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FLIGHT TEST INVESTIGATION OF TRANSONIC SHOCK-BOUNDARY LAYER PHENOMENA

Jones F. Cahill
Bill L. Cooper

Lockheed-Georgia Company

TECHNICAL REPORT AFFDL-TR-68-84
VOLUME II

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AIR FORCE FLIGHT DYNAMICS LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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FLIGHT TEST INVESTIGATION OF TRANSONIC SHOCK-BOUNDARY LAYER PHENOMENA

Jones F. Cahill
Bill L. Cooper

FOREWORD

This report describes a flight investigation of the phenomenon of scaling effects on shock-boundary layer interaction in transonic flow. It was prepared by the Flight Sciences Division of the Lockheed-Georgia Company, Marietta, Georgia, under Air Force Contract F33615-67-C-1777. The work was administered under the direction of the Air Force Flight Dynamics Laboratory, with Mr. A. J. Murn, FDMM, as Project Monitor.

The work reported here was performed during the period from 5 October 1967 to 15 July 1968. This report was submitted by the authors in July 1968.

The authors acknowledge the contributions of the following members of the Lockheed-Georgia Company to the project: Mr. H. J. Coley who supervised the Design, Construction and Installation of the Test Equipment; Mr. A. J. Youngs who directed the Flight Operations; Mr. B. M. Coleman who directed the Data Reduction; and Messrs. W. J. Campbell, P. E. Cole, T. T. Eckert, and Mrs. C. H. Sullins who assisted in the test program and data analysis.

This technical report has been reviewed and is approved.

PHILIP P. ANTONATOS
Chief, Flight Mechanics Division
Air Force Flight Dynamics Laboratory

ABSTRACT

A flight test investigation was made using a Lockheed C-141 airplane to obtain data related to scale effects on transonic shock-boundary layer interactions. The primary measurements consisted of wing surface chordwise pressure distributions at three spanwise stations, and boundary layer profiles for three chordwise positions at one spanwise station. Tests were made at nominal altitudes of 20,000 feet and 40,000 feet, resulting in Reynolds number values of approximately 70×10^6 and 40×10^6, respectively. At each altitude data were collected at a number of combinations of Mach number (from 0.7 to 0.85) and lift coefficient (from 0 to approximately 0.4). Variations in lift coefficient were obtained by varying load factor.

Volume I contains the data analysis and discussions of the test results. Volume II contains a detailed discussion of the data acquisition and reduction procedures plus a complete presentation of the basic data.

Results obtained, when compared with previously available wind tunnel data, showed that large scale effects on chordwise pressure distribution can occur with turbulent boundary layers on a wing having small Mach number gradients forward of the shock. A shock-induced separation, followed by flow reattachment, was shown to occur when the shock pressure rise reached a value approximately equal to that indicated in NACA Report 1356. Increasing Mach number or angle-of-attack sufficiently beyond the initial separation point caused the separation bubble to spread to the trailing-edge, resulting in an abrupt forward movement of the shock. While the flight shock locations were within the spread of those shown by low Reynolds number wind tunnel results, no single wind tunnel configuration (transition strip, Reynolds number, vortex generator) provided a good indication of the flight result over the whole range of conditions tested. For wing sections of the type used on the C-141, scale effects on buffet phenomena should be anticipated also.

Distribution of this abstract is unlimited.

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LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (CONTINUED)

LIST OF ABBREVIATIONS AND SYMBOLS

C_L		airplane lift coefficient (- $N_z W/qS$)
	N_z	load factor
	q	dynamic pressure
	S	wing area
	W	airplane weight
C_p		pressure coefficient
M_{BL}		Mach number in the boundary layer
M_L		Mach number outside the boundary layer
M_∞		freestream Mach number
V_{BL}		velocity in the boundary layer
V_L		velocity outside the boundary layer
X/C		streamwise coordinates in terms of airfoil chord
Y		vertical coordinate as measured from wing surface
$\Lambda_{L.E.}$		wing leading edge sweep angle
$\Lambda_{T.E.}$		wing trailing edge sweep angle

SECTION I

TEST PROGRAM

General

The C-141 airplane was used in this program to obtain wing pressure distributions and corresponding boundary layer profiles at transonic speeds. Pressure distributions were obtained at three spanwise stations, and boundary layer profiles at three chordwise locations for one spanwise station. Instrumentation consisted of standard ship's system instrumentation plus a test nose boom, surface static pressure tubing and boundary layer total pressure rakes.

The test objectives were to obtain an accurate measurement of shock locations and boundary layer characteristics over as wide a Reynolds number range as possible. Static pressure pick-ups were installed every two and one-half percent chord, on the wing upper surface, in the region of the shock. The spread in Reynolds number was from values of approximately 70×10^6 to 40×10^6.

Instrumentation

Surface pressures were measured on the right wing at the three spanwise locations shown in Figure 1. STRIP-A-TUBE of approximately one-eighth inch height and three inch width was bonded to the wing surface. Tubing was attached to the wing fixed structure and flaps separately so as to allow for full flap travel without damage to the tubing. Holes were drilled in the STRIP-A-TUBE at the desired chordwise locations and resulted in twenty-five upper surface orifices, nineteen lower surface orifices plus leading edge and trailing edge orifices at each spanwise station. SCANIVALVES were located in the flap cove area and wiring routed to an oscillograph located in the cargo compartment. Surface pressures were referenced to the test boom static source. A few of the orifices were lost during testing due to leaks in the tubing. Data were also lost on the most inboard station, during one flight, due to a malfunction of the SCANIVALVE. The malfunction was corrected and the lost data recovered on subsequent flights.

Figure 2 shows photographs of the boundary layer rakes used in this investigation. The rakes were located on the left wing at one spanwise station. This location corresponded to the middle station used in wing surface pressure measurements. The three inch high rakes were at 30% and 55% chord positions and the five inch high rake was at 80% chord. The rakes did have a small amount of spanwise variation to assure that one rake would not be in the wake of another. The spanwise variation between rakes was five inches with the 55% chord rake located at wing station 373. All rakes were equipped with two

static pressure probes. Measurement with the boundary layer static probes generally gave good agreement with surface-measured pressures for rakes forward of the shock. In the shock and aft of the shock static pressure data from the probes is subject to question because of possible large flow angles in the boundary layer. For example, in some cases it was noted that the static pressure as measured by the probes was lower than that measured on the surface. Total probes are more insensitive to flow angles and are believed to give good results except in separated flow regions.

The five inch rake has two total probes that face in the aft direction to measure the total pressure of the reversed flow in a separated boundary layer. The results of these measurements were disappointing and again the problem appeared to be large flow angularity with respect to the probes. It is believed that when the flow separates a considerable amount of spanwise flow exists. In some separated cases it was noted that the static probes and both the forward-facing and the aft-facing total probes were recording the same values of pressure. This condition would be expected if the flow were essentially normal to the axis of the probes or if the flow were completely random. No meaningful results were obtained from the aft facing probes and the results were plotted at $V_{BL}/V_L = 0$ on the boundary layer profile plots in Section III of this report.

Boom total pressure was used as the reference pressure for the rake measurements. Some problems did exist in boom total pressure on the high altitude test. Moisture apparently condensed in the total pressure probe and froze during tests above 28,000 feet. The outer probes on the boundary layer rakes were always recording freestream conditions so they were used as reference pressure for all the high altitude data. Flight 549 was made with a moisture-free boom and proved the validity of using the rake probes, outside the boundary layer, as reference sources.

Information on flight conditions (Mach number, dynamic pressure, ambient pressure and temperature, and airplane load factor) were obtained from the standard airplane instrumentation and a nose boom. Figure 3 shows details of the test boom used in the investigation. Figure 4 shows the pitot-static probe installation used as a part of the standard airplane instrumentation. Two independent pairs of pitot-static probes are located on each side of the fuselage and provide pneumatic information to the pilot's and copilot's central air data computer respectively. The ship's airspeed system was used to determine flight conditions and its accuracy was checked with the boom airspeed system. Exact agreement between the two systems existed at all flight Mach numbers.

SECTION II

TEST PROCEDURES AND DATA REDUCTION

Test Procedures

Previous wing surface pressure data were available from the original C-141 flight-demonstrated loads investigation, Reference 1. The variations between wind tunnel-measured and flight-measured shock locations were apparent but the exact magnitude of the differences could not be determined due to wide spacing (10% to 15% of the chord) of the measuring orifices. Subsequent to the loads investigation, a wind tunnel test, Reference 2, accurately measured the upper-surface shock locations and boundary layer profiles on a C-141 wing model. Variations in testing techniques were investigated by using different methods of transition location, vortex generators and changing of test Reynolds number. The purpose of the flight program has been to obtain similar information over as wide a Mach number, lift coefficient and Reynolds number range as possible to allow for comparison with the wind tunnel data.

Tests were made at nominal altitudes of 20,000 feet and 40,000 feet to obtain the widest practicable spread in Reynolds number, resulting in values of approximately 70×10^6 and 40×10^6 respectively. At each altitude, data were collected at a number of combinations of Mach number (from 0.7 to 0.85) and lift coefficient (from 0 to approximately 0.4). Variations in lift coefficient were obtained by varying load factor since the range available from gross weight changes alone was not sufficient for the purposes of this investigation.

The test procedures in some cases were difficult and required considerable skill on the part of the pilots. The airplane was stabilized at a Mach number and altitude and the positive load factors achieved by turning flight. The negative load factors were achieved by a roller coaster maneuver and data recorded while going over the top in a nose over condition. Attempts to hold the steady condition resulted normally in 15 to 20 seconds of data records, and in the most severe case in 5 to 6 seconds of records. The SCANIVALVE sequence time was 3 seconds. Checks for steadiness of the data were made by comparing adjacent records. During each test run the SCANIVALVE was allowed to record continuously.

Since it is not possible to maintain constant values of all primary flight conditions (Mach number, altitude, lift coefficient) during tests of this type, it was considered desirable to demonstrate the absence of extraneous effects in the data measured. In this test series, the most practicable procedure was to hold Mach number and load factor constant and to accept the altitude changes which were necessary to attain the desired test point.

Figures 5 and 6 present the results of tests designed to measure the lag effects on total and static pressures due to altitude changes. Conditions 547/4B1 and 547/4B2 were made in stable flight at an altitude of approximately 20,000 feet. The pressure data were recorded holding the aircraft at constant altitude, Mach number, and load factor. The effects of lag were tested and are shown as conditions 547/4A1 and 547/4A2. The aircraft was placed in a dive at an altitude of approximately 30,000 feet and a constant rate-of-sink established at 8,000 feet per minute. As the aircraft passed through 20,000 feet, the data as shown for conditions 547/4A1 and 547/4A2 were recorded. The Mach numbers and load factors were the same as recorded during the constant altitude test. The results indicate that the measurable lag in the pressure system is zero. Therefore, any altitude changes that might exist in the remainder of the test data should be of no consequence.

Figure 7 presents the scope of the flight test investigation. Lift coefficients and Mach numbers are presented for both the low and high altitude test.

Data Reduction

Data Reduction involved reducing the surface pressure measurements to pressure coefficients and the boundary layer profiles to velocity ratios. These computations were performed by a UNIVAC 1108 computer and the data plotted by a cathode ray tube plotter.

The surface pressure measurements were reduced to pressure coefficients and corrected for the boom position error. Superimposed on each pressure distribution plot are lines showing constant values of local Mach number normal to the local wing element lines. The following equation was used to calculate pressure coefficients for constant local Mach lines:

$$C_p = \left(\frac{2.0}{\gamma M_\infty^2}\right)\left[\left(\frac{1.0 + [(\gamma-1)/2]\, M_\infty^2 \cos^2\beta}{1.0 + [(\gamma-1)/2]\, M^2_{LOCAL}}\right)^{\frac{\gamma}{\gamma-1}} - 1.0\right]$$

where $$\beta = \tan^{-1}\left[\tan\Lambda_{LE} - (X/C)(\tan\Lambda_{LE} - \tan\Lambda_{TE})\right]$$

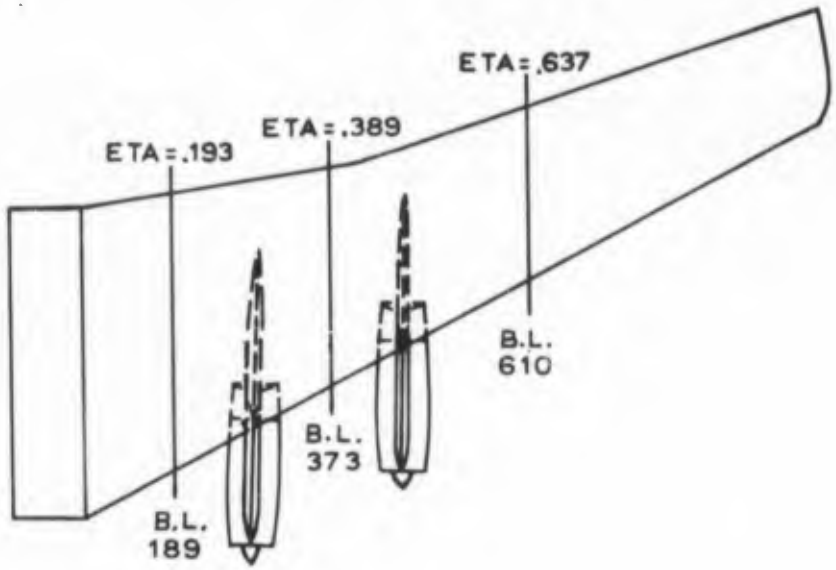
The boundary layer total pressure profiles were reduced to ratios of velocity within the boundary layer (V_{BL}) to velocity outside the boundary layer (V_L). The following equation was used to calculate velocity profiles:

$$V_{BL}/V_L = (M_{BL}/M_L)\left[\sqrt{\frac{1.0 + [(\gamma-1)/2]\, M_L^2}{1.0 + [(\gamma-1)/2]\, M_{BL}^2}}\right]$$

where $$M = \sqrt{5\,(P_t/P_s)^{2/7} - 5}$$

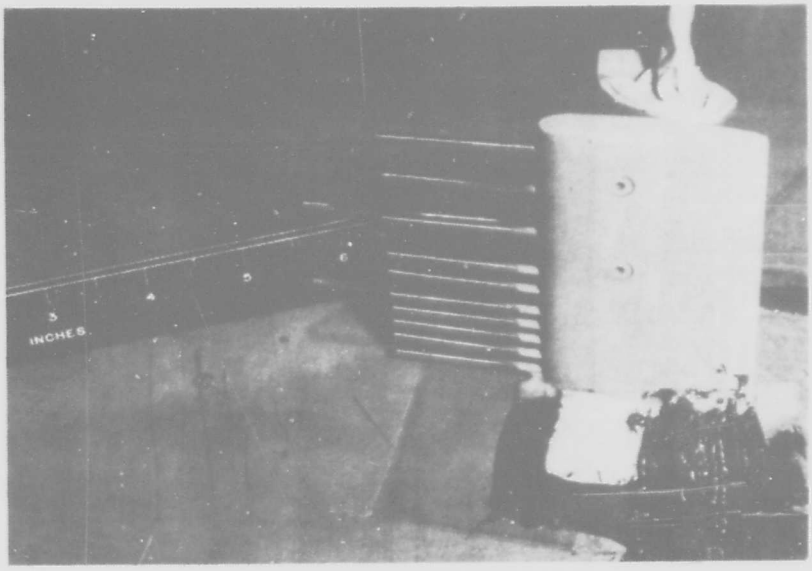
Static pressures in the boundary layer were obtained from the surface pressure measurements obtained by use of the STRIP-A-TUBE on the right wing at the same wing station.

The airplane angle-of-attack was obtained by use of a vane on the test boom. The boom indicated angle-of-attack was corrected for position error to arrive at the correct angle-of-attack. In cases where it was desirable to know the angle-of-attack of an equivalent rigid airplane (for comparisons with wind tunnel model data) it was necessary to account for aerodynamic twist. The twist angle at each spanwise station was calculated for the specific flight condition. The equivalent rigid angle-of-attack was obtained by algebraically adding the aerodynamic twist angle to the corrected angle-of-attack. This calculation allowed airplane and model data to be compared with the corresponding wing sections at the same angles-of-attack. All wind tunnel and flight comparisons in this report are compared at equivalent angles-of-attack.



WING DIMENSIONS	
Span	159.67 ft
Area total including aileron flaps and 450.0 sq ft of fuselage	3228.1 sq ft
Aspect ratio	7.90
Airfoil Chord:	
At root	398.00 in.
At construction tip	132.62 in.
Mean (MAC)	266.51 in.
Airfoil Section Designation and Thickness (Percent Chord):	
At root NACA 0013.00 (Mod)	13.00
At construction tip NACA 0010.00 (Mod)	10.00
At construction joint (B.L. 415) NACA 0011.00 (Mod)	11.00
Incidence:	
At root	4.89 deg
At construction break	2.25 deg
At construction tip	-0.69 deg
Sweep at 25 Percent Chord:	
Outboard of construction joint	25.02 deg
Inboard of construction joint	23.73 deg
Dihedral at 25 Percent Chord:	
Outboard of construction joint	-1.195 deg
Inboard of construction joint	-0.941 deg

FIGURE 1 WING PLANFORM AND DIMENSIONS



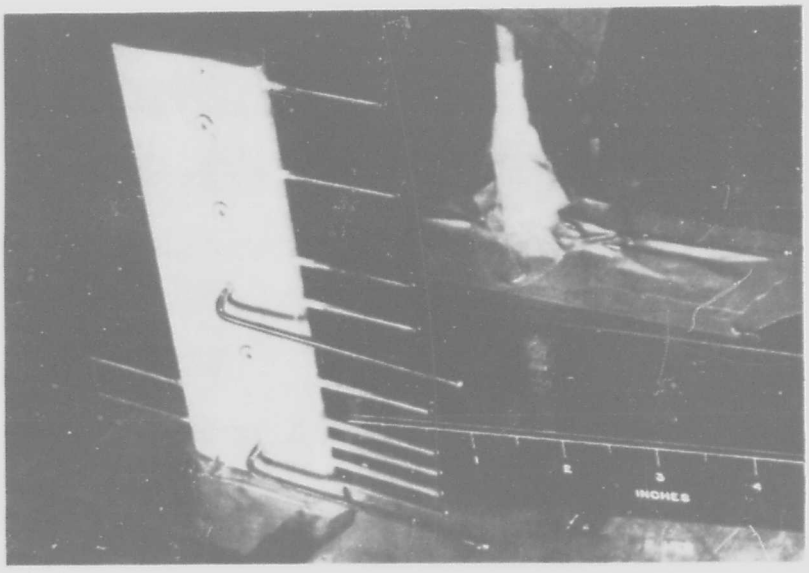


FIGURE 2 BOUNDARY LAYER RAKES

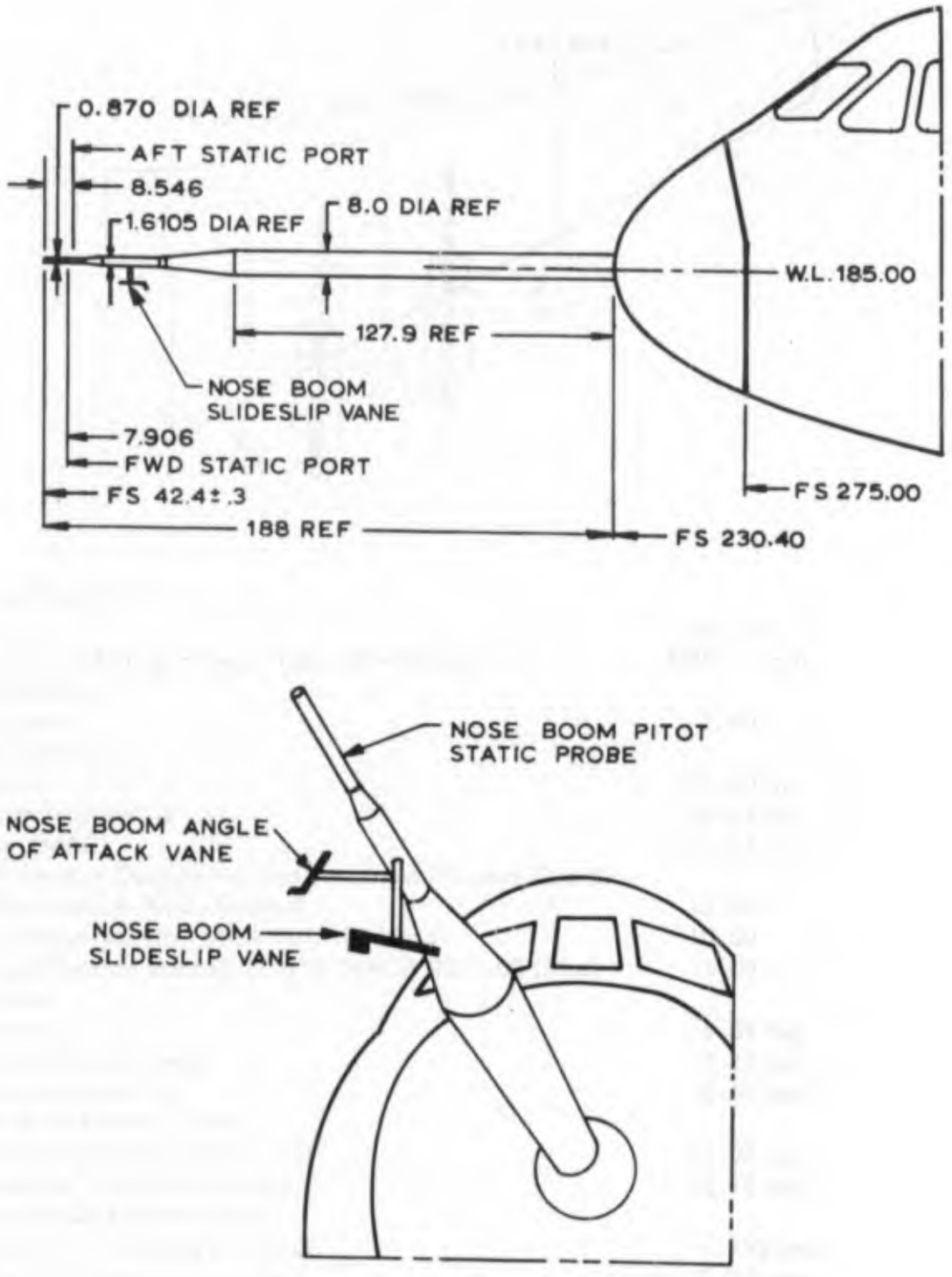


FIGURE 3 NOSE BOOM INSTALLATION

FIGURE 4 SHIP SYSTEM PITOT-STATIC PROBE INSTALLATION (RIGHT SIDE)

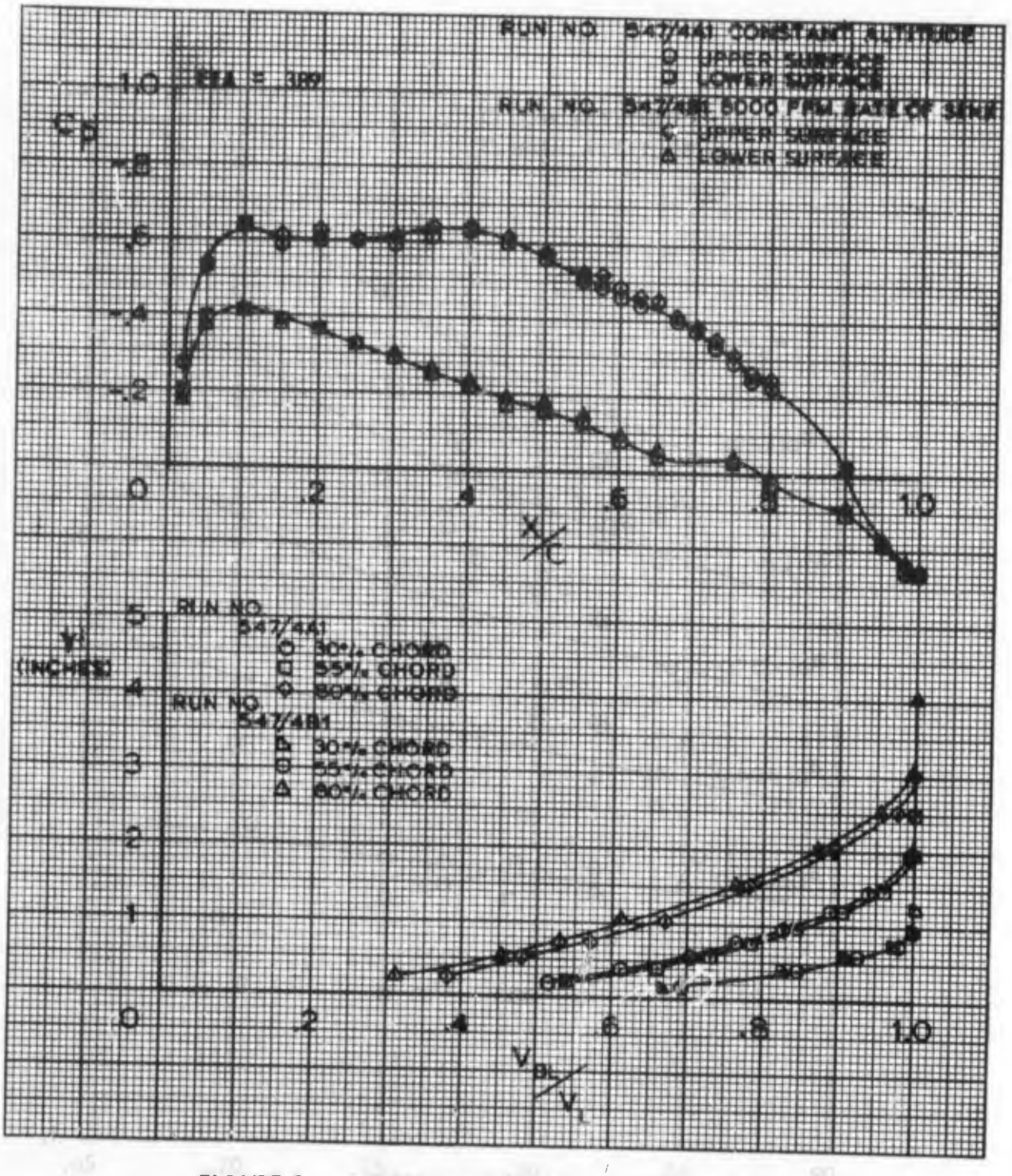


FIGURE 5 PRESSURE DISTRIBUTION COMPARISON
LAG CHECK MACH = .742

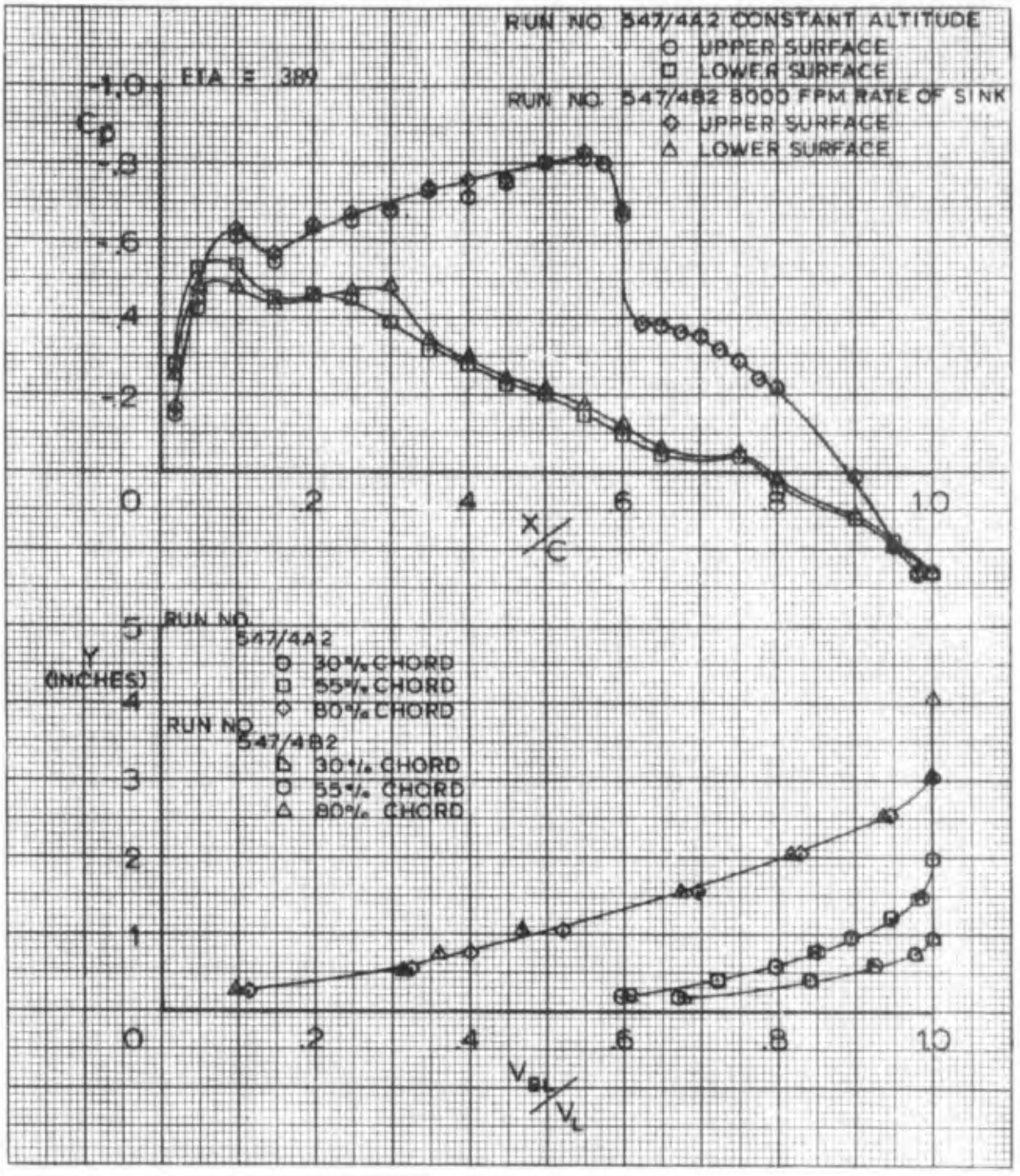


FIGURE 6 PRESSURE DISTRIBUTION COMPARISON
LAG CHECK MACH = .800

SECTION III

BASIC DATA PRESENTATION

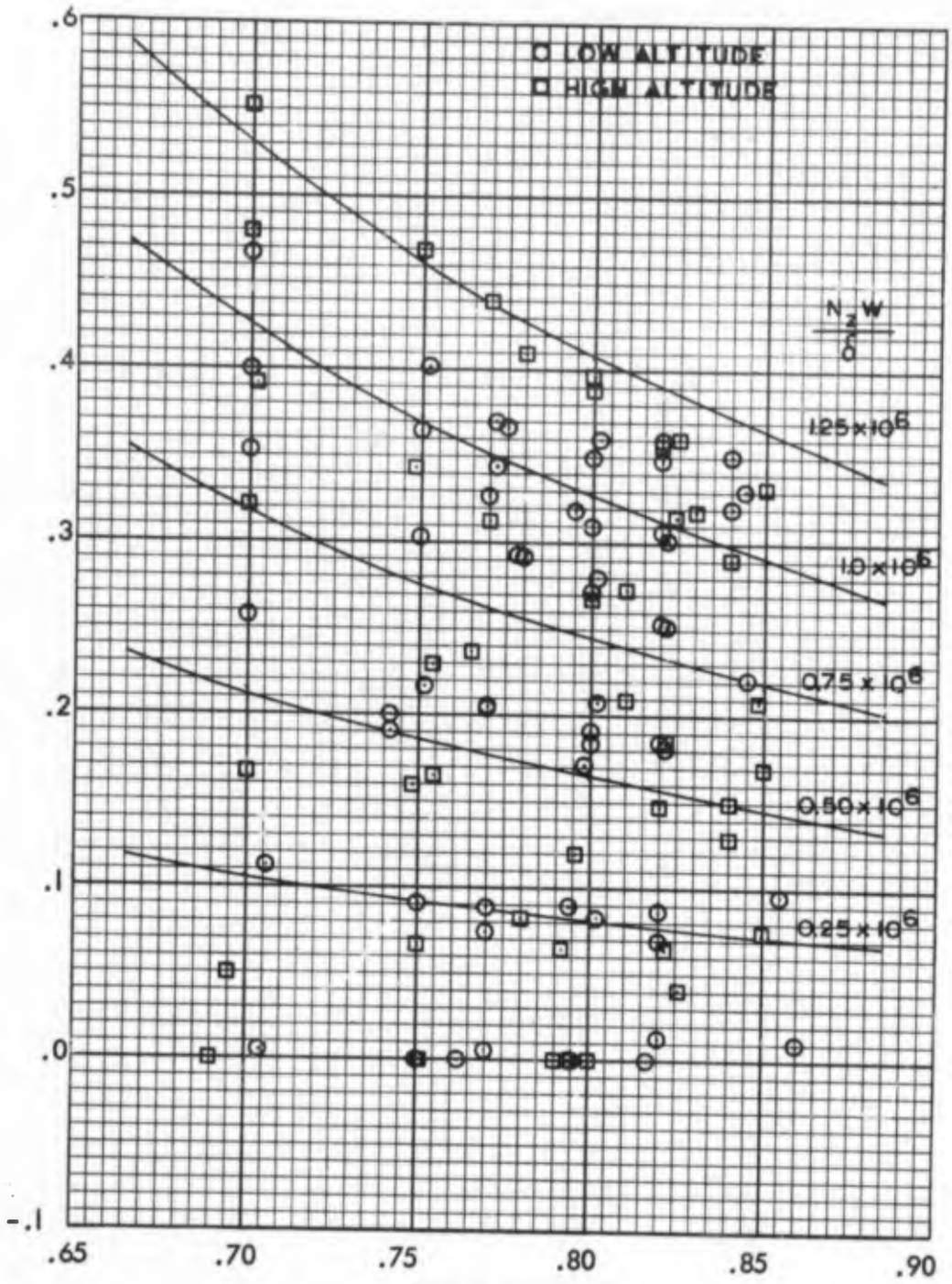


FIGURE 7 SCOPE OF FLIGHT TEST INVESTIGATION

TABLE

FLIGHT TEST PRESSURE SURVEY

LOW ALTITUDE (≃ 20,000 FT)

FIGURE NUMBER	MACH NUMBER	REYNOLD'S NUMBER x 10^{-6}	CORRECTED ALPHA ~ deg
8 a)	.704	56.61	-2.87
b)	.706	57.72	-1.86
c)	.700	58.52	-0.54
d)	.700	57.64	0.22
e)	.700	59.72	0.58
f)	.700	58.28	1.07
9 a)	.750	61.50	-2.87
b)	.750	62.19	-2.02
c)	.752	62.48	-0.95
d)	.742	64.89	-0.56
e)	.742	71.21	-0.45
f)	.750	62.41	-0.35
g)	.750	62.35	0.22
h)	.752	63.83	0.31
10 a)	.762	62.72	-2.78
b)	.770	71.63	-2.64
c)	.770	64.92	-2.01
d)	.770	71.13	-1.88
e)	.770	63.47	-1.01
f)	.770	69.73	-0.96
g)	.780	65.45	-0.44
h)	.778	71.21	-0.28
k)	.770	64.34	-0.18
l)	.772	70.97	0.04
m)	.772	64.70	0.15
n)	.775	72.49	0.22
11 a)	.795	63.17	-2.78
b)	.794	73.88	-2.73
c)	.794	62.32	-1.95
d)	.802	77.09	-1.95
e)	.800	71.79	-1.12
f)	.802	62.75	-1.10
g)	.798	72.48	-0.70
h)	.800	72.16	-0.70
k)	.802	63.63	-0.62
l)	.800	72.43	-0.54
m)	.795	62.43	-0.28
n)	.800	72.77	-0.27
o)	.800	72.51	-0.07
p)	.802	64.19	-0.07

TABLE (CONTINUED)

FLIGHT TEST PRESSURE SURVEY

LOW ALTITUDE (≈ 20,000 FT)

FIGURE NUMBER	MACH NUMBER	REYNOLD'S NUMBER x 10^{-6}	CORRECTED ALPHA ~ deg
12 a)	.820	76.21	-2.72
b)	.817	67.24	-2.70
c)	.820	65.04	-2.20
d)	.820	74.93	-2.06
e)	.820	63.71	-1.27
f)	.822	72.50	-1.27
g)	.820	63.77	-0.78
h)	.822	73.13	-0.70
k)	.822	64.76	-0.35
l)	.820	72.82	-0.20
m)	.820	73.07	0.22
n)	.820	64.74	0.22
13 a)	.860	53.38	-2.24
b)	.855	60.93	-1.30
c)	.845	59.05	0.13
d)	.840	58.84	1.00
e)	.844	59.30	1.35
f)	.840	60.95	1.62

HIGH ALTITUDE (≈ 40,000 FT)

14 a)	.690	25.47	-2.40
b)	.695	25.37	-1.90
c)	.700	25.43	-0.87
d)	.700	25.40	0.57
e)	.702	25.61	1.17
f)	.700	25.18	1.93
g)	.700	25.27	2.63
15 a)	.751	33.64	-2.40
b)	.750	36.22	-1.64
c)	.748	33.98	-0.97
d)	.754	32.74	-0.97
e)	.754	33.75	-0.37
f)	.748	31.23	0.65
g)	.750	26.64	1.77

TABLE (CONCLUDED)

FLIGHT TEST PRESSURE SURVEY

HIGH ALTITUDE (≈40,000 FT)

FIGURE NUMBER	MACH NUMBER	REYNOLD'S NUMBER x 10^{-6}	CORRECTED ALPHA - deg
16 a)	.780	36.03	-1.55
b)	.765	32.75	-0.37
c)	.770	32.39	0.13
d)	.770	31.89	1.25
e)	.780	32.85	1.51
17 a)	.790	38.46	-2.31
b)	.800	39.73	-2.14
c)	.796	39.26	-1.30
d)	.810	39.72	-0.70
e)	.810	42.11	-0.60
f)	.800	35.40	-0.18
g)	.792	40.47	0.04
h)	.800	34.05	0.74
k)	.800	33.81	1.25
18 a)	.826	43.76	-2.55
b)	.822	42.14	-2.28
c)	.820	45.43	-1.62
d)	.822	44.27	-1.27
e)	.824	41.35	-0.10
f)	.825	37.52	0.83
g)	.820	35.86	1.10
h)	.830	40.17	1.16
19 a)	.850	45.65	-2.20
b)	.850	44.26	-1.12
c)	.840	44.64	-0.87
d)	.840	42.85	-0.70
e)	.848	46.52	-0.60
f)	.840	44.51	0.31
g)	.850	39.77	1.77

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1A1
MACH NO .704

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

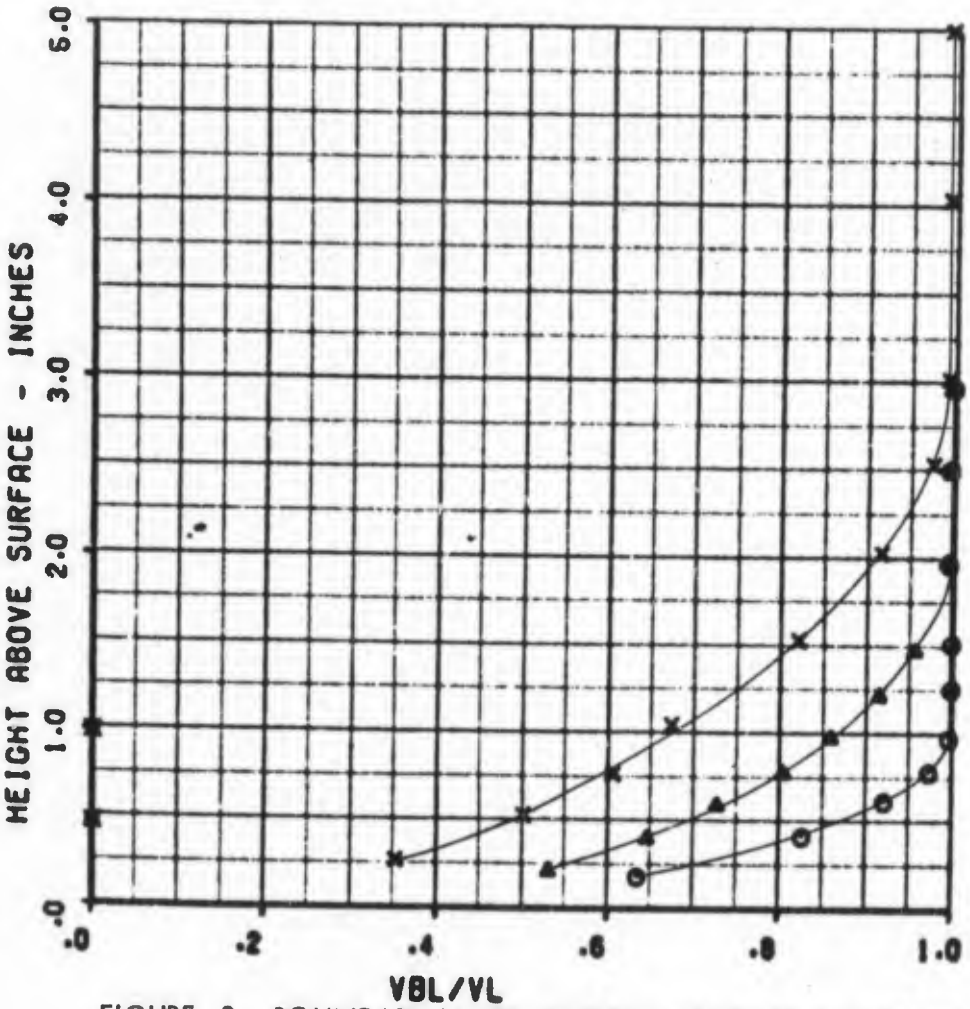
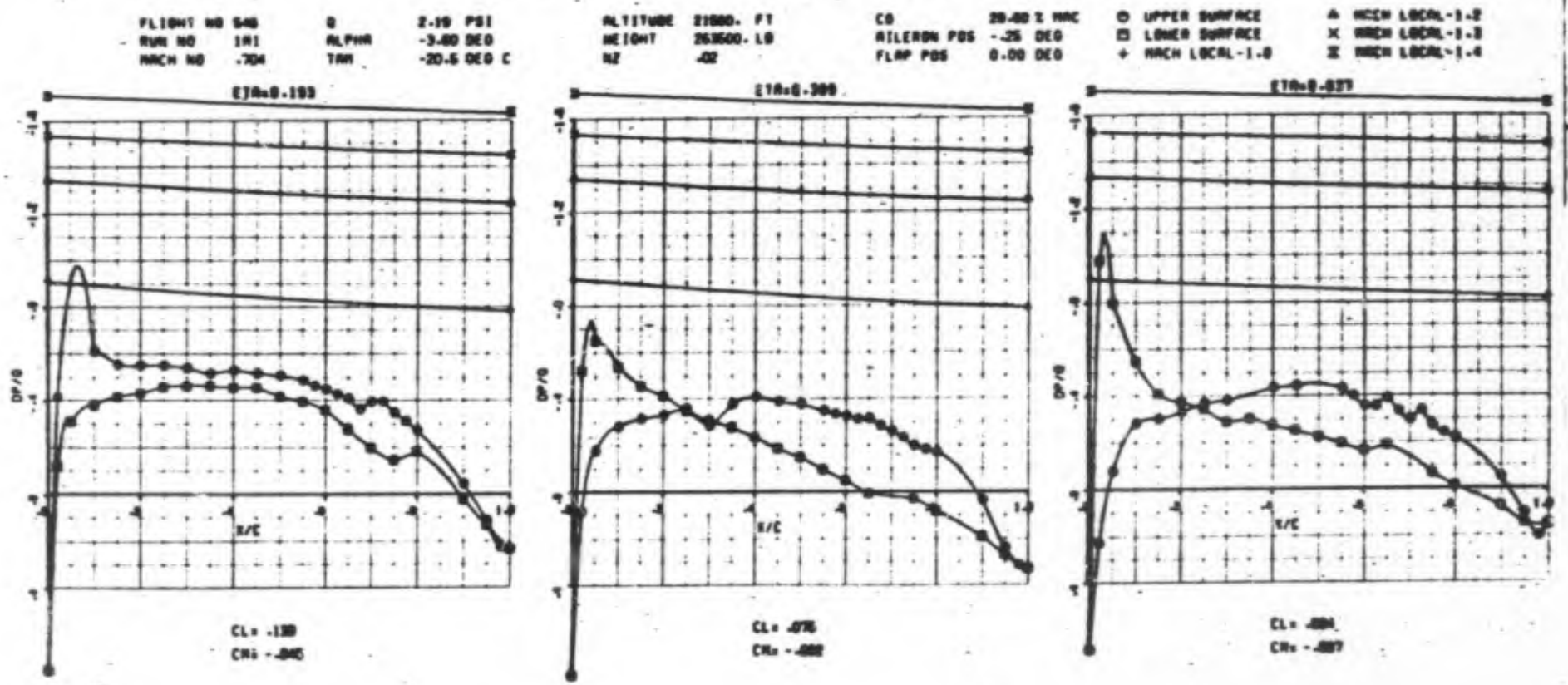


FIGURE 8 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .700 TO .706
(a) CORRECTED ALPHA = -2.87

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1A2
MACH NO .706

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 90 %(AFT)

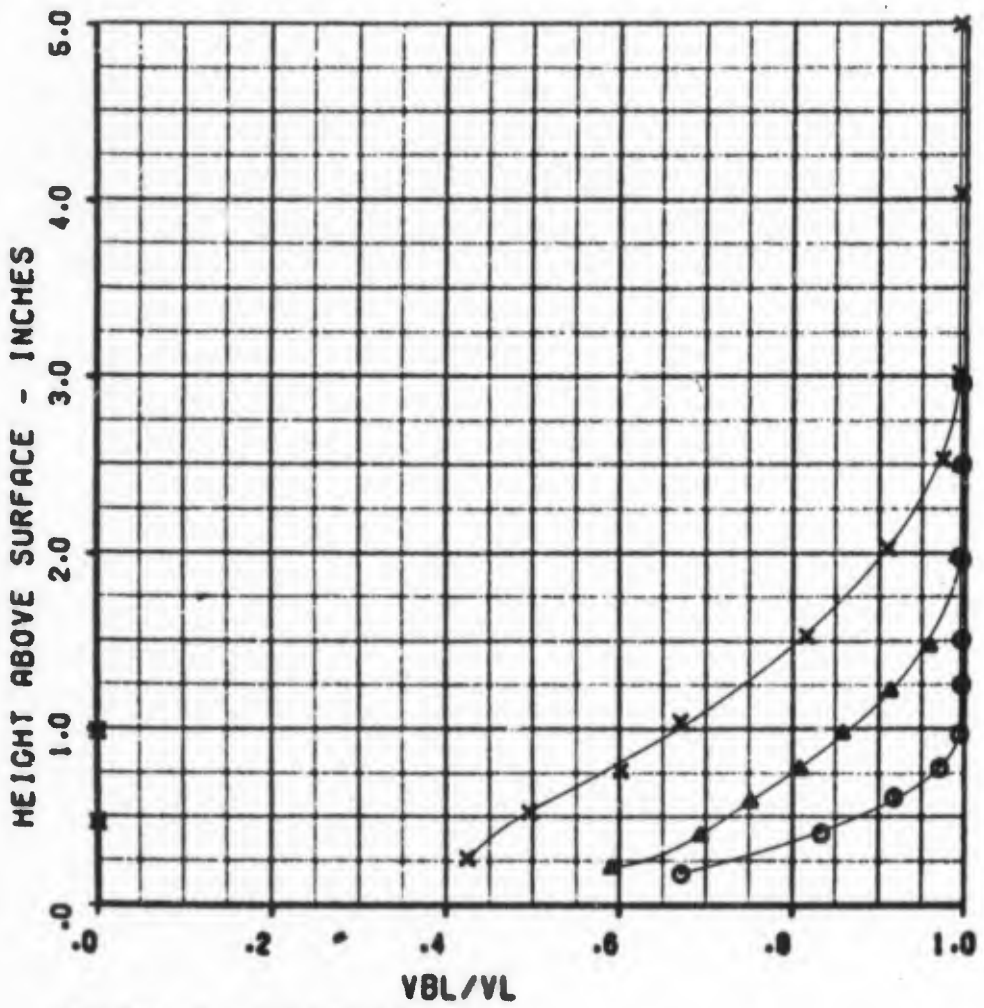
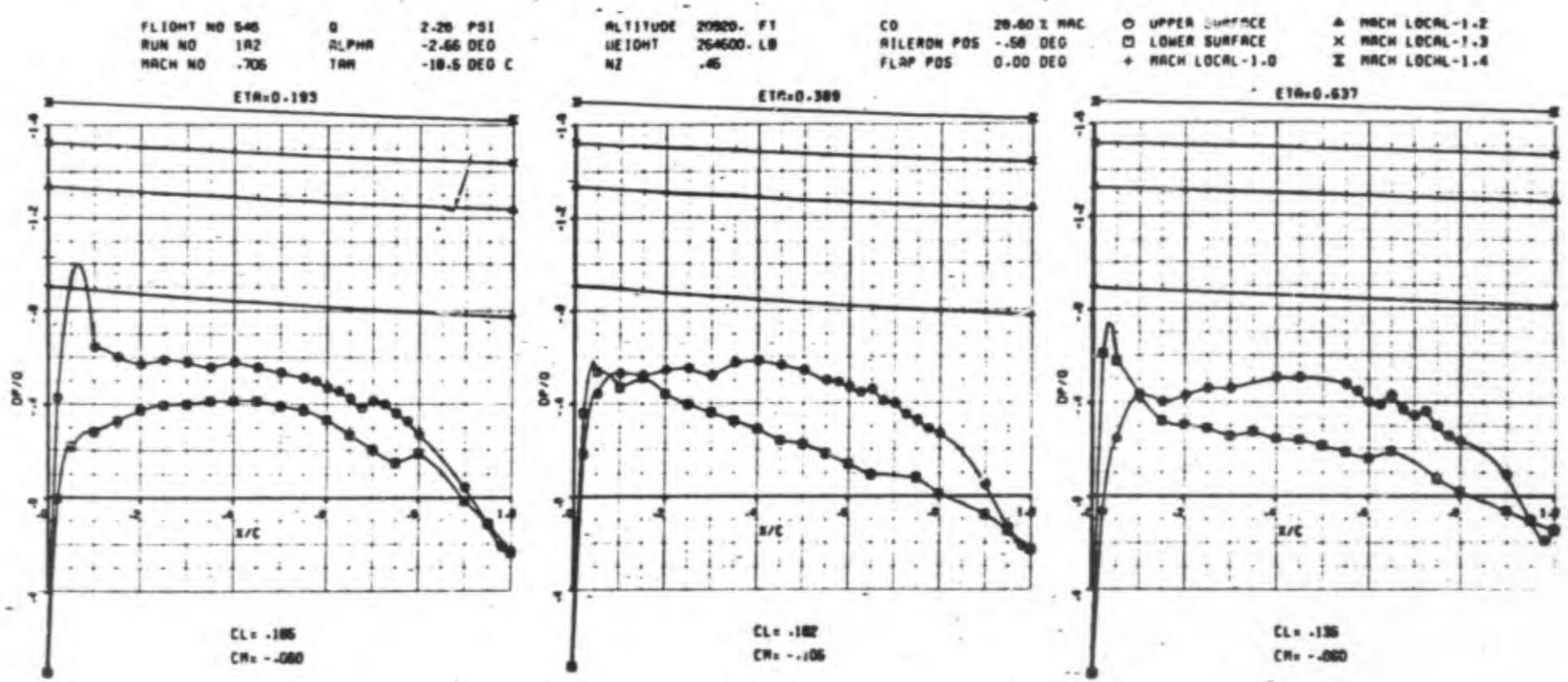


FIGURE 8 (CONTINUED)
(b) CORRECTED ALPHA = -1.86

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1A
MACH NO .700

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

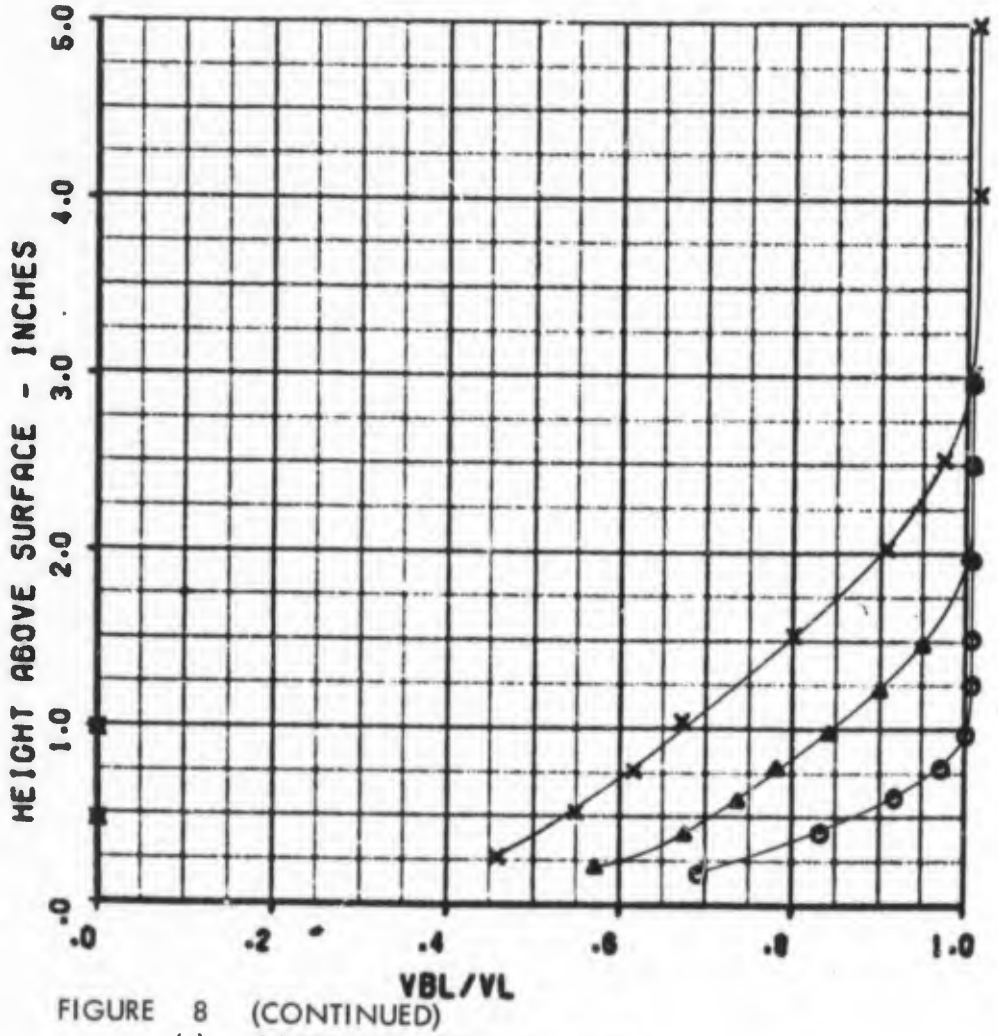
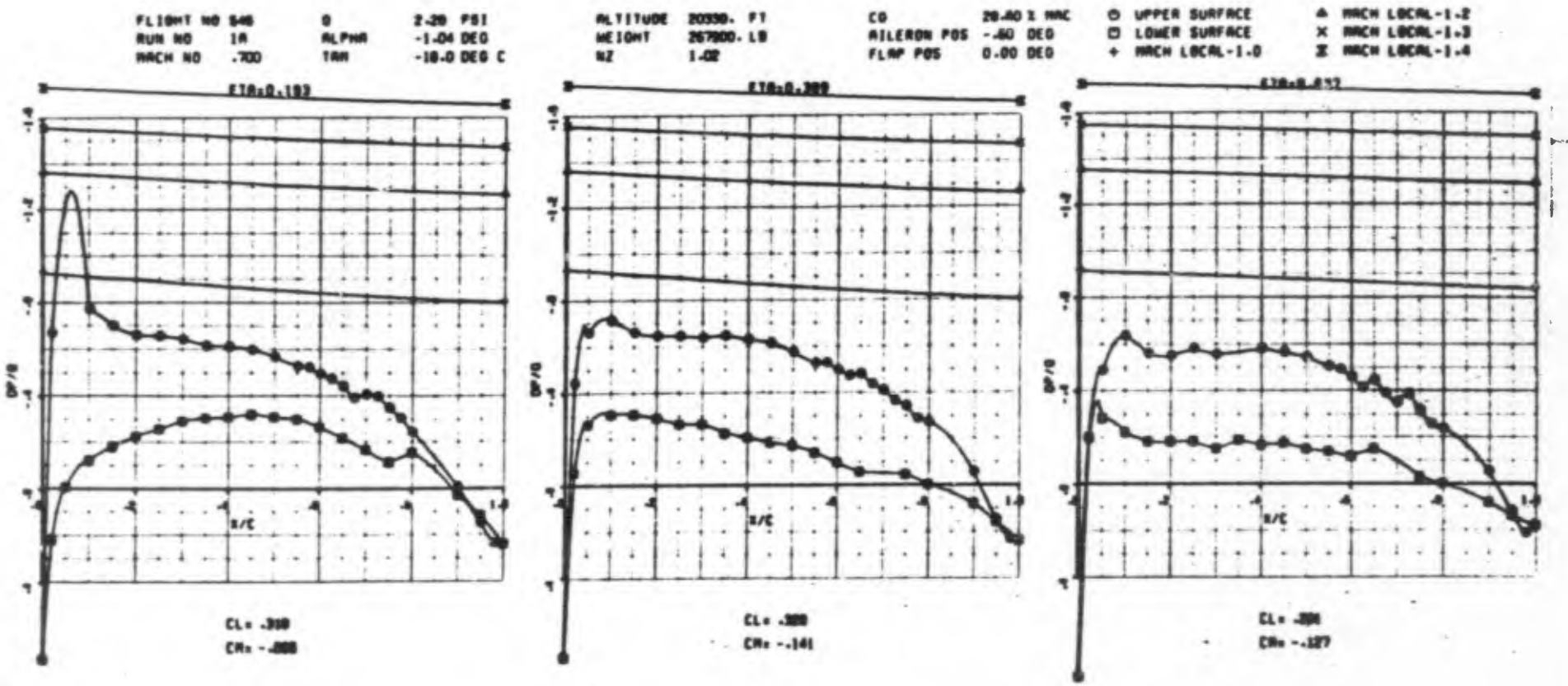


FIGURE 8 (CONTINUED)
(c) CORRECTED ALPHA = -0.54

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1A3
MACH NO .700

RAKE LOCATIONS

⊙ 30 %
▲ 65 %
× 80 %
✱ 80 %(AFT)

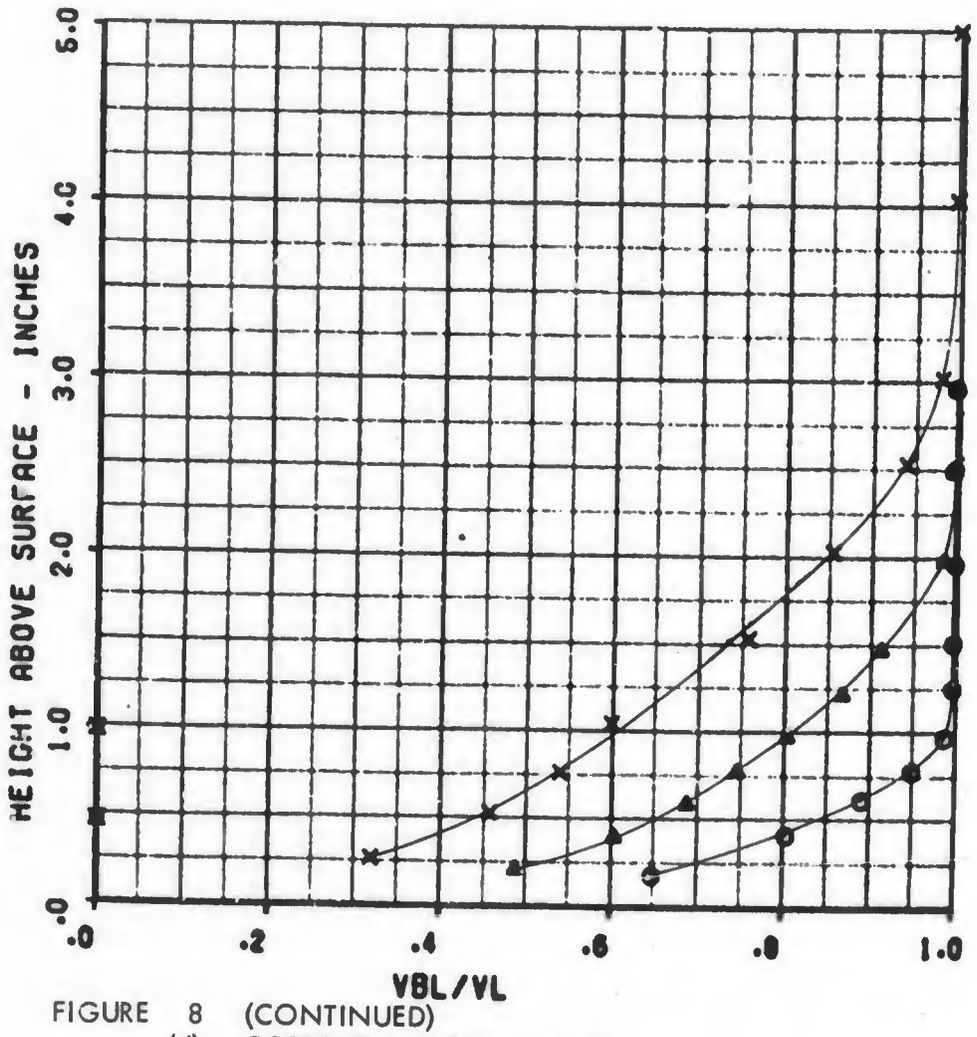
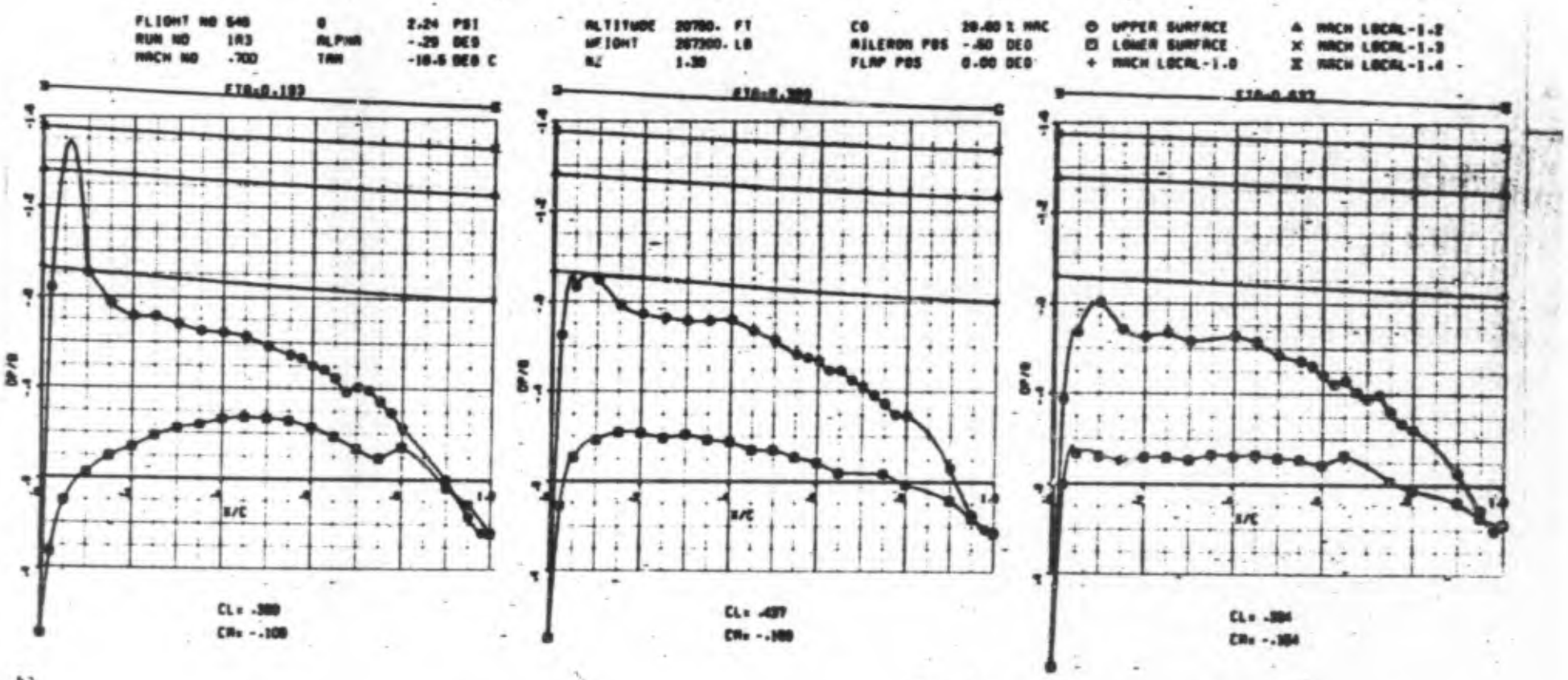


FIGURE 8 (CONTINUED)
(d) CORRECTED ALPHA = 0.22

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1A4
MACH NO .700

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

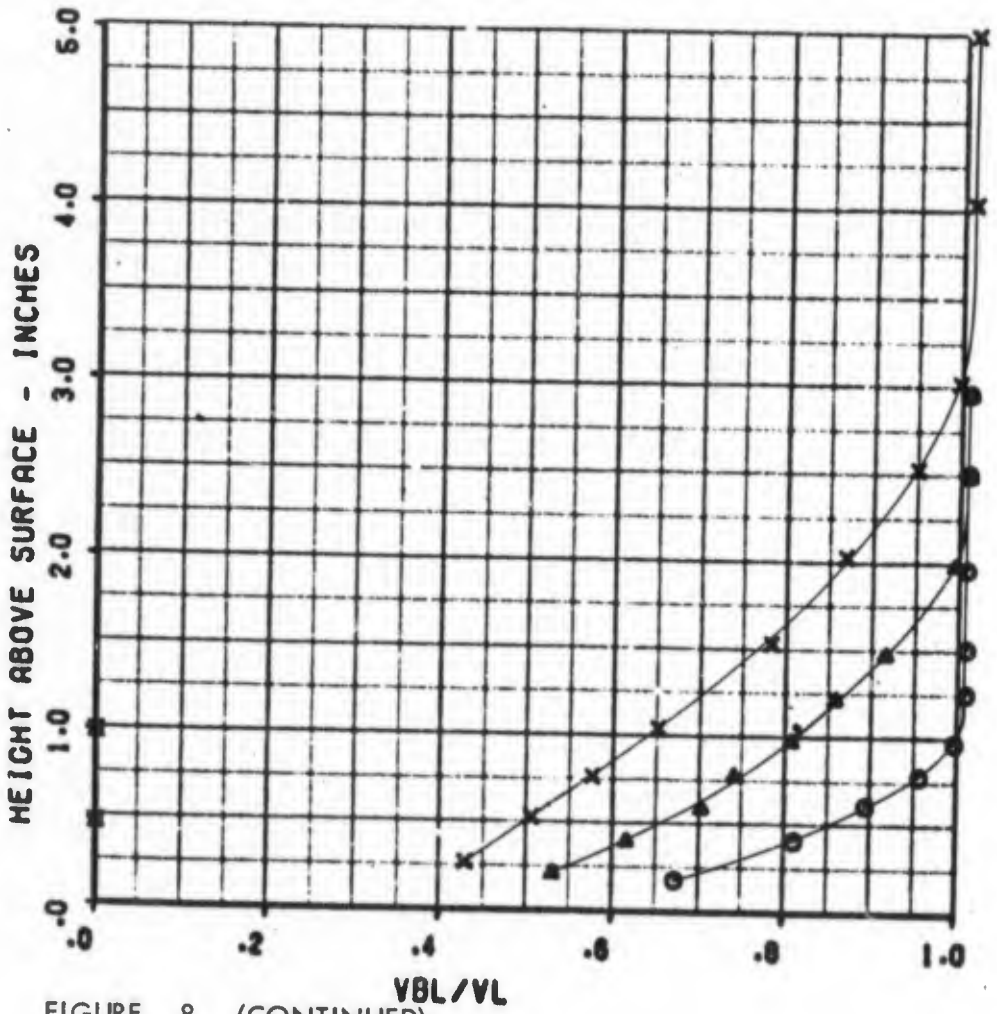


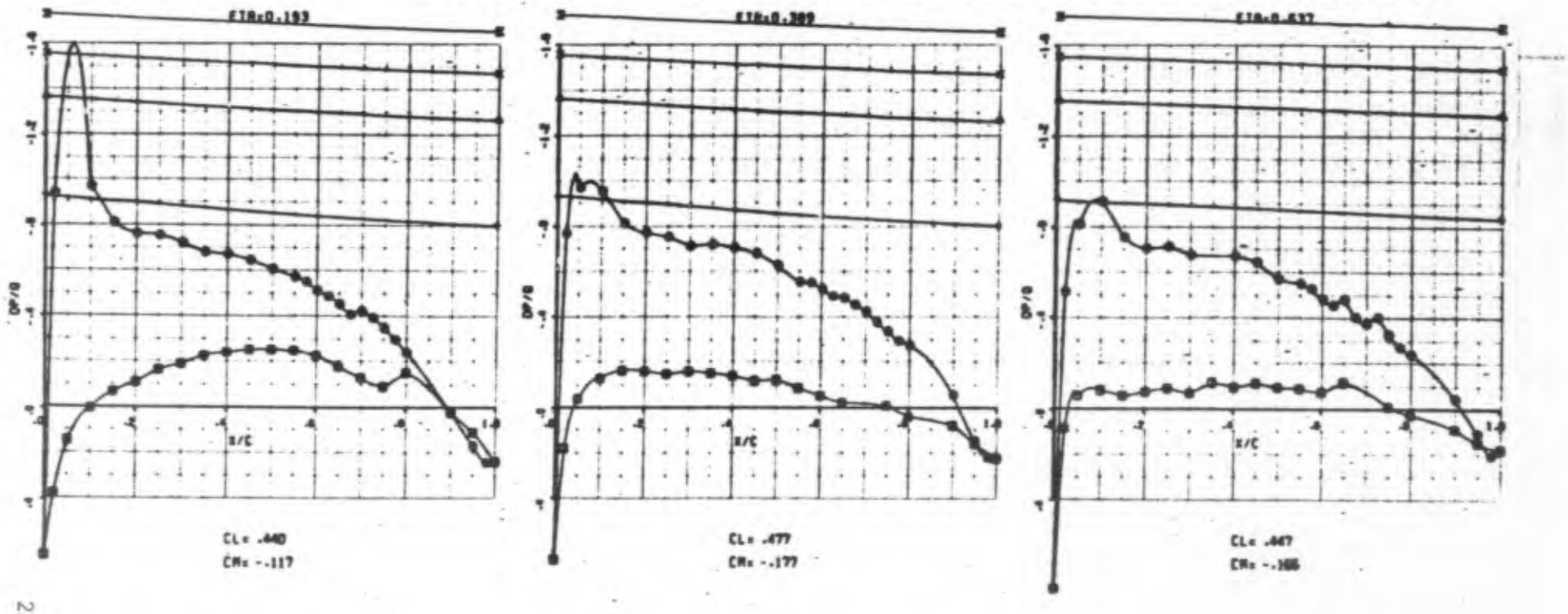
FIGURE 8 (CONTINUED)
(e) CORRECTED ALPHA = 0.58

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	2.34 PSI	ALTITUDE	19880. FT	CG	28.60 % MAC
RUN NO	184	ALPHA	.10 DEG	WEIGHT	268600.-LB	AILERON POS	-1.33 DEG
MACH NO	.700	TAM	-16.5 DEG C	NZ	1.64	FLAP POS	0.00 DEG

○ UPPER SURFACE
□ LOWER SURFACE
+ MACH LOCAL-1.0
△ MACH LOCAL-1.2
× MACH LOCAL-1.3
⧖ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 135
MACH NO .700

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

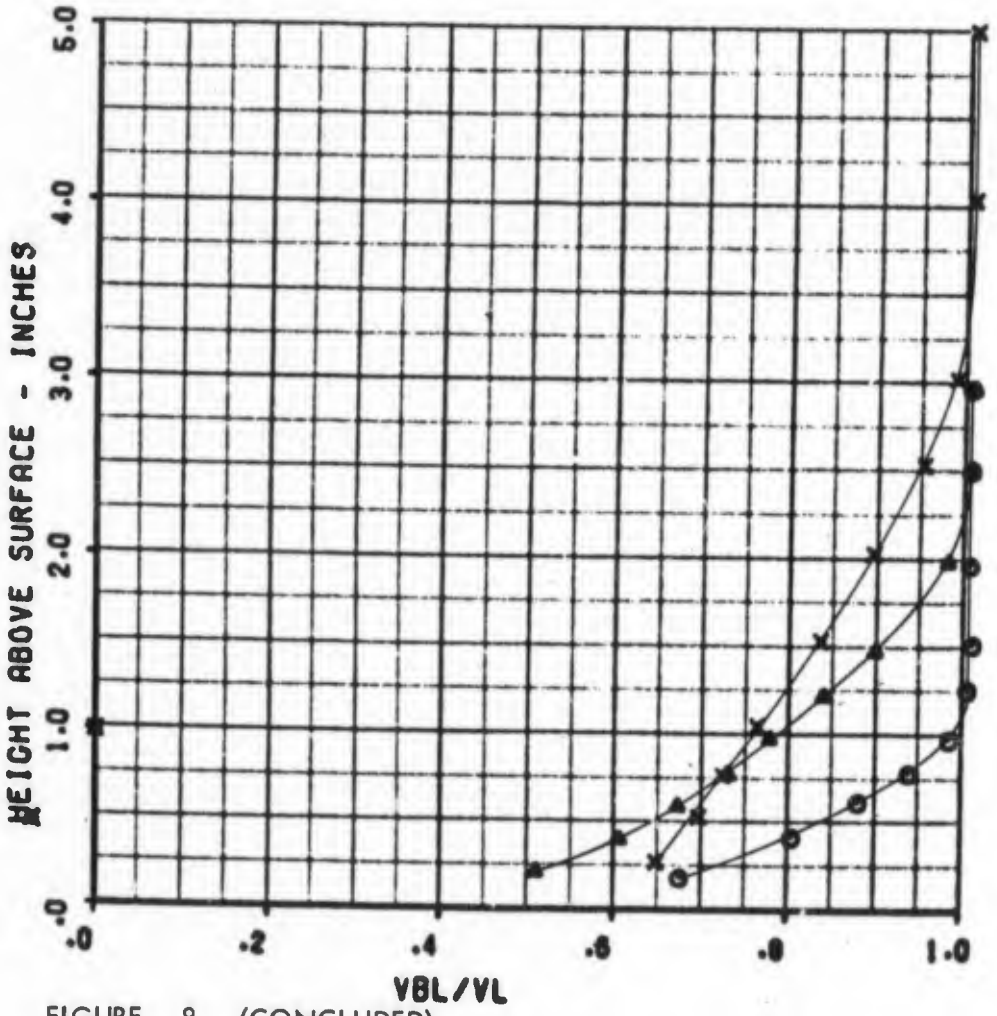
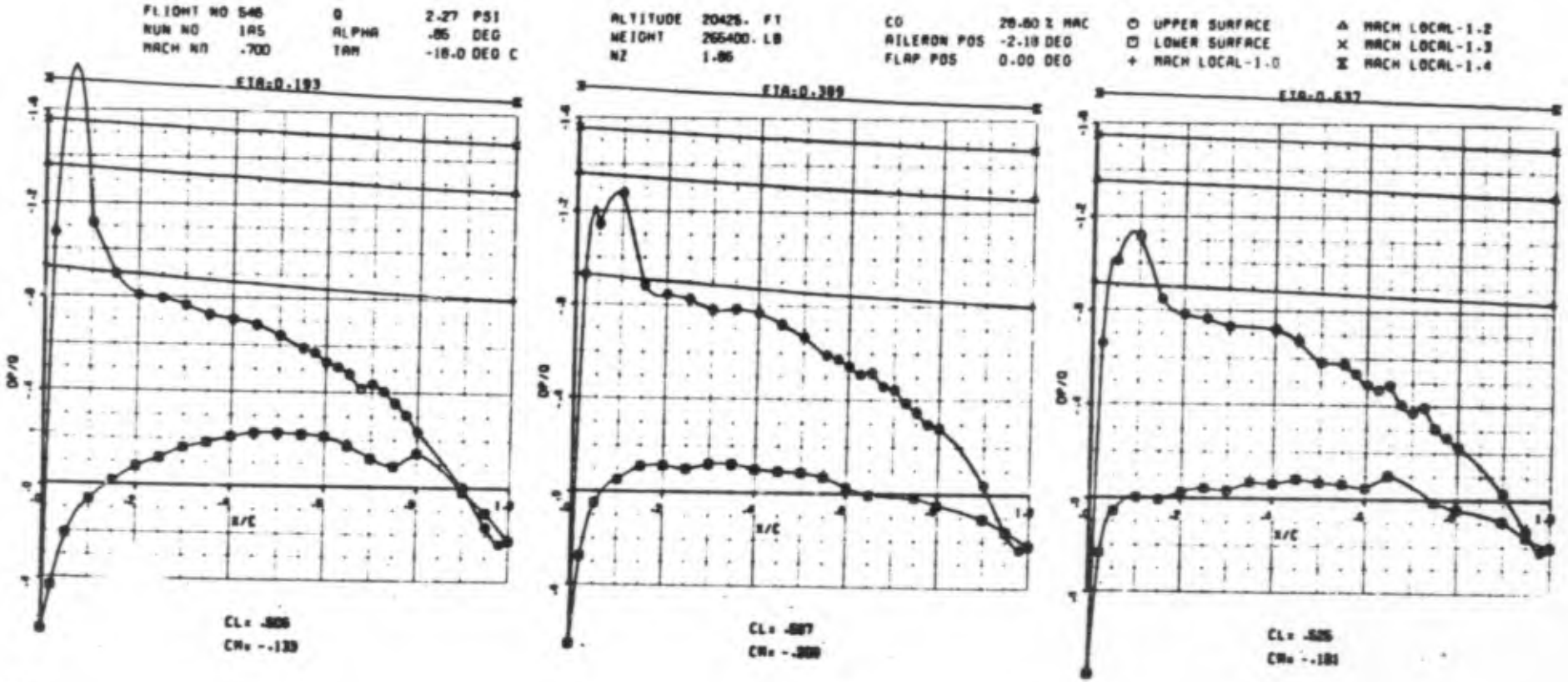


FIGURE 8 (CONCLUDED)
(f) CORRECTED ALPHA = 1.07

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 181
MACH NO .750

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

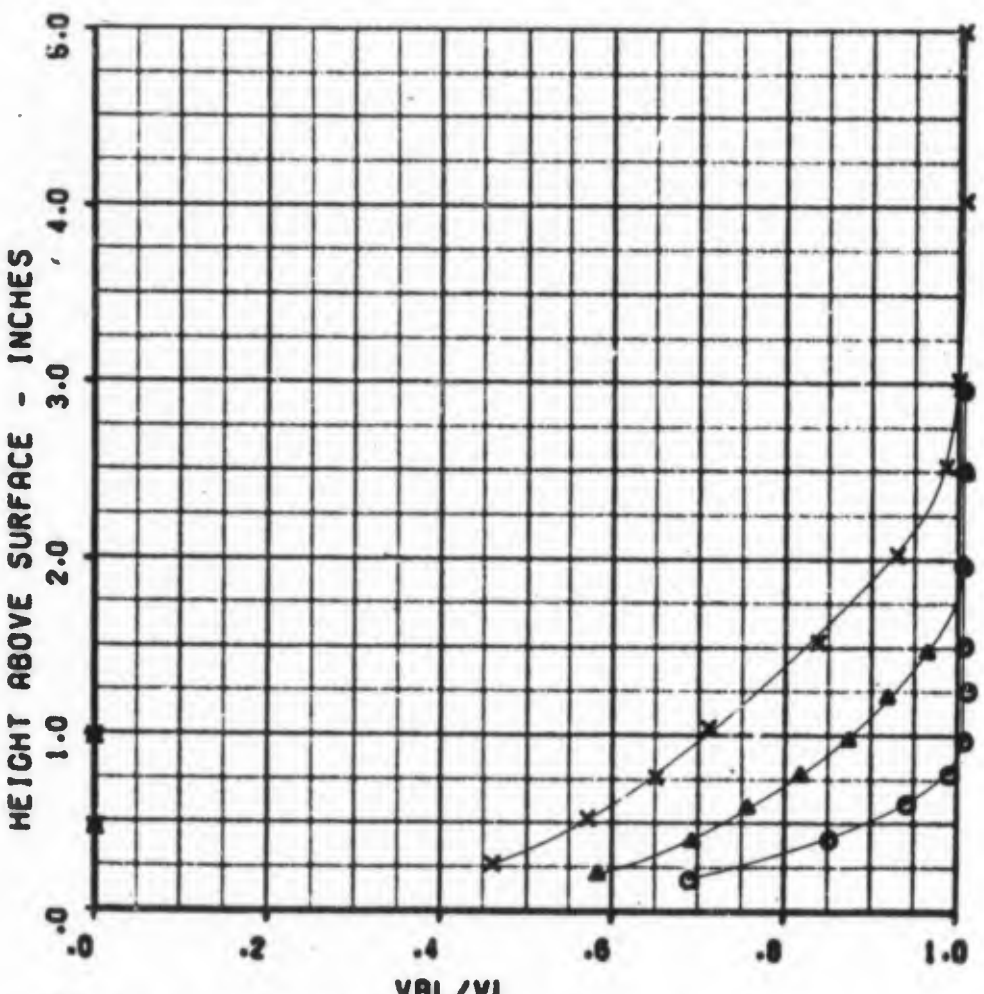


FIGURE 9 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .742 TO .752

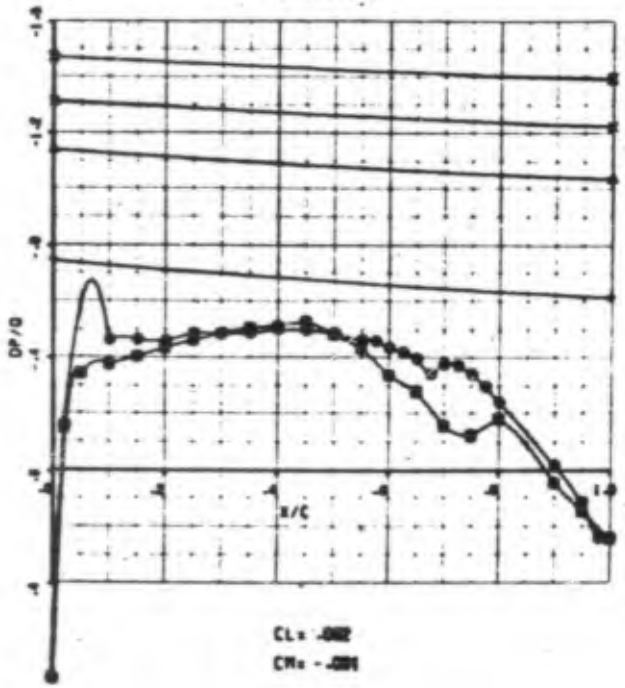
(a) CORRECTED ALPHA = -2.87

LOCKHEED C-141A

PRESSURE DISTRIBUTION

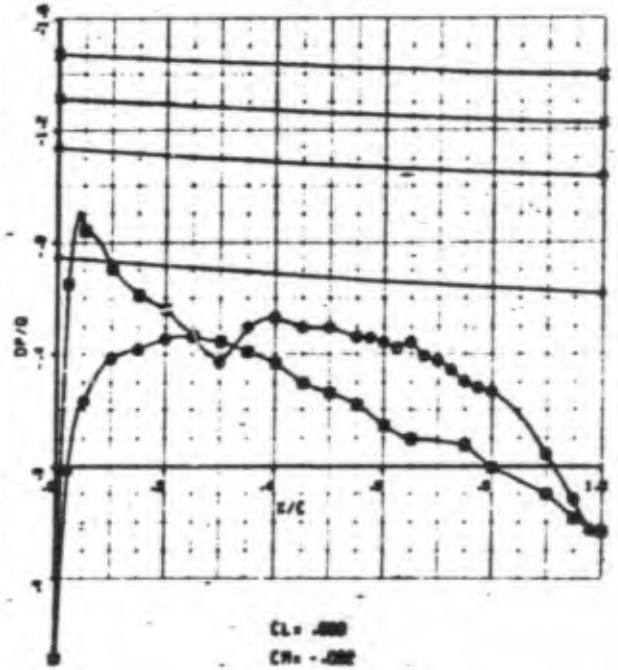
FLIGHT NO	548	Q	2.56 PSI	ALTITUDE	20850. FT	CG	29.50 % MAC	○	UPPER SURFACE	△	MACH LOCAL-1.2
RUN NO	181	ALPHA	-3.80 DEG	WEIGHT	258300. LB	AILERON POS	-.75 DEG	□	LOWER SURFACE	×	MACH LOCAL-1.3
MACH NO	.750	TAM	-18.5 DEG C	NZ	0.00	FLAP POS	0.00 DEG	+	MACH LOCAL-1.0	⧖	MACH LOCAL-1.4

ETA=0.193



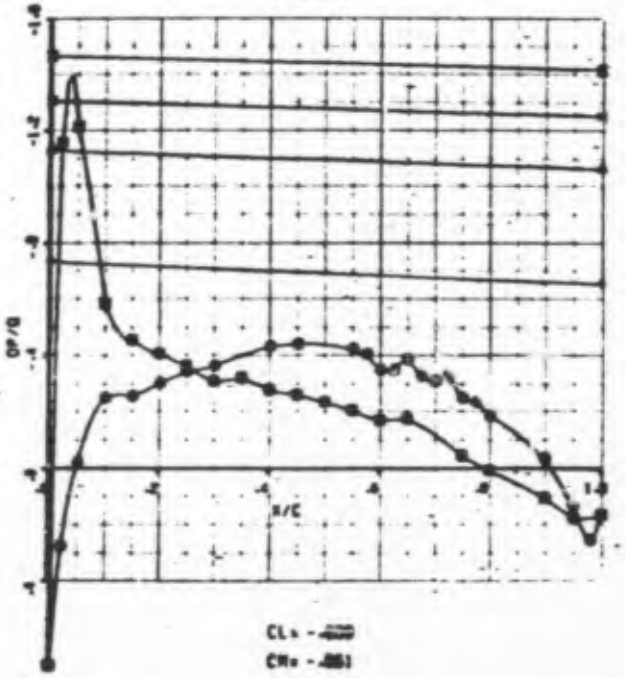
CL= .082
CM= -.084

ETA=0.309



CL= .080
CM= -.082

ETA=0.637



CL= -.030
CM= -.051

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 182
MACH NO .750

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

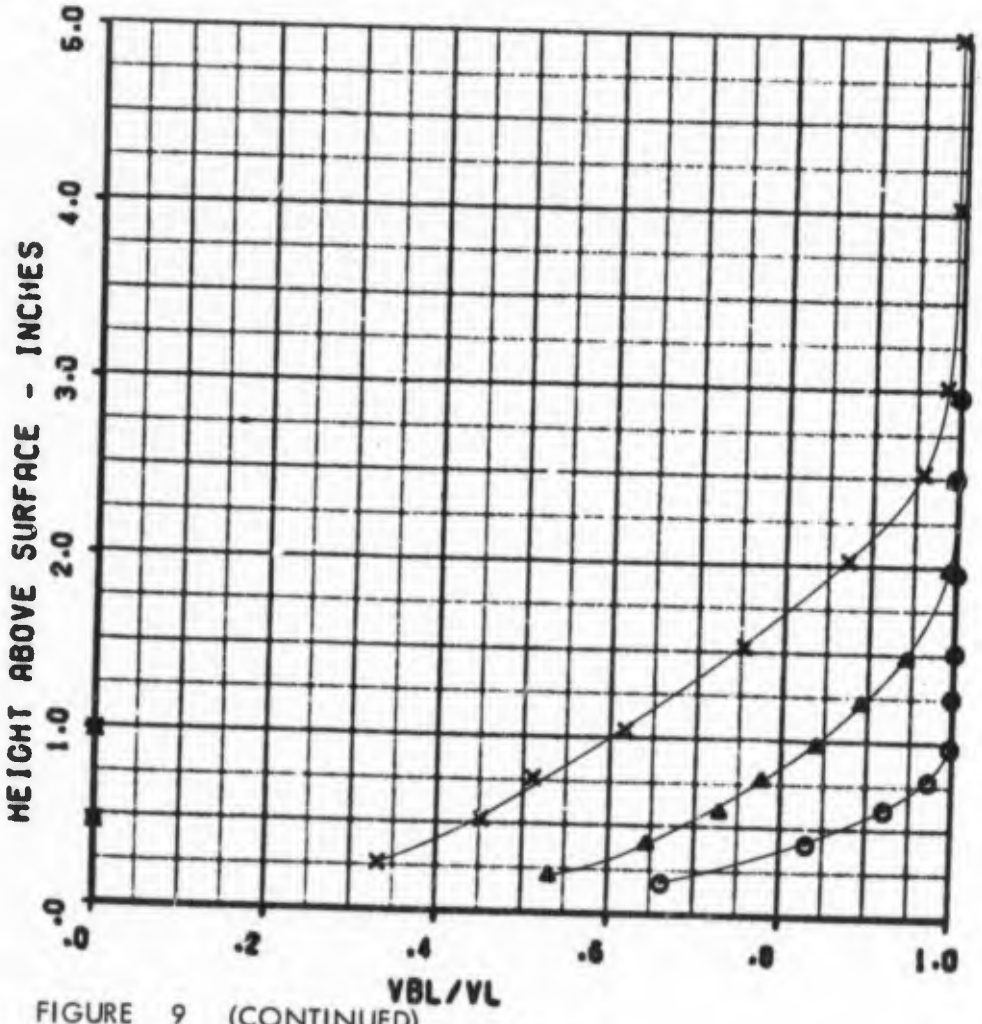
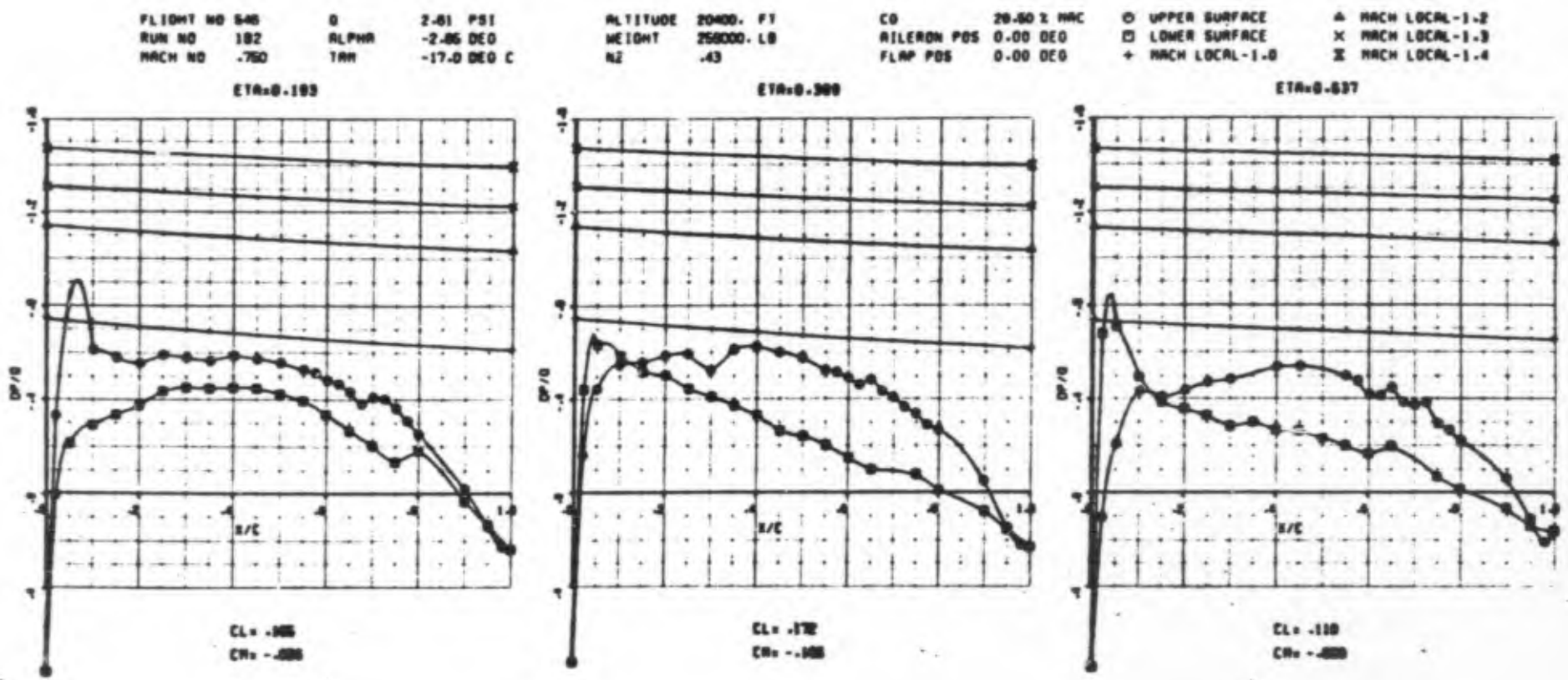


