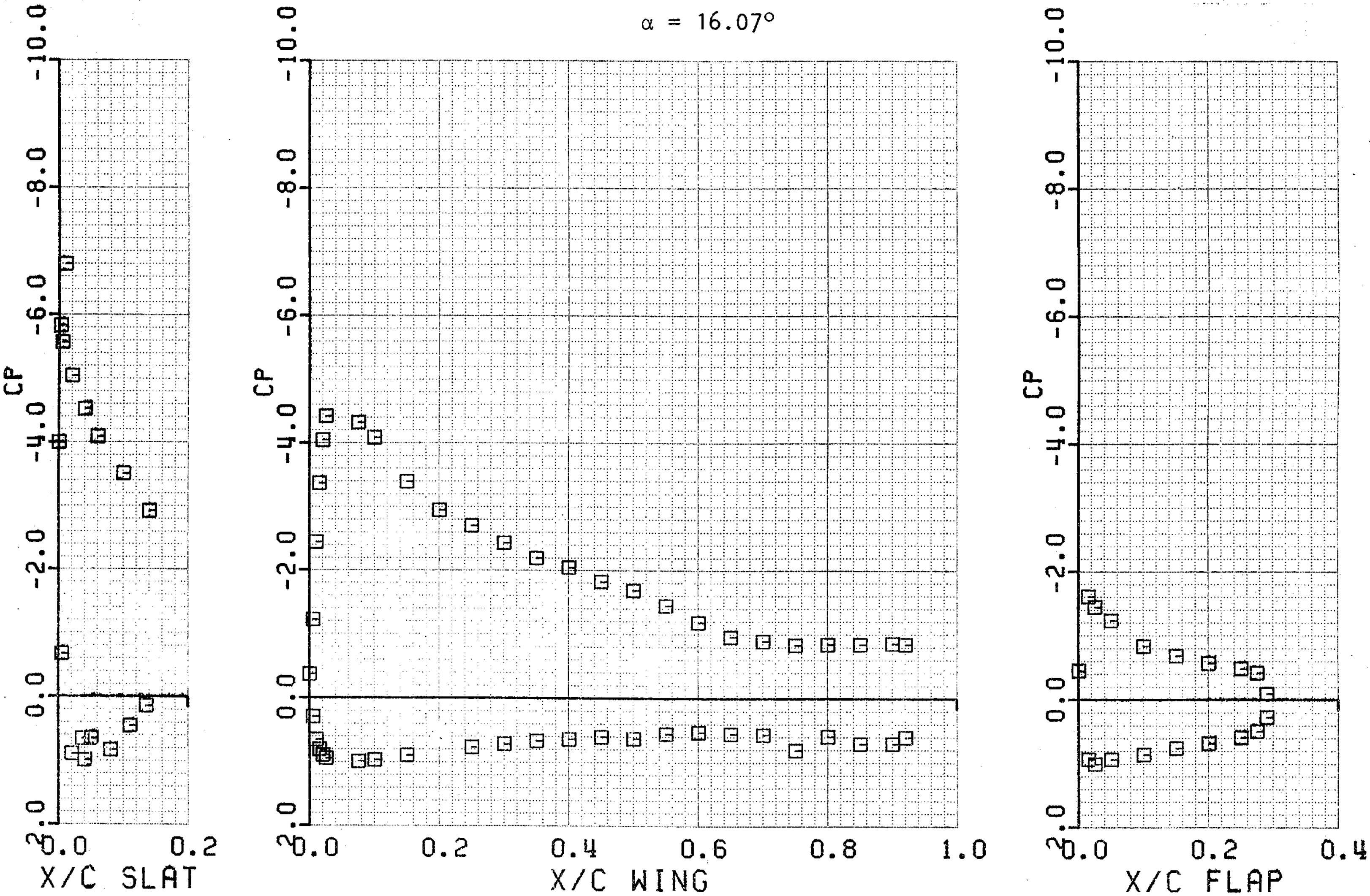

FIGURE 28 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS - PRESSURE DISTRIBUTION, CONFIG. E-3

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δ_{f_o}	G/C	OH/C	δ_s	G/C	OH/C
40	0.015	0.025	42	0.015	0.015

$\alpha = 5.3°$

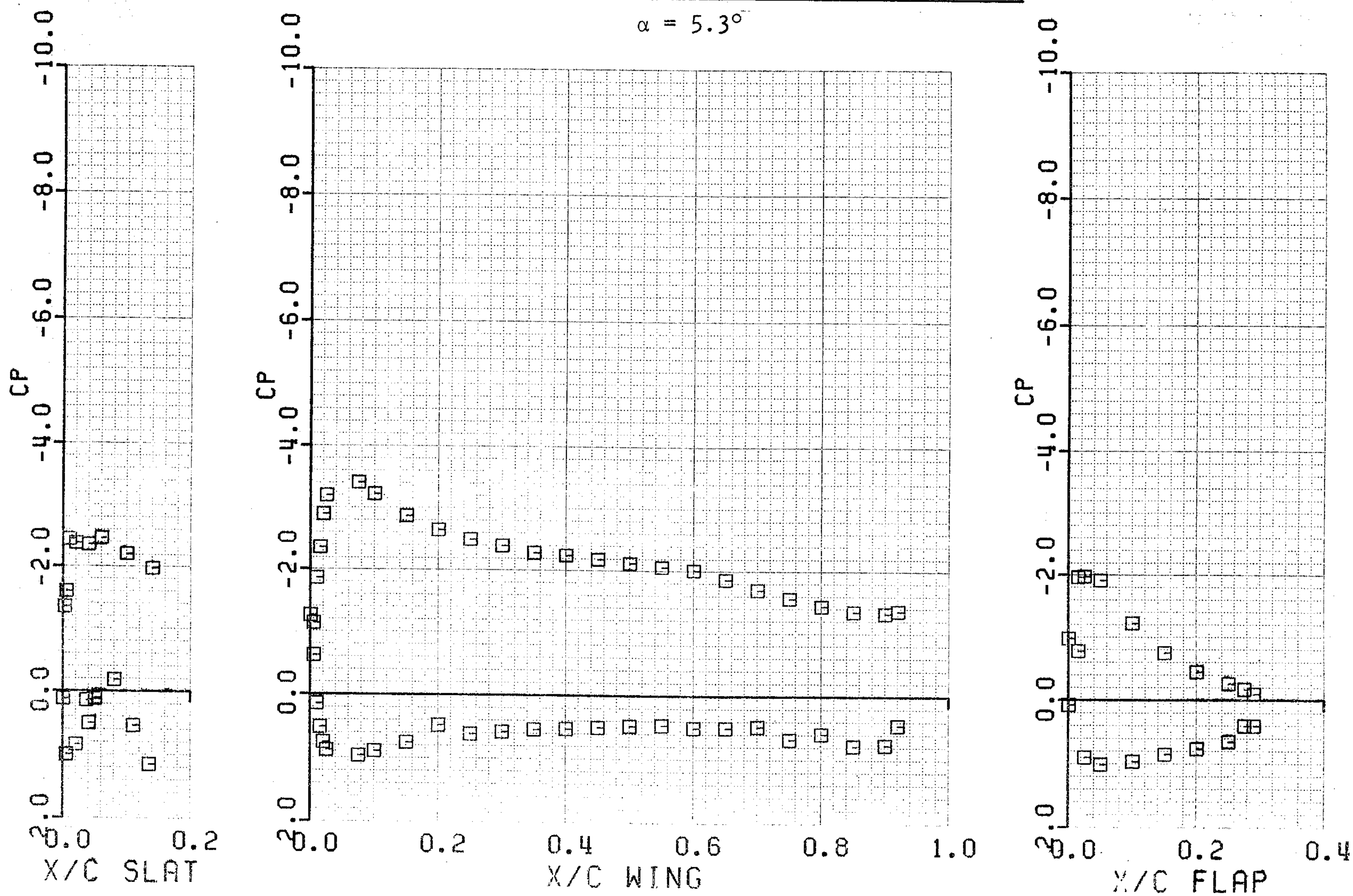

FIGURE 29 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-
PRESSURE DISTRIBUTION, CONFIG. F-1

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δ_f	G/C	OH/C	δ_s	G/C	OH/C
40°	0.015	0.025	42	0.015	0.015

$\alpha = 9.5°$

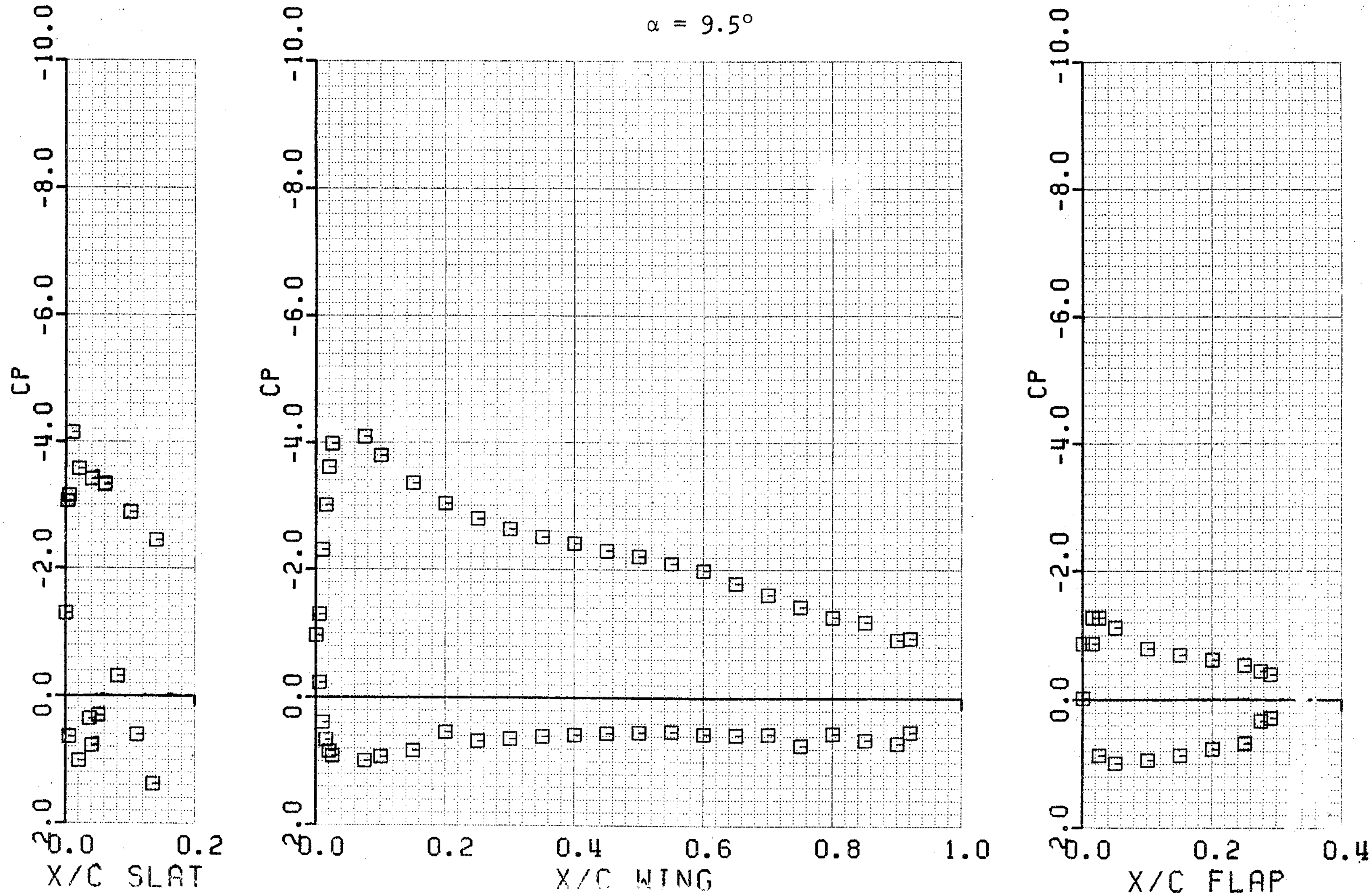

FIGURE 30 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-
PRESSURE DISTRIBUTION, CONFIG. F-2

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δ_f	G/C	OH/C	δ_s	G/C	OH/C
40°	0.015	0.025	42°	0.015	0.015

