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RESULTS FROM INVESTIGATIONS IN THREE NASA/LaRC
 HYPERSONIC WIND TUNNELS ON A .004 SCALE MODEL
 SPACE SHUTTLE ORBITER (MODEL 13P-0) TO DETERMINE
 REAL GAS EFFECTS (LA78, LA87, LA88)

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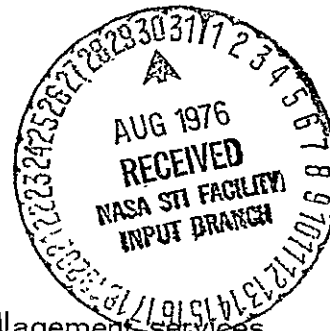
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SPACE SHUTTLE

AEROTHERMODYNAMIC DATA REPORT

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SPACE DIVISION



CHRYSLER CORPORATION

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REAL GAS EFFECTS (LA78, LA87, LA88)

Prepared under NASA Contract Number NAS9-13247

by

Data Management Services
Chrysler Corporation Space Division
New Orleans, La. 70189

for

Engineering Analysis Division
Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas

WIND TUNNEL TEST SPECIFICS:

Test Numbers: LaRC CF4 267, 268, 272, 273;
LaRC 22" 446; LaRC 20" M6 6468
NASA Series Numbers: LA78, LA87, LA88
Model Number: 13P-0
Test Dates: May 21, 1975 through January 29, 1976
Occupancy Hours: 16, 36, 16

FACILITY COORDINATOR:

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Langley Research Center
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Phone: (804) 827-3911

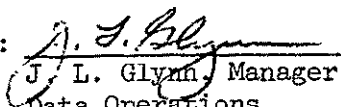
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HYPERSONIC WIND TUNNELS ON A .004 SCALE MODEL
SPACE SHUTTLE ORBITER (MODEL 13P-0) TO DETERMINE
REAL GAS EFFECTS (LA78, LA87, LA88)

ABSTRACT

Results from tests in the NASA/CF₄, 20 inch Mach 6 and the 22 inch Helium Tunnel consist of pressure measurements on the lower surfaces of the Rockwell Space Shuttle Orbiter. All data are in absolute pressures.

Data were recorded with the model at a Mach number of 6 and 20 at angles of attack of 10° to 30°.

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NOMENCLATURE

<u>PLOT SYMBOL</u>	<u>MNEMONIC</u>	<u>DEFINITION</u>
A_b		base area, in. ²
b	BREF	reference span, in.
l_{ref}	LREF	reference length, in.
M	MACH	Mach number
P_{local}	PL	static pressure, millimeters of mercury
P_0	PO, PTOT	total pressure, millimeters of mercury
q	Q(MMH)	dynamic pressure, millimeters of mercury
S_{ref}	SREF	reference area, ft. ²
T	TO, TTOT	temperature, °C
X	XO	longitudinal displacement along centerline, inches
Y	YO	lateral displacement from centerline, inches
Z	ZO	vertical displacement from centerline, inches
α	ALPHA	angle of attack, angle between the projection of the wind Z axis on the body X, Z plane and the body X axis, deg.
β	BETA	sideslip angle, angle between the wind Z axis and the projection of this axis on the body X, Z plane, deg.
RN	RN/L	Reynolds number; per m, per ft.
	ELEVON	elevon deflection angle, degrees
	SPDBRK	speedbrake deflection angle, degrees
	BDFLAP	body flap deflection angle, degrees

INTRODUCTION

A series of wind tunnel tests have been conducted to investigate real-gas effects. Pressures have been obtained on the windward surface of a .004 scale model space shuttle orbiter in three Langley Research Center facilities: the 20-Inch Hypersonic Tunnel (Mach 6), the 22-Inch Helium Tunnel, and the CF₄ Tunnel.

Data are presented at angles of attack from 10° to 30° as absolute pressures (mm of Hg) for Mach numbers of 6 and 20. The Rockwell designation of the model is 13P-0.