FIGURE 9 (CONTINUED)
(b) CORRECTED ALPHA = -2.02

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 18
MACH NO .752

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

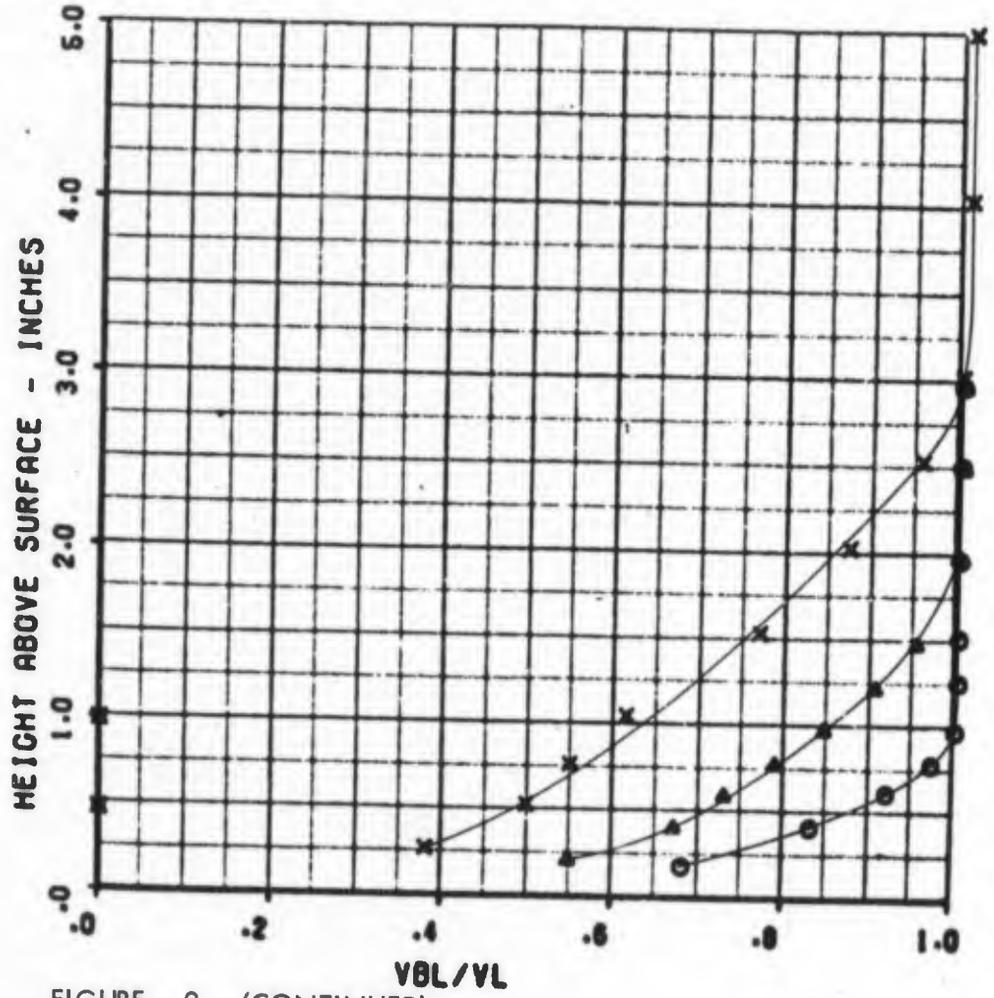
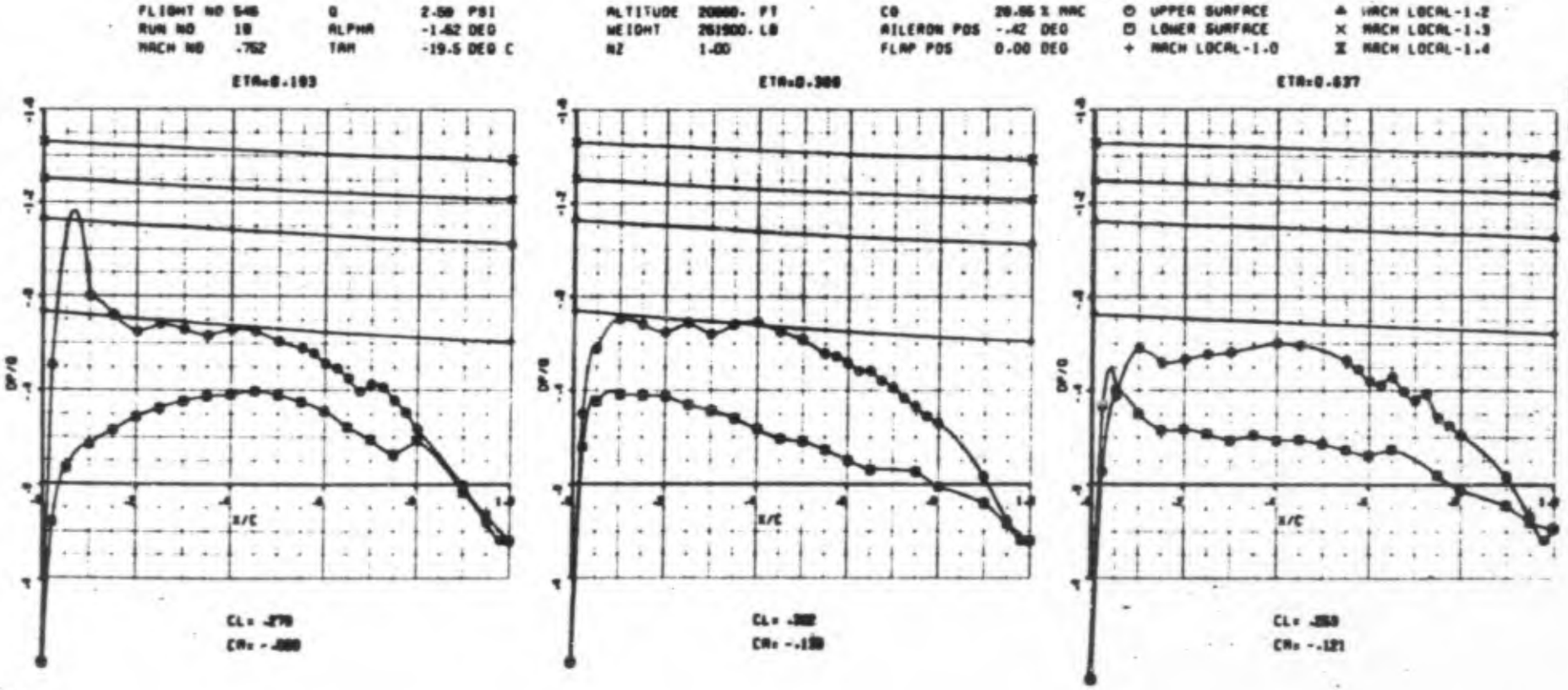


FIGURE 9 (CONTINUED)
(c) CORRECTED ALPHA = -0.95

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 4A1
MACH NO .742

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

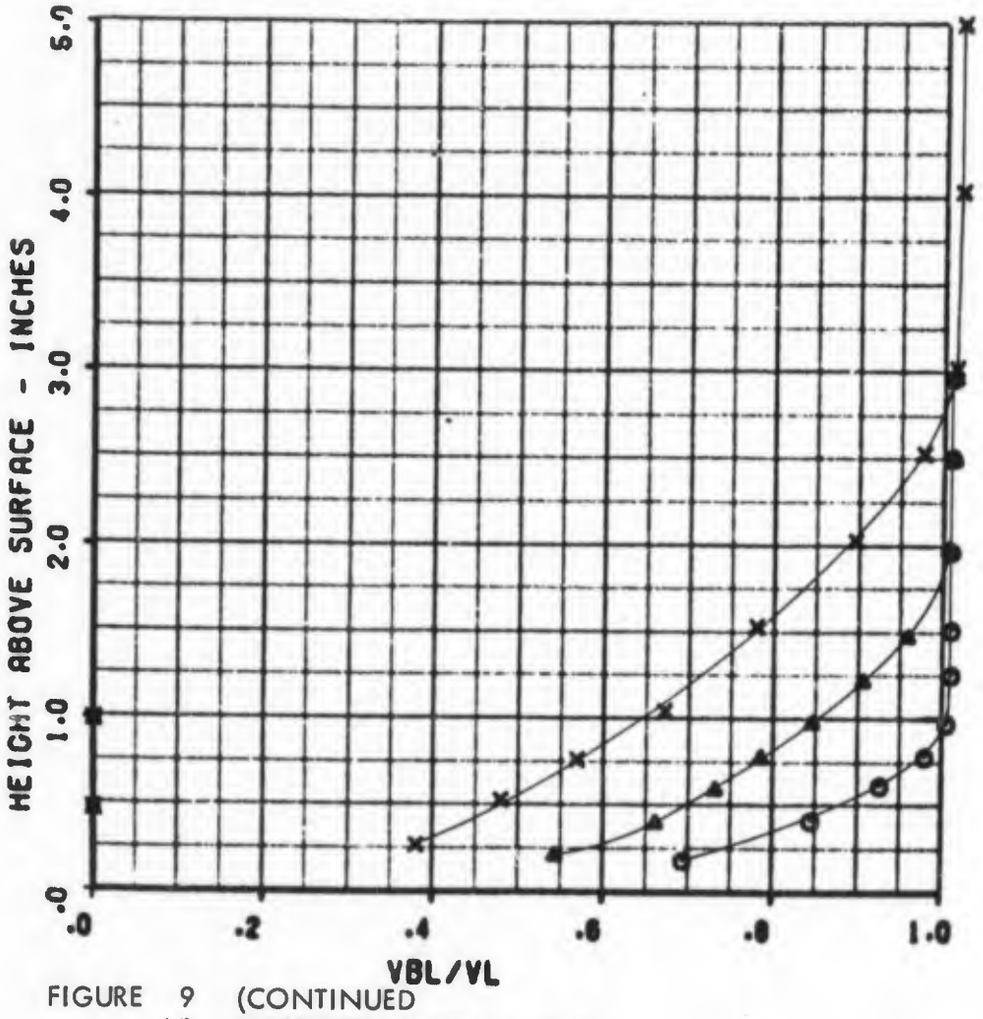
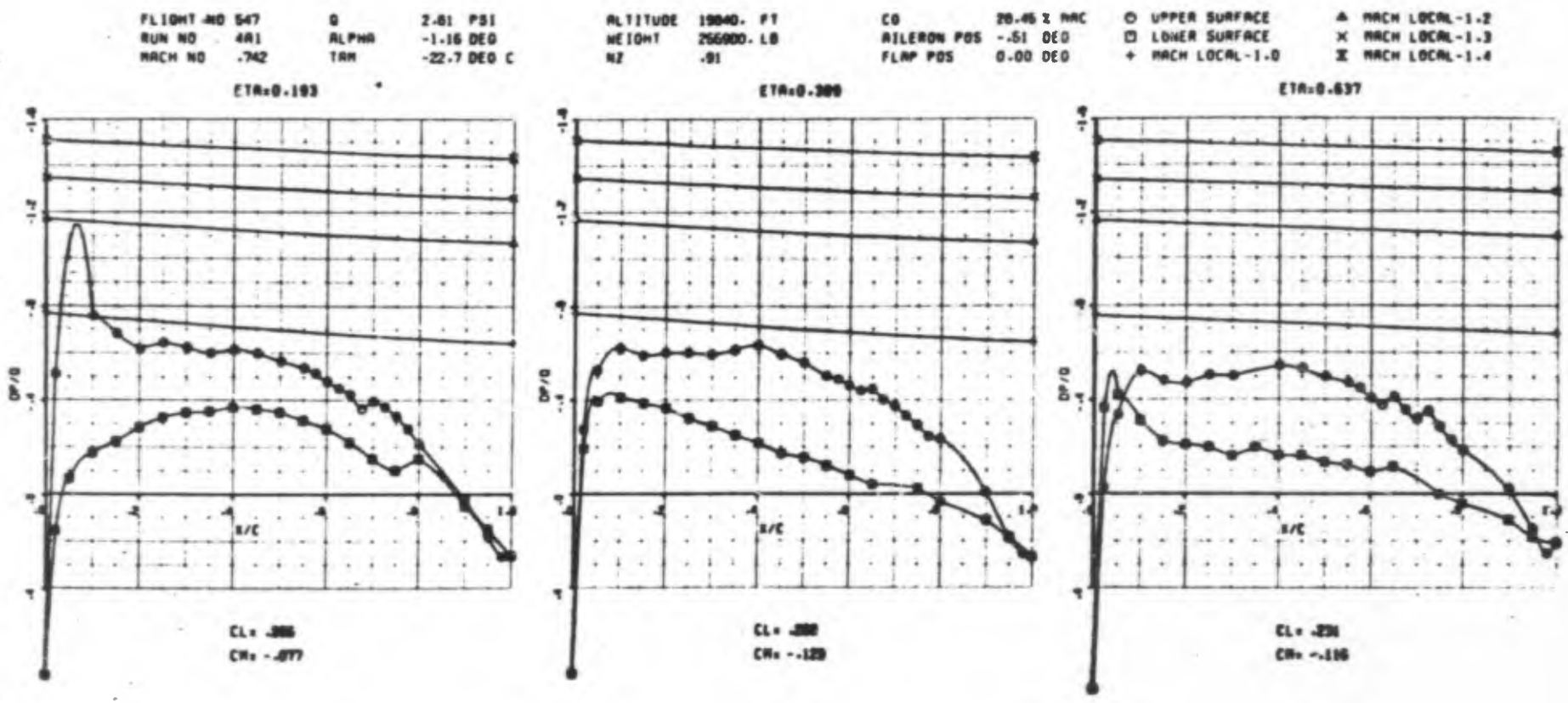


FIGURE 9 (CONTINUED
(d) CORRECTED ALPHA = -0.56

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO. 481
MACH NO .742

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

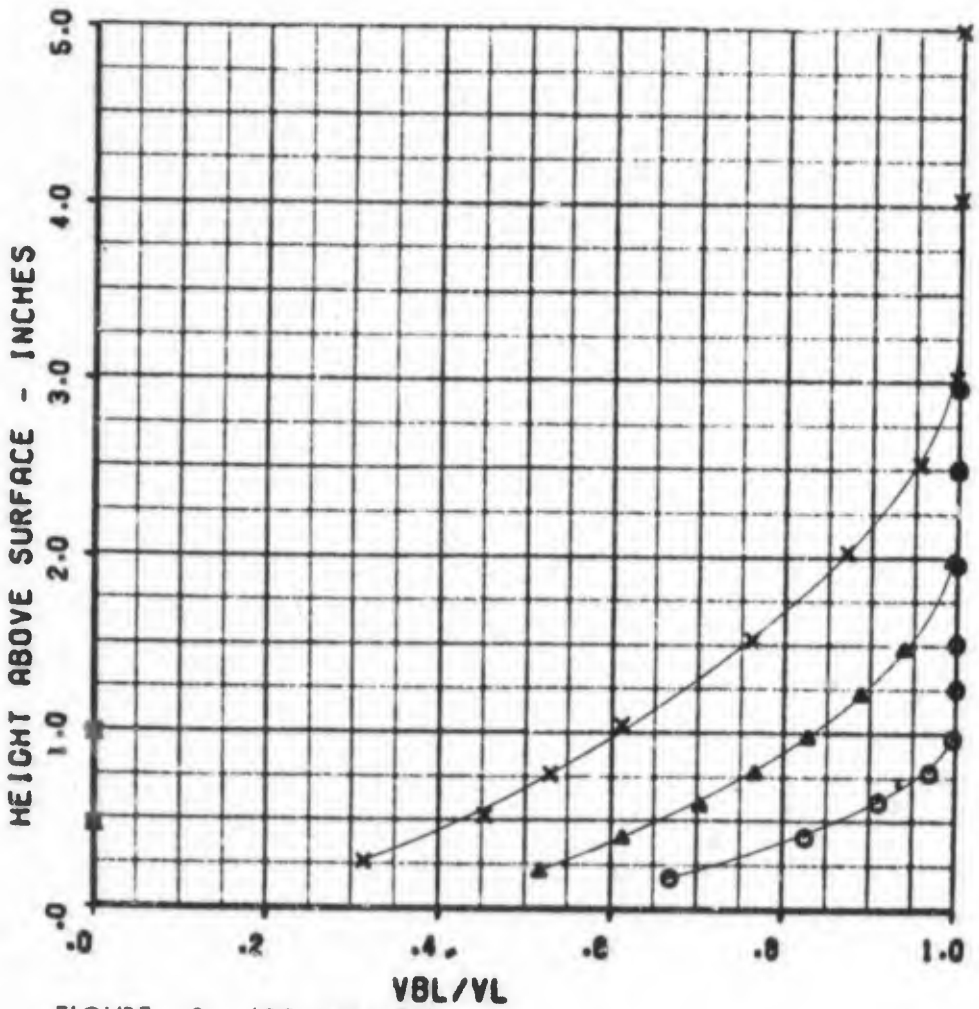
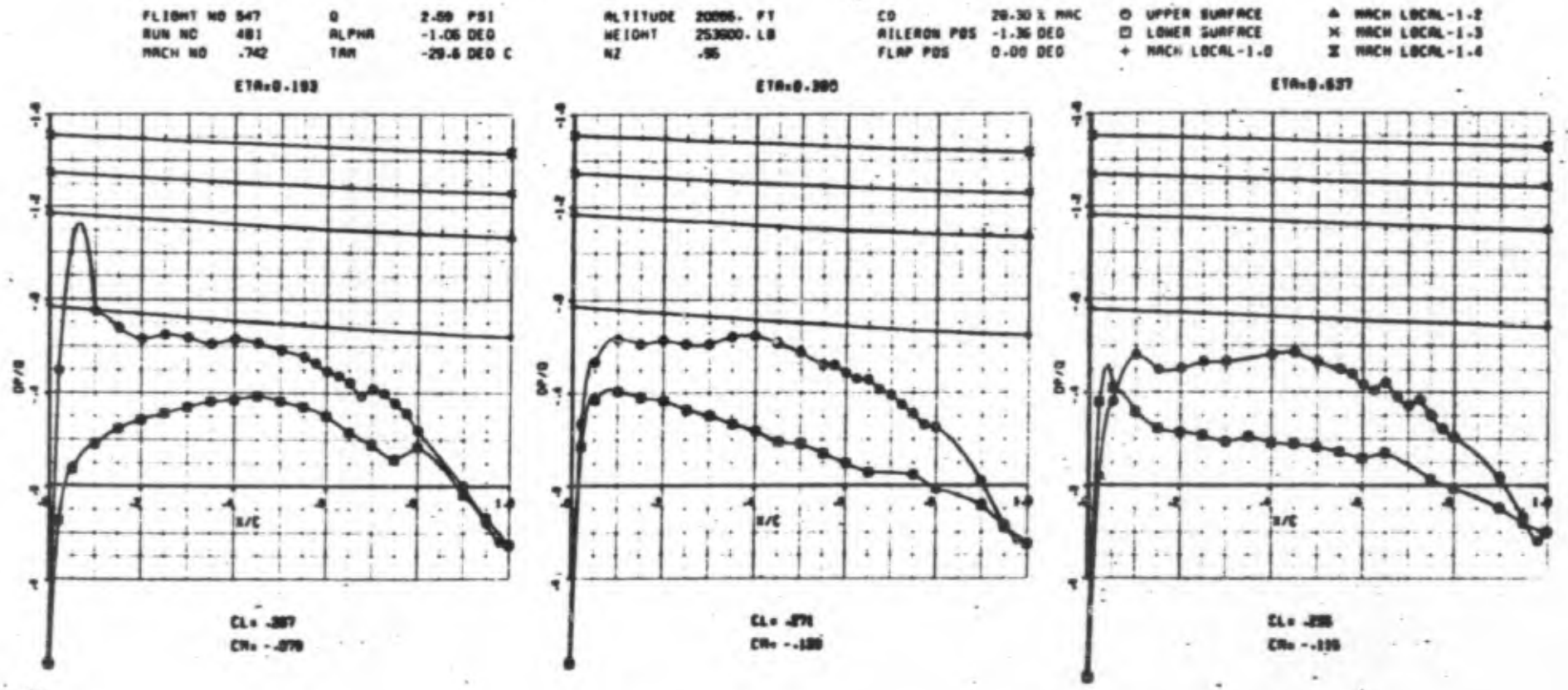


FIGURE 9 (CONTINUED)
(e) CORRECTED ALPHA = -0.45

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 183
MACH NO .750

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

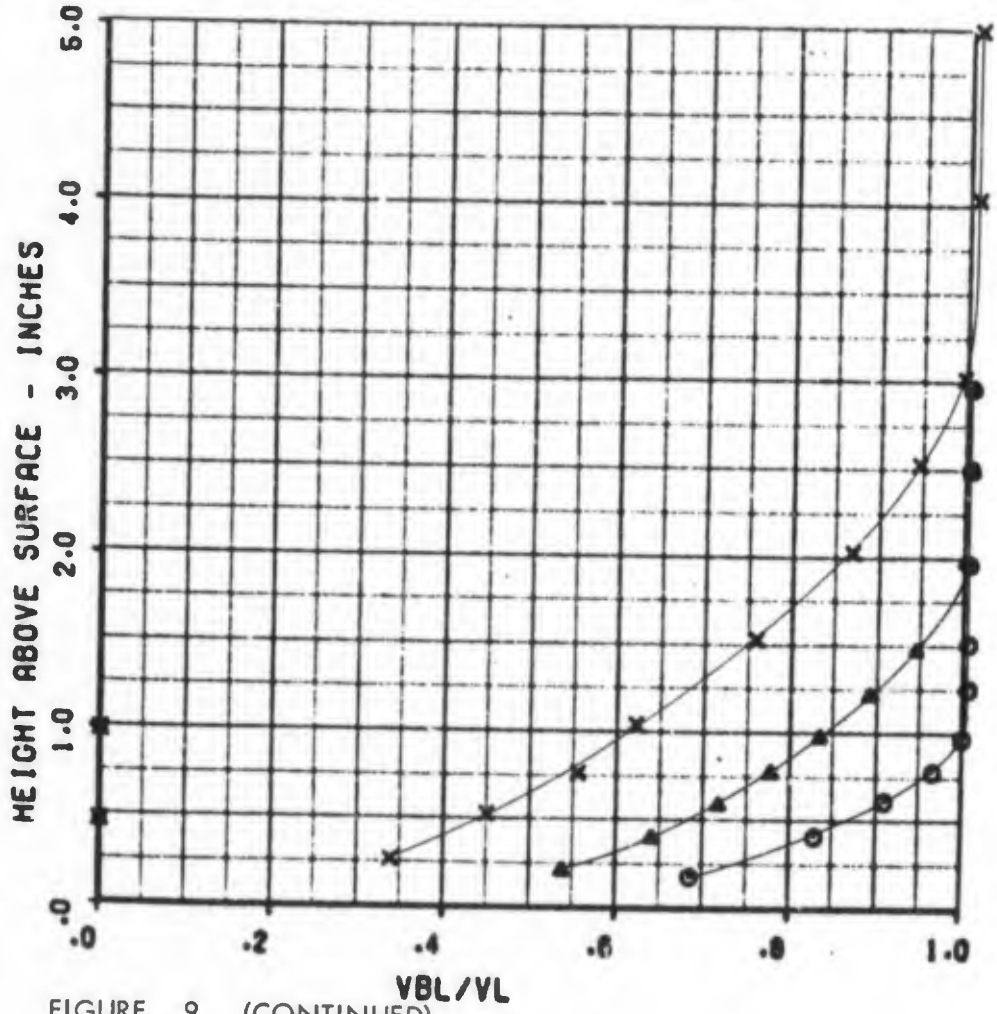
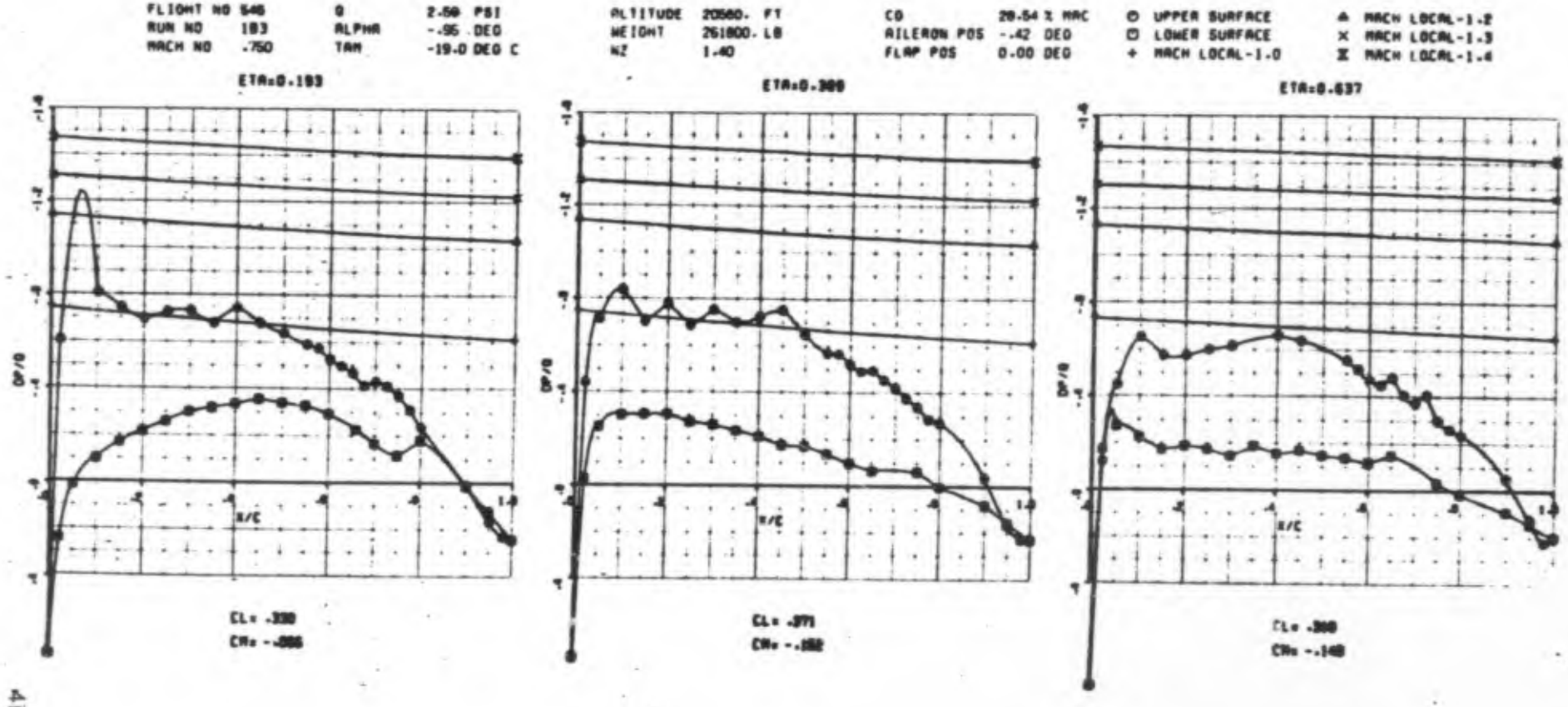


FIGURE 9 (CONTINUED)
(f) CORRECTED ALPHA = -0.35

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 184
MACH NO .750

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

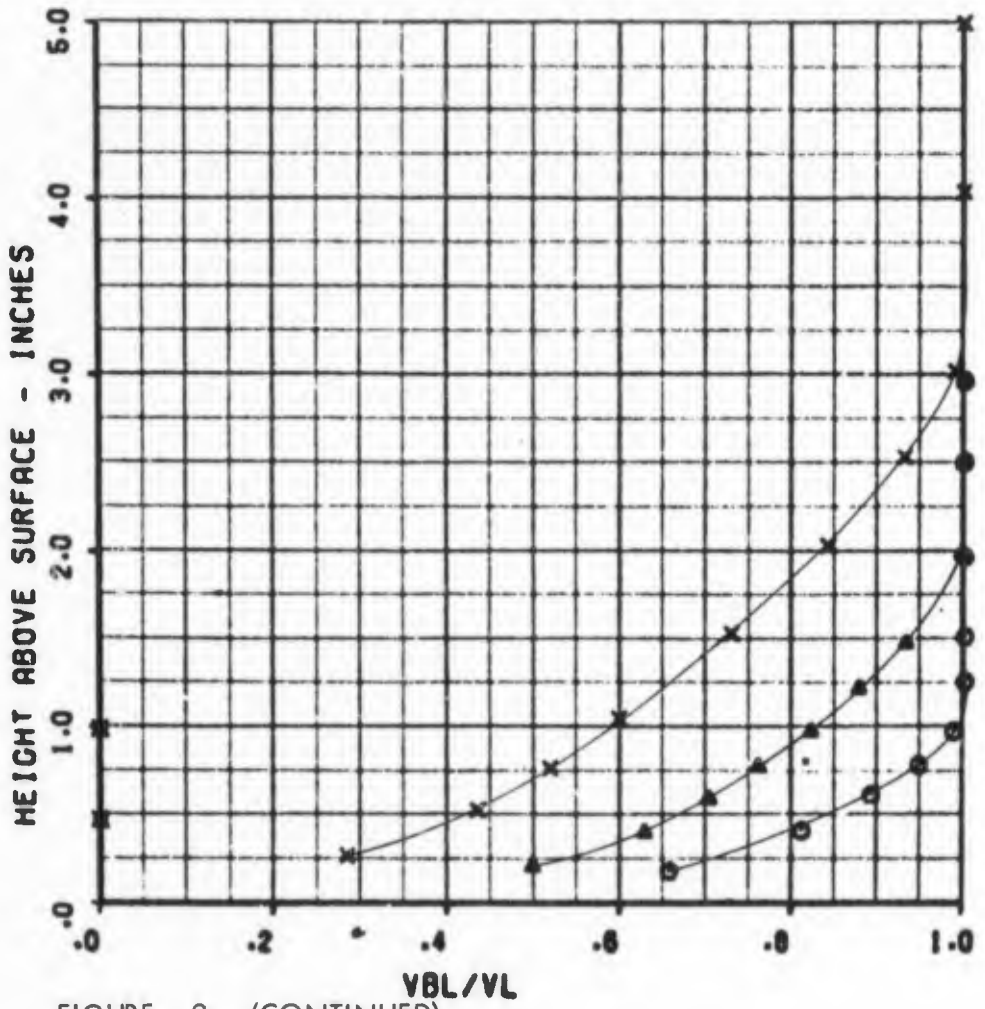
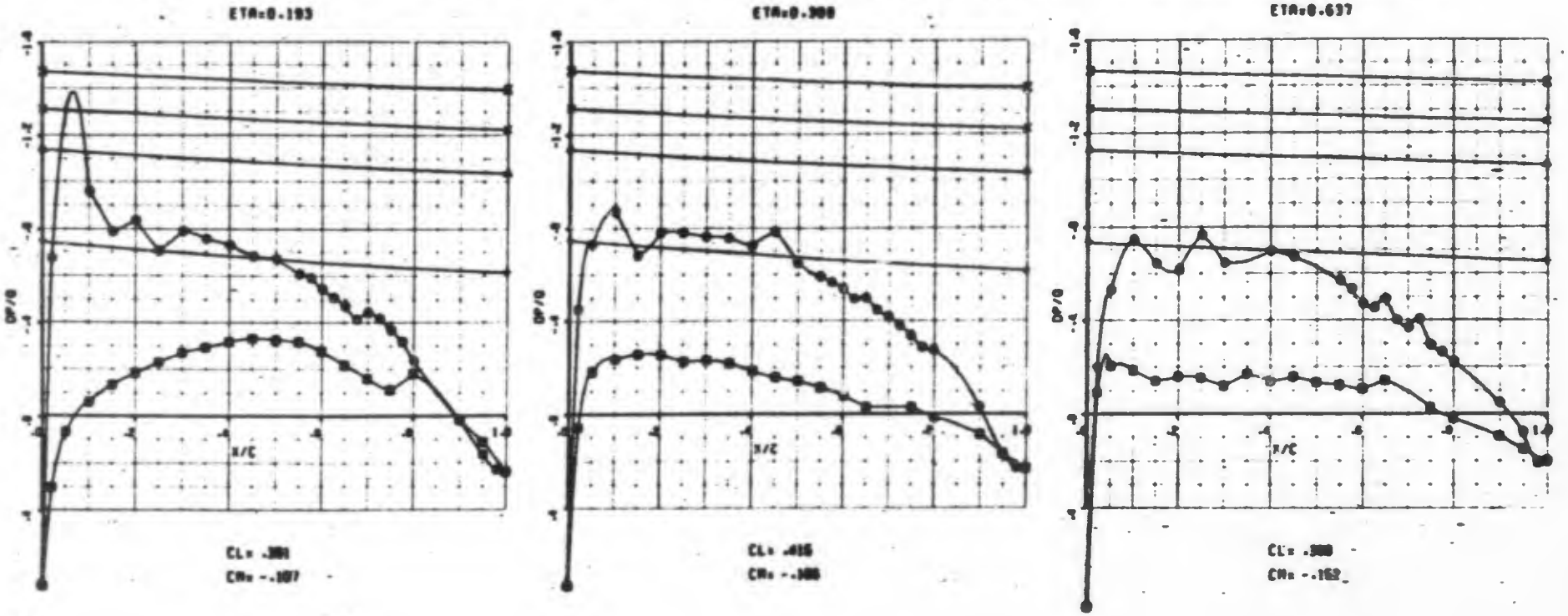


FIGURE 9 (CONTINUED)
(g) CORRECTED ALPHA = 0.22

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	2.61	PSI	ALTITUDE	20390.	FT	CG	26.52	% MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	184	ALPHA	-.29	DEG	WEIGHT	261300.	LB	AILERON POS	.08	DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.750	TAM	-17.4	DEG C	NZ	1.70		FLAP POS	0.00	DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 185
MACH NO .752

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

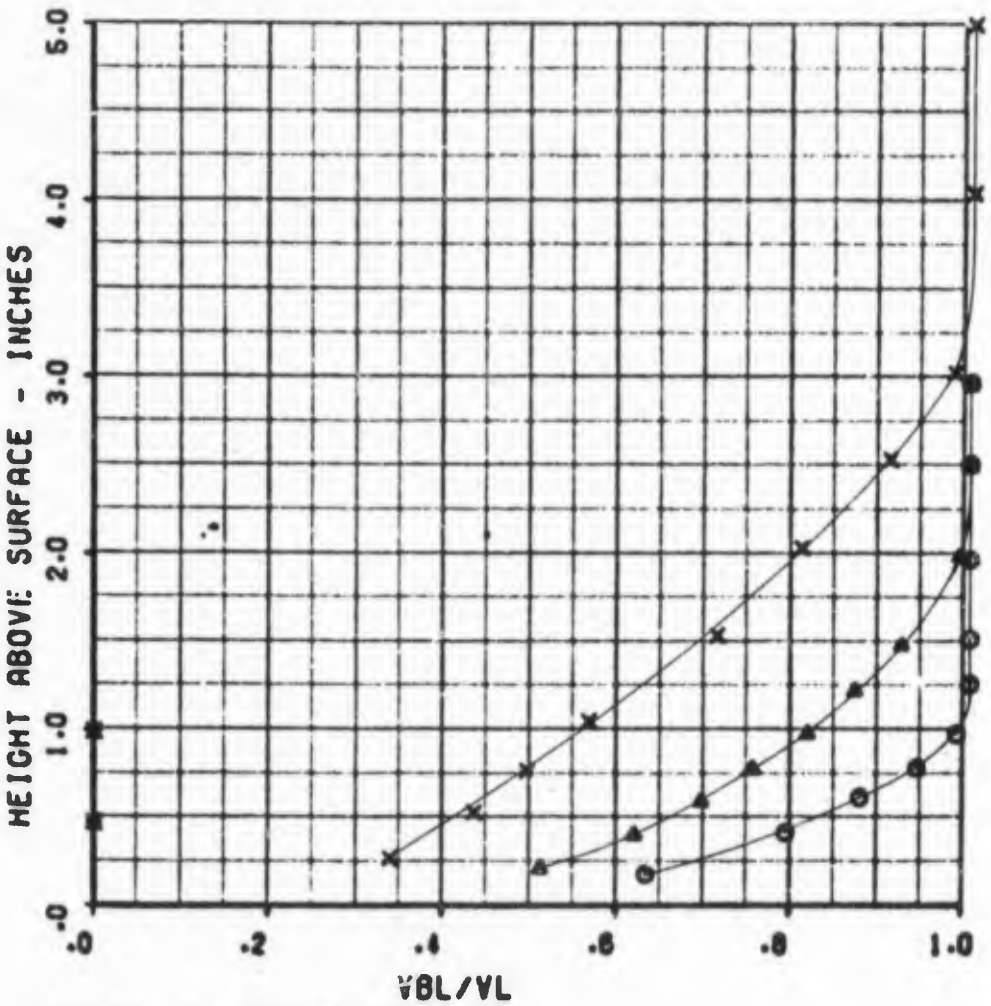


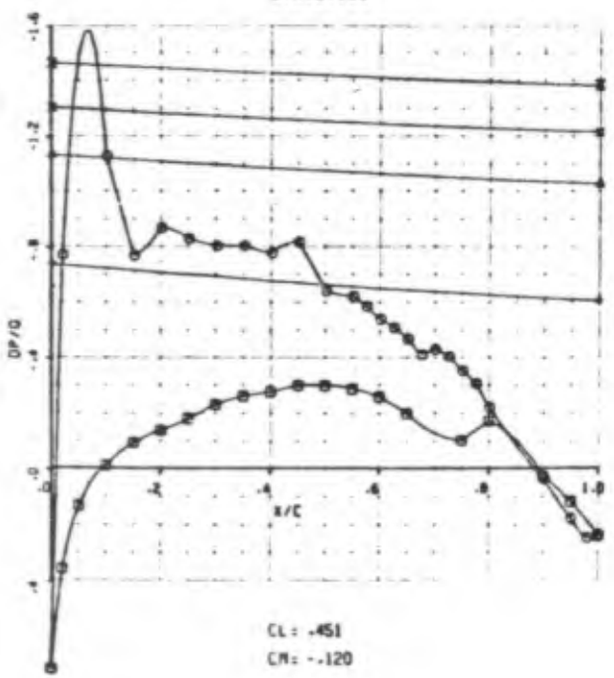
FIGURE 9 (CONCLUDED)
(h) CORRECTED ALPHA = 0.31

LOCKHEED C-141A

PRESSURE DISTRIBUTION

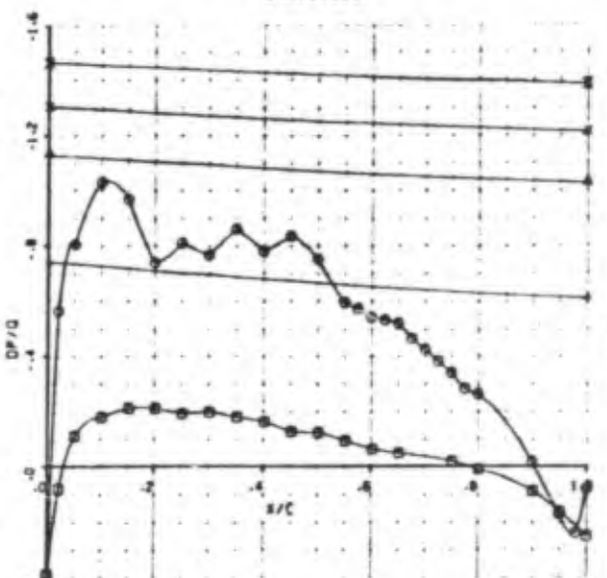
FLIGHT NO	546	Q	2.69 PSI	ALTITUDE	19780. FT	CG	28.50 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	185	ALPHA	-.19 DEG	WEIGHT	259900. LB	AILERON POS	-.58 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.752	TAM	-16.5 DEG C	NZ	1.94	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA:0.193



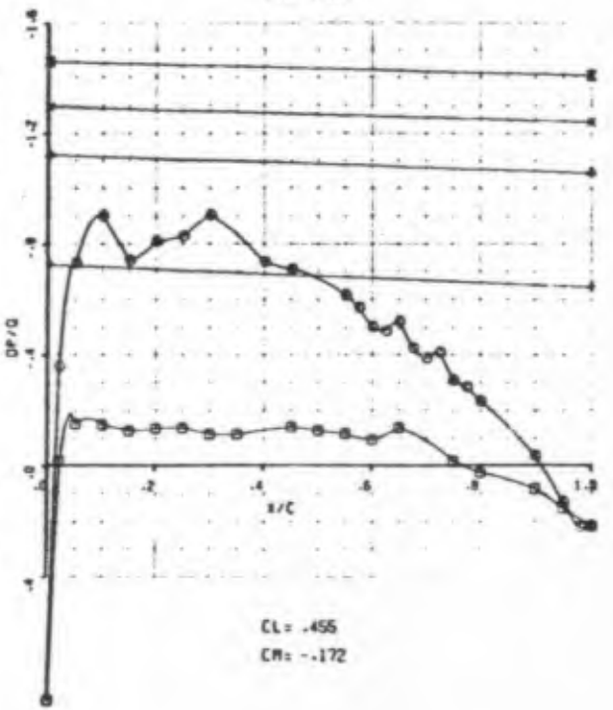
CL= .451
CM= -.120

ETA:0.389



CL= .480
CM= -.181

ETA:0.637



CL= .455
CM= -.172

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1C1
MACH NO .762

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 60 %
✱ 80 %(AFT)

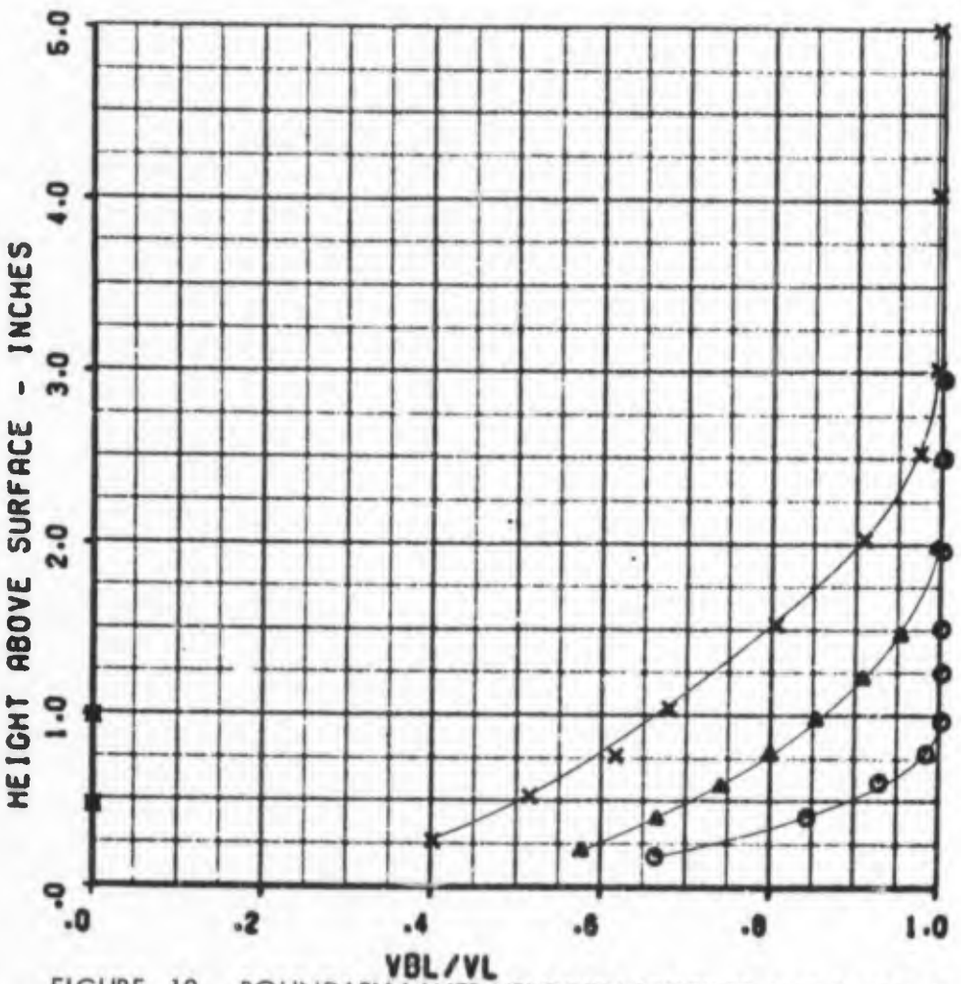


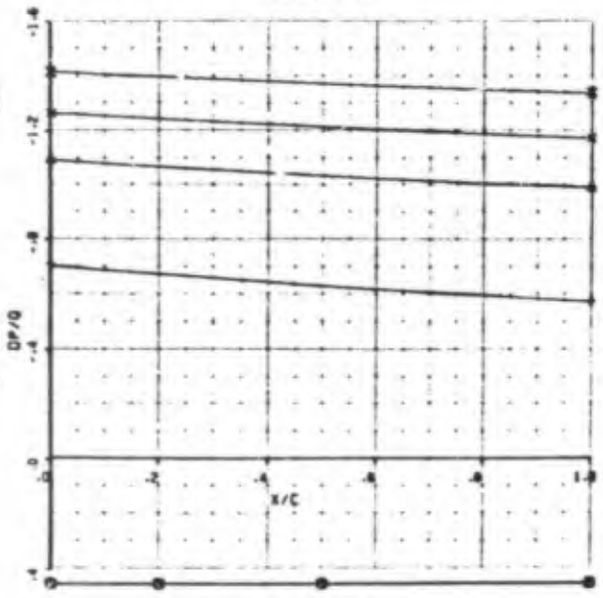
FIGURE 10 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .762 TO .780
(a) CORRECTED ALPHA = -2.78

LOCKHEED C-141A

PRESSURE DISTRIBUTION

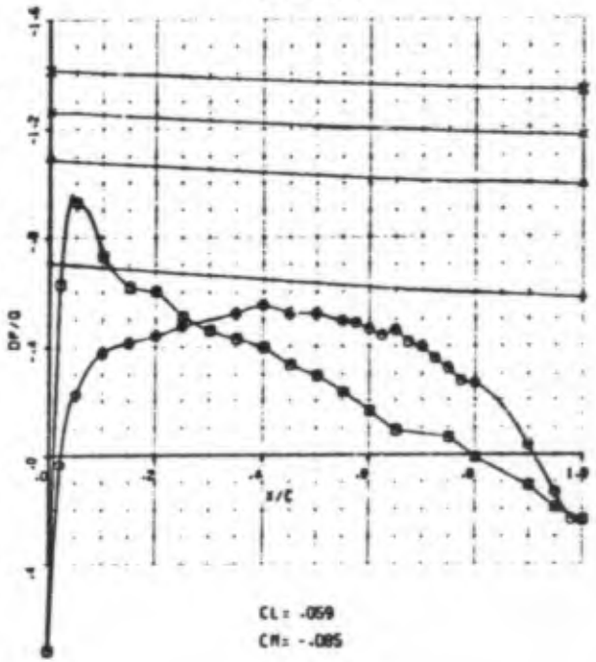
FLIGHT NO	548	Q	2.65 PSI	ALTITUDE	20760. FT	CG	28.35 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	IC1	ALPHA	-3.71 DEG	WEIGHT	253600. LB	AILERON POS	-.42 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.762	TAT	-19.5 DEG C	NZ	0.00	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA:0.193



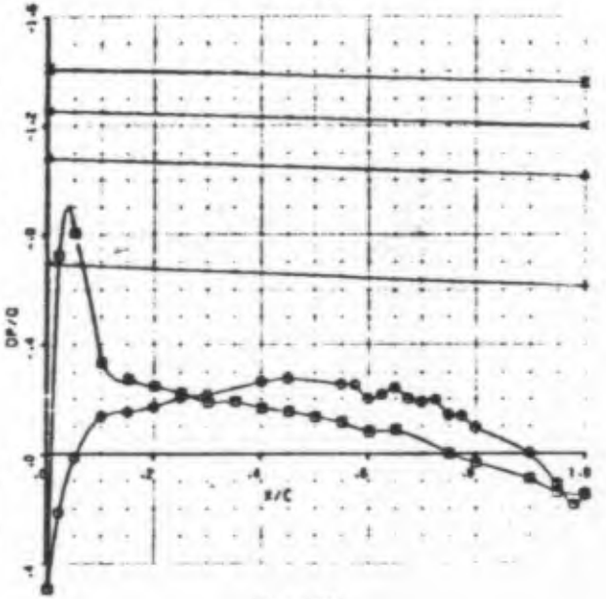
CL= 0.030
CM= 0.000

ETA:0.389



CL= .059
CM= -.085

ETA:0.637



CL= -.004
CM= -.042

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO: 548
RUN NO 2A5
MACH NO .770

RAKE LOCATIONS

○ 30 %
△ 55 %
× 60 %
✱ 80 %(AFT)

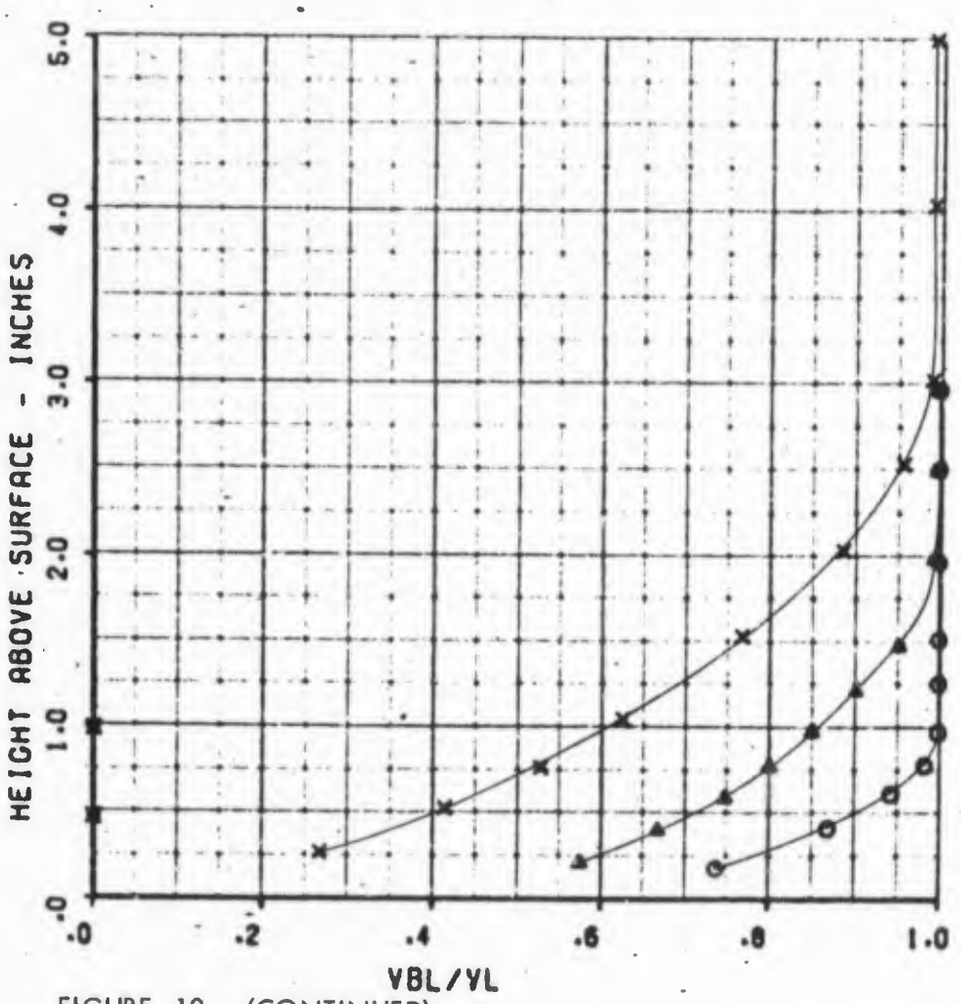
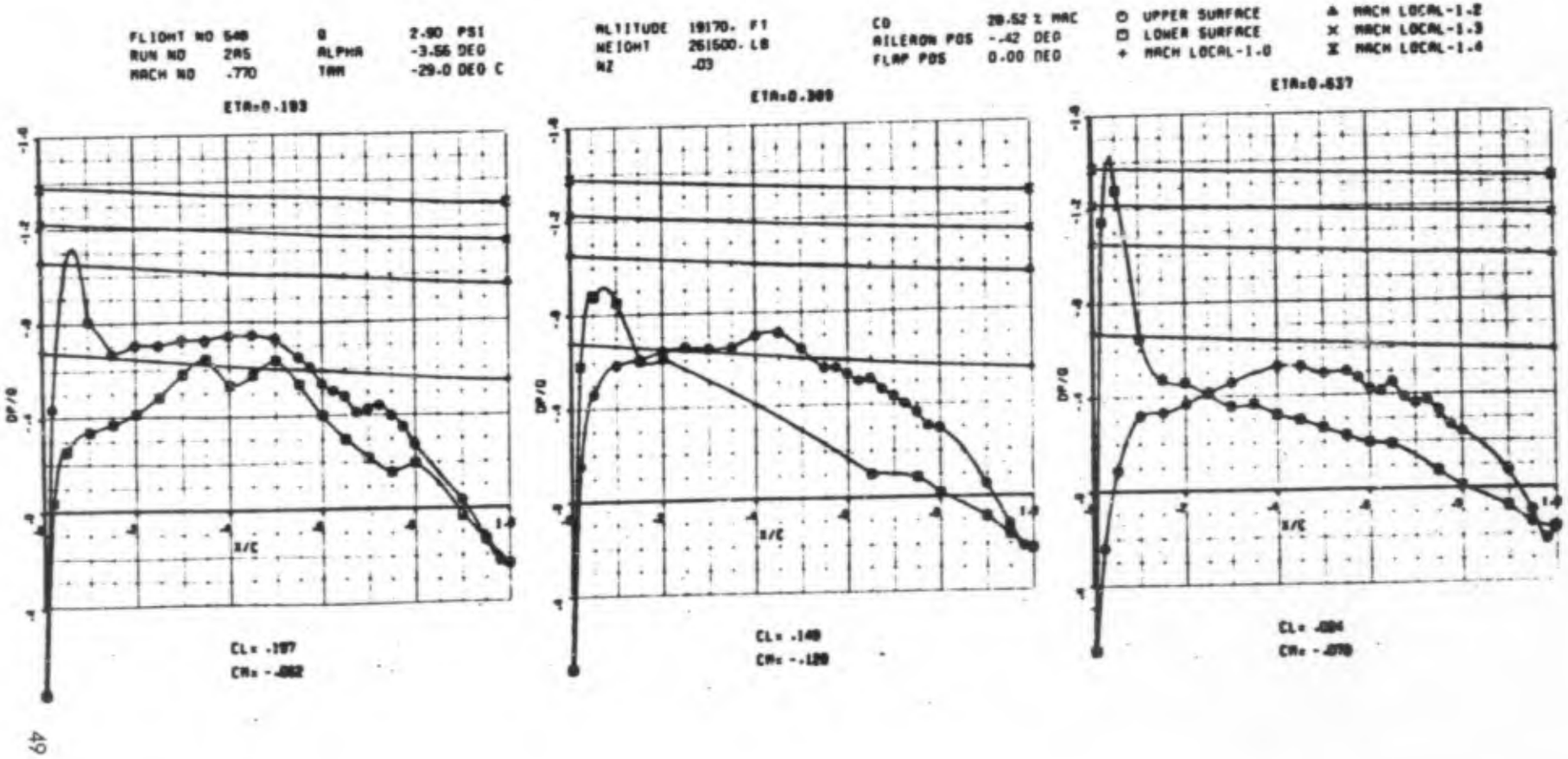


FIGURE 10 (CONTINUED)
(b) CORRECTED ALPHA = -2.64

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141C

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1C2
MACH NO .770

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

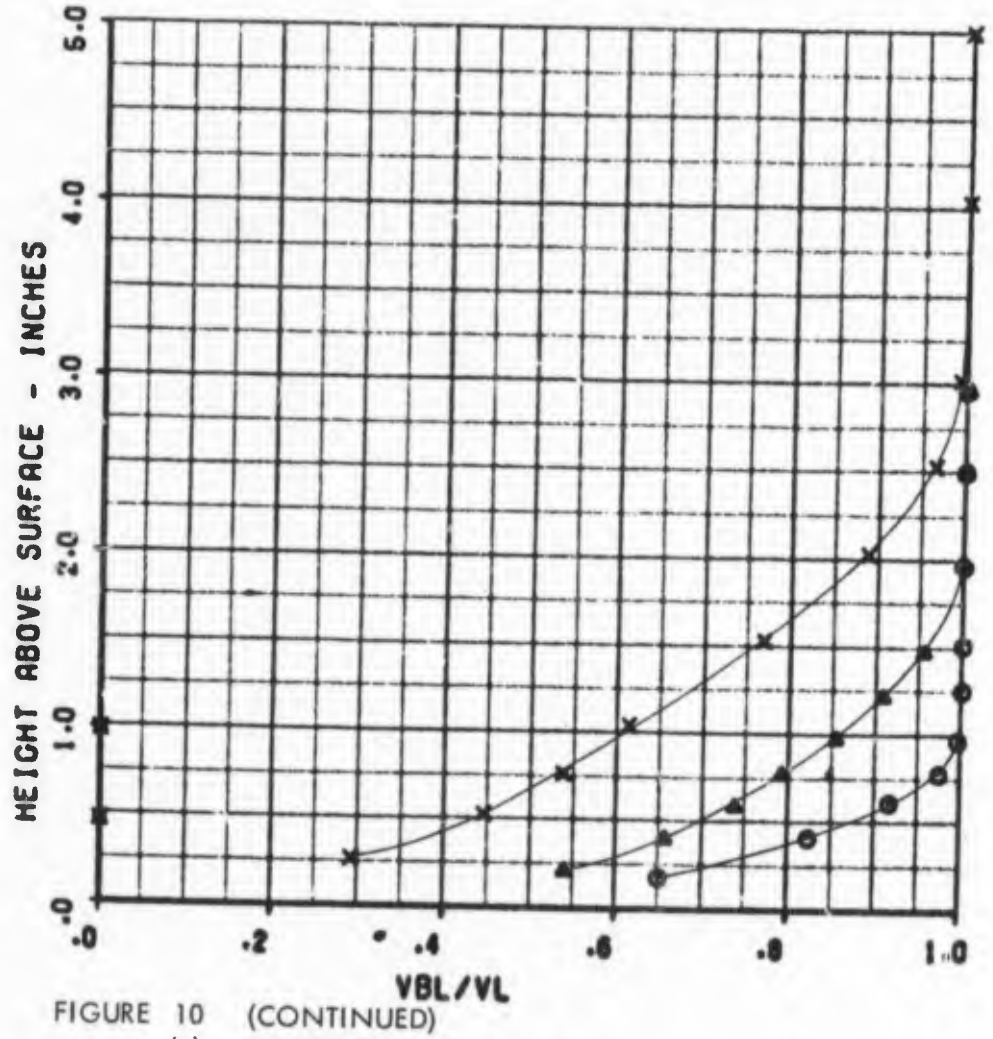
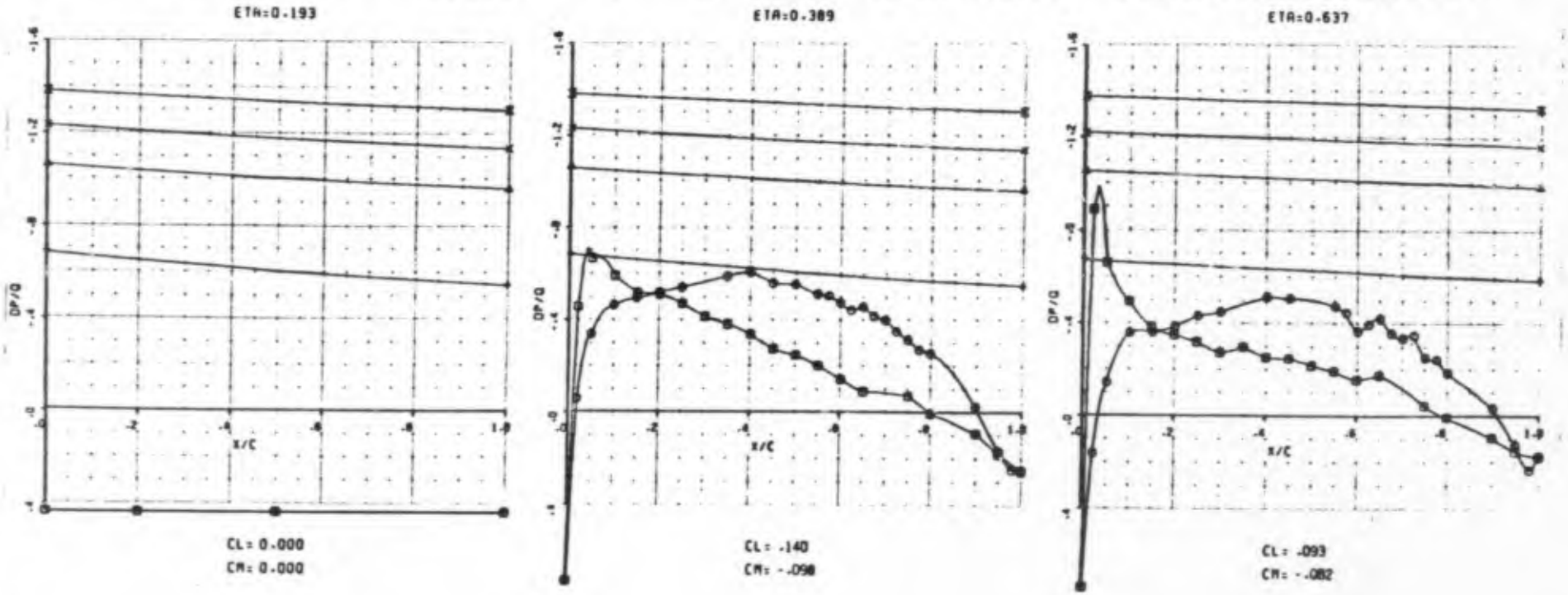


FIGURE 10 (CONTINUED)
(c) CORRECTED ALPHA = -2.01

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	546	Q	2.79 PSI	ALTITUDE	20030. FT	CG	28.35 % MAC	○	UPPER SURFACE	△	MACH LOCAL-1.2
RUN NO	IC2	ALPHA	-2.85 DEG	WEIGHT	256000. LB	AILERON POS	-.25 DEG	□	LOWER SURFACE	×	MACH LOCAL-1.3
MACH NO	.770	TAM	-17.2 DEG C	NZ	.98	FLAP POS	0.00 DEG	+	MACH LOCAL-1.0	⧖	MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2A4
MACH NO .770

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

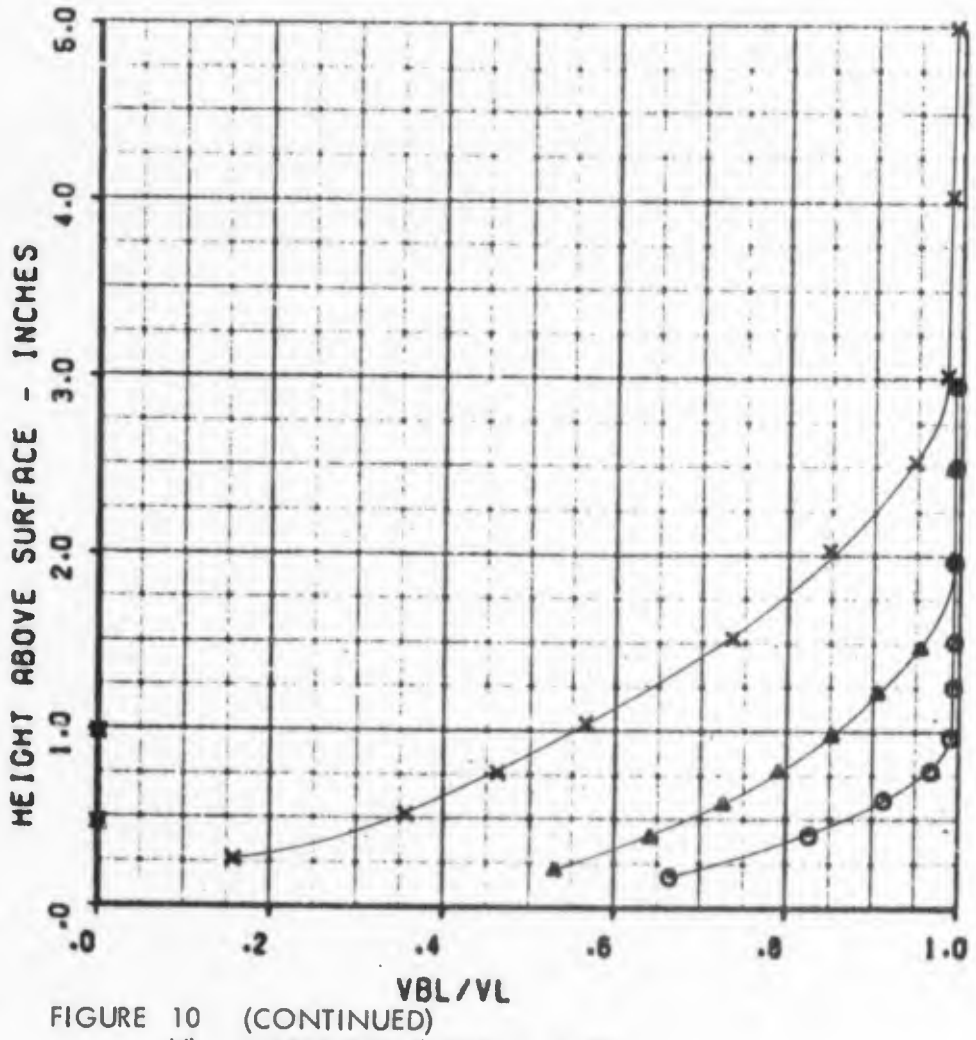
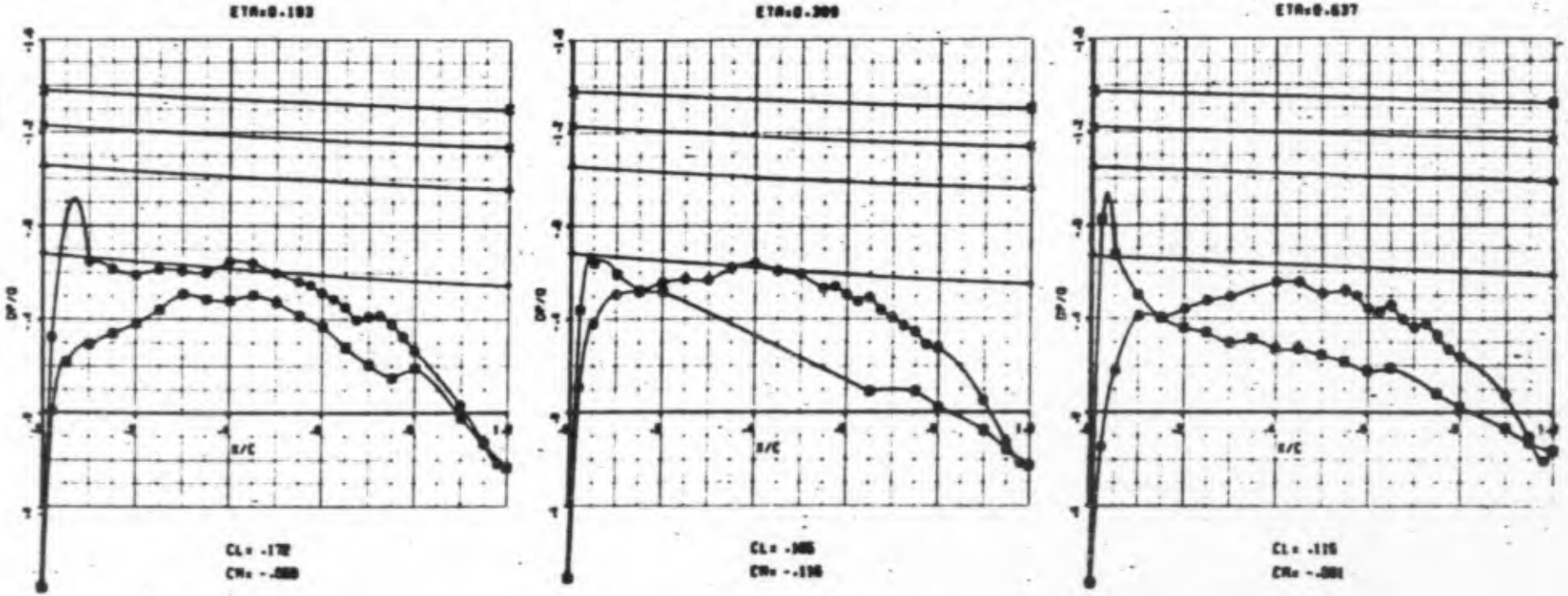


FIGURE 10 (CONTINUED)
(d) CORRECTED ALPHA = -1.88

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	2.86 PSI	ALTITUDE	19956. FT	CG	28.54 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	2R4	ALPHA	-2.68 DEG	WEIGHT	262100. LB	AILERON POS	-.61 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.770	TAT	-30.2 DEG C	NZ	.46	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1C
MACH NO .770

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

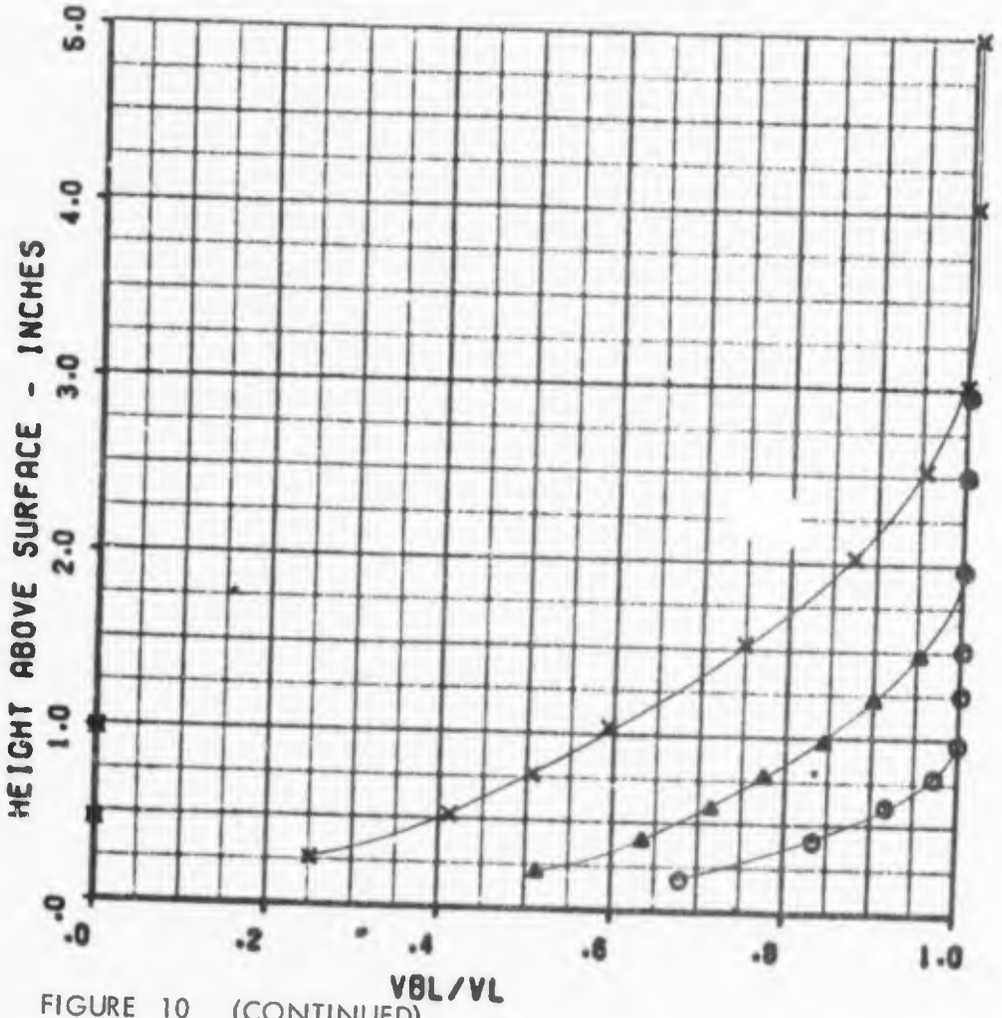
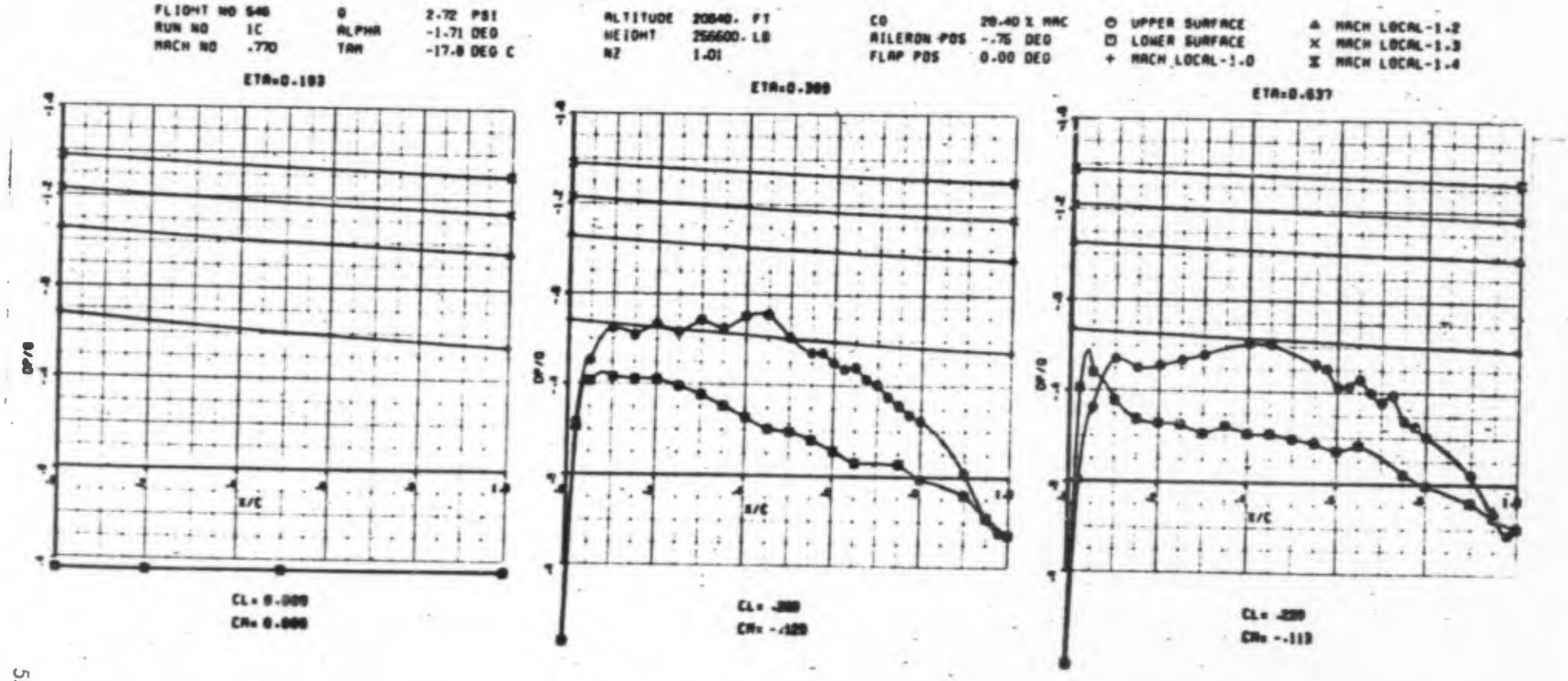


FIGURE 10 (CONTINUED)
(e) CORRECTED ALPHA = -1.01

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2A
MACH NO .770

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

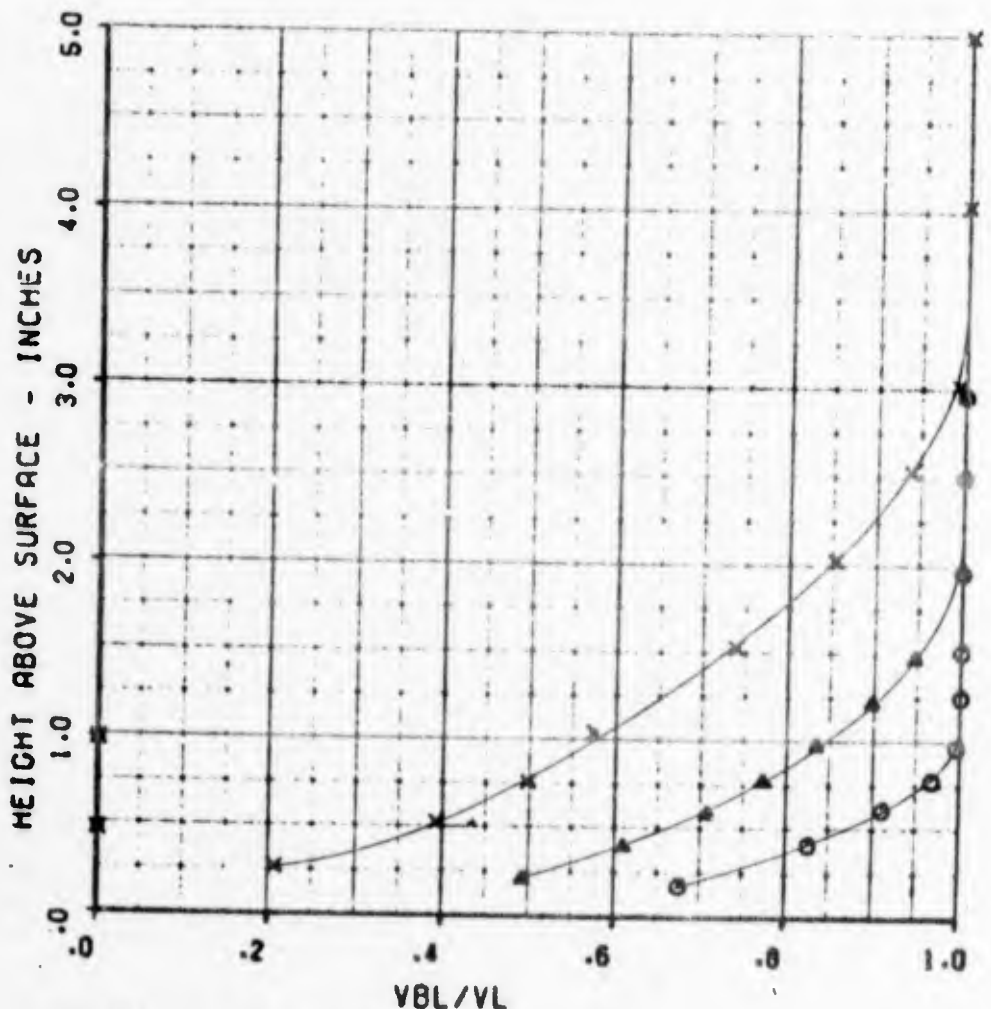
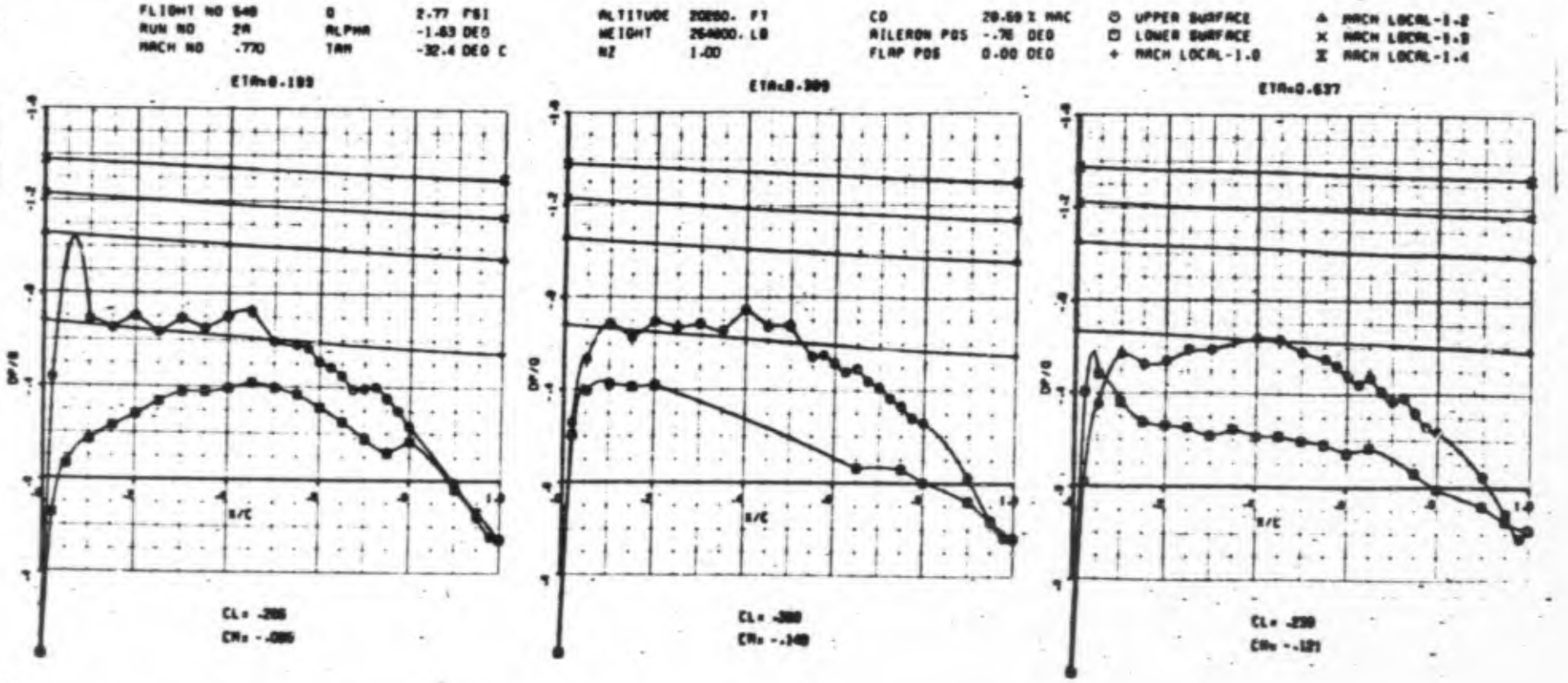


FIGURE 10 (CONTINUED)
(f) CORRECTED ALPHA = -0.96

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1C3
MACH NO .780

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

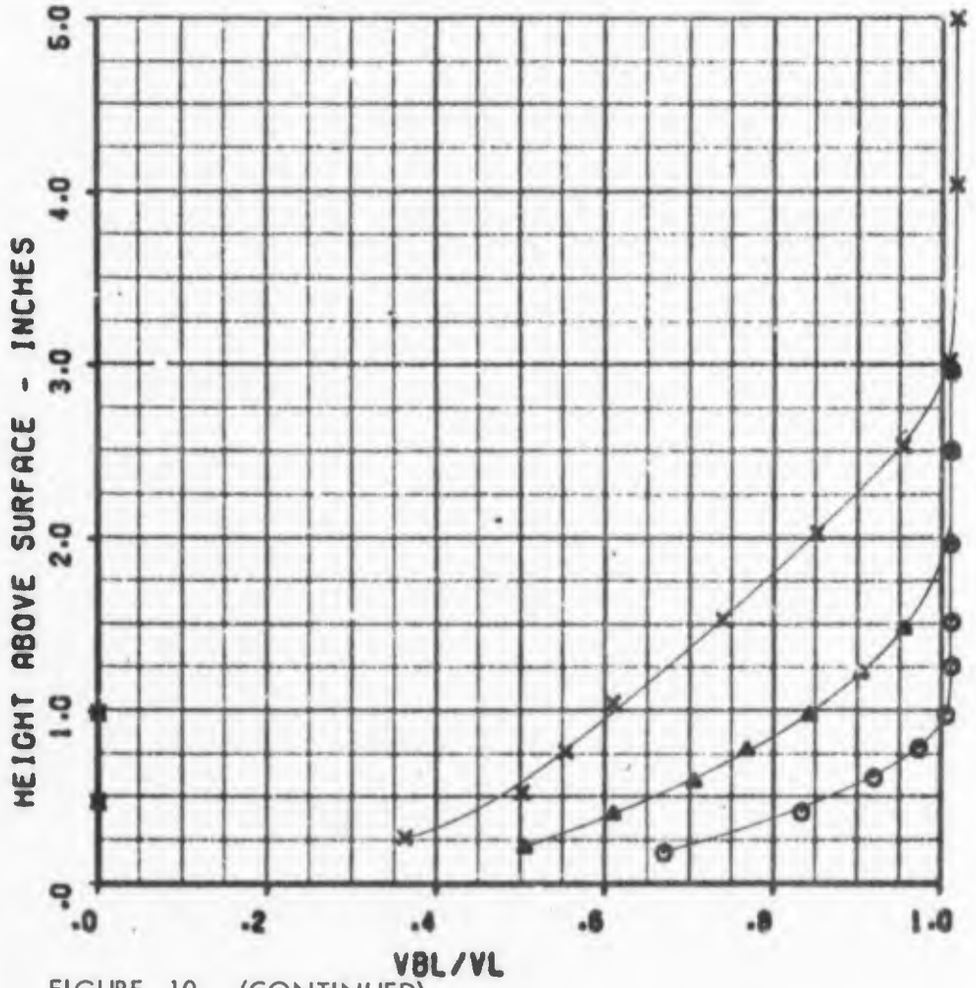
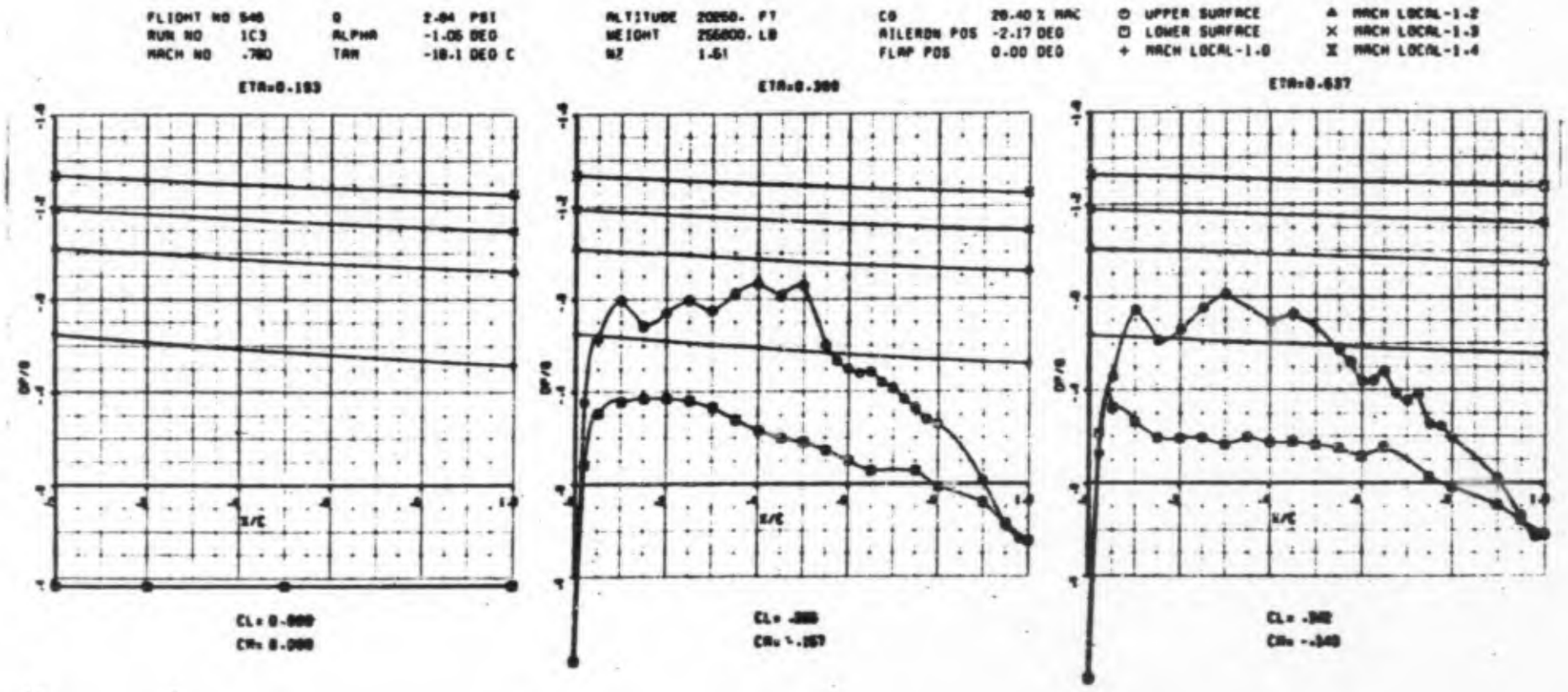


FIGURE 10 (CONTINUED)
(g) CORRECTED ALPHA = -0.44

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2A1
MACH NO .778

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

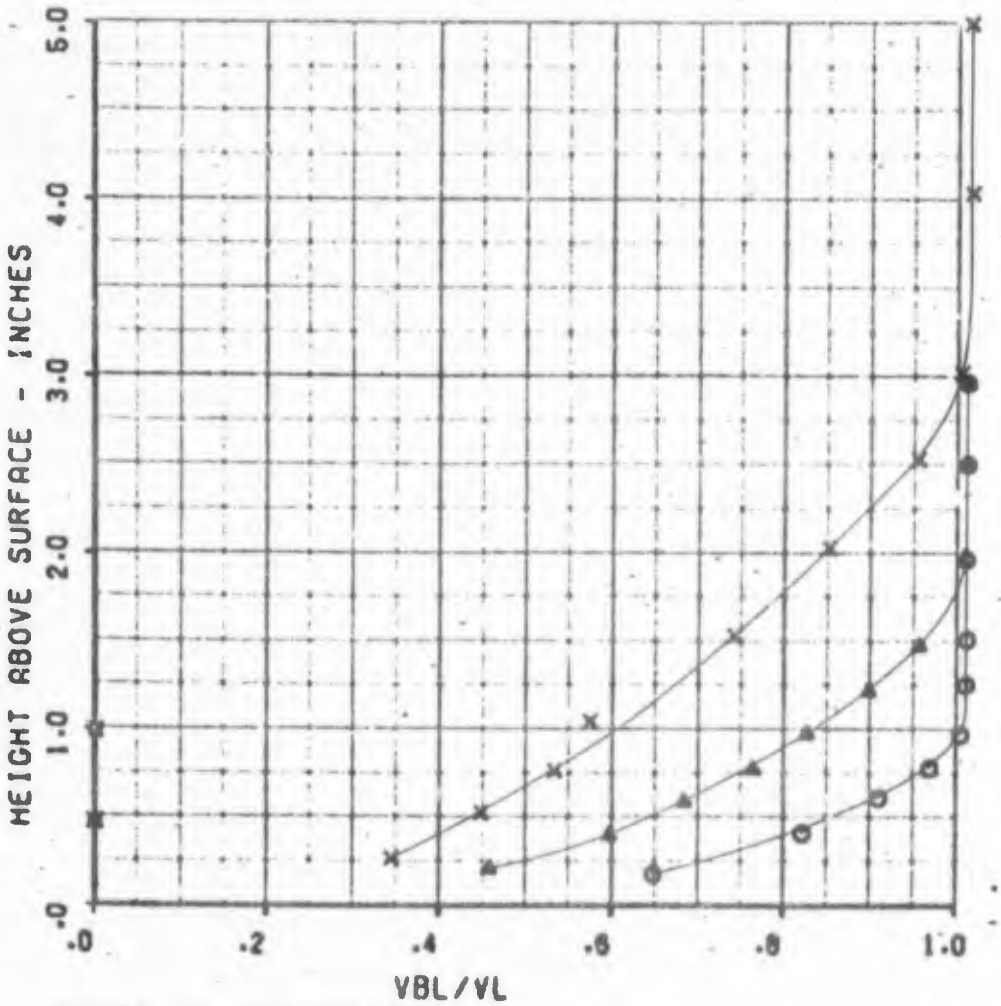


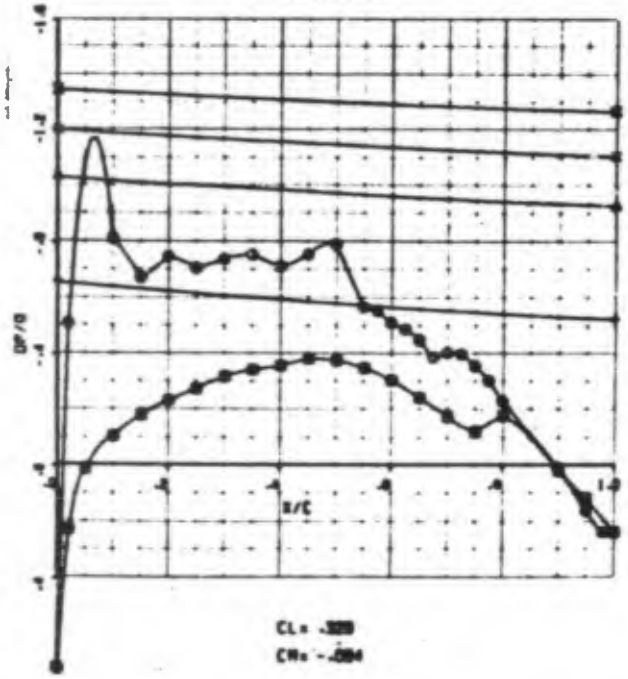
FIGURE 10 (CONTINUED)
(h) CORRECTED ALPHA = -0.28

LOCKHEED C-141A

PRESSURE DISTRIBUTION

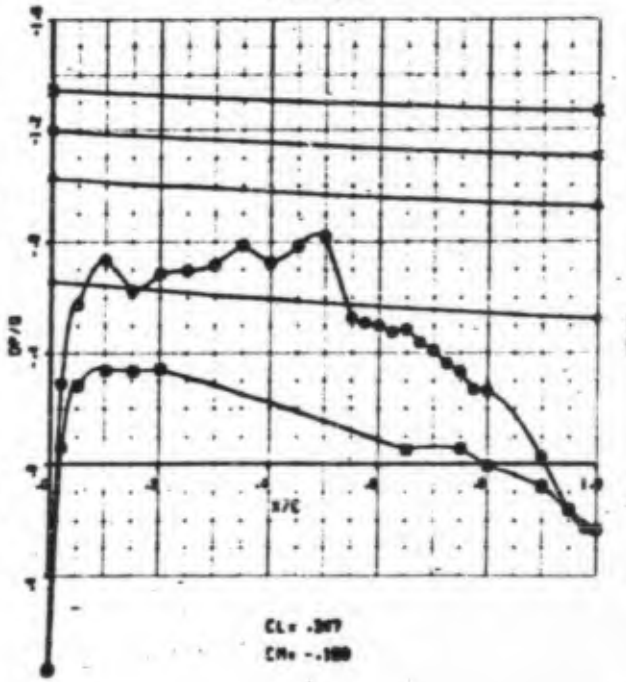
FLIGHT NO	548	Q	2.88 PSI	ALTITUDE	19925. FT	CG	20.58 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	2R1	ALPHA	-.85 DEG	WEIGHT	264500. LB	AILERON POS	-.93 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.778	TAM	-31.8 DEG C	NZ	1.48	FLAP POS	0.00 DEG	◇ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4

ETA=0.193



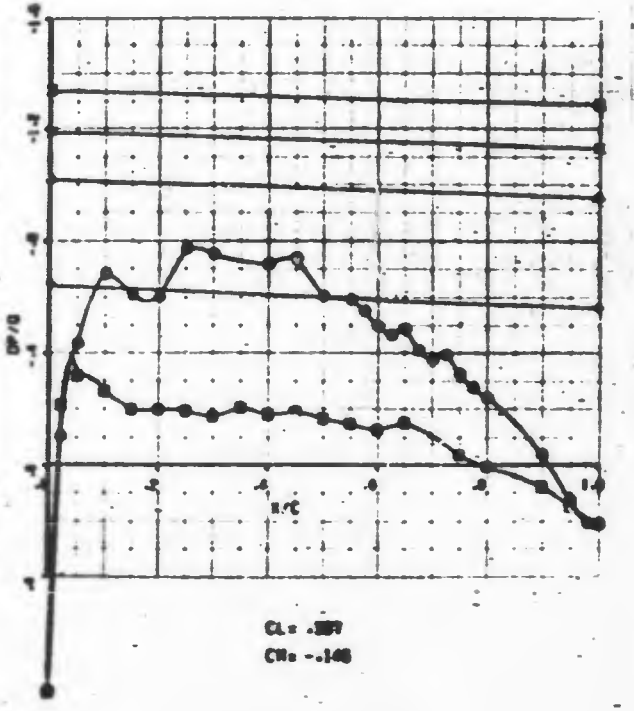
CL= .328
CM= -.084

ETA=0.389



CL= .347
CM= -.100

ETA=0.637



CL= .387
CM= -.148

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1C4
MACH NO .770

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
※ 80 %(AFT)