$\alpha = 14.07°$

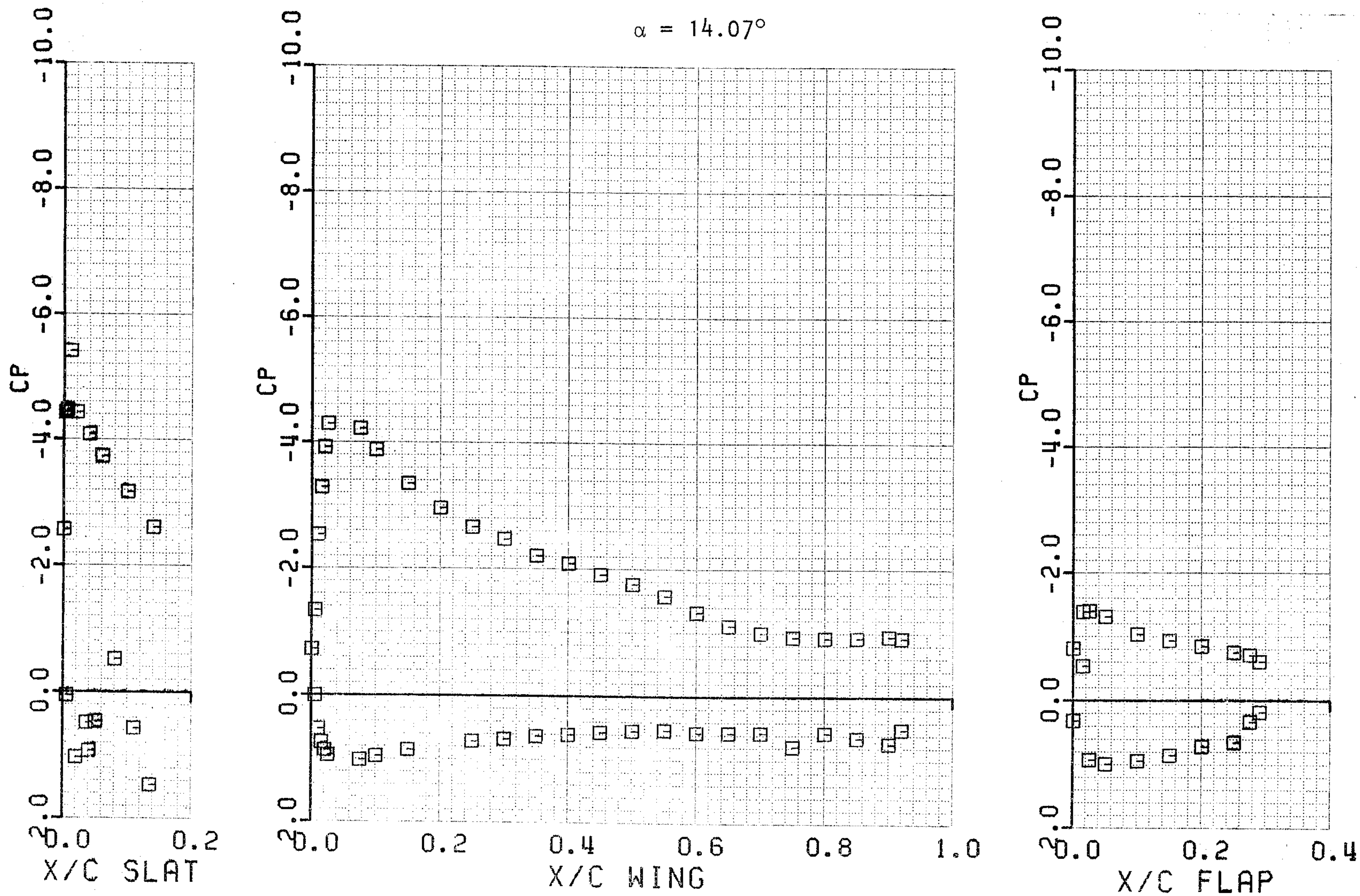

FIGURE 31 GAW-1 AIRFOIL CONFIGURATION FOR LV-SURVEYS-
PRESSURE DISTRIBUTION, CONFIG. F-3

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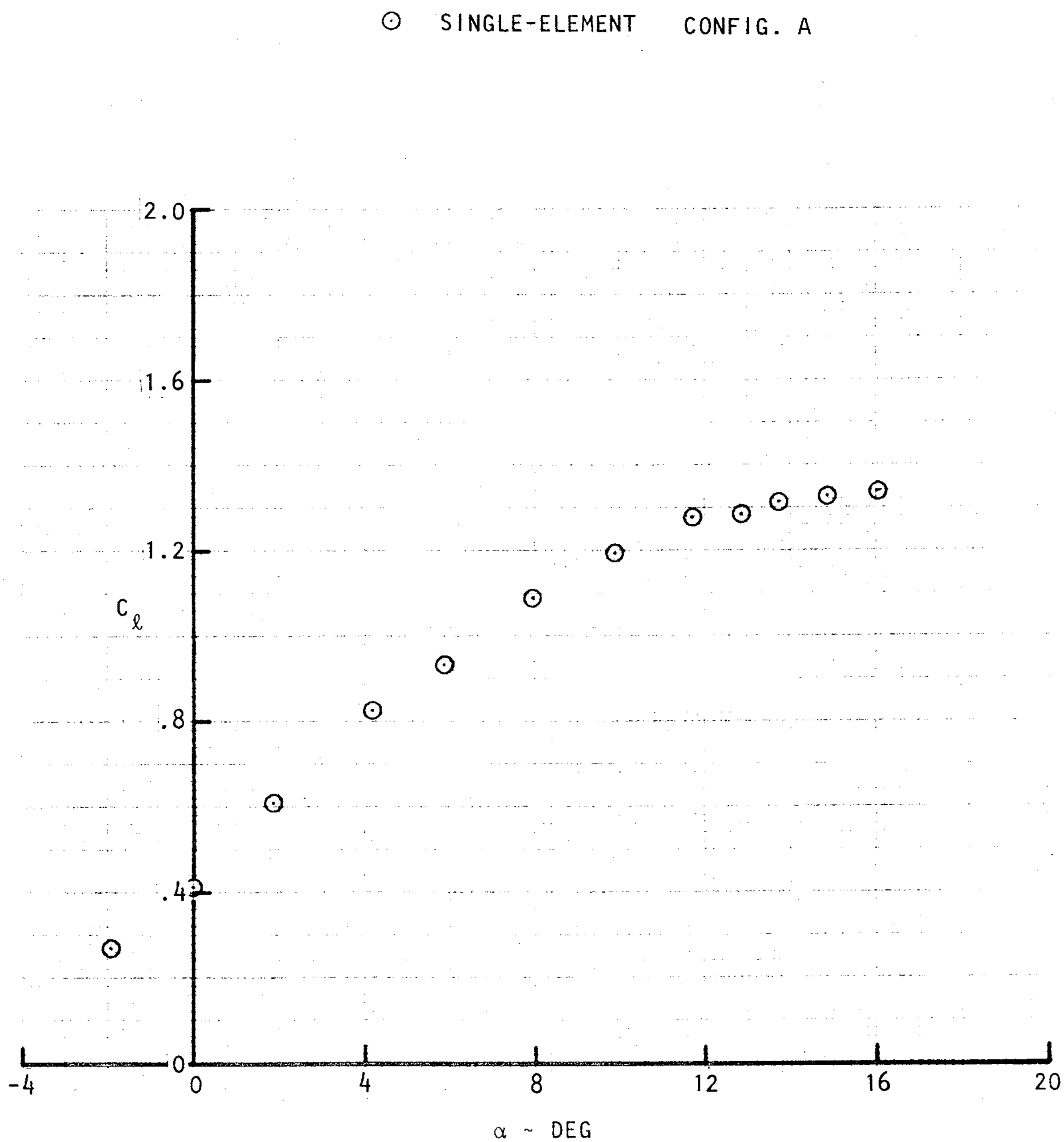

FIGURE 32 VARIATION OF LIFT COEFFICIENT WITH ANGLE-OF-ATTACK, GAW-1 AIRFOIL

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SYM	δ_f	G/C	OH/C	CONFIG.
⊙	30°	0.040	0.0	B(1-3)
⊡	30°	0.025	0.0	B(4-6)

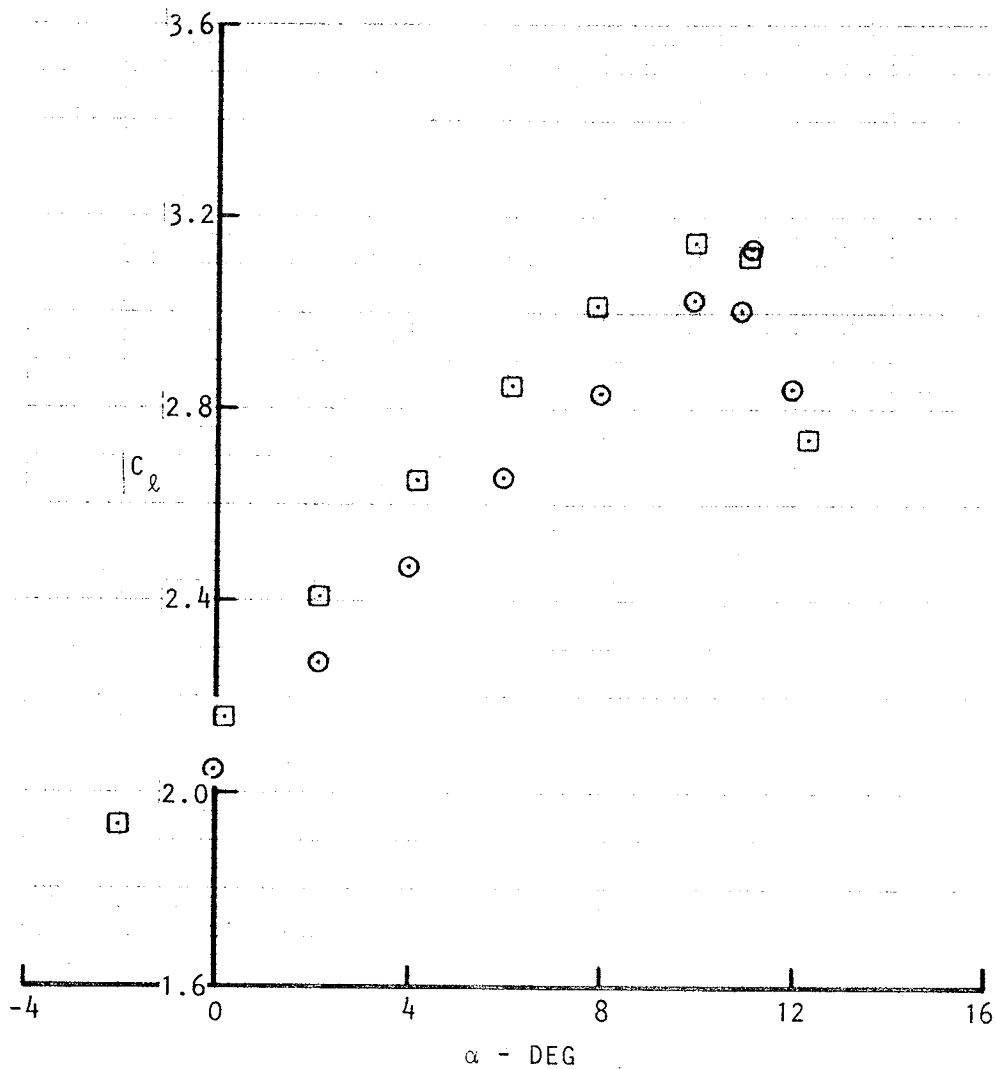

FIGURE 33 VARIATION OF LIFT COEFFICIENT WITH ANGLE-OF-ATTACK, GAW-1 AIRFOIL

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SYM	δ_f	G/C	OH/C	CONFIG.
⊙	40	.015	.025	C(1-3)
⊡	40	.015	0.0	C(4-6)

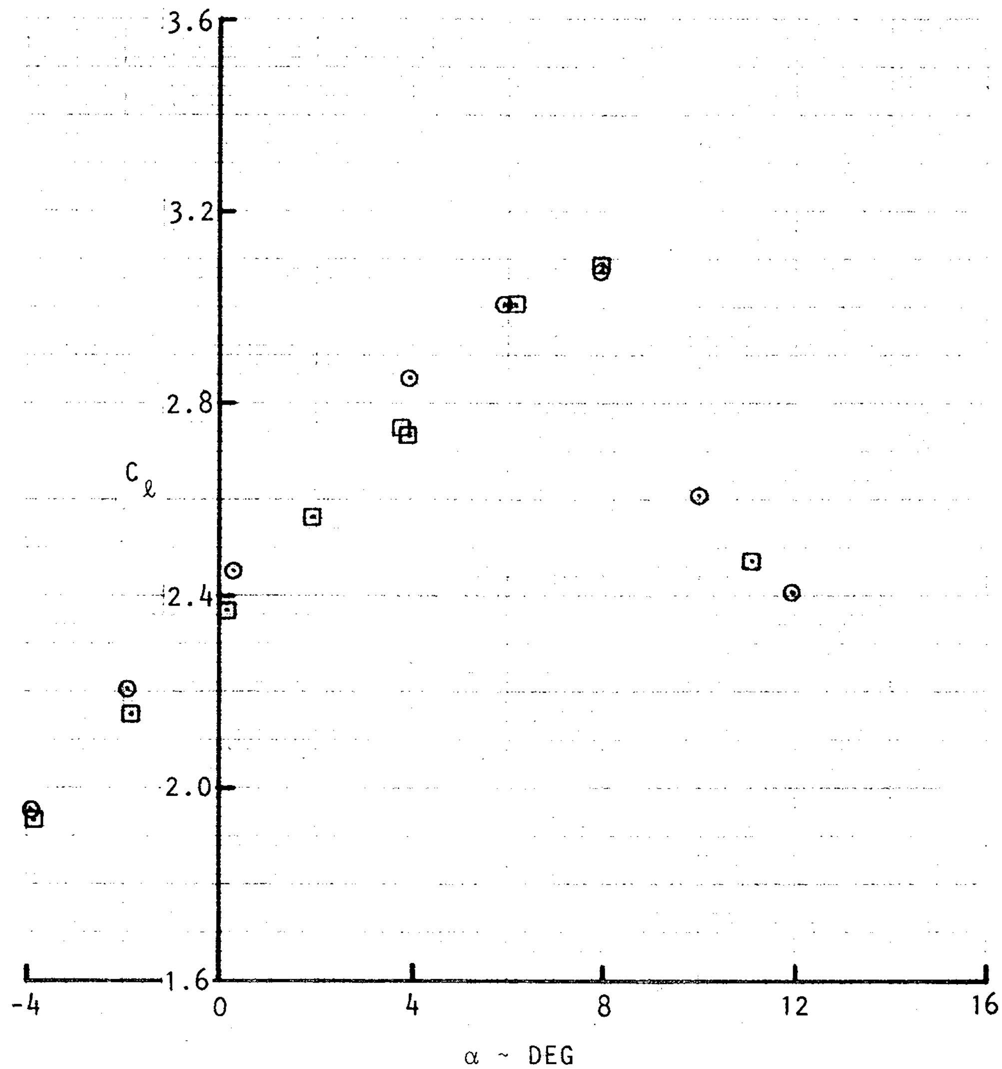

FIGURE 34 VARIATION OF LIFT COEFFICIENT WITH ANGLE-OF-ATTACK, GAW-1 AIRFOIL, CONFIG. C

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SYM	δ_f	G/C	OH/C	δ_s	G/C	OH/C	CONFIG
⊙	0.0	—	—	27°	.023	.028	Ⓓ
⊡	30°	0.025	0.0	42	.015	.015	Ⓔ
△	40	0.015	0.025	42	.015	.015	Ⓕ