CONFIGURATIONS INVESTIGATED

The model used in this test is designated 13P-0. It is constructed to .004 scale Vehicle 2A (modified), with provisions for 19 pressure measurements. Elevon, aileron, rudder and speed brake deflections were all zero. The specific elements of the orbiter vehicle are:

<u>Element</u>	<u>Identifier</u>
Body	B58
Canopy	C5
Elevon	E18
Body Flap	F4
OMS Pods	M3
Rudder	R5
Vertical Tail	V5
Wing	W87

Modifications to the vehicle 2A configuration consisted of removal of the manipulator arm fairings (D7) and alteration of the nose forward of body station 300 to approximate vehicle 3 contours (Drawing VL70-000139B). Dimensional data for these elements are given in table III.

The arrangement and locations of the pressure orifices on the orbiter wing are shown in figure 2. The locations of the pressure orifices on the orbiter wing are given in terms of Full Scale Dimensions of the theoretical wing in figure 2.

TEST CONDITIONS

All data were recorded with the model at 10 to 30 degrees angle of attack and zero degree sideslip. The tunnel conditions during the tests are presented in table I.

TEST FACILITY DESCRIPTIONS

Langley 22-Inch Helium Tunnel;

The test medium is purified helium. Models are mounted on a vertical strut. The nozzle is contoured and the test section is 57.1 cm in diameter. The test core is 20 to 25 cm in diameter and the helium exhausts into a vacuum system. Nominal operating conditions are as follows:

Stagnation pressure, pascals	3.4×10^6 to 24.8×10^6
Stagnation temperature, °K	up to 477
Mach number	20
Reynolds number, per meter	1×10^6 to 4.7×10^6
Running time, sec	80

Langley 20-Inch Hypersonic Tunnel (Mach 6);

Test medium is air. Models are sting mounted on a model injection mechanism. Nozzle blocks are two dimensional and contoured. The test section is 50.8 by 50.8 cm. It exhausts through a movable second minimum into atmosphere with the aid of an annular ejector. Examples of operating conditions are as follows:

Stagnation pressure, pascals	1.4×10^6 to 3.4×10^6
Stagnation temperature, °K	up to 555
Mach number	6
Reynolds number, per meter	1×10^6 to 3.2×10^6
Running time, min	over 15

TEST FACILITY DESCRIPTIONS (Concluded)

Langley CF₄ Tunnel;

Test medium is CF₄ (Tetrafluoromethane). Models are sting mounted on a model injection mechanism. The tunnel has a contoured nozzle and an open jet test section. It exhausts to a vacuum sphere and is reclaimed and purified. Operational conditions are as follows:

Stagnation pressure, pascals	1.0 X 10 ⁷ to 1.7 X 10 ⁷
Stagnation temperature, °K	389 to 666
Mach number	6.1, 6.4
Reynolds number, per meter	.10 X 10 ⁶ to .15 X 10 ⁶
Running time, sec	90

DATA REDUCTION

Data were recorded on facility system and quantity program was used to reduce data to absolute pressure. There were no corrections to the data.

TABLE III.
MODEL DIMENSIONAL DATA

MODEL COMPONENT : Body B58

GENERAL DESCRIPTION : Double Delta Wing Fuselage Per Lines VL70-000093
except nose modified to conform to Vehicle 3 configuration forward of
Station 300 (Station₃₃₈ on Lines VL70-000139)

VL72-000061 VL70-000139

DRAWING NUMBER : VL70-000093

DIMENSIONS :	FULL SCALE	MODEL SCALE
Length, in.	<u>1328.3</u>	<u>5.313</u>
Max Width $X_{.560}$ to $X_{.1307}$, in.	<u>216.0</u>	<u>0.864</u>
Max Depth, in.	<u>239.0</u>	<u>0.956</u>
Fineness Ratio	<u>5.495</u>	<u>5.495</u>
Area	<u> </u>	<u> </u>
Max. Cross-Sectional	<u>319.556</u>	<u>0.005</u>
Planform	<u> </u>	<u> </u>
Wetted	<u> </u>	<u> </u>
Base	<u> </u>	<u> </u>

TABLE III (Continued)