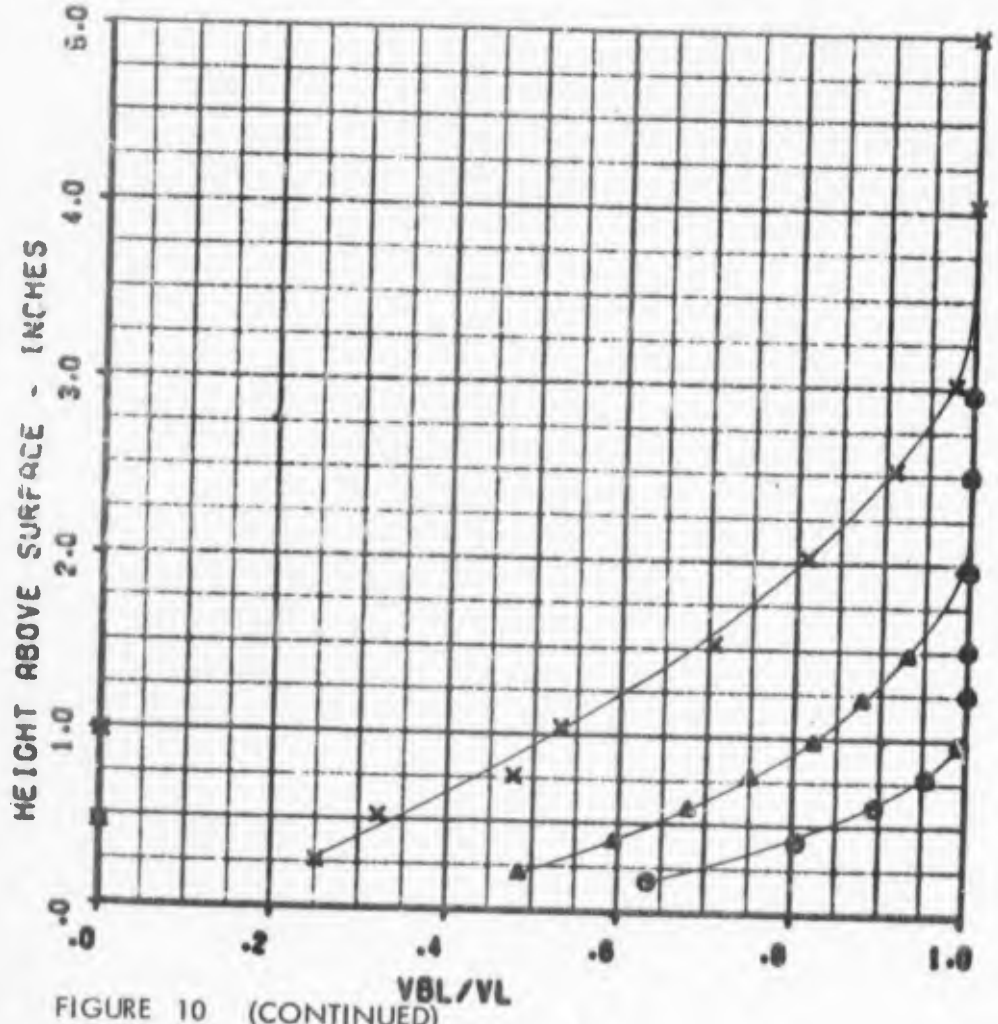
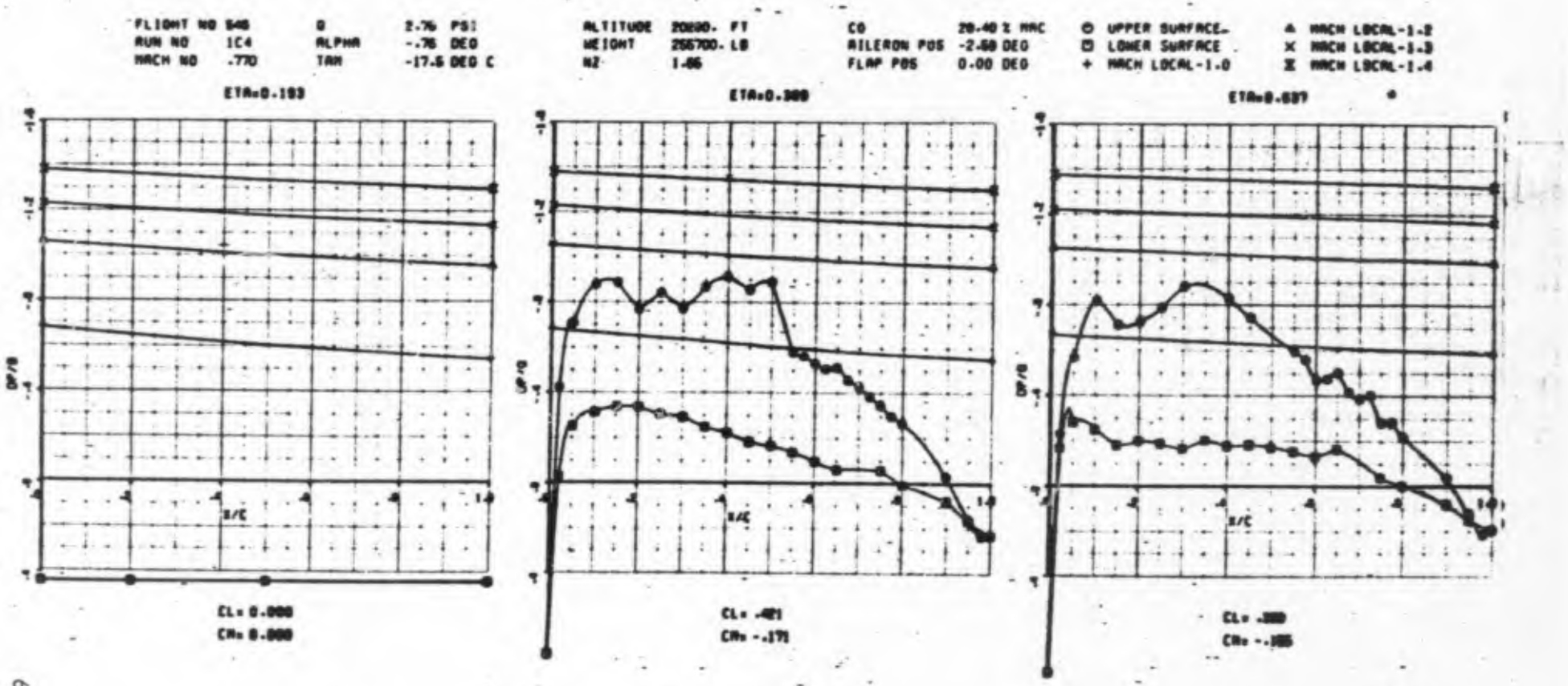


FIGURE 10 (CONTINUED)
(k) CORRECTED ALPHA = -0.18

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2A2
MACH NO .772

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
⋇ 80 %(AFT)

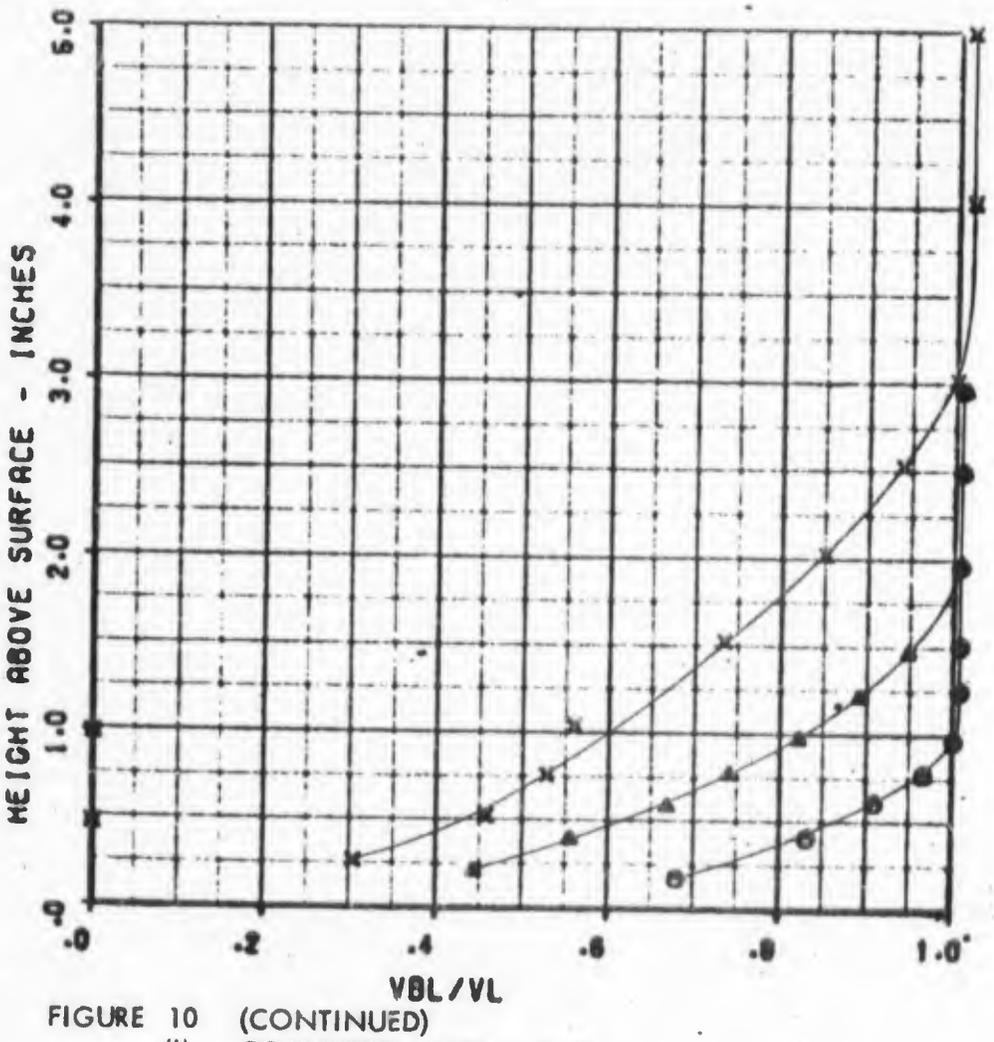
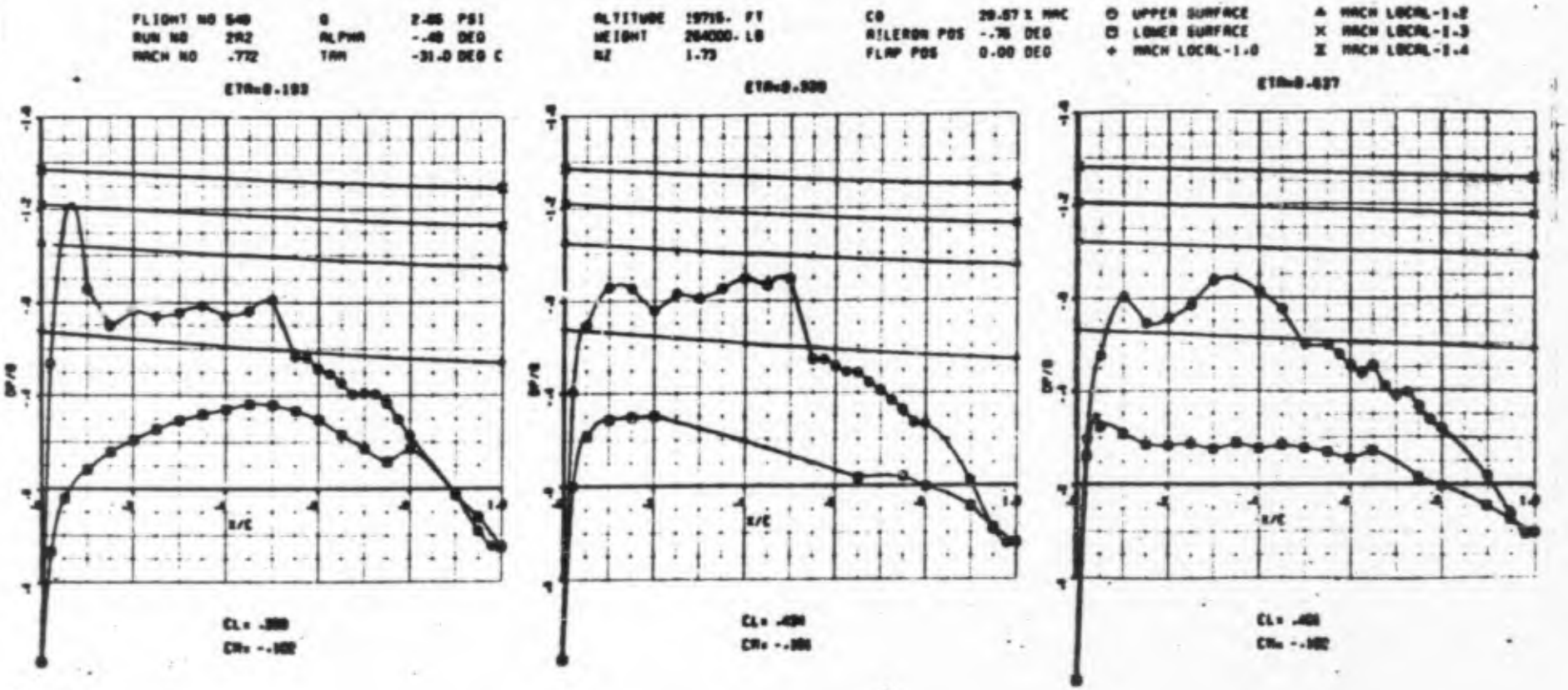


FIGURE 10 (CONTINUED)
(l) CORRECTED ALPHA = 0.04

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1C5
MACH NO .772

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

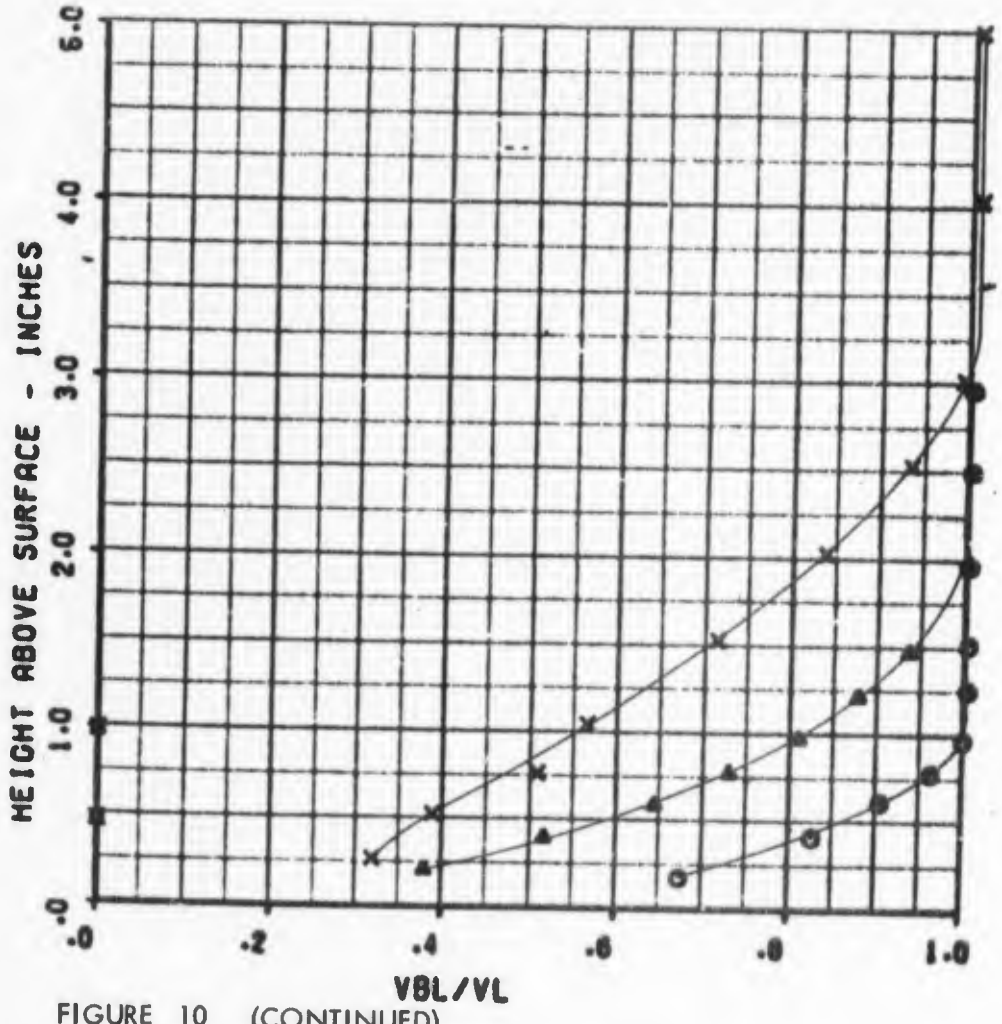


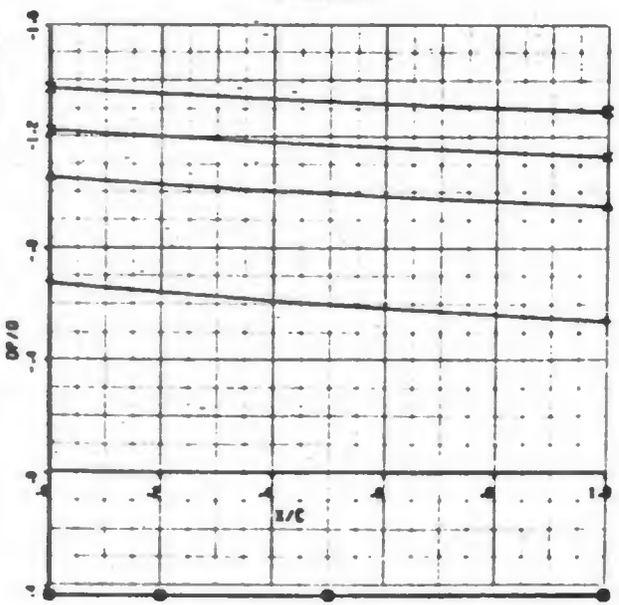
FIGURE 10 (CONTINUED)
(m) CORRECTED ALPHA = 0.15

LOCKHEED C-141A

PRESSURE DISTRIBUTION

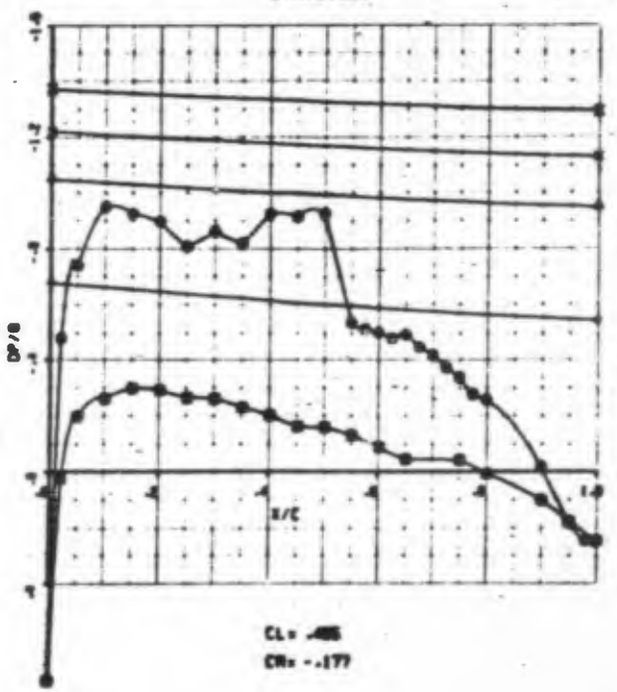
FLIGHT NO	548	Q	2.80	PSI	ALTITUDE	20120.	FT	CG	20.35	% MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	105	-ALPHA	-.38	DEG	WEIGHT	256400.	LB	AILERON POS	-1.33	DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.772	TAK	-16.8	DEG C	NZ	1.09		FLAP POS	0.00	DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4

ETA=0.193



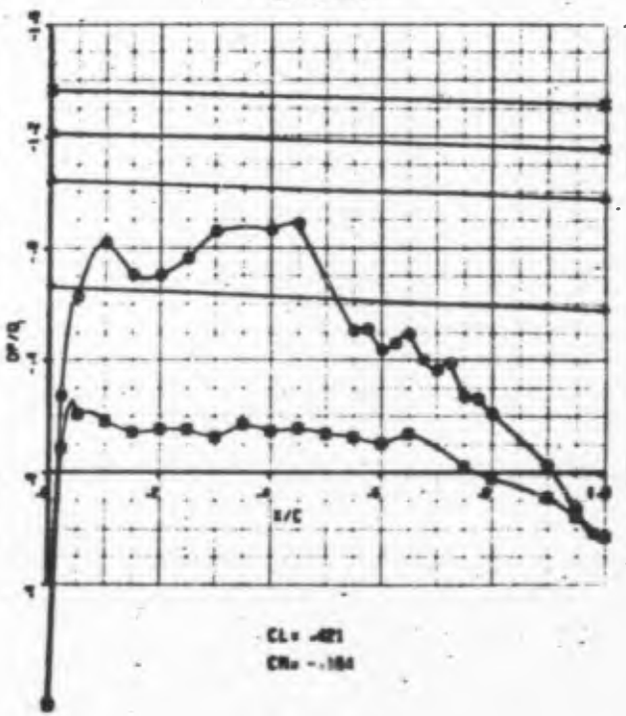
CL= 0.000
CM= 0.000

ETA=0.389



CL= .486
CM= -.177

ETA=0.637



CL= .421
CM= -.184

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2A3
MACH NO .775

RAKE LOCATIONS

⊙ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

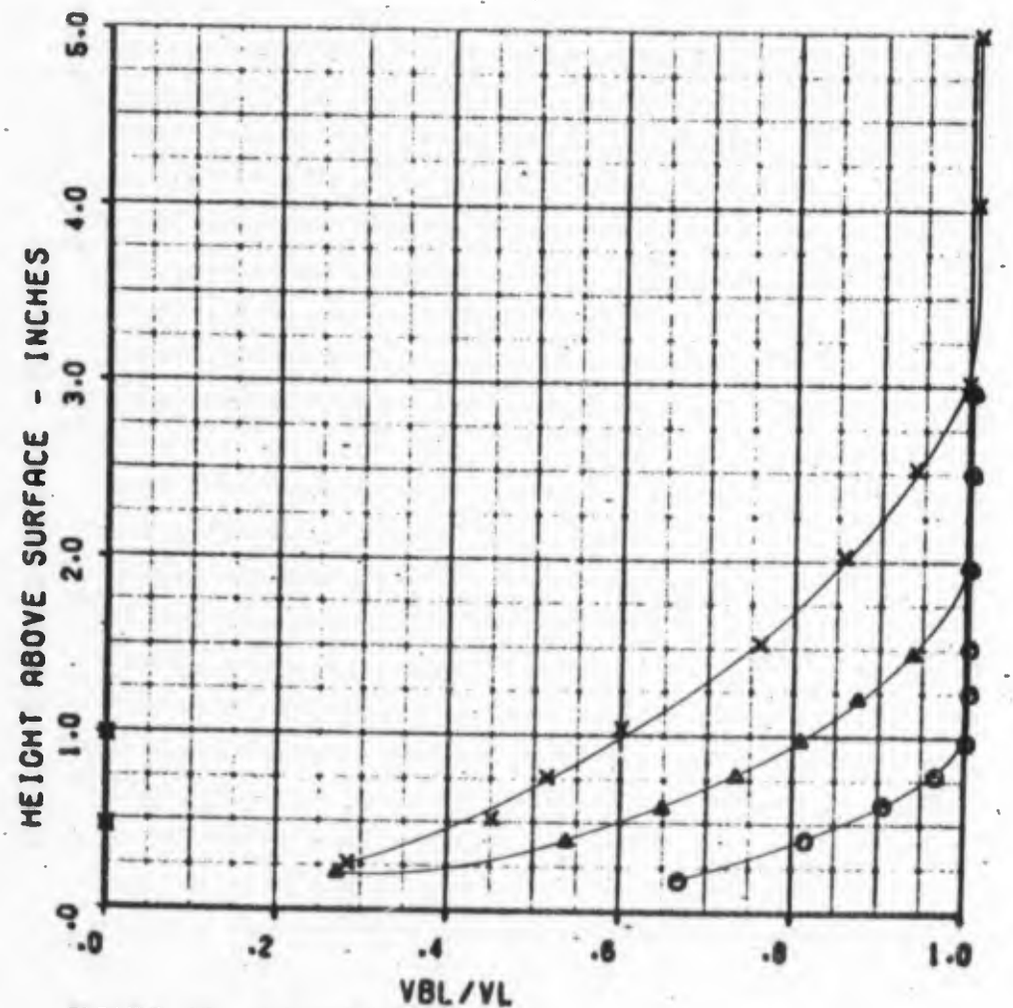


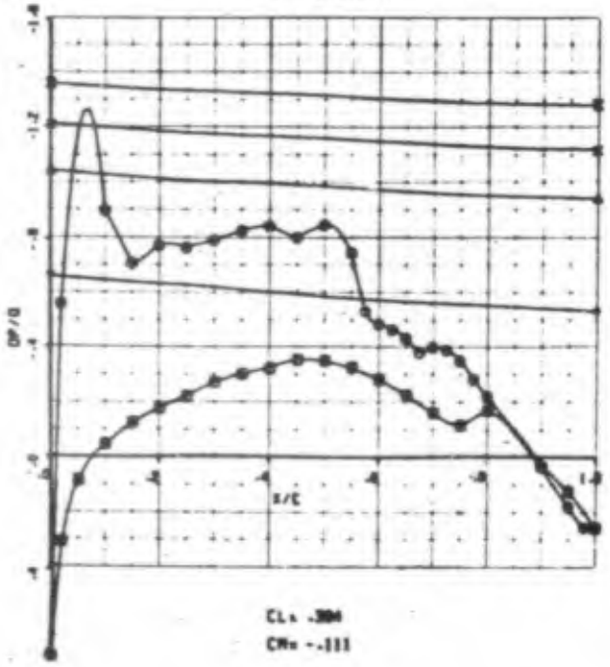
FIGURE 10 (CONCLUDED)
(n) CORRECTED ALPHA = 0.22

LOCKHEED C-141A

PRESSURE DISTRIBUTION

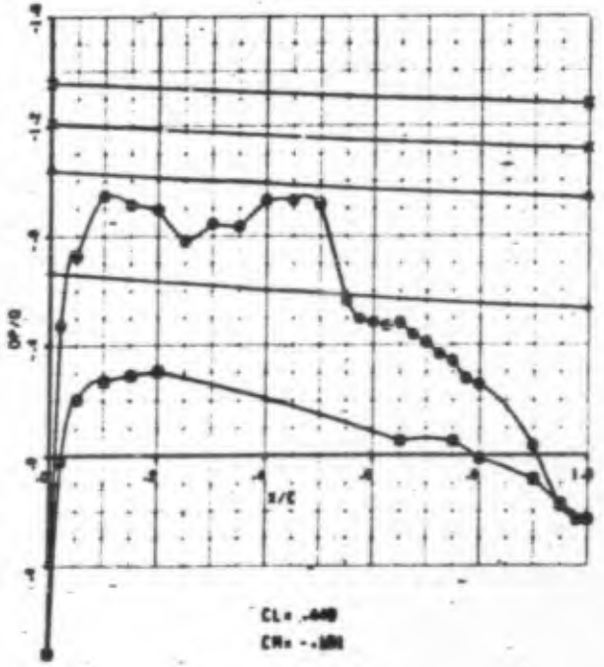
FLIGHT NO	540	Q	2.94 PSI	ALTITUDE	19000. FT	CG	20.66 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	2A3	ALPHA	-.29 DEG	WEIGHT	263600. LB	AILERON POS	-.68 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.775	TAN	-29.4 DEG C	NZ	1.91	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA=0.193



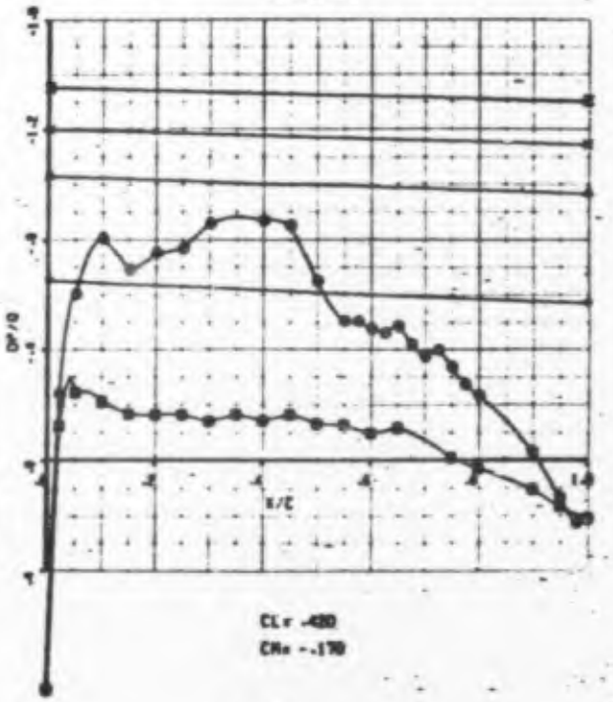
CL= .384
CM= -.111

ETA=0.389



CL= .648
CM= -.184

ETA=0.637



CL= .430
CM= -.170

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 101
MACH NO .795

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

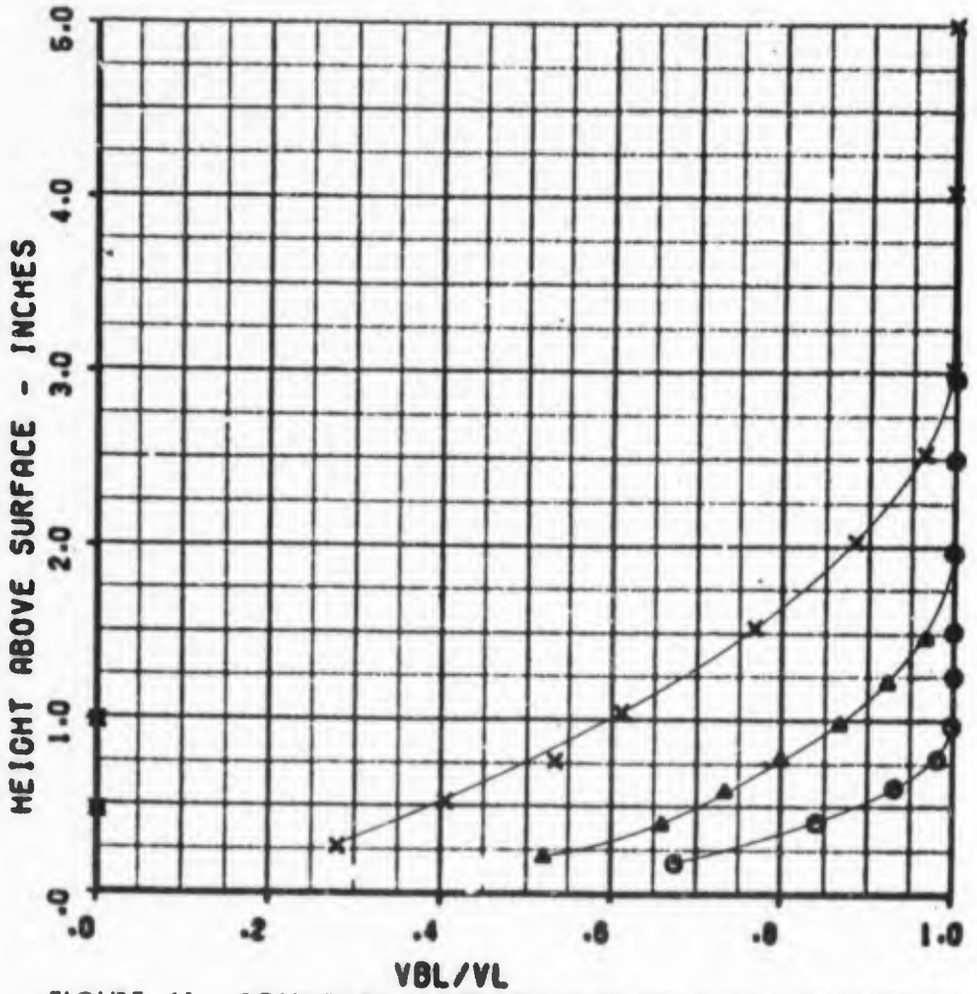


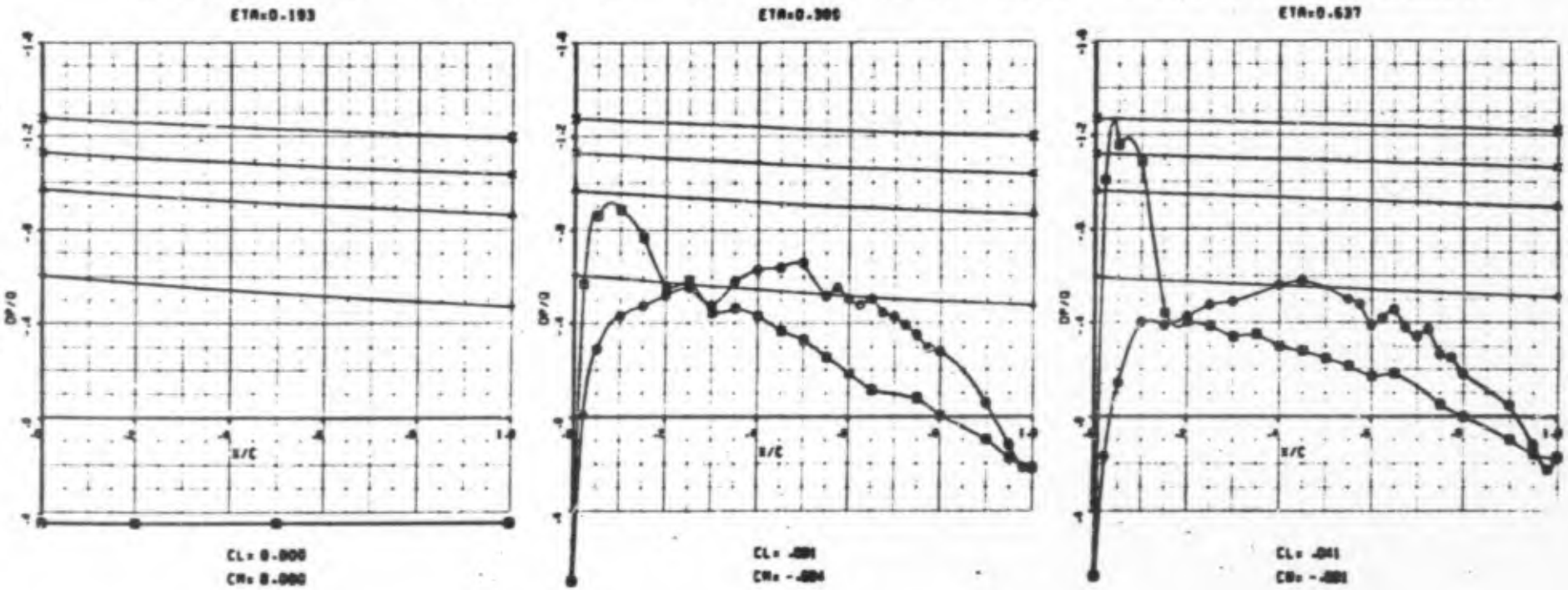
FIGURE 11 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .794 TO .802

(a) CORRECTED ALPHA = -2.78

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	648	Q	2.74 PSI	ALTITUDE	22010. FT	CG	28.15 % MAC	○	UPPER SURFACE	△	MACH LOCAL-1.2
RUN NO	101	ALPHA	-3.71 DEG	WEIGHT	247500. LB	AILERON POS	-.33 DEG	□	LOWER SURFACE	×	MACH LOCAL-1.3
MACH NO	.795	TAN	-21.9 DEG C	NZ	0.00	FLAP POS	0.00 DEG	+	MACH LOCAL-1.0	⧗	MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 285
MACH NO .794

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
⁂ 80 %(AFT)

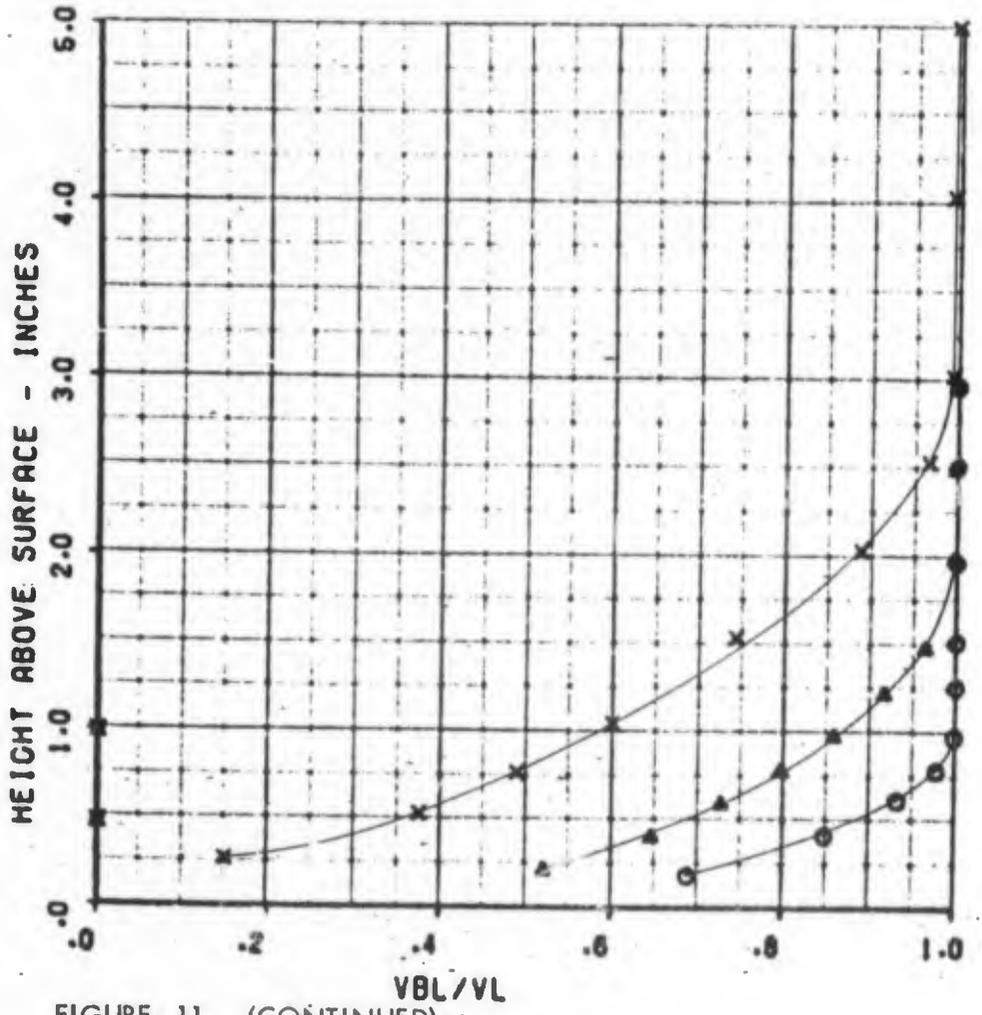
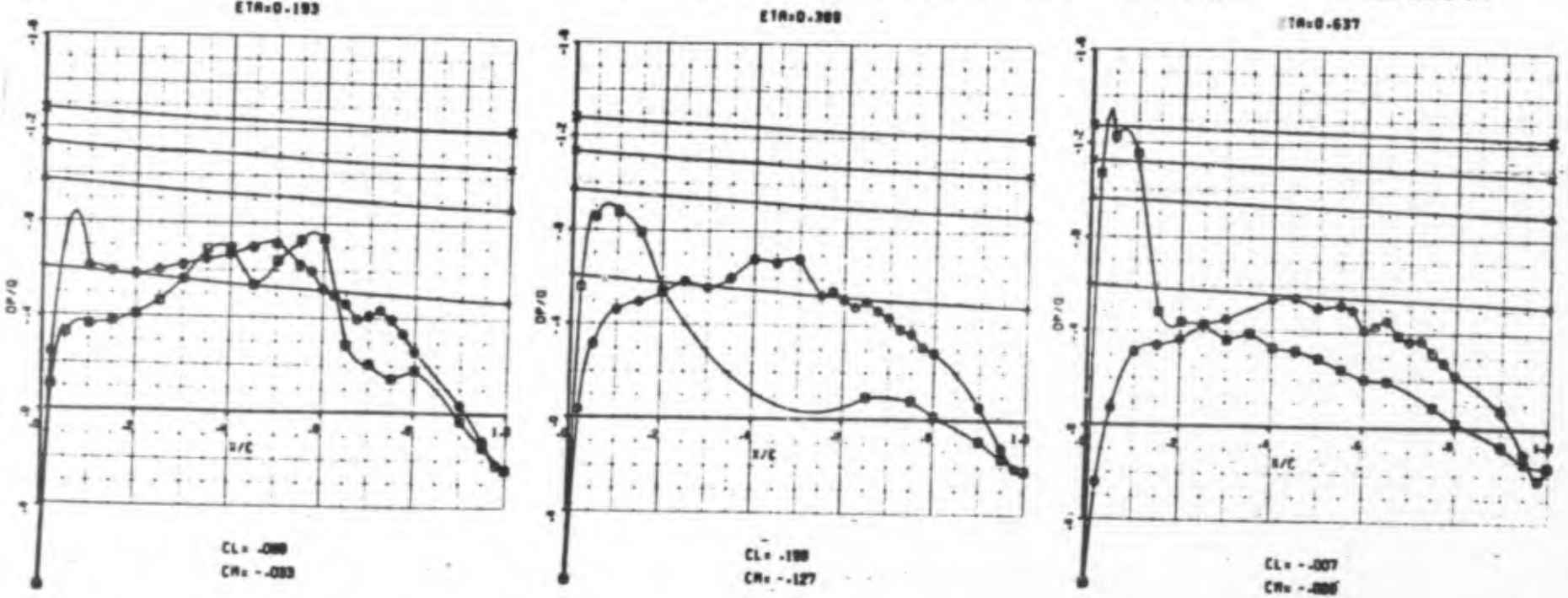


FIGURE 11 (CONTINUED)
(b) CORRECTED ALPHA = -2.73

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO 548 | Q 3.12 PSI | ALTITUDE 18000. FT | CG 29.30 % MAC | ○ UPPER SURFACE | △ MACH LOCAL-1.2
RUN NO 285 | ALPHA -3.64 DEG | WEIGHT 257000. LB | AILERON POS -1.70 DEG | □ LOWER SURFACE | × MACH LOCAL-1.3
MACH NO .794 | TAM -26.9 DEG C | NZ 0.00 | FLAP POS 0.00 DEG | + MACH LOCAL-1.4 | ⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 102
MACH NO .794

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

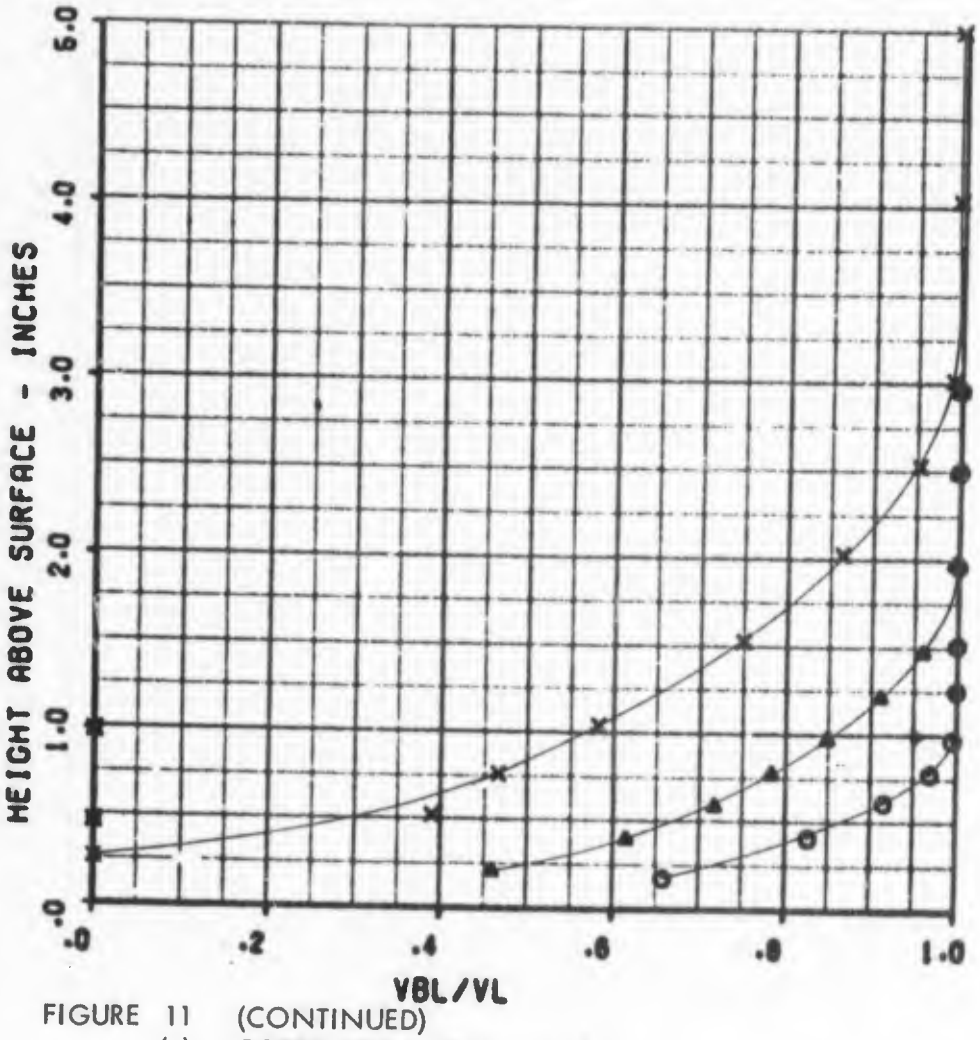
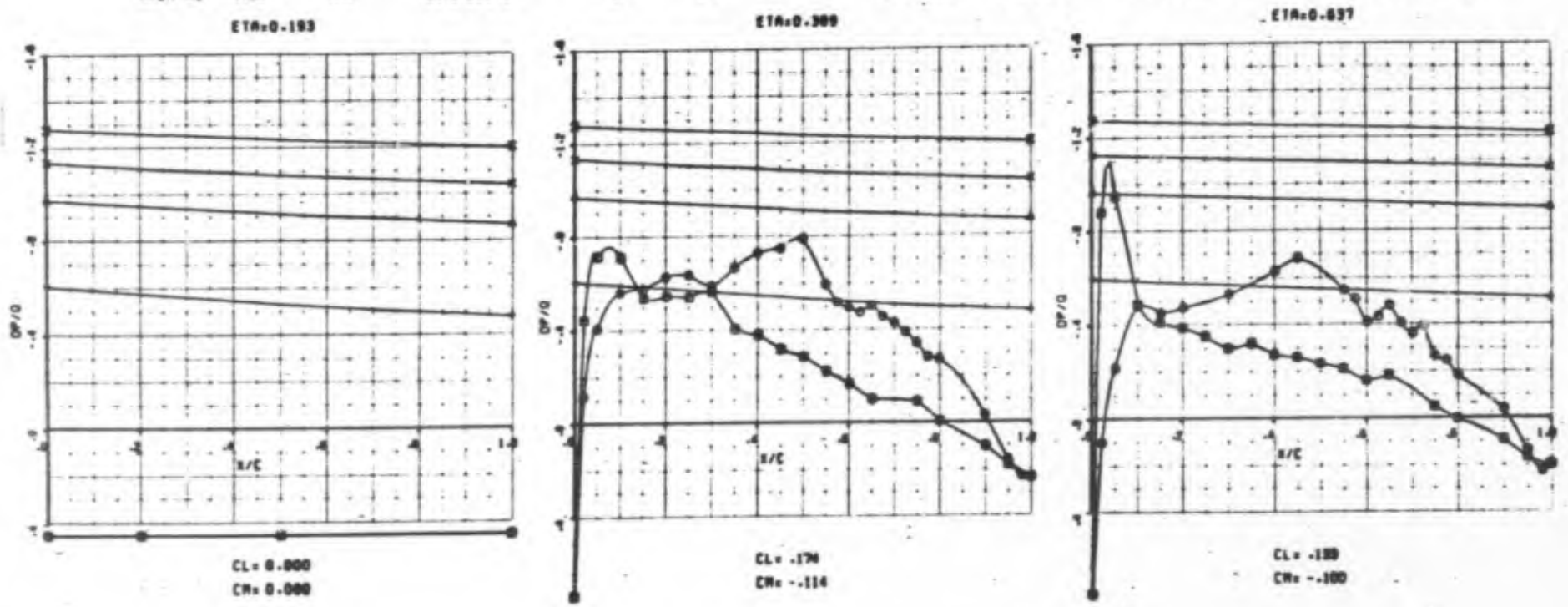


FIGURE 11 (CONTINUED)
(c) CORRECTED ALPHA = -1.95

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO 546 | Q 2.70 PSI | ALTITUDE 22300. FT | CG 20.15 % MAC | ○ UPPER SURFACE | △ MACH LOCAL-1.2
RUN NO 102 | ALPHA -2.76 DEG | WEIGHT 248500. LB | AILERON POS -.92 DEG | □ LOWER SURFACE | × MACH LOCAL-1.3
MACH NO .794 | TAM -21.9 DEG C | NZ .46 | FLAP POS 0.00 DEG | + MACH LOCAL-1.0 | ⧖ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 284
MACH NO .802

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

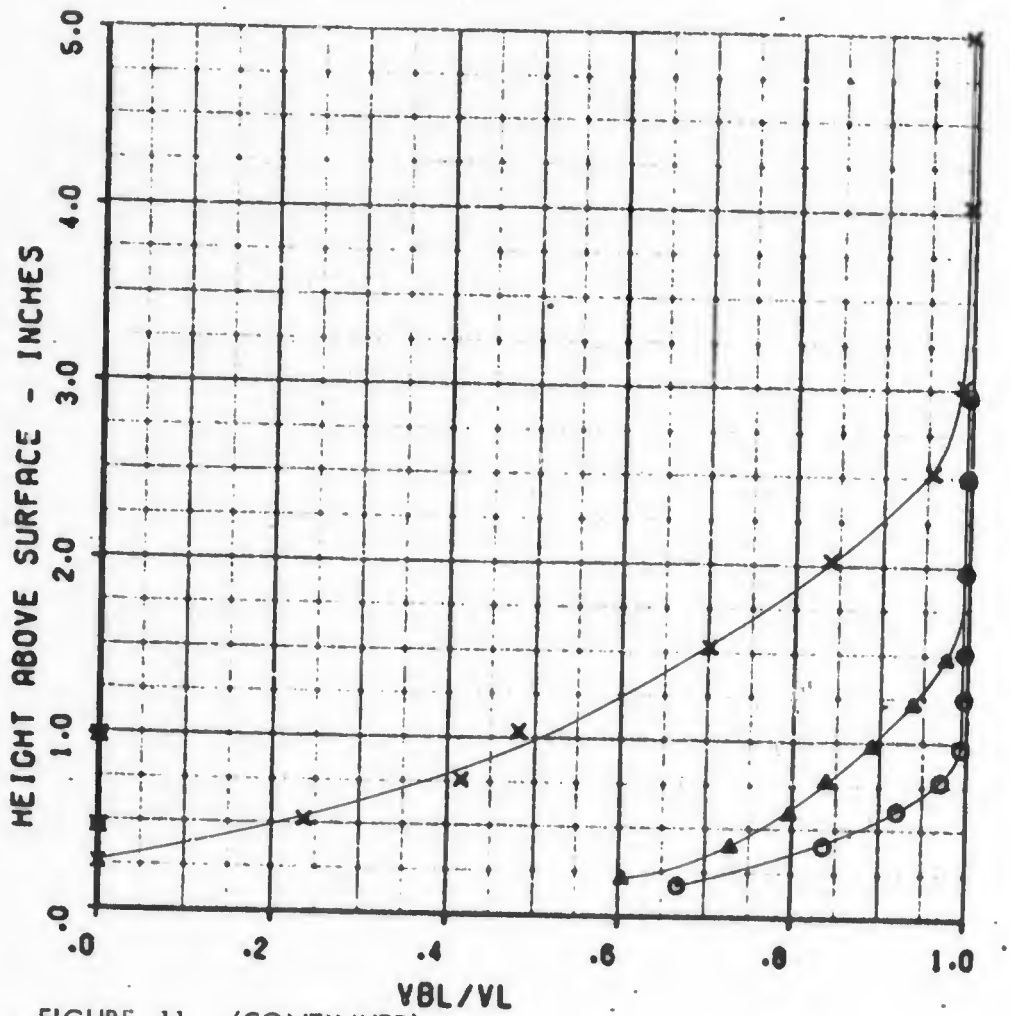


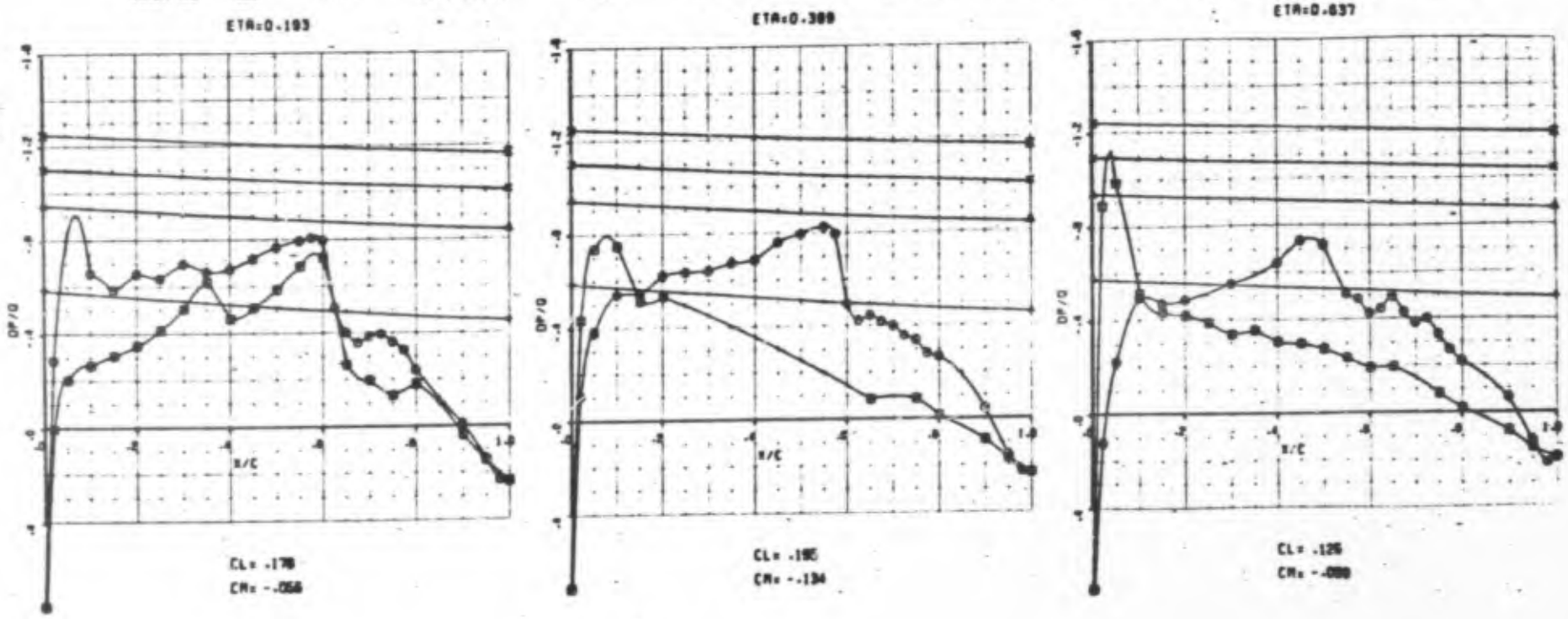
FIGURE 11 (CONTINUED)
(d) CORRECTED ALPHA = -1.95

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	3.18 PSI	ALTITUDE	18910. FT	CG	28.40 % MAC
RUN NO	284	ALPHA	-2.78 DEG	WEIGHT	257600. LB	AILERON POS	-.34 DEG
MACH NO	.802	TAN	-33.0 DEG C	NZ	.48	FLAP POS	0.00 DEG

○ UPPER SURFACE
□ LOWER SURFACE
+ MACH LOCAL-1.0
△ MACH LOCAL-1.2
× MACH LOCAL-1.3
⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 28
MACH NO .800

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

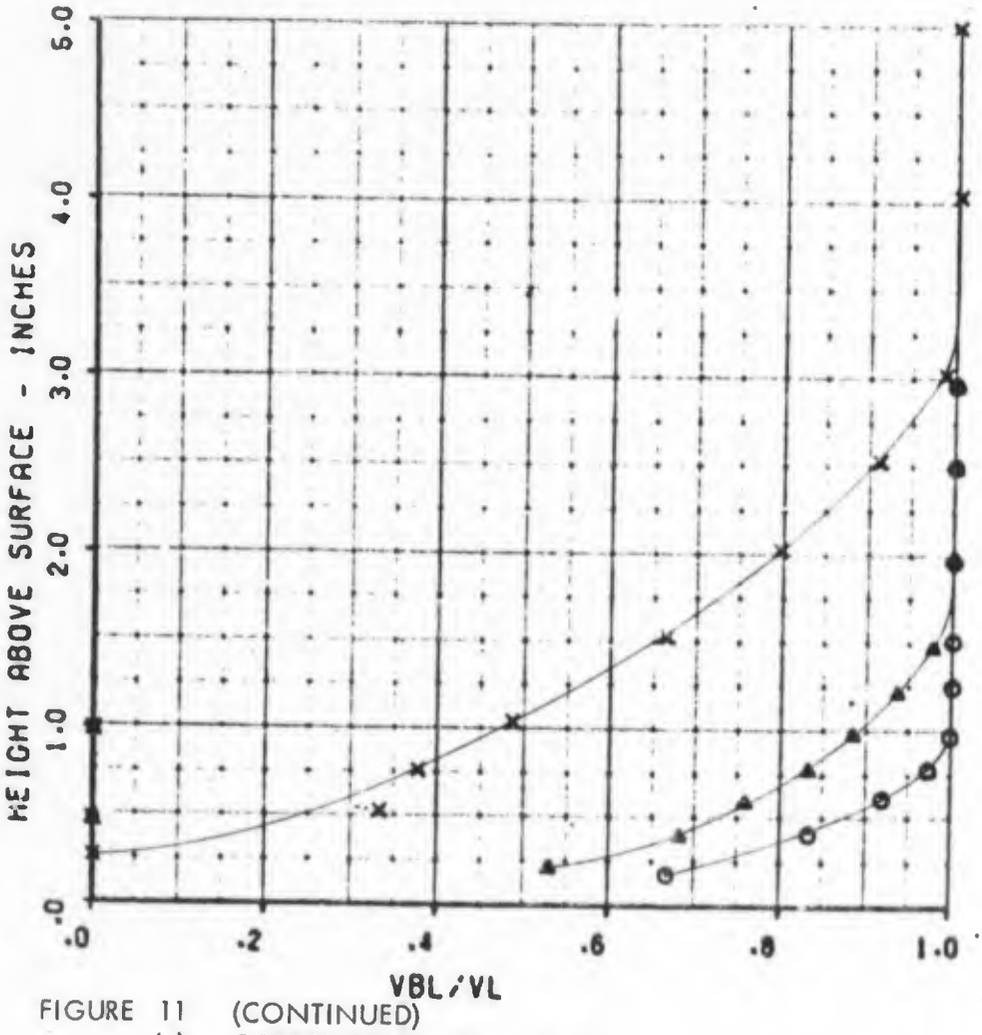


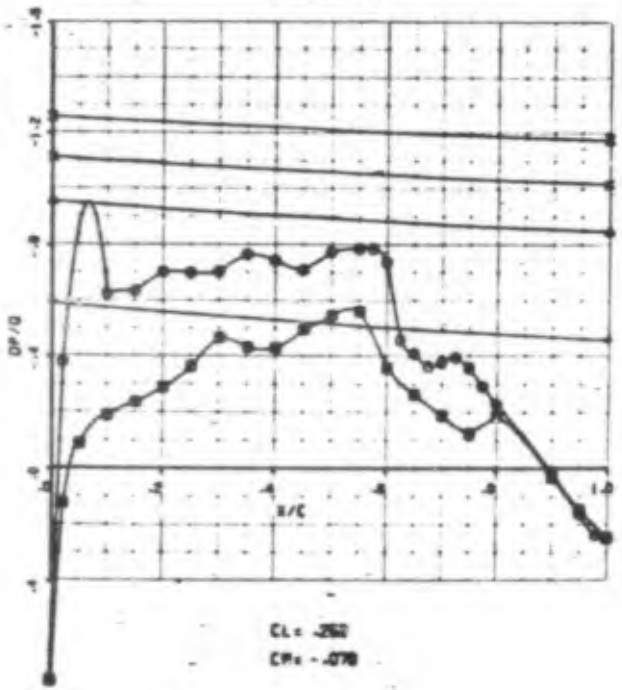
FIGURE 11 (CONTINUED)
(e) CORRECTED ALPHA = -1.12

LOCKHEED C-141A

PRESSURE DISTRIBUTION

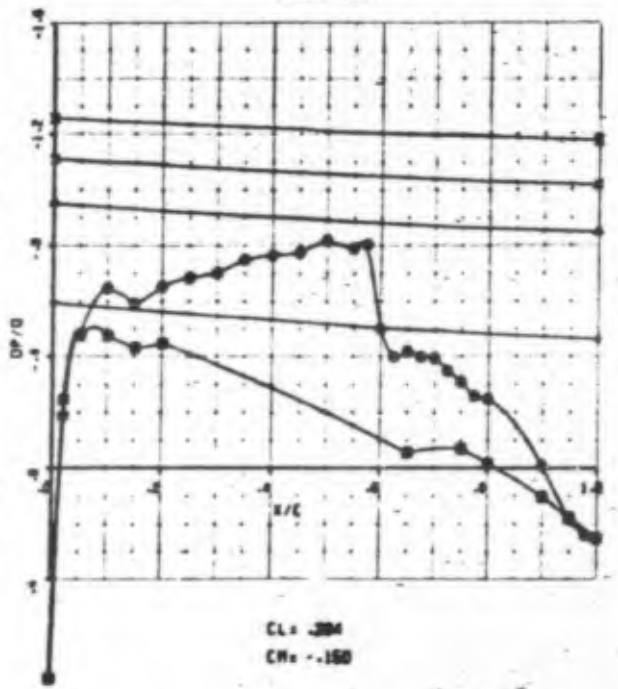
FLIGHT NO	548	Q	2.94 PSI	ALTITUDE	20860. FT	CG	28.50 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	28	ALPHA	-1.82 DEG	WEIGHT	260000. LB	AILERON POS	-1.44 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.800	TAM	-39.8 DEG C	NZ	1.01	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA=0.193



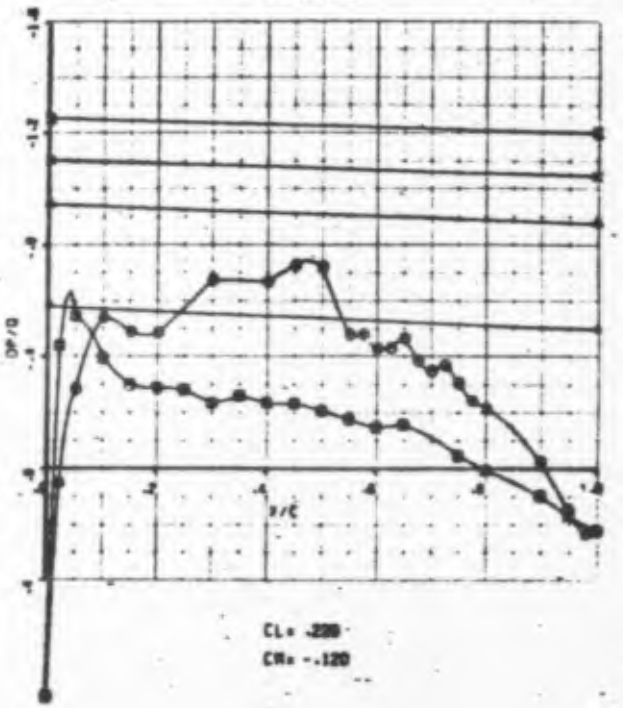
CL= .252
CM= -.078

ETA=0.389



CL= .384
CM= -.150

ETA=0.637



CL= .228
CM= -.120

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 10
MACH NO .802

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

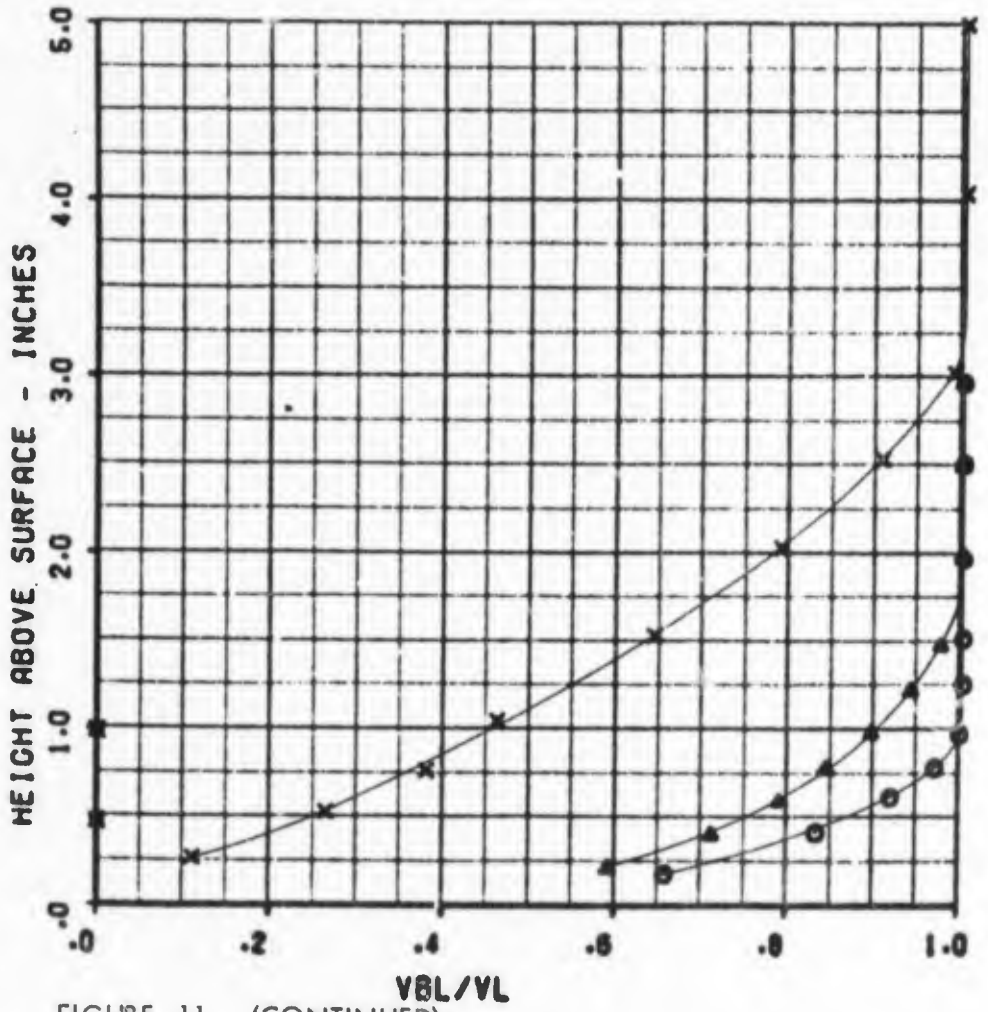


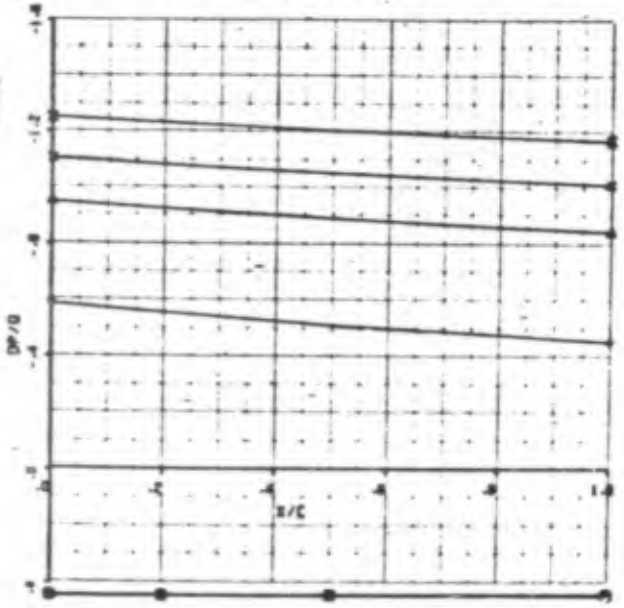
FIGURE 11 (CONTINUED)
(f) CORRECTED ALPHA = -1.10

LOCKHEED C-141A

PRESSURE DISTRIBUTION

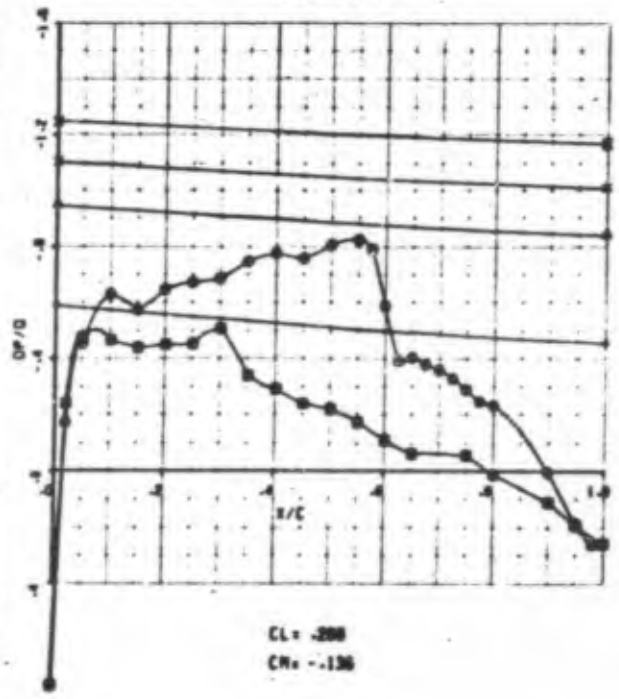
FLIGHT NO	546	Q	2.73 PSI	ALTITUDE	22460. FT	CG	20.15 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	10	ALPHA	-1.81 DEG	WEIGHT	251900. LB	AILERON POS	-1.08 DEG	□ LOWER SURFACE	X MACH LOCAL-1.3
MACH NO	.802	TAM	-22.6 DEG C	NZ	1.05	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4

ETA=0.193



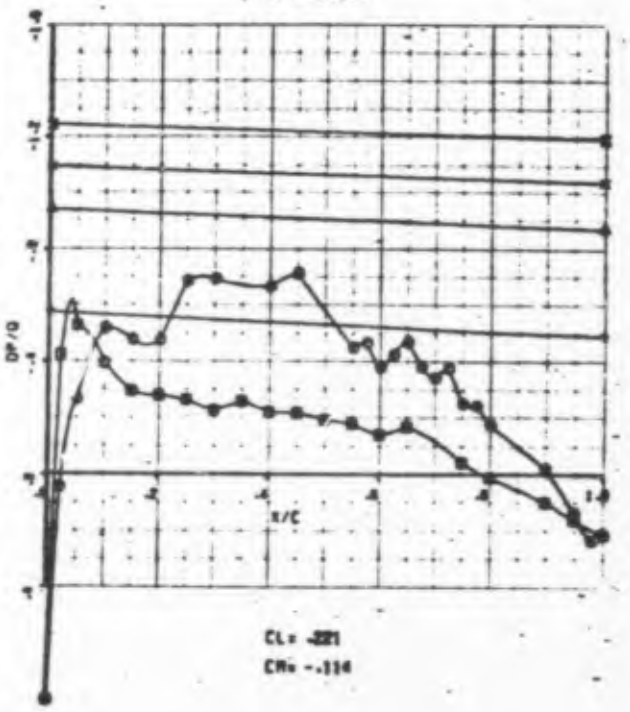
CL= 0.000
CM= 0.000

ETA=0.388



CL= -.208
CM= -.136

ETA=0.637



CL= -.221
CM= -.114

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 4A2
MACH NO .798

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

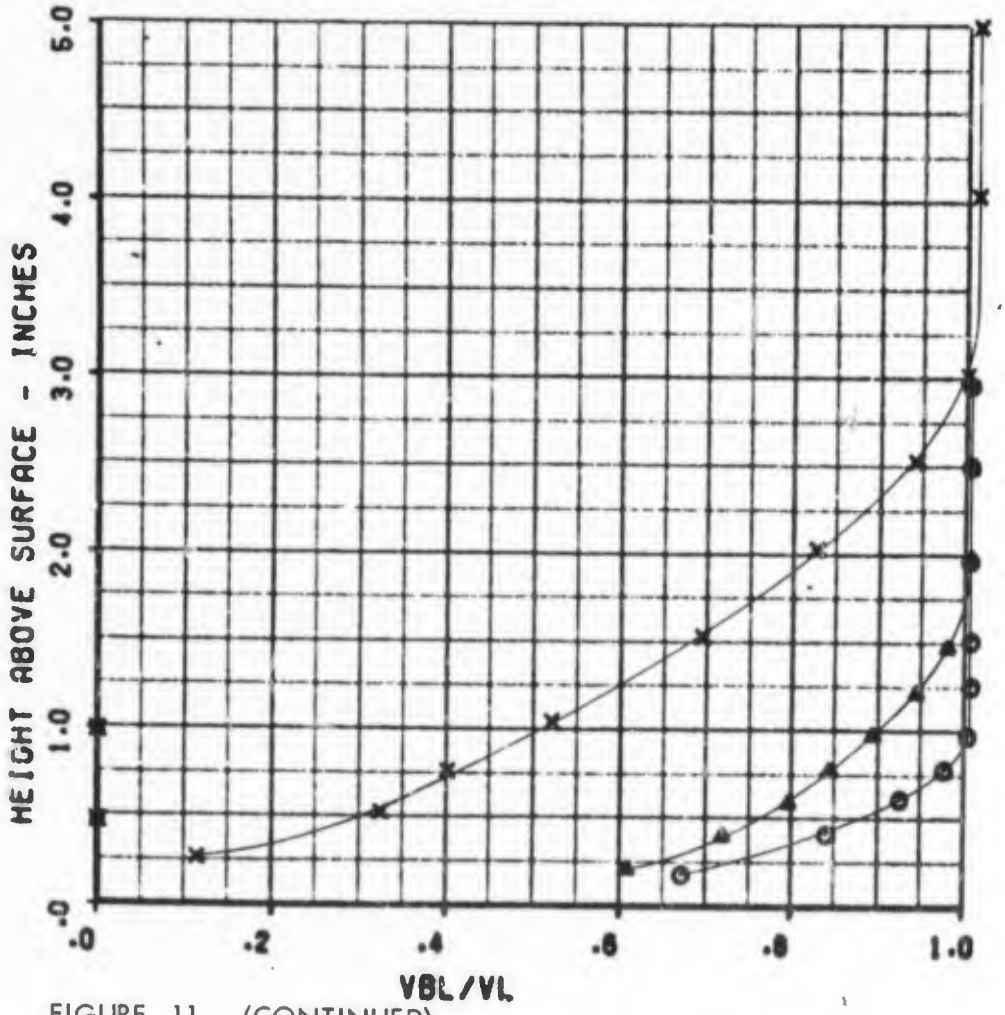


FIGURE 11 (CONTINUED)
(g) CORRECTED ALPHA = -0.70

LOCKHEED C-141A

PRESSURE DISTRIBUTION

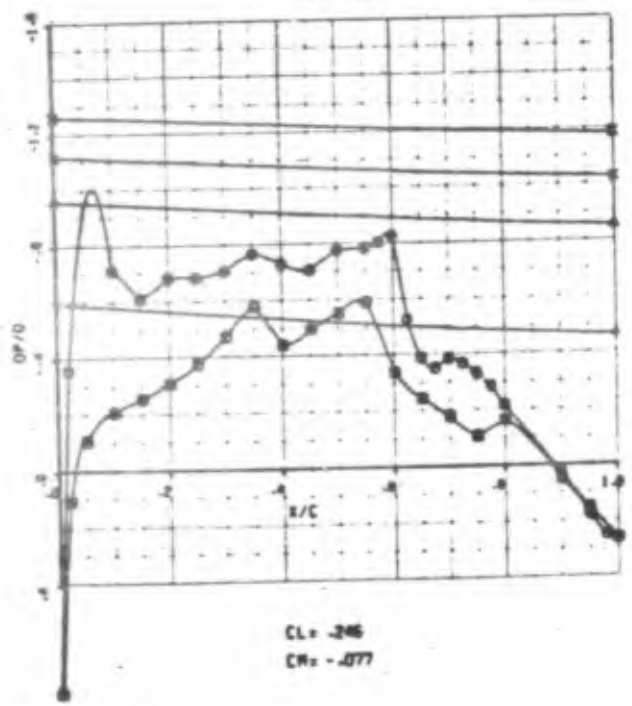
FLIGHT NO 547 Q 3.01 PSI
RUN NO 4R2 ALPHA -1.36 DEG
MACH NO .798 TAM -30.5 DEG C

ALTITUDE 19840. FT
WEIGHT 254650. LB
NZ .95

CG 28.35 % MAC
AILERON POS -.51 DEG
FLAP POS 0.00 DEG

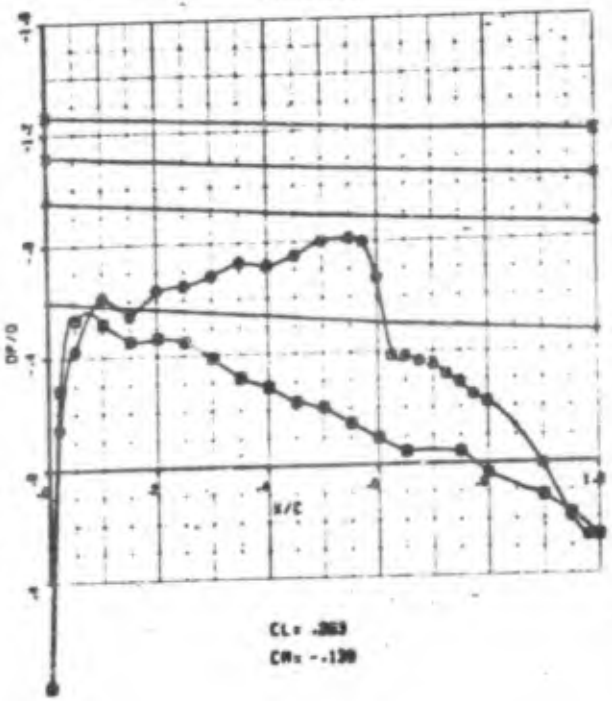
○ UPPER SURFACE
□ LOWER SURFACE
+ MACH LOCAL-1.0
△ MACH LOCAL-1.2
× MACH LOCAL-1.3
⧖ MACH LOCAL-1.4

ETA=0.183



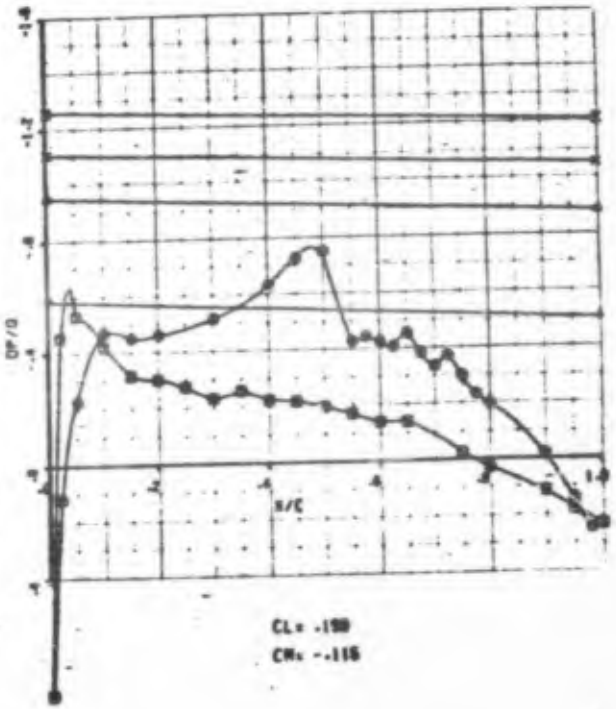
CL= .246
CM= -.077

ETA=0.309



CL= .263
CM= -.130

ETA=0.637



CL= .198
CM= -.115

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 482
MACH NO .800

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

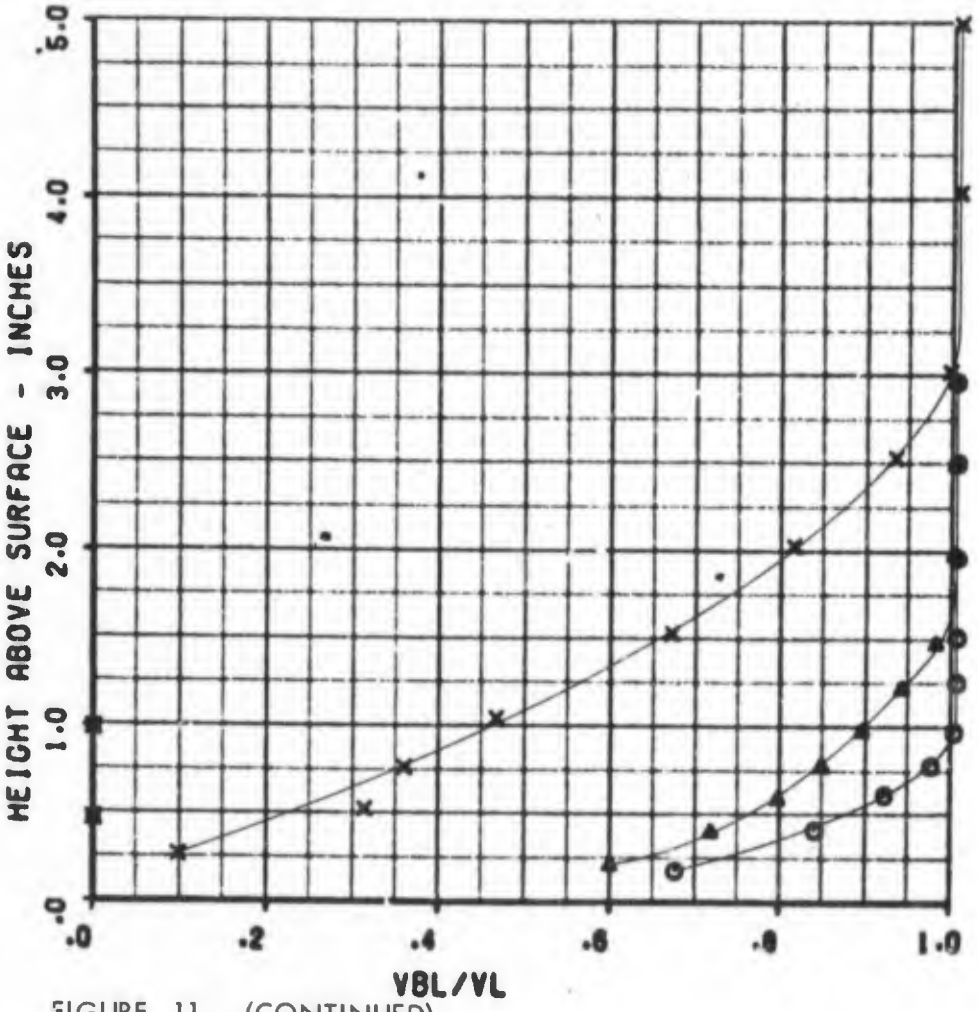


FIGURE 11 (CONTINUED)
(h) CORRECTED ALPHA = -0.70

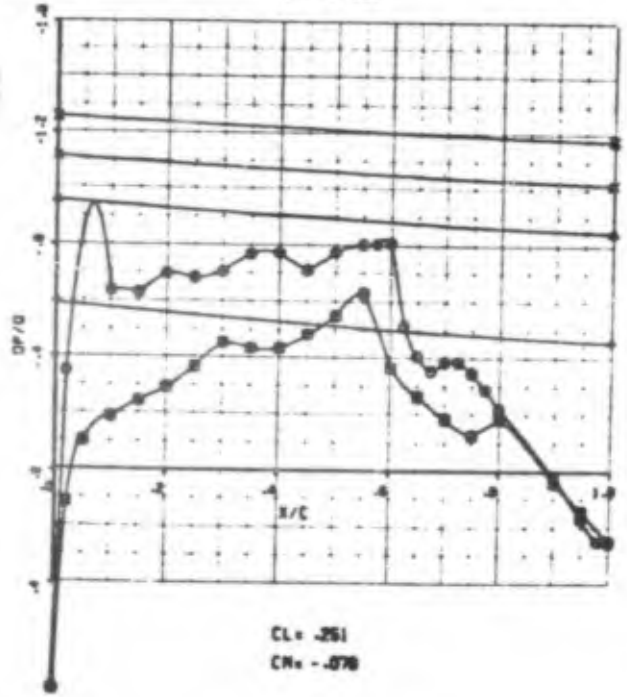
LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	547	Q	3.01 PSI	ALTITUDE	20106. FT	CG	28.25 % MAC
RUN NO	482	ALPHA	-1.36 DEG	WEIGHT	252900. LB	AILERON POS	-1.70 DEG
MACH NO	.800	TAM	-30.5 DEG C	NZ	1.02	FLAP POS	0.00 DEG

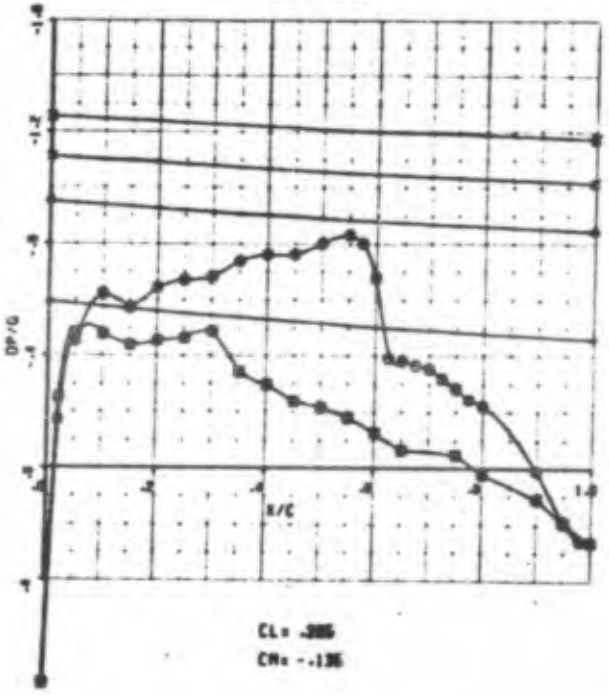
○ UPPER SURFACE △ MACH LOCAL-1.2
□ LOWER SURFACE × MACH LOCAL-1.3
+ MACH LOCAL-1.0 ⧗ MACH LOCAL-1.4

ETA=0.193



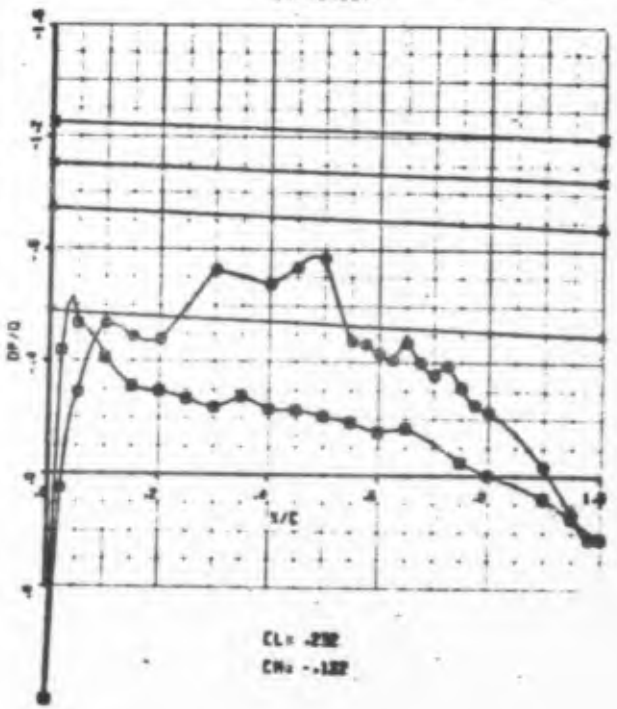
CL= .251
CM= -.078

ETA=0.389



CL= .285
CM= -.136

ETA=0.637



CL= .232
CM= -.122

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 103
MACH NO .802

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

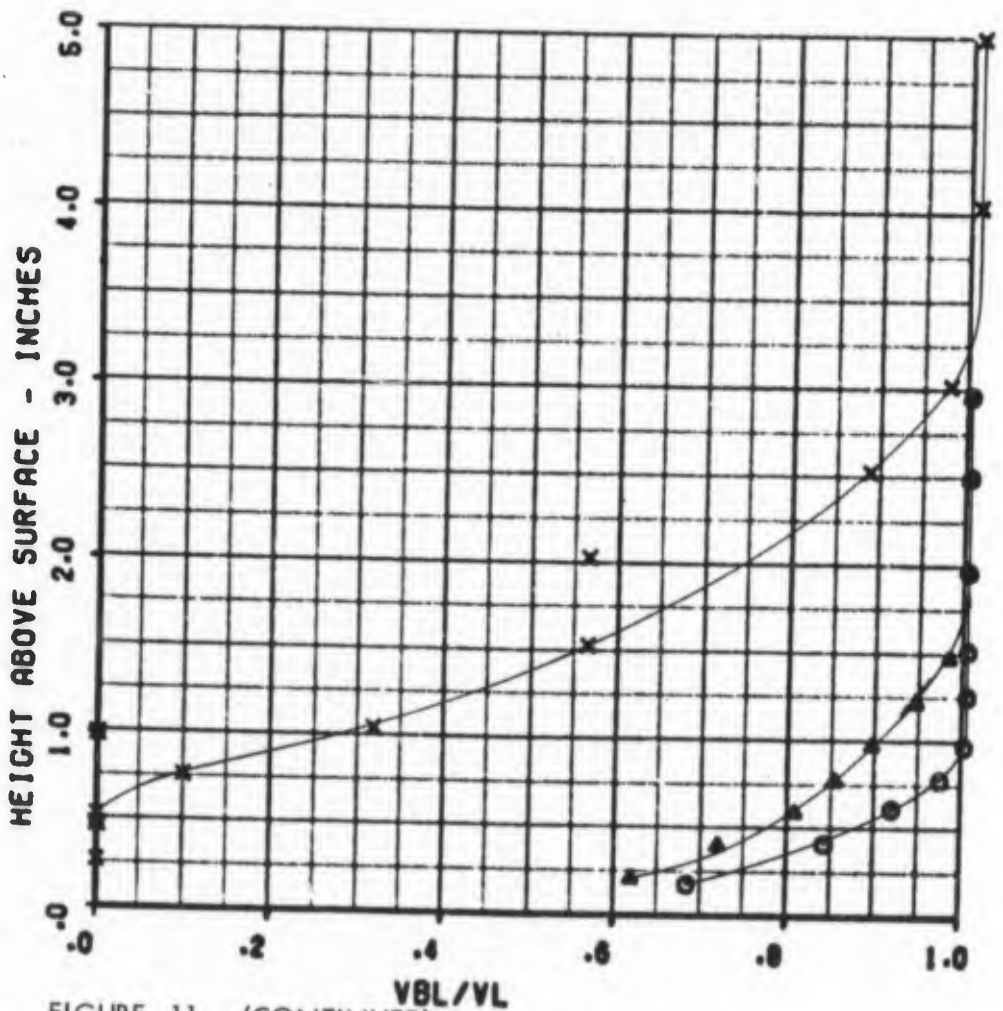


FIGURE 11 (CONTINUED)
(k) CORRECTED ALPHA = -0.62

LOCKHEED C-141A

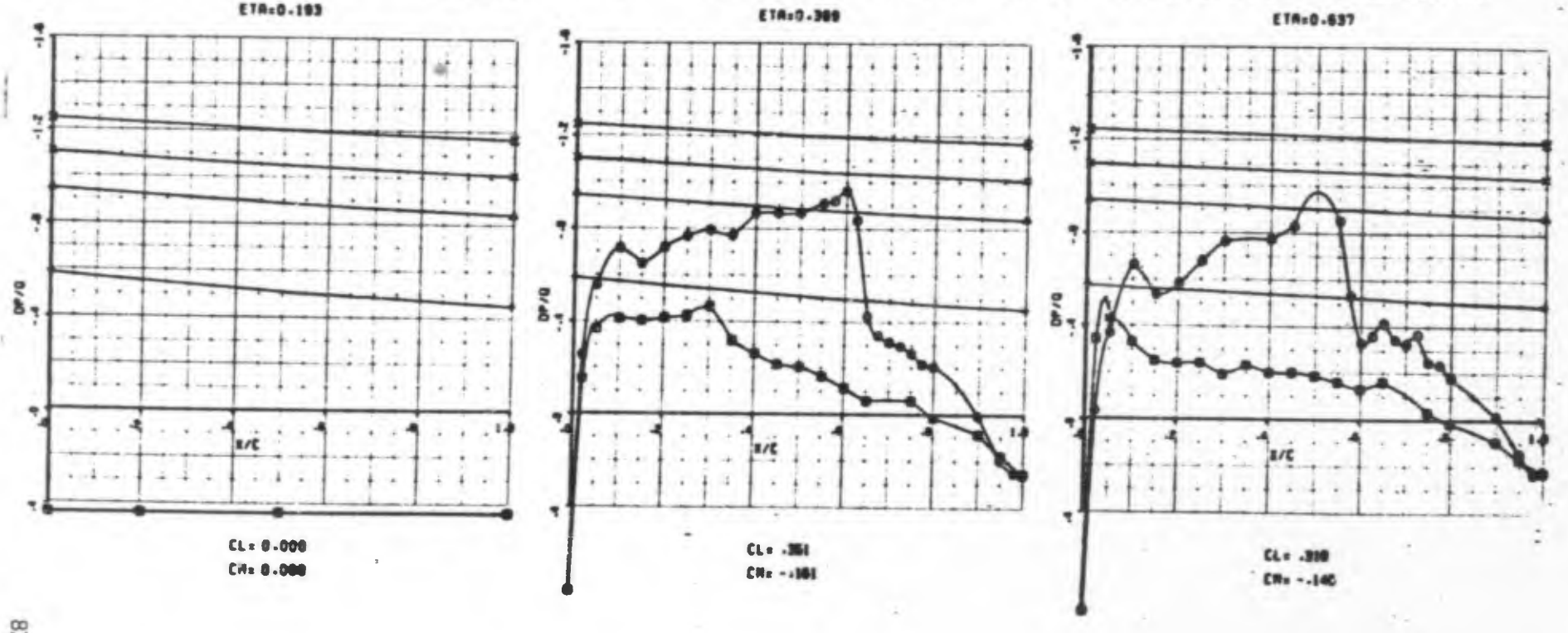
PRESSURE DISTRIBUTION

FLIGHT NO 546 Q 2.78 PSI
RUN NO 103 ALPHA -1.24 DEG
MACH NO .802 TAM -22.0 DEG C

ALTITUDE 22060. FT
WEIGHT 251700. LB
NZ 1.44

CG 29.15 % MAC
AILERON POS -.92 DEG
FLAP POS 0.00 DEG

○ UPPER SURFACE
□ LOWER SURFACE
+ MACH LOCAL-1.0
△ MACH LOCAL-1.2
× MACH LOCAL-1.3
⧖ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 281
MACH NO .800