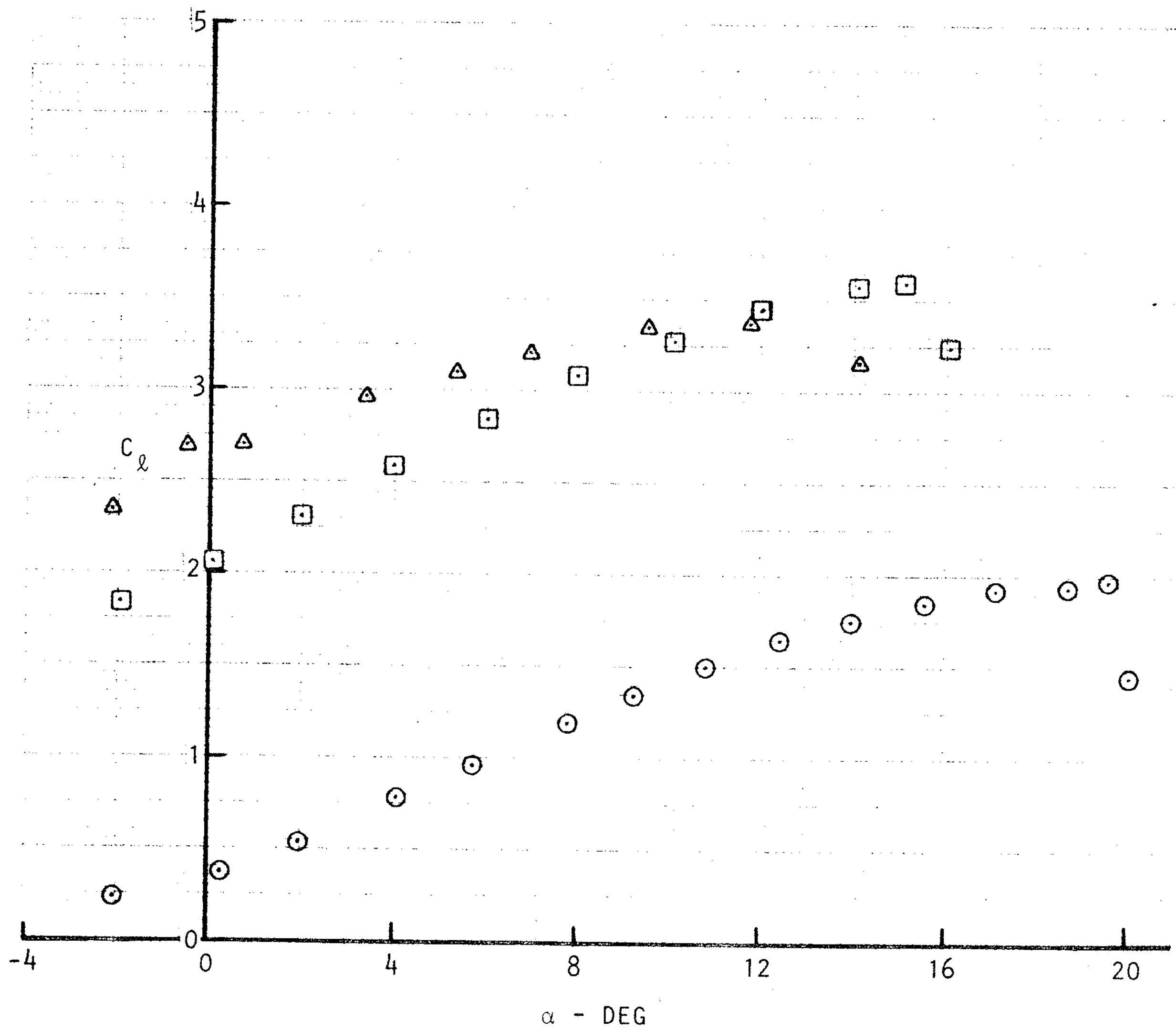

FIGURE 35 VARIATION OF LIFT COEFFICIENT WITH ANGLE-OF-ATTACK, GAW-1 AIRFOIL

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

ERF Ø27 GAW-1M ALPHA=-Ø.5Ø VELOCITY VECTORS

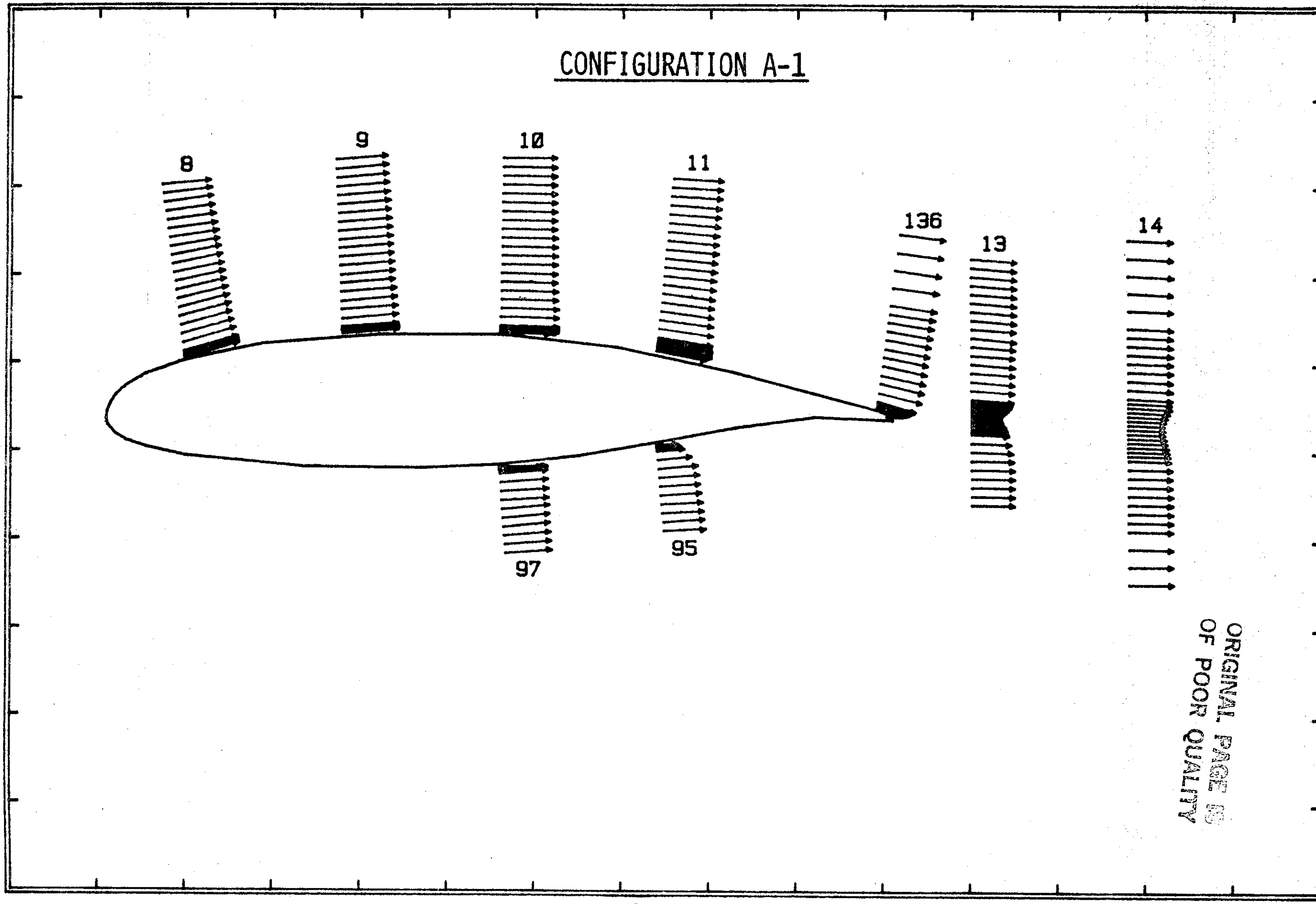

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FIGURE 36

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

ERF Ø27 GAW-1M ALPHA= 3.72 VELOCITY VECTORS

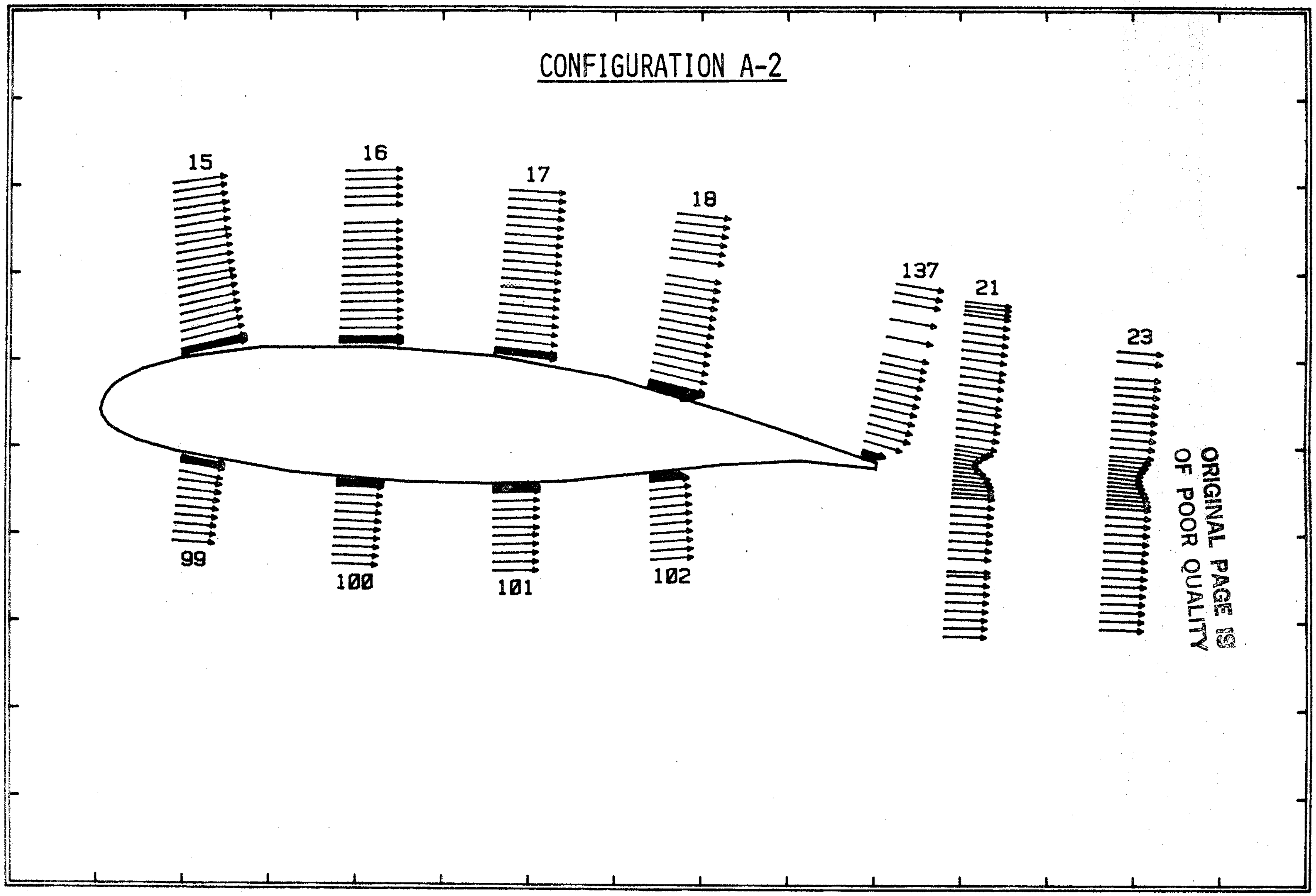

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FIGURE 37

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

ERF 027 GAW-1M

ALPHA= 7.60 VELOCITY VECTORS

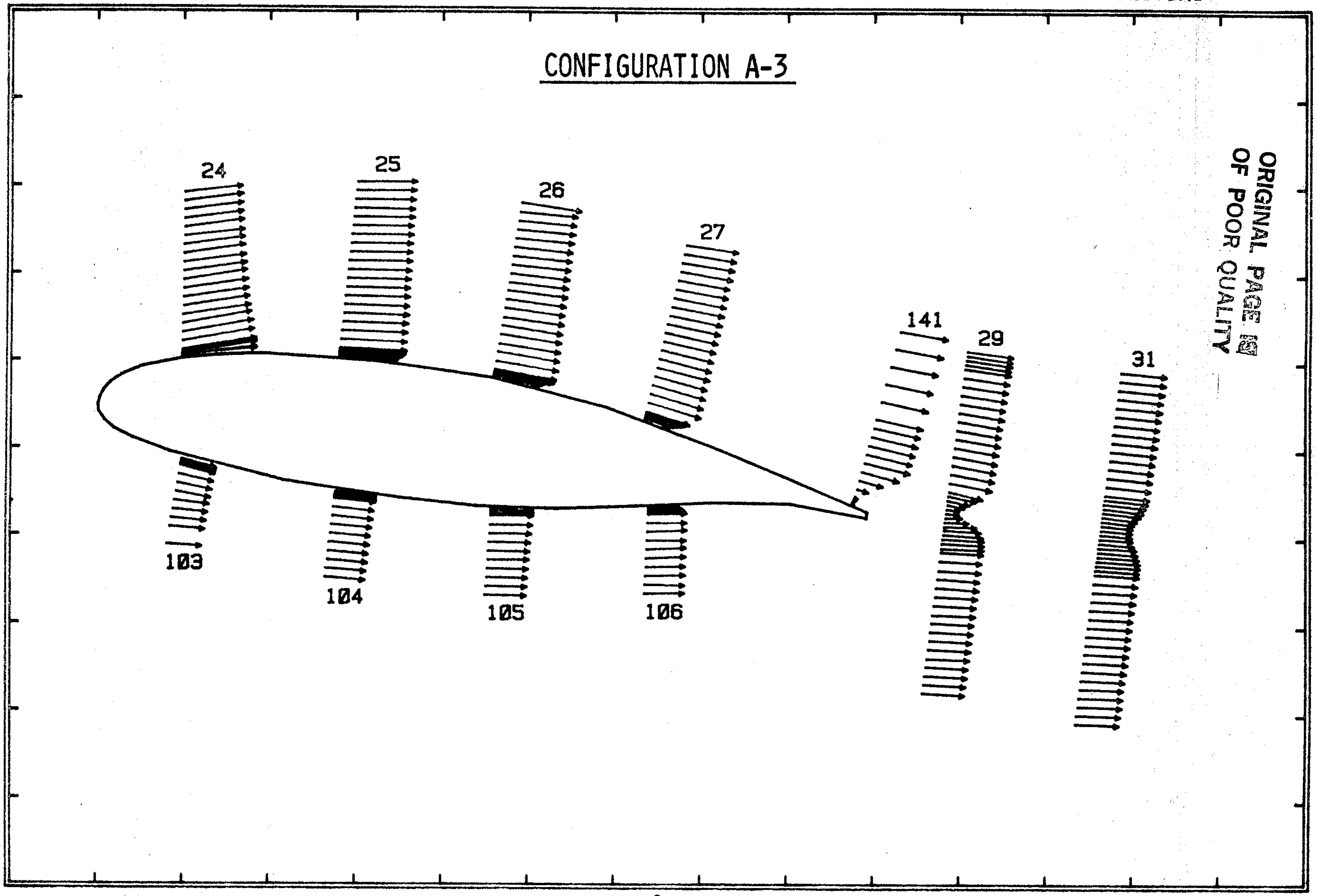

FIGURE 38

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LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

4A

ERF Ø27 GAW-1M   ALPHA=11.48   VELOCITY VECTORS

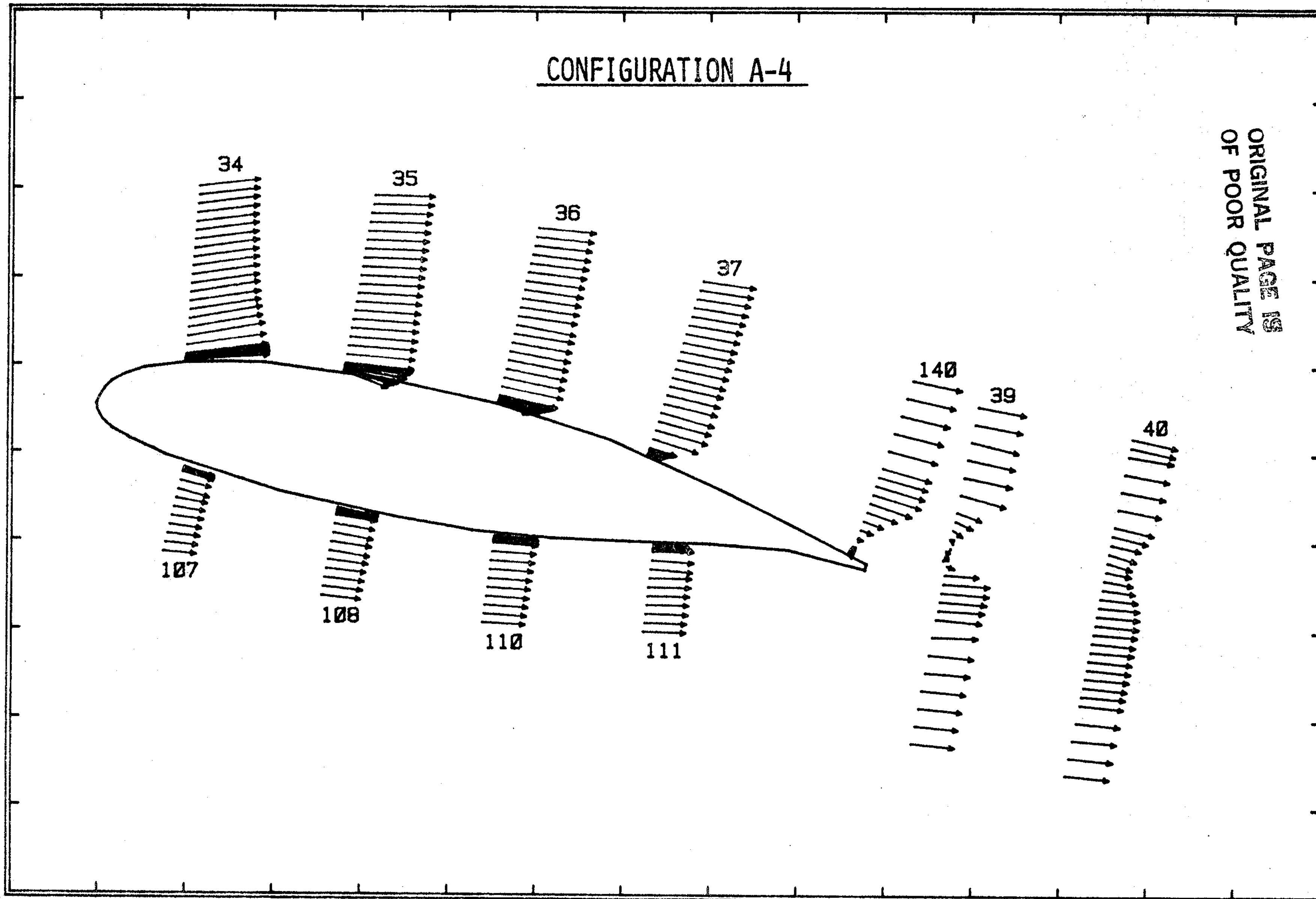

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FIGURE 39

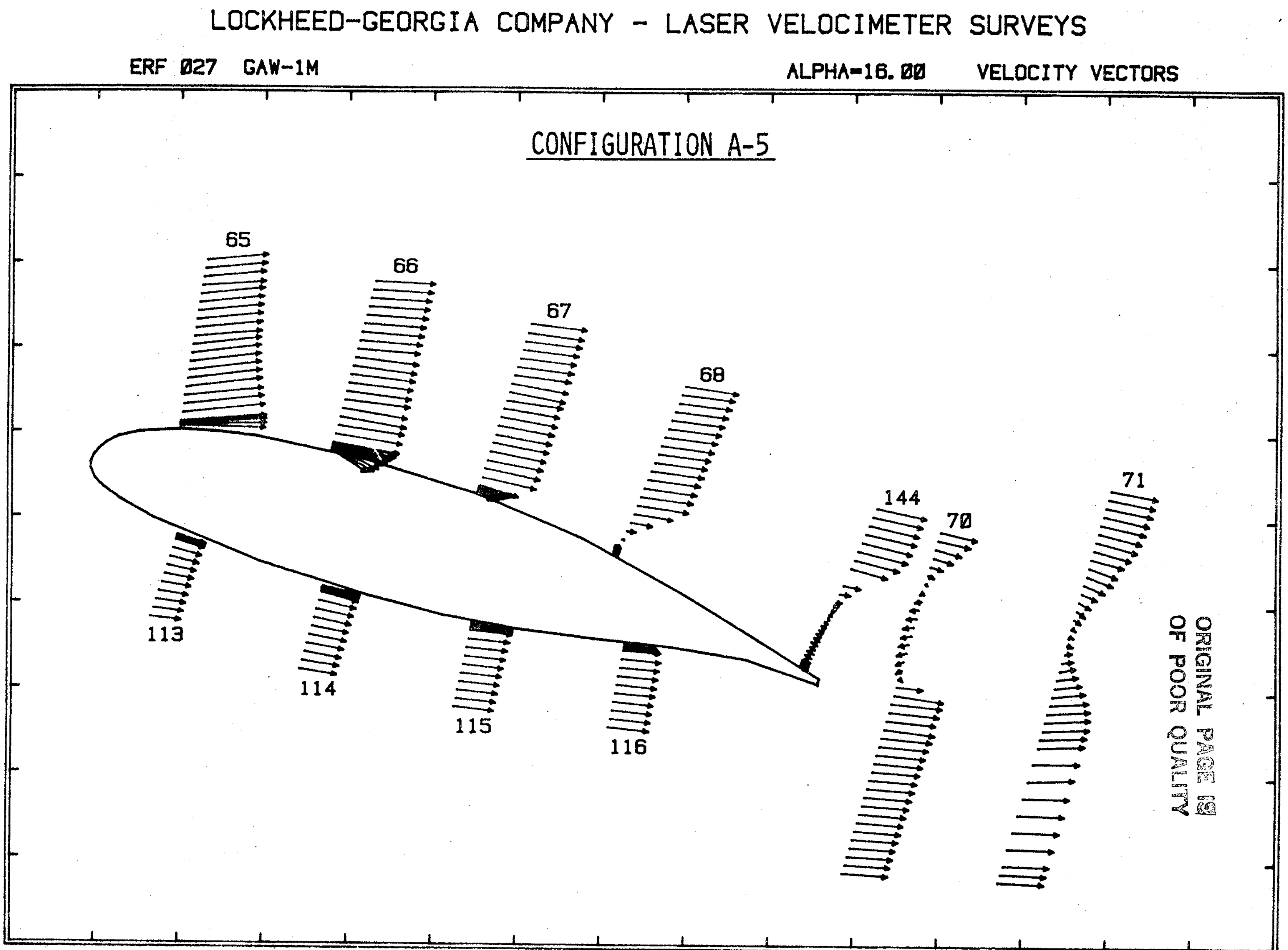

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FIGURE 40

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=30 G=0.040 OH=0.0 ALPHA= 4.00 VELOCITY VECTORS