MODEL DIMENSIONAL DATA

MODEL COMPONENT : Canopy - C5

GENERAL DESCRIPTION : 2A Configuration Per NR Lines VL70-000092

Scale Model= .004

DRAWING NUMBER : VL70-000092

DIMENSIONS :	FULL SCALE	MODEL SCALE
Sta. Fwd. Bulkhead	<u>391.00</u>	<u>1.564</u>
Sta. T. E.	<u>560.0</u>	<u>2.240</u>
Canopy Intersects Body ML	<u>391.00</u>	<u>1.564</u>
Fineness Ratio	<u> </u>	<u> </u>
Area	<u> </u>	<u> </u>
Max. Cross-Sectional	<u> </u>	<u> </u>
Planform	<u> </u>	<u> </u>
Wetted	<u> </u>	<u> </u>
Base	<u> </u>	<u> </u>

TABLE III - Continued
MODEL DIMENSIONAL DATA

MODEL COMPONENT : Eleven E-18

GENERAL DESCRIPTION : 2A Configuration Per W-87. NR Lines VL70-000093

Data for (1) of (2) Sides

Model Scale = .004

DRAWING NUMBER VL70-000093

DIMENSIONS	FULL SCALE	MODEL SCALE
Area, FT ²	<u>205.517</u>	<u>0.0033</u>
Span (equivalent), in.	<u>353.34</u>	<u>1.413</u>
Inb'd equivalent chord	<u>114.78</u>	<u>0.459</u>
Outb'd equivalent chord	<u>55.00</u>	<u>0.220</u>
Ratio movable surface chord/ total surface chord	<u> </u>	<u> </u>
At Inb'd equiv. chord	<u>.208</u>	<u>.208</u>
At Outb'd equiv. chord	<u>.400</u>	<u>.400</u>
Sweep Back Angles, degrees	<u> </u>	<u> </u>
Leading Edge	<u>0.00</u>	<u>0.00</u>
Trailing Edge	<u>10.02</u>	<u>10.02</u>
Hingeline	<u>0.00</u>	<u>0.00</u>
Area Moment (Normal to hinge line), FT ³	<u>1548.07</u>	<u>0.00010</u>
Product of area moment	<u> </u>	<u> </u>

TABLE III (Continued)
 MODEL DIMENSIONAL DATA

MODEL COMPONENT : F4 Body Flap

GENERAL DESCRIPTION : 2A Configuration Per NR Lines VL70-000094 "A"

Scale Model = .004

DRAWING NUMBER : VL70-000094A

DIMENSIONS :	FULL SCALE	MODEL SCALE
Length, in.	<u>84.70</u>	<u>0.3388</u>
Max Width, in.	<u>265.00</u>	<u>1.060</u>
Max Depth	<u> </u>	<u> </u>
Fineness Ratio	<u> </u>	<u> </u>
Area	<u> </u>	<u> </u>
Max. Cross-Sectional	<u> </u>	<u> </u>
Planform, ft. ²	<u>142.63715</u>	<u>0.002282</u>
Wetted	<u> </u>	<u> </u>
Base	<u> </u>	<u> </u>

TABLE III. (Continued)
MODEL DIMENSIONAL DATA

MODEL COMPONENT : OMS PODS-M3

GENERAL DESCRIPTION: 2A Light WT Configuration ; per MC120074
Per NR Lines VL70-000094

Scale Model = .004

DRAWING NUMBER : VL70-000094

DIMENSIONS :	FULL SCALE	MODEL SCALE
Length, in.	<u>346.0</u>	<u>1.384</u>
Max Width, in.	<u>108.0</u>	<u>0.432</u>
Max Depth, in.	<u>72.8</u>	<u>0.291</u>
Fineness Ratio	<u> </u>	<u> </u>
Area	<u> </u>	<u> </u>
Max. Cross-Sectional	<u> </u>	<u> </u>
Planform	<u> </u>	<u> </u>
Wetted	<u> </u>	<u> </u>
Base	<u> </u>	<u> </u>

☉ of OMS POD

WP = 463.9 inches FS; $400.0 + 63.9 = 463.90$ INFS
 $1.600 + .2556 = 1.8556$ INMS