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

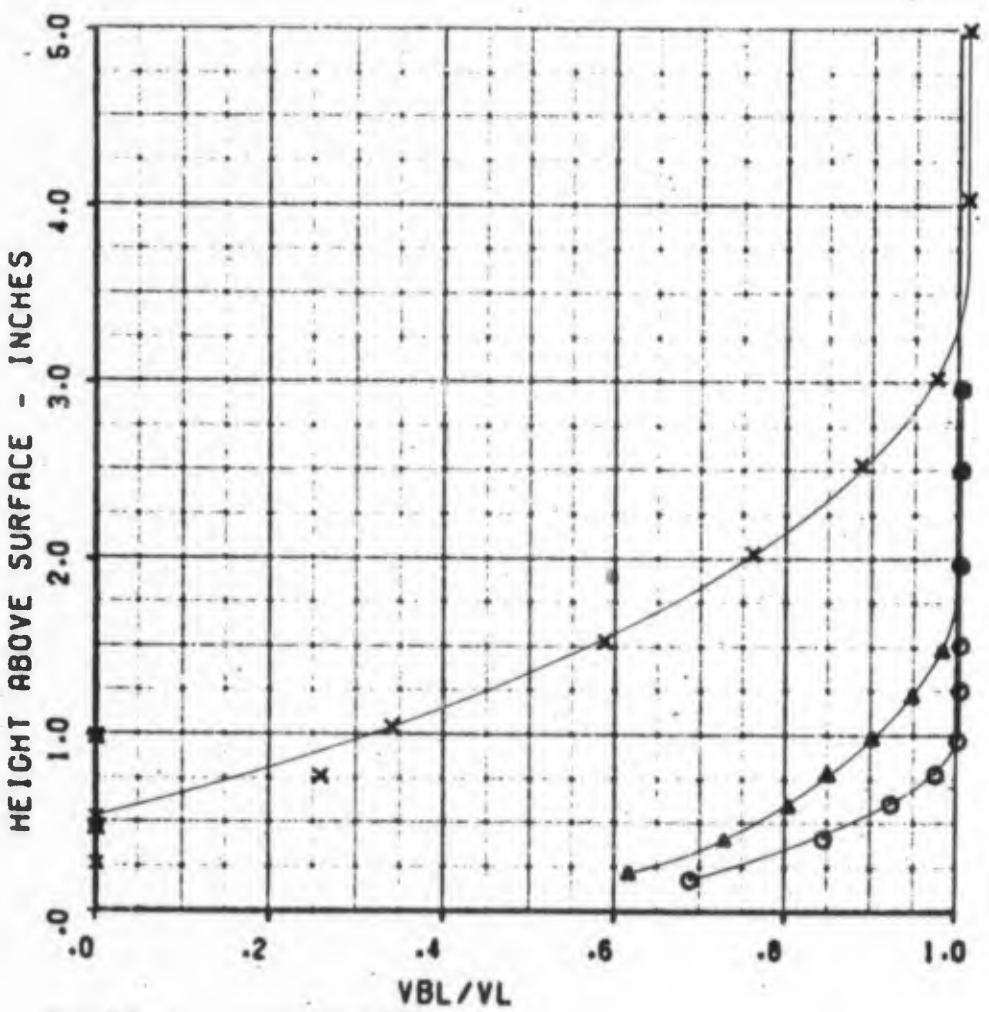


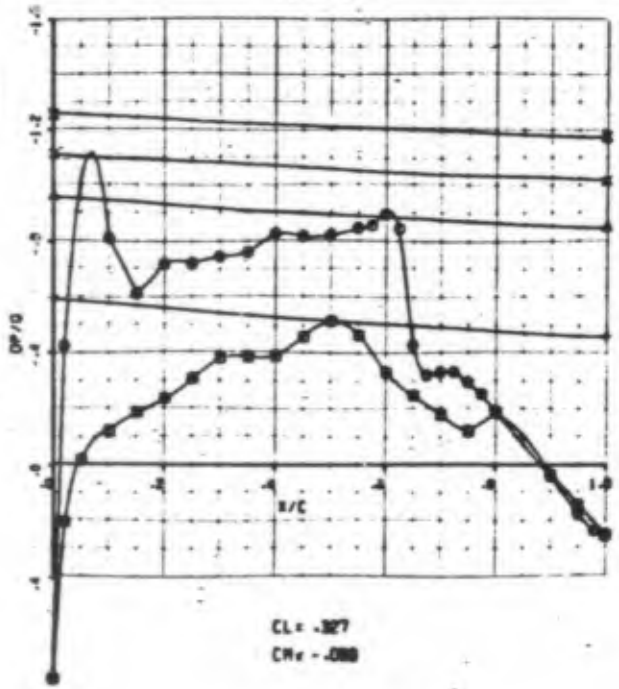
FIGURE 11. (CONTINUED)
(l) CORRECTED ALPHA = -0.54

LOCKHEED C-141A

PRESSURE DISTRIBUTION

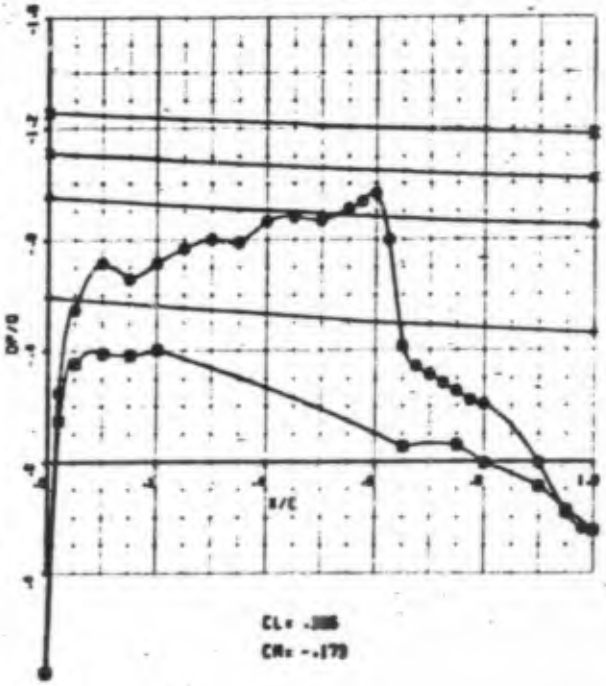
FLIGHT NO	548	Q	2.99 PSI	ALTITUDE	20266. FT	CG	29.50 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	281	ALPHA	-1.15 DEG	WEIGHT	259750. LB	AILERON POS	-1.44 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.800	TAM	-32.4 DEG C	NZ	1.46	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4

ETA=0.193



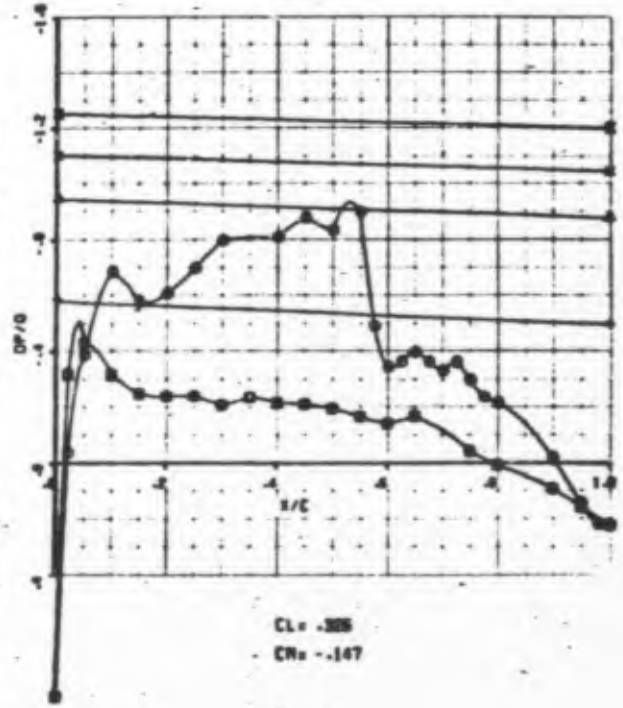
CL= .327
CM= -.088

ETA=0.389



CL= .388
CM= -.179

ETA=0.637



CL= .385
CM= -.147

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 104
MACH NO .795

RAKE LOCATIONS

⊙ 30 %
▲ 65 %
× 80 %
✱ 80 %(AFT)

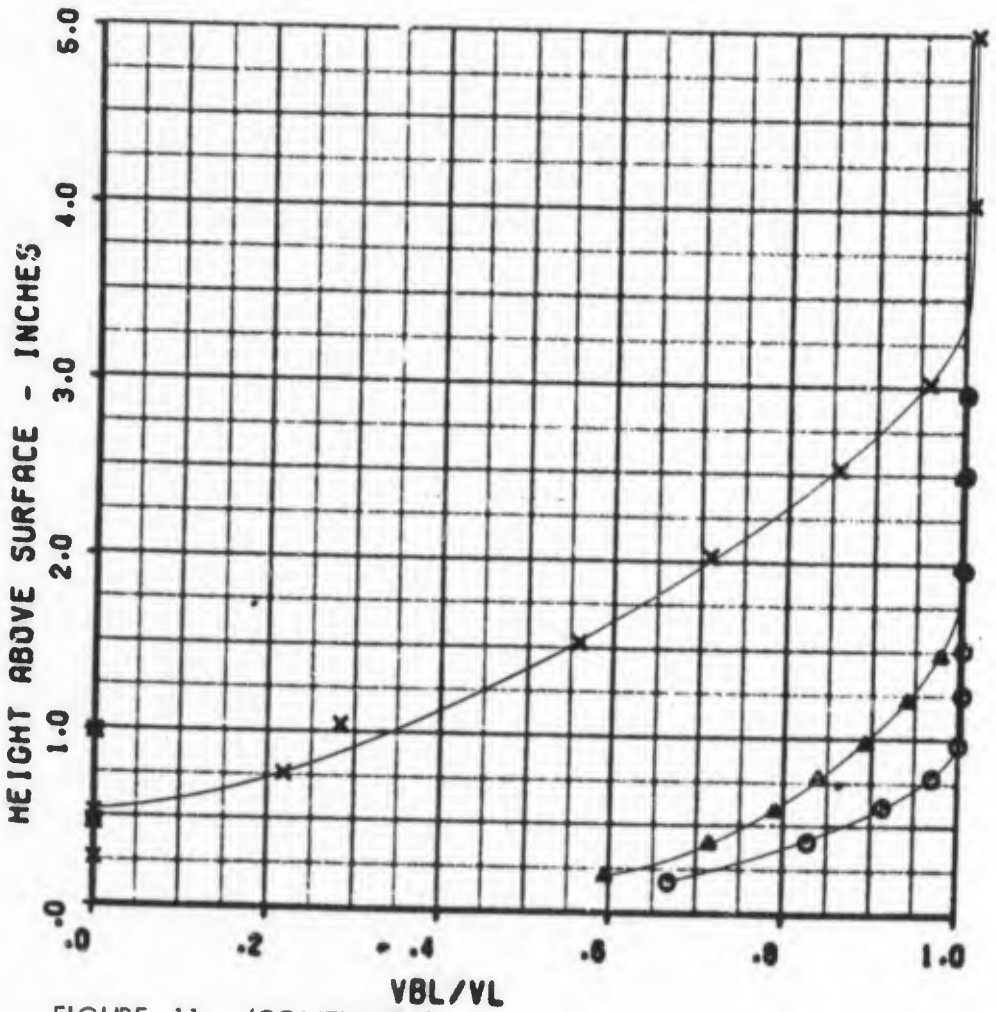
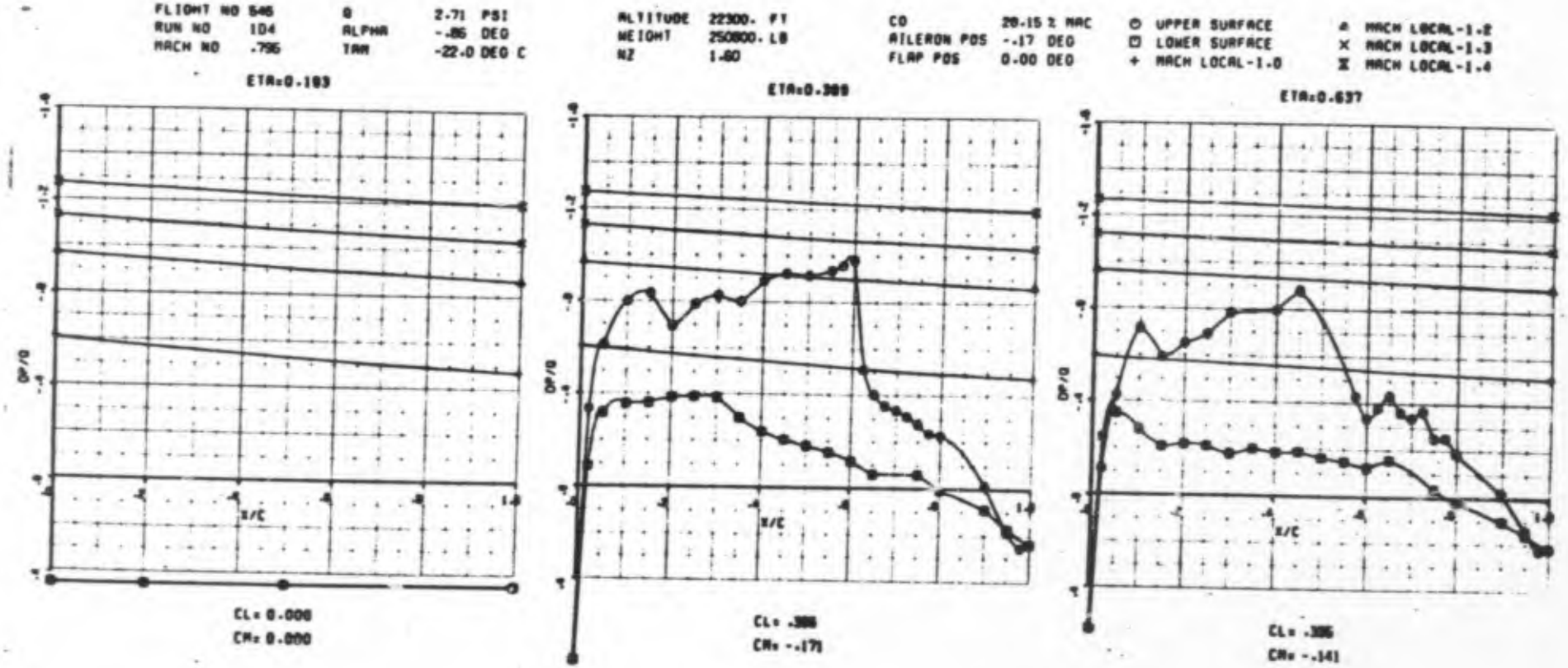


FIGURE 11 (CONTINUED)
(m) CORRECTED ALPHA = -0.28

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 282
MACH NO .800

RAKE LOCATIONS

⊙ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

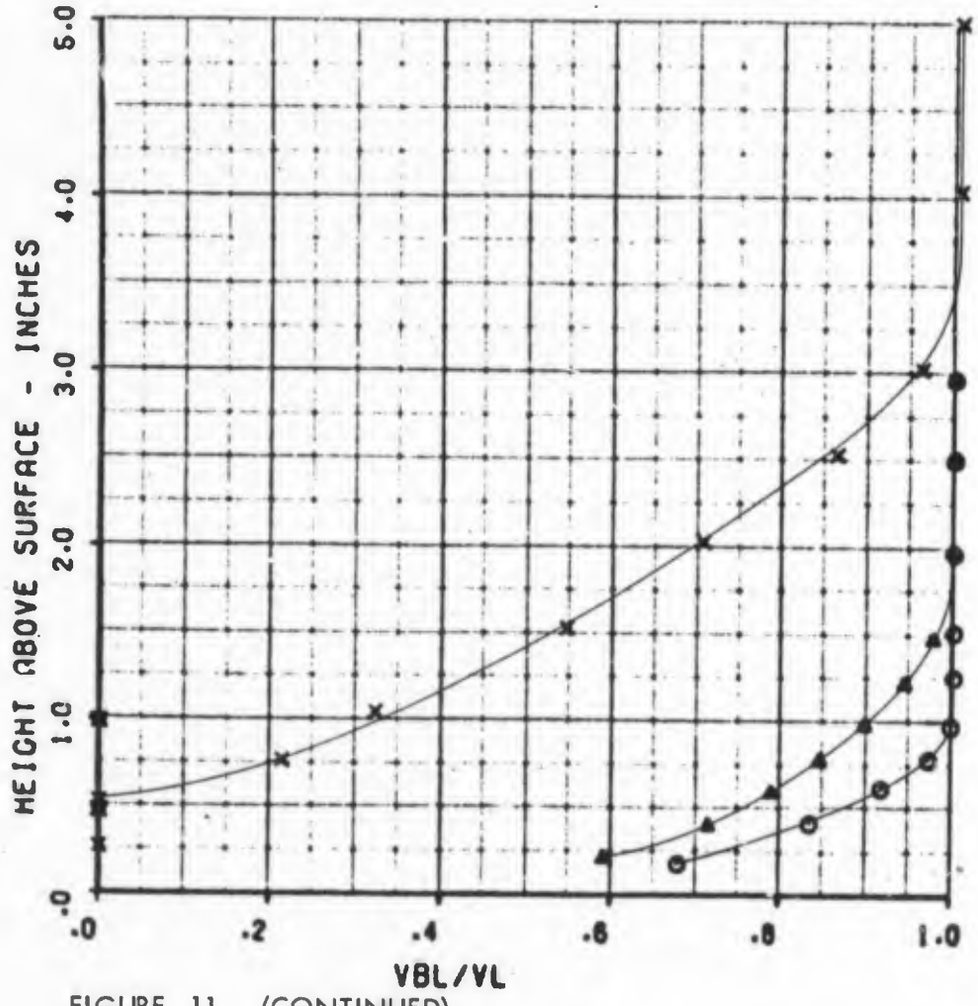


FIGURE 11 (CONTINUED)
(n) CORRECTED ALPHA = -0.27

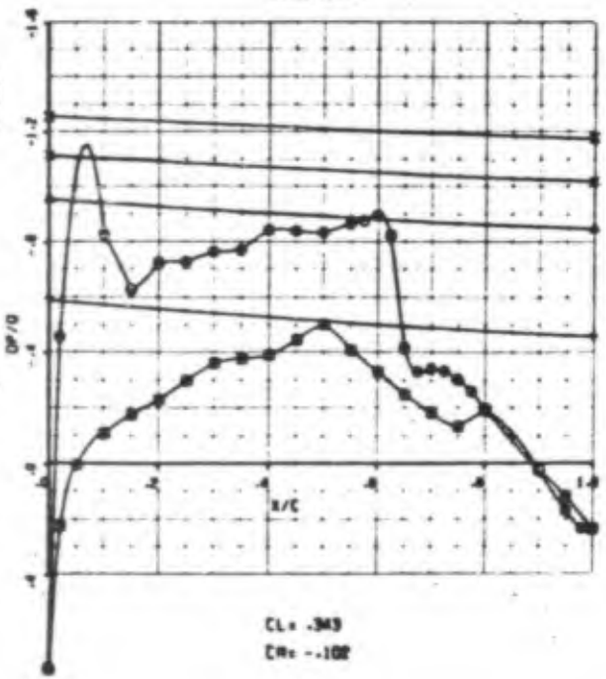
LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	3.02	PSI	ALTITUDE	20036.	FT	CG	28.48 % MAC
RUN NO	282	ALPHA	-.86	DEG	WEIGHT	259000.	LB	AILERON POS	.68 DEG
MACH NO	.800	TAM	-31.5	DEG C	NZ	1.68		FLAP POS	0.00 DEG

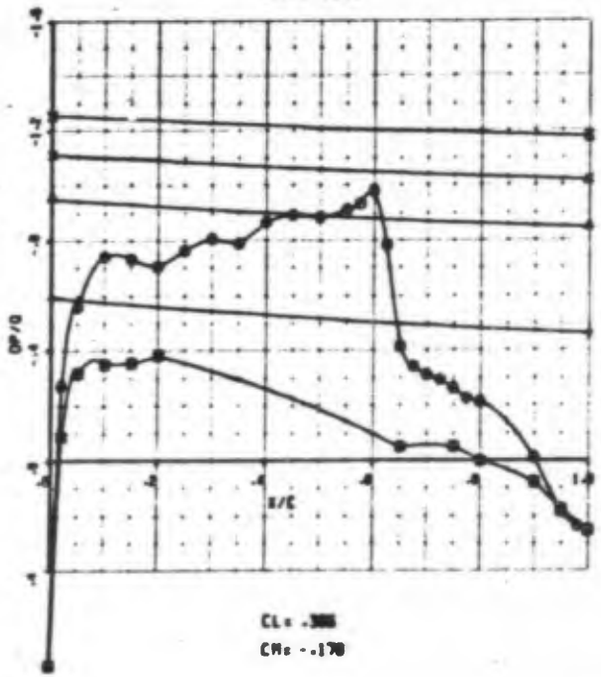
○ UPPER SURFACE △ MACH LOCAL-1.2
□ LOWER SURFACE × MACH LOCAL-1.3
+ MACH LOCAL-1.0 ⧗ MACH LOCAL-1.4

ETA=0.193



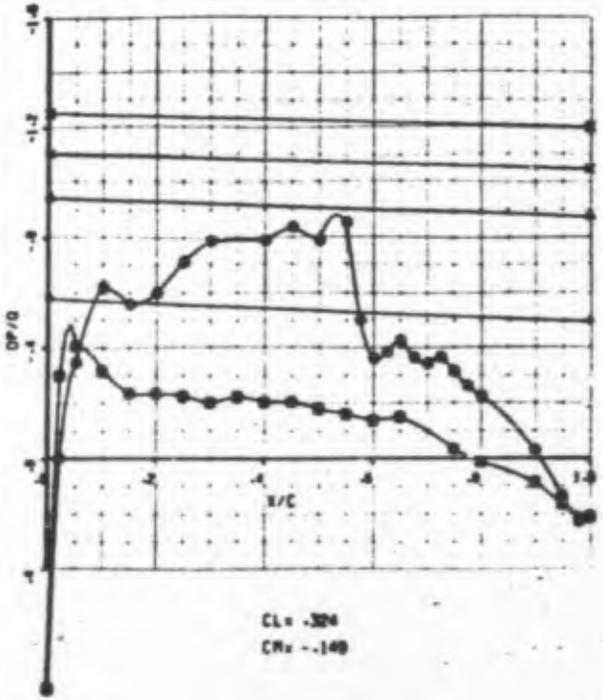
CL= .343
CM= -.102

ETA=0.389



CL= .386
CM= -.170

ETA=0.637



CL= .324
CM= -.140

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 283
MACH NO .800

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 % (AFT)

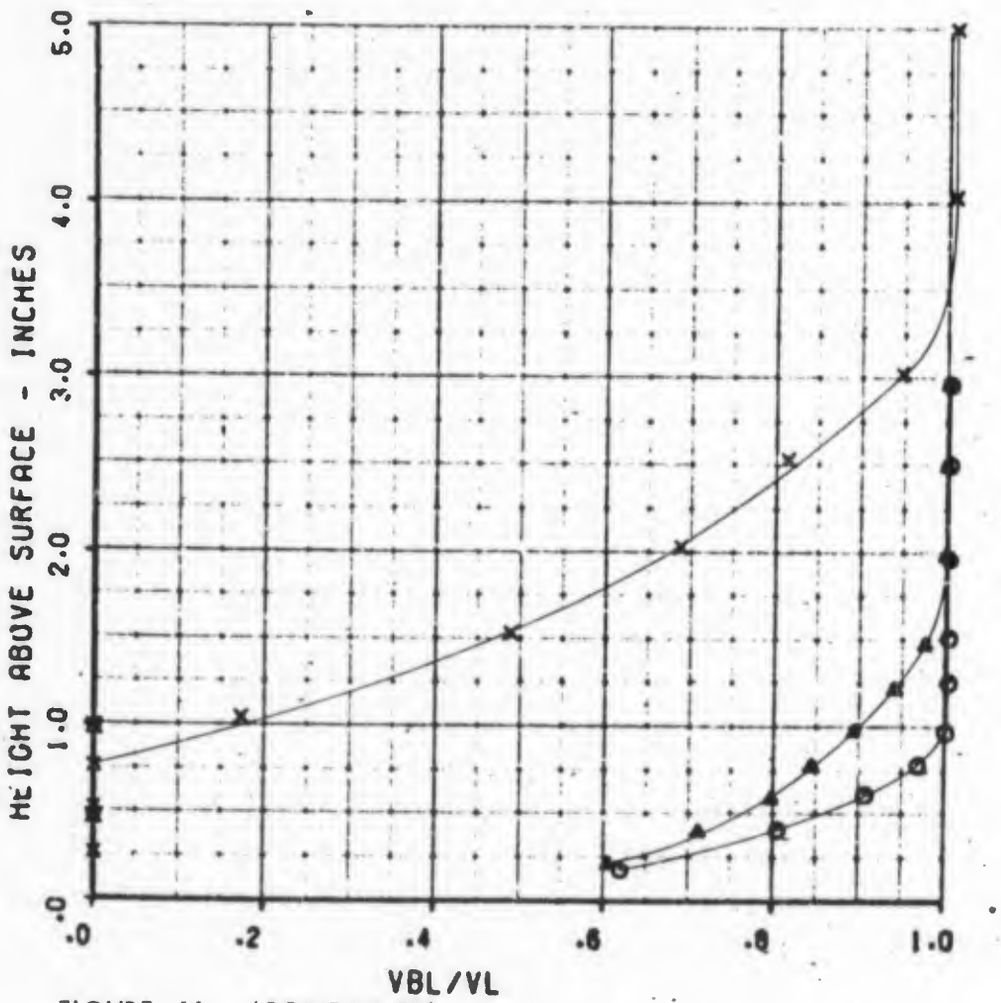


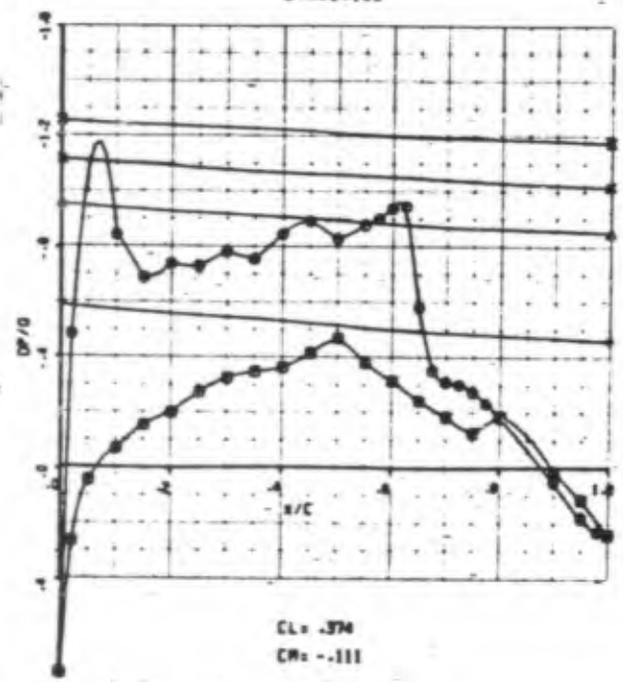
FIGURE 11 (CONTINUED)
(o) CORRECTED ALPHA = -0.07

LOCKHEED C-141A

PRESSURE DISTRIBUTION

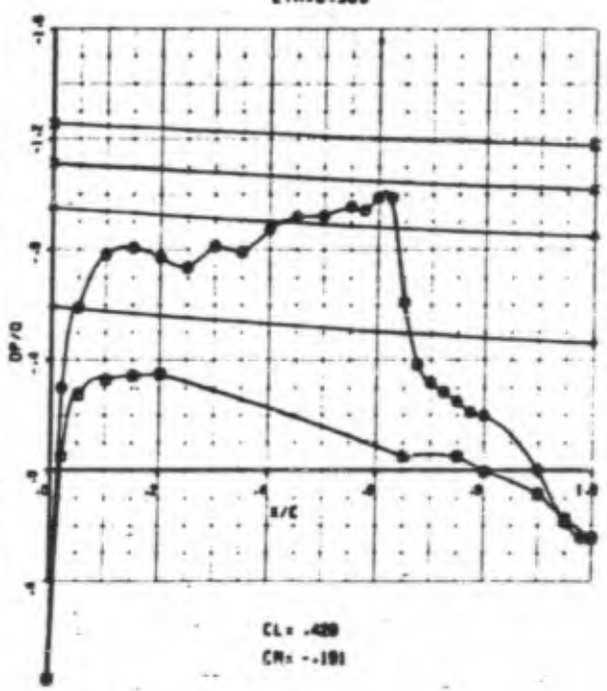
FLIGHT NO	548	Q	3.01 PSI	ALTITUDE	20056. FT	CG	28.42 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	283	ALPHA	-.58 DEG	WEIGHT	258300. LB	AILERON POS	-.93 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.800	TAM	-31.0 DEG C	NZ	1.90	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4

ETA=0.193



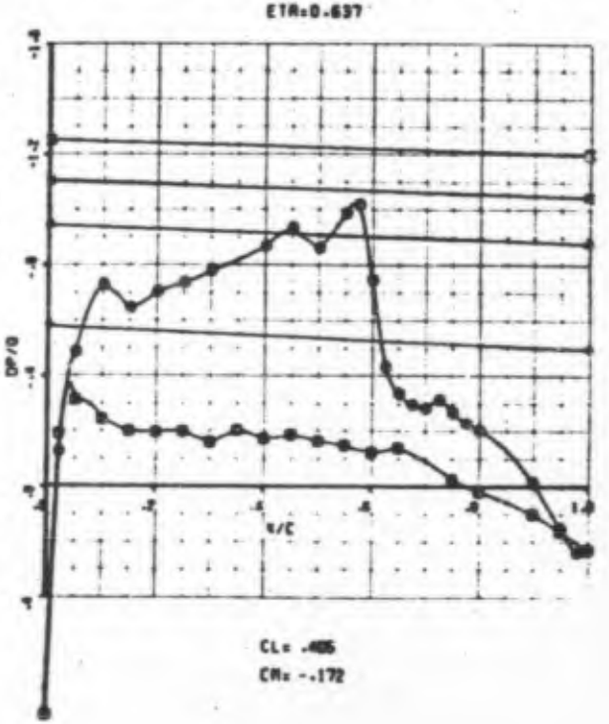
CL= .374
CM= -.111

ETA=0.369



CL= .420
CM= -.191

ETA=0.637



CL= .405
CM= -.172

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 105
MACH NO .802

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

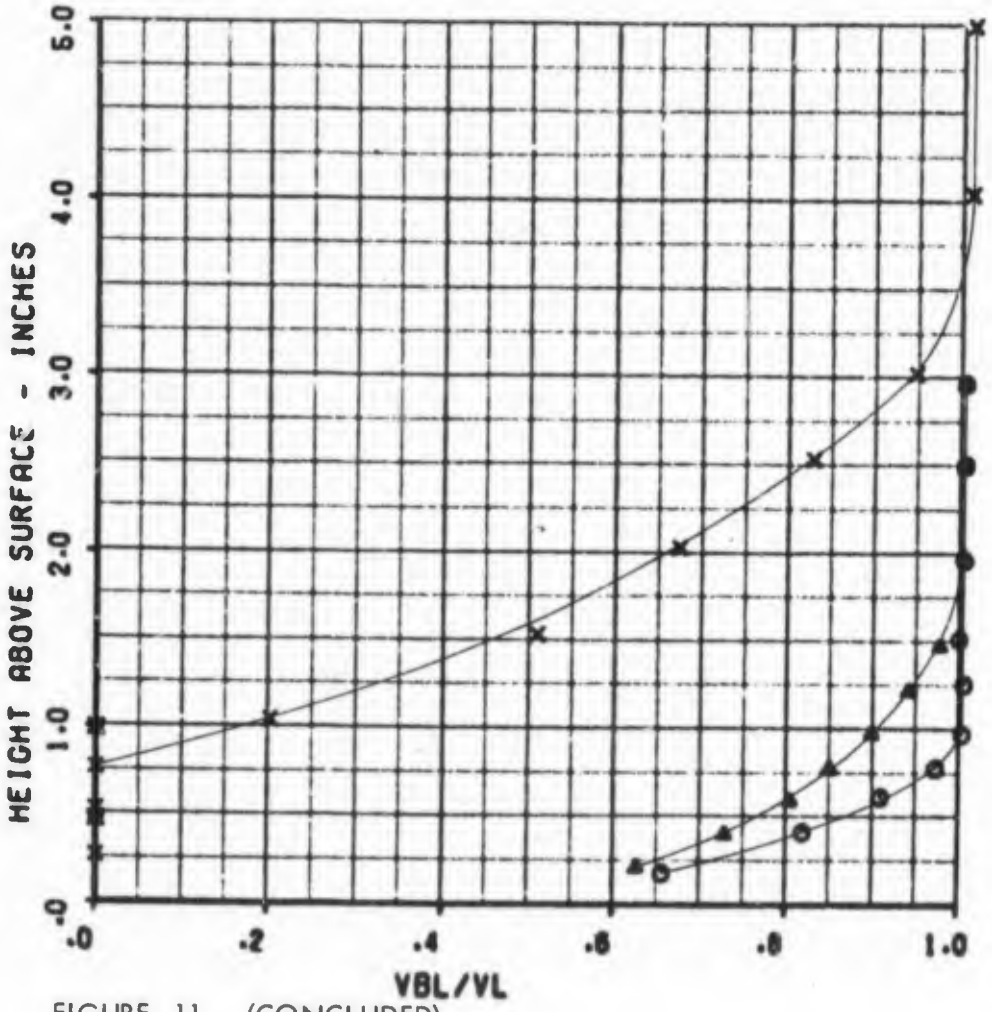


FIGURE 11 (CONCLUDED)
(p) CORRECTED ALPHA = -0.07

LOCKHEED C-141A

PRESSURE DISTRIBUTION

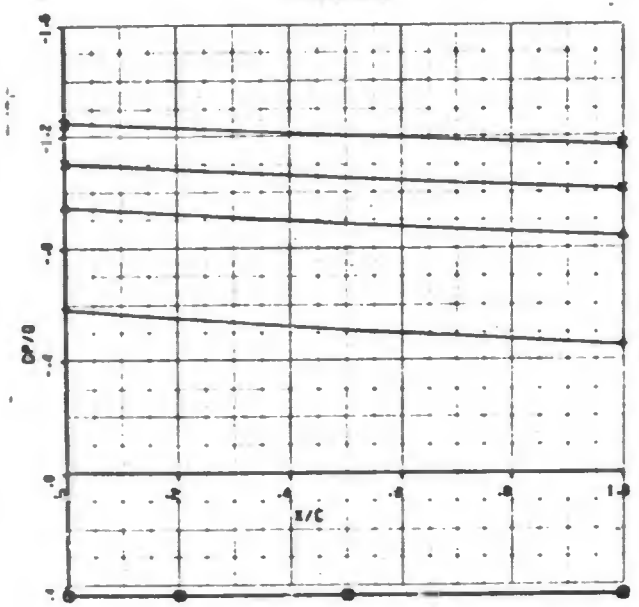
FLIGHT NO 546 Q 2.81 PSI
RUN NO 105 ALPHA -.57 DEG
MACH NO .802 TAM -21.4 DEG C

ALTITUDE 21780. FT
WEIGHT 250100. LB
NZ 1.89

CG 28.15 % MAC
AILERON POS -3.92 DEG
FLAP POS 0.00 DEG

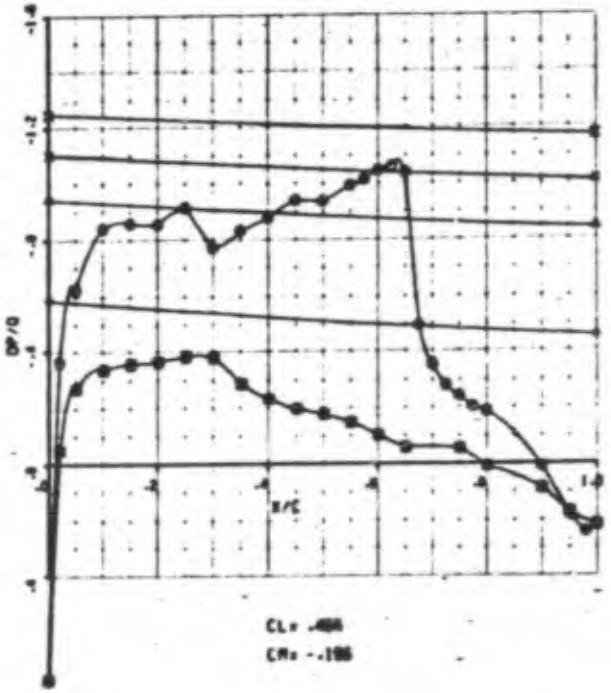
○ UPPER SURFACE
□ LOWER SURFACE
\+ MACH LOCAL-1.0
▲ MACH LOCAL-1.2
× MACH LOCAL-1.3
⧗ MACH LOCAL-1.4

ETA=0.193



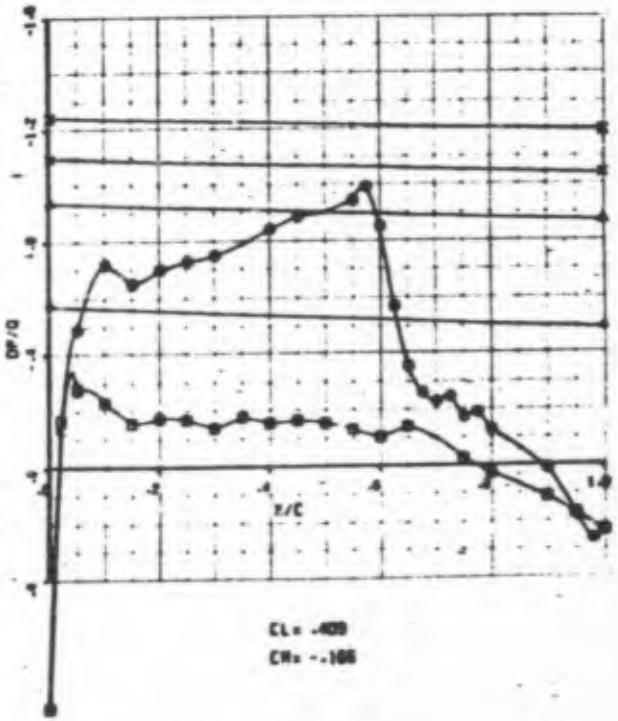
CL= 0.000
CM= 0.000

ETA=0.389



CL= .468
CM= -.186

ETA=0.637



CL= .409
CM= -.186

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2C5
MACH NO .820

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

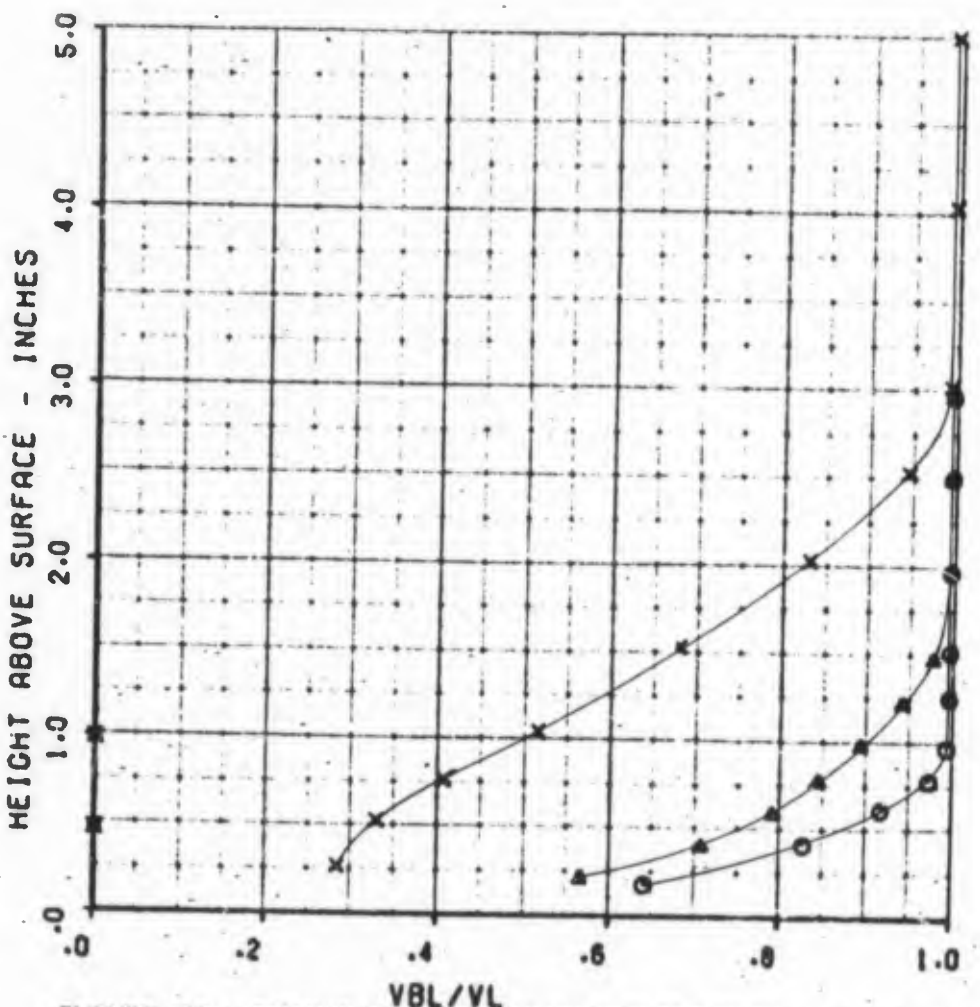
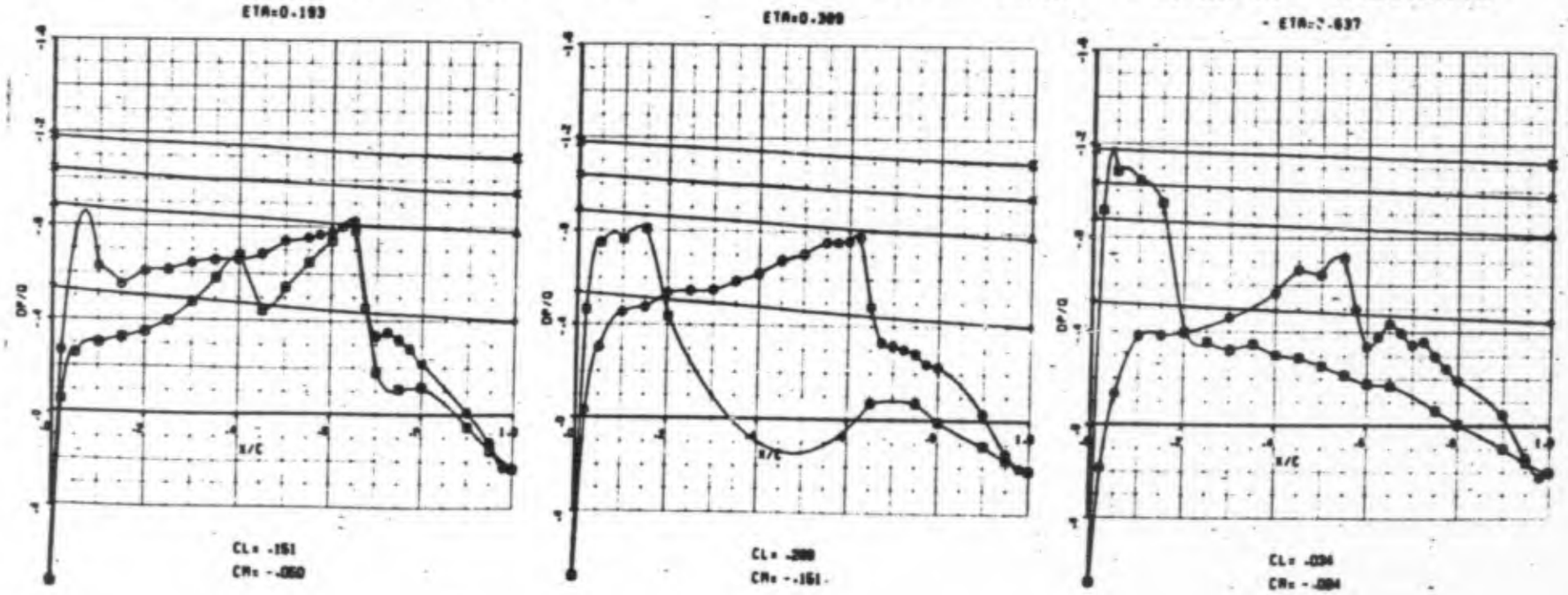


FIGURE 12 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .817 TO .822
(a) CORRECTED ALPHA = -2.72

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	3.21 PSI	ALTITUDE	20720. FT	CG	28.25 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	2CS	ALPHA	-3.64 DEG	WEIGHT	252500. LB	AILERON POS	-2.28 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.820	TAM	-33.0 DEG C	NZ	.08	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1E1
MACH NO .817

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

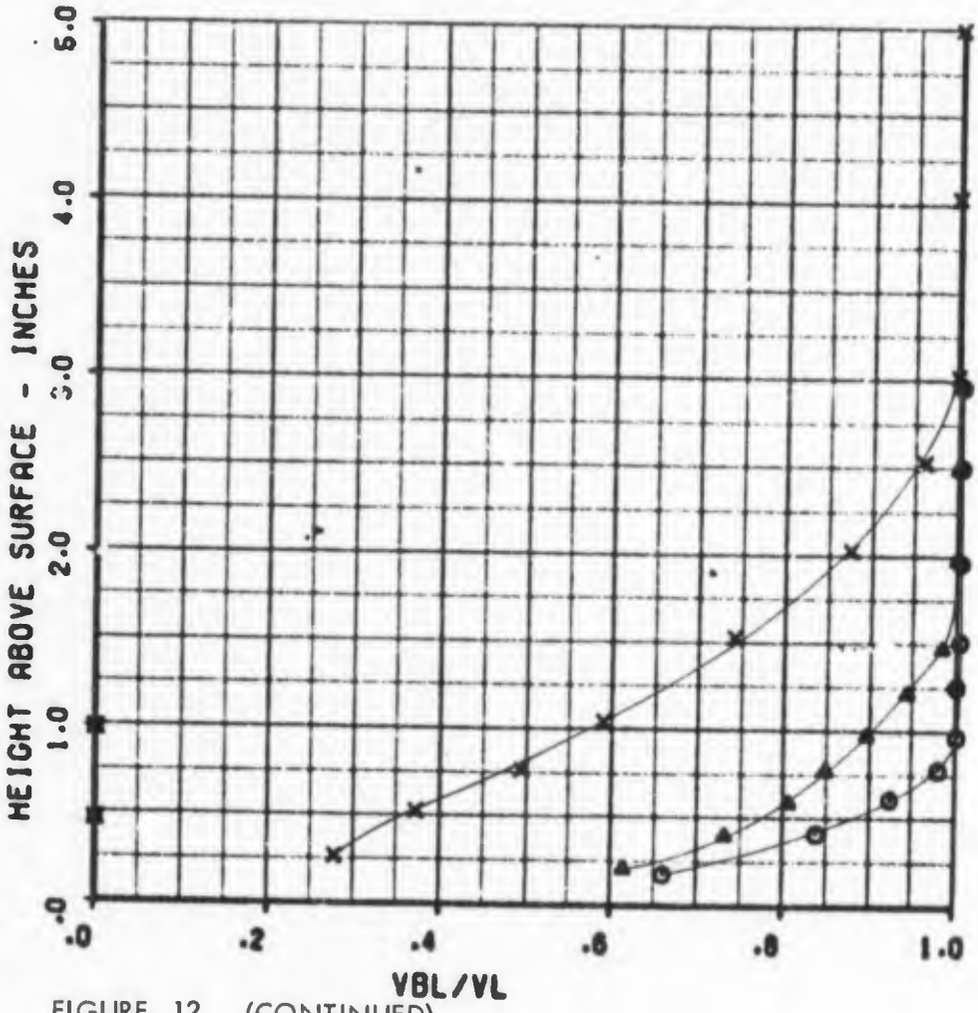


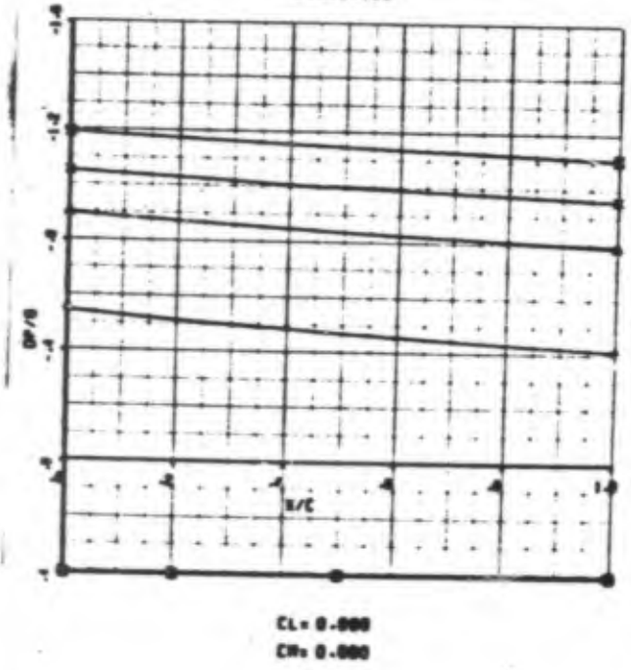
FIGURE 12 (CONTINUED)
(b) CORRECTED ALPHA = -2.70

LOCKHEED C-141A

PRESSURE DISTRIBUTION

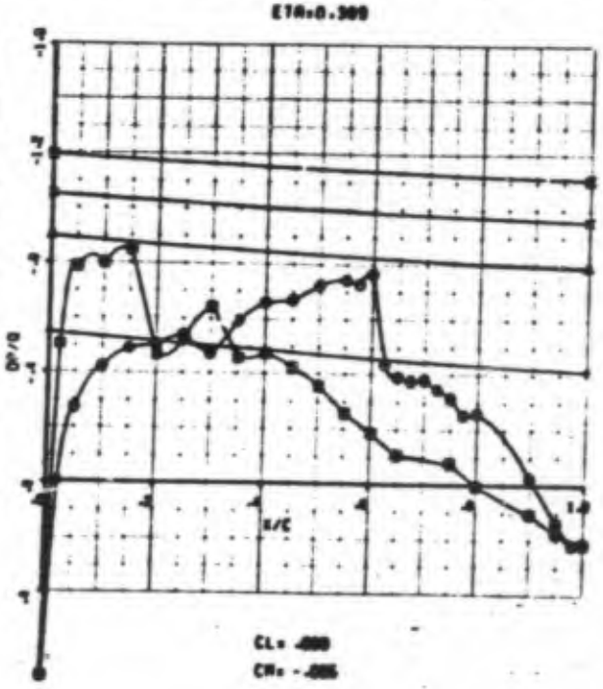
FLIGHT NO 548 | Q 3.05 PSI | ALTITUDE 21750. FT | CG 29.15 % MAC | ○ UPPER SURFACE | △ MACH LOCAL-1.2
RUN NO 1E1 | ALPHA -3.61 DEG | WEIGHT 247900. LB | AILERON POS -1.08 DEG | □ LOWER SURFACE | × MACH LOCAL-1.3
MACH NO .817 | TAM -18.4 DEG C | NZ 0.00 | FLAP POS 0.00 DEG | + MACH LOCAL-1.0 | ⧗ MACH LOCAL-1.4

ETA=0.193



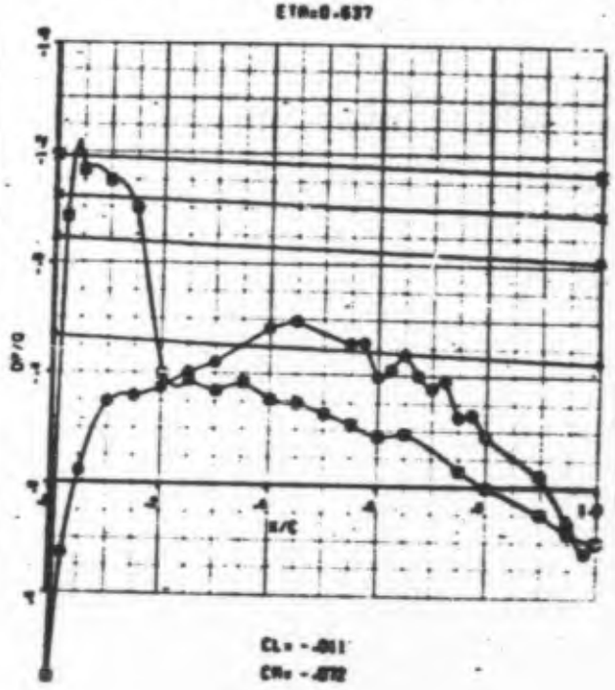
CL= 0.000
CM= 0.000

ETA=0.389



CL= -.000
CM= -.005

ETA=0.637



CL= -.011
CM= -.012

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1E2
MACH NO .820

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

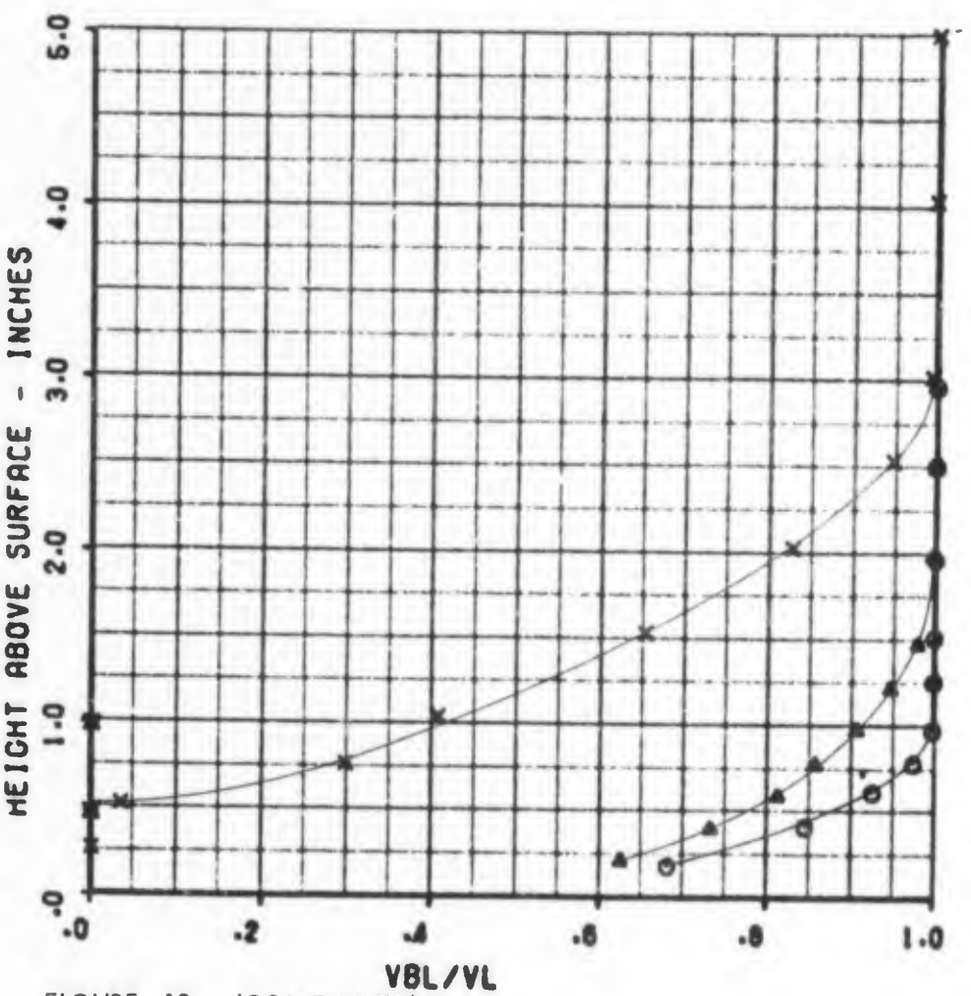
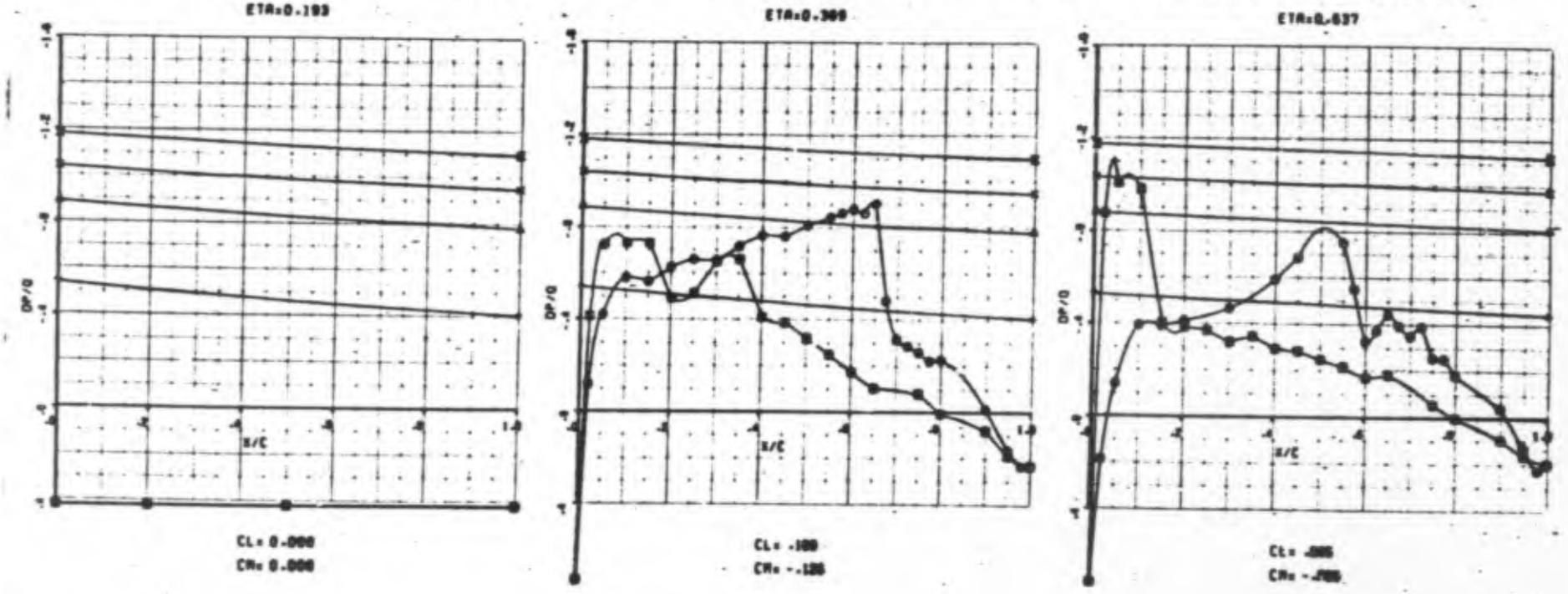


FIGURE 12 (CONTINUED)
(c) CORRECTED ALPHA = -2.20

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	546	Q	2.93 PSI	ALTITUDE	21000. FT	CG	20.15 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	1E2	ALPHA	-3.04 DEG	WEIGHT	243500. LB	AILERON POS	-.58 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.820	TAM	-20.5 DEG C	NZ	.39	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2C4
MACH NO .820

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

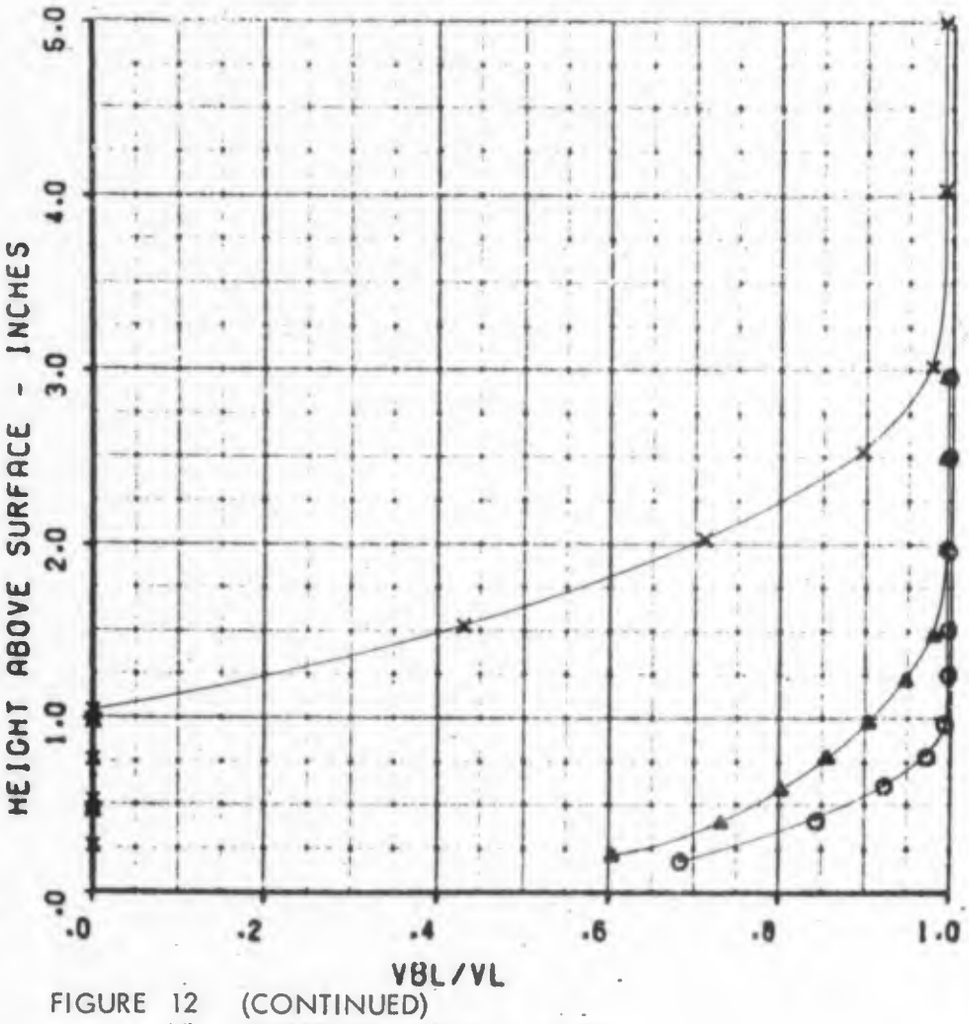
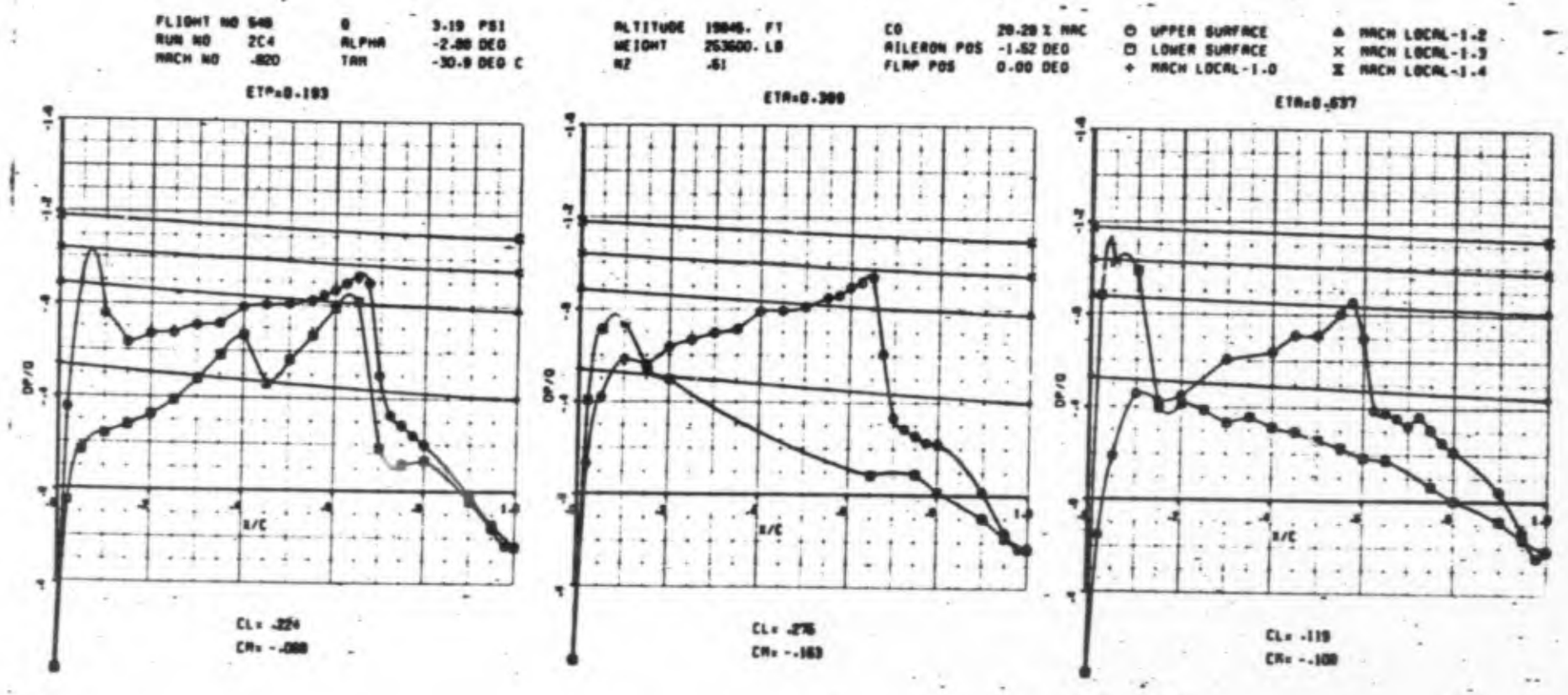


FIGURE 12 (CONTINUED)
(d) CORRECTED ALPHA = -2.06

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1E
MACH NO .820

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

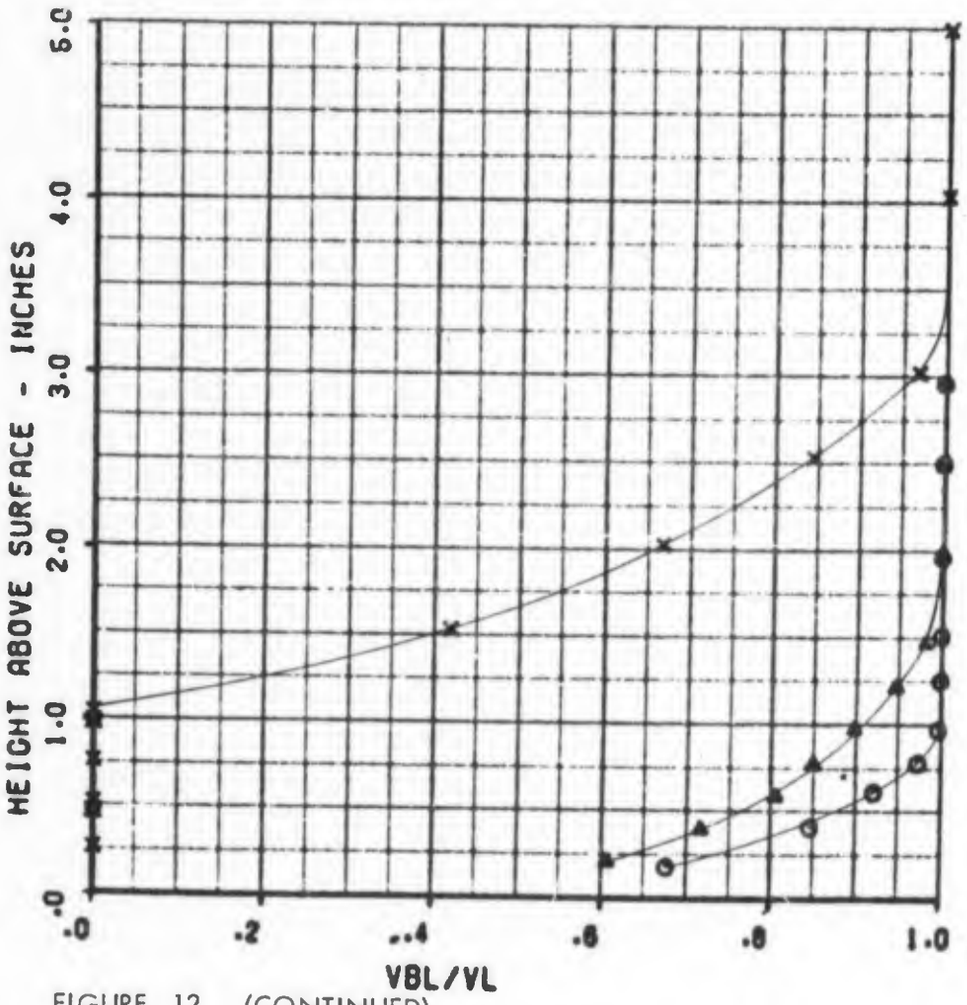
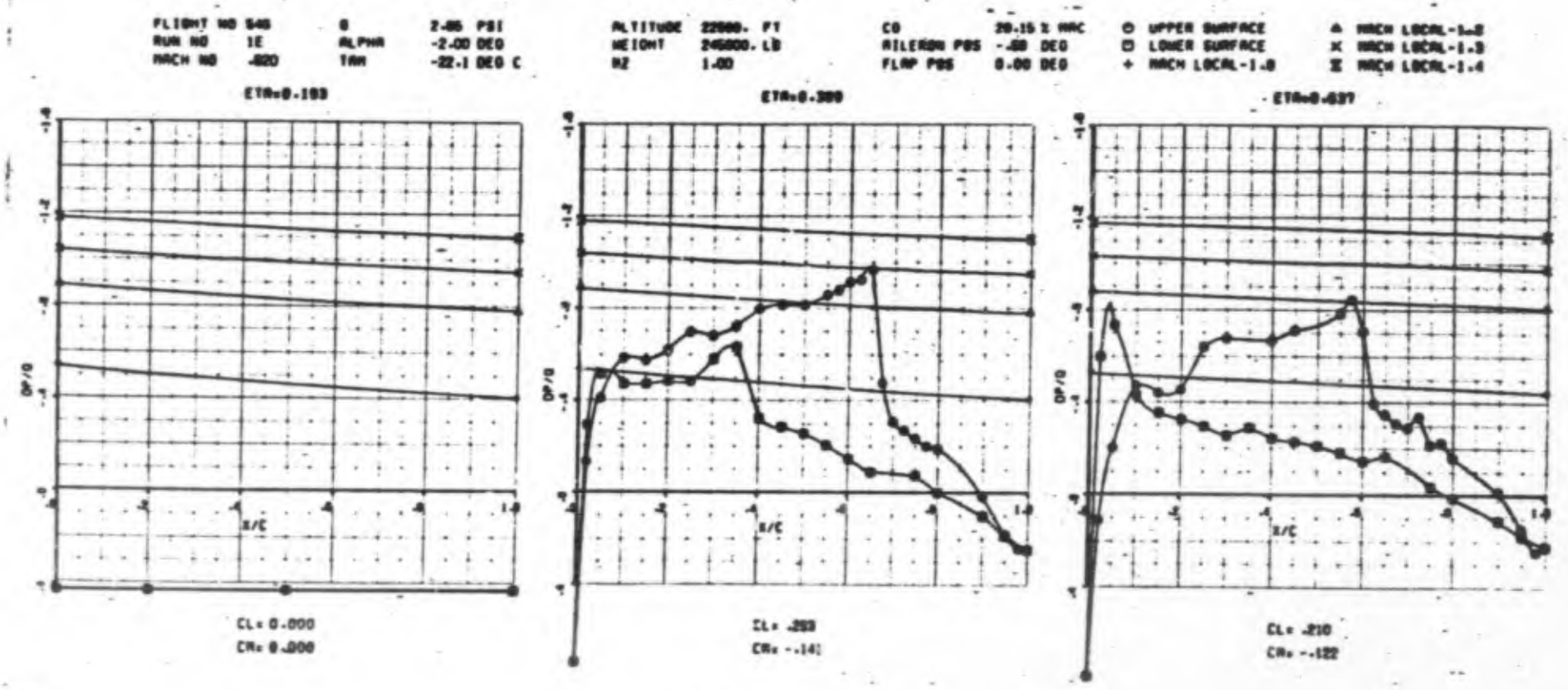


FIGURE 12 (CONTINUED)
(e) CORRECTED ALPHA = -1.27

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2C
MACH NO .822

RAKE LOCATIONS

⊙ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

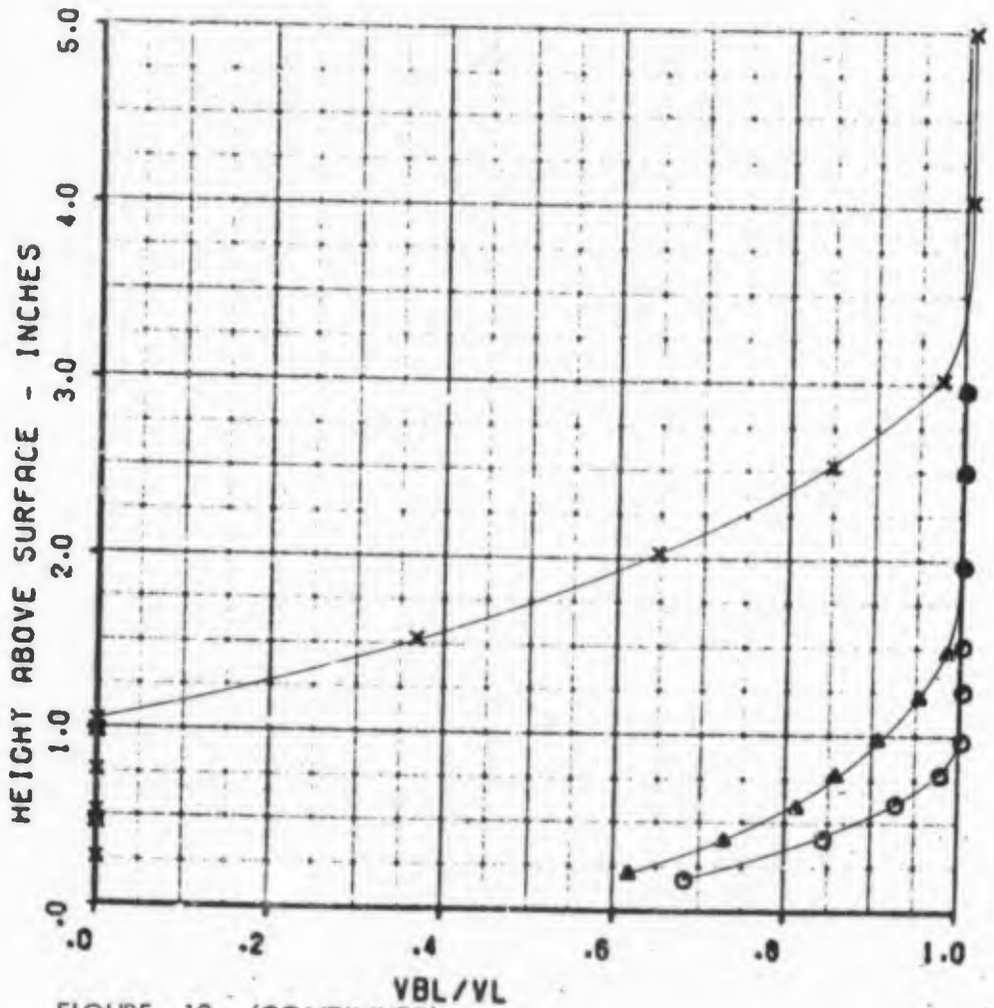
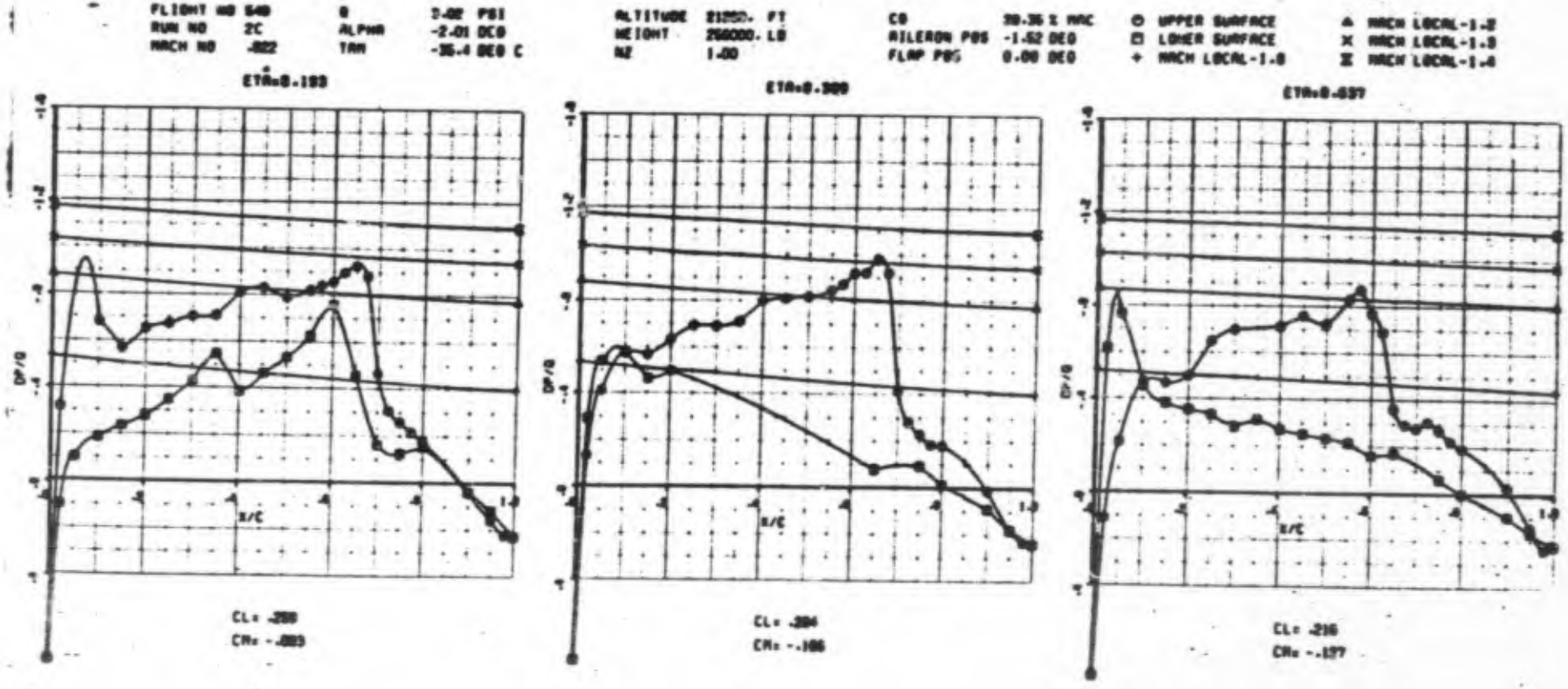


FIGURE 12 (CONTINUED).
(f) CORRECTED ALPHA = -1.27

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1E3
MACH NO .820

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

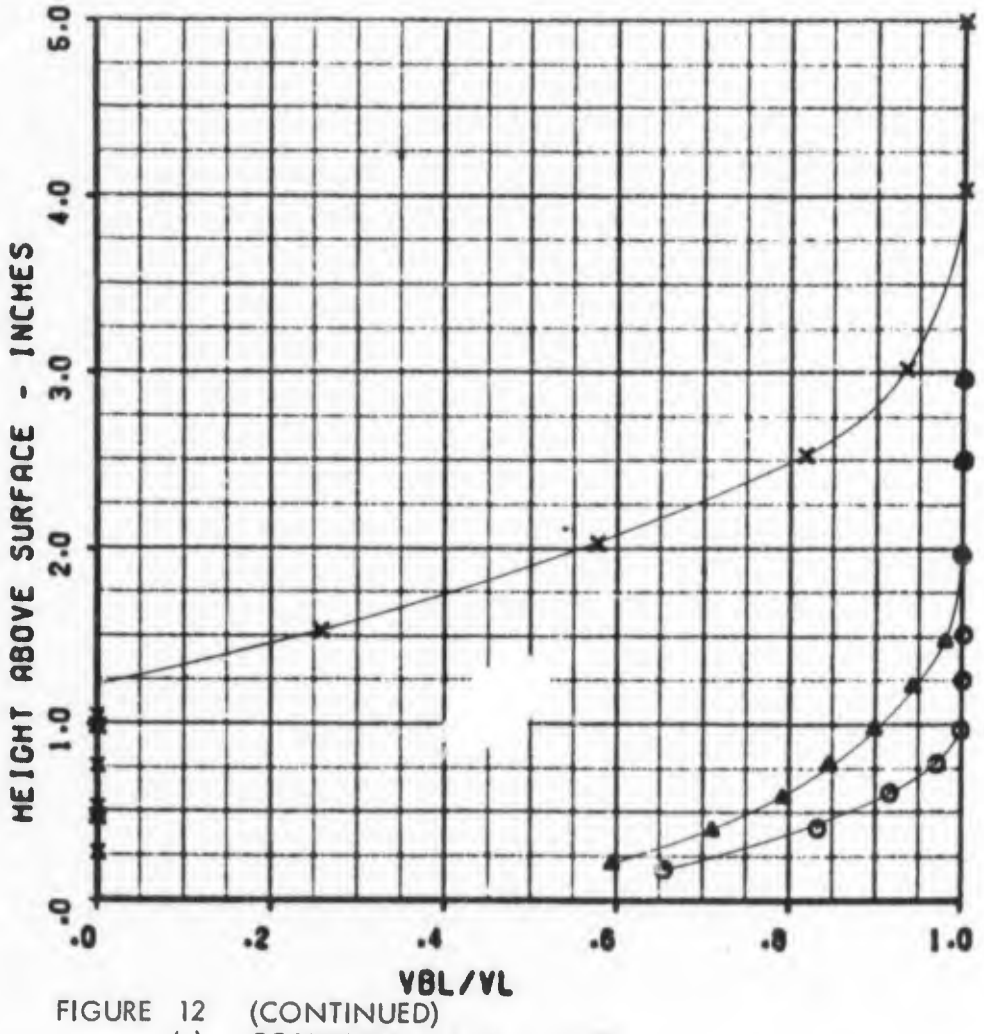


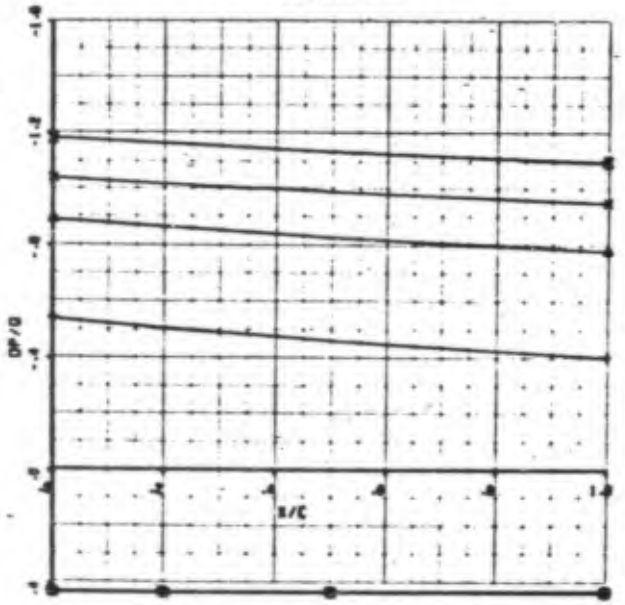
FIGURE 12 (CONTINUED)
(g) CORRECTED ALPHA = -0.78

LOCKHEED C-141A

PRESSURE DISTRIBUTION

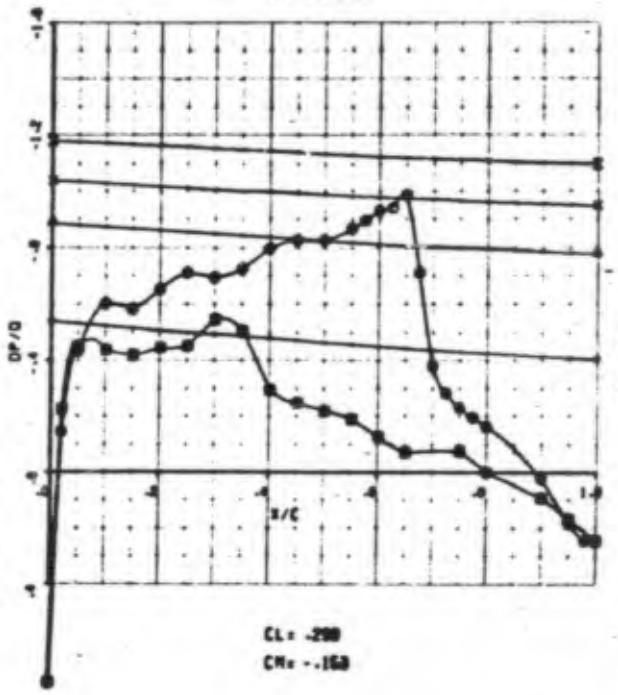
FLIGHT NO	548	Q	2.82 PSI	ALTITUDE	22750. FT	CG	28.15 % MAC	○	UPPER SURFACE	△	MACH LOCAL-1.2
RUN NO	1E3	ALPHA	-1.43 DEG	WEIGHT	245600. LB	AILERON POS	-.67 DEG	□	LOWER SURFACE	×	MACH LOCAL-1.3
MACH NO	.820	TAM	-23.8 DEG C	NZ	1.36	FLAP POS	0.00 DEG	+	MACH LOCAL-1.0	⧗	MACH LOCAL-1.4

ETA=0.193



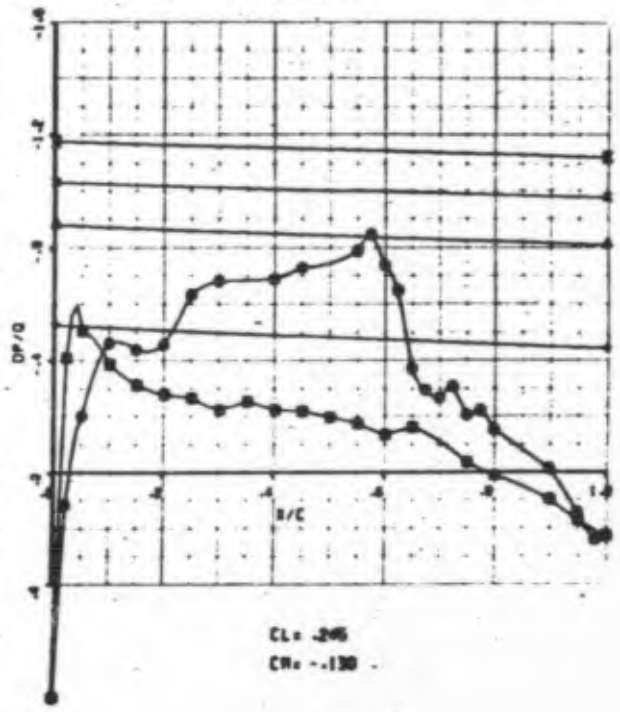
CL= 0.000
CM= 0.000

ETA=0.389



CL= .298
CM= -.163

ETA=0.637



CL= .245
CM= -.130

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS.