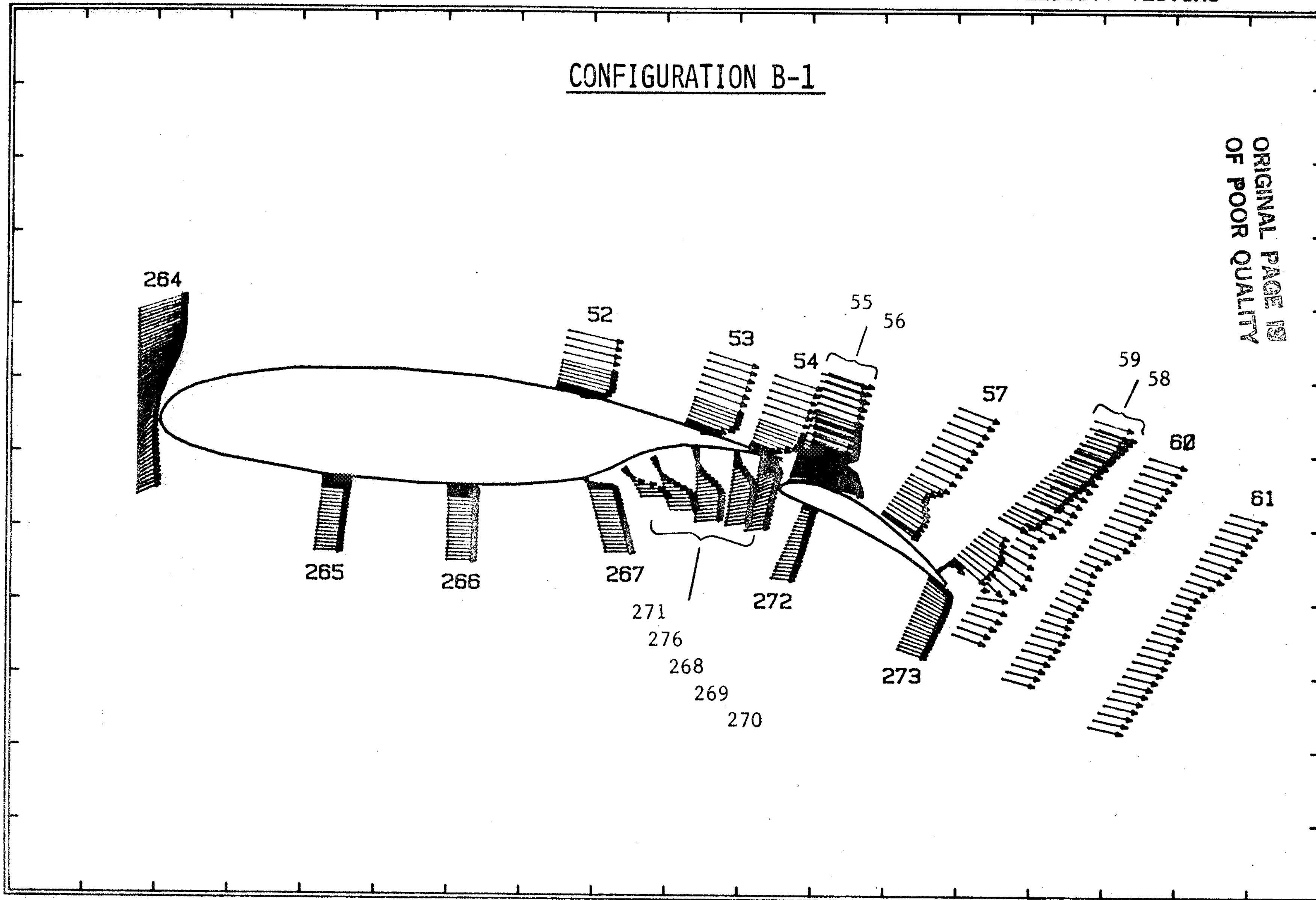

FIGURE 41

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LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=30 G=0.040 OH=0.0 ALPHA= 8.00 VELOCITY VECTORS

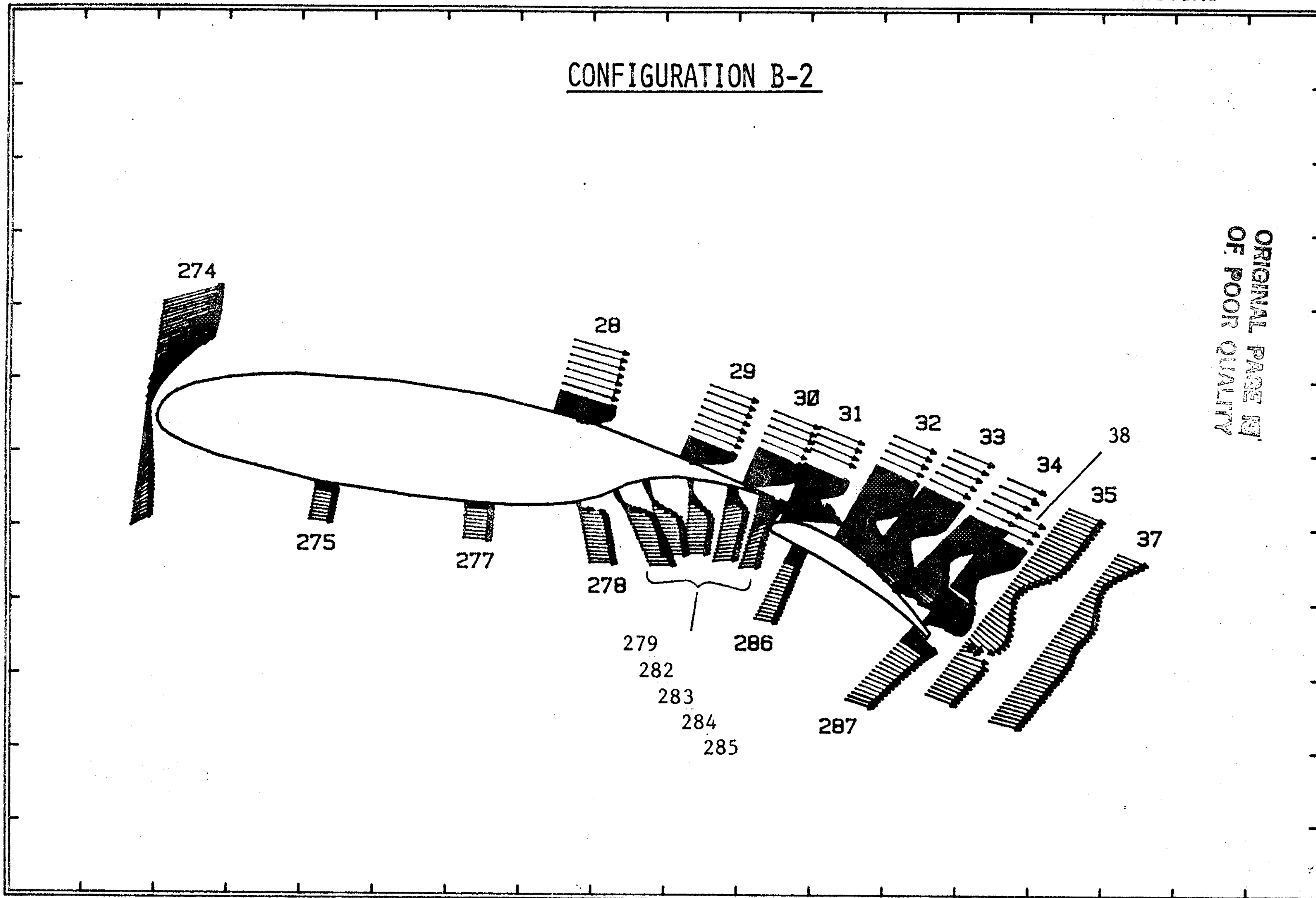

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FIGURE 42

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=30 G=0.040 OH=0.0 ALPHA=12.00 VELOCITY VECTORS

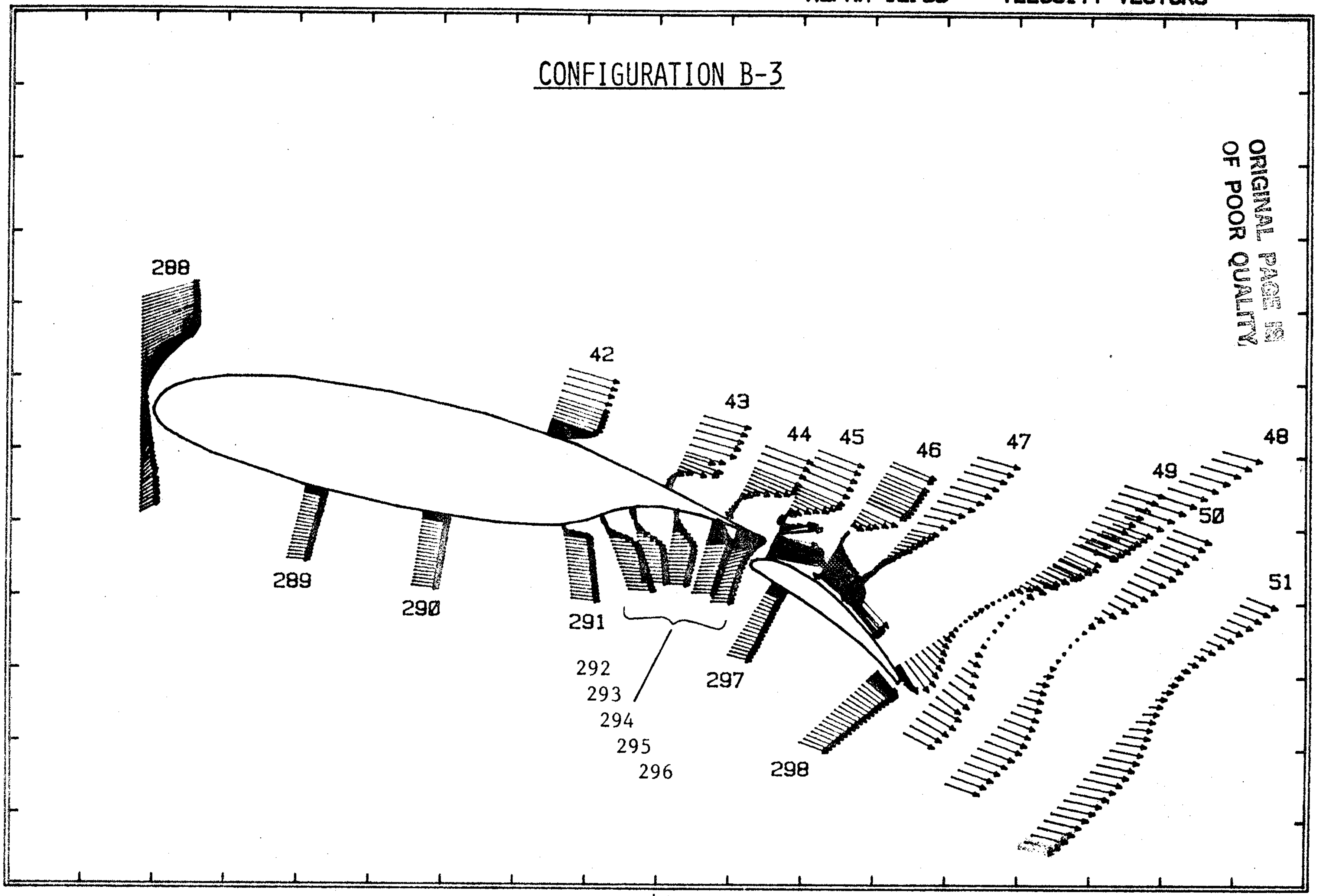

FIGURE 43

4B

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=30 G=0.025 OH=0.0 ALPHA= 4.00 VELOCITY VECTORS

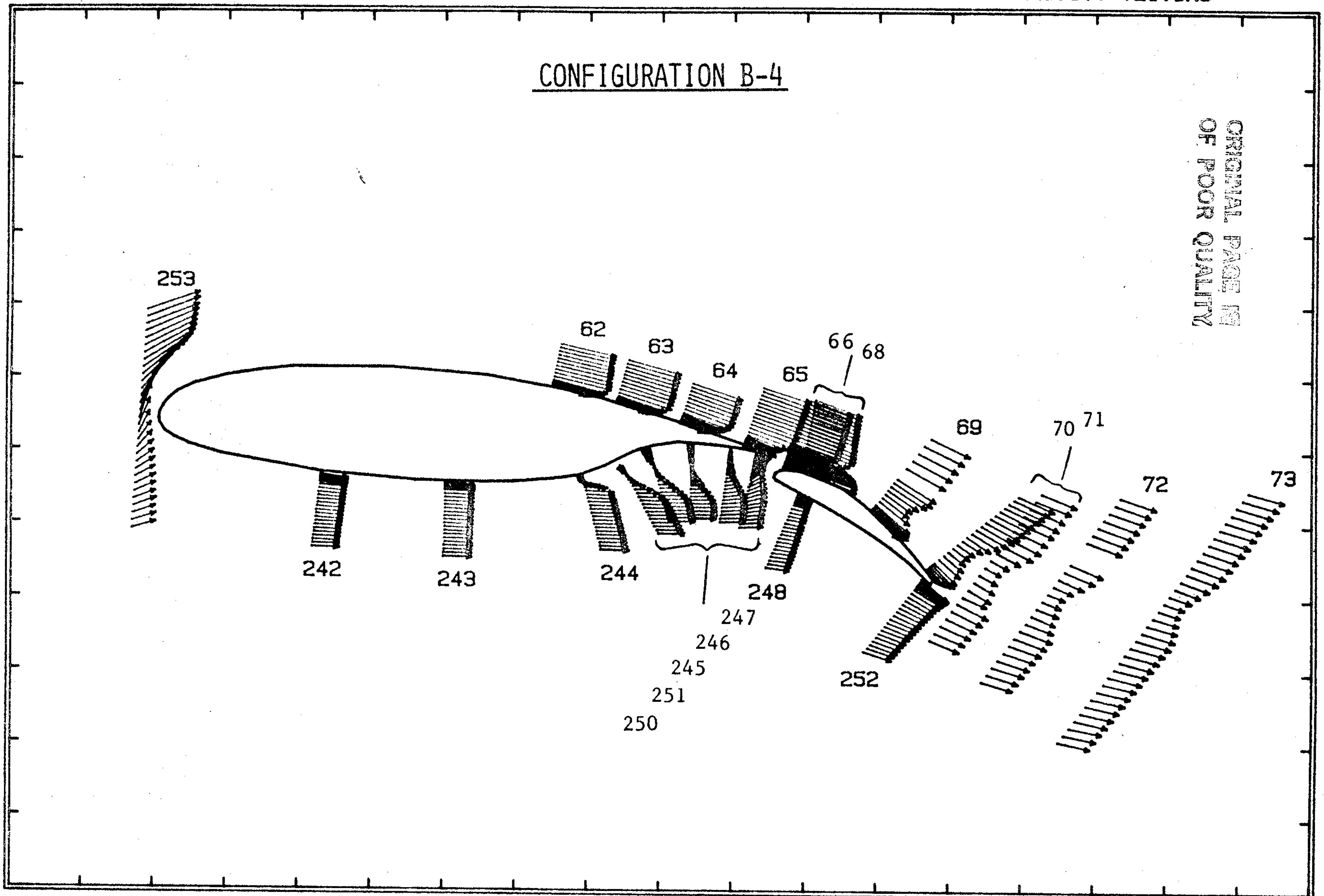

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FIGURE 44

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W FLAP=30 GAP=0.025 OH=0   ALPHA=12.00   VELOCITY VECTORS