BP = 80.0 in. FS; 0.320 INMS

From Fuselage Station 1214.0 to 1560 INFS = 346.0 INFS
 $4.956 \text{ yo } 6.240 = 1.384$ INMS

TABLE III--(Continued)
MODEL DIMENSIONAL DATA

MODEL COMPONENT : Rudder R5

GENERAL DESCRIPTION 2A Configuration Per NR Lines VL70-000095

~~Scale Model~~ .004

DRAWING NUMBER VL70-000095

DIMENSIONS	FULL SCALE	MODEL SCALE
Area, FT ²	<u>98.67</u>	<u>0.0016</u>
Span (equivalent), in.	<u>201.0</u>	<u>0.804</u>
Inb'd equivalent chord	<u>91.585</u>	<u>0.366</u>
Outb'd equivalent chord	<u>50.833</u>	<u>0.203</u>
Ratio movable surface chord/ total surface chord	<u> </u>	<u> </u>
At Inb'd equiv. chord	<u>0.400</u>	<u>0.400</u>
At Outb'd equiv. chord	<u>0.400</u>	<u>0.400</u>
Sweep Back Angles, degrees	<u> </u>	<u> </u>
Leading Edge	<u>34.83314</u>	<u>34.83314</u>
Trailing Edge	<u>26.24915</u>	<u>26.24915</u>
Hingeline	<u>34.83314</u>	<u>34.83314</u>
Area Moment (Normal to hinge line), FT ³ Product of area and mean chord	<u>526.125</u>	<u>0.00003</u>

TABLE III. MODEL COMPONENT DIMENSIONAL DATA (Continued)

MODEL COMPONENT: Vertical Tail V5 (Light Wt. Orbiter config)

GENERAL DESCRIPTION: Center Line Vertical Tail on the Double Delta Configuration with Double Wedge Airfoil and Rounded Leading Edge, Total Data Includes Void Area Listed Below

Scale Model = .004

DRAWING NUMBER: VL70-000095

DIMENSIONS:

	<u>FULL-SCALE</u>	<u>MODEL SCALE</u>
<u>TOTAL DATA</u>		
Area, FT ²	386.05	0.006
Void (included above), FT ²	13.17	0.0002
Blanketed included above, FT ²	12.67	0.0002
Span (equivalent), FT	24.37	0.097
Aspect Ratio	1.590	1.590
Rate of Taper	0.507	0.507
Taper Ratio	0.426	0.426
Dihedral Angle, degrees	--	--
Incidence Angle, degrees	--	--
Aerodynamic Twist, degrees	--	--
Toe-In Angle	0.0	0.0
Cant Angle	0.0	0.0
Sweep Back Angles, degrees		
Leading Edge	45.000	45.000
Trailing Edge	26.249	26.249
0.25 Element Line	41.130	41.130
Chords:		
Root (Wing Sta. 0.0)	257.99	1.032
Tip, (equivalent)	109.78	0.439
MAC	193.84	0.775
Fus. Sta. of .25 MAC	1473.64	5.895
W.P. of .25 MAC	647.31	2.589
B.L. of .25 MAC	0.0	0.0
Airfoil Section		
Root		
Tip		
<u>EXPOSED DATA</u>		
Area		
Span, (equivalent)		
Aspect Ratio		
Taper Ratio		
Chords		
Root		
Tip		
MAC		
Fus. Sta. of .25 MAC		
W.P. of .25 MAC		
B.L. of .25 MAC		

TABLE III. MODEL COMPONENT DIMENSIONAL DATA (Concluded)