FLIGHT NO 548
RUN NO 2C1
MACH NO .822

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

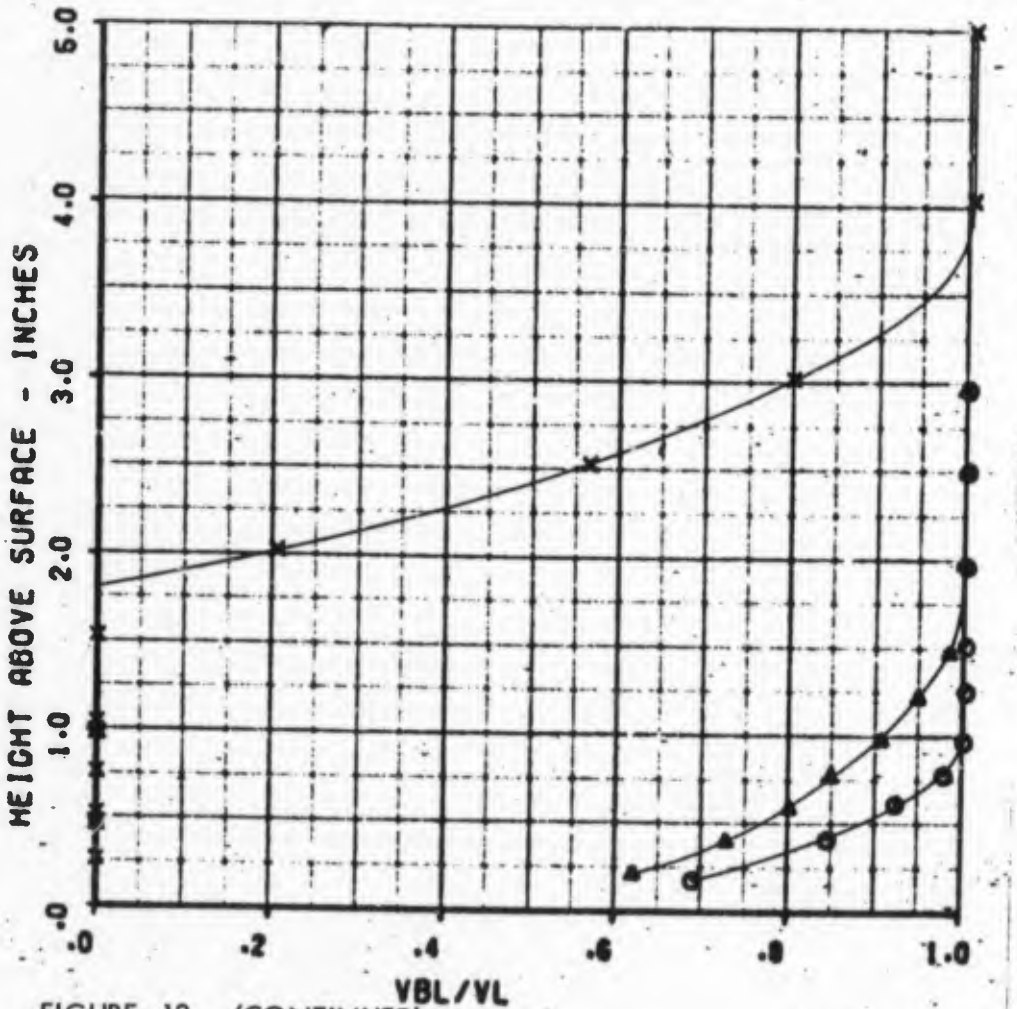


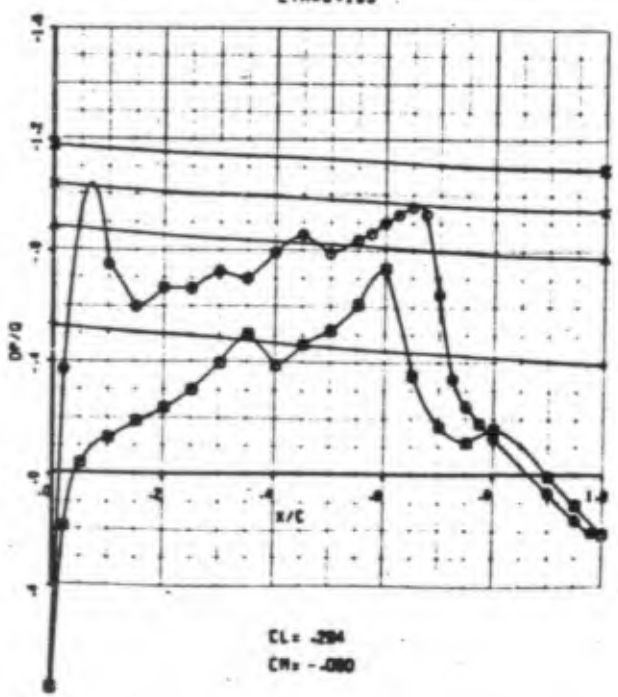
FIGURE 12 (CONTINUED)
(h) CORRECTED ALPHA = -0.70

LOCKHEED C-141A

PRESSURE DISTRIBUTION

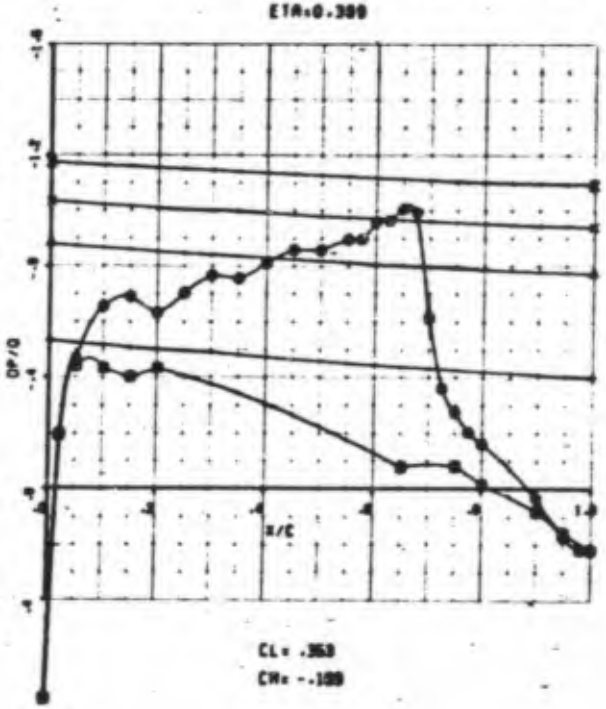
FLIGHT NO	548	Q	3.08 PSI	ALTITUDE	20800. FT	CG	28.34 % MAC	○	UPPER SURFACE	△	MACH LOCAL-1.2
RUN NO	2C1	ALPHA	-1.34 DEG	WEIGHT	256700. LB	AILERON POS	.34 DEG	□	LOWER SURFACE	×	MACH LOCAL-1.3
MACH NO	.822	TAN	-33.3 DEG C	NZ	1.42	FLAP POS	0.00 DEG	+	MACH LOCAL-1.0	⧗	MACH LOCAL-1.4

ETA=0.183



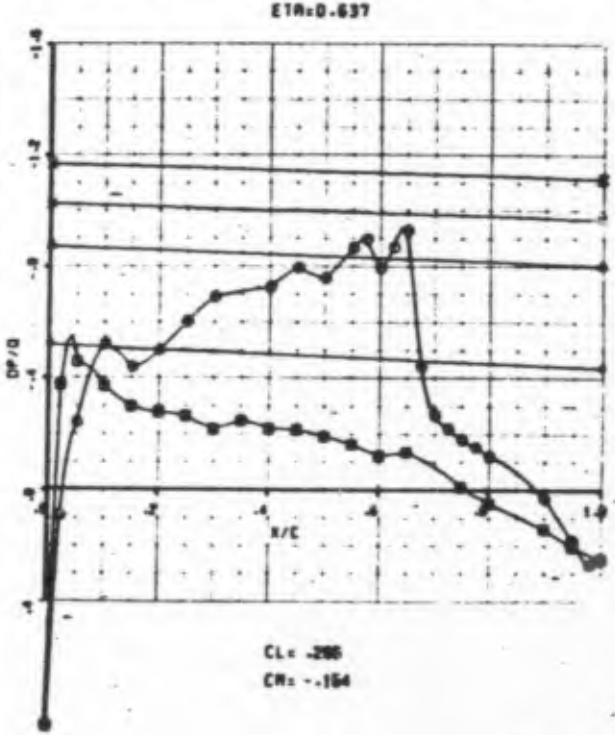
CL= .294
CM= -.080

ETA=0.388



CL= .353
CM= -.109

ETA=0.637



CL= .286
CM= -.154

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1E4
MACH NO .822

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

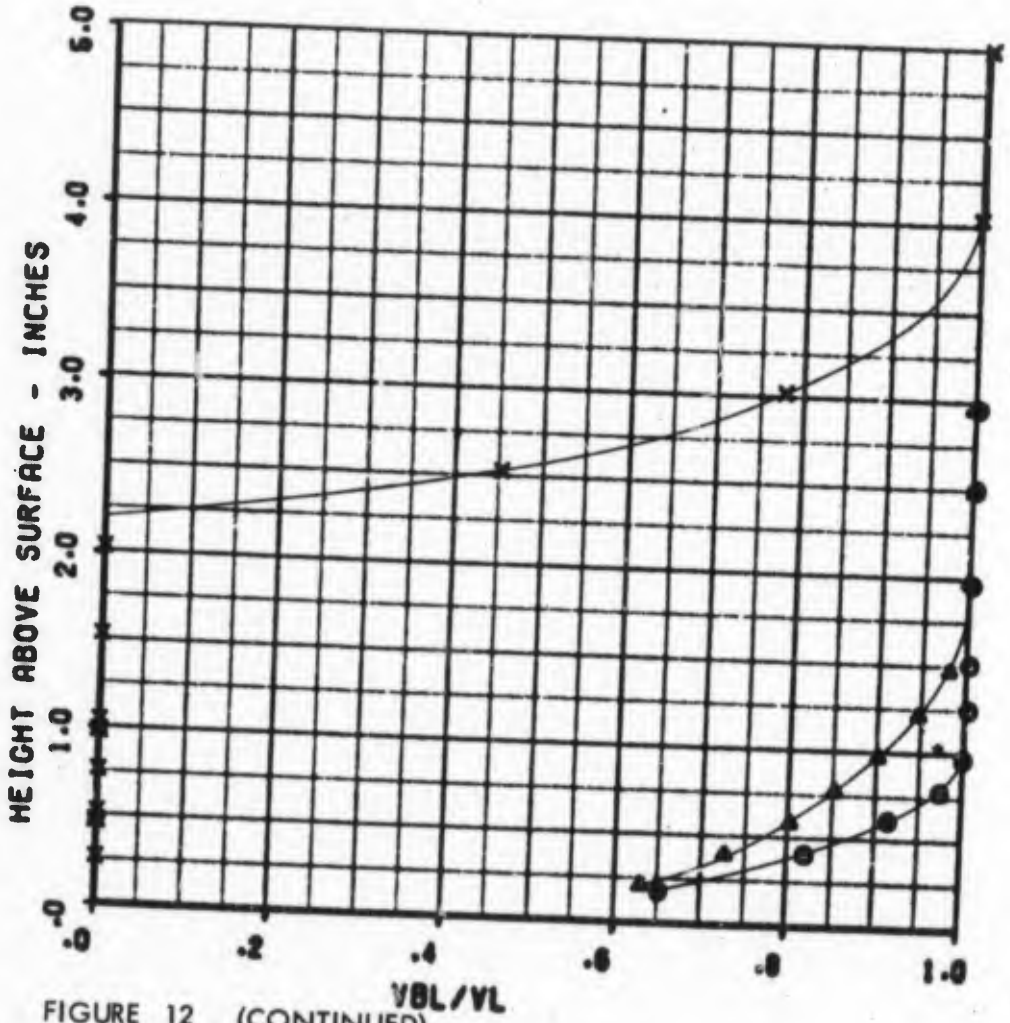
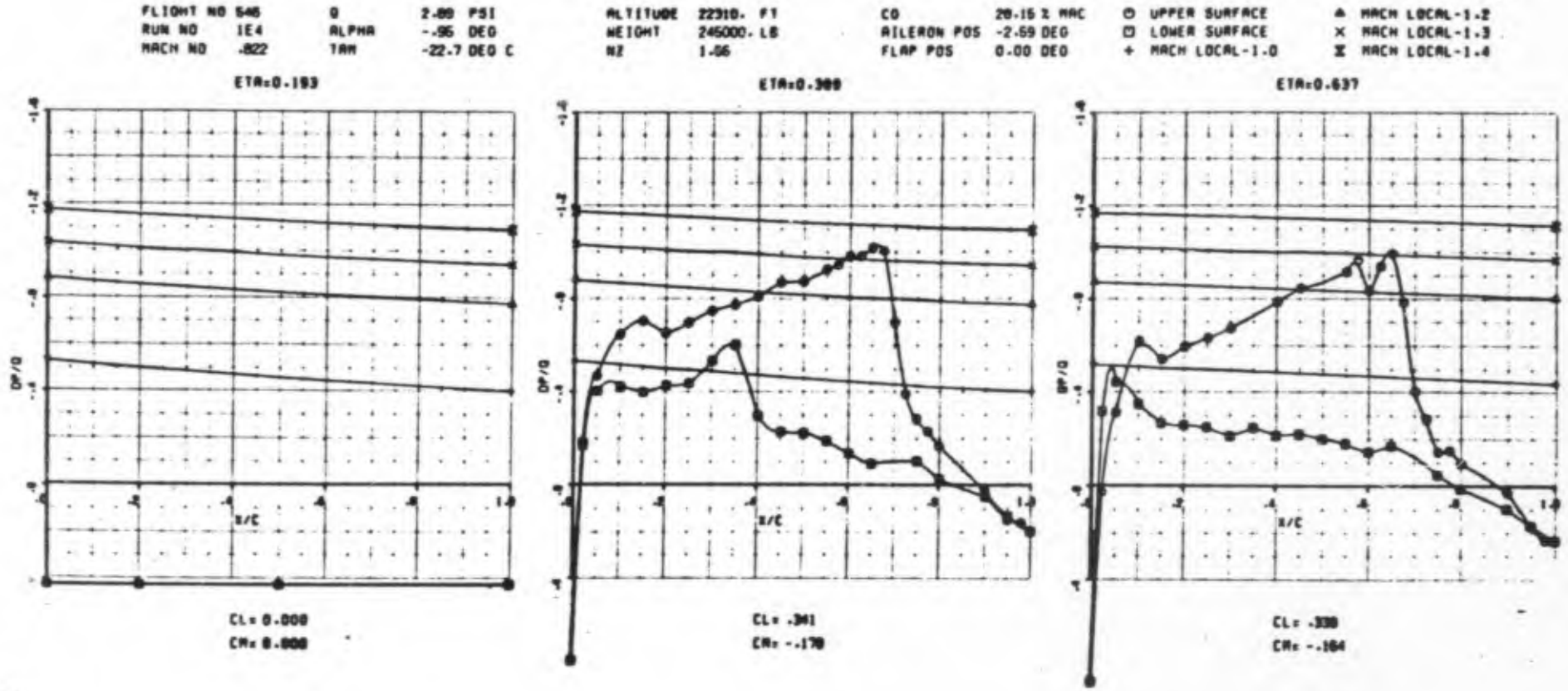


FIGURE 12 (CONTINUED)
(k) CORRECTED ALPHA = -0.35

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2C2
MACH NO .820

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

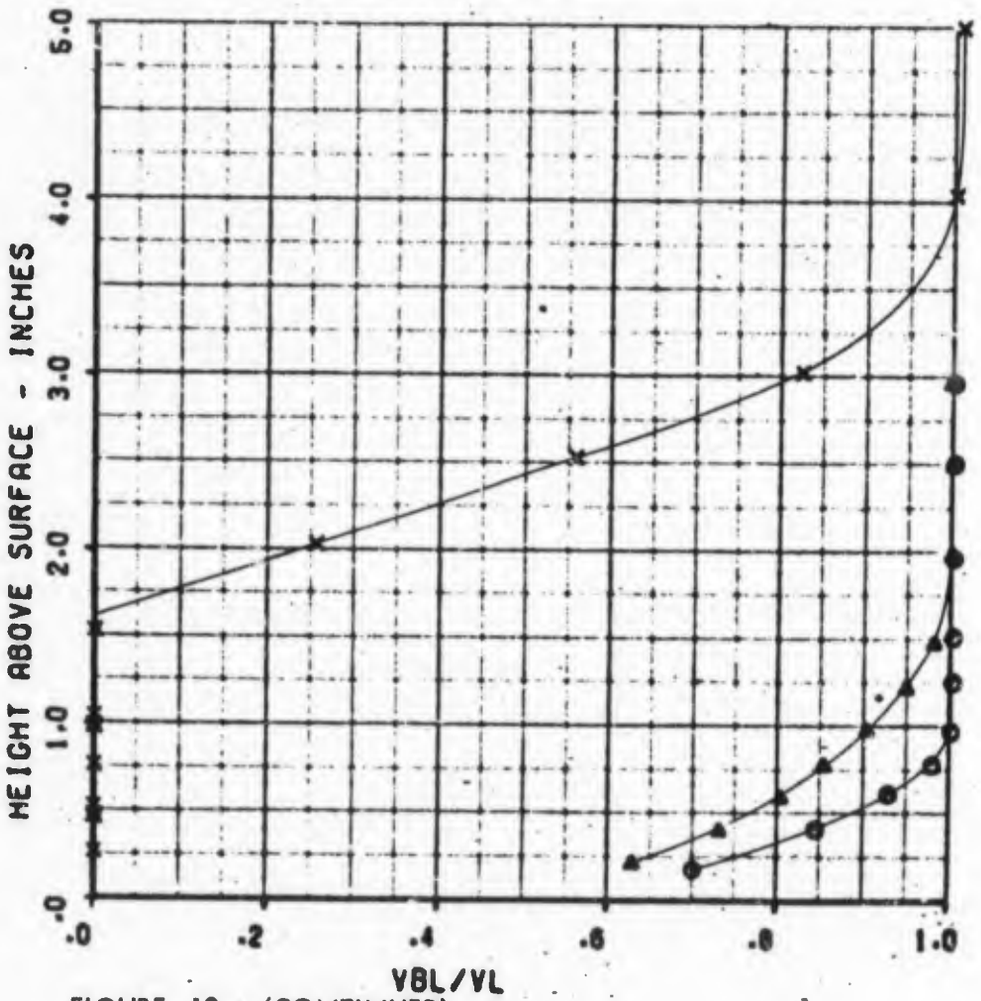
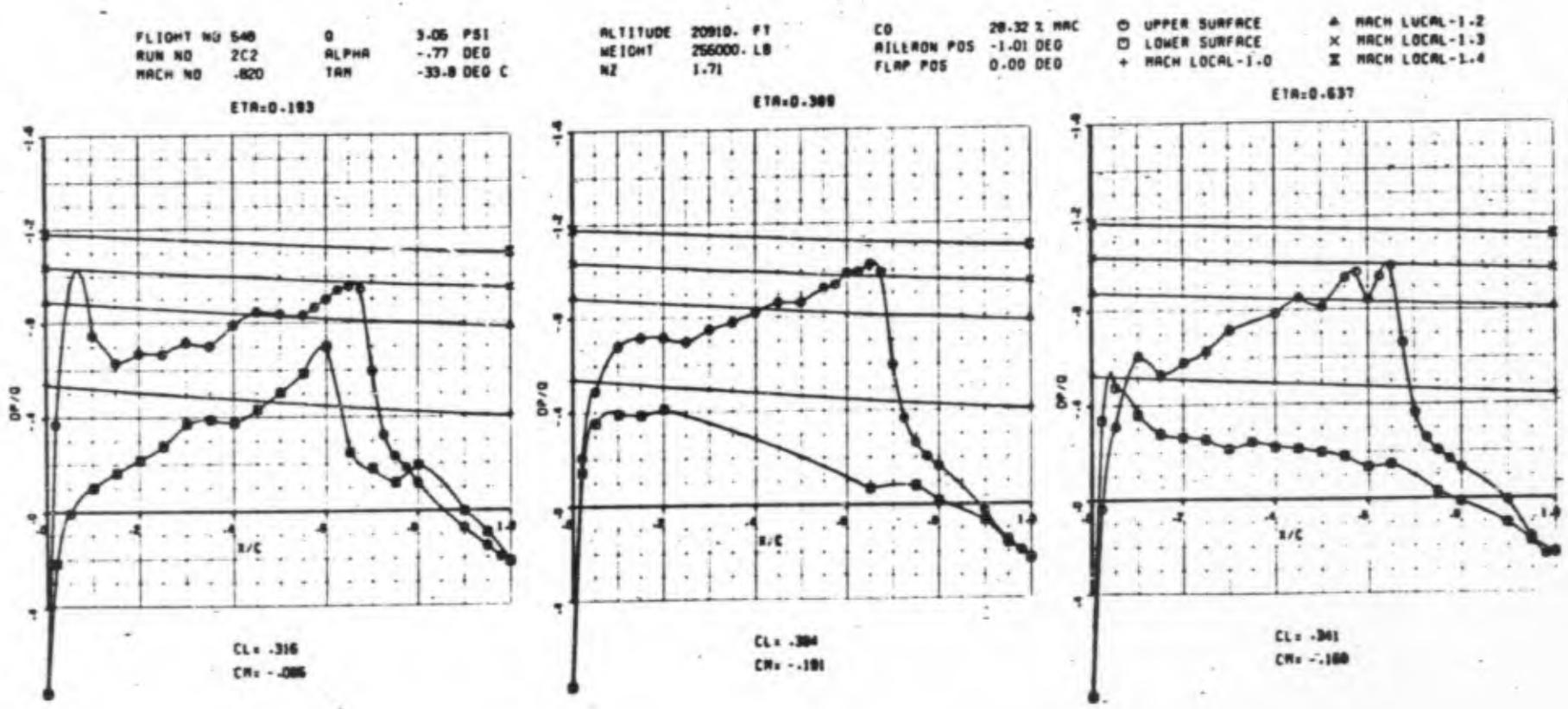


FIGURE 12 (CONTINUED)
(I) CORRECTED ALPHA = -0.20

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 2C3
MACH NO .820

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

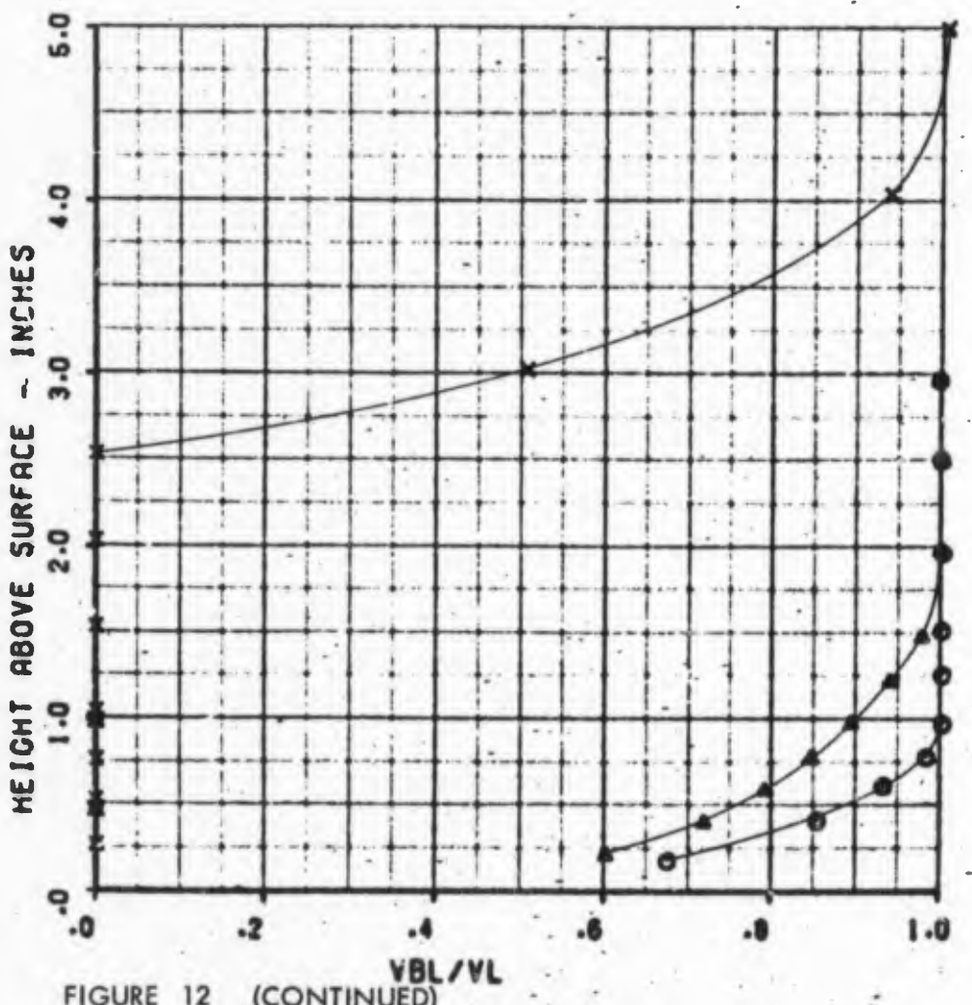


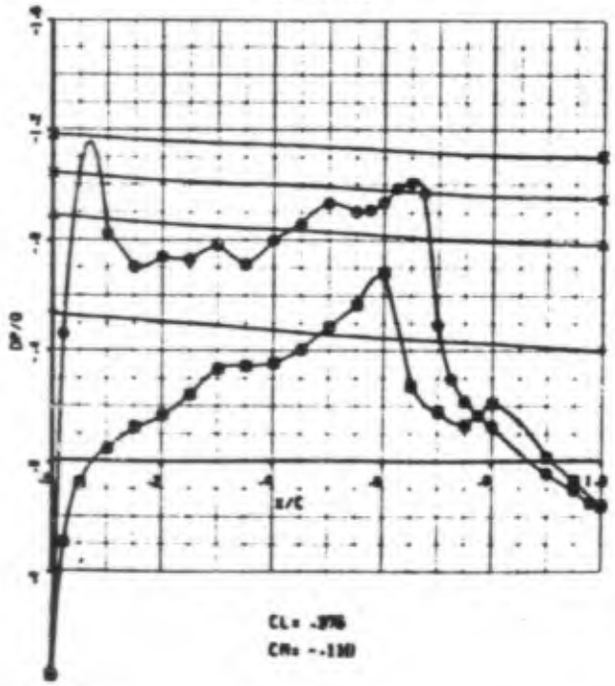
FIGURE 12 (CONTINUED)
(m) CORRECTED ALPHA = 0.22

LOCKHEED C-141A

PRESSURE DISTRIBUTION

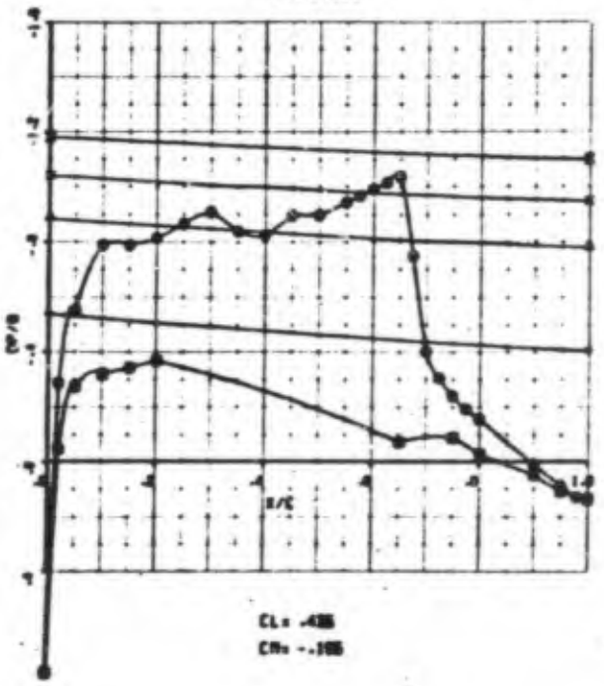
FLIGHT NO	548	Q	3.07 PSI	ALTITUDE	20750. FT	CG	28.30 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	2C3	ALPHA	-.29 DEG	WEIGHT	254200. LB	AILERON POS	-.42 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.820	TAM	-33.2 DEG C	NZ	1.06	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4

ETA=0.183



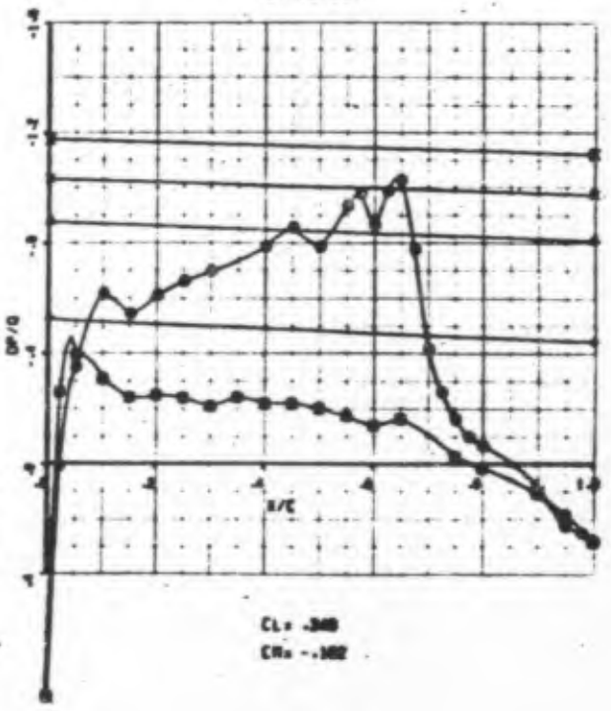
CL= .376
CM= -.130

ETA=0.389



CL= .435
CM= -.105

ETA=0.637



CL= .340
CM= -.102

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 546
RUN NO 1E5
MACH NO .820

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

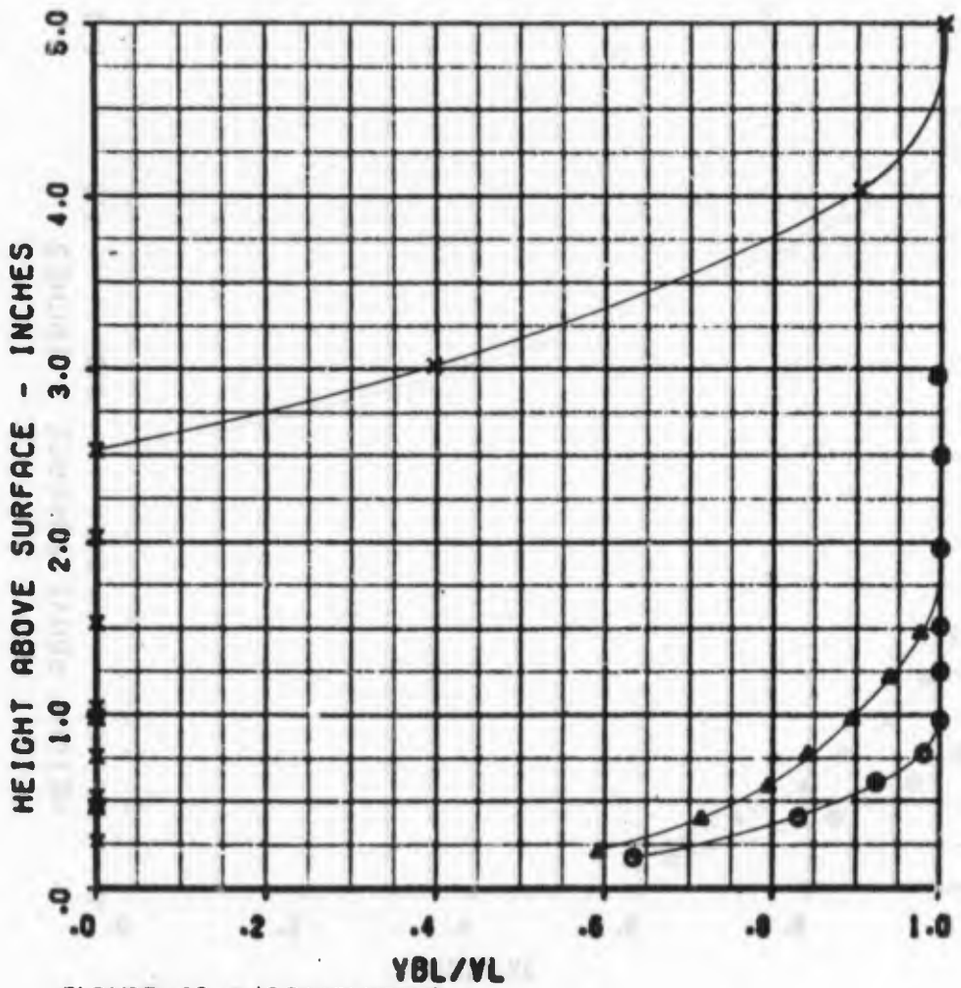
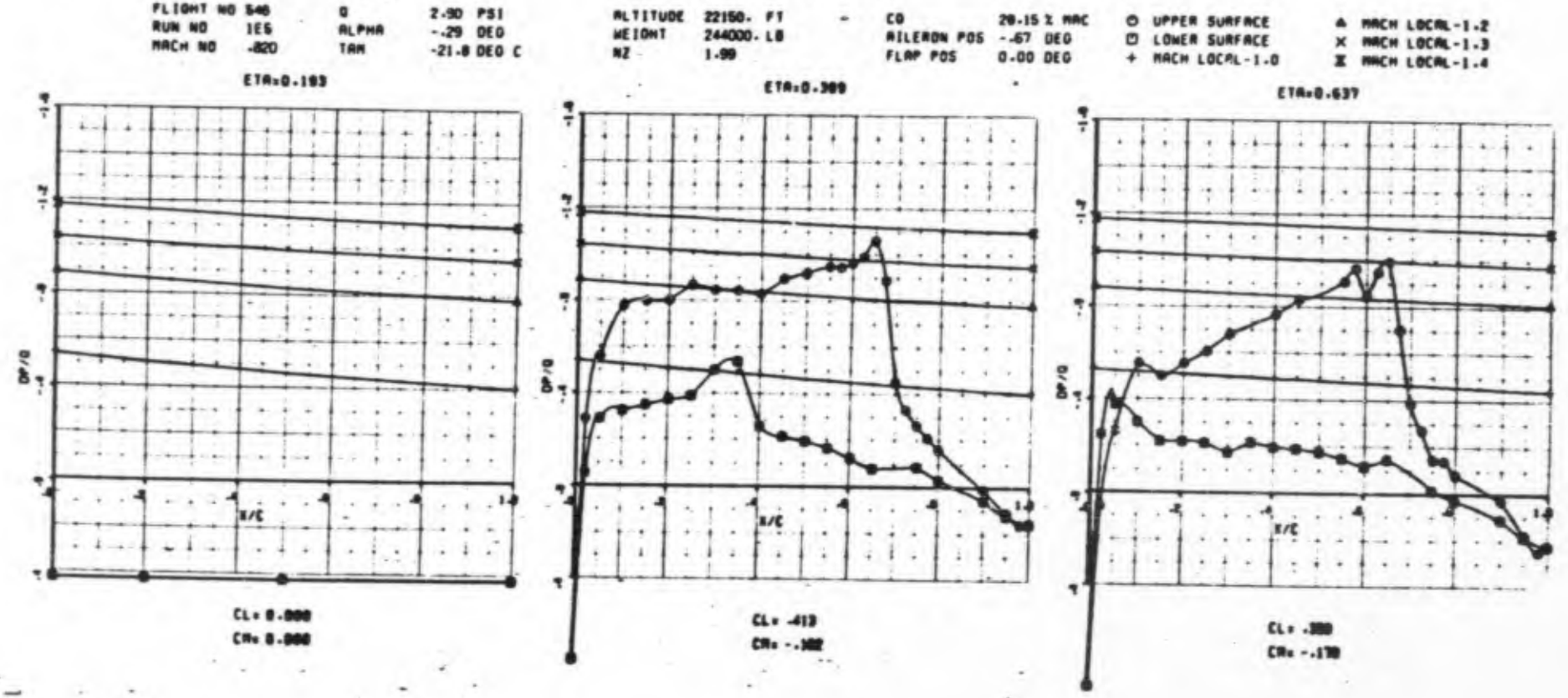


FIGURE 12 (CONCLUDED)
(n) CORRECTED ALPHA = 0.22

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 2A5
MACH NO .860

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

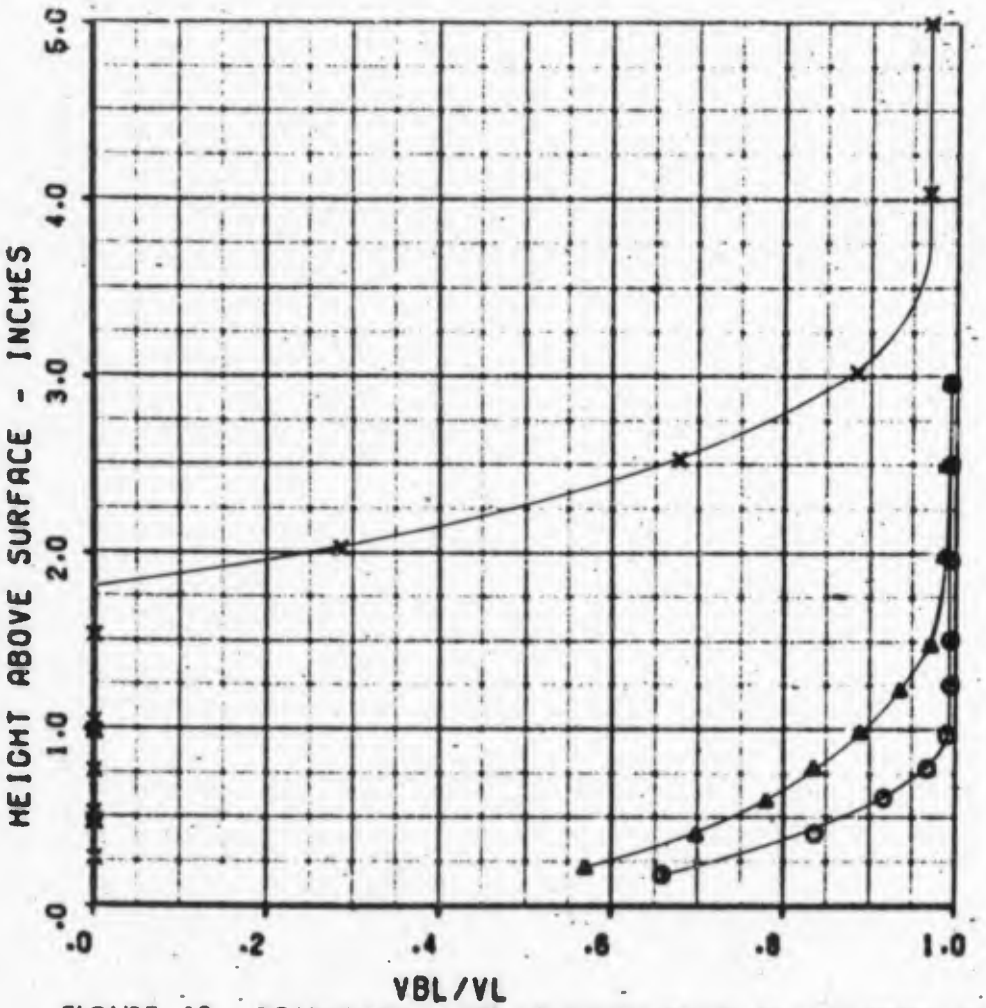


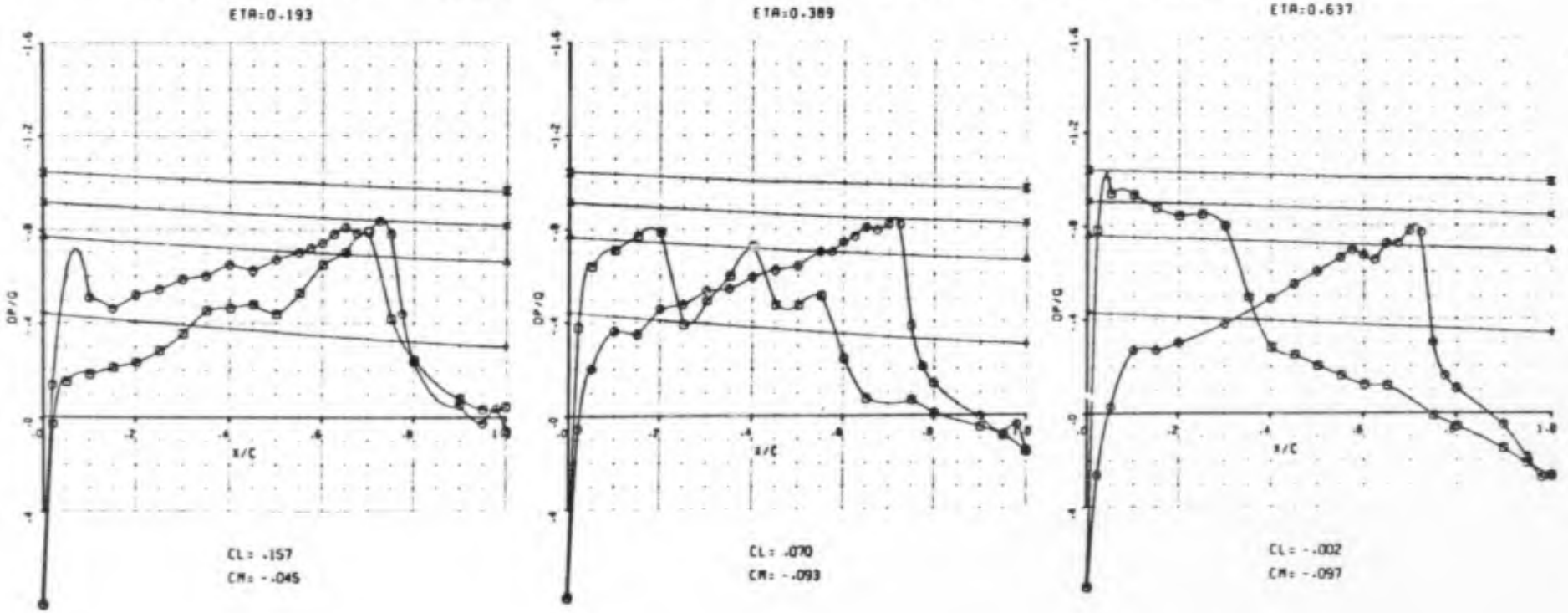
FIGURE 13 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .840 TO .860

(a) CORRECTED ALPHA = -2.24

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	547	Q	2.65 PSI	ALTITUDE	26415. FT	CG	27.70 % MAC	○	UPPER SURFACE	△	MACH LOCAL-1.2
RUN NO	2A5	ALPHA	-3.09 DEG	WEIGHT	244000. LB	AILERON POS	1.11 DEG	□	LOWER SURFACE	×	MACH LOCAL-1.3
MACH NO	.860	TAM	-44.0 DEG C	NZ	.05	FLAP POS	0.00 DEG	+	MACH LOCAL-1.0	⧖	MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 2A4
MACH NO .855

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

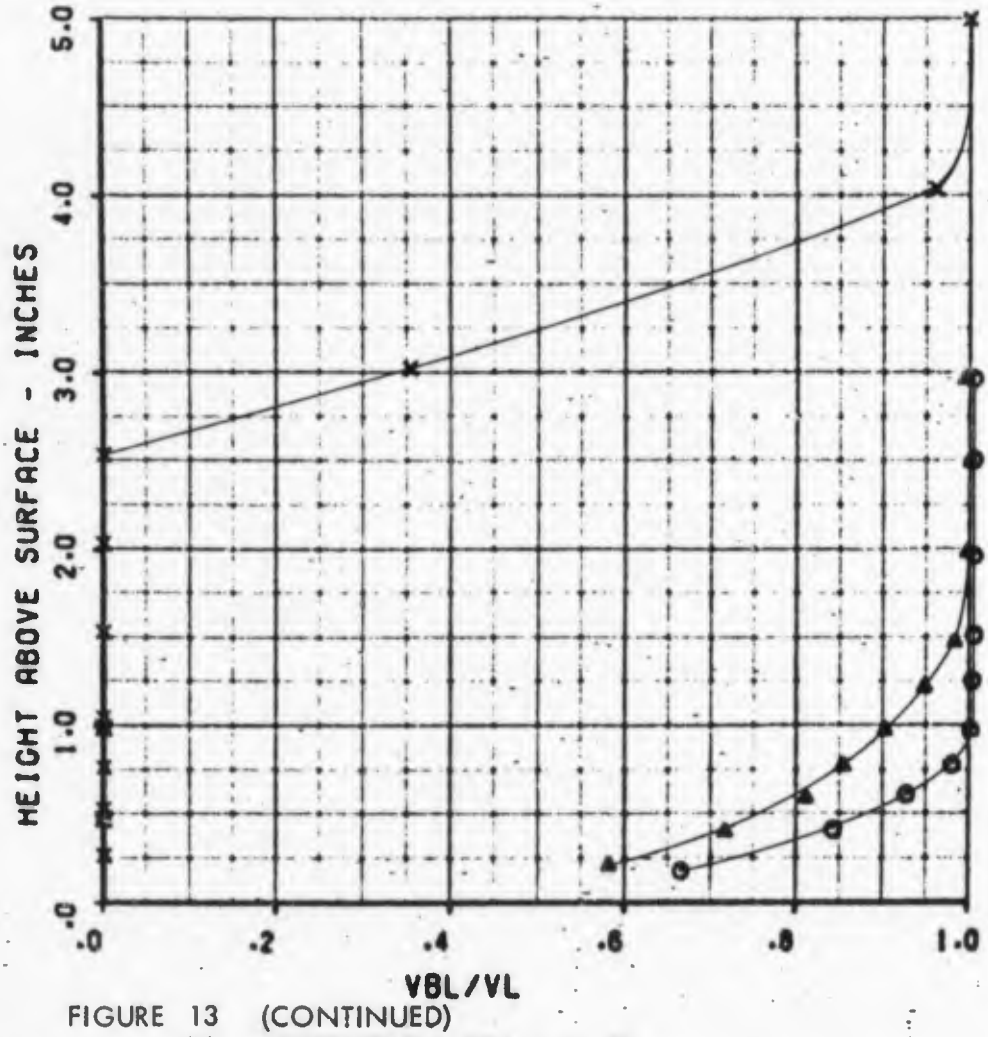


FIGURE 13 (CONTINUED)
(b) CORRECTED ALPHA = -1.30

LOCKHEED C-141A

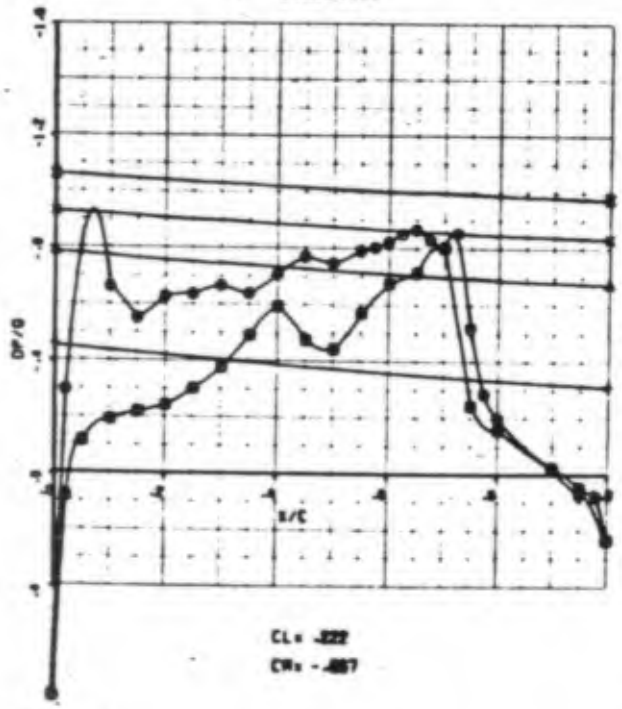
PRESSURE DISTRIBUTION

FLIGHT NO 547 Q 7.62 PSI
RUN NO 2A4 ALPHA -2.03 DEG
MACH NO .855 TAM -43.5 DEG C

ALTITUDE 27266. FT CG 27.75 % MAC
WEIGHT 244800. LB AILERON POS -.26 DEG
NZ .46 FLAP POS 0.00 DEG

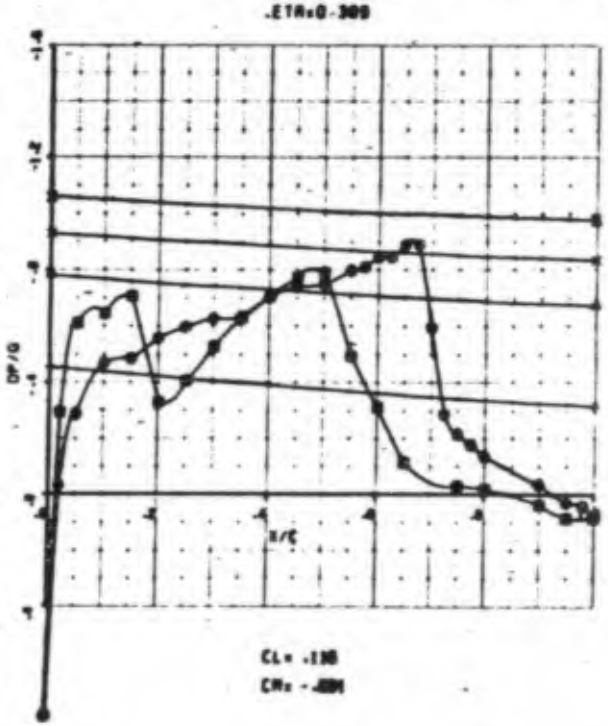
○ UPPER SURFACE △ MACH LOCAL-1.2
□ LOWER SURFACE × MACH LOCAL-1.3
+ MACH LOCAL-1.0 ⧖ MACH LOCAL-1.4

ETA=0.193



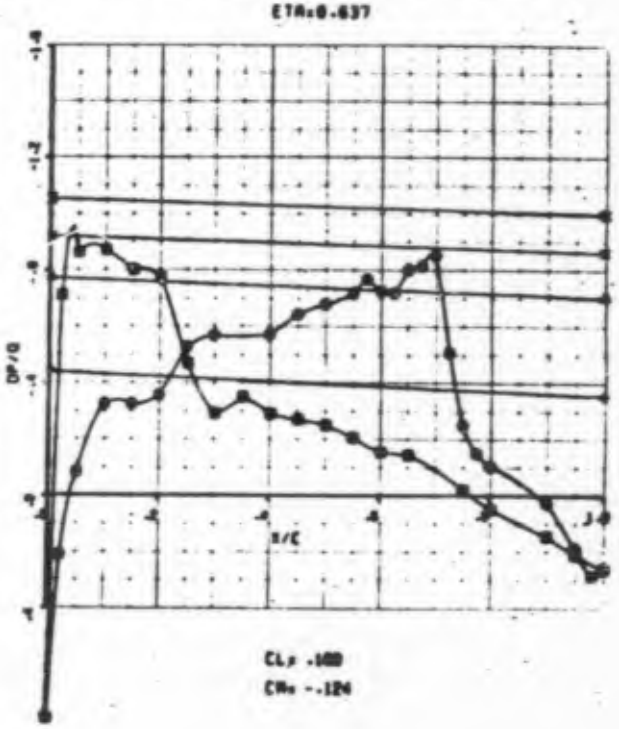
CL= .222
CM= -.087

ETA=0.389



CL= .136
CM= -.091

ETA=0.637



CL= .100
CM= -.124

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 2A
MACH NO .845

RAKE LOCATIONS

○ 30 %
▲ 65 %
× 80 %
✱ 80 %(AFT)

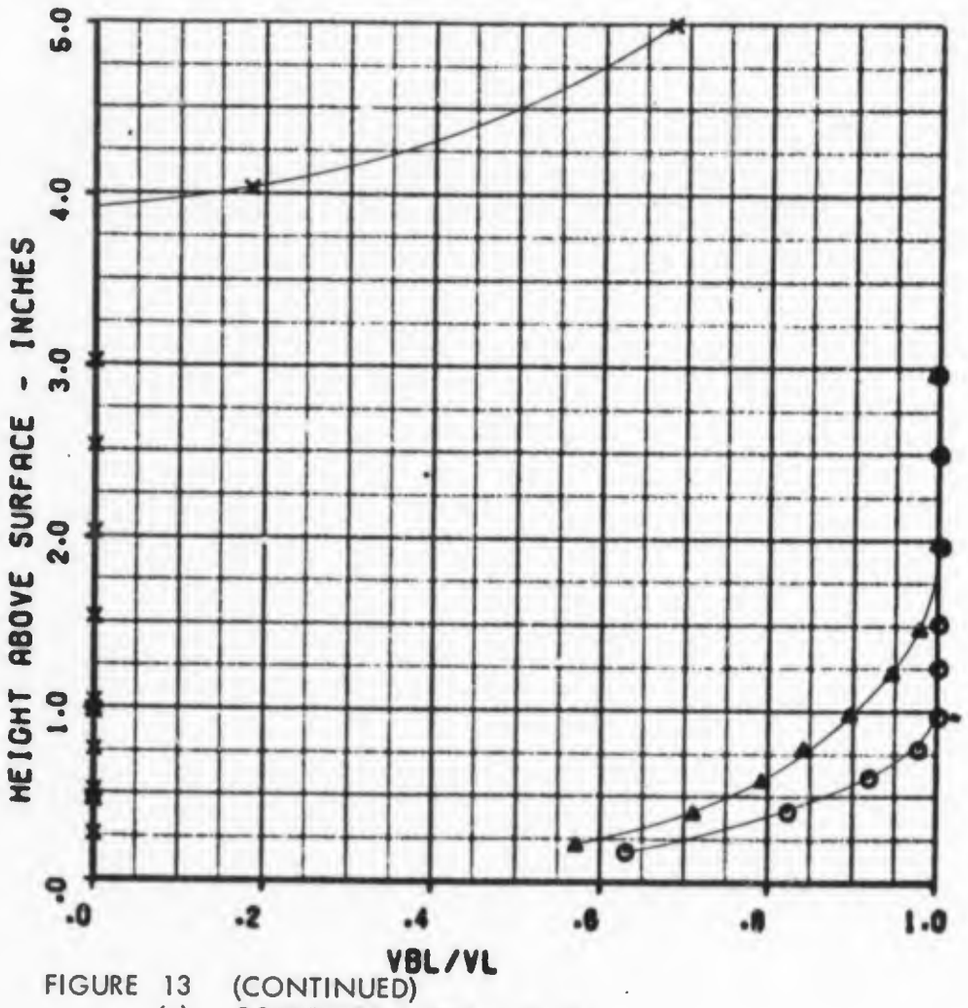
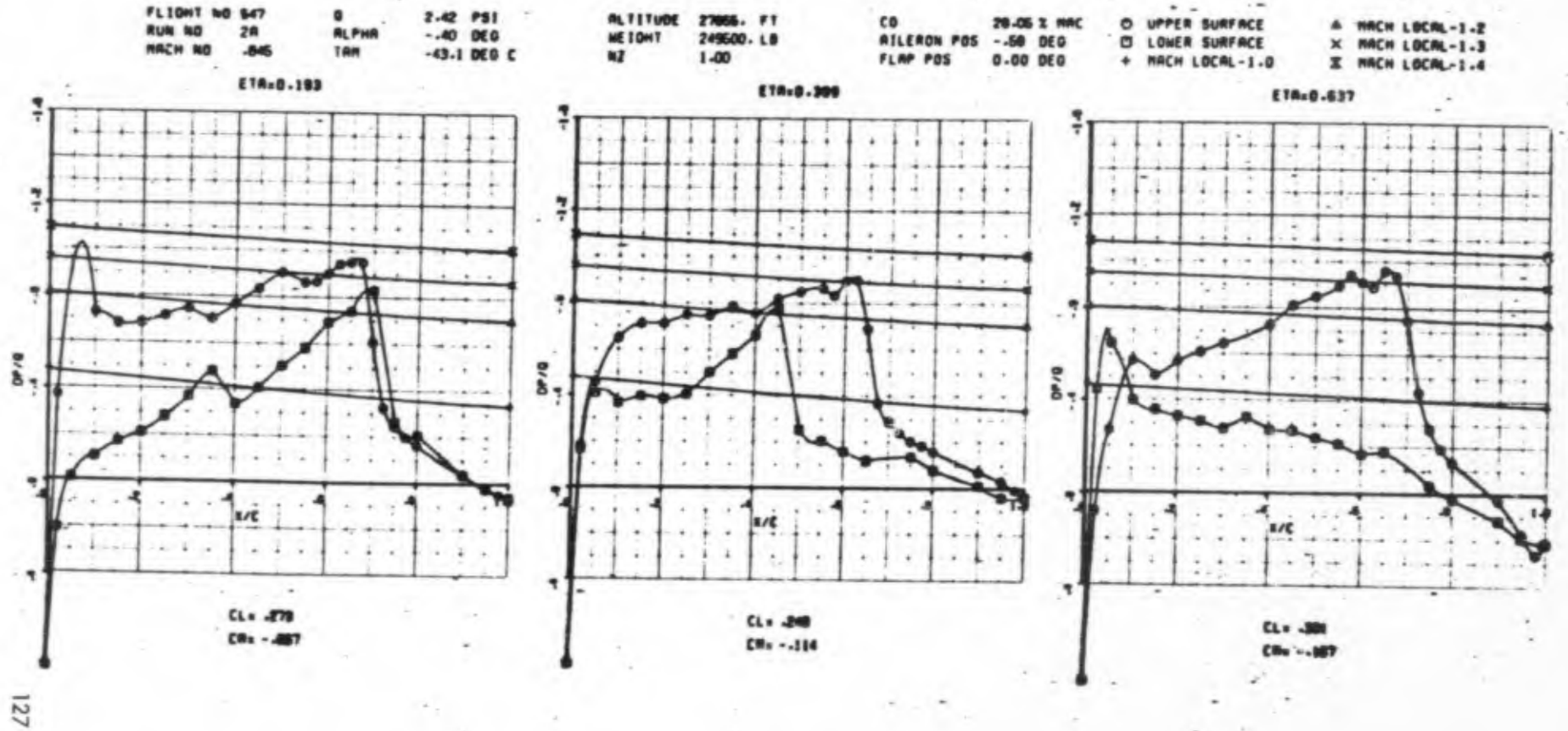


FIGURE 13 (CONTINUED)
(c) CORRECTED ALPHA = 0.13

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 2A1
MACH NO .840

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

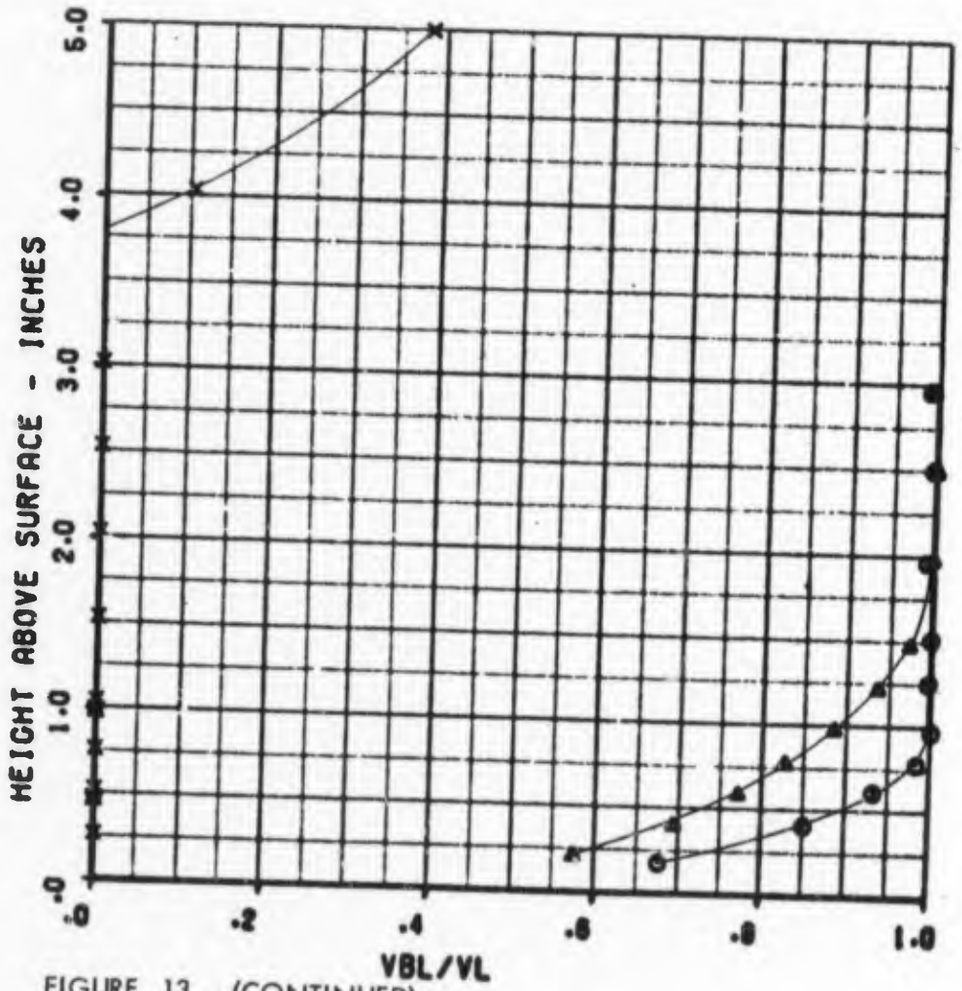
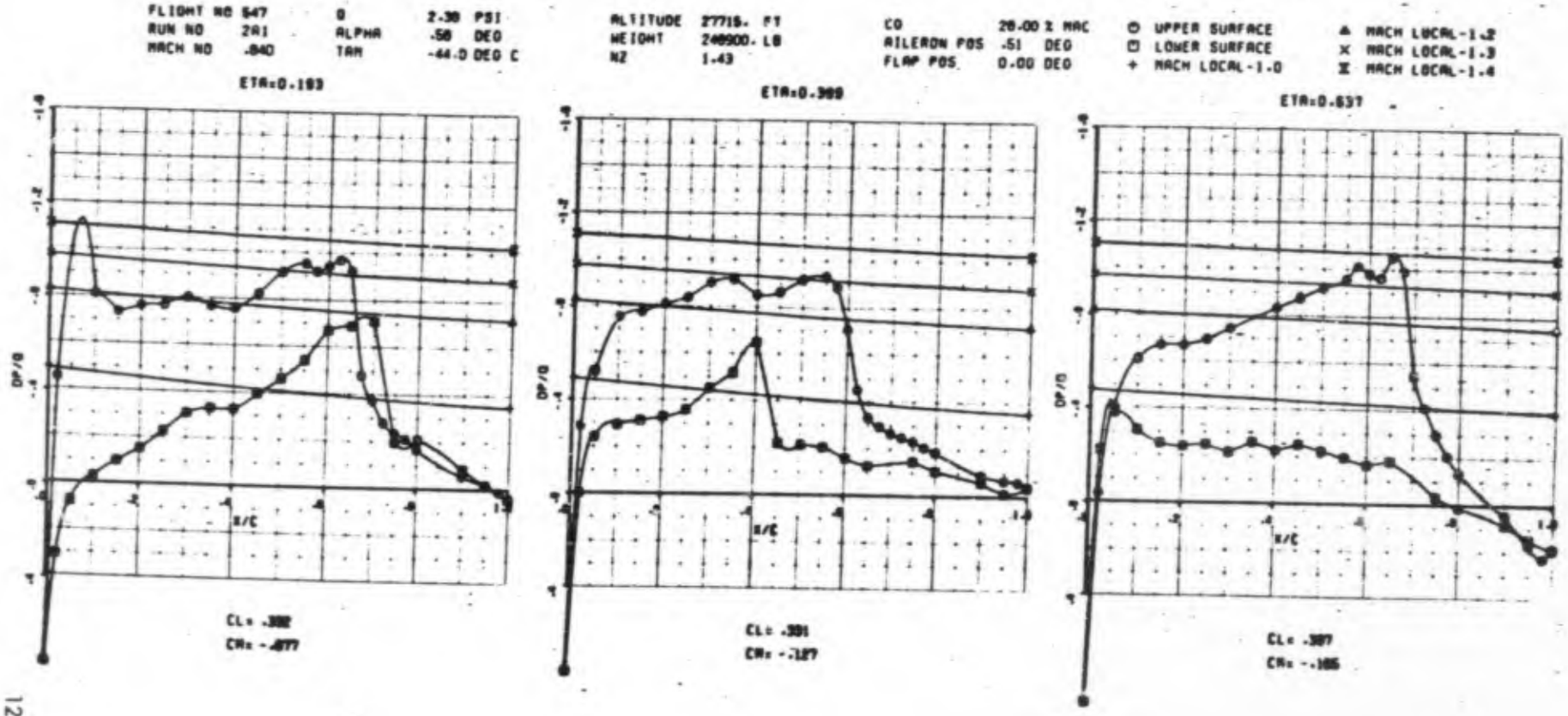


FIGURE 13 (CONTINUED)
(d) CORRECTED ALPHA = 1.00

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 2A3
MACH NO .844

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

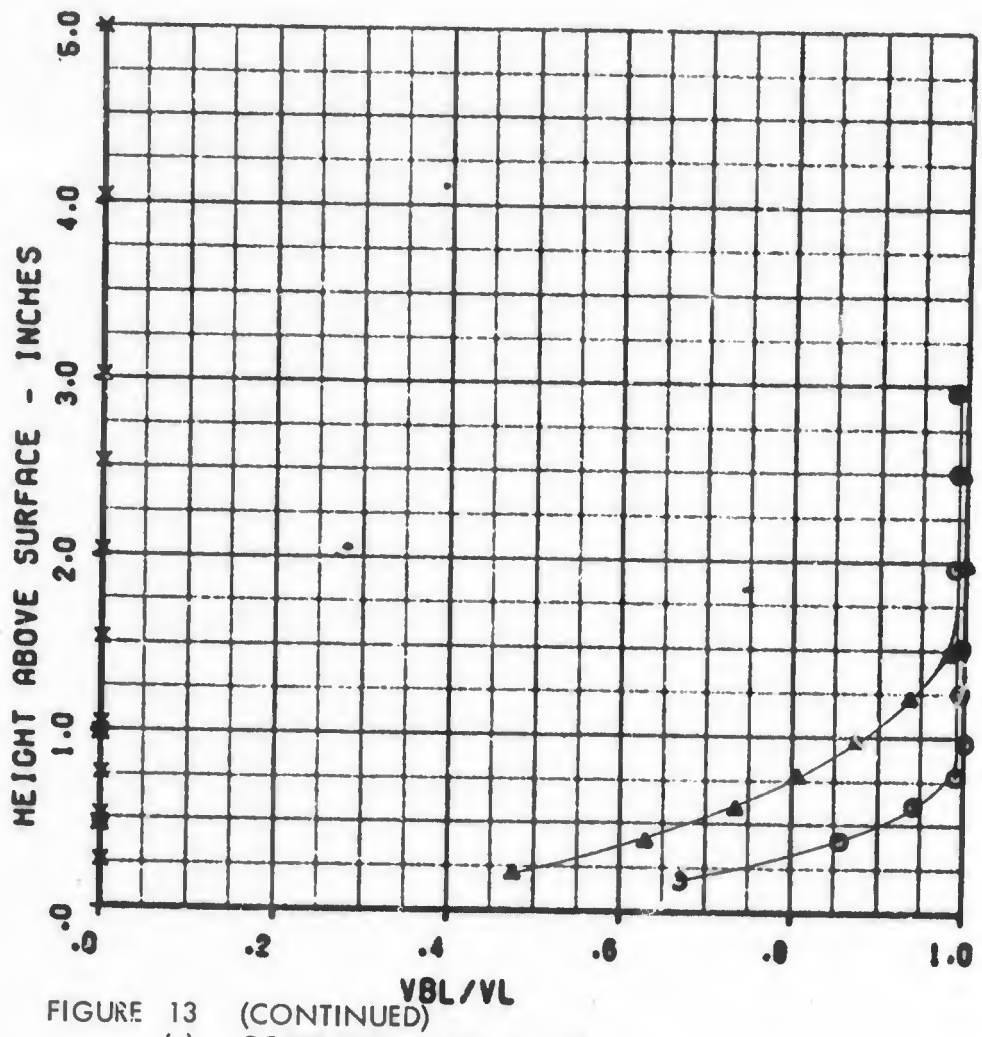


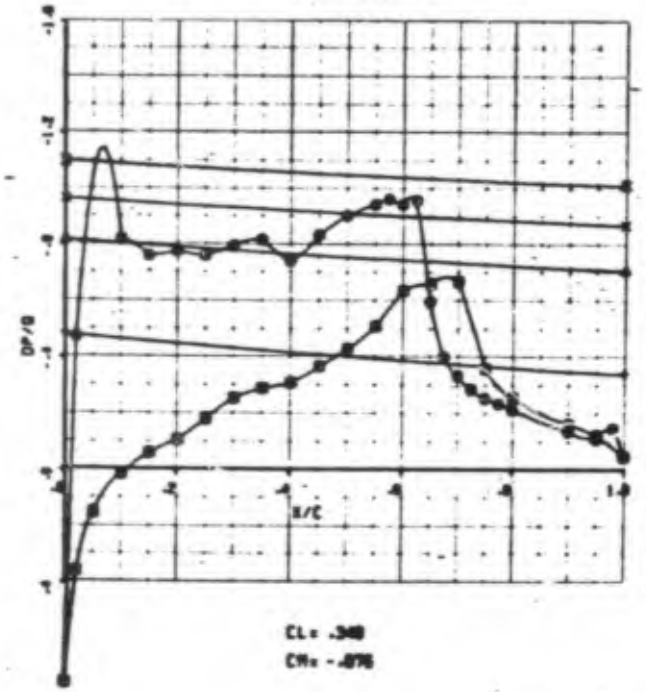
FIGURE 13 (CONTINUED)
(e) CORRECTED ALPHA = 1.35

LOCKHEED C-141A

PRESSURE DISTRIBUTION

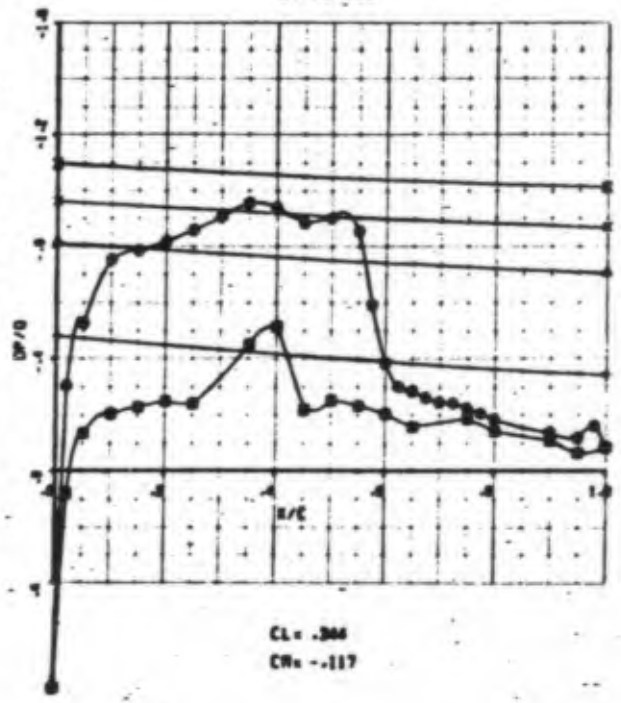
FLIGHT NO	647	Q	2.43	PSI	ALTITUDE	27495.	FT	CG	27.85 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	2R3	ALPHA	.97	DEG	WEIGHT	346600.	LB	AILERON POS	-.60 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.844	TAN	-42.8	DEG C	NZ	1.20		FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4

ETA=0.193



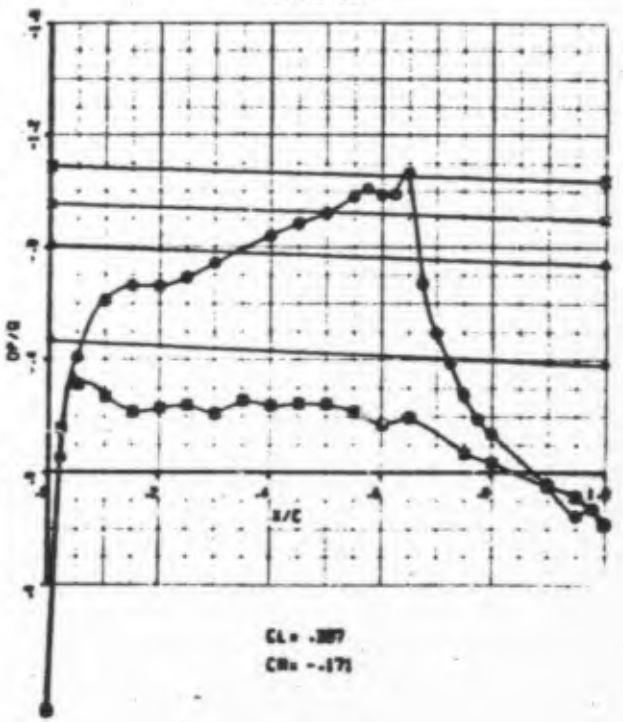
CL= .348
CM= -.076

ETA=0.389



CL= .366
CM= -.117

ETA=0.637



CL= .387
CM= -.171

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 2A2
MACH NO .840

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
⊠ 80 %(AFT)

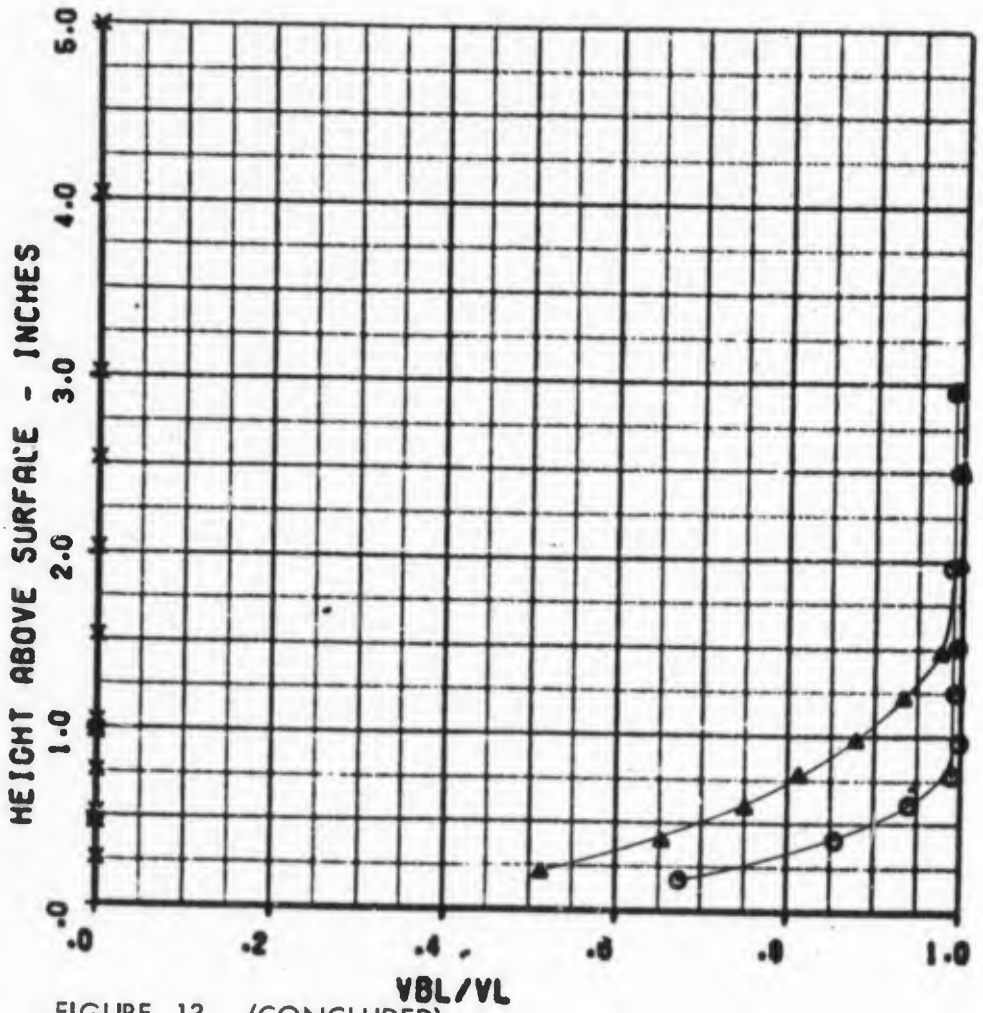
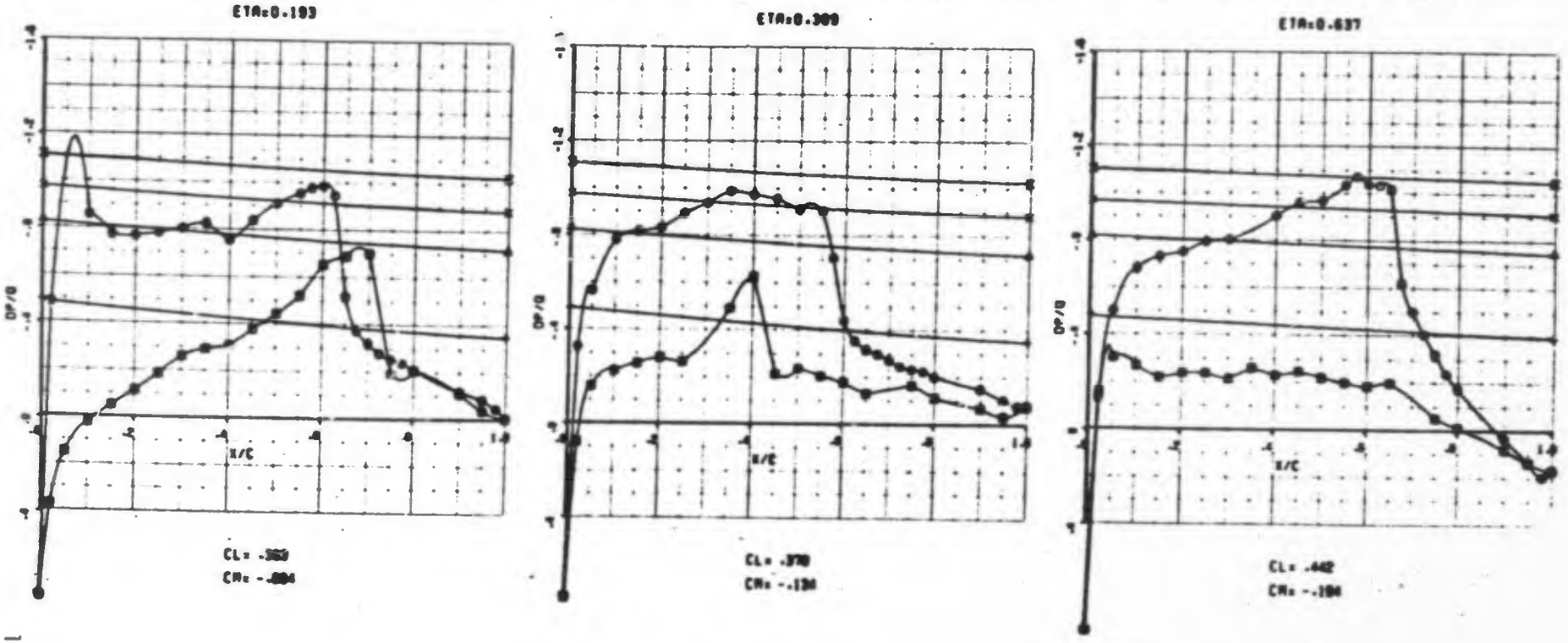


FIGURE 13 (CONCLUDED)
(f) CORRECTED ALPHA = 1.62

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	547	Q	2.49 PSI	ALTITUDE	28740. FT	CG	27.95 % MAC	⊙ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	2A2	ALPHA	1.26 DEG	WEIGHT	248200. LB	AILERON POS	1.10 DEG	⊡ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.840	TAM	-42.6 DEG C	NZ	1.64	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3A5
MACH NO .690

RAKE LOCATIONS

⊙ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

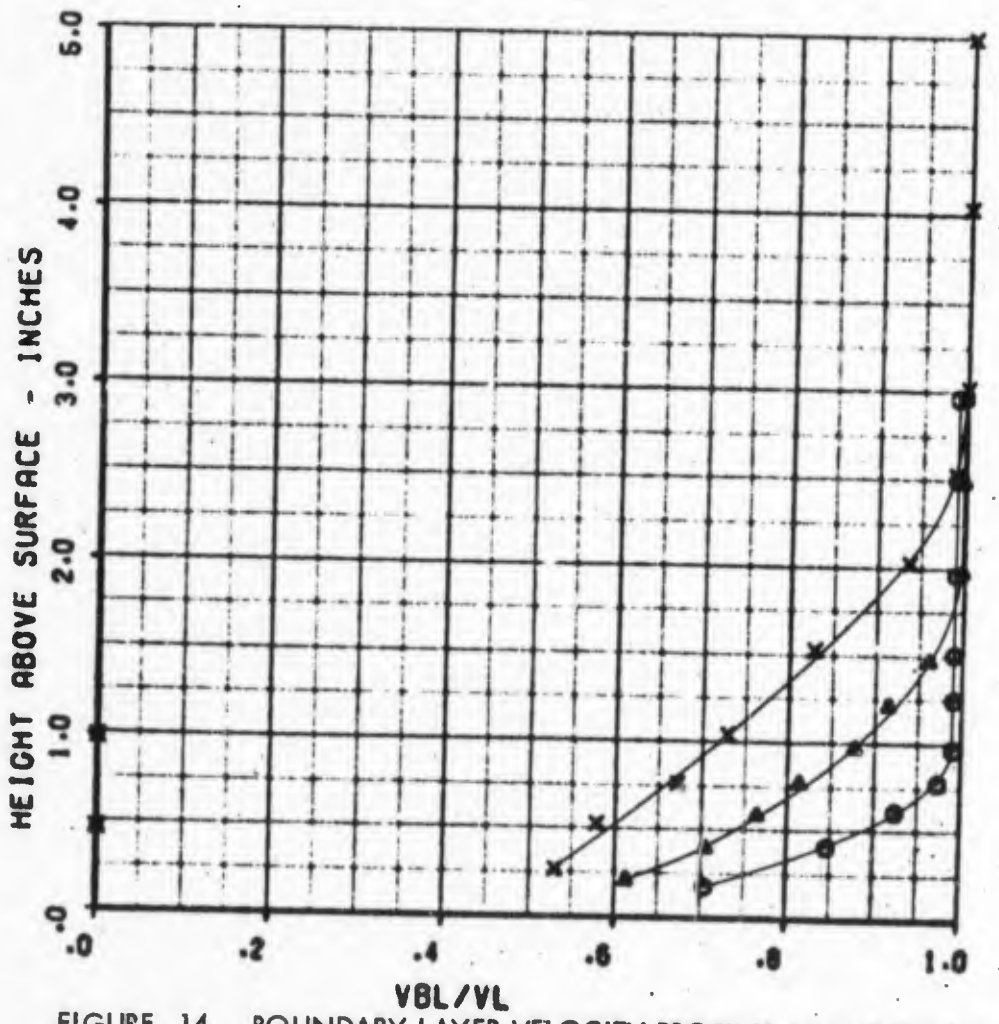
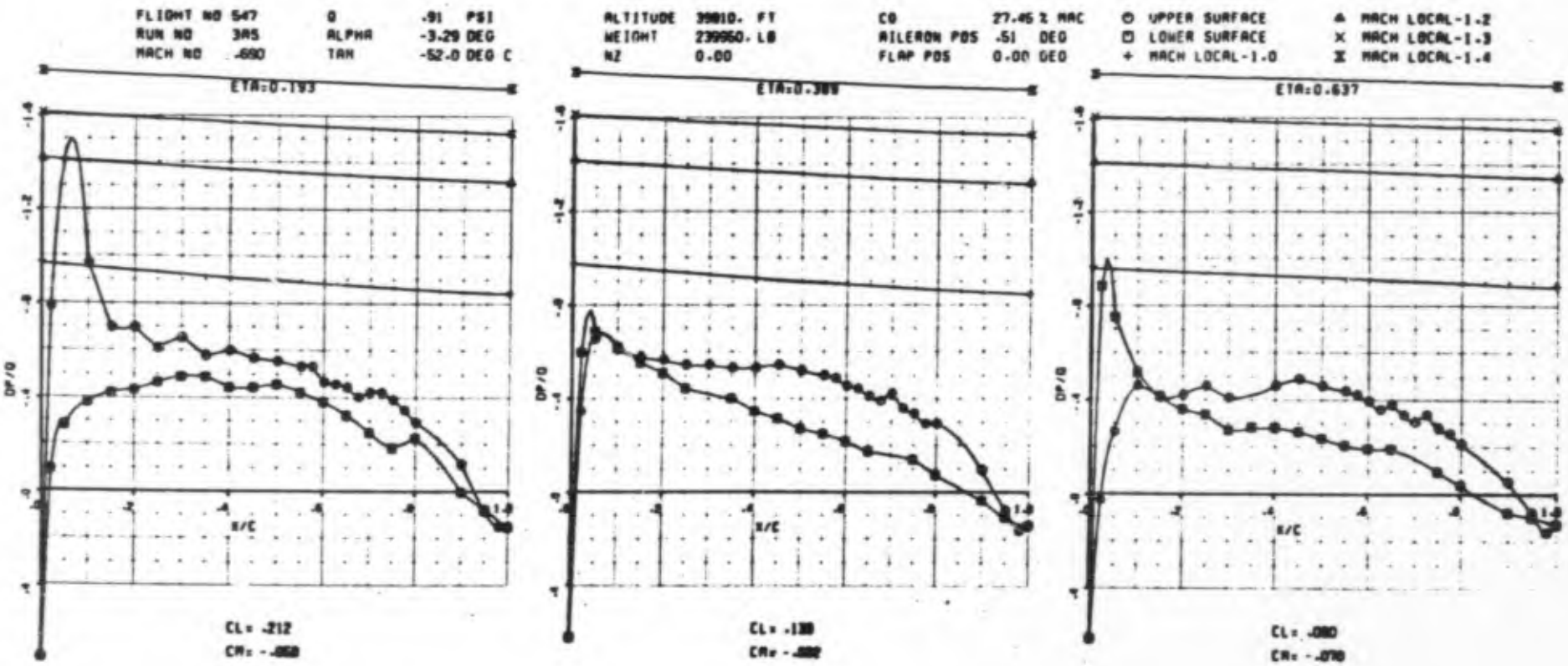


FIGURE 14 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .690 TO .702

(a) CORRECTED ALPHA = -2.40

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3A4
MACH NO .695

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

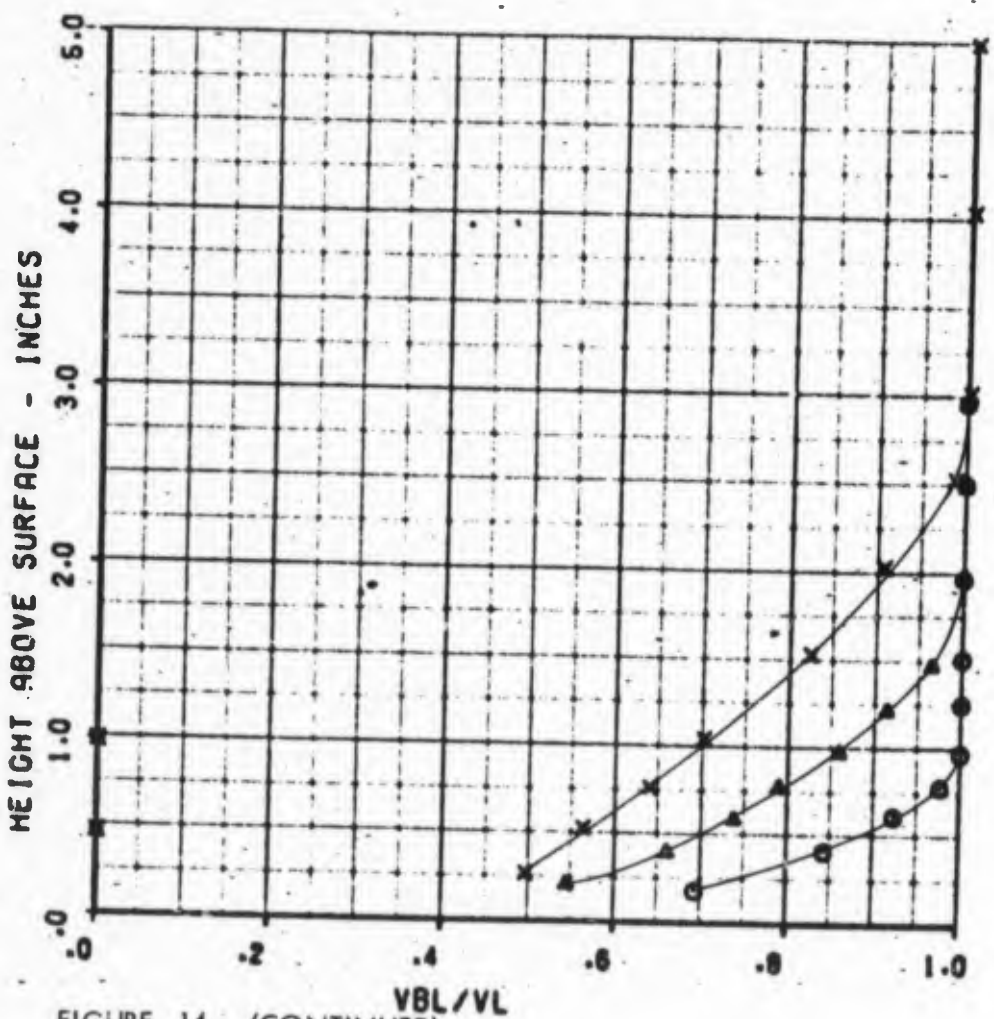
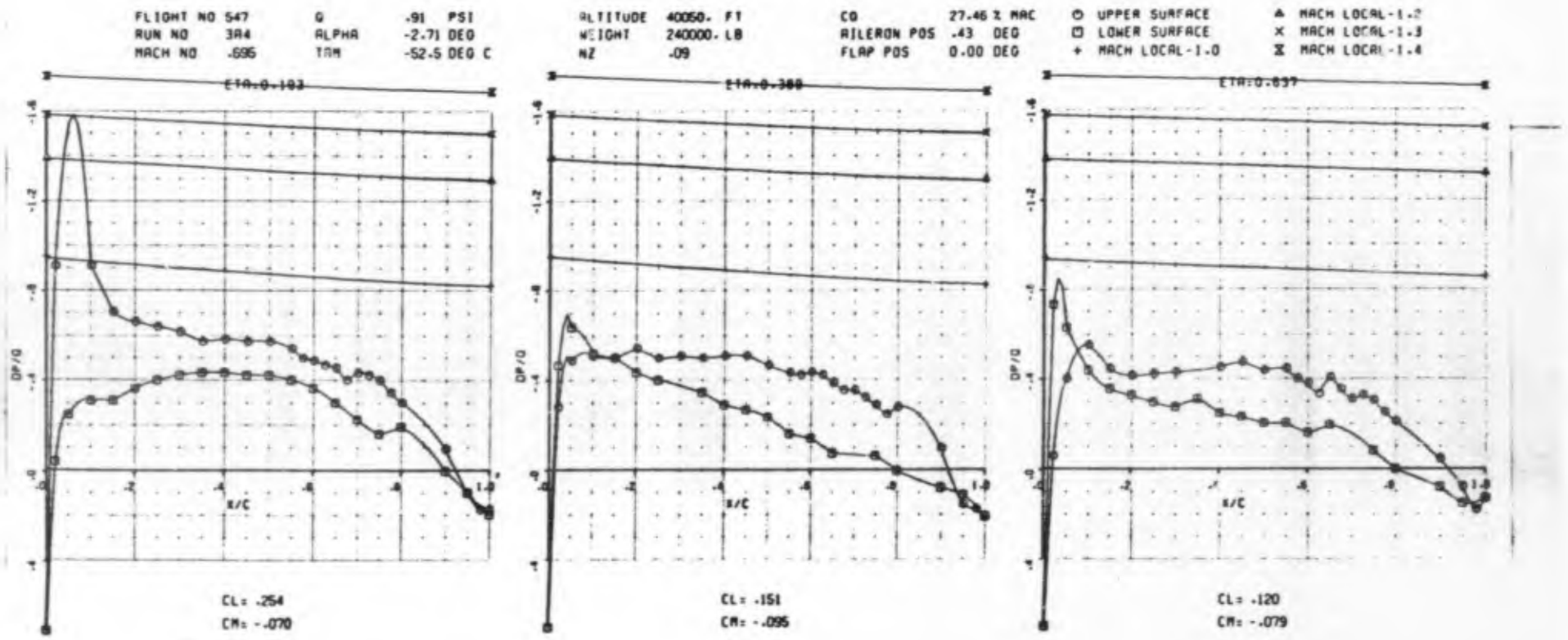


FIGURE 14 (CONTINUED)
(b) CORRECTED ALPHA = -1.90

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3A1
MACH NO . .700

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

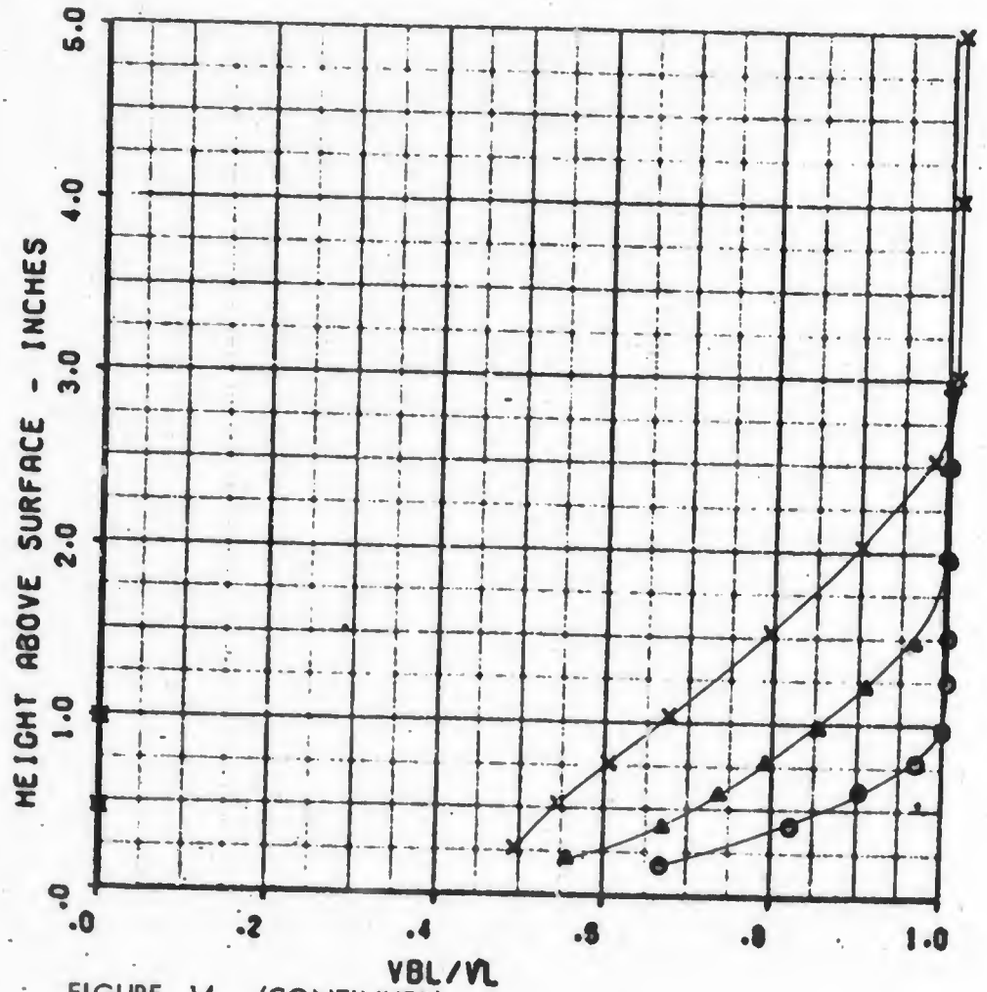
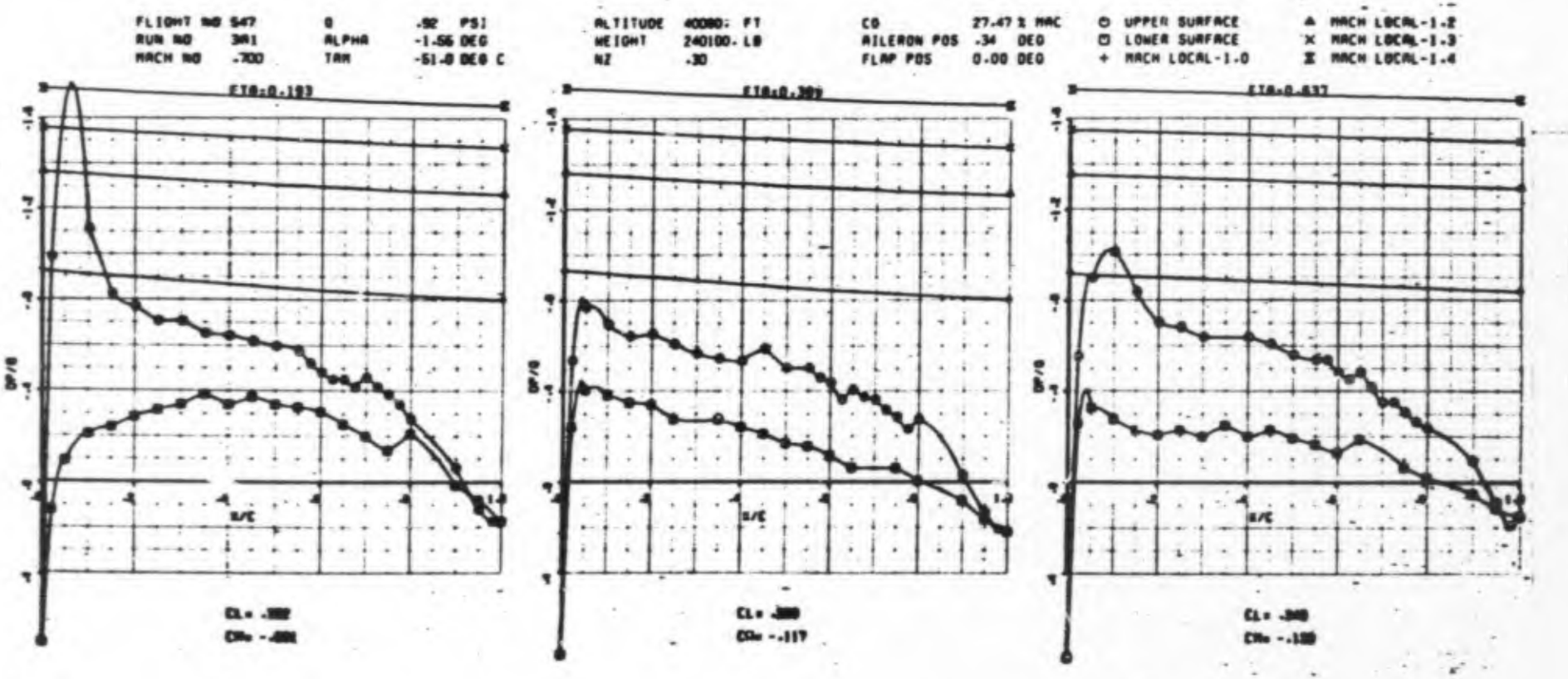