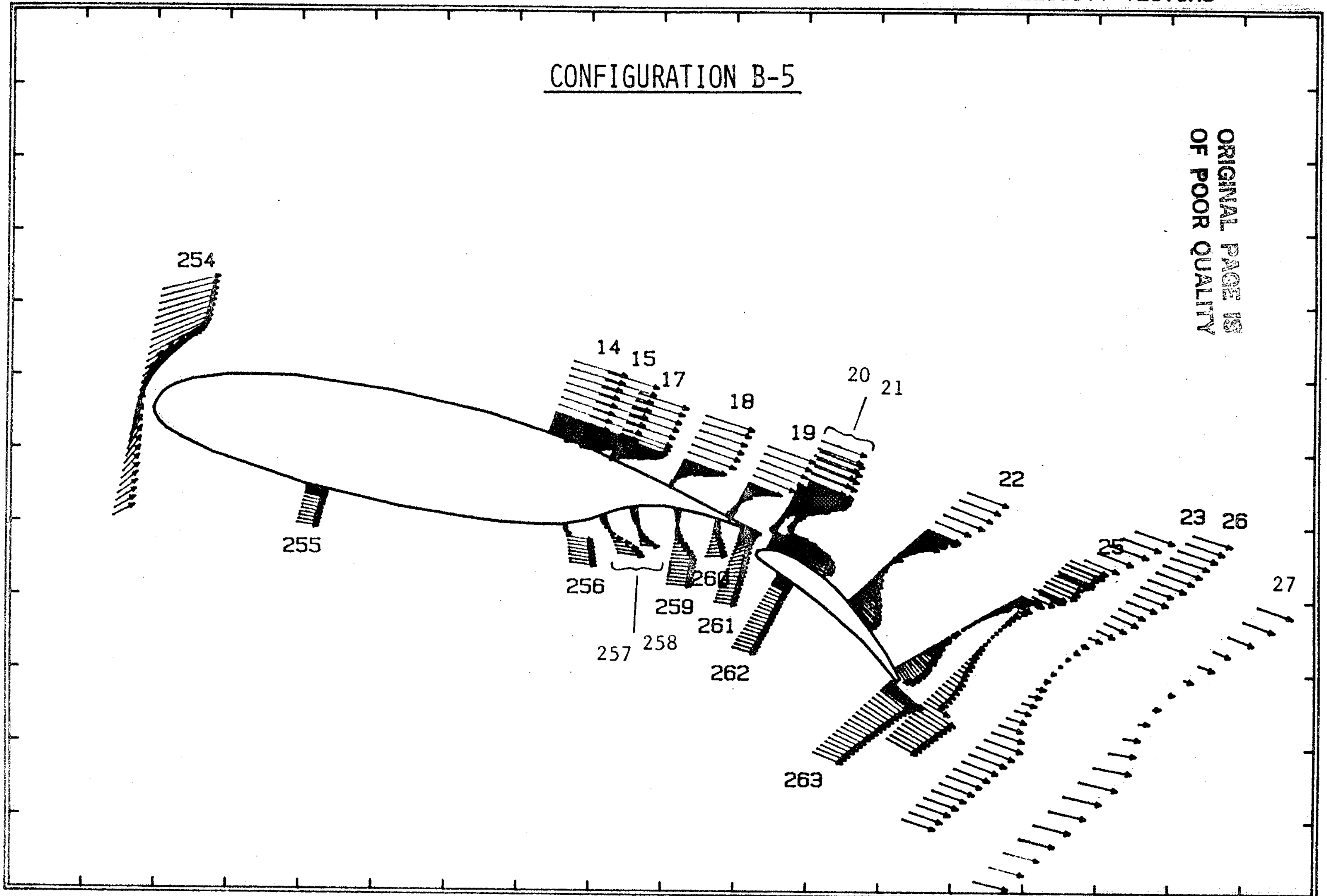

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FIGURE 45

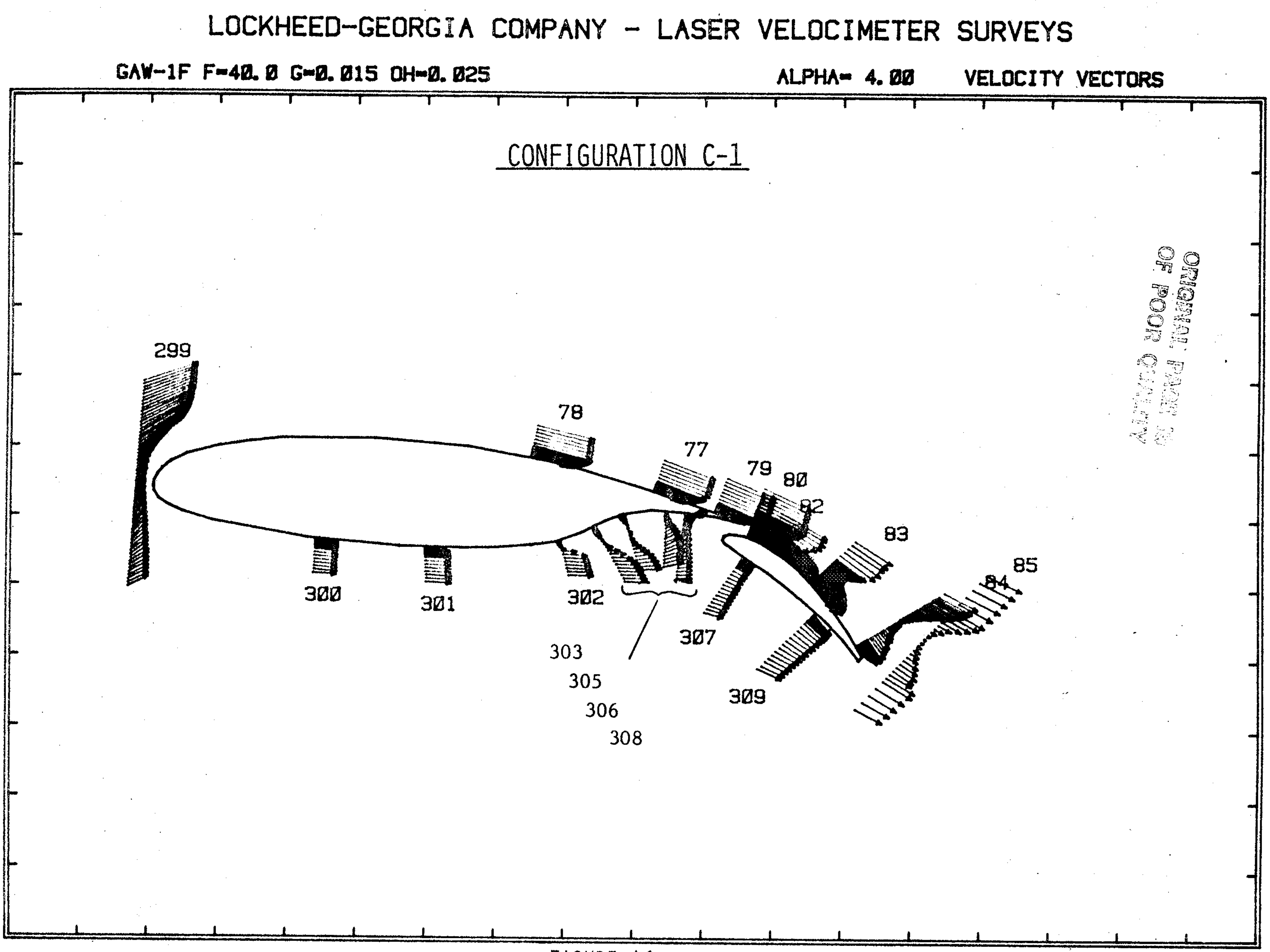

FIGURE 46

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LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=40 G=0.015 OH=0.025 ALPHA= 8.00 VELOCITY VECTORS

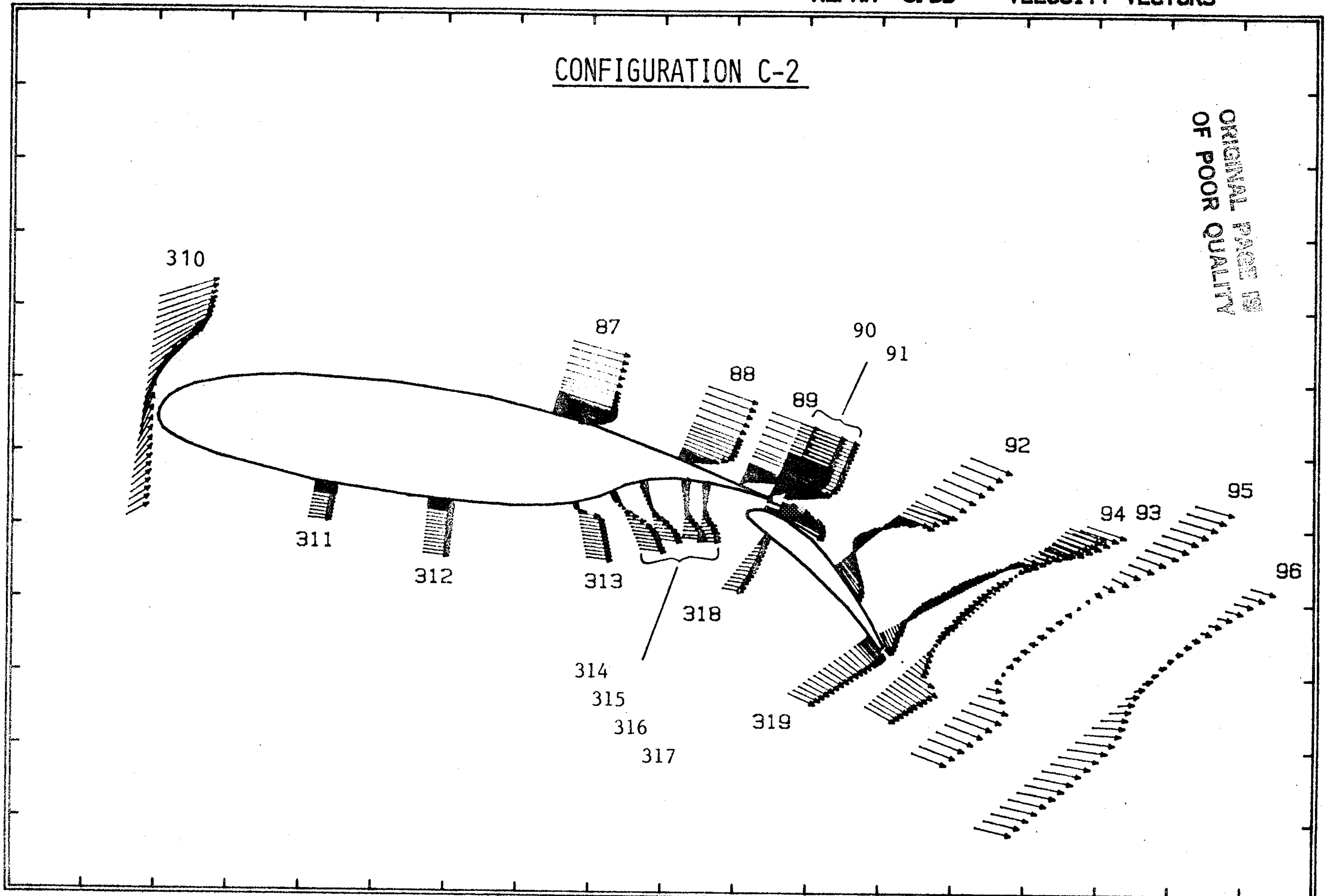

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FIGURE 47

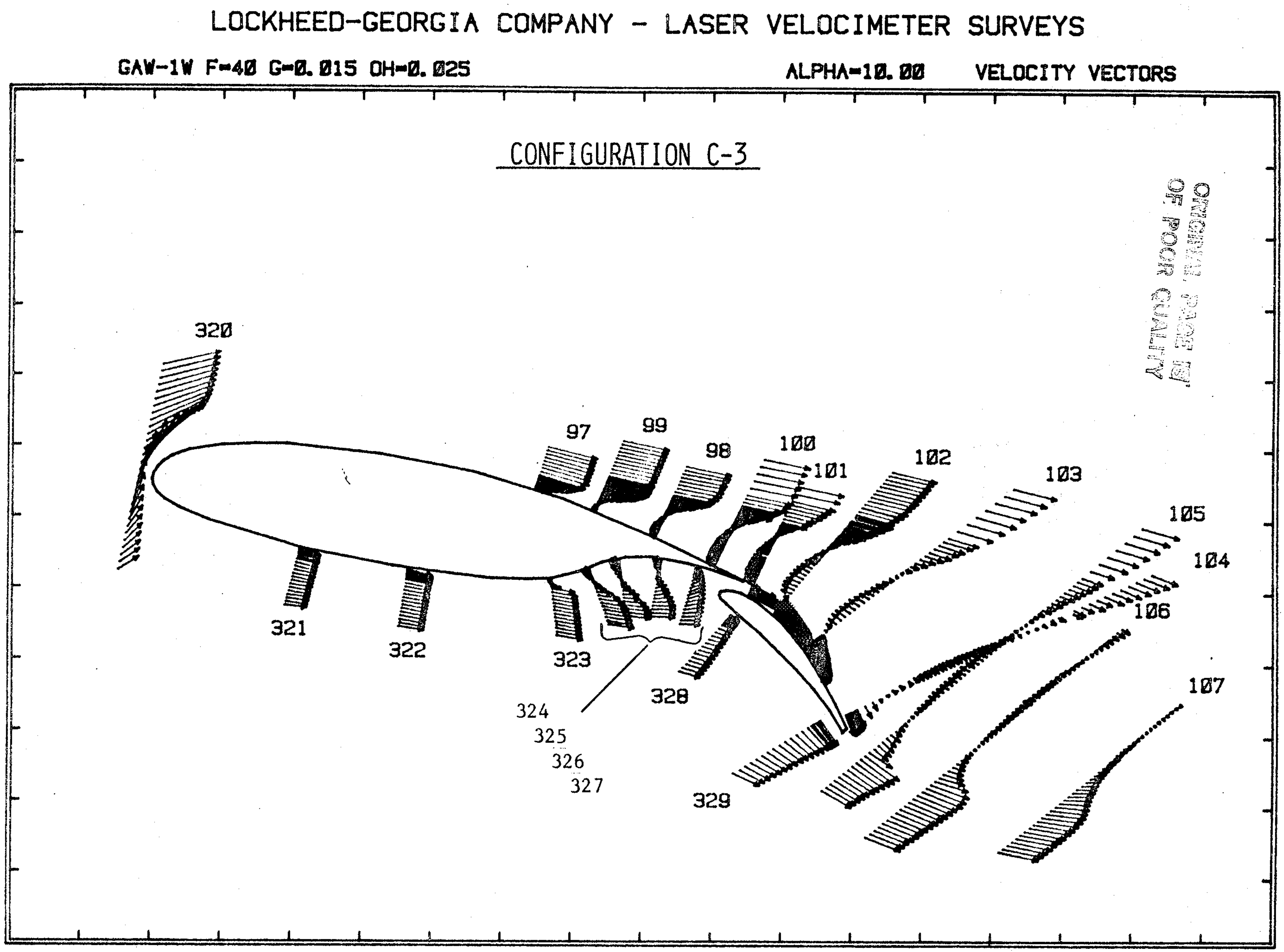

FIGURE 48

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LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=40 G=0.015 OH=0.0 ALPHA= 4.00 VELOCITY VECTORS