MODEL COMPONENT:- Wing W 87-New Light Weight

GENERAL DESCRIPTION: Oribter Configuration per lines VL70-000093

Scale Model= .004

DRAWING NUMBER: VL70-000093

DIMENSIONS: FULL-SCALE MODEL SCALE

TOTAL DATA

Area, FT ² (W.R.P.)		
Planform	2689.38	0.043
Wetted		
Span (equivalent)	77.12	0.308
Aspect Ratio	2.214	2.214
Rate of Taper	1.176	1.176
Taper Ratio	0.209	0.209
Dihedral Angle, degrees @ 75.33% line	3.860	3.860
Incidence Angle, degrees @ $4.25 \frac{1}{2}$ to $1.00 \frac{1}{2}$	3.000	3.000
Aerodynamic Twist, degrees	--	--
Toe-In Angle	--	--
Cant Angle	--	--
Sweep Back Angles, degrees		
Leading Edge	44.873	44.873
Trailing Edge	10.242	10.242
0.25 Element Line	35.050	35.050
Chords:		
Root (Wing Sta. 0.0)	690.19	2.761
Tip, (equivalent)	144.30	0.577
MAC	476.76	1.907
Fus. Sta. of .25 MAC	1136.12	4.544
W.P. of .25 MAC	289.44	1.158
B.L. of .25 MAC	181.03	0.724
Airfoil Section		
Root		
Tip		

EXPOSED DATA

Area, FT ²	1746.87	.0279
Span, (equivalent)	59.16	0.237
Aspect Ratio	2.004	2.004
Taper Ratio	0.256	0.256
Chords		
Root	562.77	2.251
Tip	144.30	0.577
MAC	394.81	1.579
Fus. Sta. of .25 MAC	1185.17	4.741
W.P. of .25 MAC	291.56	1.166
B.L. of .25 MAC	250.54	1.002

LEADING EDGE CUFF (data for (1) side)

Plan form area, FT ² (BP 108.0)	120.333	0.0019
L.E. Intersect Fus ML STA	560.0	2.240
L.E. Intersects Wing STA	1035.0	4.140

Notes:

1. Positive directions of force coefficients, moment coefficients, and angles are indicated by arrows
2. For clarity, origins of wind and stability axes have been displaced from the center of gravity