FIGURE 14 (CONTINUED)
(c) CORRECTED ALPHA = -0.87

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3A3.2
MACH NO .700

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

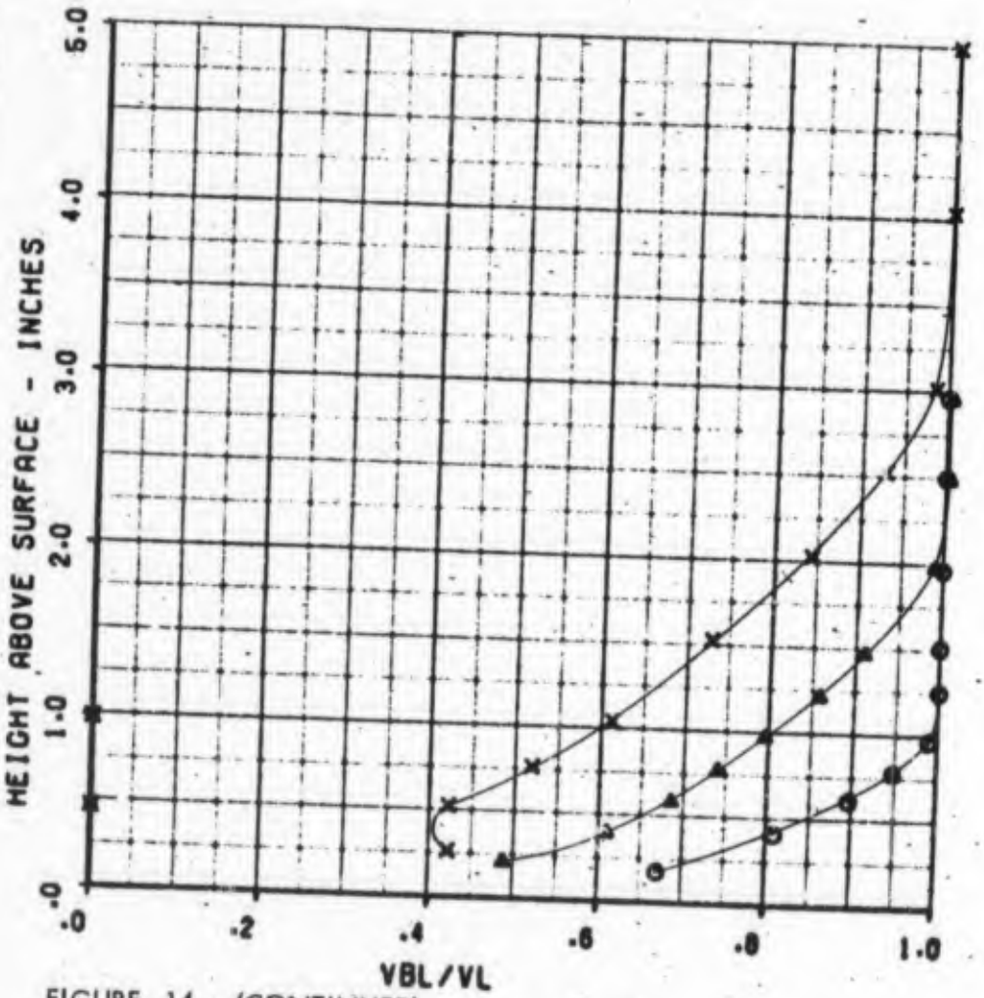
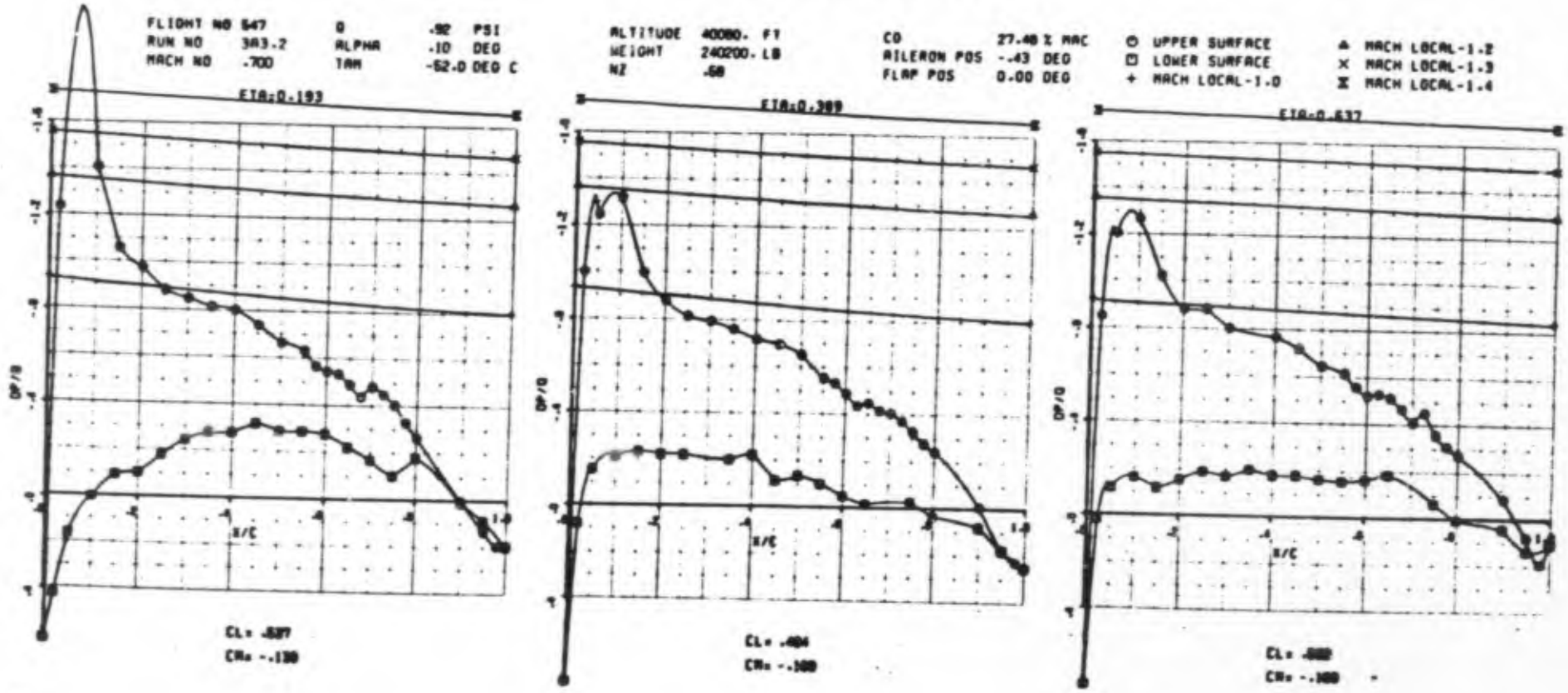


FIGURE 14 (CONTINUED)
(d) CORRECTED ALPHA = 0.57

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3A2
MACH NO .702

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

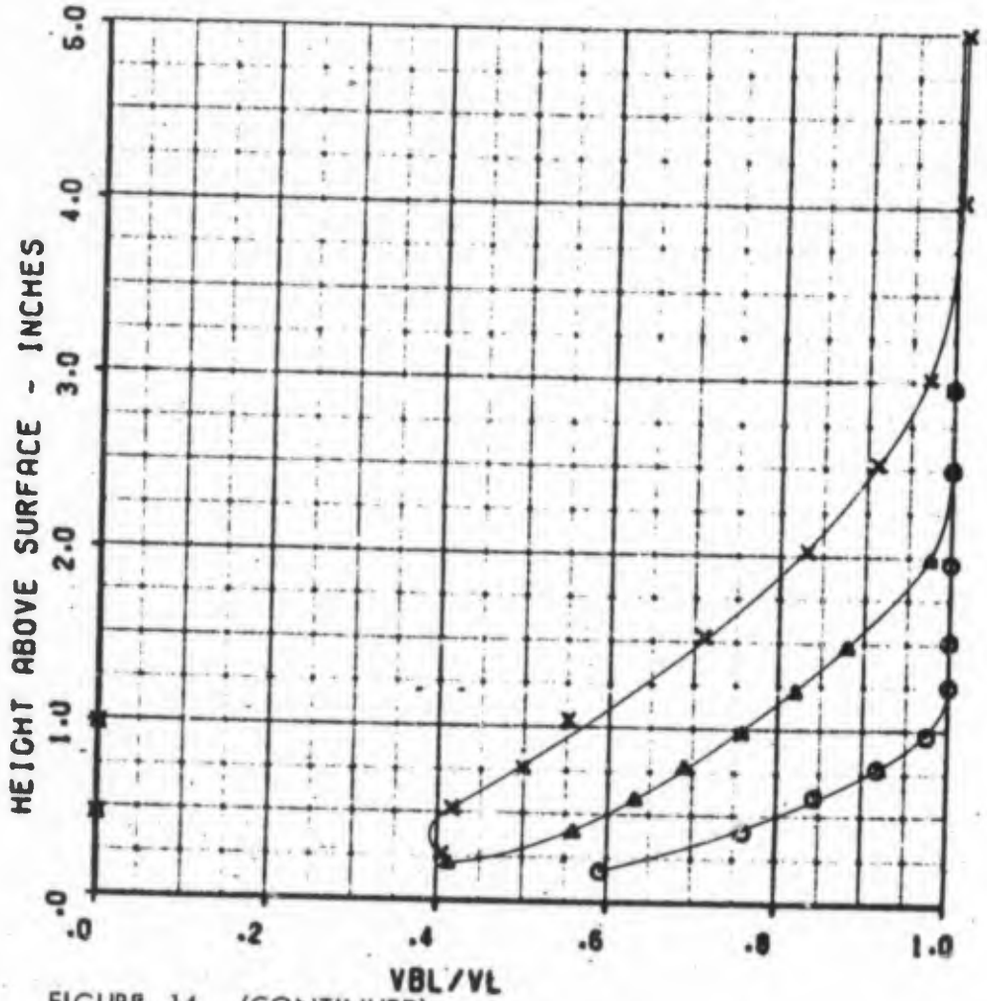
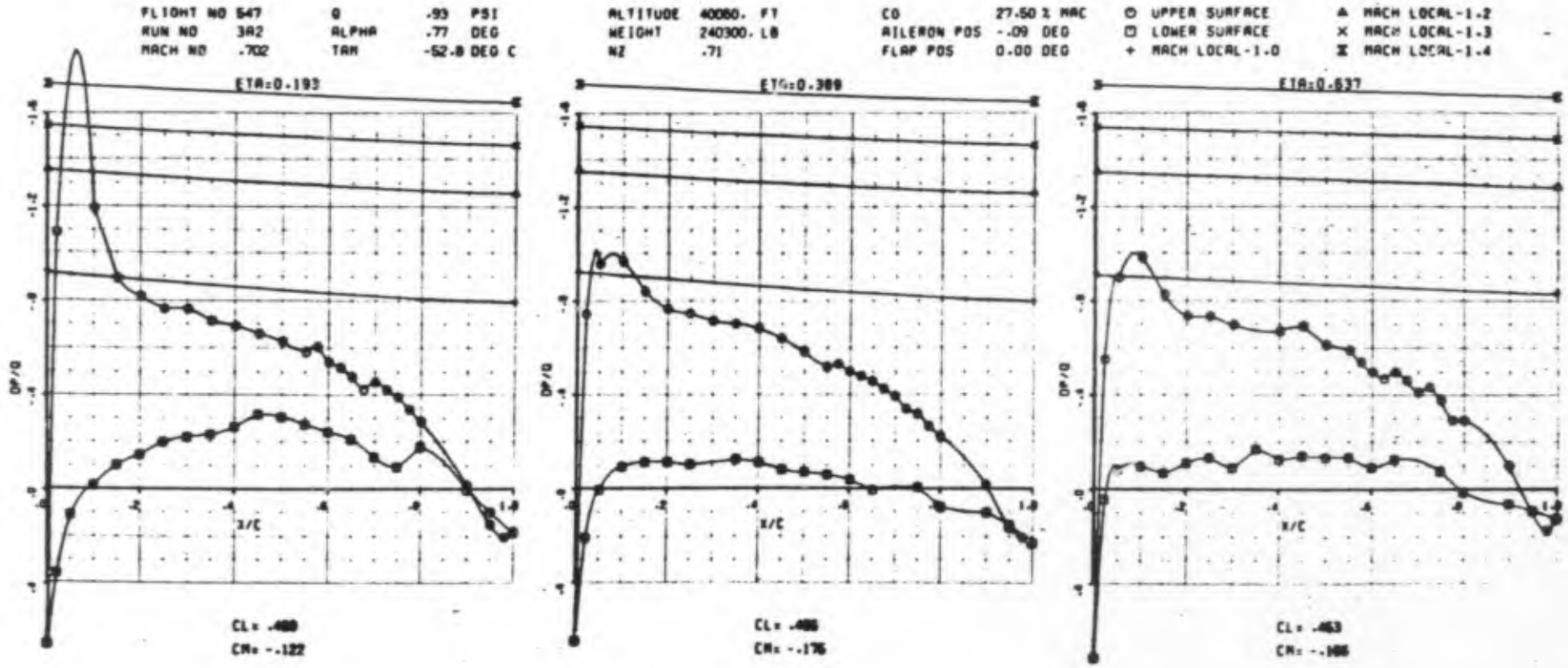


FIGURE 14 (CONTINUED)
(e) CORRECTED ALPHA = 1.17

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 383.1
MACH NO .700

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

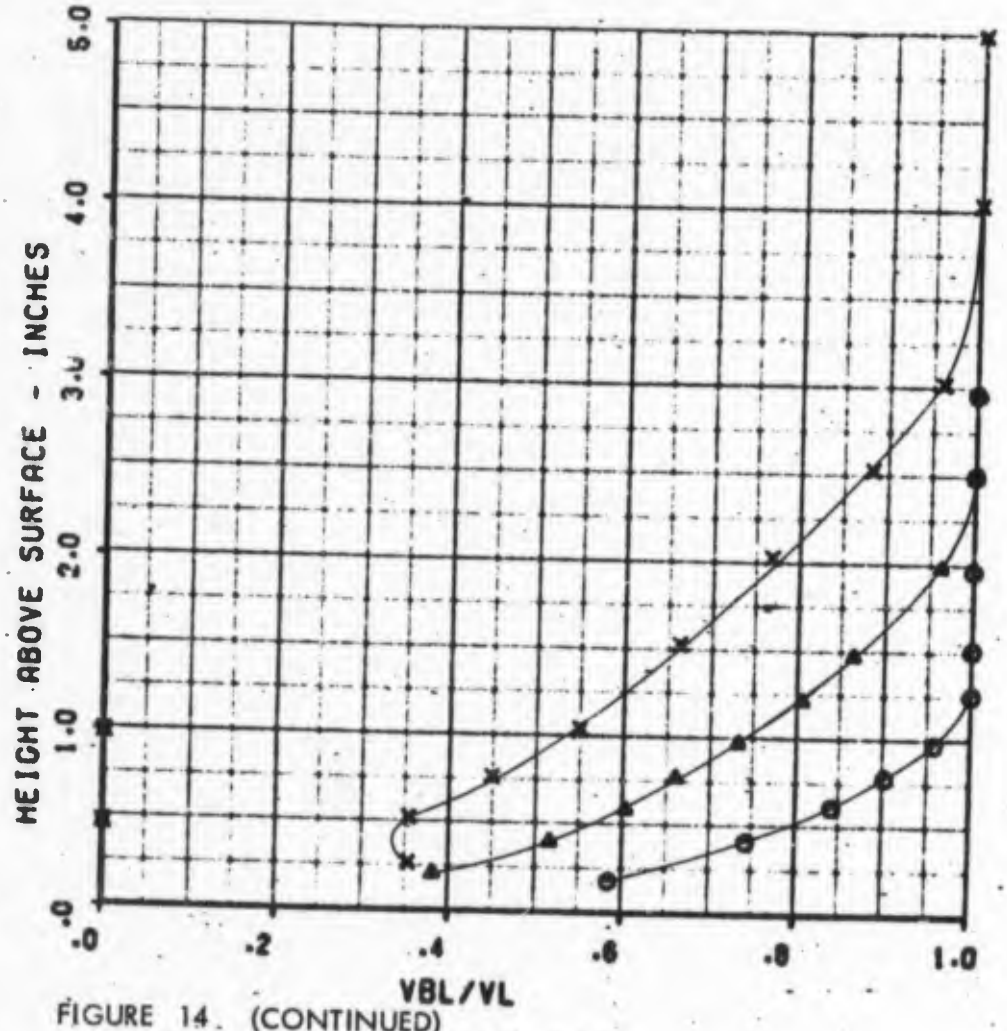
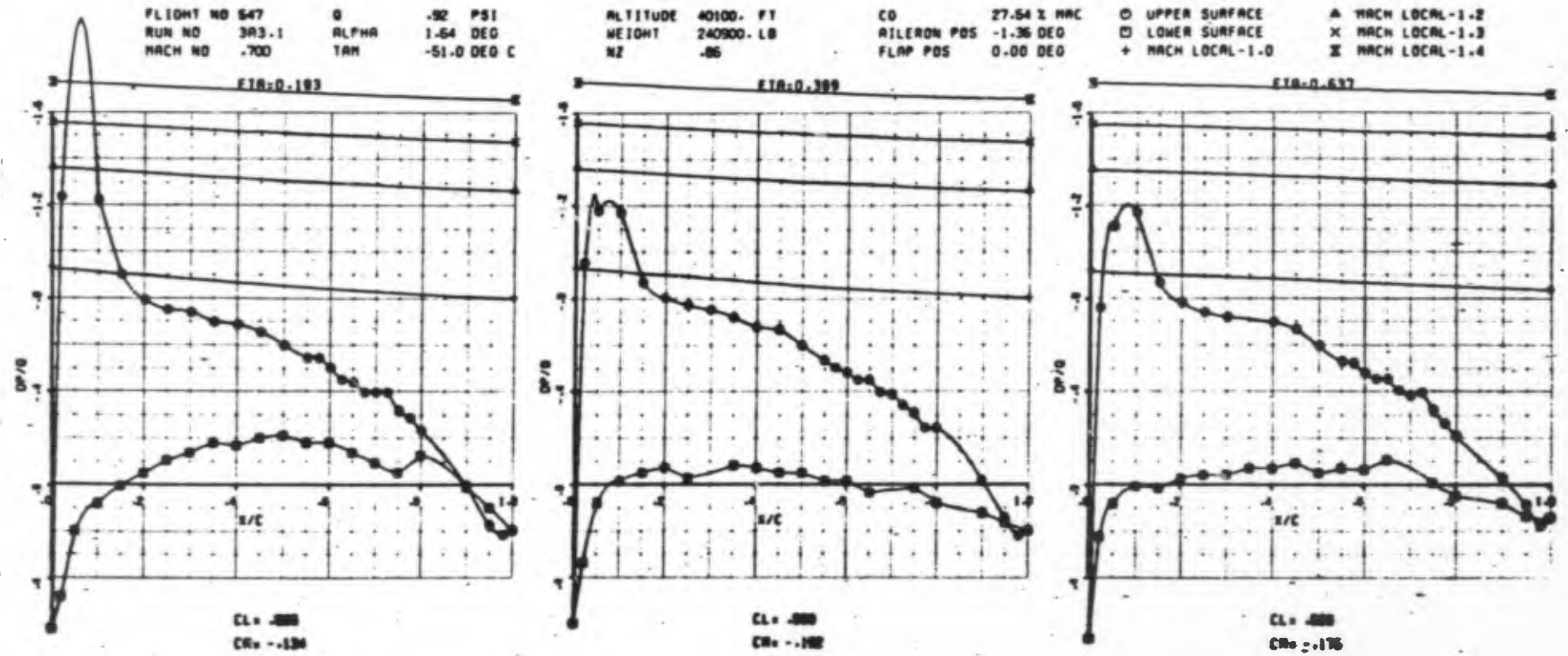


FIGURE 14. (CONTINUED)
(f) CORRECTED ALPHA = 1.93

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3A
MACH NO .700

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

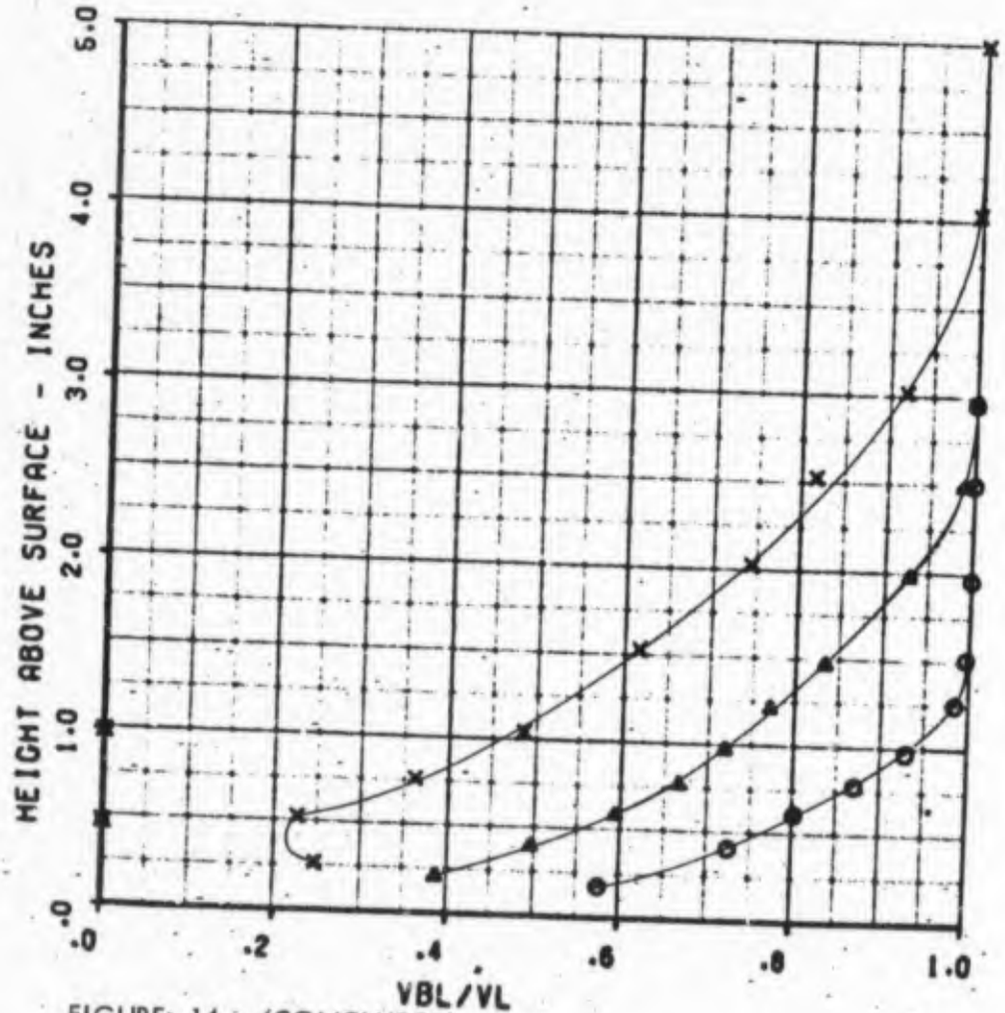
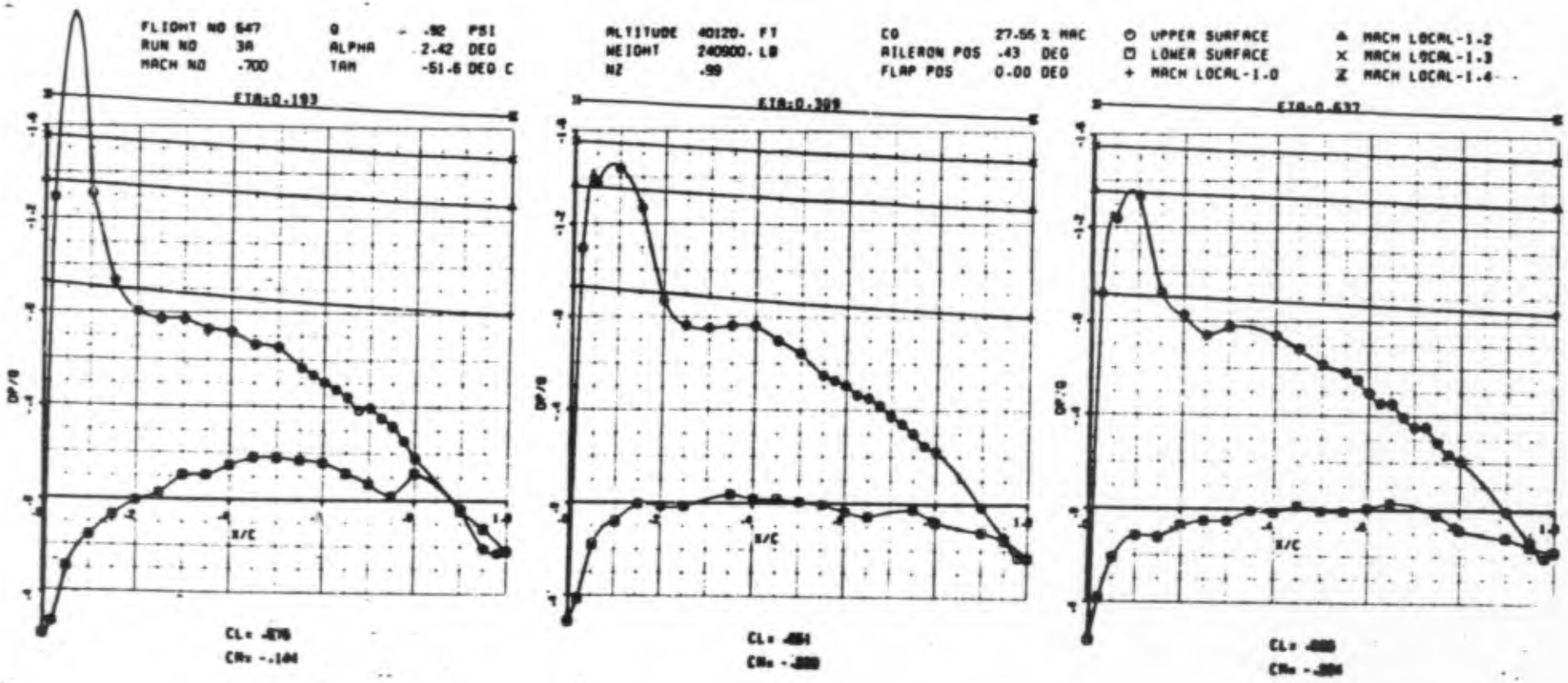


FIGURE 14 (CONCLUDED)
(g) CORRECTED ALPHA = 2.63

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 385
MACH NO .751

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

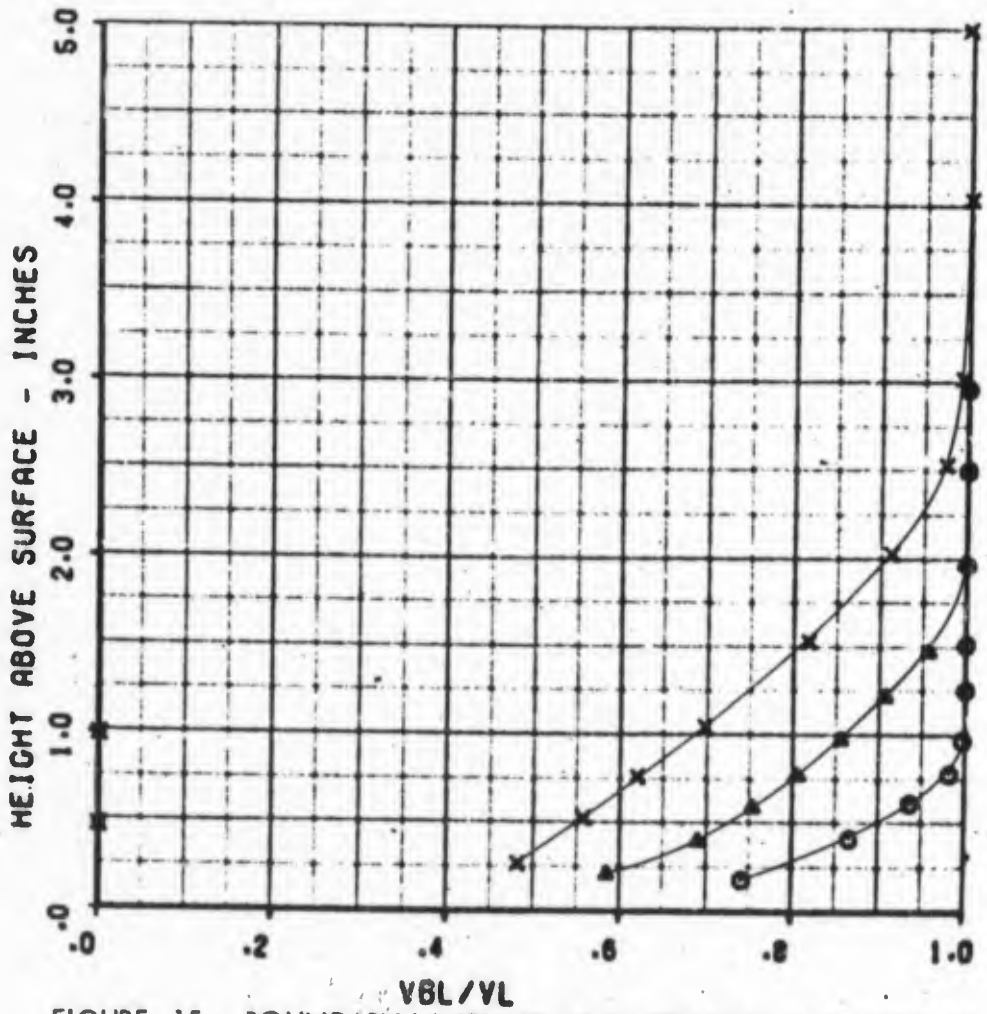


FIGURE 15 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .748 TO .754

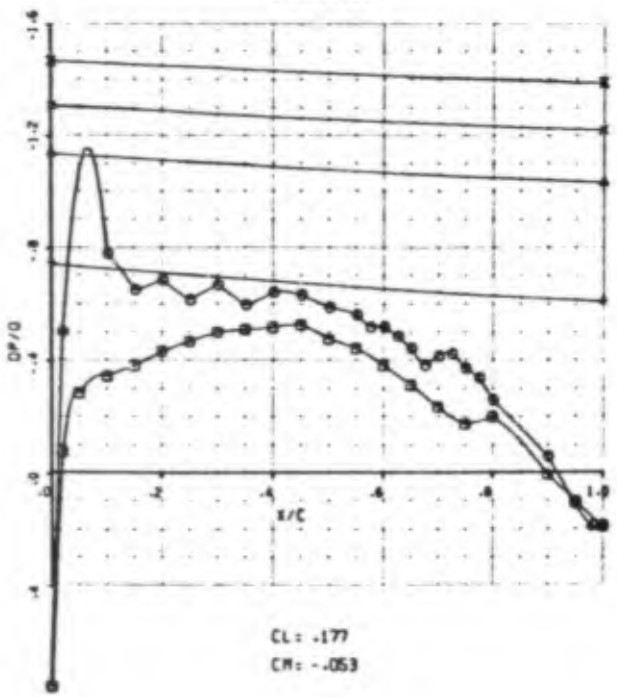
(a) CORRECTED ALPHA = -2.40

LOCKHEED C-141A

PRESSURE DISTRIBUTION

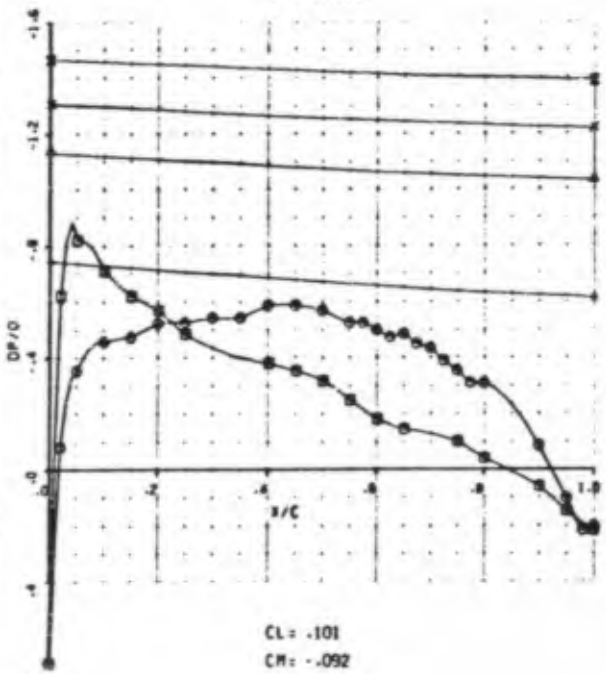
FLIGHT NO	547	Q	1.15 PSI	ALTITUDE	30500. FT	CG	27.27 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	385	ALPHA	-3.20 DEG	WEIGHT	236700. LB	AILERON POS	-1.45 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.751	TAM	-53.4 DEG C	NZ	0.00	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA:0.193



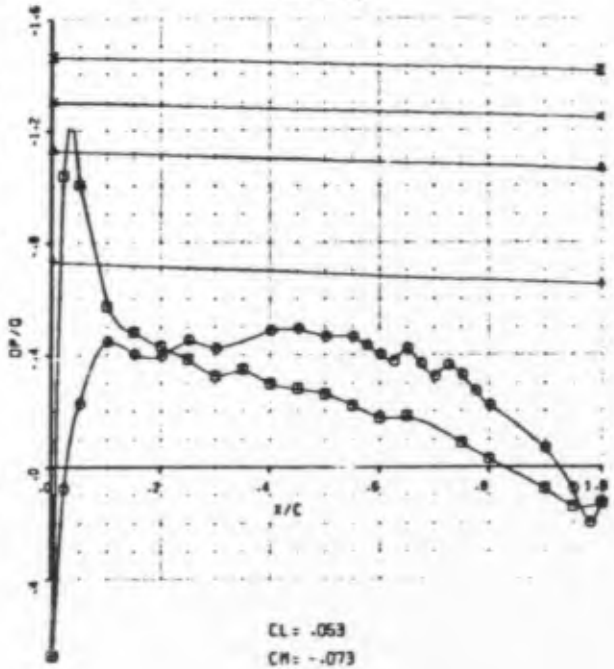
CL: .177
CM: -.053

ETA:0.389



CL: .101
CM: -.092

ETA:0.637



CL: .053
CM: -.073

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 384
MACH NO .750

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

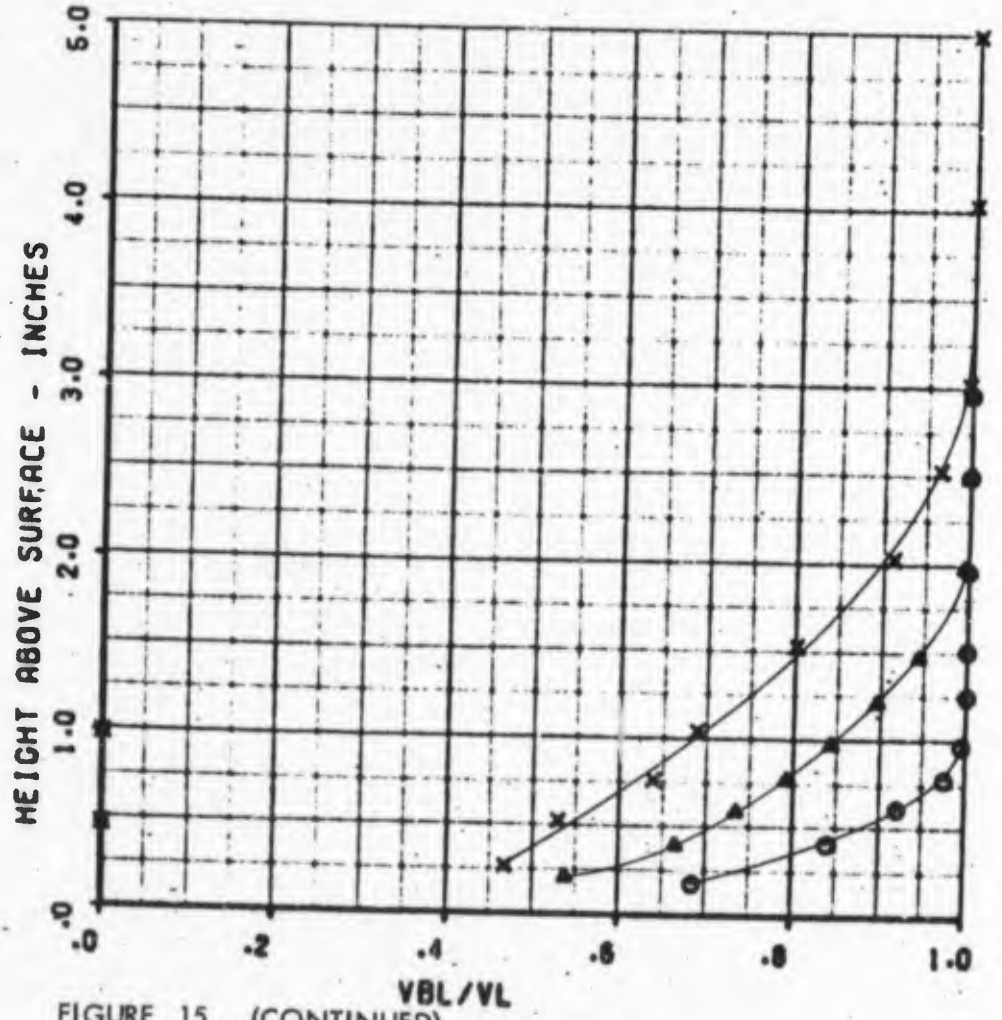
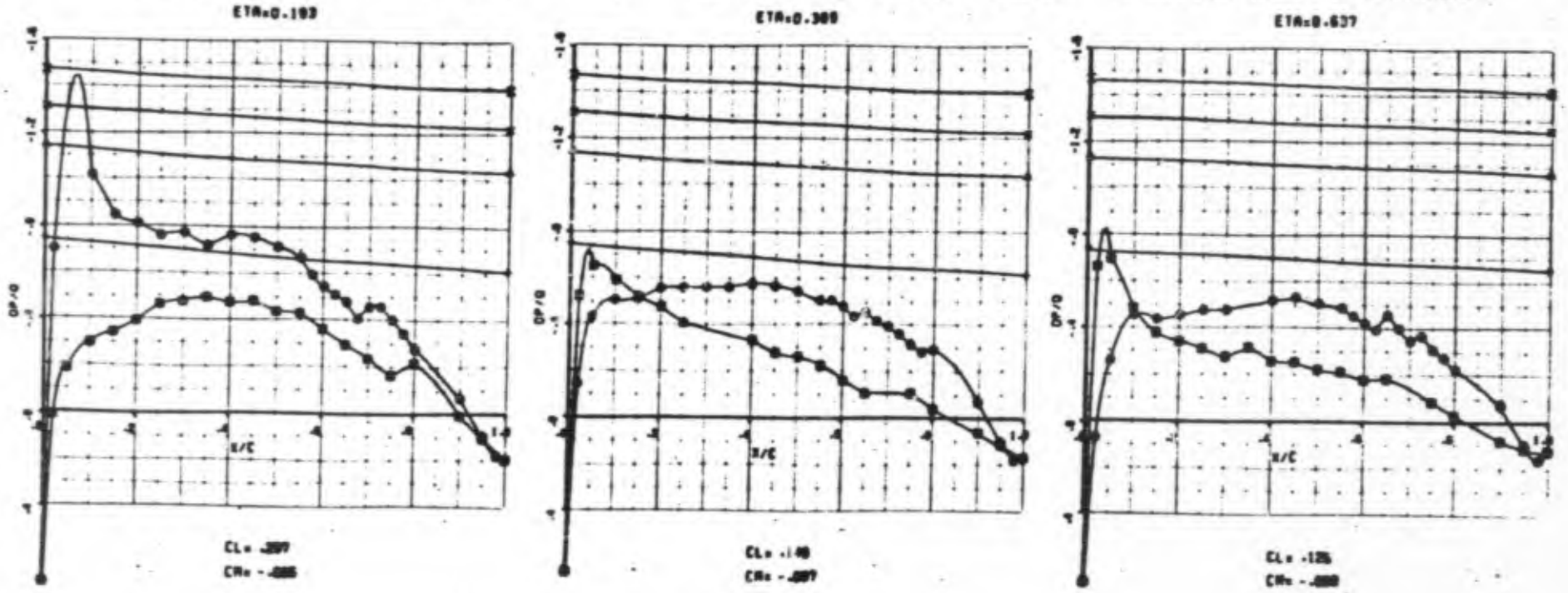


FIGURE 15 (CONTINUED)
(b) CORRECTED ALPHA = -1.64

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	647	Q	1.23 PSI	ALTITUDE	37050. FT	CG	27.32 % MAC	○	UPPER SURFACE	△	MACH LOCAL-1.2
RUN NO	384	ALPHA	-2.42 DEG	HEIGHT	238000. LB	AILERON POS	.09 DEG	□	LOWER SURFACE	×	MACH LOCAL-1.3
MACH NO	.750	TAT	-54.3 DEG C	NZ	.16	FLAP POS	0.00 DEG	+	MACH LOCAL-1.0	⧖	MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 381
MACH NO .748

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

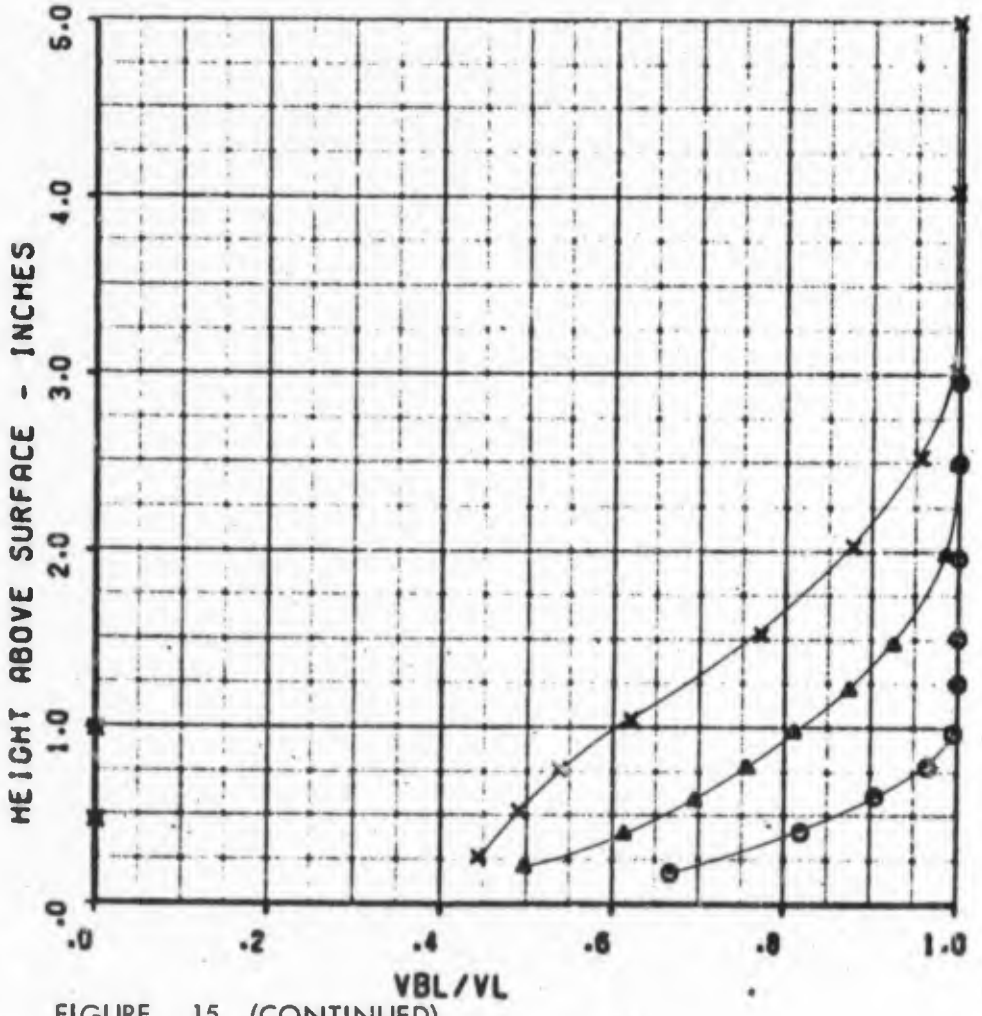
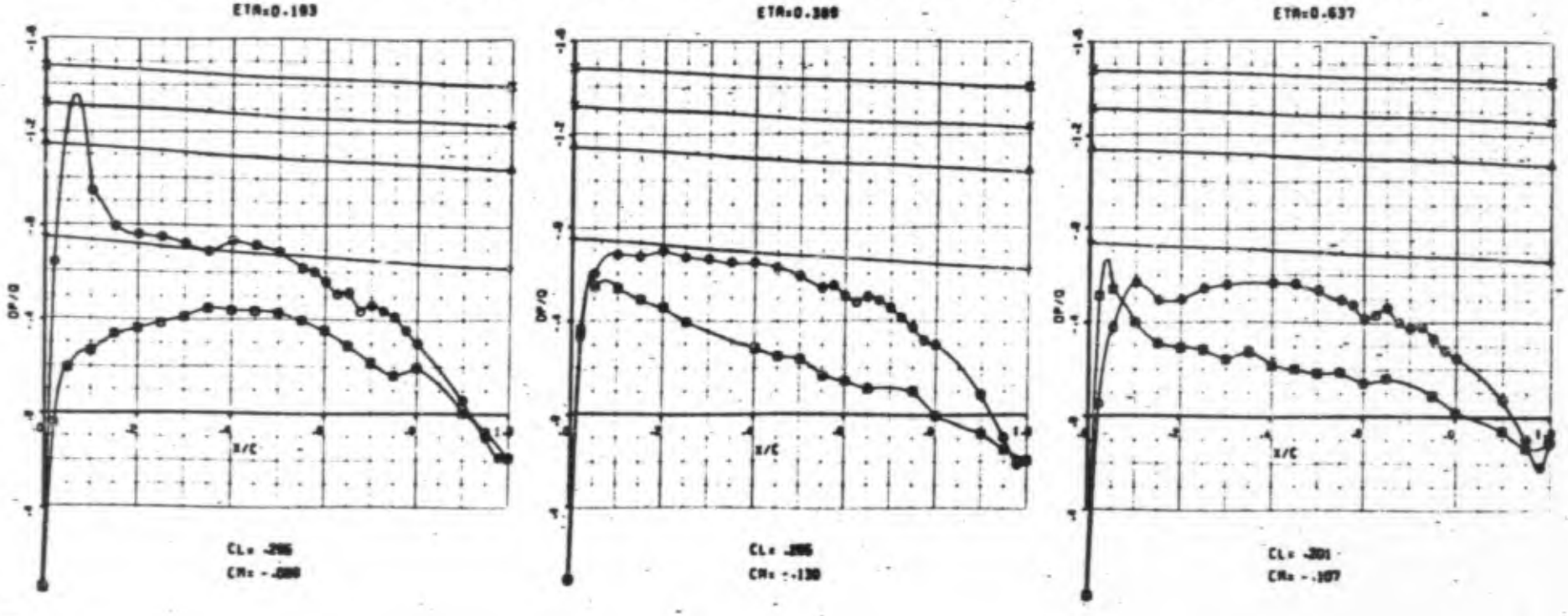


FIGURE 15 (CONTINUED)
(c) CORRECTED ALPHA = -0.97

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	547	Q	1.15 PSI	ALTITUDE	38290. FT	CG	27.33 % MAC	○	UPPER SURFACE	△	MACH LOCAL-1.2
RUN NO	381	ALPHA	-1.64 DEG	WEIGHT	239100. LB	AILERON POS	-1.28 DEG	□	LOWER SURFACE	×	MACH LOCAL-1.3
MACH NO	.748	TAM	-53.8 DEG C	NZ	.96	FLAP POS	0.00 DEG	+	MACH LOCAL-1.0	⧖	MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3C1
MACH NO .754

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

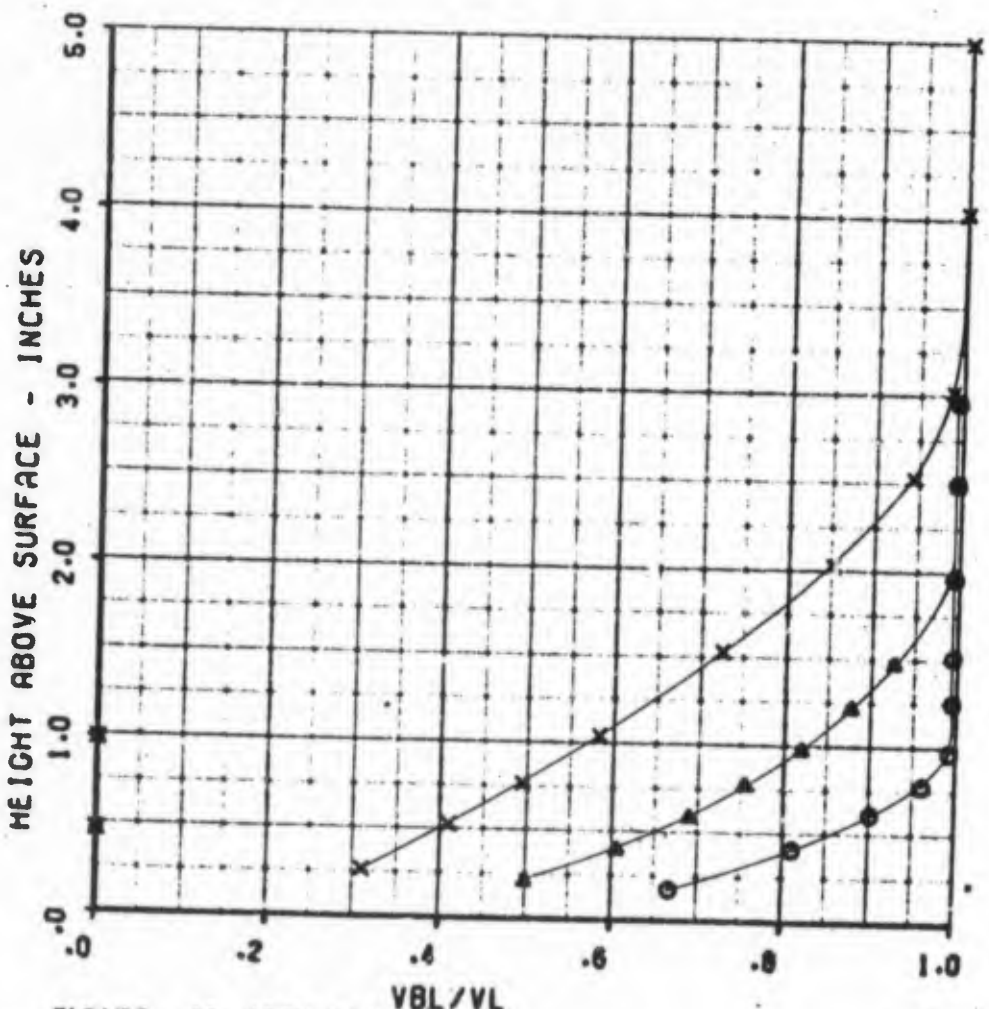
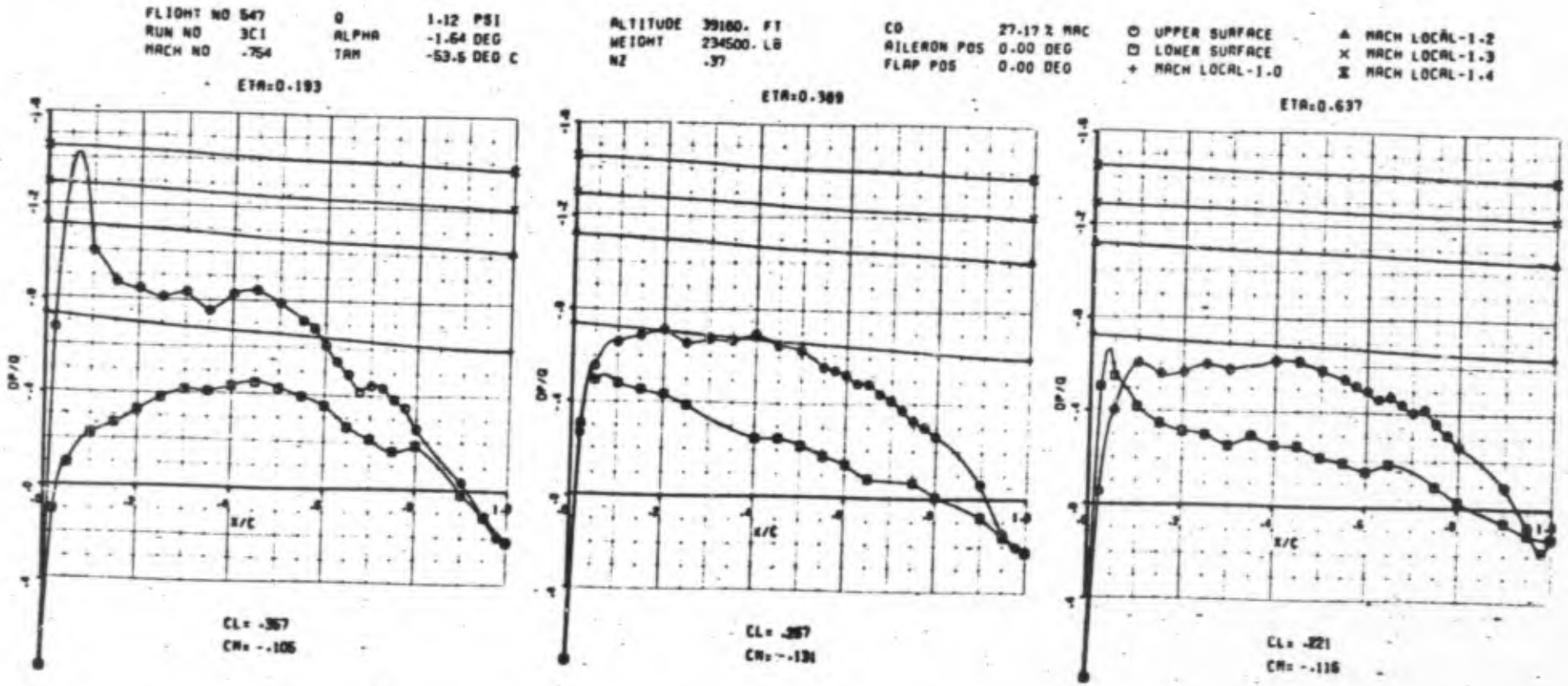


FIGURE 15 (CONTINUED)
(d) CORRECTED ALPHA = -0.97

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 382
MACH NO .754

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

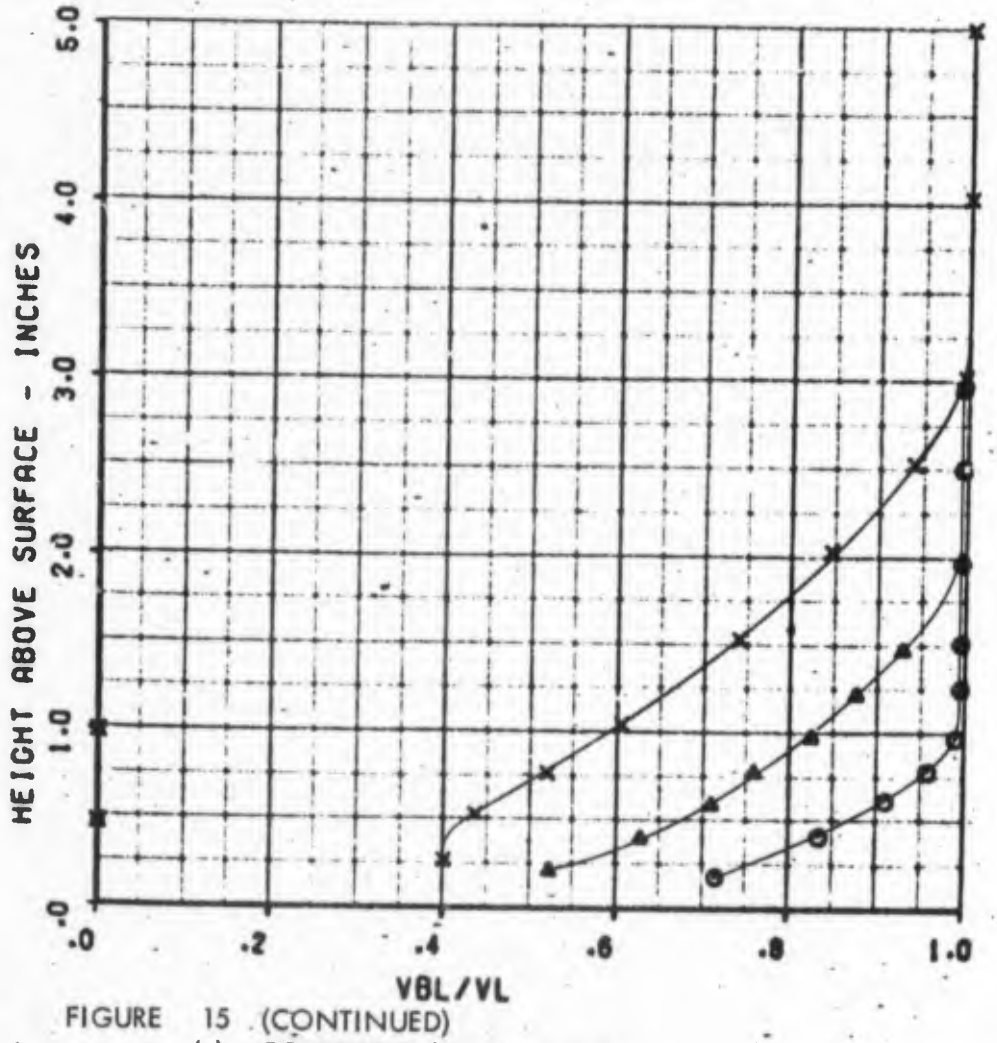


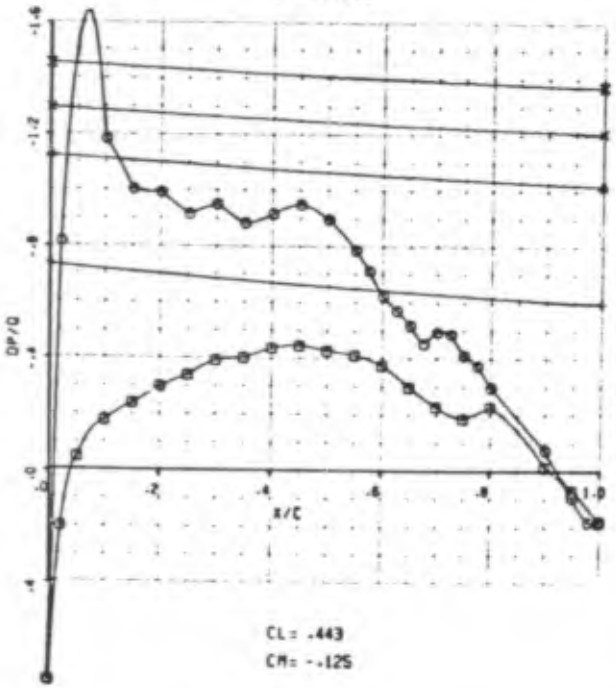
FIGURE 15 (CONTINUED)
(e) CORRECTED ALPHA = -0.37

LOCKHEED C-141A

PRESSURE DISTRIBUTION

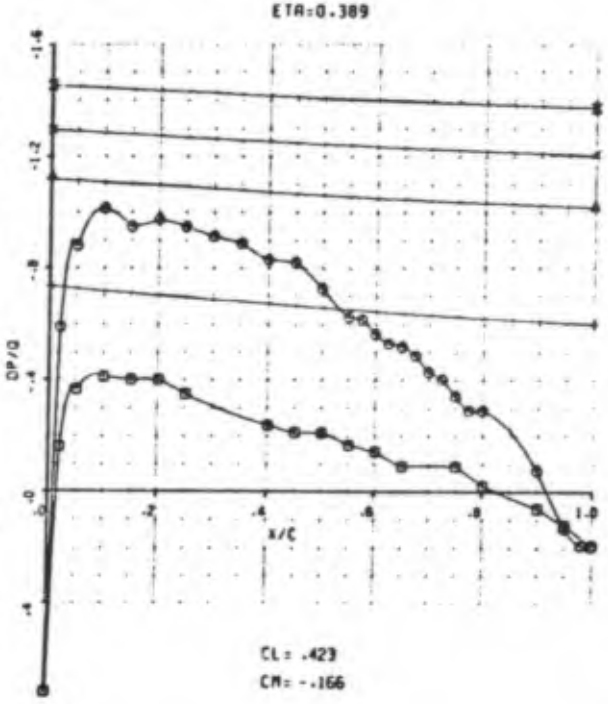
FLIGHT NO	547	Q	1.16 PSI	ALTITUDE	38460. FT	CG	27.34 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	382	ALPHA	-.97 DEG	WEIGHT	233300. LB	AILERON POS	-.94 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.754	TAM	-53.0 DEG C	NZ	.52	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA=0.193



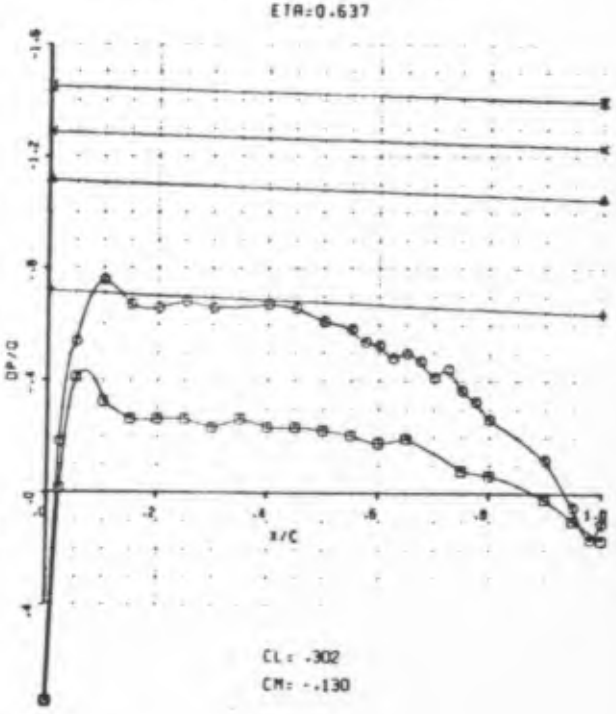
CL= .443
CM= -.125

ETA=0.389



CL= .423
CM= -.166

ETA=0.637



CL= .302
CM= -.130

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 383
MACH NO .748

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
※ 80 %(AFT)

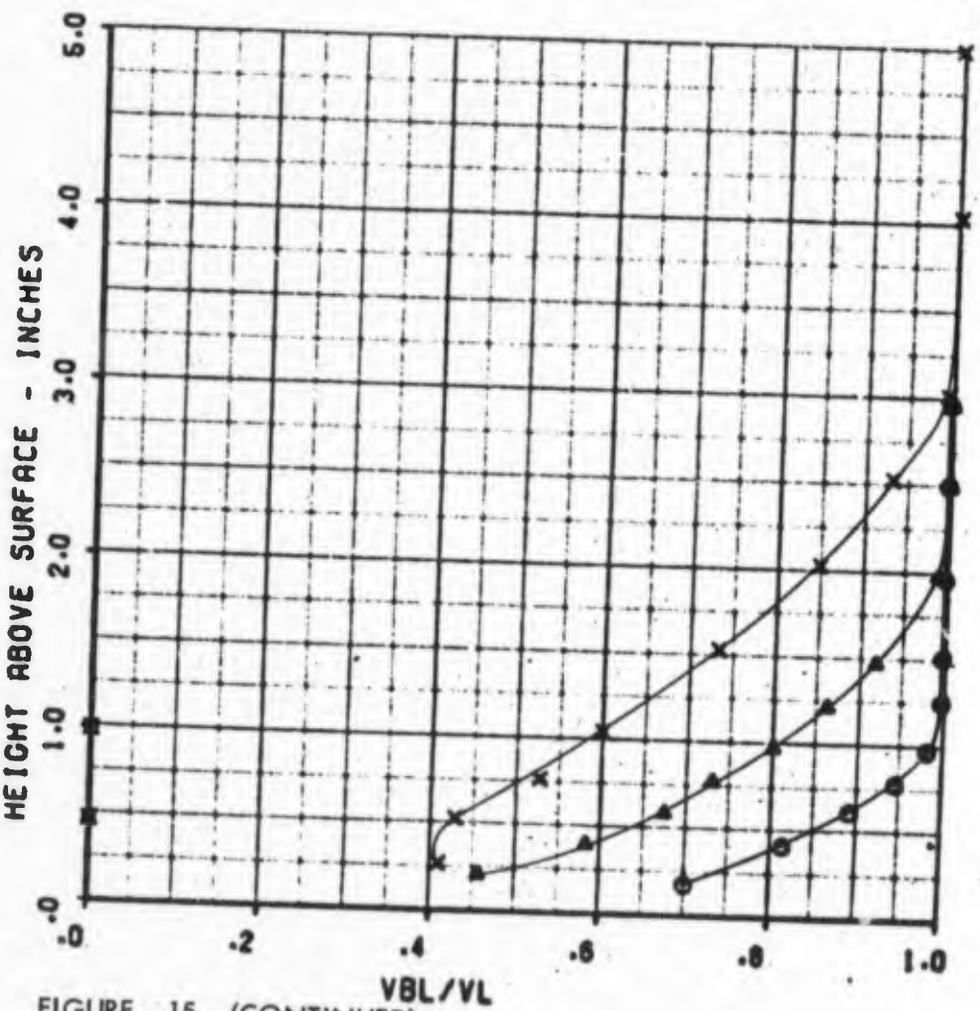
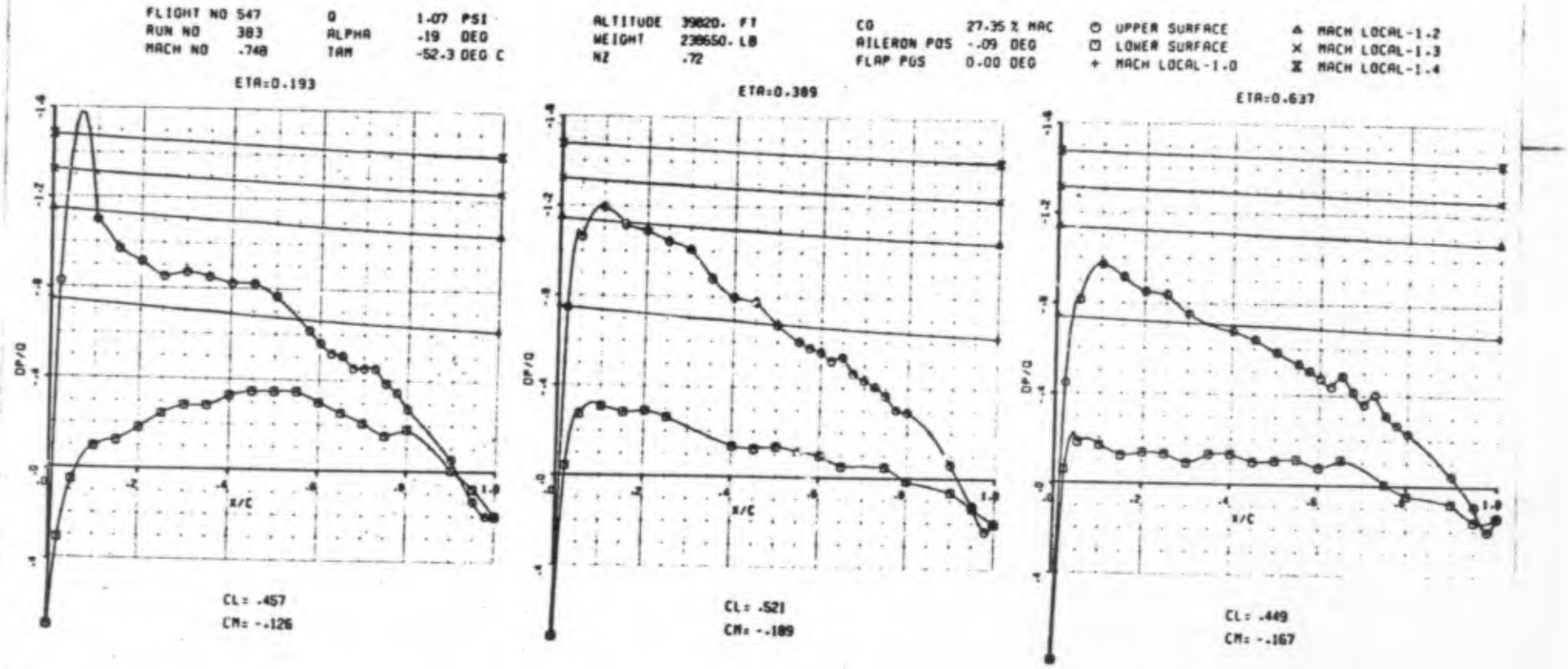


FIGURE 15 (CONTINUED)
(f) CORRECTED ALPHA = 0.65

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 38
MACH NO .750

RAKE LOCATIONS

⊙ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

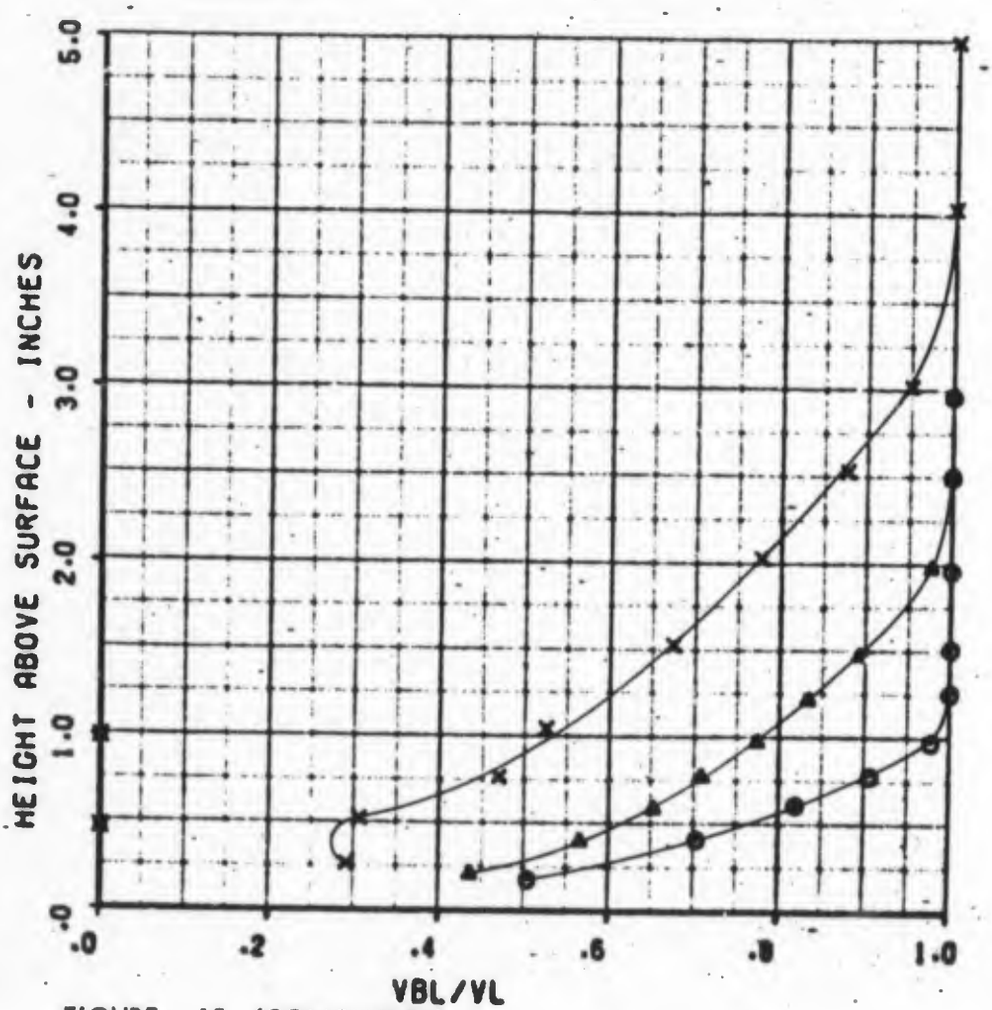
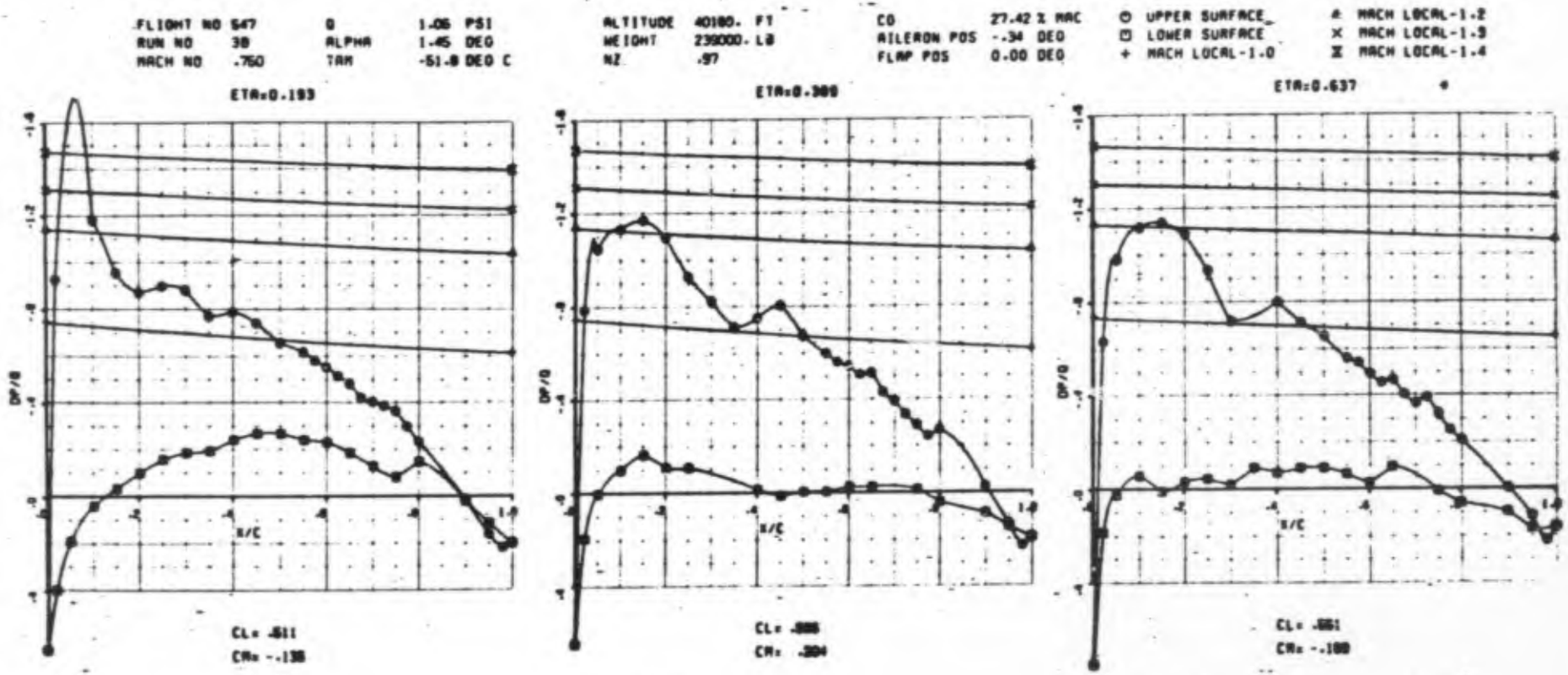


FIGURE 15 (CONCLUDED)
(g) CORRECTED ALPHA = 1.77

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3C4
MACH NO .780

RAKE LOCATIONS

○ 30 %
▲ 65 %
× 80 %
✱ 80 %(AFT)

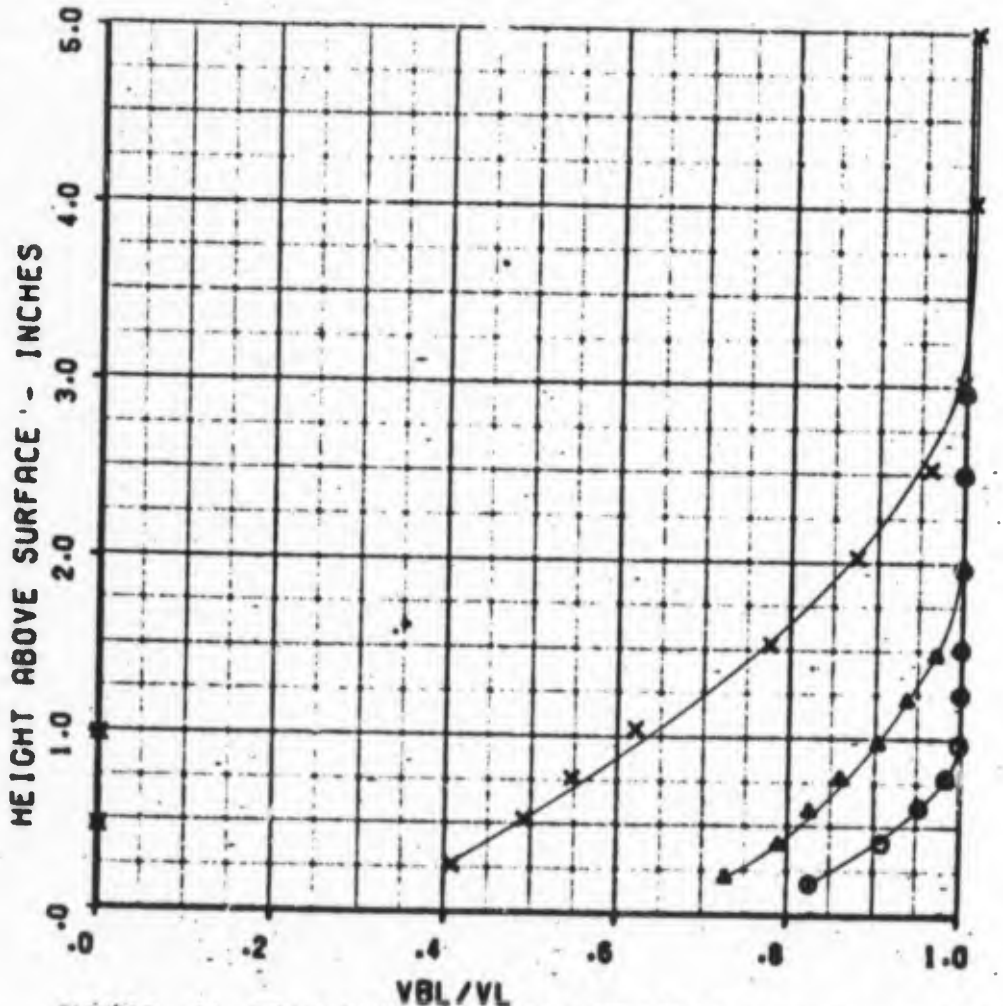
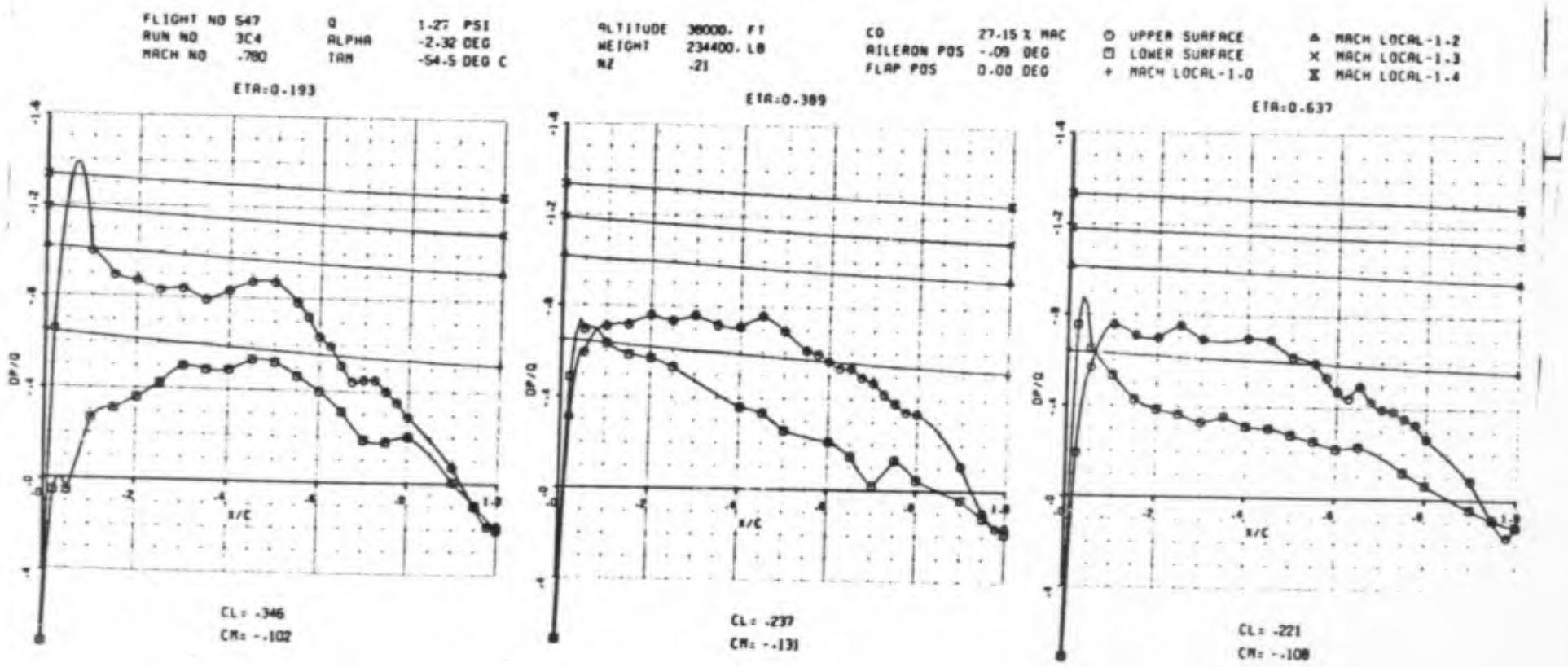


FIGURE 16 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .765 TO .780
(a) CORRECTED ALPHA = -1.55

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3C2
MACH NO .765

RAKE LOCATIONS

⊙ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

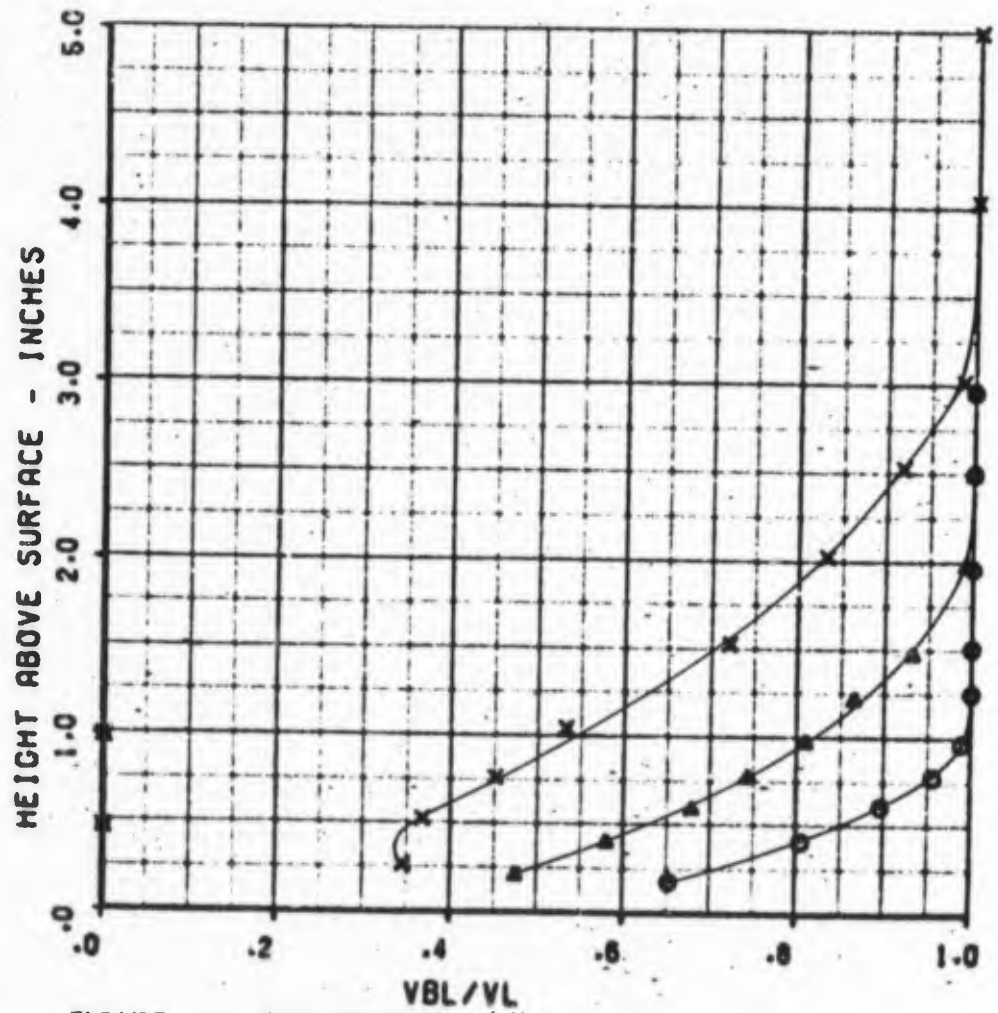
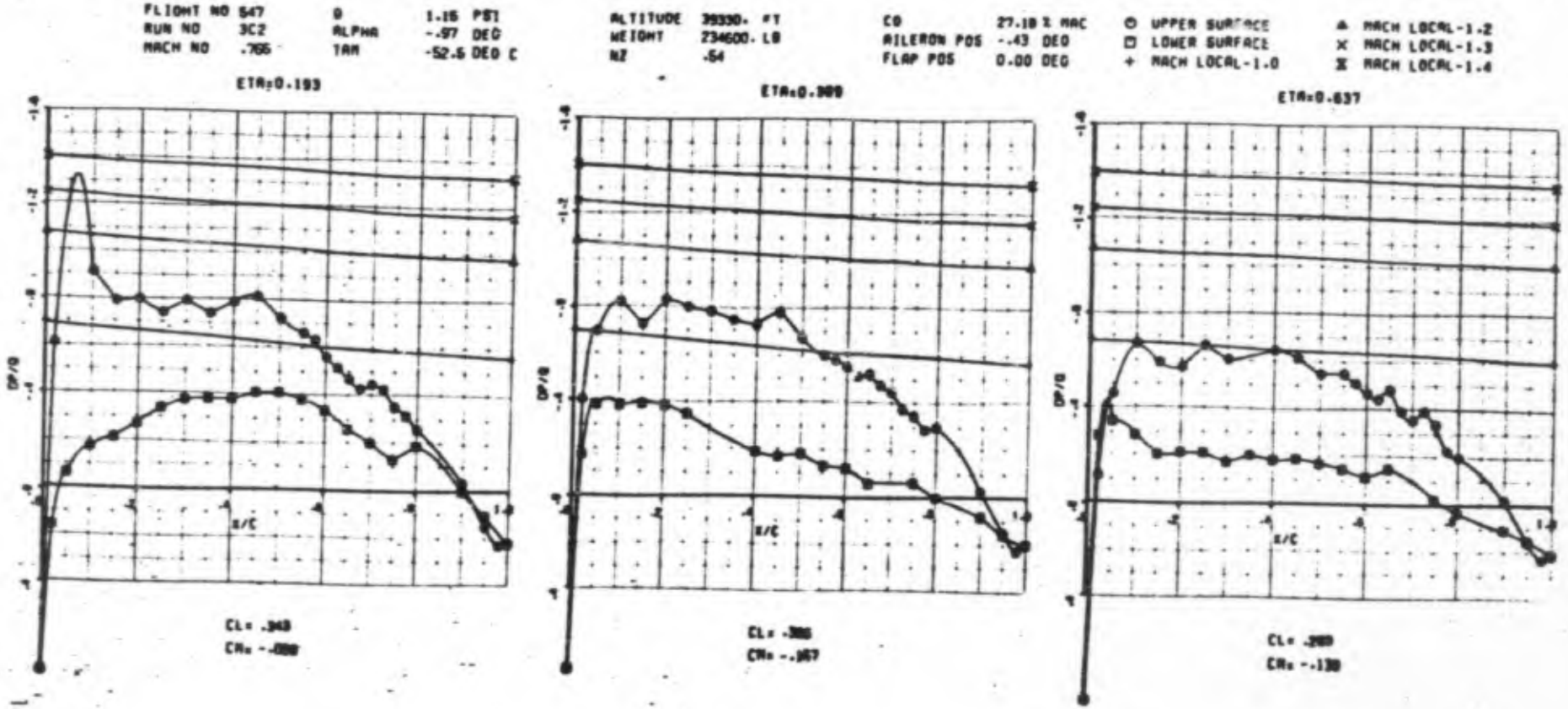


FIGURE 16 (CONTINUED)
(b) CORRECTED ALPHA = -0.37

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3C3
MACH NO .770

RAKE LOCATIONS

○ 30 %
▲ 56 %
× 80 %.
✱ 80 %(AFT)

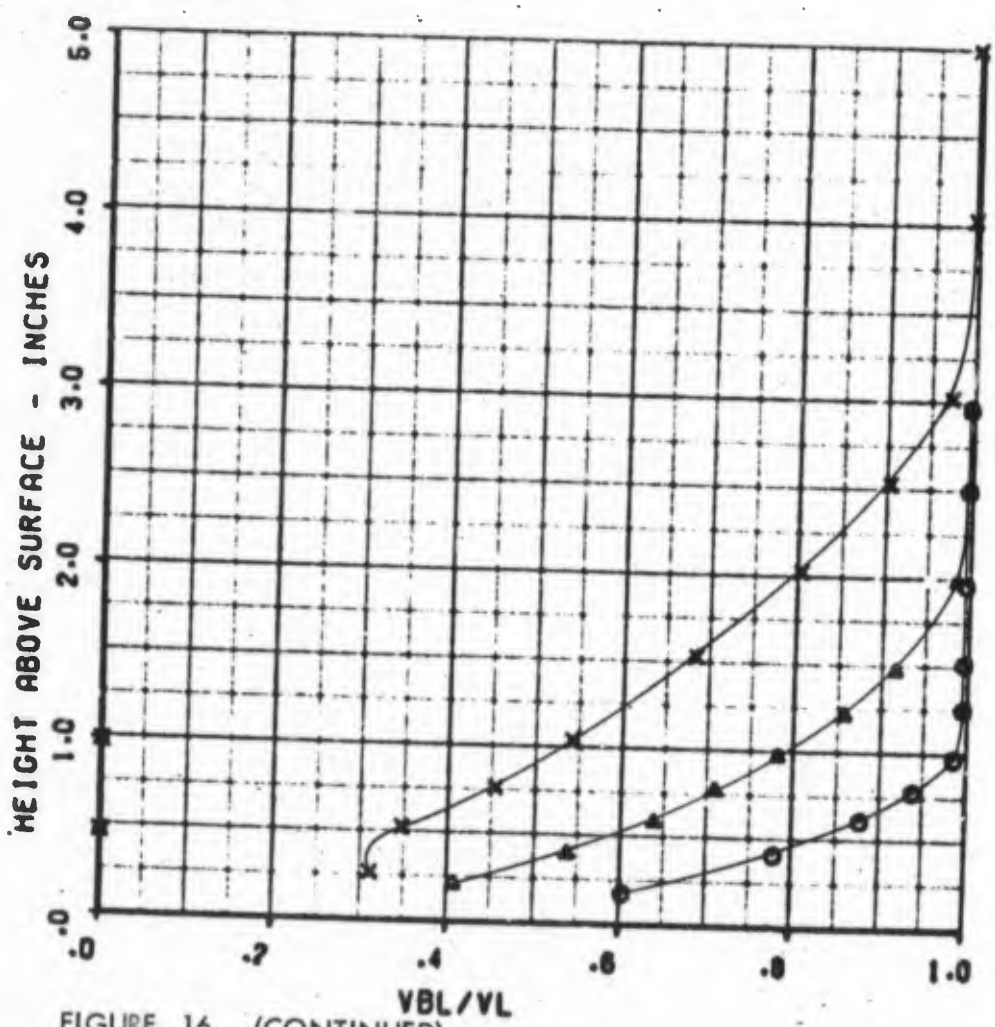
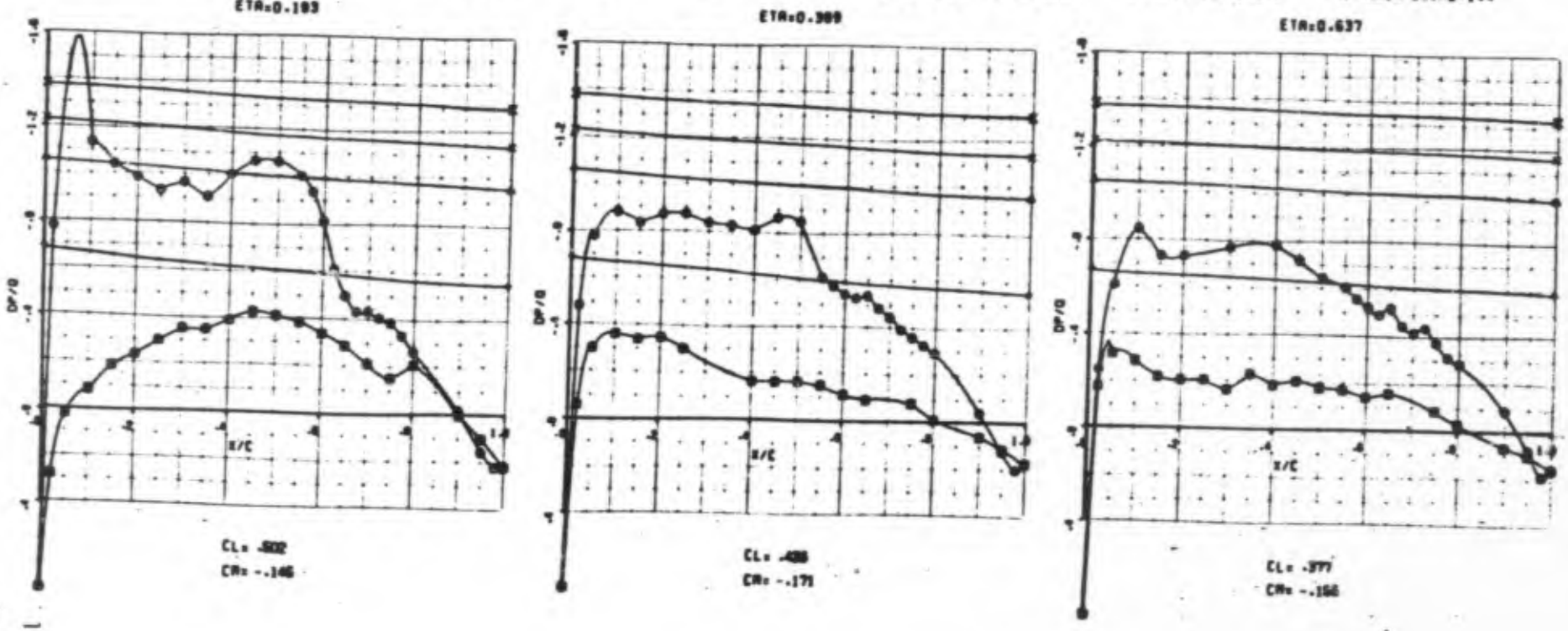


FIGURE 16 (CONTINUED)
(c) CORRECTED ALPHA = 0.13

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	547	Q	1.14 PSI	ALTITUDE	39730. FT	CG	27.19 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	3C3	ALPHA	-.39 DEG	WEIGHT	234800. LB	AILERON POS	.09 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.770	TAM	-52.8 DEG C	NZ	.71	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3C
MACH NO .770