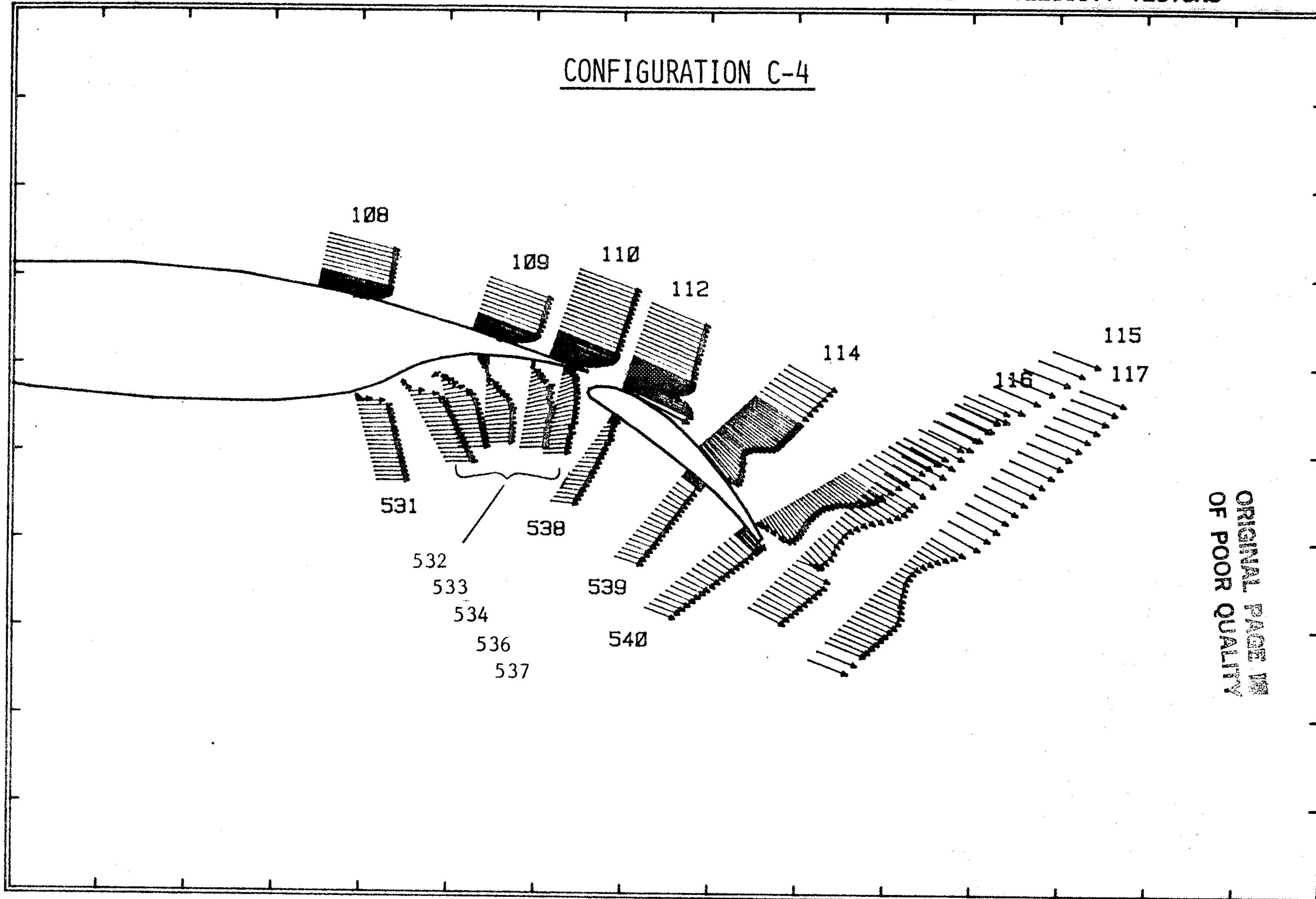

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FIGURE 49

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

ERF 032 GAW-1 FLAP=40 GAP=.015 OH=0.0   ALPHA= 8.00   VELOCITY VECTORS

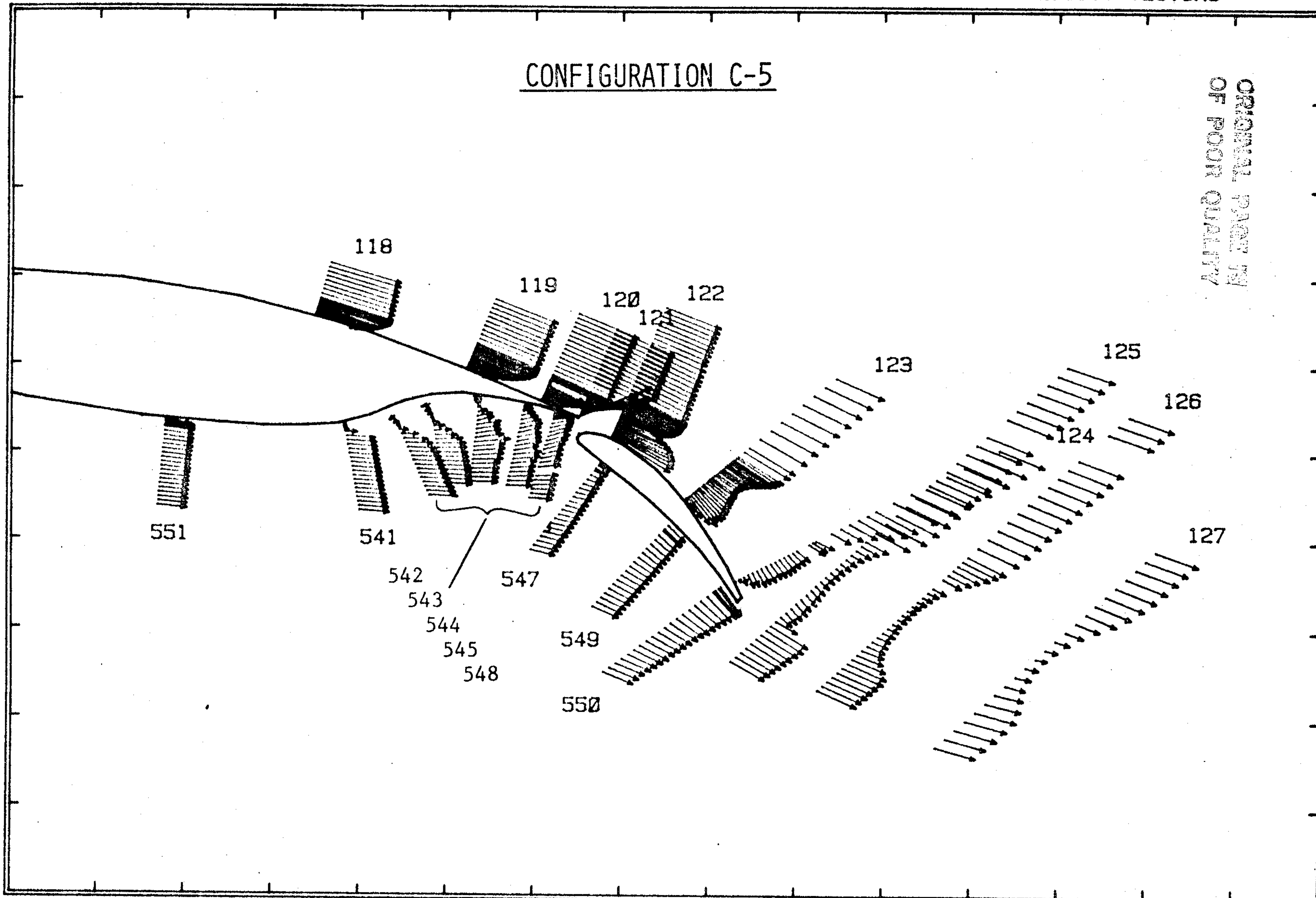

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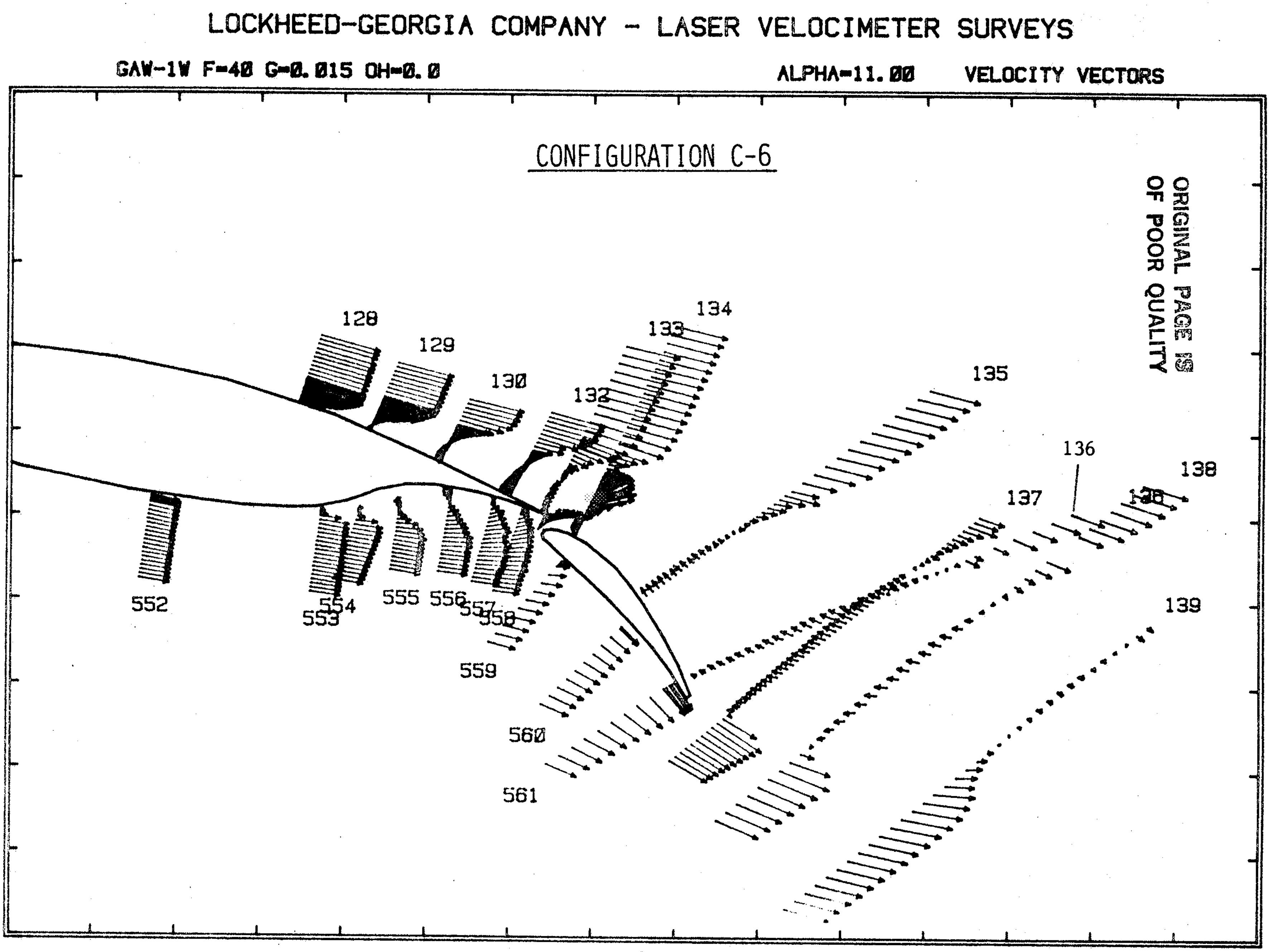
FIGURE 50


LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS
GAW-1W F=40 G=0.015 OH=0.0
ALPHA=11.00
VELOCITY VECTORS
CONFIGURATION C-6
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128
129
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552
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560
561

FIGURE 51

D-1

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=Ø S=27.Ø G=.Ø23 Ø=.Ø28 ALPHA=18.ØØ VELOCITY VECTORS

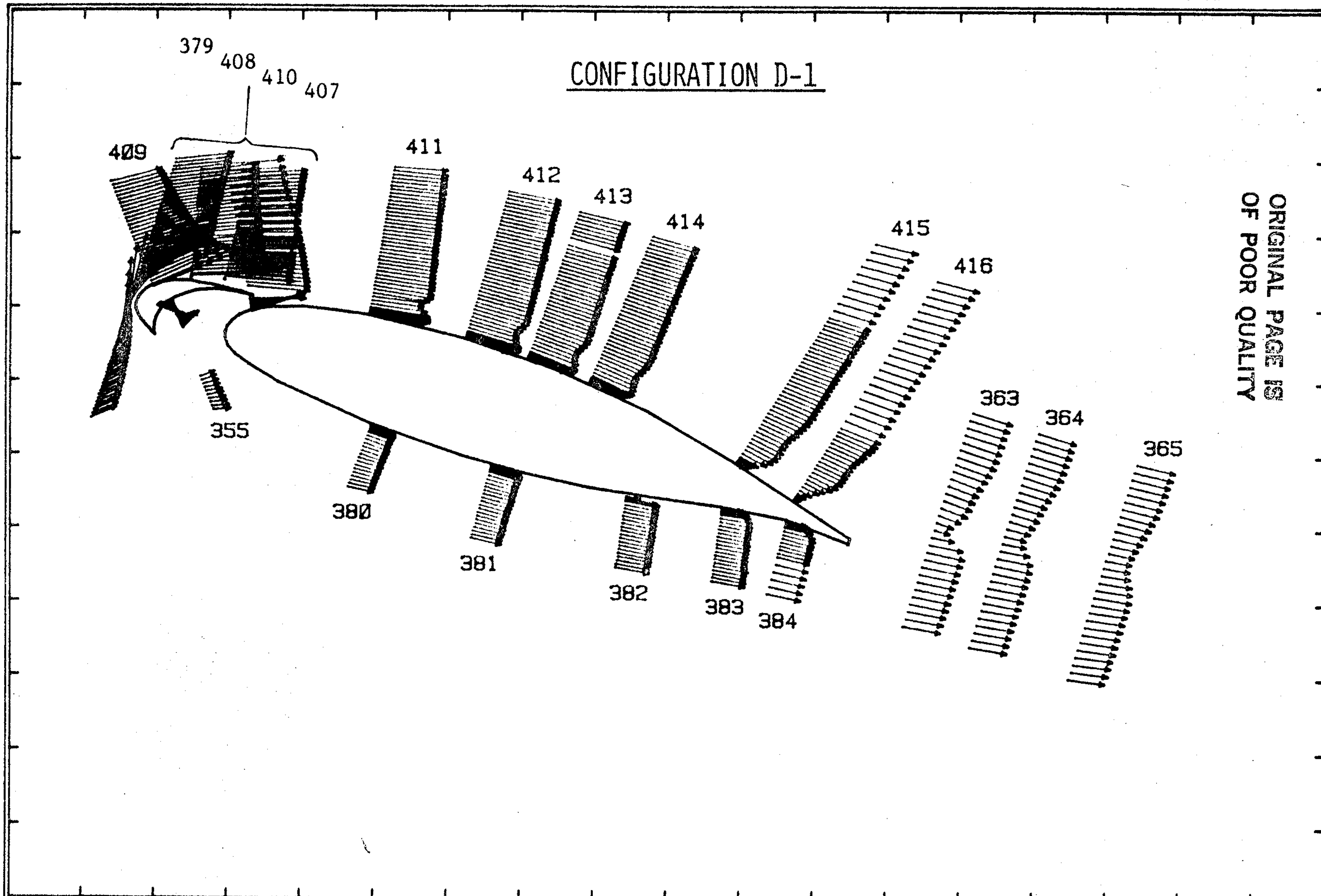

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FIGURE 52

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=0.0 S=27.0 G=0.023 OH=0.028 ALPHA=22.00 VELOCITY VECTORS