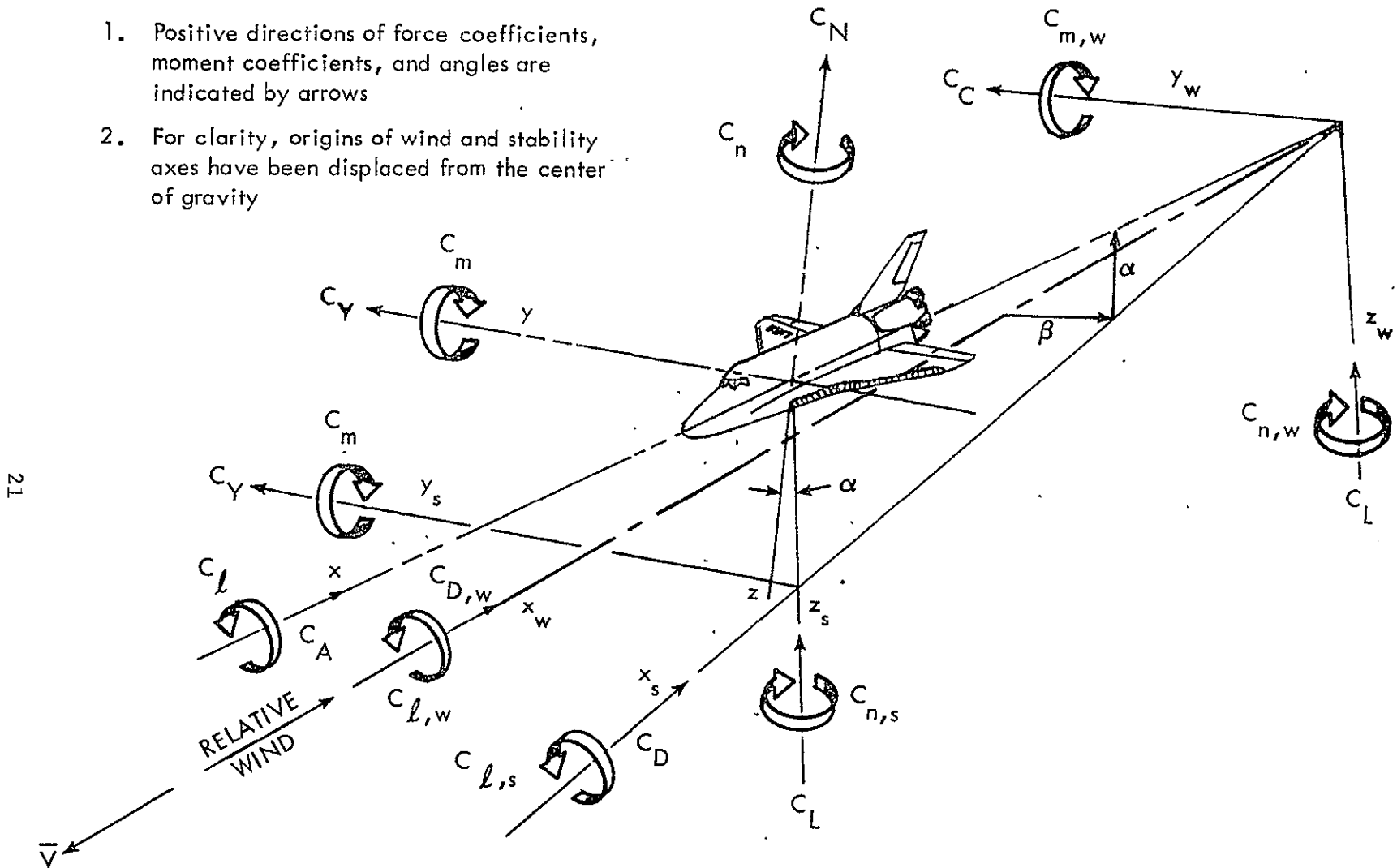
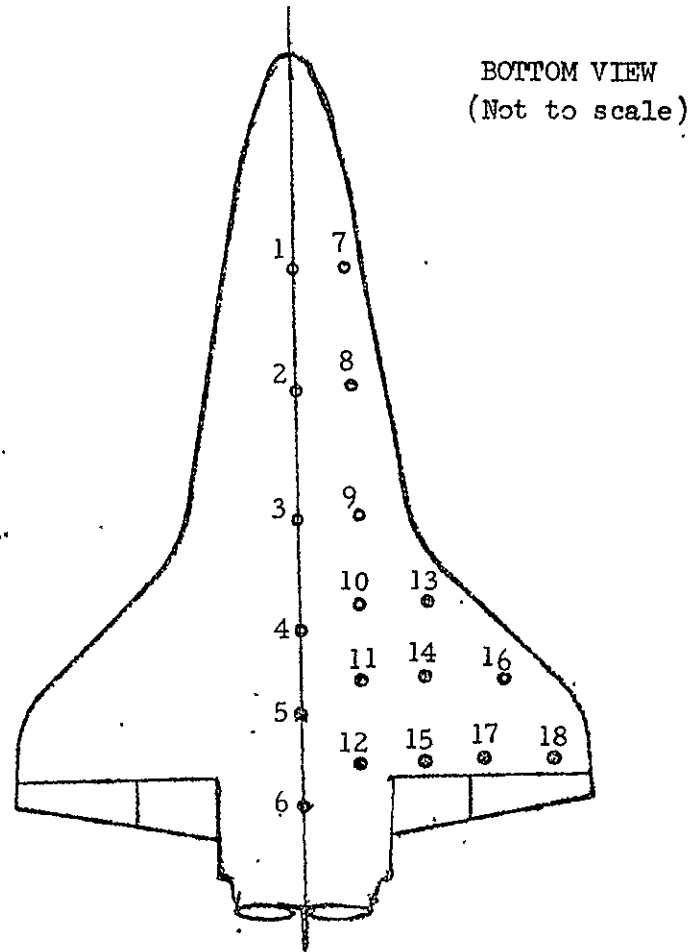