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

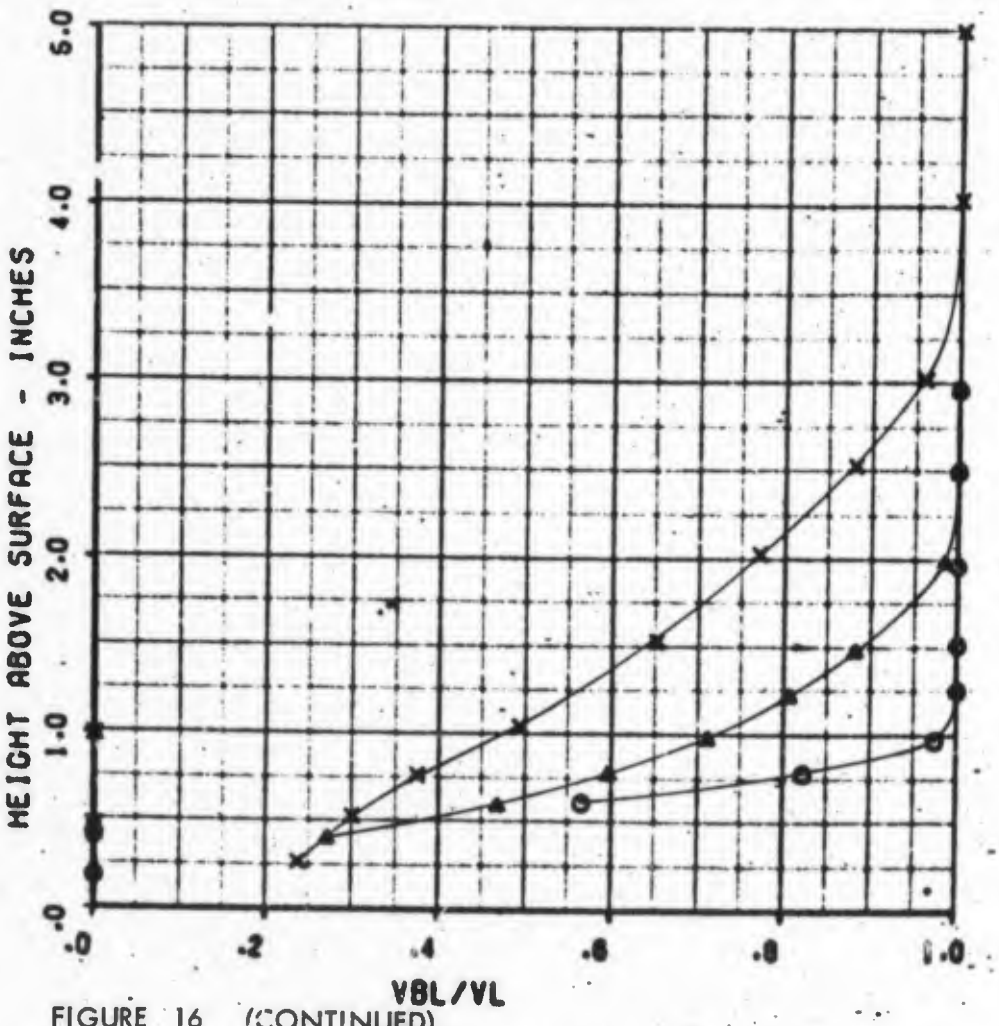
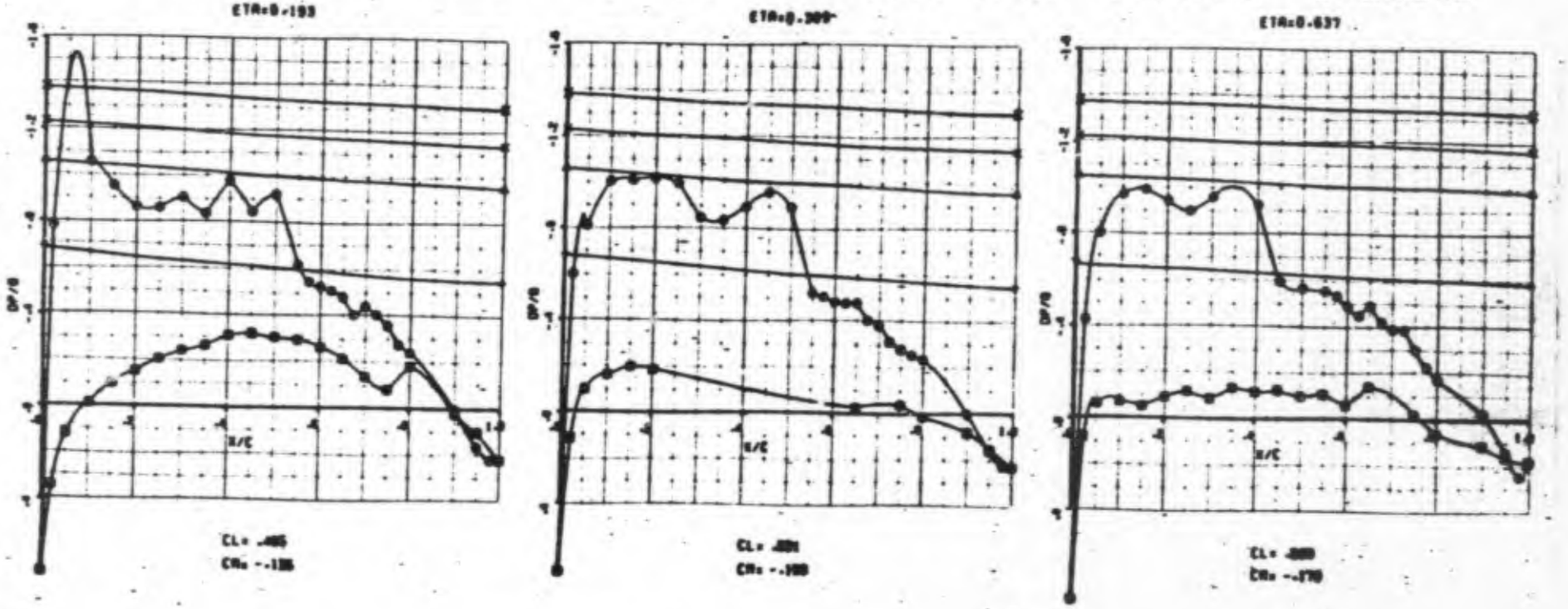


FIGURE 16 (CONTINUED)
(d) CORRECTED ALPHA = 1.25

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO 547 | Q 1.12 PSI | ALTITUDE 40080. FT | CG 27.20 % MAC | ○ UPPER SURFACE | △ MACH LOCAL-1.2
RUN NO 3C | ALPHA .87 DEG | WEIGHT 235000. LB | AILERON POS -.77 DEG | □ LOWER SURFACE | × MACH LOCAL-1.3
MACH NO .770 | TAM -53.0 DEG C | NZ .99 | FLAP POS 0.00 DEG | + MACH LOCAL-1.0 | ⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 549
RUN NO 2A
MACH NO .780

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

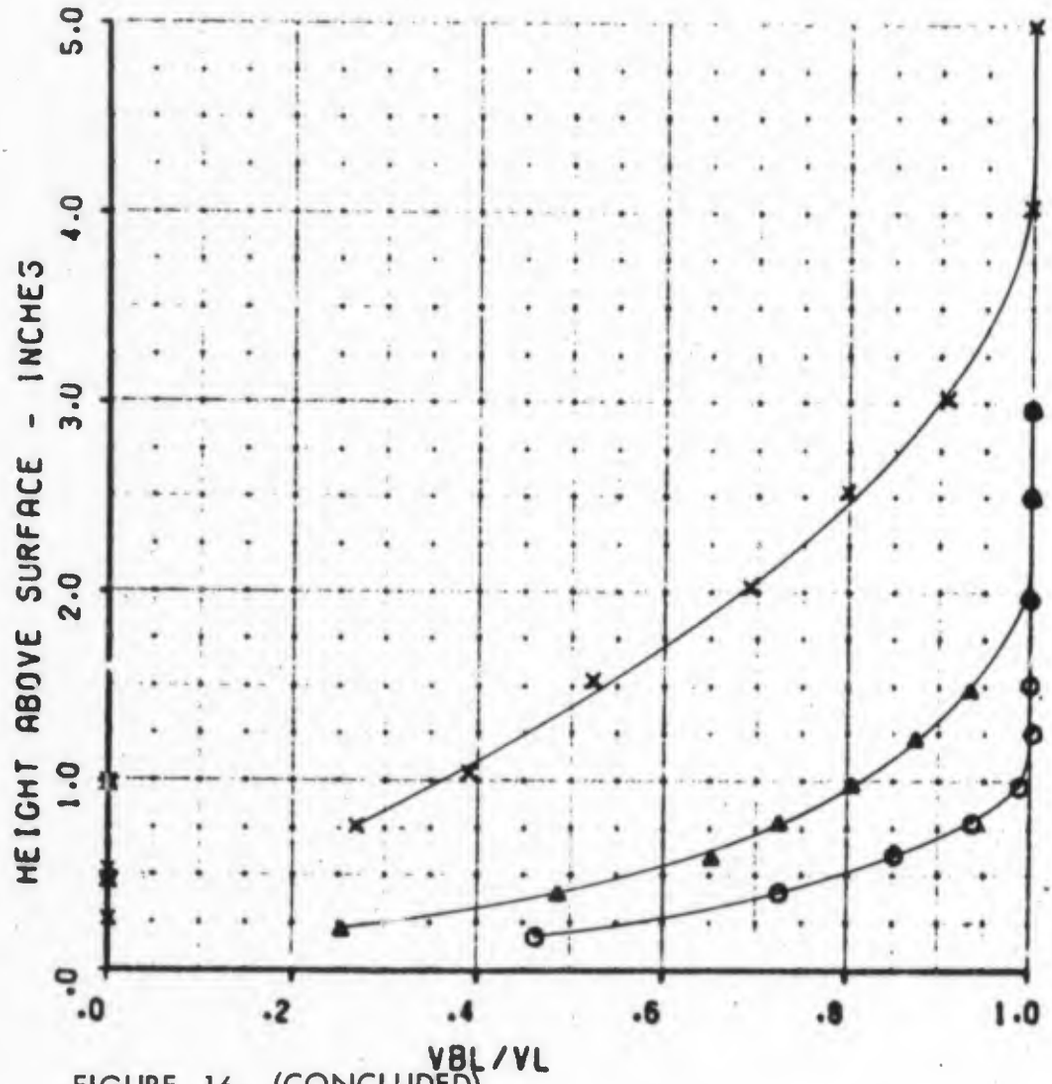
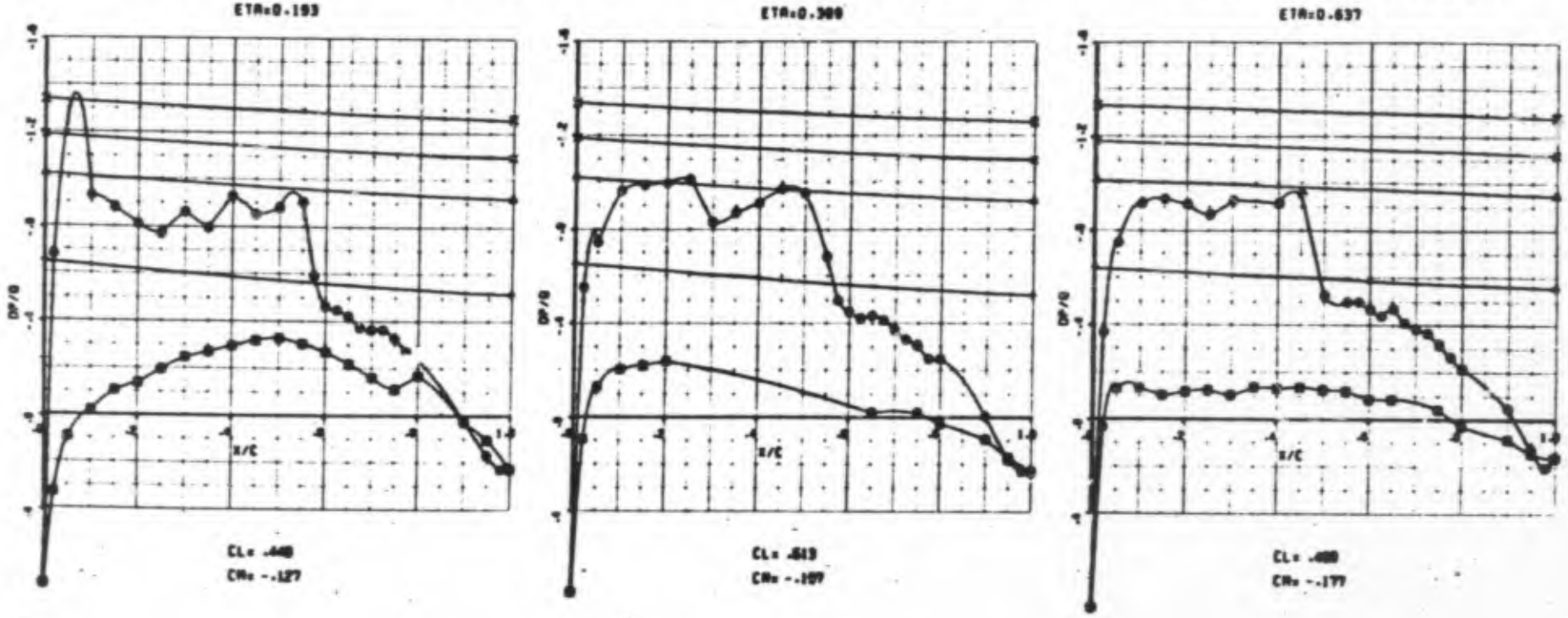


FIGURE 16 (CONCLUDED)
(e) CORRECTED ALPHA = 1.51

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	549	Q	1.19 PSI	ALTITUDE	39290. FT	CG	23.70 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	2A	ALPHA	1.16 DEG	WEIGHT	232900. LB	AILERON POS	.08 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.780	TAM	-49.6 DEG C	NZ	.98	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3C5
MACH NO .790

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

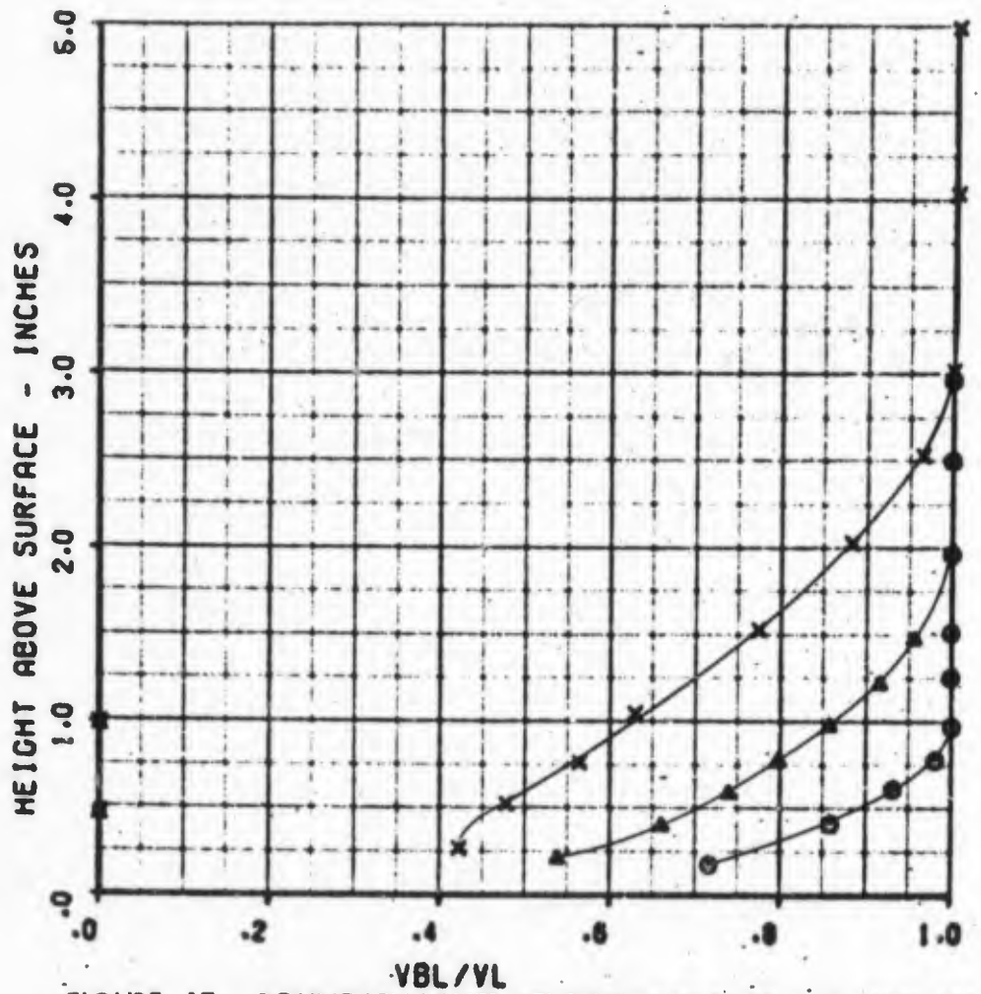
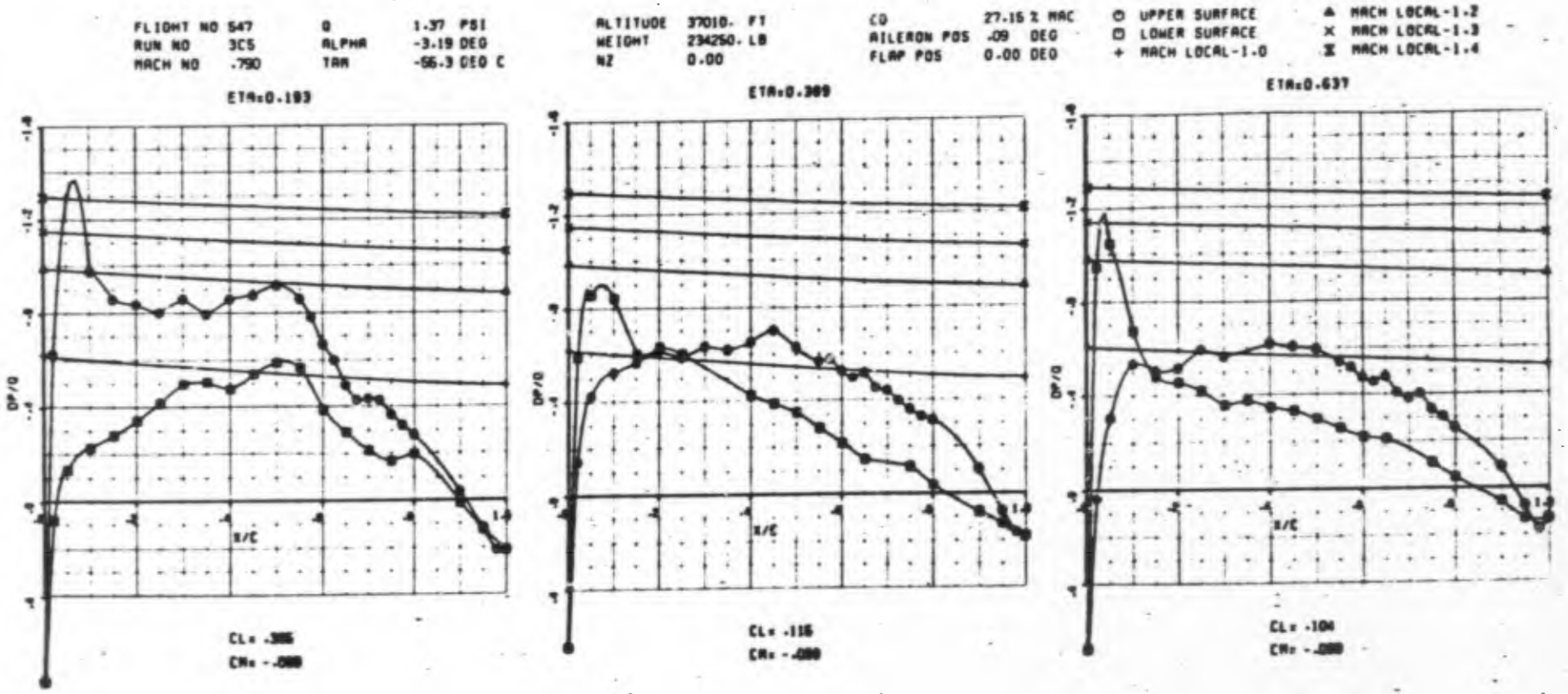


FIGURE 17 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .790 TO .810

(a) CORRECTED ALPHA = -2.31

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 305
MACH NO .900

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 % (AFT)

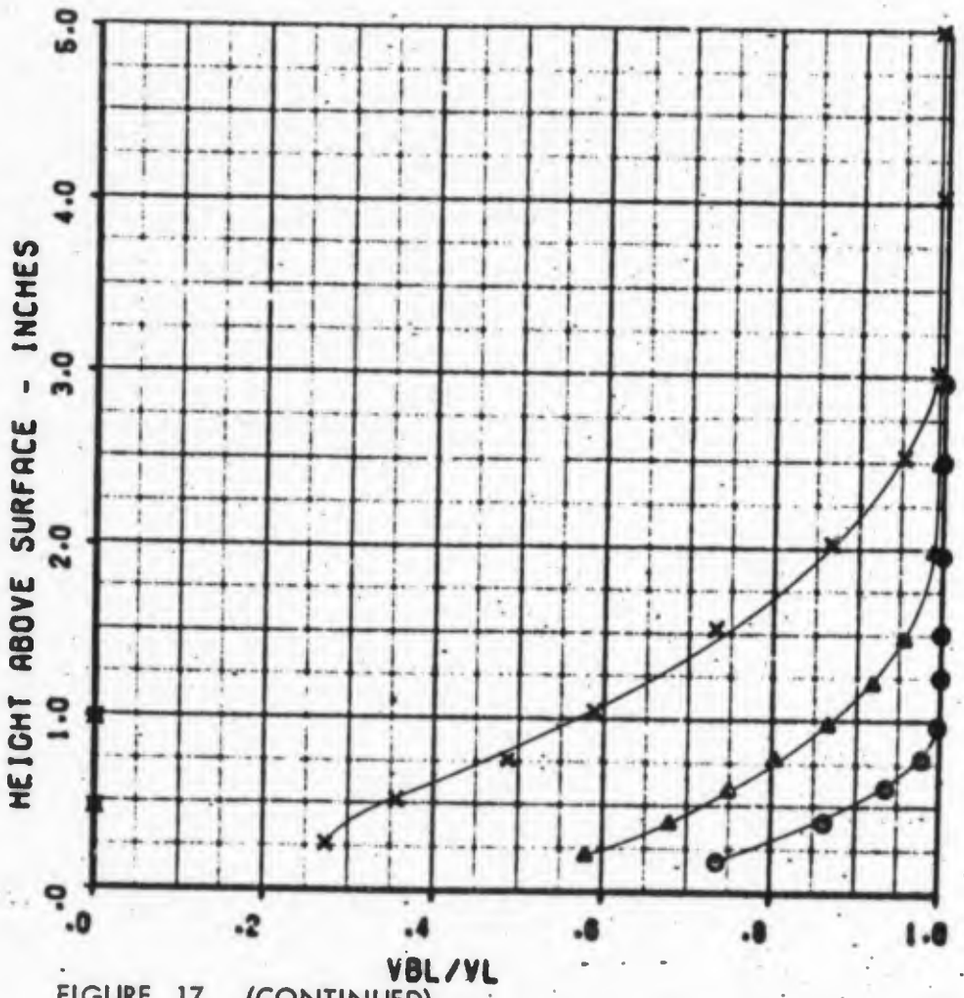


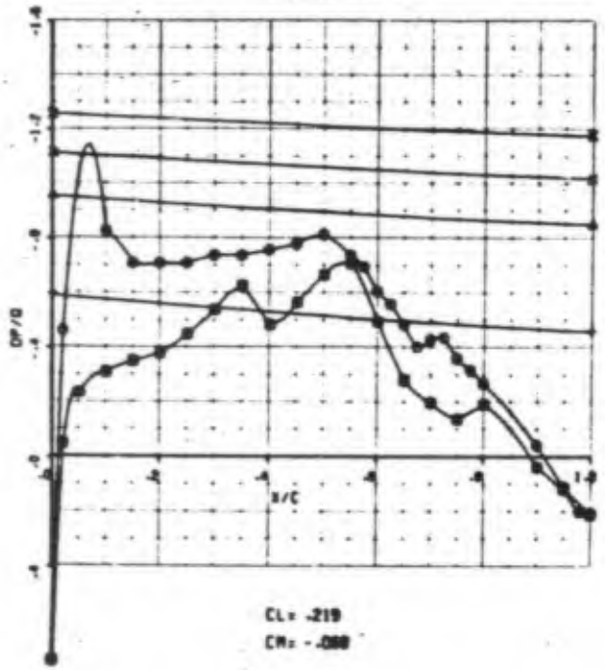
FIGURE 17 (CONTINUED)
(b) CORRECTED ALPHA = -2.14

LOCKHEED C-141A

PRESSURE DISTRIBUTION

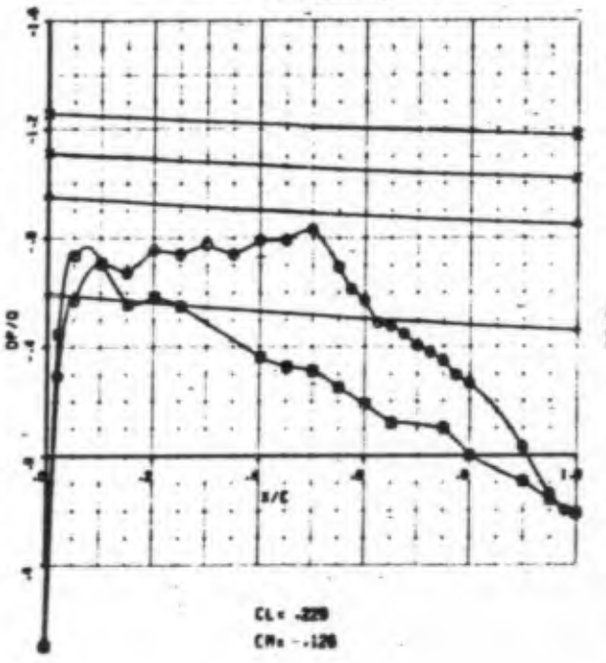
FLIGHT NO 547	Q	1.44 PSI	ALTITUDE 36430. FT	CG	26.95 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO 305	ALPHA	-3.00 DEG	WEIGHT 231400. LB	AILERON POS	-.85 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO .800	TAM	-54.0 DEG C	NZ 0.00	FLAP POS	0.0C DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA=0.193



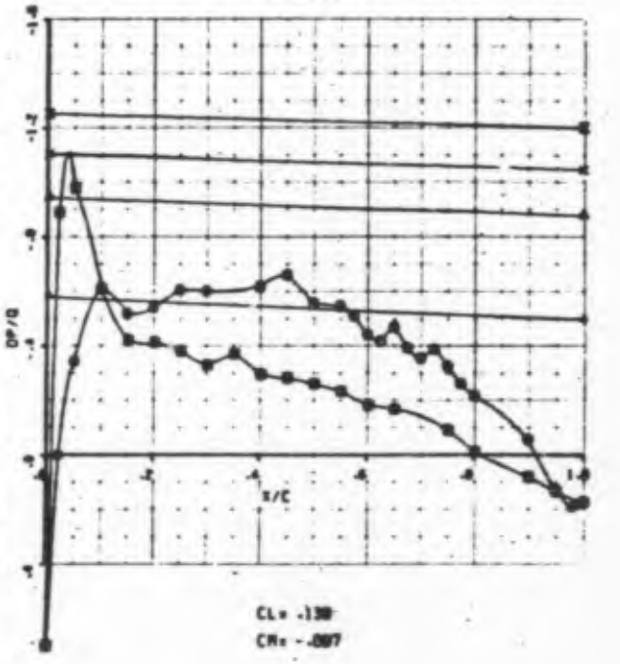
CL= .219
CM= -.088

ETA=0.389



CL= .229
CM= -.126

ETA=0.637



CL= .138
CM= -.097

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 301
MACH NO .796

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

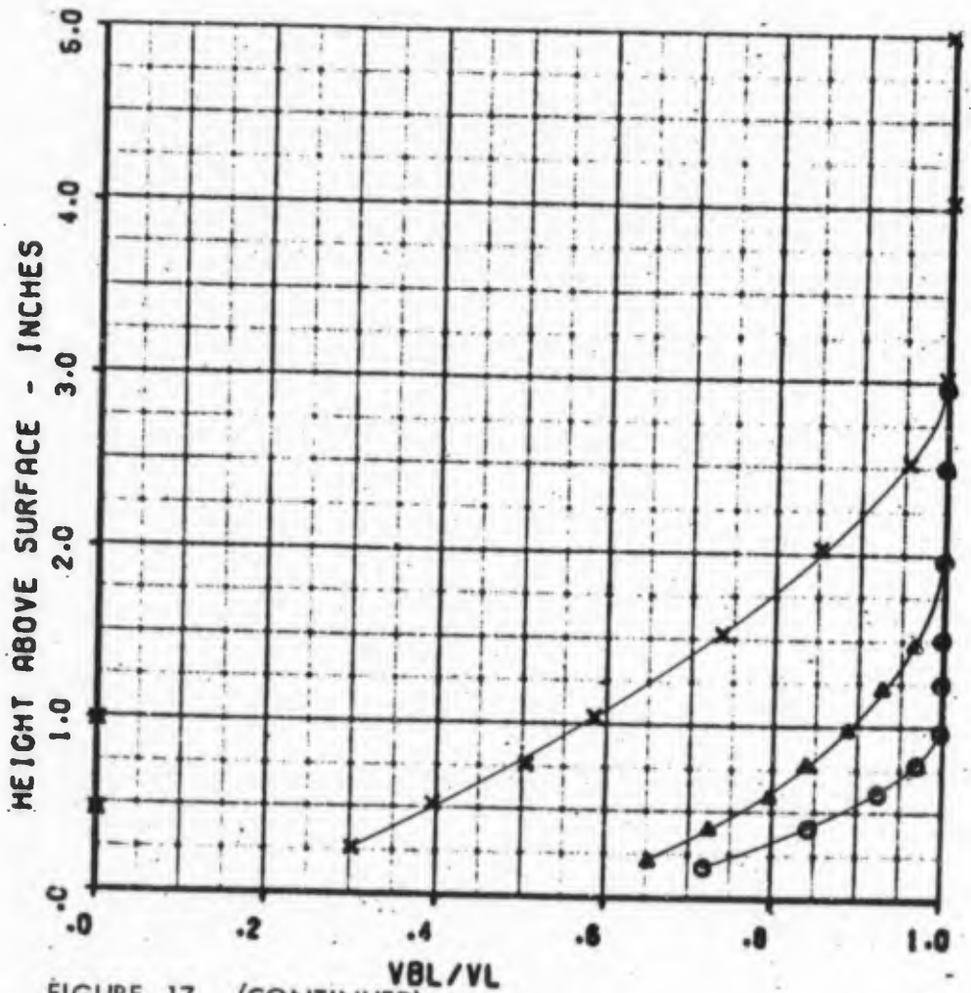


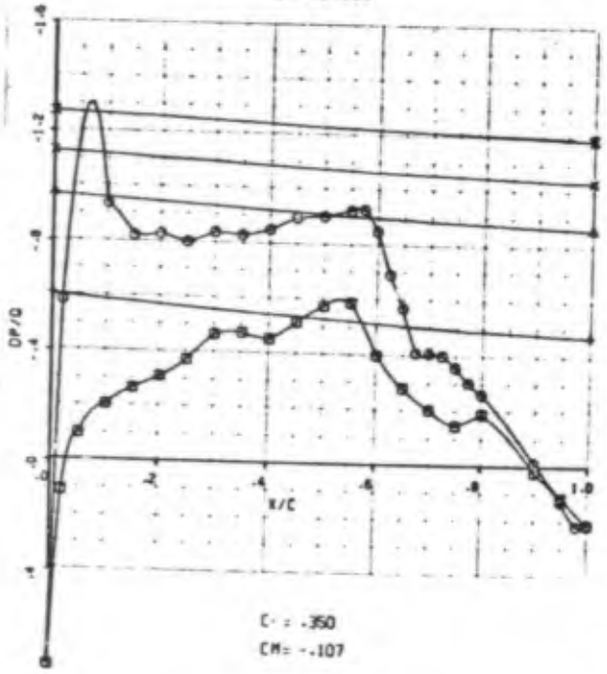
FIGURE 17 (CONTINUED)
(c) CORRECTED ALPHA = -1.30

LOCKHEED C-141A

PRESSURE DISTRIBUTION

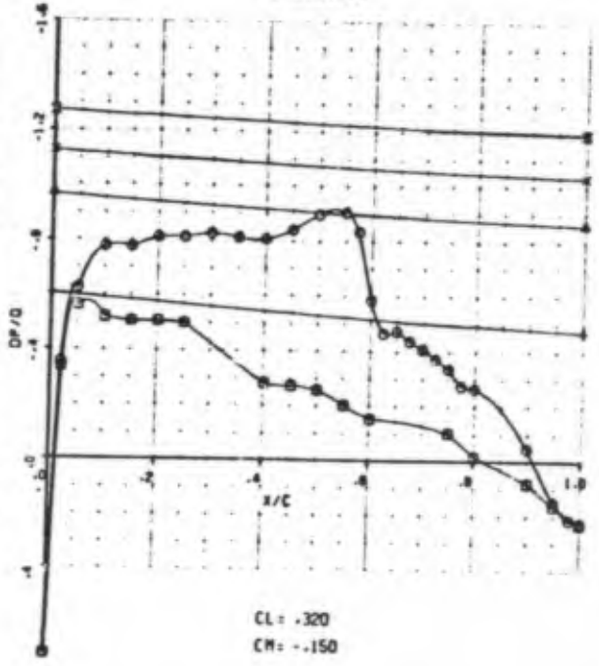
FLIGHT NO	547	Q	1.42 PSI	ALTITUDE	36600. FT	CG	27.03 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	301	ALPHA	-2.03 DEG	WEIGHT	232450. LB	AILERON POS	-1.36 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.796	TAM	-54.2 DEG C	NZ	.34	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA=0.193



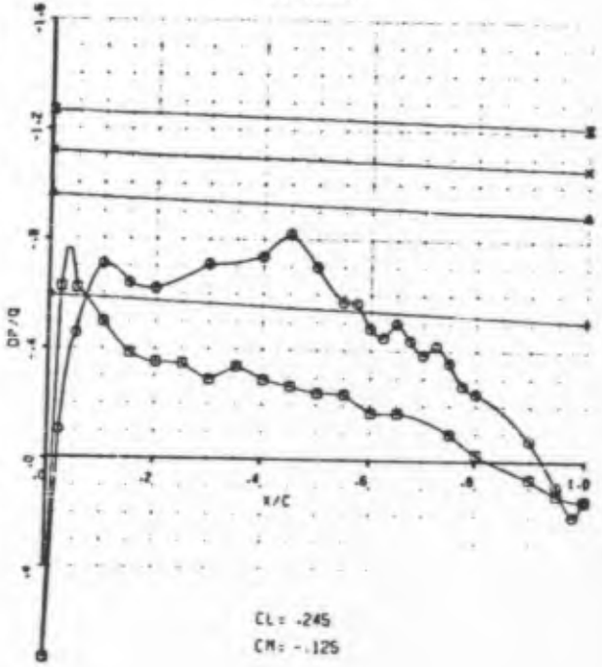
CL= .350
CM= -.107

ETA=0.389



CL= .320
CM= -.150

ETA=0.637



CL= .245
CM= -.125

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 302
MACH NO .810

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

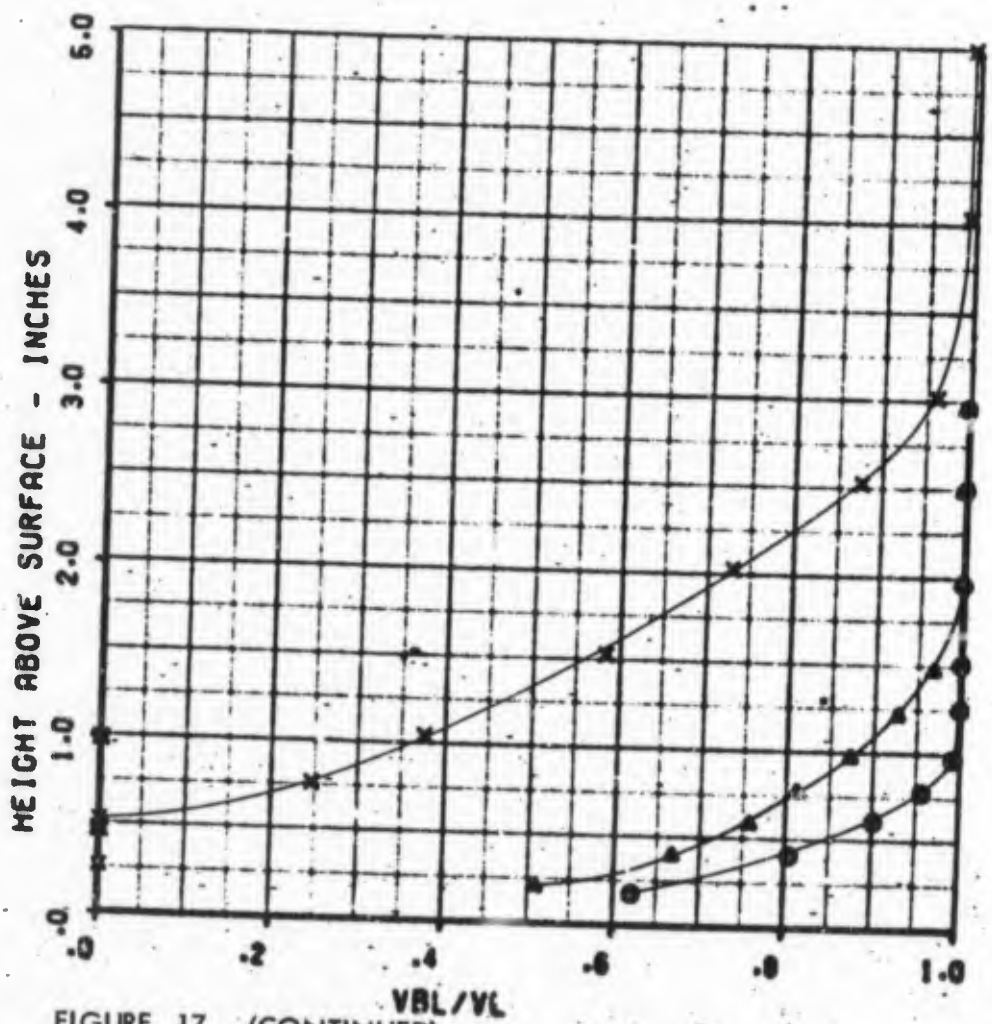


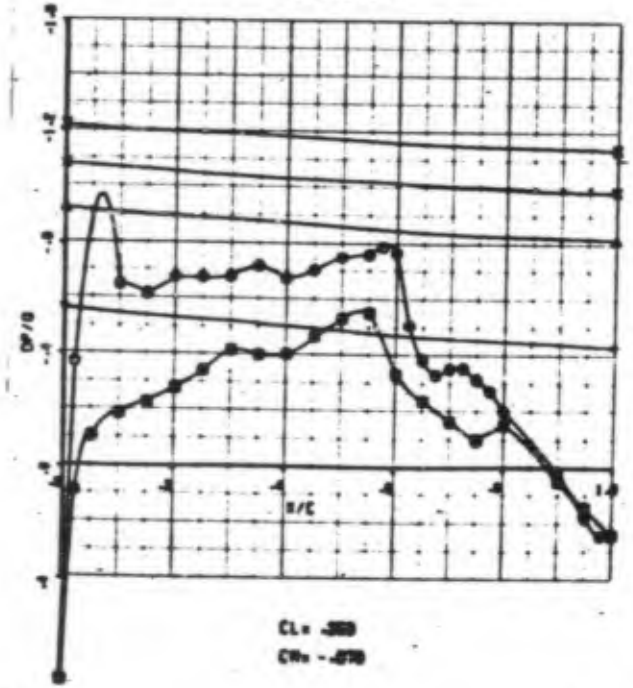
FIGURE 17 (CONTINUED)
(d) CORRECTED ALPHA = -0.70

LOCKHEED C-141A

PRESSURE DISTRIBUTION

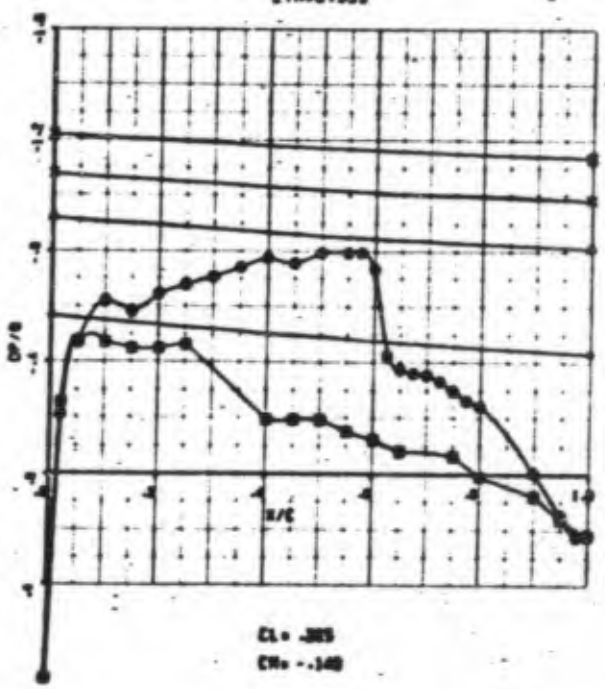
FLIGHT NO	847	Q	1.43 PSI	ALTITUDE	37080. FT	CG	27.04 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	302	ALPHA	-1.36 DEG	WEIGHT	232660. LB	AILERON POS	-.09 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.810	TAN	-57.0 DEG C	NZ	.80	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA=0.183



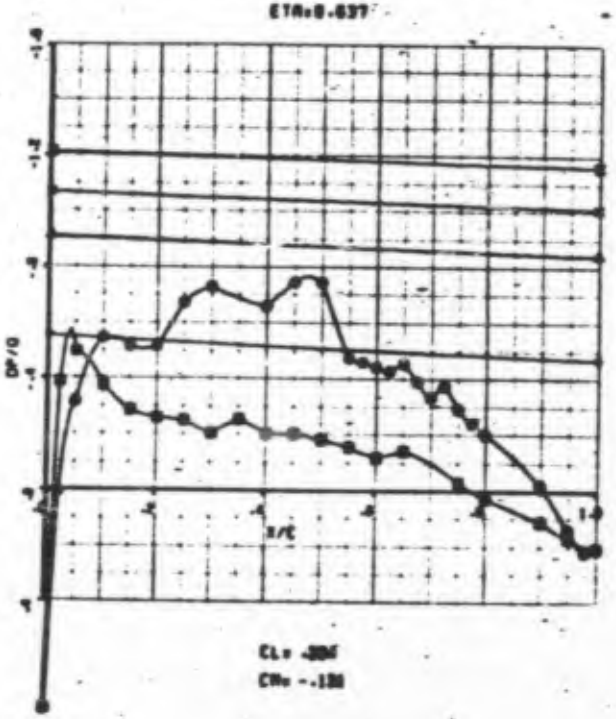
CL= .388
CM= -.078

ETA=0.399



CL= .385
CM= -.148

ETA=0.637



CL= .384
CM= -.138

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 3A1
MACH NO .810

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

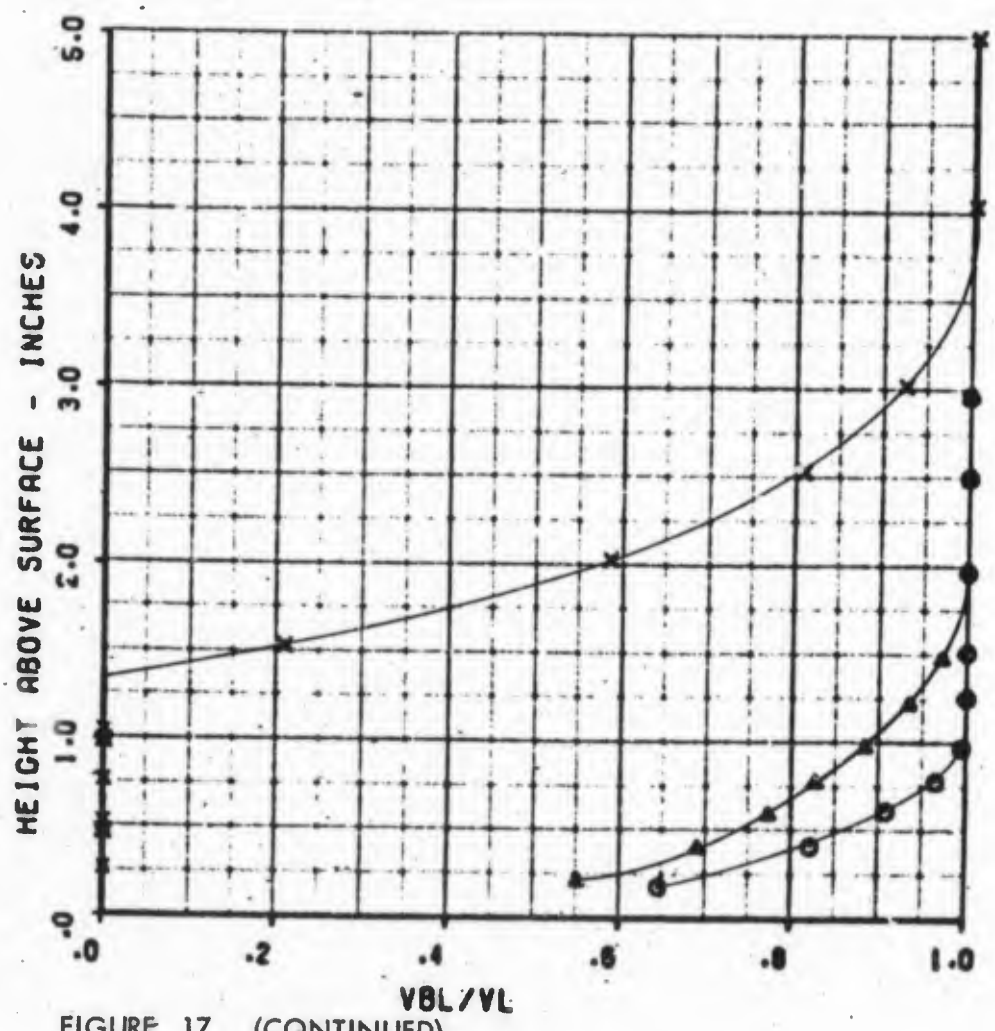
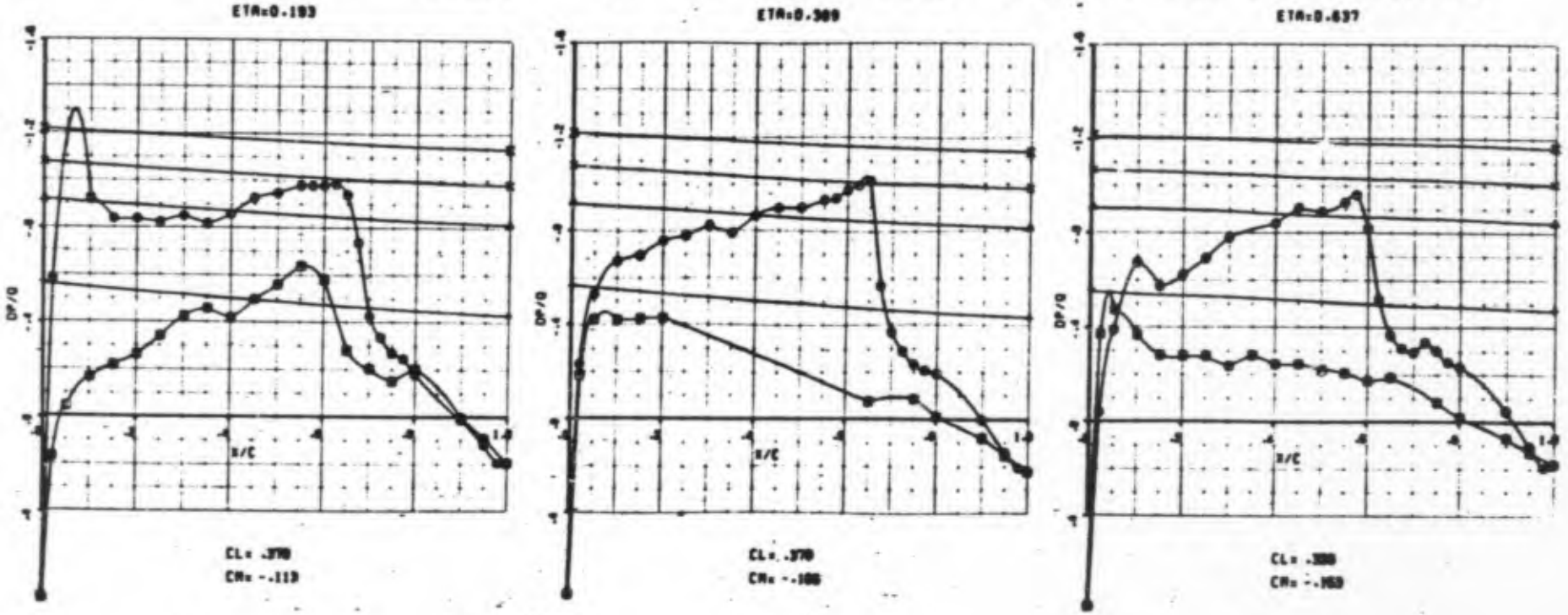


FIGURE 17 (CONTINUED)
(e) CORRECTED ALPHA = -0.60

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	1.54 PSI	ALTITUDE	35640. FT	CG	21.34 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	3A1	ALPHA	-1.25 DEG	WEIGHT	226600. LB	AILERON POS	-2.03 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.810	TAM	-64.5 DEG C	NZ	.87	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 303
MACH NO .800

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

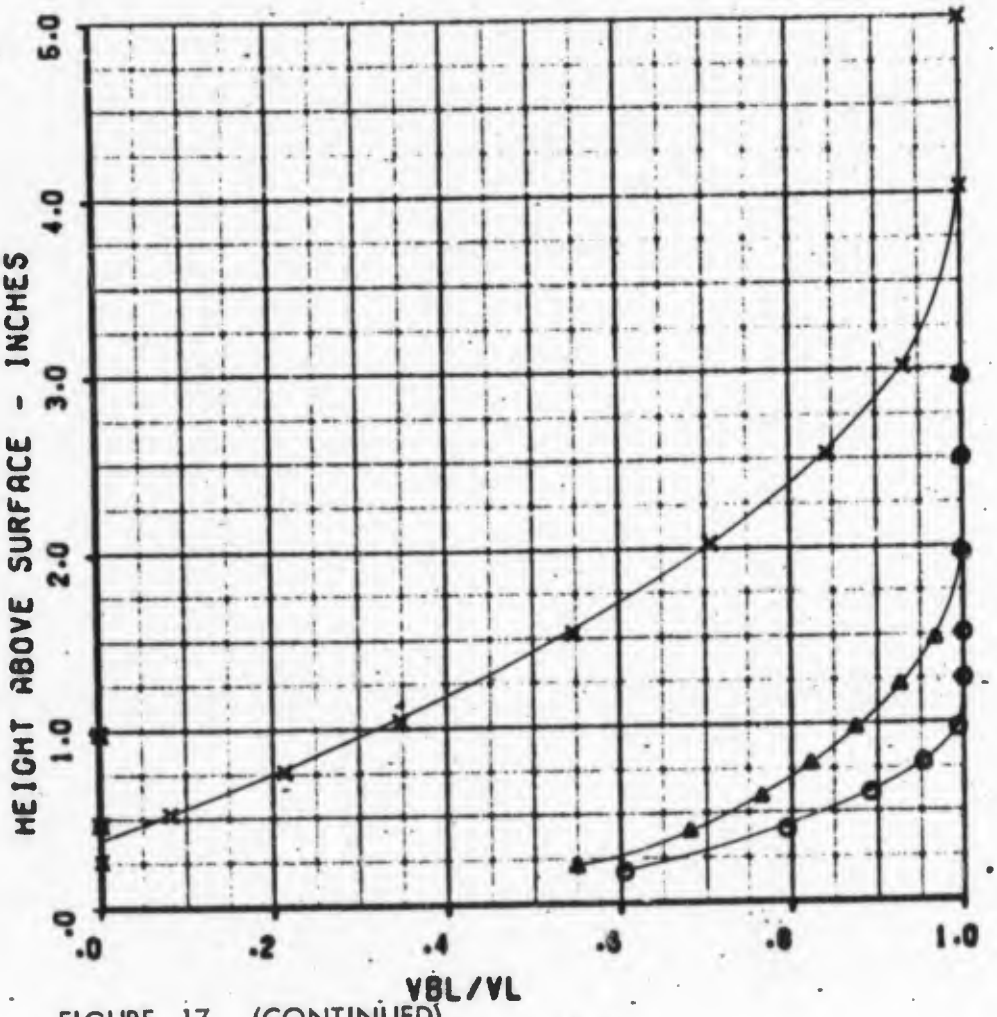
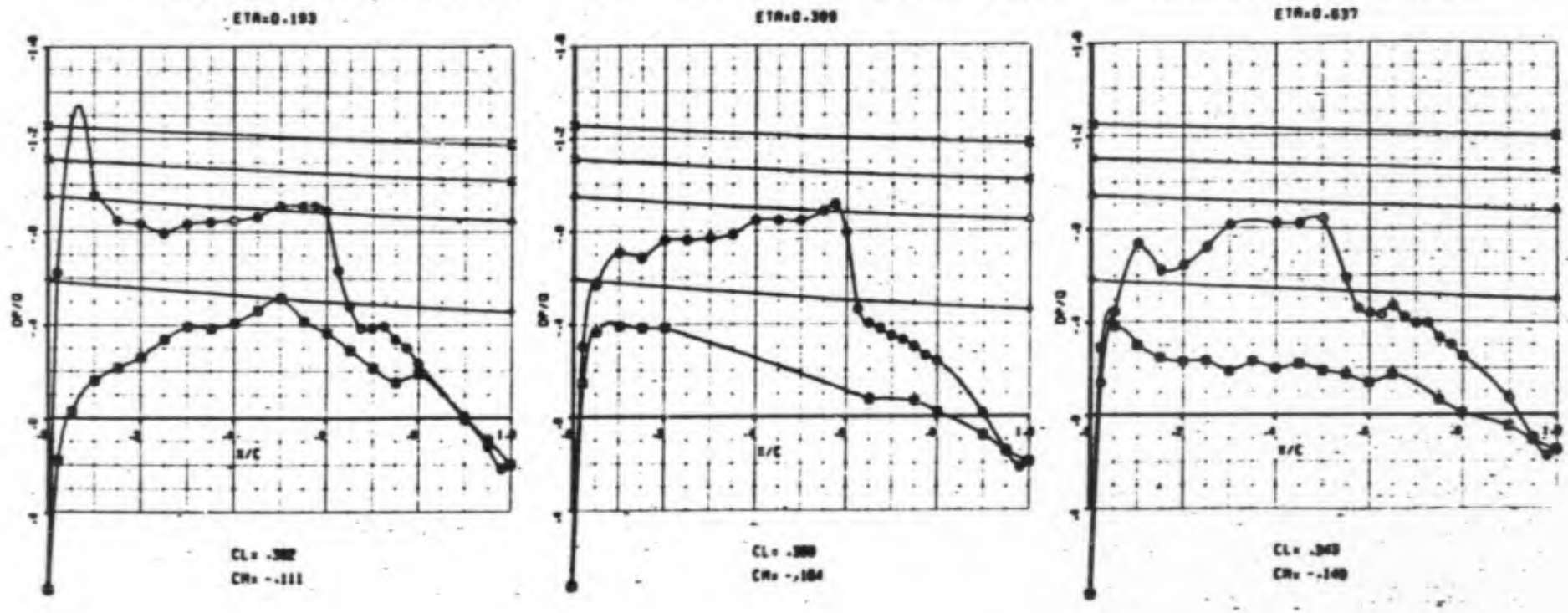


FIGURE 17 (CONTINUED)
(f) CORRECTED ALPHA = -0.18

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	547	Q	1.29 PSI	ALTITUDE	38780. FT	CG	27.05 % MAC	○	UPPER SURFACE	△	MACH LOCAL-1.2
RUN NO	303	ALPHA	-.77 DEG	WEIGHT	232760. LB	AILERON POS	.17 DEG	□	LOWER SURFACE	×	MACH LOCAL-1.3
MACH NO	.800	TAM	-53.6 DEG C	NZ	.98	FLAP POS	0.00 DEG	+	MACH LOCAL-1.0	⧖	MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 304
MACH NO .792

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
⊻ 80 %(AFT)

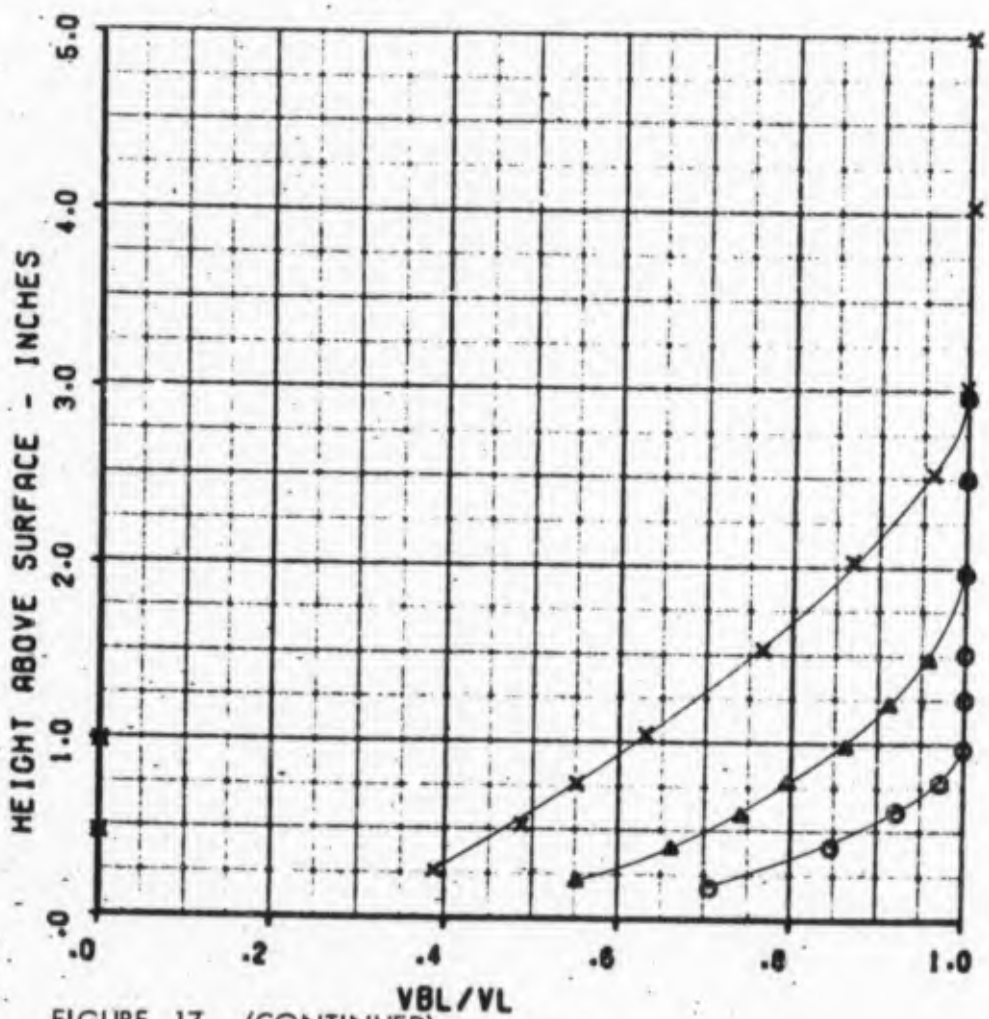
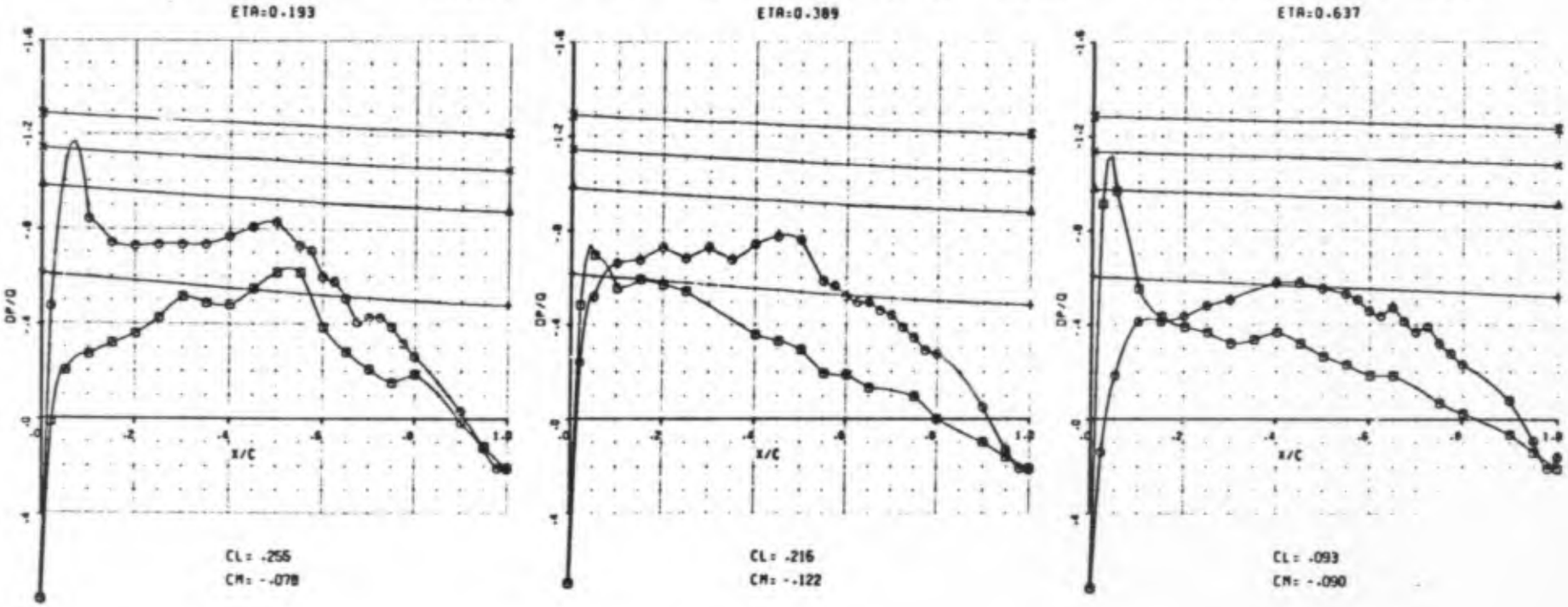


FIGURE 17 (CONTINUED)
(g) CORRECTED ALPHA = 0.04

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	547	Q	1.46	PSI	ALTITUDE	35810.	FT	CG	27.02	% MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	304	ALPHA	-.48	DEG	WEIGHT	232350.	LB	AILERON POS	-.60	DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.792	TAM	-53.8	DEG C	NZ	.19		FLAP POS	0.00	DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 30
MACH NO .800

RAKE LOCATIONS -

⊙ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

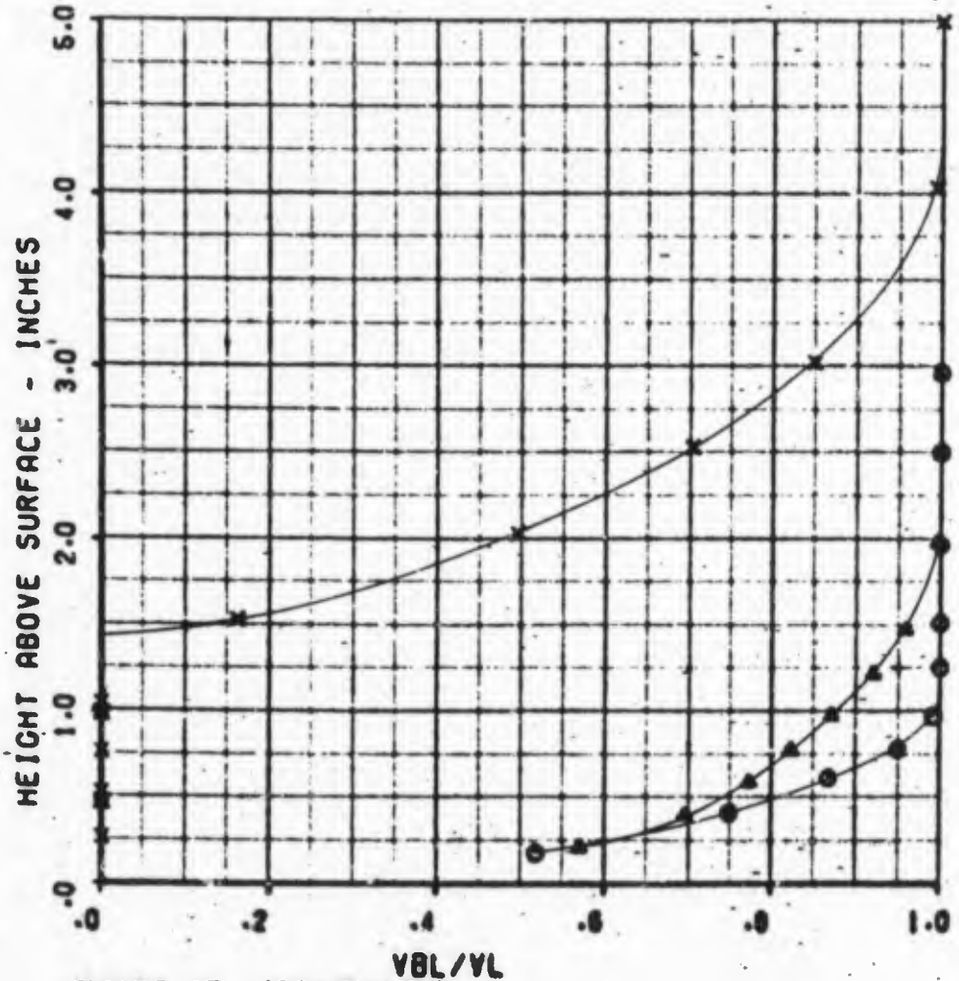


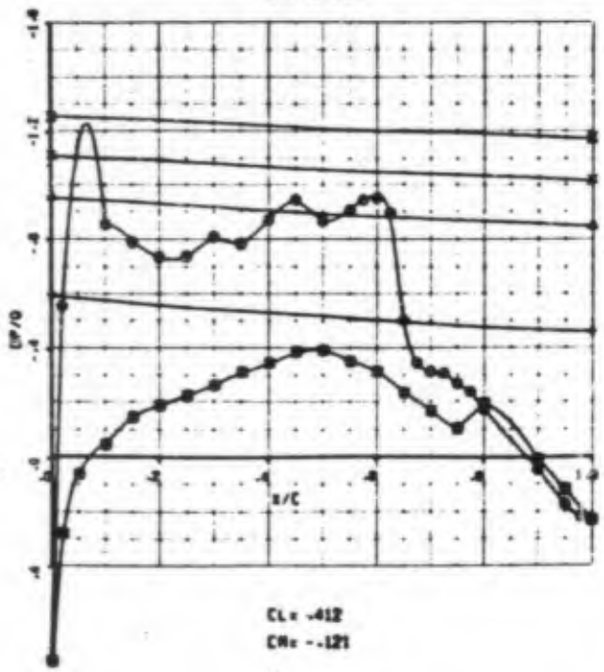
FIGURE 17 (CONTINUED)
(h) CORRECTED ALPHA = 0.74

LOCKHEED C-141A

PRESSURE DISTRIBUTION

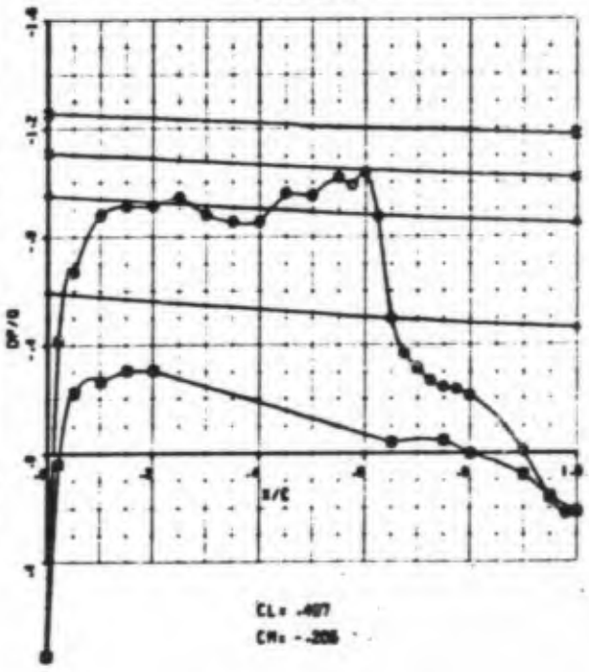
FLIGHT NO	547	Q	1.25 PSI	ALTITUDE	39460. FT	CG	27.08 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	30	ALPHA	.29 DEG	WEIGHT	233000. LB	AILERON POS	.26 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.800	TAM	-52.5 DEG C	NZ	.99	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA=0.193



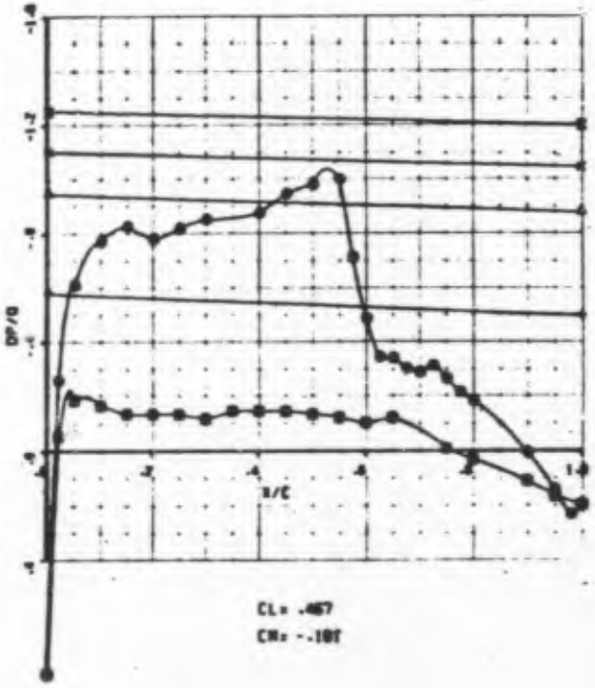
CL= .412
CM= -.121

ETA=0.389



CL= .407
CM= -.206

ETA=0.637



CL= .457
CM= -.187

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 549
RUN NO 28
MACH NO .800

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

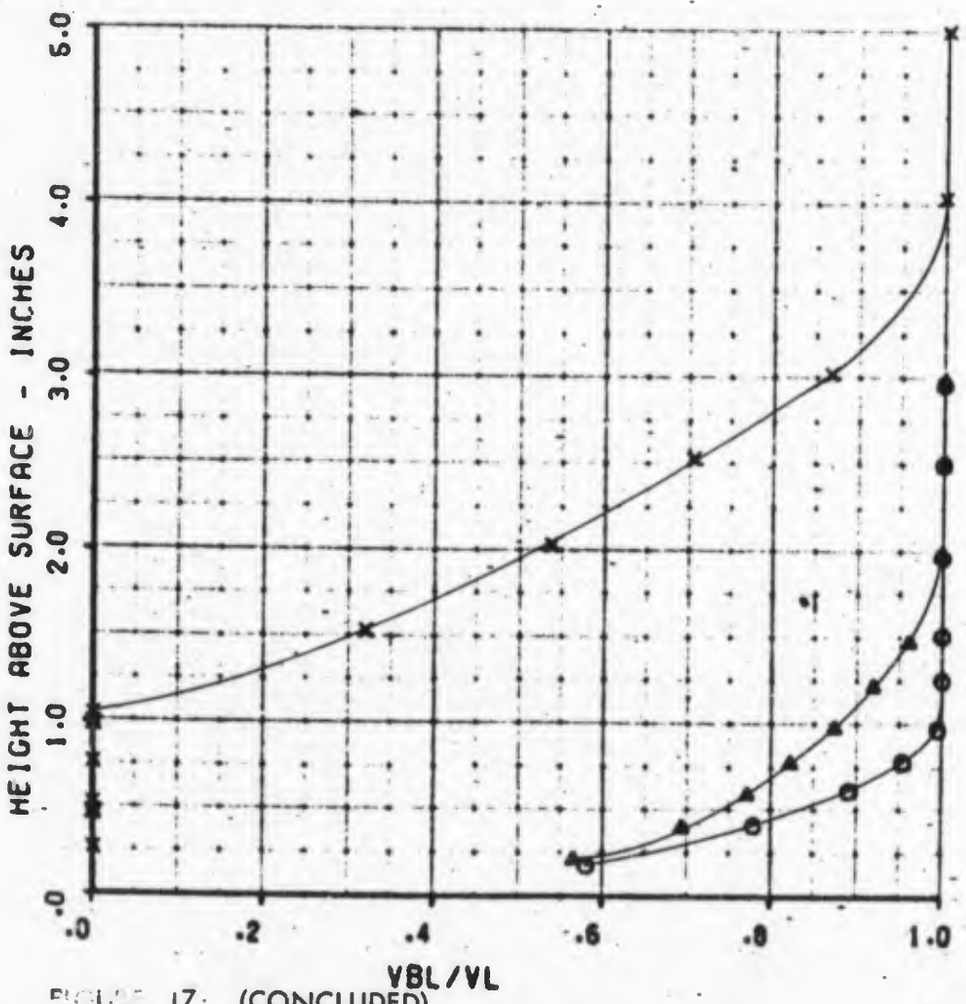
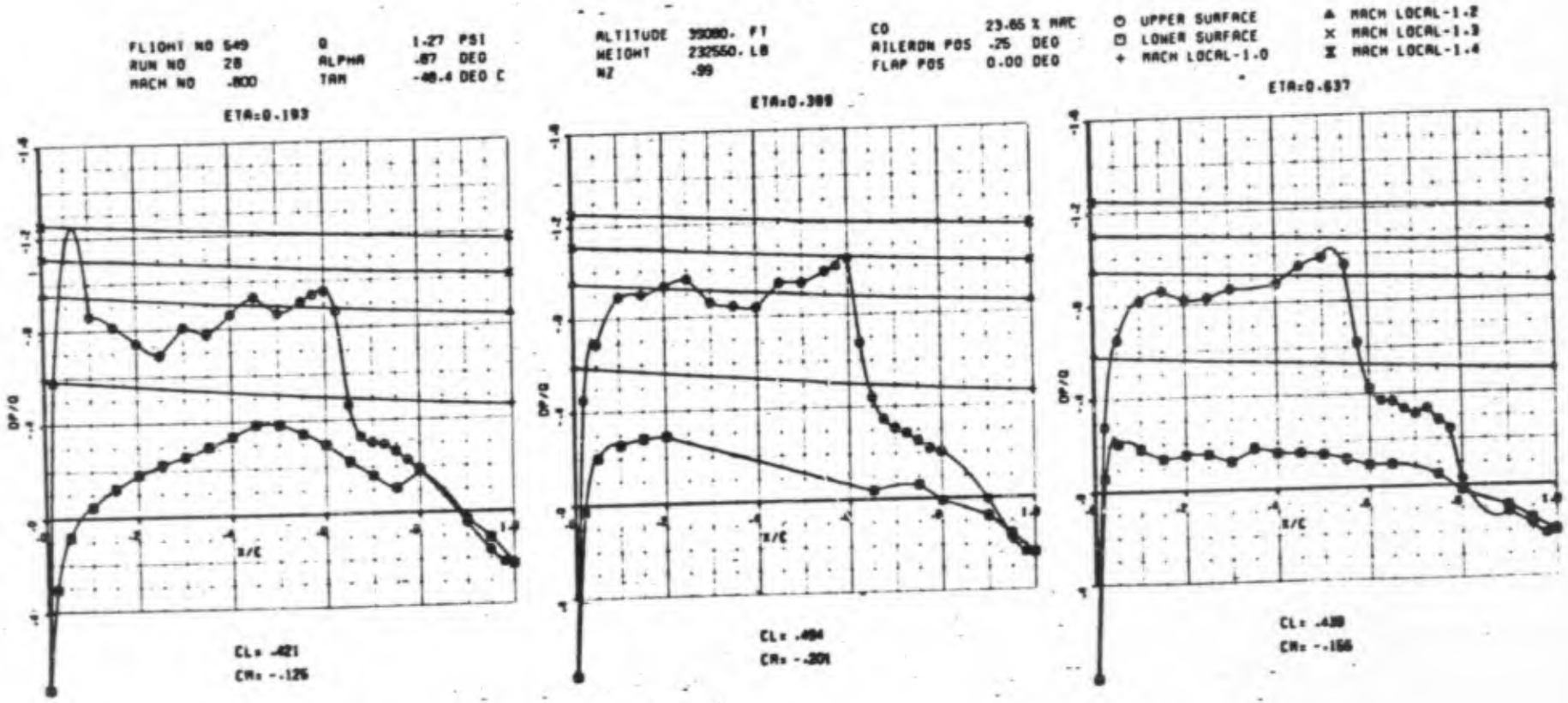


FIGURE 17 (CONCLUDED)
(k) CORRECTED ALPHA = 1.25.

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 3A5
MACH NO .826

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

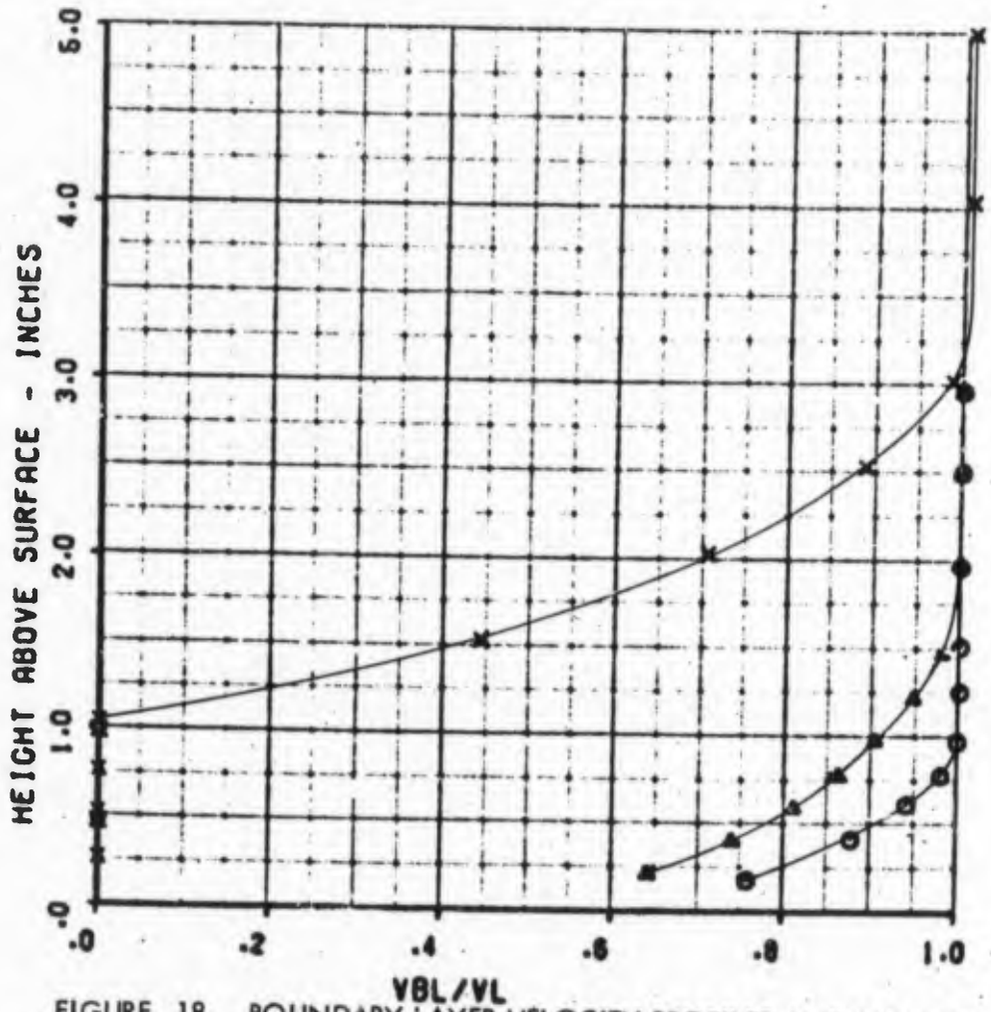


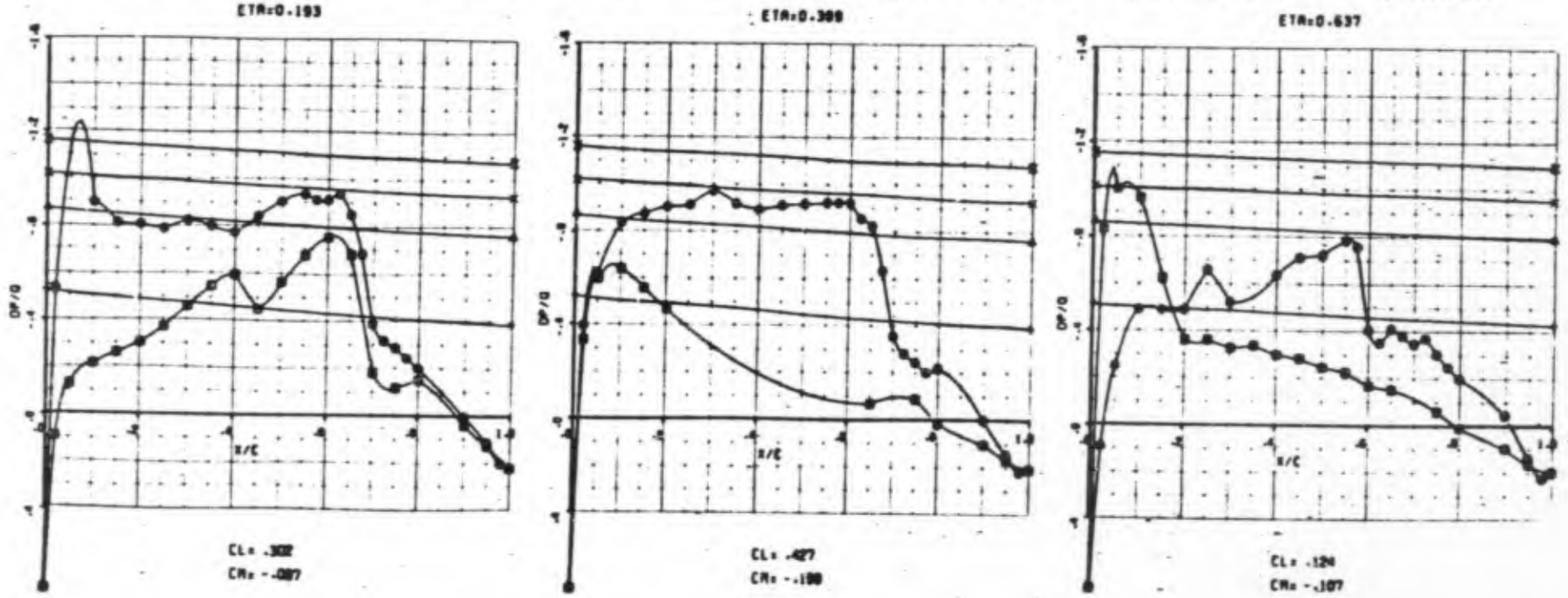
FIGURE 18 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .820 TO .830

(a) CORRECTED ALPHA = -2.55

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	1.61 PSI	ALTITUDE	35470. FT	CG	20.52 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	3A5	ALPHA	-3.45 DEG	WEIGHT	221450. LB	AILERON POS	-.68 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.826	TAM	-57.0 DEG C	NZ	.14	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 3A4
MACH NO .822

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

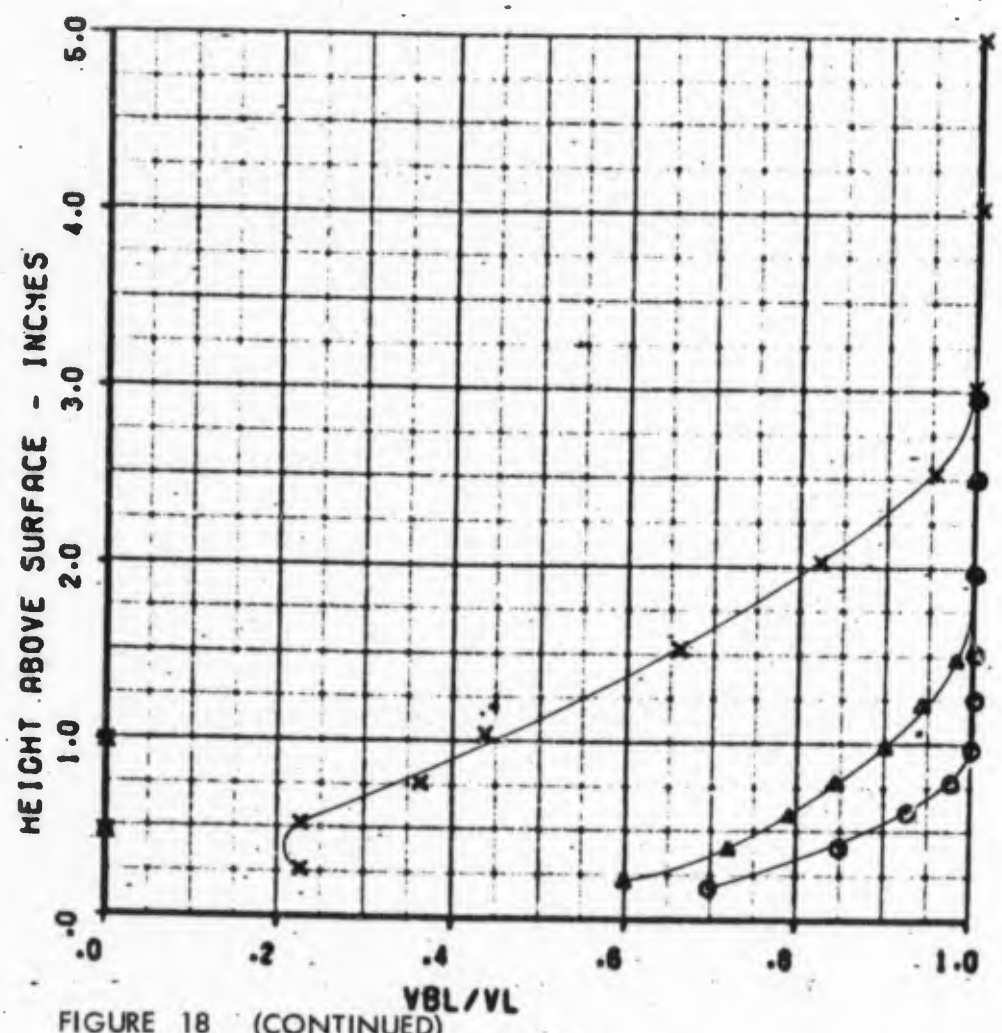


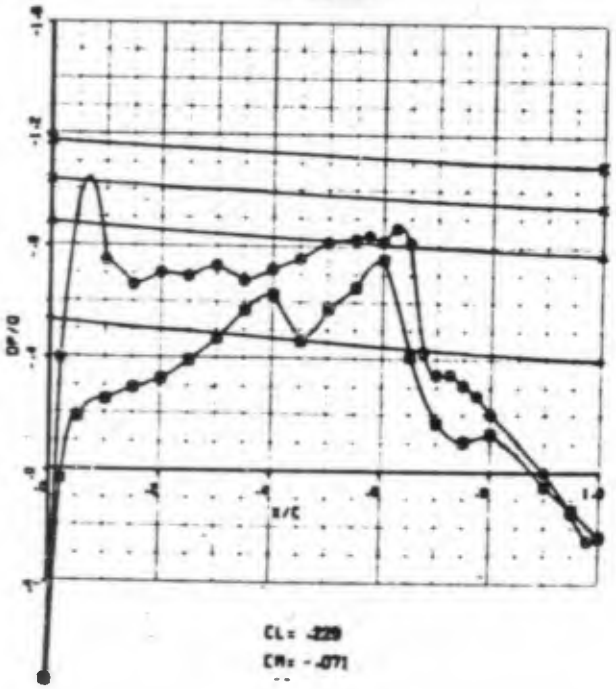
FIGURE 18 (CONTINUED)
(b) CORRECTED ALPHA = -2.28

LOCKHEED C-141A

PRESSURE DISTRIBUTION

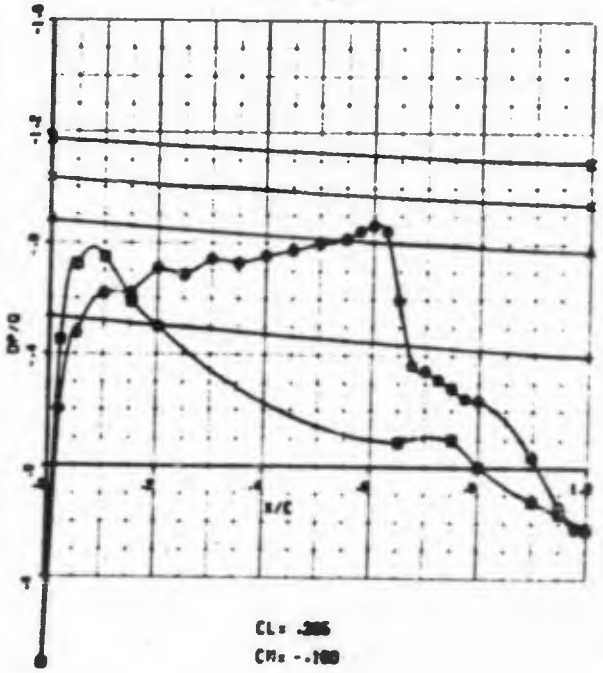
FLIGHT NO	548	Q	1.55 PSI	ALTITUDE	38050. FT	CG	20.66 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	3R4	ALPHA	-3.16 DEG	WEIGHT	222200. LB	AILERON POS	-.08 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.822	TAM	-56.2 DEG C	NZ	.21	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4

ETA=0.193



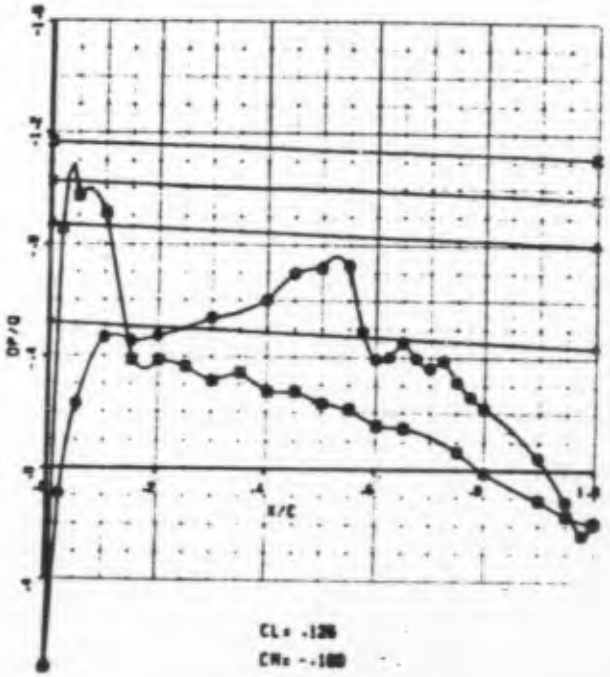
CL= .229
CM= -.071

ETA=0.389



CL= .385
CM= -.100

ETA=0.637



CL= .128
CM= -.100

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 3A3
MACH NO .820

RAKE LOCATIONS

○ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

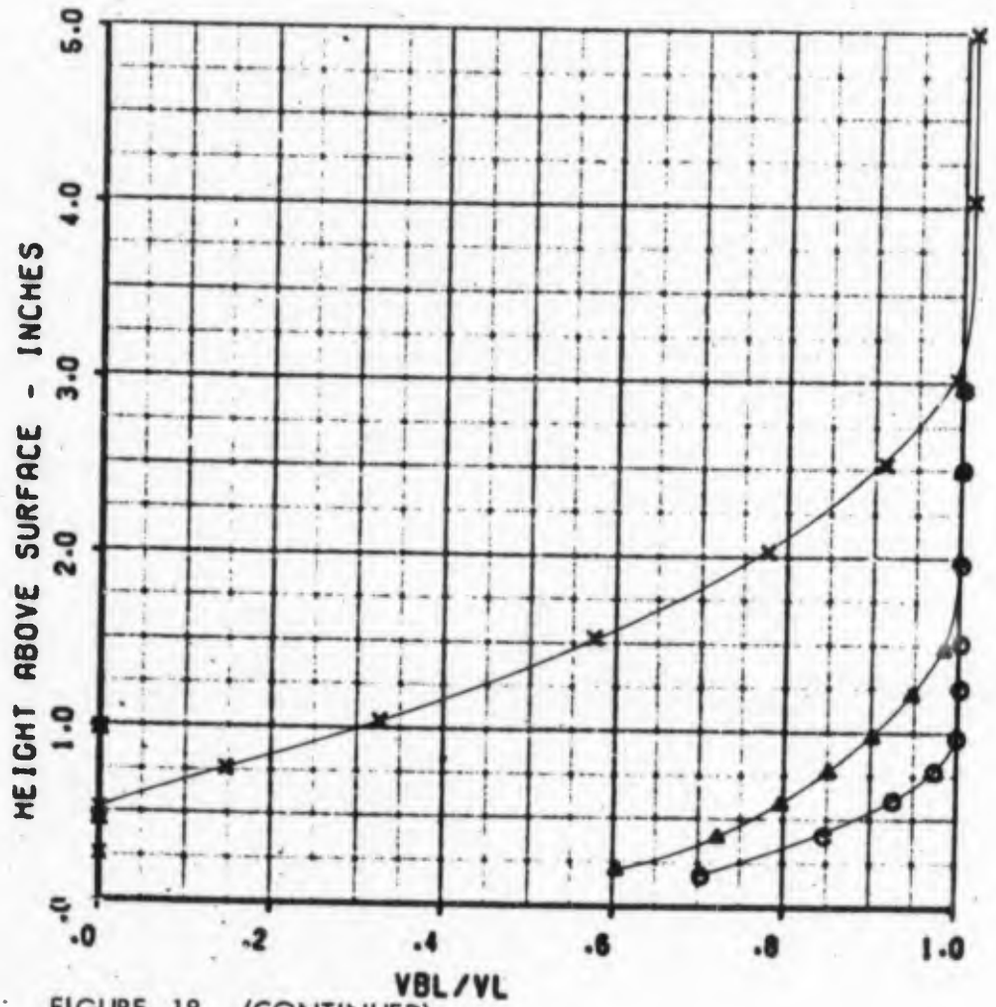
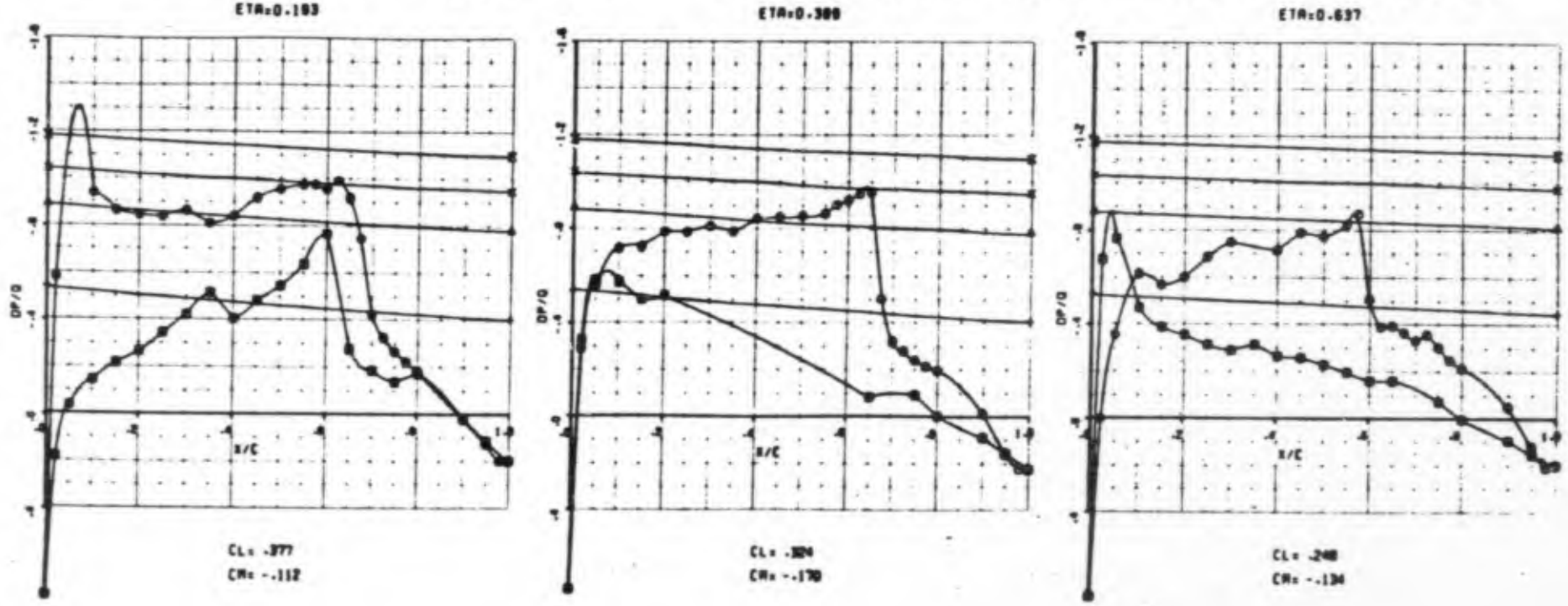