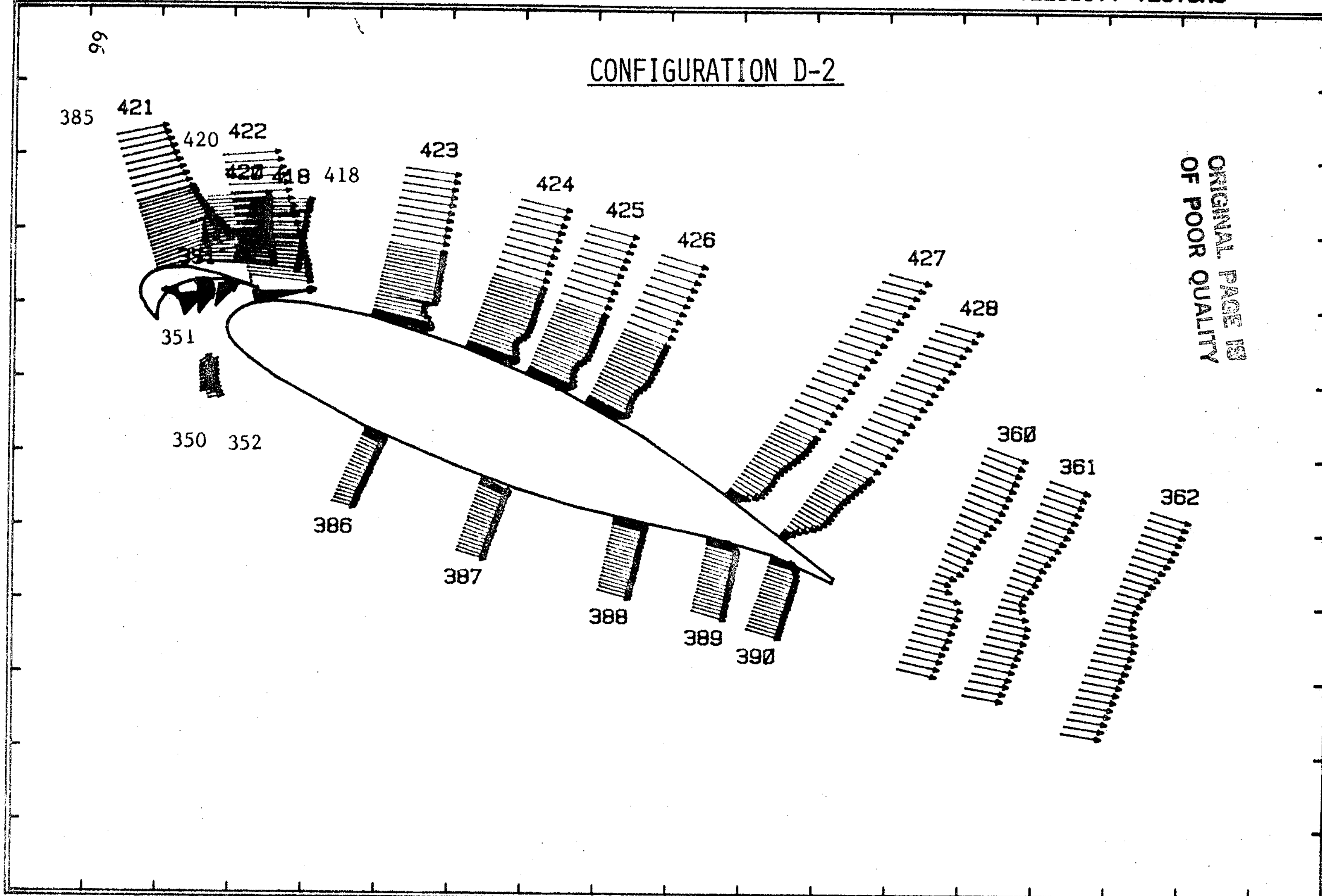

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FIGURE 53

D3

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=0 S=27.0 G=.023 O=.028 ALPHA=24.00 VELOCITY VECTORS

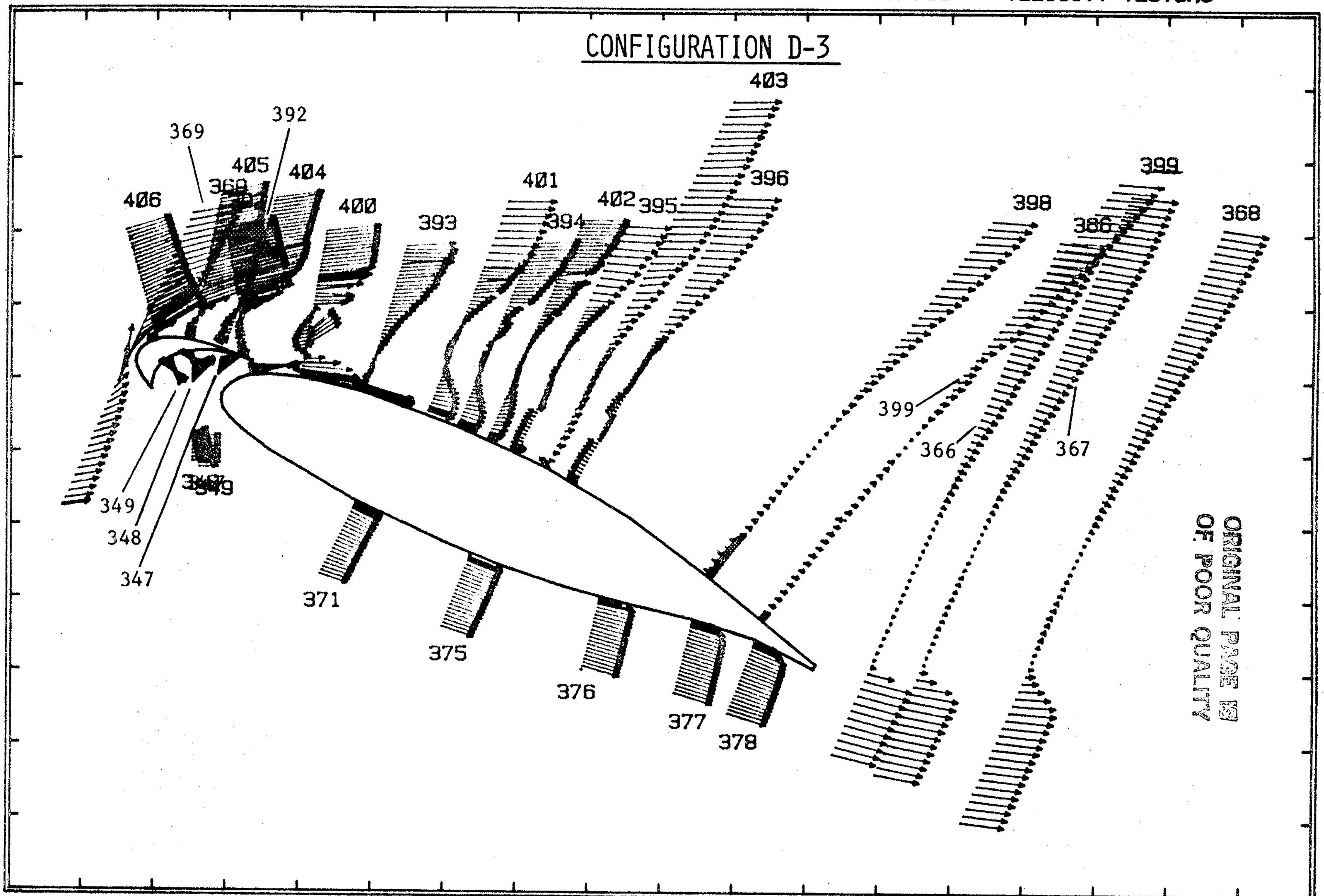

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FIGURE 54

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=30 G=0.025 OH=0.0 S=42.5 G=0.015 OH=0.015 ALPHA=12.00 VELOCITY VECTORS

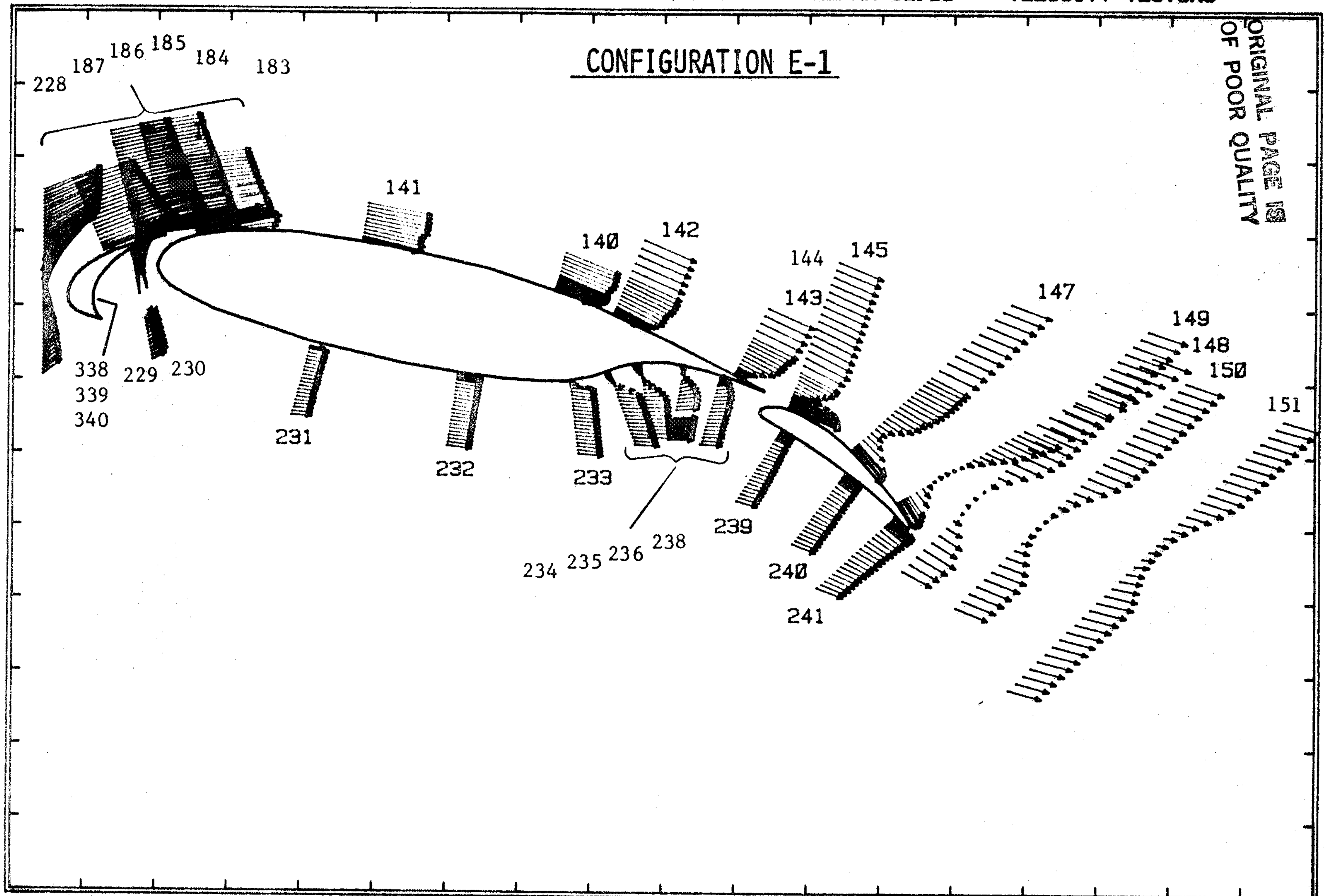

FIGURE 55

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=30 G=0.025 OH=0.0 S=42.5 G=0.015 OH=0.015 ALPHA=14.00 VELOCITY VECTORS

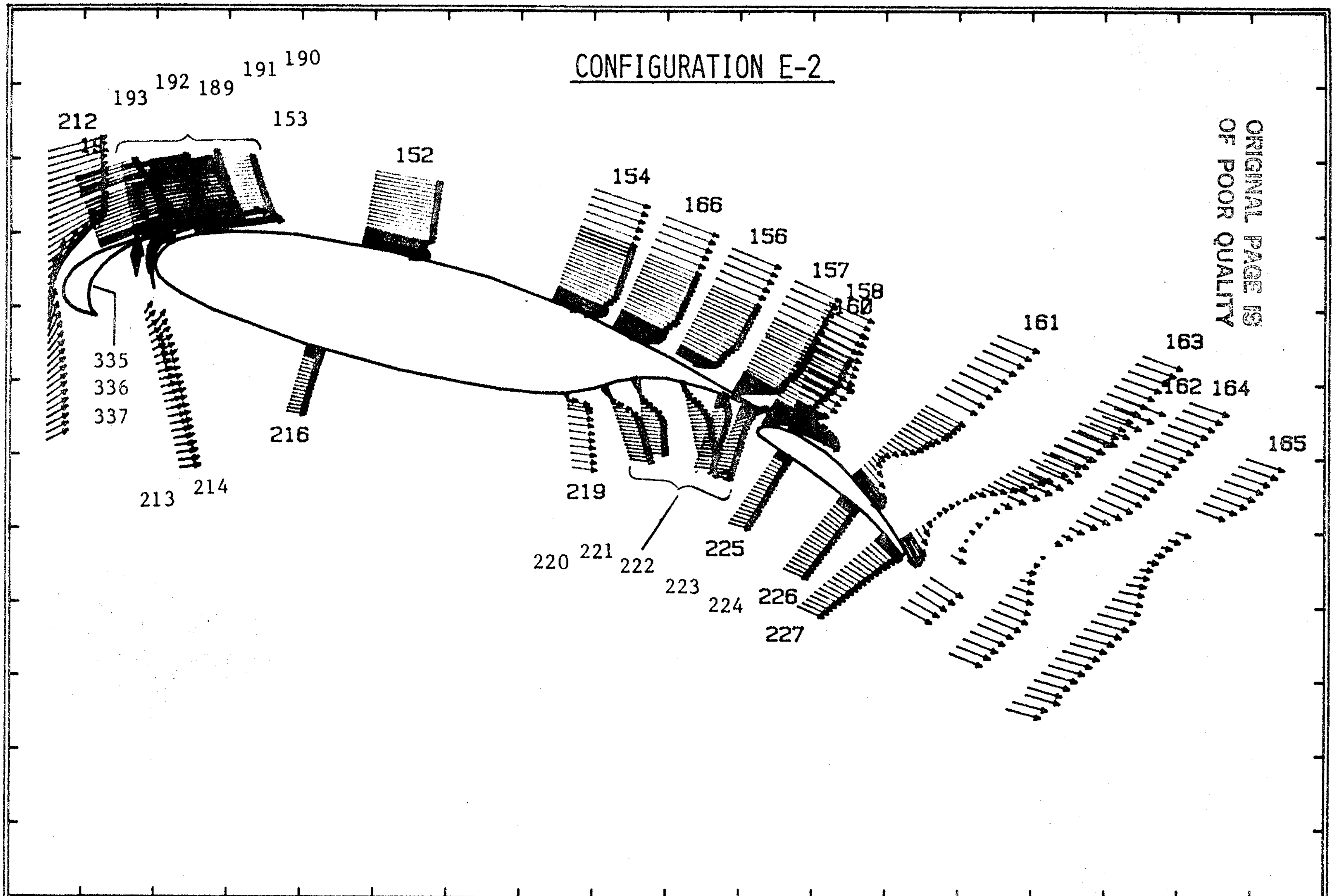

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FIGURE 56

E-3

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=30 G=0.025 OH=0.0 S=42.5 G=0.015 OH=0.015 ALPHA=16.00 VELOCITY VECTORS