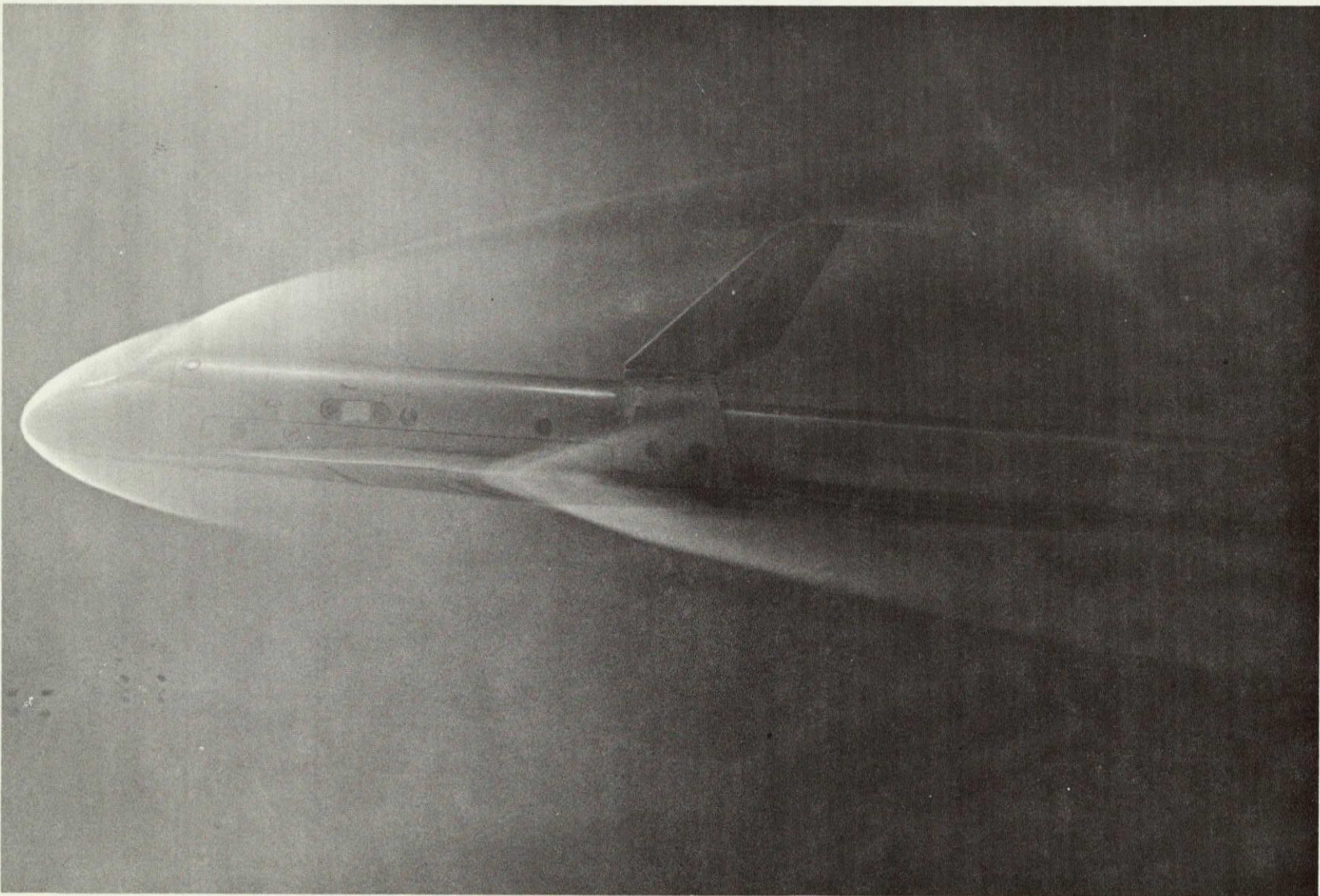