FIGURE 18 (CONTINUED)
(c) CORRECTED ALPHA = -1.62

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	1.86 PSI	ALTITUDE	34560. FT	CO	20.80 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	383	ALPHA	-2.40 DEG	WEIGHT	223300. LB	AILERON POS	.08 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.820	TAM	-57.2 DEG C	NZ	.51	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 3A2
MACH NO .822

RAKE LOCATIONS

⊙ 30 %
▲ 55 %
× 80 %
✱ 80 %(AFT)

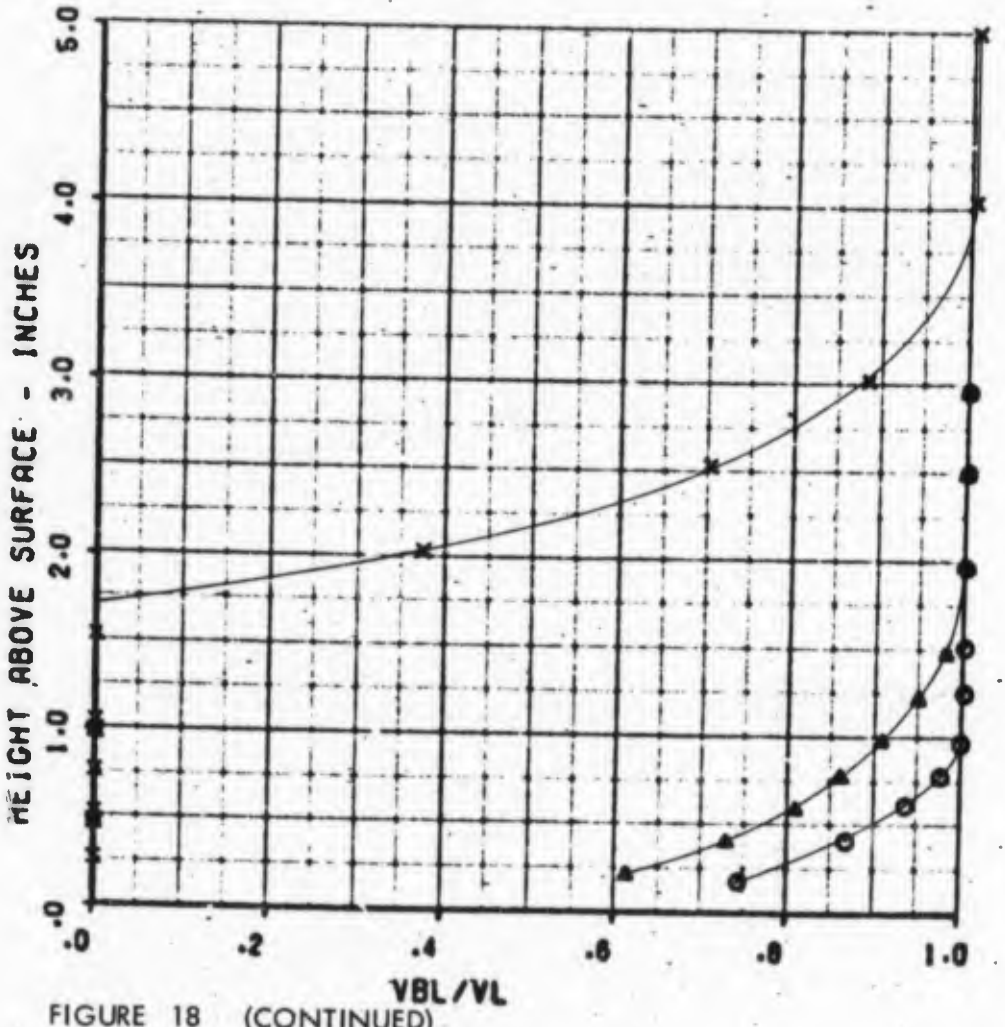
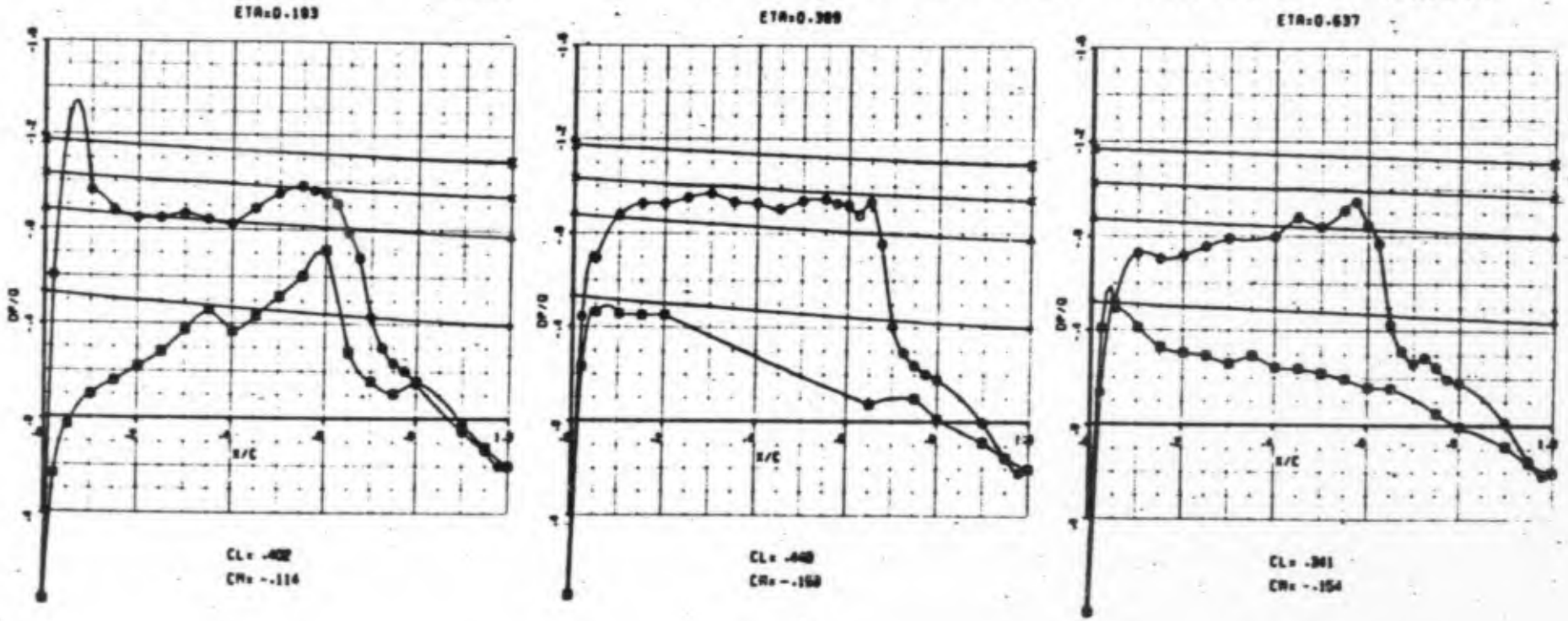


FIGURE 18 (CONTINUED)
(d) CORRECTED ALPHA = -1.27

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	1.83 PSI	ALTITUDE	34970. FT	CG	21.12 % MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	3R2	ALPHA	-2.01 DEG	WEIGHT	224600. LB	AILERON POS	-.42 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.822	TAM	-55.8 DEG C	NZ	.63	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 3A
MACH NO .824

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
⊠ 80 %(AFT)

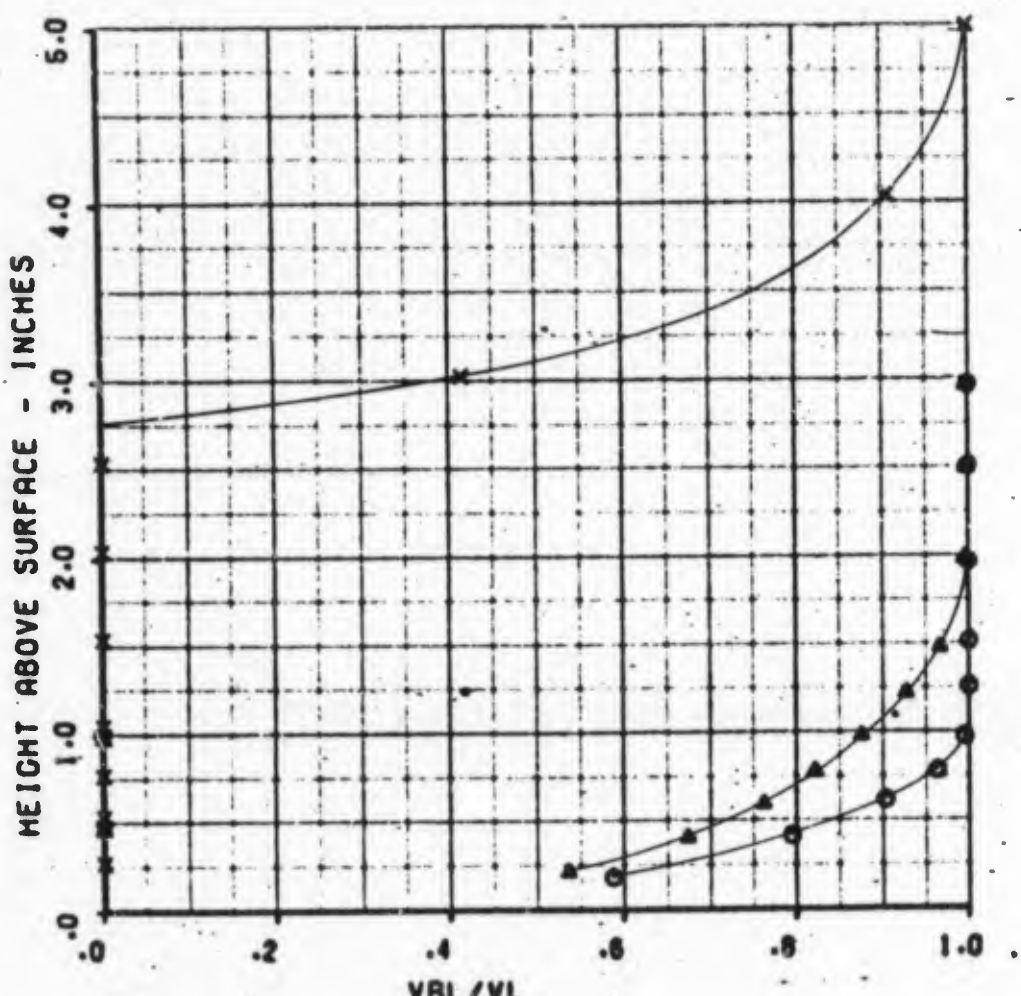
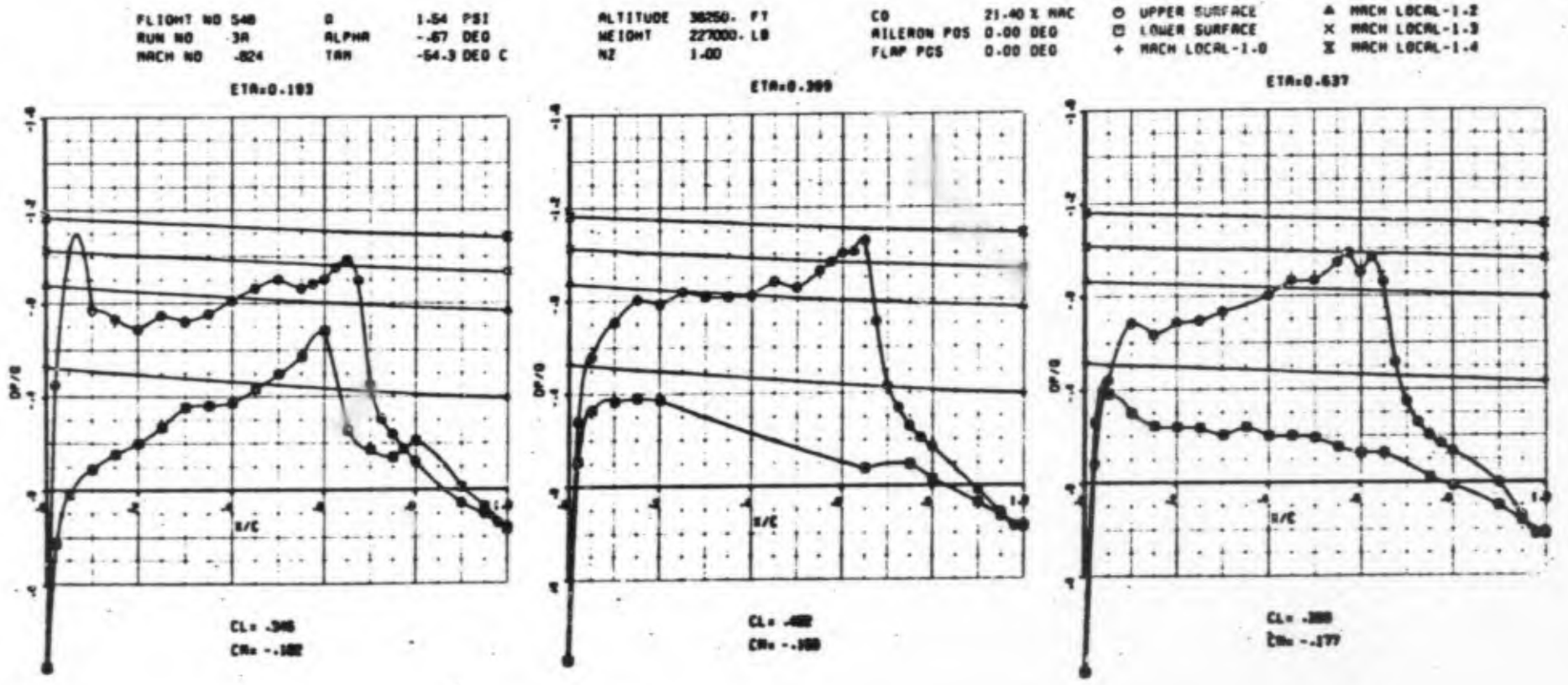


FIGURE 18. (CONTINUED)
(e) CORRECTED ALPHA = -0.10

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3E
MACH NO .825

RAKE LOCATIONS

⊙ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

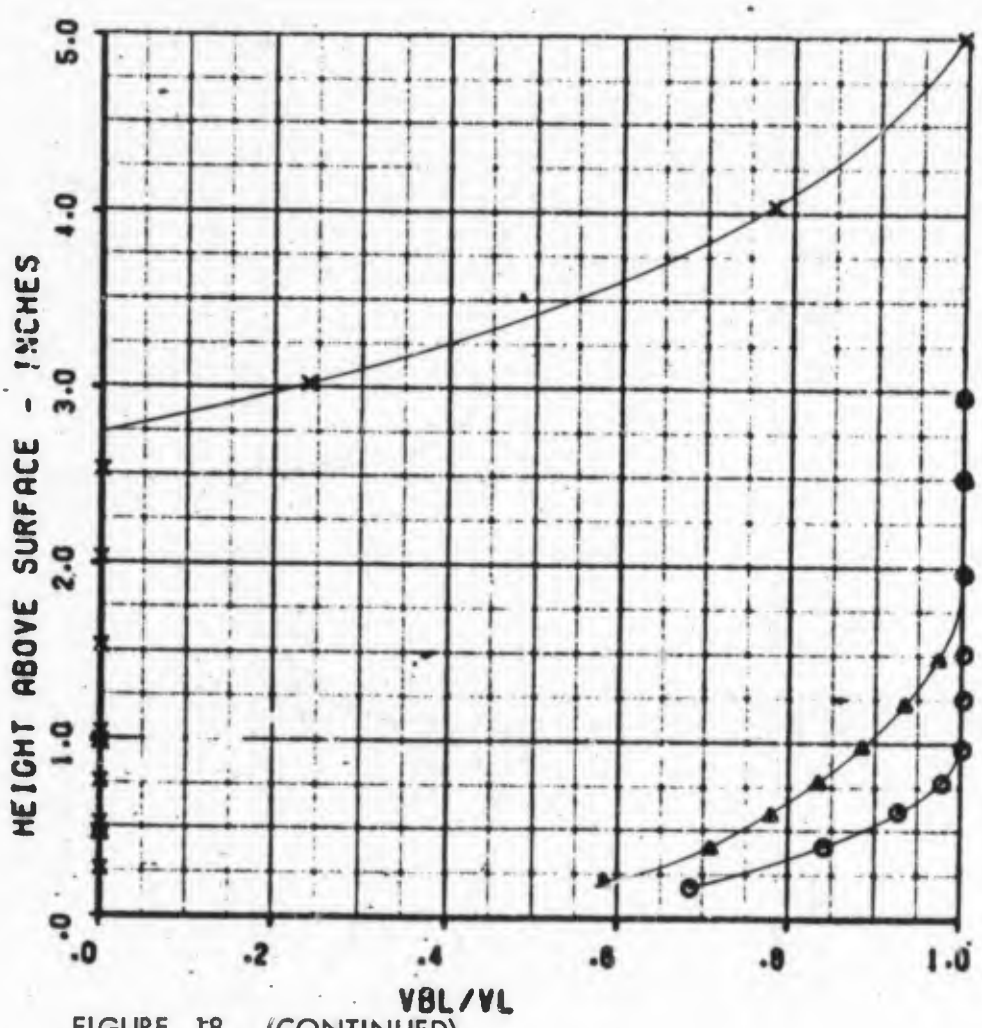
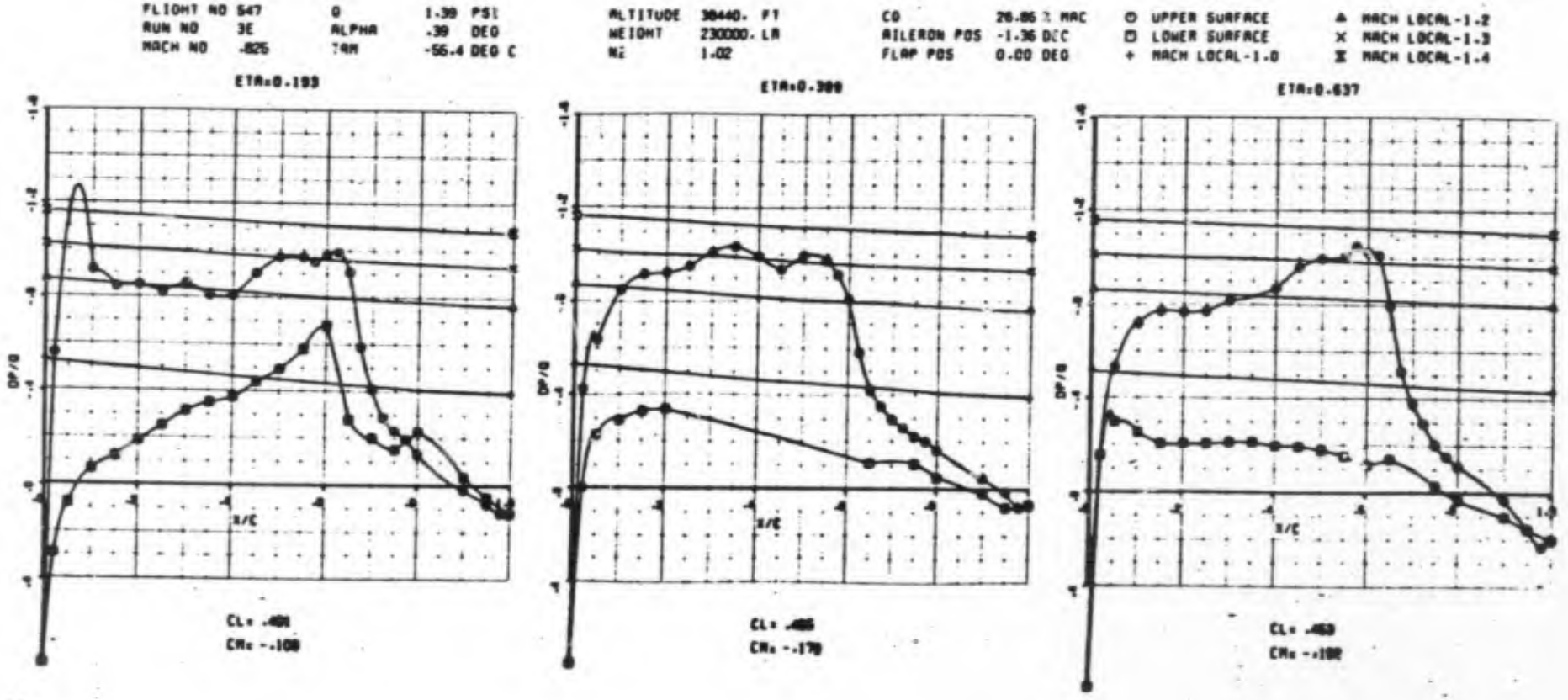


FIGURE 18 (CONTINUED)
(f) CORRECTED ALPHA = 0.83

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 549
RUN NO 2C
MACH NO .820

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

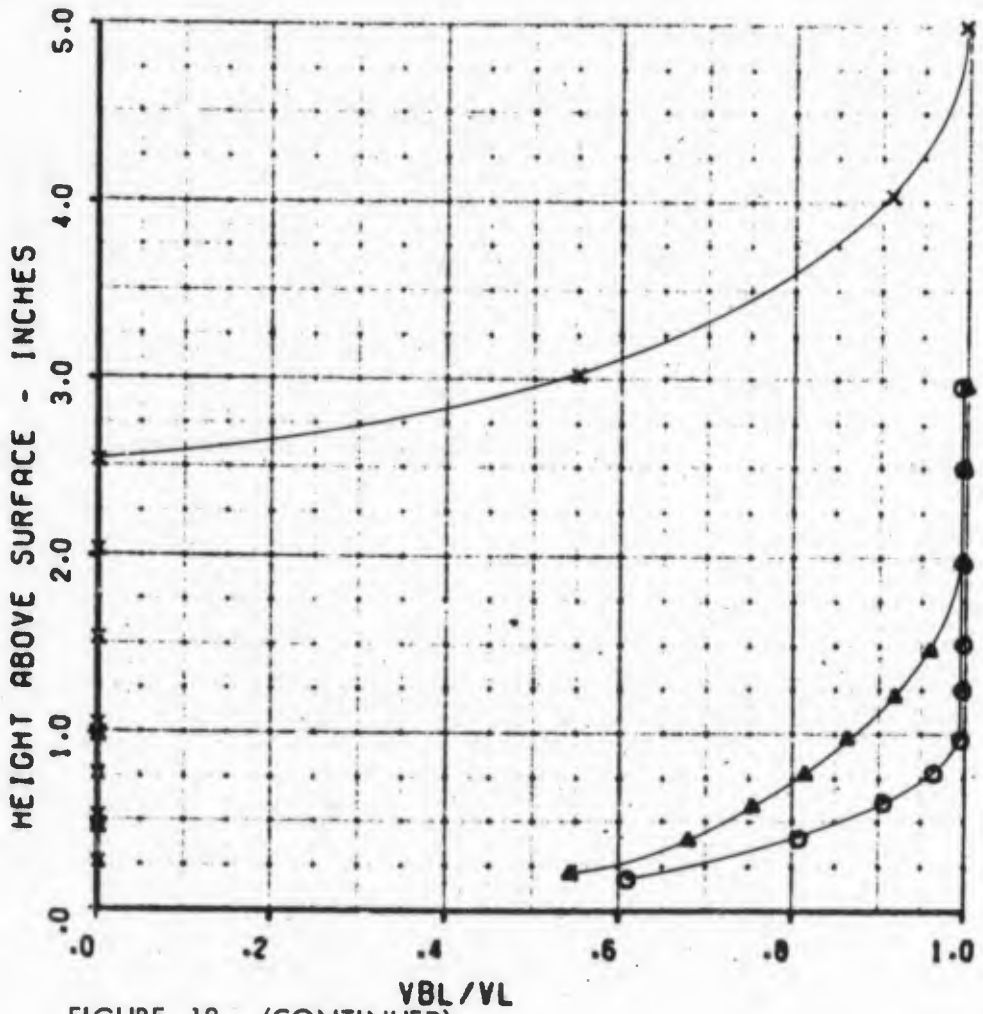


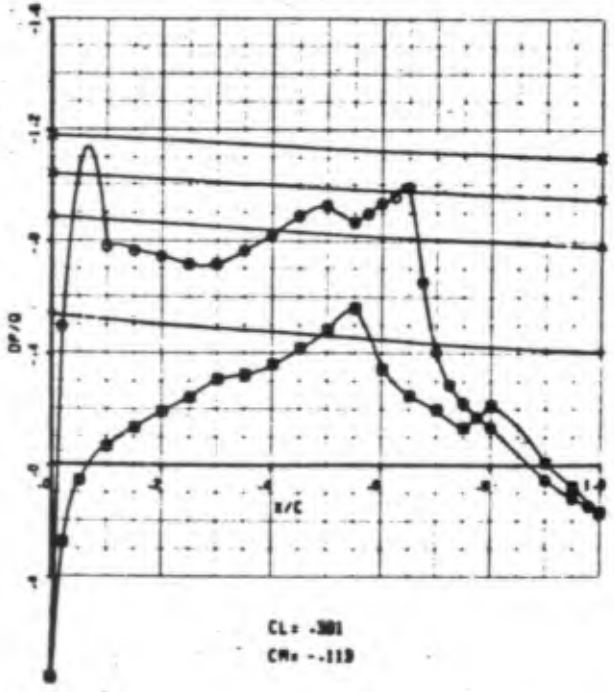
FIGURE 18 (CONTINUED)
(g) CORRECTED ALPHA = 1.10

LOCKHEED C-141A

PRESSURE DISTRIBUTION

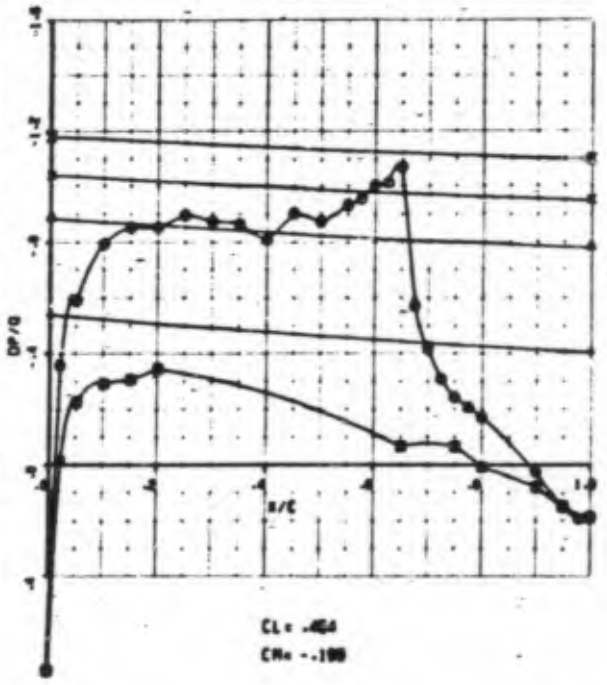
FLIGHT NO	549	Q	1.37	PSI	ALTITUDE	38670.	FT	CG	23.60	% MAC	○ UPPER SURFACE	△ MACH LOCAL-1.2
RUN NO	2C	ALPHA	.68	DEG	WEIGHT	232000.	LB	AILERON POS	.34	DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.820	TAM	-50.0	DEG C	NZ	.98		FLAP POS	0.00	DEG	+ MACH LOCAL-1.0	⧖ MACH LOCAL-1.4

ETA=0.193



CL= .381
CM= -.113

ETA=0.389



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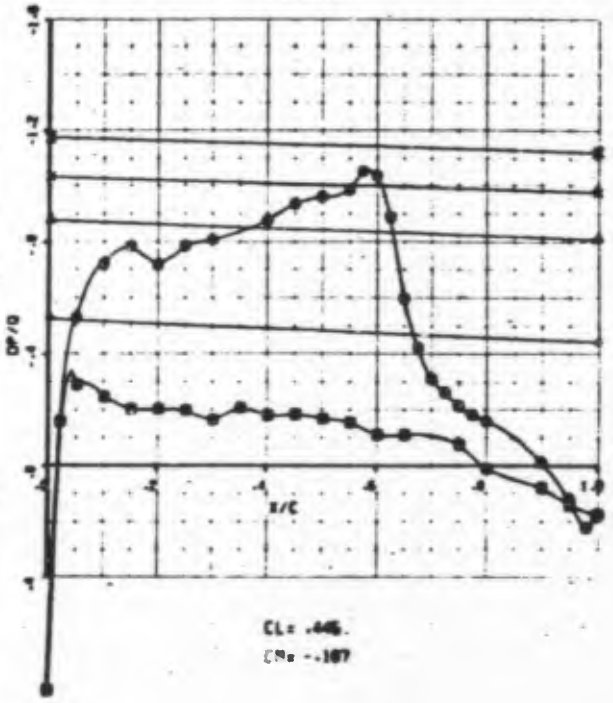
CM= -.108

ETA=0.637



CL= .445
CM= -.107

LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 549
RUN NO 20
MACH NO .830

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

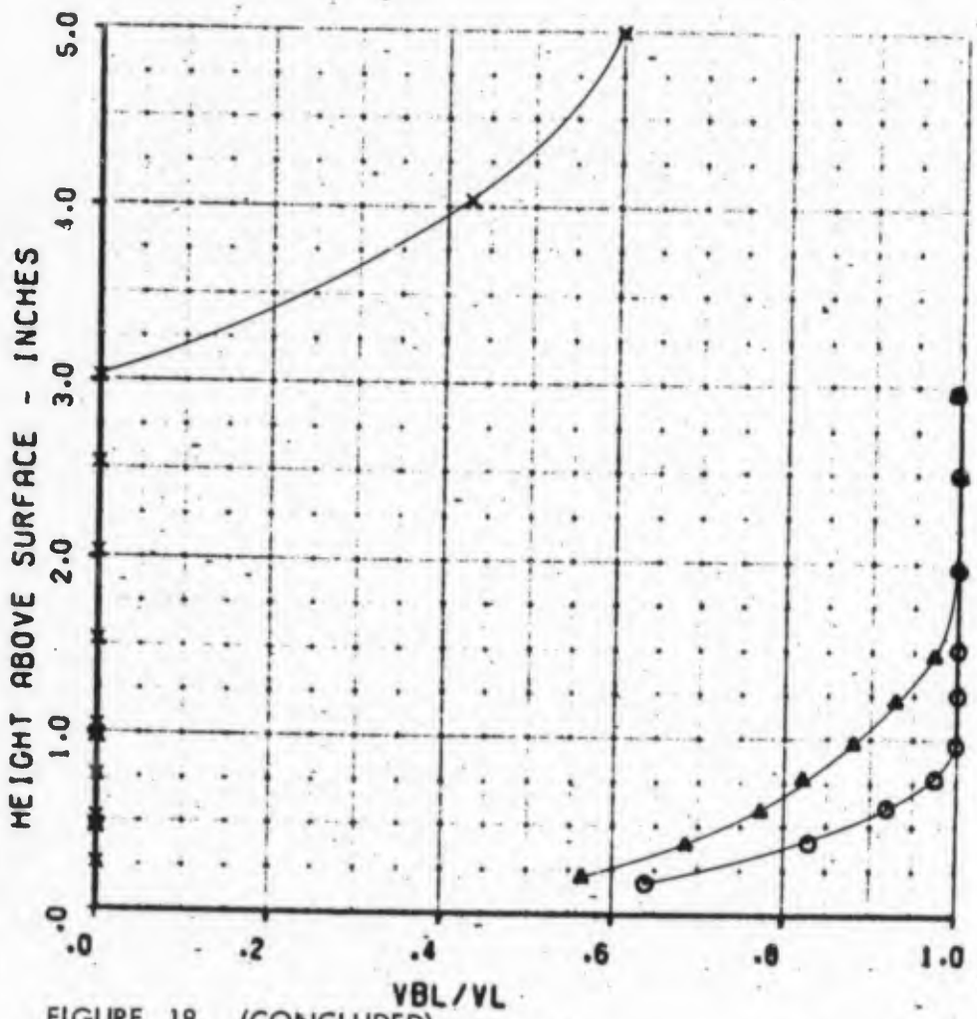
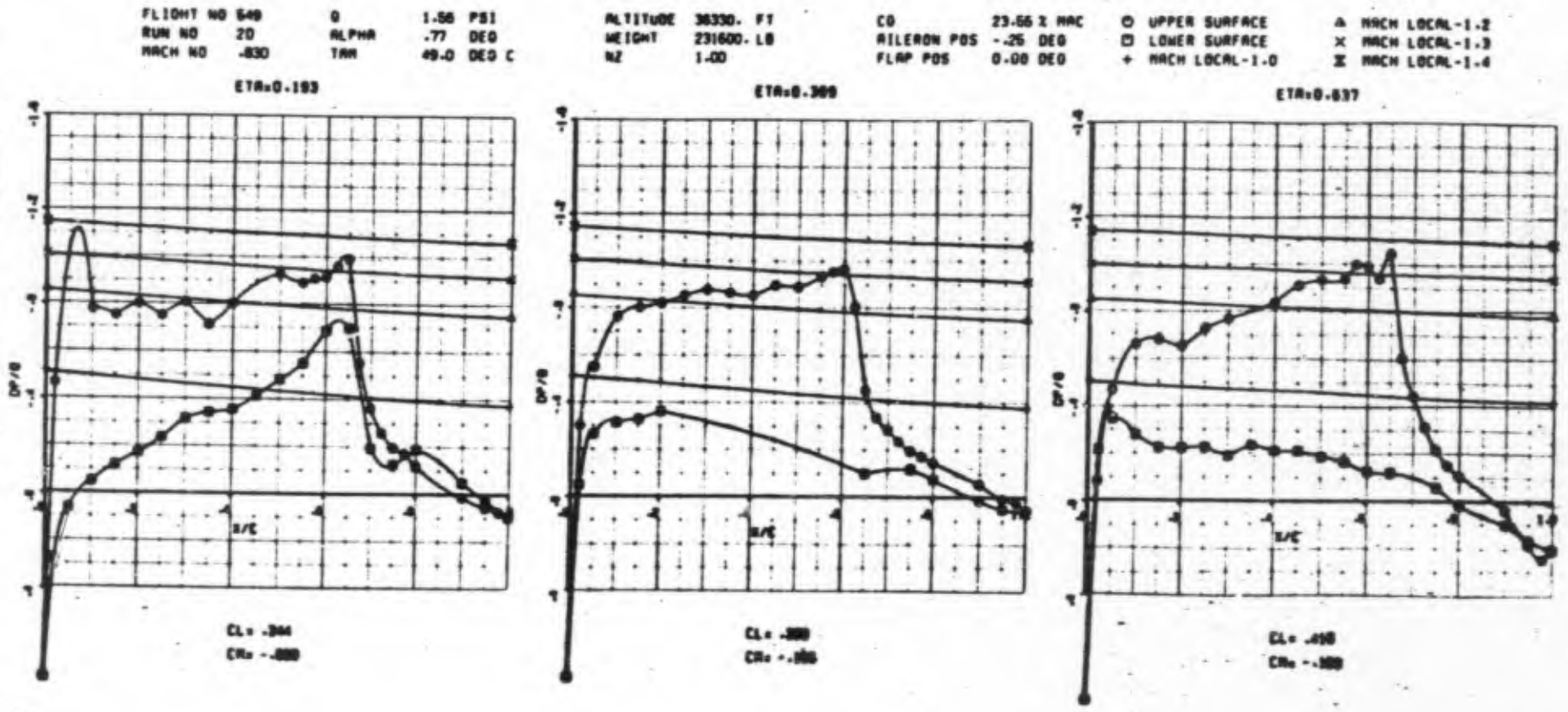


FIGURE 18 (CONCLUDED)
(h) CORRECTED ALPHA = 1.16

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 384
MACH NO .850

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

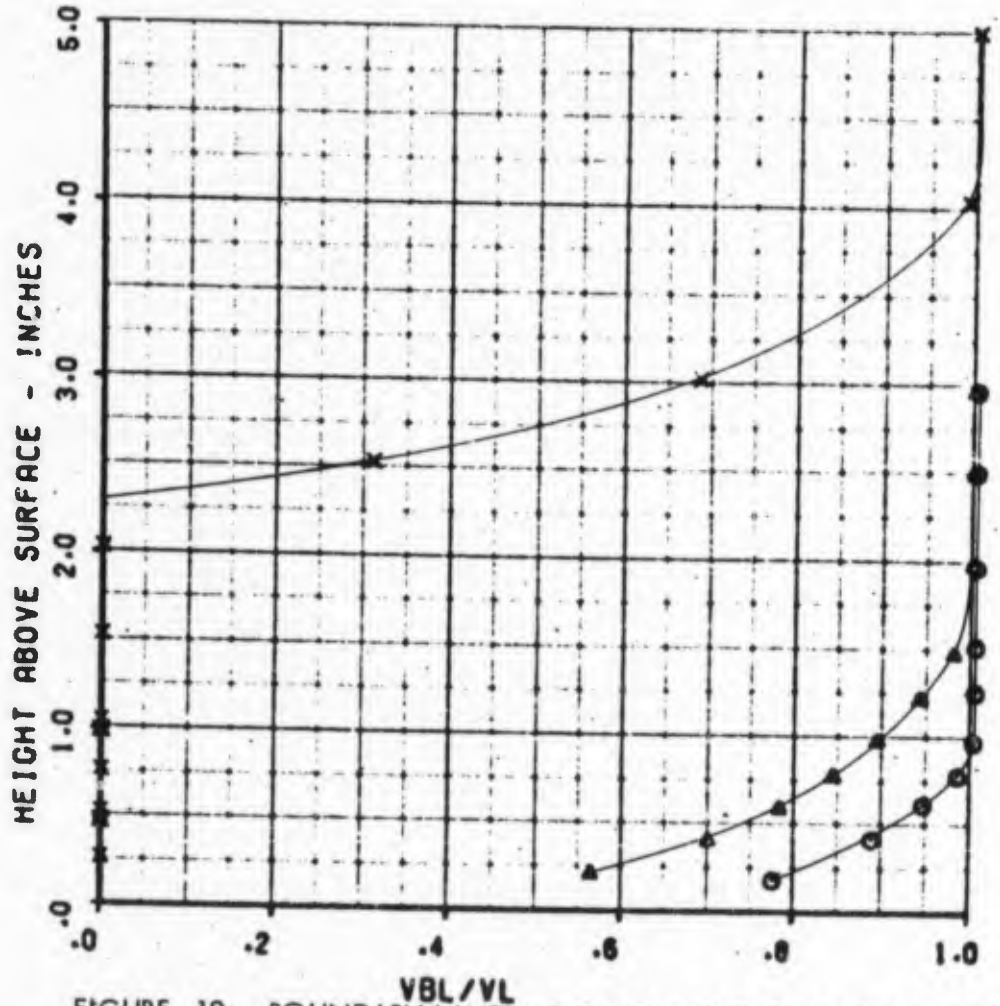


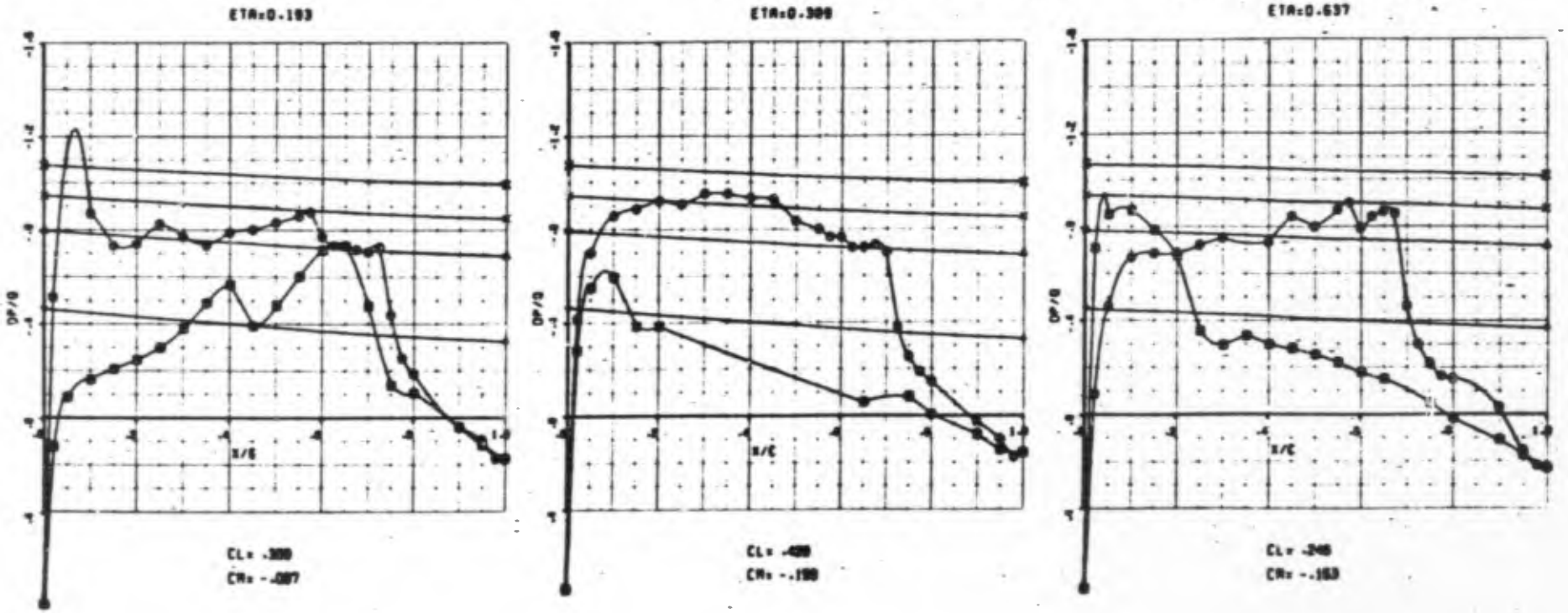
FIGURE 19 BOUNDARY LAYER VELOCITY PROFILES AND PRESSURE DISTRIBUTIONS MACH .840 TO .850

(a) CORRECTED ALPHA = -2.20

LOCKHEED C-141A

PRESSURE DISTRIBUTION

FLIGHT NO	548	Q	1.74 PSI	ALTITUDE	36040. FT	CG	20.00 % MAC	○ UPPER SURFACE	▲ MACH LOCAL-1.2
RUN NO	384	ALPHA	-3.07 DEG	WEIGHT	217000. LB	AILERON POS	.08 DEG	□ LOWER SURFACE	× MACH LOCAL-1.3
MACH NO	.850	TAM	-56.9 DEG C	NZ	.28	FLAP POS	0.00 DEG	+ MACH LOCAL-1.0	⧗ MACH LOCAL-1.4



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 382
MACH NO .850

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

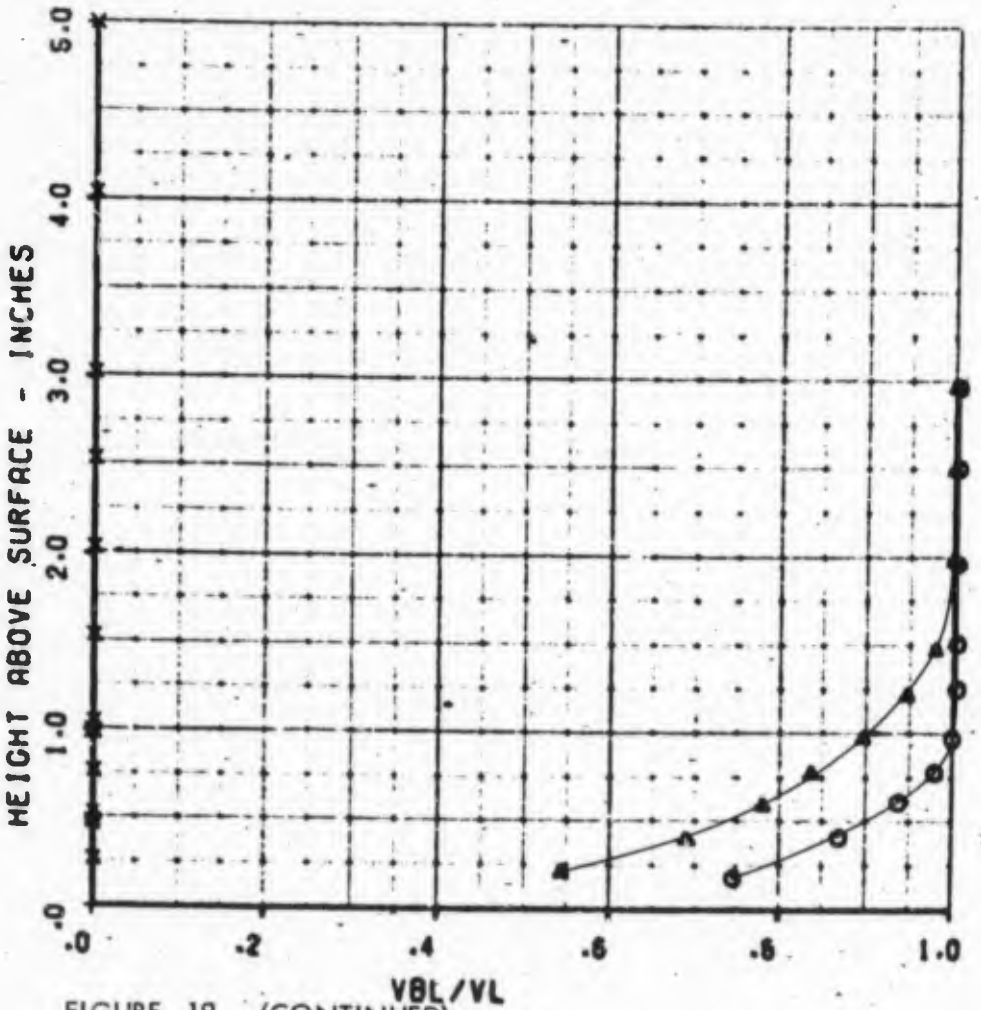
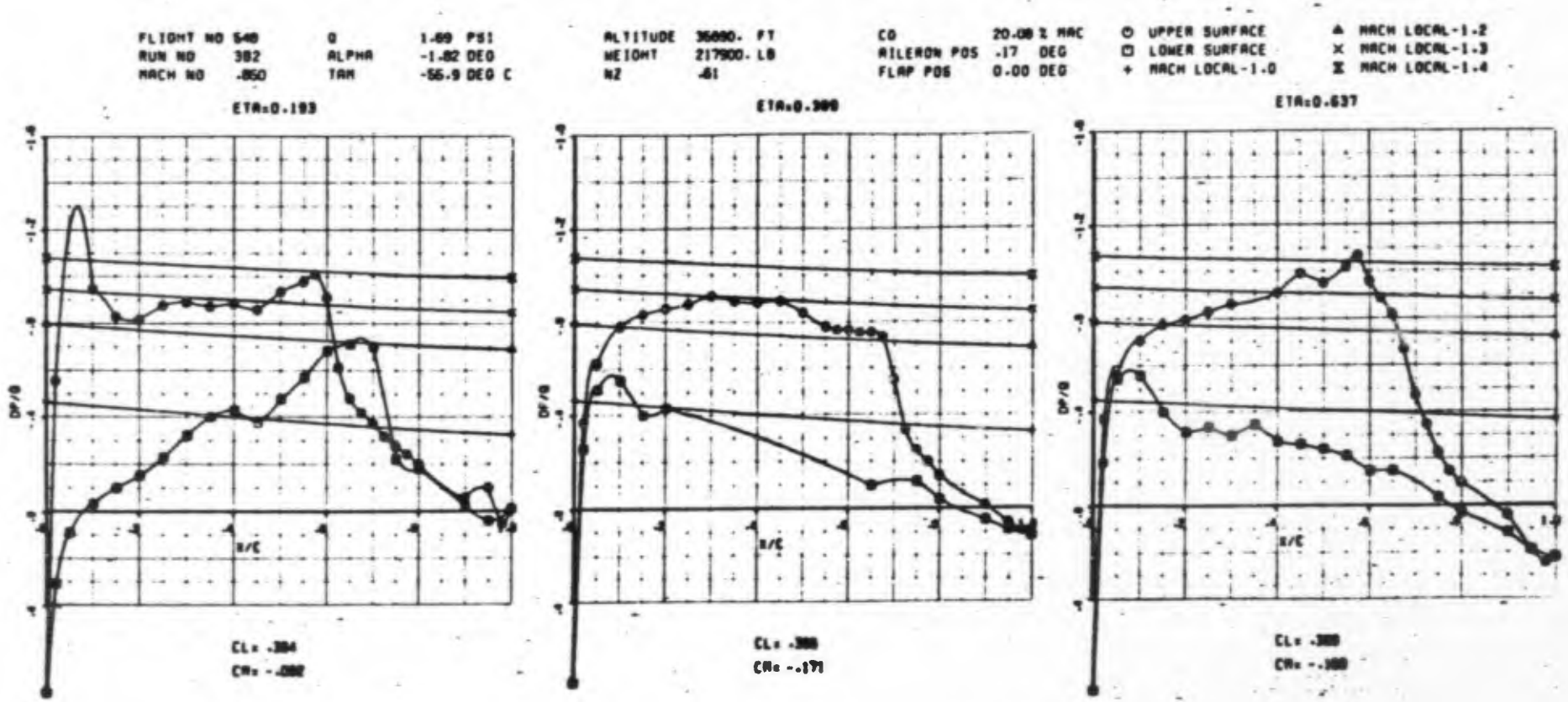


FIGURE 19 (CONTINUED)
(b) CORRECTED ALPHA = -1.12

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 549
RUN NO 2E1
MACH NO .840

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

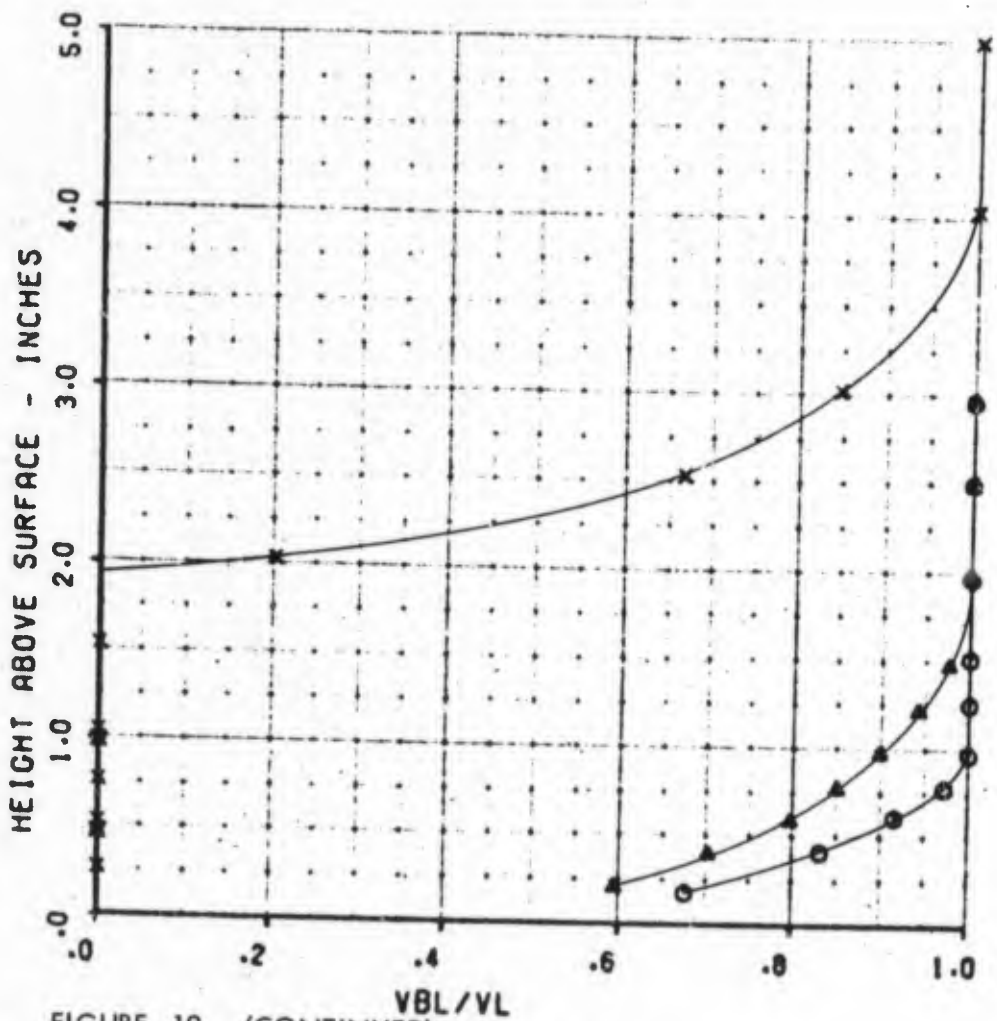
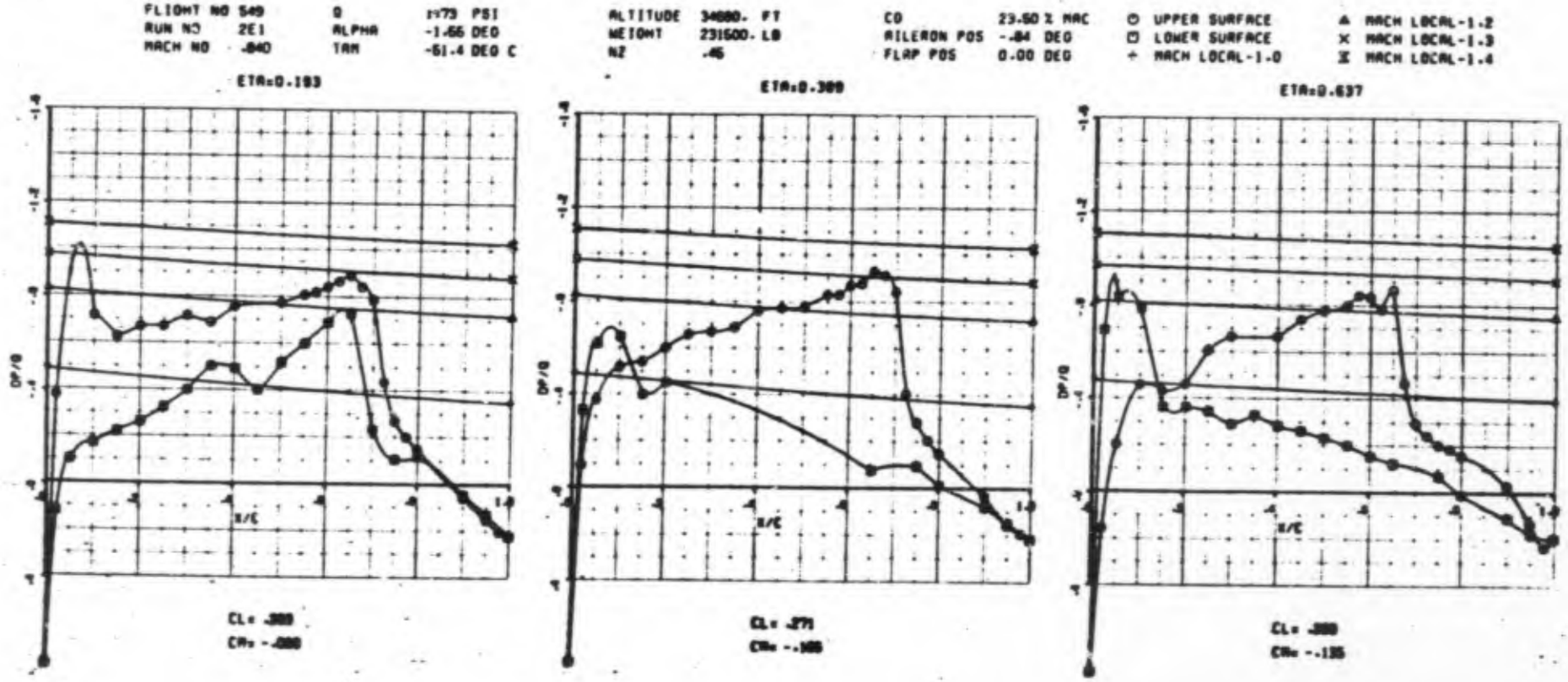


FIGURE 19 (CONTINUED)
(c) CORRECTED ALPHA = -0.87

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 549
RUN NO 2E2
MACH NO .840

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

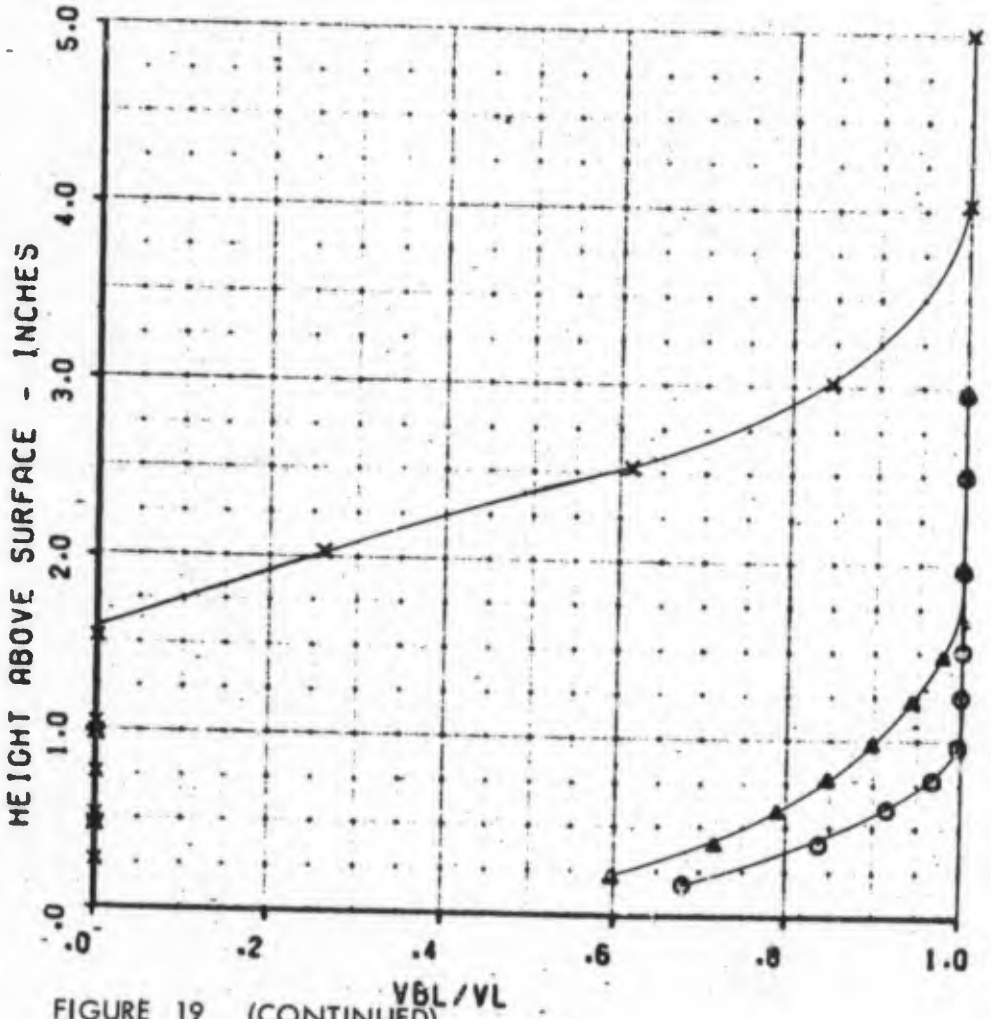
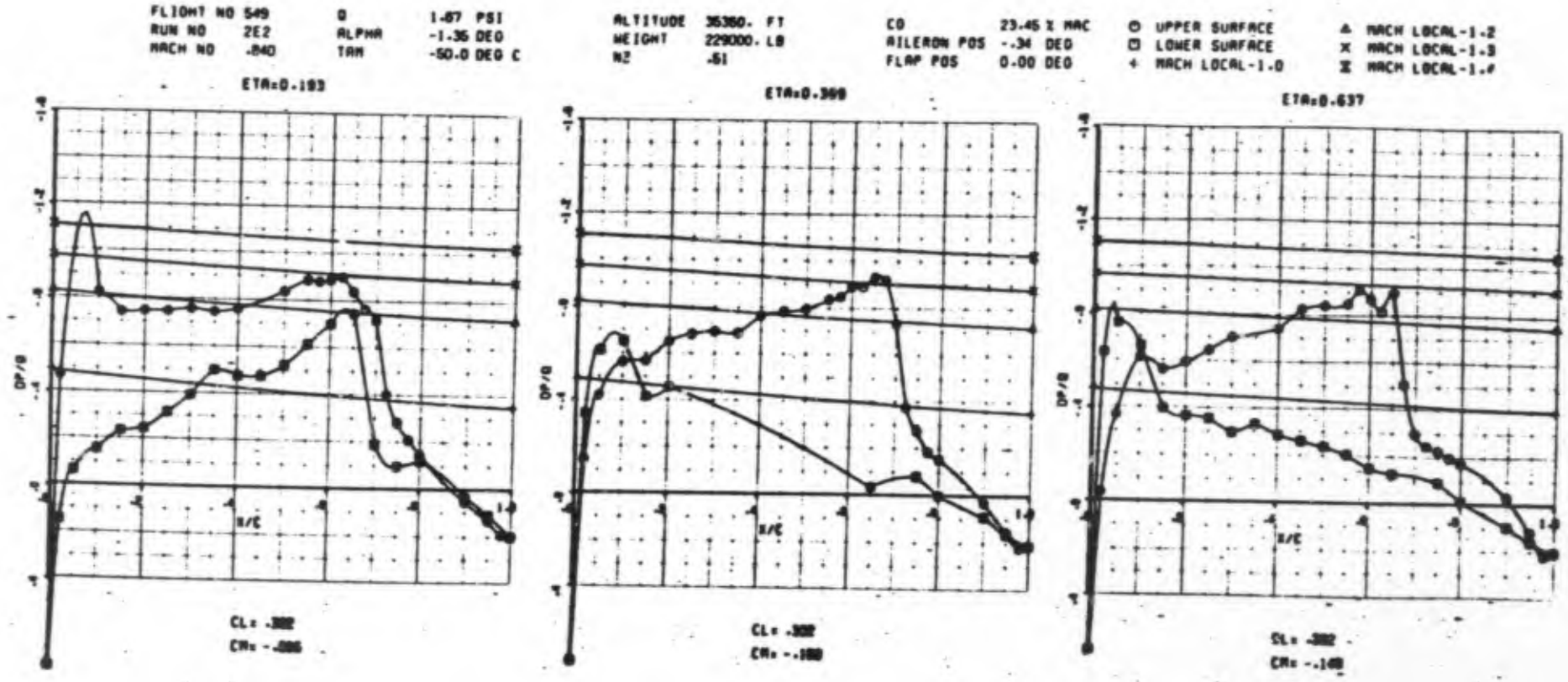


FIGURE 19 (CONTINUED)
(d) CORRECTED ALPHA = -0.70

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 381
MACH NO .848

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

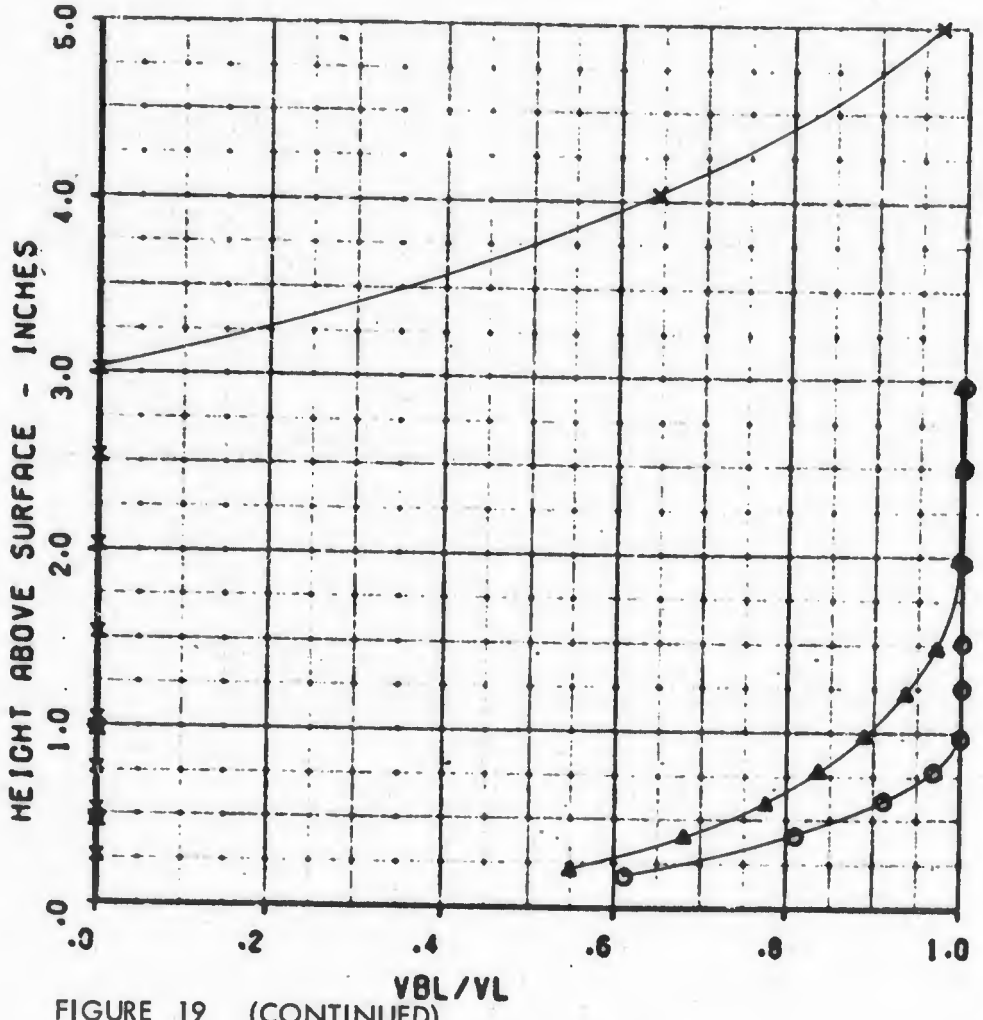
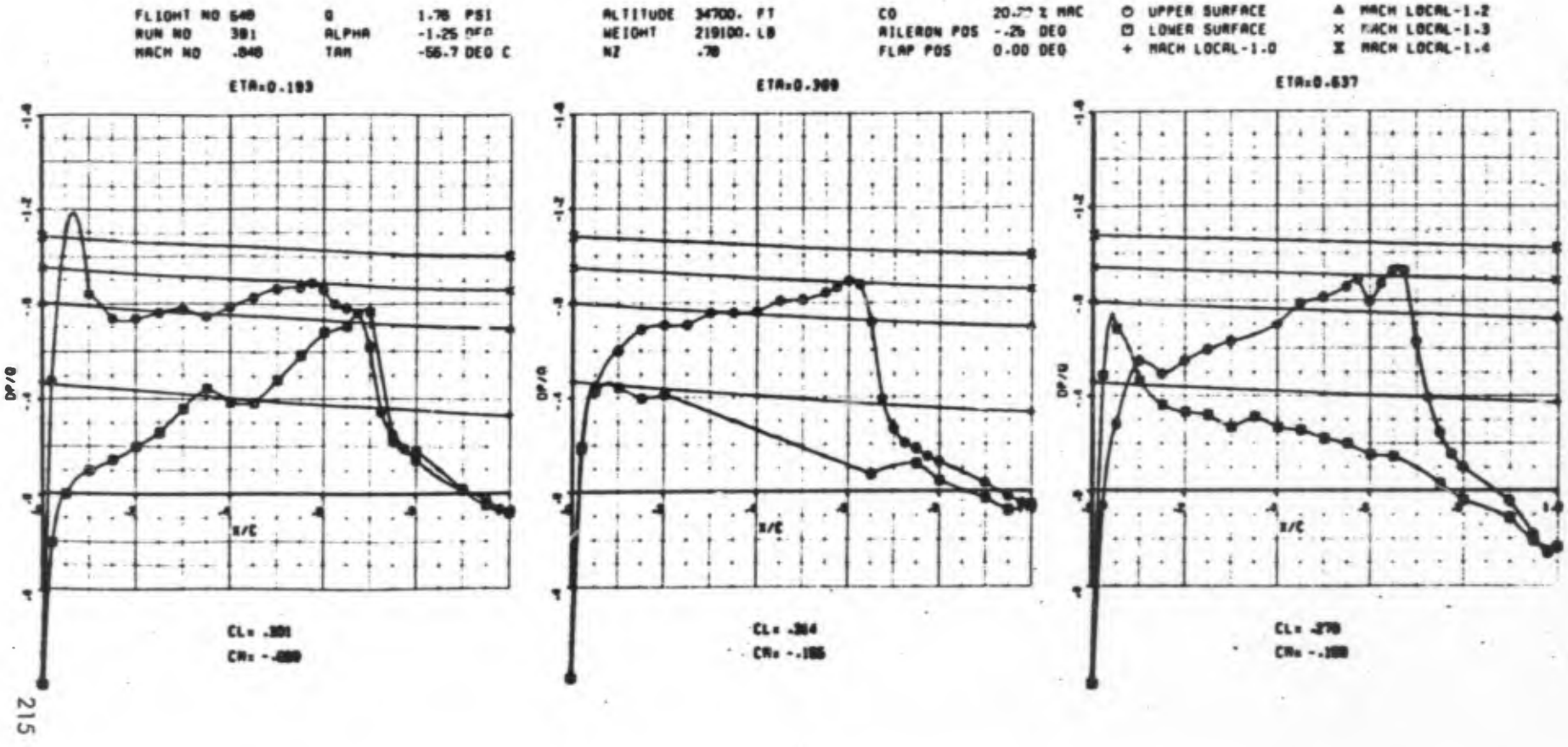


FIGURE 19 (CONTINUED)
(e) CORRECTED ALPHA = -0.60

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 548
RUN NO 38
MACH NO .840

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AFT)

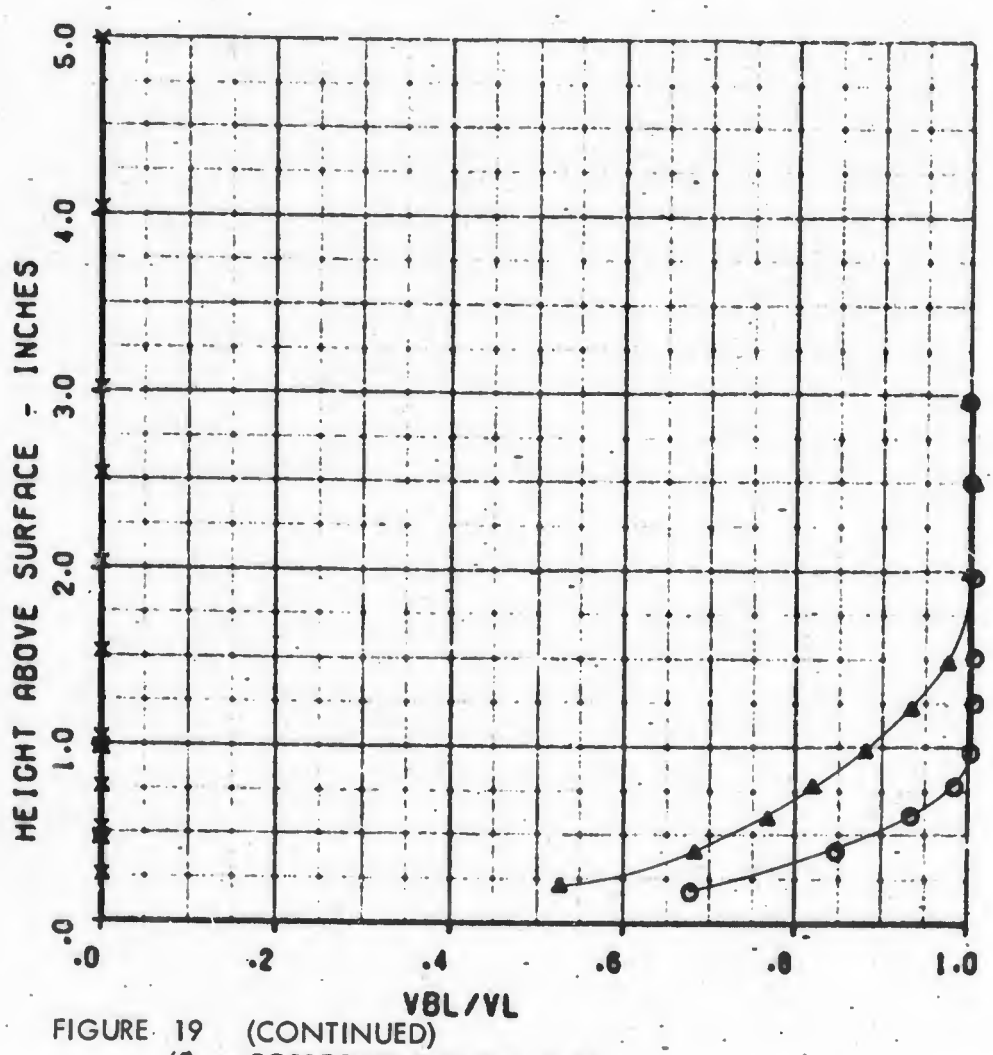
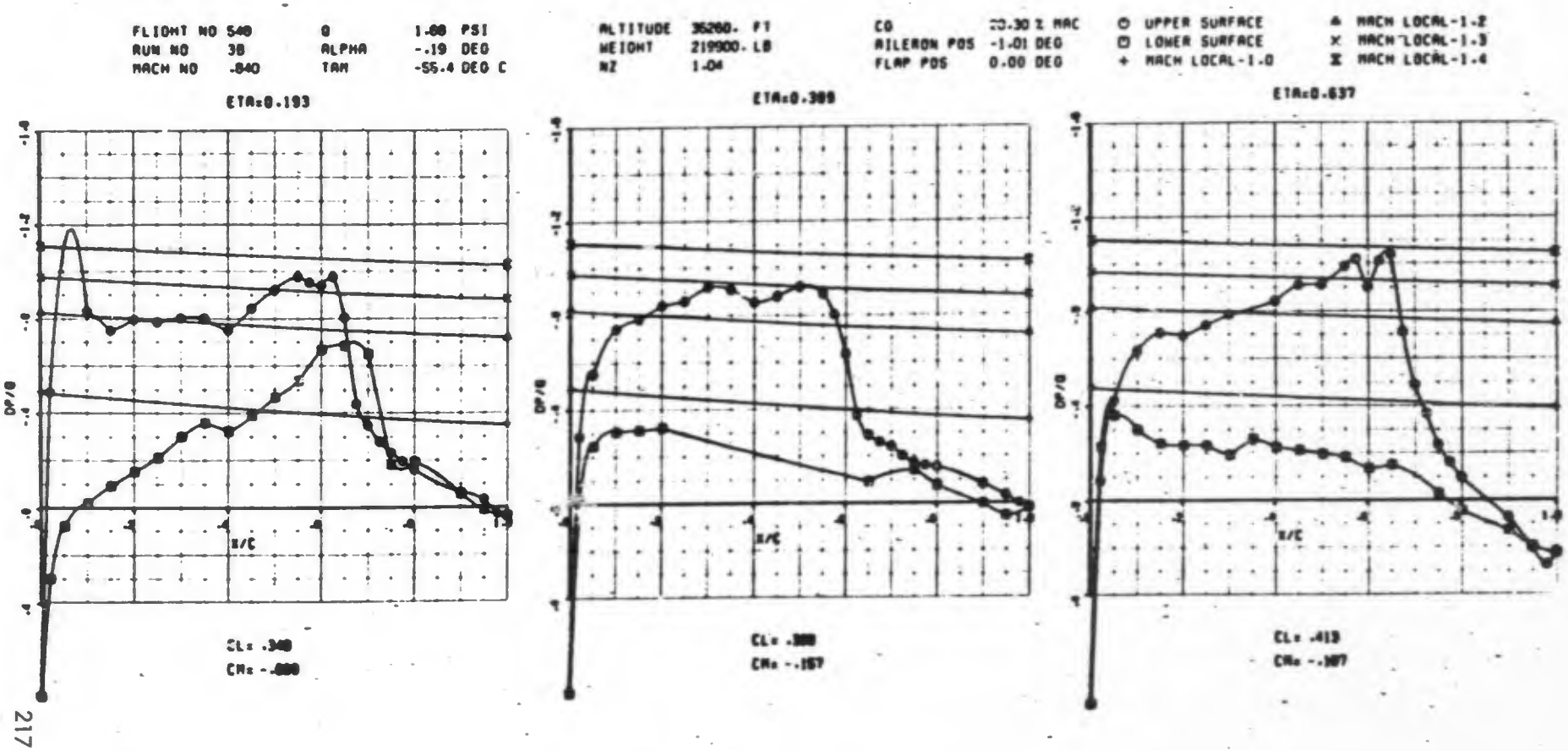


FIGURE 19 (CONTINUED)
(f) CORRECTED ALPHA = 0.31

LOCKHEED C-141A

PRESSURE DISTRIBUTION



LOCKHEED C-141A

BOUNDARY-LAYER RAKE SURVEY

RUN CONDITIONS

FLIGHT NO 547
RUN NO 3F
MACH NO .850

RAKE LOCATIONS

○ 30 %
△ 55 %
× 80 %
✱ 80 %(AET)

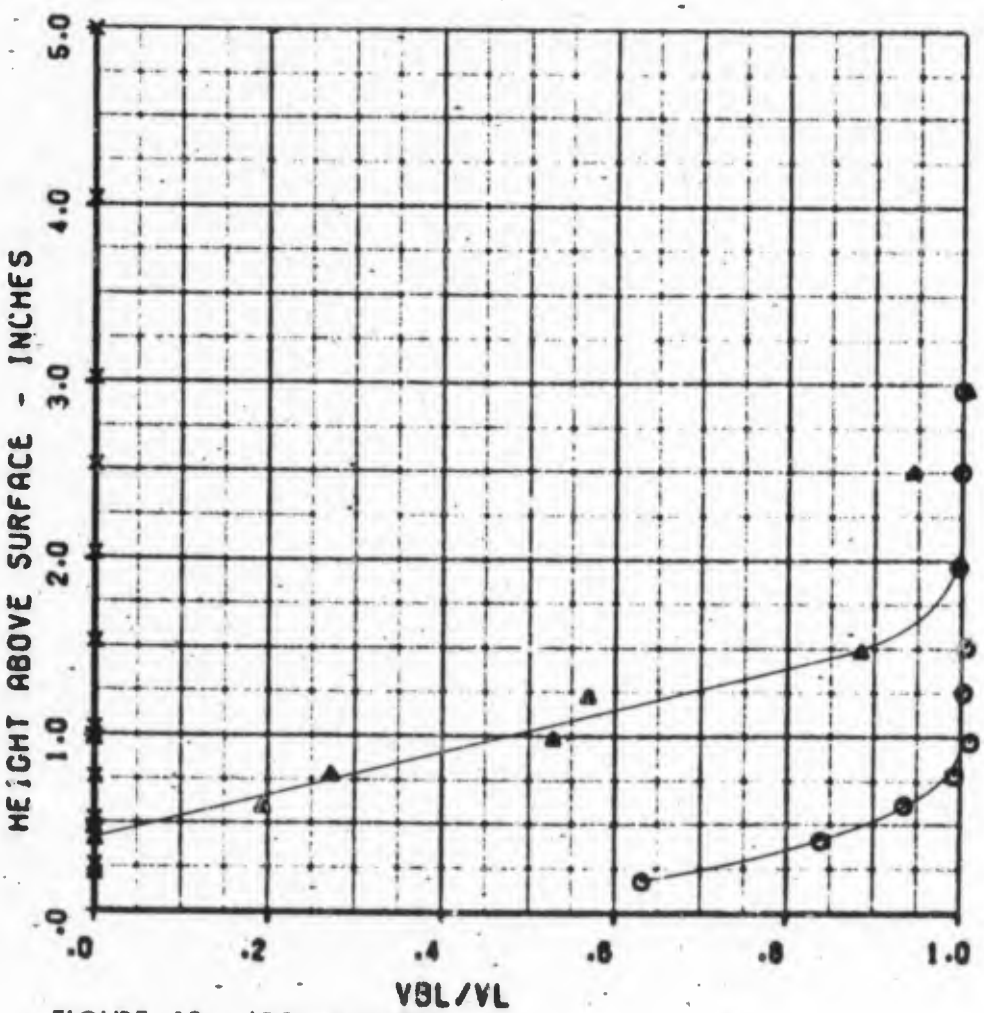
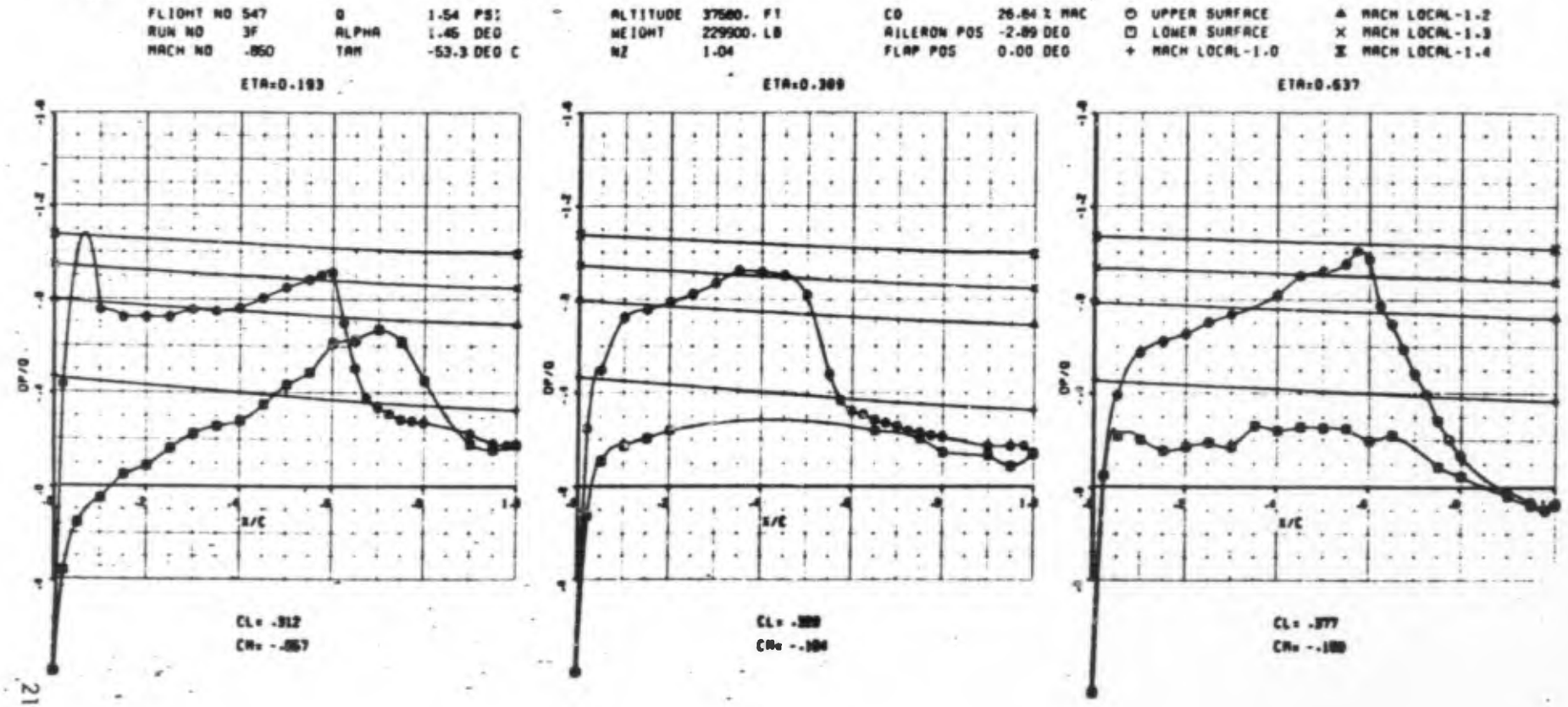


FIGURE 19 (CONCLUDED)
(g) CORRECTED ALPHA = 1.77

LOCKHEED C-141A

PRESSURE DISTRIBUTION



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2. Wright, J. M., "Development of Testing Technique Required to Duplicate Full Scale Wing Shock Location On A Wind Tunnel Model", Lockheed-Georgia Company, LG1T6-1-16, May 1966.

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VOLUME II

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Vol. I - Data Analysis and Discussion Vol. II - Presentation of Basic Data	Air Force Flight Dynamics Laboratory Air Force Systems Command Wright-Patterson Air Force Base, Ohio 45433

13. ABSTRACT

A flight test investigation was made using a Lockheed C-141 airplane to obtain data related to scale effects on transonic shock-boundary layer interactions. The primary measurements consisted of wing surface chordwise pressure distributions at three spanwise stations, and boundary layer profiles for three chordwise positions at one spanwise station.

Volume I contains the data analysis and discussions of the test results. Volume II contains a detailed discussion of the data acquisition and reduction procedures plus a complete presentation of the basic data.

Results obtained, when compared with previously available wind tunnel data, showed that large scale effects on chordwise pressure distribution can occur with turbulent boundary layers on a wing having small Mach number gradients forward of the shock. A shock-induced separation, followed by flow reattachment, was shown to occur when the shock pressure rise reached a value approximately equal to that indicated in NACA Report 1356. For wing sections of the type used on the C-141, scale effects on buffet phenomena should be anticipated also.

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Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Transonic Flow						
Shock Waves						
Boundary Layer Parameters						
Scaling Effects						
Shock Boundary Layer Interaction						
Flight Investigation						
Buffet Analysis						
Wing Static Pressure Distribution						
Shock Induced Separation						
C-141 Airplane						

AFFDL-TR-68-84

JULY 1968

ERRATA

FLIGHT TEST INVESTIGATION OF TRANSONIC SHOCK-BOUNDARY LAYER PHENOMENA

As an unfortunate and unforeseen side effect of the use of a computer-coupled automatic plotting system, the reproduction of some basic data figures in this report is rather poor. The enclosed pages list the section lift and pitching moment coefficients obtained from integration of the surface pressure distributions measured in this program. Section pitching moments are referenced to the section leading edge point.

AIR FORCE FLIGHT DYNAMICS LABORATORY

AIR FORCE SYSTEMS COMMAND

WRIGHT-PATTERSON AIR FORCE BASE, OHIO

FIG. NO.	MACH NO.	ETA .193 C_l	ETA .193 C_m	ETA .389 C_l	ETA .389 C_m	ETA .637 C_l	ETA .637 C_m
8a	.704	.130	-.045	.075	-.082	.034	-.067
8b	.706	.185	-.060	.182	-.106	.136	-.090
8c	.700	.318	-.090	.382	-.141	.291	-.127
8d	.700	.399	-.109	.437	-.169	.394	-.154
8e	.700	.440	-.117	.477	-.177	.447	-.165
8f	.700	.506	-.133	.567	-.200	.525	-.181
9a	.750	.062	-.031	.060	-.082	-.009	-.061
9b	.750	.165	-.056	.172	-.106	.119	-.089
9c	.752	.279	-.080	.302	-.138	.253	-.121
9d	.742	.266	-.077	.268	-.129	.231	-.116
9e	.742	.267	-.079	.271	-.128	.236	-.116
9f	.750	.339	-.096	.371	-.152	.318	-.140
9g	.750	.391	-.107	.415	-.166	.368	-.152
9h	.752	.451	-.120	.480	-.181	.455	-.172
10a	.762	0.0	0.0	0.59	-.085	-.004	-.042
10b	.770	.197	-.062	.149	-.120	.024	-.078
10c	.770	0.0	0.0	.140	-.098	.093	-.082
10d	.770	.172	-.058	.165	-.116	.115	-.091
10e	.770	0.0	0.0	.268	-.129	.220	-.113
10f	.770	.266	-.080	.280	-.140	.239	-.121
10g	.780	0.0	0.0	.366	-.157	.342	-.143
10h	.778	.329	-.094	.347	-.158	.337	-.146
10k	.770	0.0	0.0	.421	-.171	.389	-.155
10l	.772	.359	-.102	.434	-.181	.401	-.162
10m	.772	0.0	0.0	.455	-.177	.421	-.164
10n	.775	.394	-.111	.449	-.181	.420	-.170
11a	.795	0.0	0.0	.081	-.094	.041	-.081
11b	.794	.099	-.033	.193	-.127	-.007	-.069
11c	.794	0.0	0.0	.174	-.114	.133	-.100
11d	.802	.178	-.056	.195	-.134	.126	-.099
11e	.800	.253	-.078	.284	-.150	.228	-.120

FIG. NO.	MACH NO.	ETA .193		ETA .389		ETA .637	
		C_l	C_m	C_l	C_m	C_l	C_m
11f	.802	0.0	0.0	.268	-.136	.221	-.114
11g	.798	.246	-.077	.263	-.139	.198	-.115
11h	.800	.251	-.078	.265	-.135	.232	-.122
11k	.802	0.0	0.0	.351	-.161	.318	-.146
11l	.800	.327	-.098	.366	-.173	.326	-.147
11m	.795	0.0	0.0	.396	-.171	.335	-.141
11n	.800	.343	-.102	.386	-.178	.324	-.149
11o	.800	.374	-.111	.428	-.191	.405	-.172
11p	.802	0.0	0.0	.456	-.196	.403	-.166
12a	.820	.151	-.050	.288	-.151	.034	-.084
12b	.817	0.0	0.0	.089	-.095	-.011	-.072
12c	.820	0.0	0.0	.189	-.126	.086	-.096
12d	.820	.224	-.068	.275	-.163	.119	-.108
12e	.820	0.0	0.0	.258	-.141	.210	-.122
12f	.822	.258	-.083	.284	-.166	.216	-.127
12g	.820	0.0	0.0	.299	-.153	.245	-.130
12h	.822	.294	-.090	.353	-.183	.296	-.154
12k	.822	0.0	0.0	.341	-.170	.338	-.164
12l	.820	.316	-.095	.384	-.191	.341	-.169
12m	.820	.375	-.110	.436	-.195	.348	-.162
12n	.820	0.0	0.0	.413	-.182	.350	-.170
13a	.860	.157	-.045	.070	-.093	-.002	-.097
13b	.855	.222	-.067	.116	-.091	.108	-.124
13c	.845	.273	-.067	.248	-.114	.301	-.167
13d	.840	.332	-.077	.331	-.127	.397	-.185
13e	.844	.348	-.076	.344	-.117	.387	-.171
13f	.840	.363	-.084	.370	-.134	.442	-.194
14a	.690	.212	-.058	.133	-.082	.080	-.070
14b	.695	.254	-.070	.151	-.095	.120	-.079
14c	.700	.352	-.091	.269	-.117	.348	-.130
14d	.700	.537	-.133	.494	-.169	.500	-.169

FIG. NO.	MACH NO.	ETA .193		ETA .389		ETA .637	
		C_l	C_m	C_l	C_m	C_l	C_m
14e	.702	.469	-.122	.486	-.175	.453	-.166
14f	.700	.526	-.134	.559	-.192	.526	-.175
14g	.700	.576	-.144	.651	-.209	.626	-.204
15a	.751	.177	-.053	.101	-.092	.053	-.075
15b	.750	.297	-.086	.149	-.097	.125	-.088
15c	.748	.295	-.088	.255	-.130	.201	-.107
15d	.754	.367	-.105	.267	-.131	.221	-.116
15e	.754	.443	-.125	.423	-.166	.302	-.130
15f	.748	.457	-.126	.521	-.189	.449	-.167
15g	.750	.511	-.136	.586	-.204	.561	-.189
16a	.780	.346	-.102	.237	-.131	.221	-.108
16b	.765	.343	-.099	.366	-.157	.293	-.130
16c	.770	.502	-.146	.426	-.171	.377	-.155
16d	.770	.485	-.135	.531	-.193	.509	-.179
16e	.780	.448	-.127	.513	-.197	.488	-.177
17a	.790	.335	-.099	.115	-.099	.104	-.090
17b	.800	.219	-.068	.229	-.126	.139	-.097
17c	.796	.350	-.107	.320	-.150	.245	-.125
17d	.810	.253	-.079	.286	-.143	.264	-.131
17e	.810	.378	-.113	.379	-.186	.328	-.153
17f	.800	.382	-.111	.359	-.164	.343	-.149
17g	.792	.255	-.078	.216	-.122	.093	-.090
17h	.800	.412	-.121	.497	-.205	.467	-.181
17k	.800	.421	-.125	.494	-.201	.439	-.156
18a	.826	.302	-.087	.427	-.199	.124	-.107
18b	.822	.229	-.071	.285	-.160	.126	-.108
18c	.820	.377	-.112	.324	-.170	.248	-.134
18d	.822	.402	-.114	.440	-.198	.341	-.154
18e	.824	.346	-.102	.442	-.193	.389	-.177
18f	.825	.401	-.109	.456	-.179	.453	-.192
18g	.820	.381	-.113	.464	-.199	.445	-.187
18h	.830	.344	-.088	.390	-.166	.410	-.183

FIG. NO.	MACH NO.	ETA .193		ETA .389		ETA .637	
		C_l	C_m	C_l	C_m	C_l	C_m
19a	.850	.309	-.087	.428	-.193	.246	-.153
19b	.850	.364	-.082	.366	-.171	.388	-.190
19c	.840	.263	-.080	.271	-.166	.200	-.135
19d	.840	.302	-.086	.302	-.180	.262	-.148
19e	.848	.301	-.069	.314	-.155	.279	-.158
19f	.840	.348	-.083	.388	-.157	.413	-.187
19g	.850	.312	-.057	.320	-.104	.377	-.159