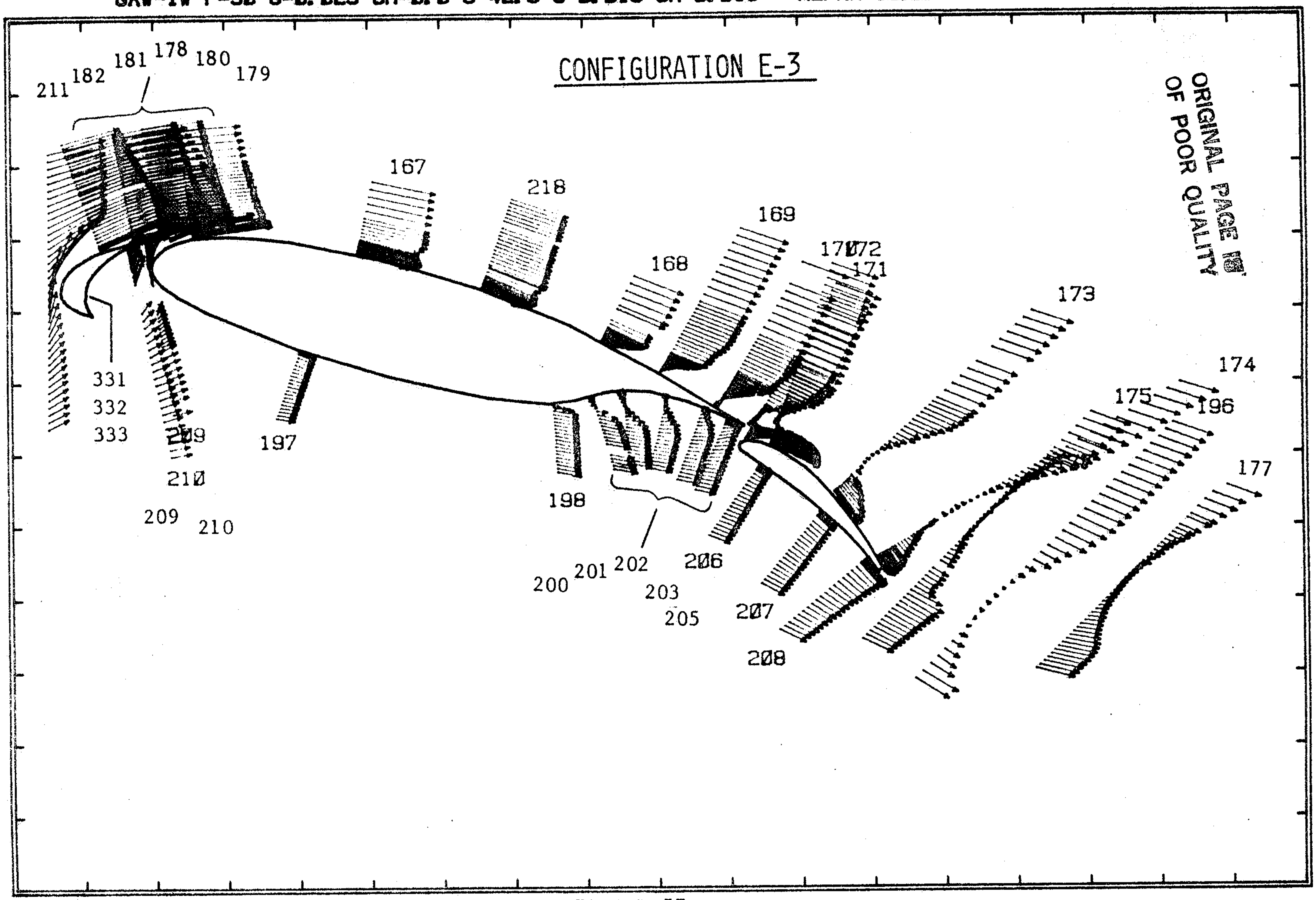

FIGURE 57

F1

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=40 G=.015 OH=.025 S=42 G=.015 OH=.015 ALPHA= 6.00 VELOCITY VECTORS

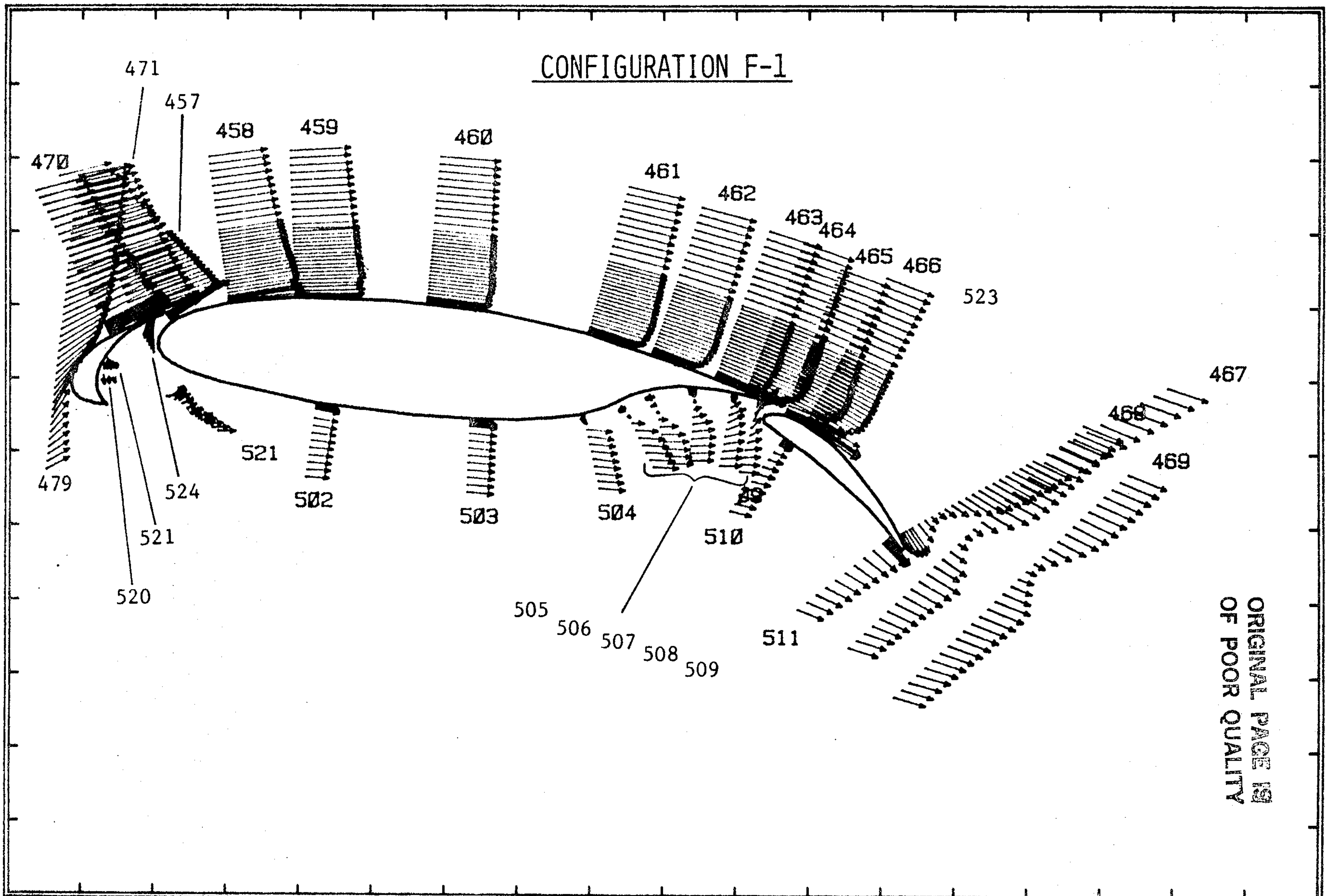

FIGURE 58

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LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=40 G=.015 OH=.025 S=42 G=.015 OH=.015 ALPHA=10.00 VELOCITY VECTORS

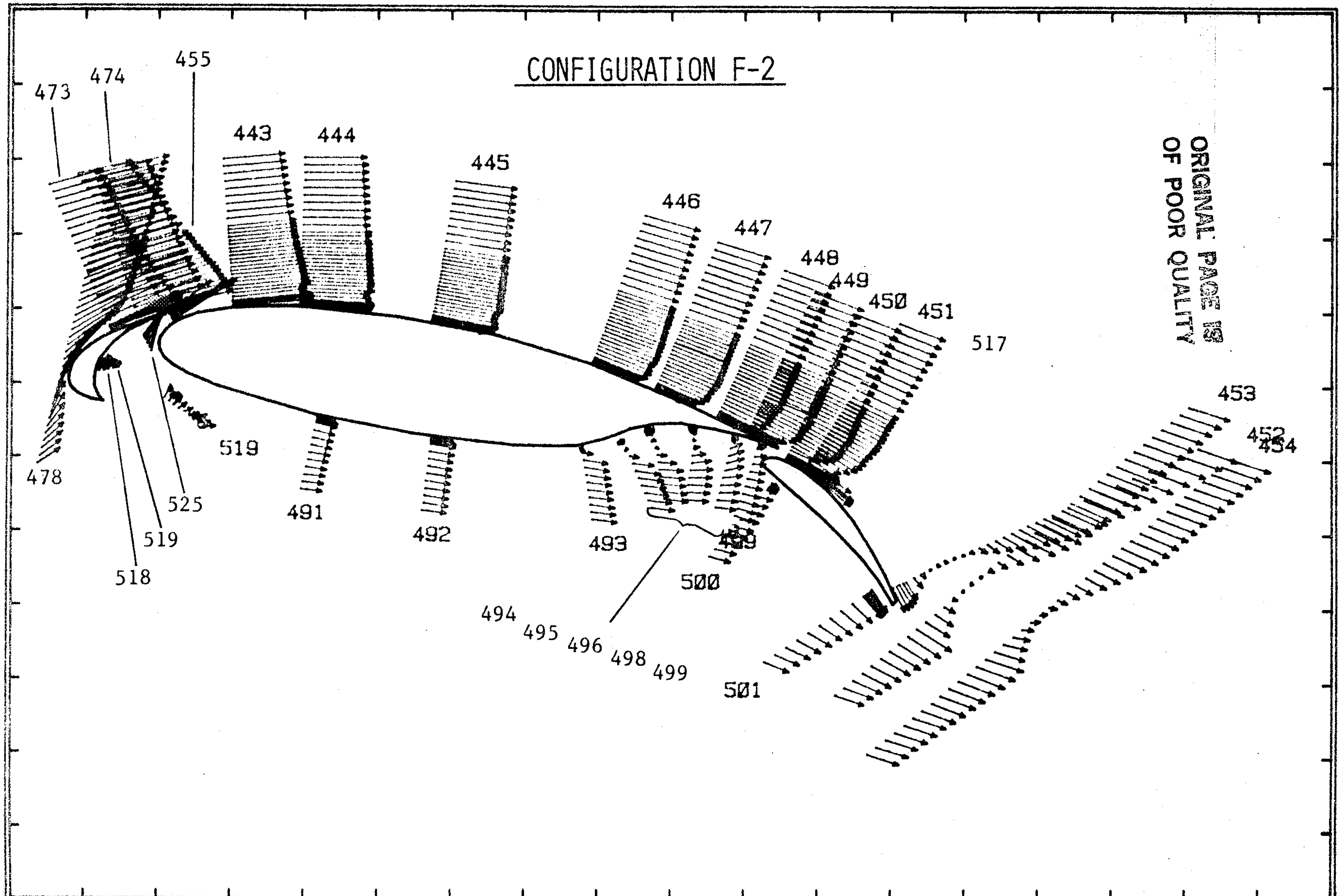

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FIGURE 59

LOCKHEED-GEORGIA COMPANY - LASER VELOCIMETER SURVEYS

GAW-1W F=40 G=.015 OH=.025 S=42 G=.015 OH=.015 ALPHA=14.00 VELOCITY VECTORS

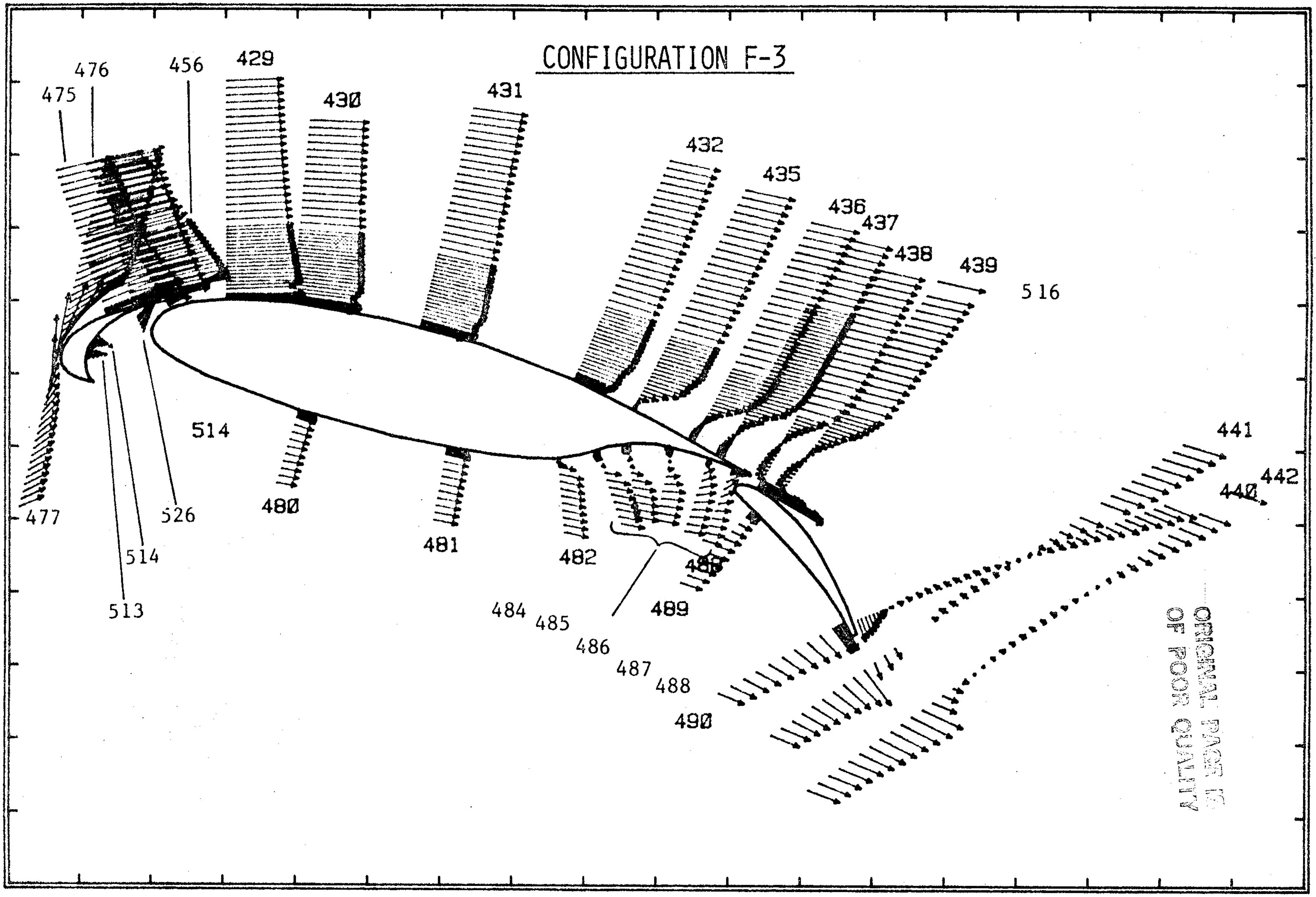

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FIGURE 60

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15. Supplementary Notes

Langley Technical Monitor: Harry L. Morgan, Jr.
Supplement to NASA CR-166018 is available on request.
Final Report

16. Abstract

Test descriptions and results are documented from an experimental low-speed study of the separating confluent boundary-layer on a NASA GAW-1 (General Aviation) high-lift airfoil. The airfoil was tested in a variety of high-lift configurations comprised of leading-edge slat and trailing-edge flap combinations. The primary test instrumentation was a two-dimensional laser-velocimeter (LV) system operating in a "back-scatter" mode. Surface-pressures and corresponding LV-derived boundary-layer profiles are given in terms of velocity components, turbulence intensities and Reynolds shear stresses as characterizing confluent boundary-layer behavior up to and beyond stall. Comparisons are given between LV-derived profiles and associated boundary-layer parameters and those obtained from more conventional instrumentation such as pitot-static traverses, Preston-tube measurements and hot-wire surveys. The complete data set are presented in two separate volumes. Volume I (NASA CR 3655) presents a descriptive summary of the experimental set-up along with limited test results. Pertinent comparisons of the results are made where possible with those from other sources. The present document and its supplement contain the bulk of the experimental measurements in both tabulated and plotted forms.

17. Key Words (Suggested by Author(s)) Boundary Layers Multi-Element Airfoils Laser-Velocimetry	18. Distribution Statement Unclassified - Unlimited Subject Category 02		
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Appendixes A, B, C, D, and E which contain the LV-derived boundary-layer and wake data for approximately 30,000 combinations of airfoil geometric locations and configurations in the form of velocity vectors, turbulence intensities and Reynolds shear stresses are included in a microfilm "Supplement to NASA CR-166018."

Copies of this "Supplement to NASA CR-166018" will be furnished upon request. Request for the supplement should be addressed to:

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