Figure 1. - Axis systems.

ORIFICE NUMBER	X _O , in. F.S.	Y _O , in. F.S.
1	361.0	0.0
2	527.0	0.0
3	782.0	0.0
4	982.0	0.0
5	1102.0	0.0
6	1282.0	0.0
7	364.0	93.0
8	530.0	100.0
9	784.0	107.0
10	911.0	114.0
11	1049.0	114.0
12	1200.0	114.0
13	913.0	236.0
14	1046.0	251.0
15	1200.0	202.0
16	1041.0	365.0
17	1200.0	317.0
18	1202.0	411.0

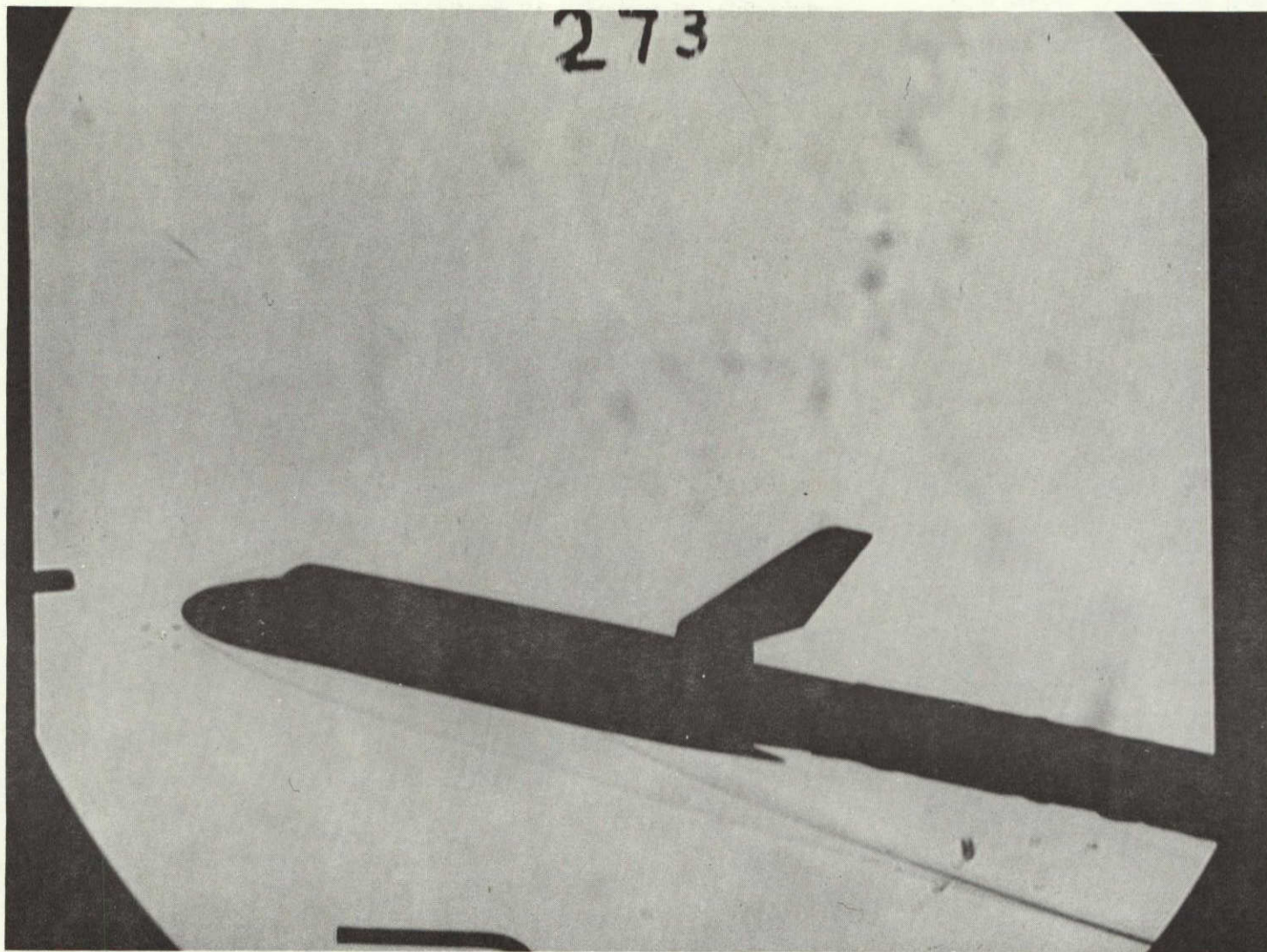


a. Pressure Tap Location
Figure 2. - Model Sketches

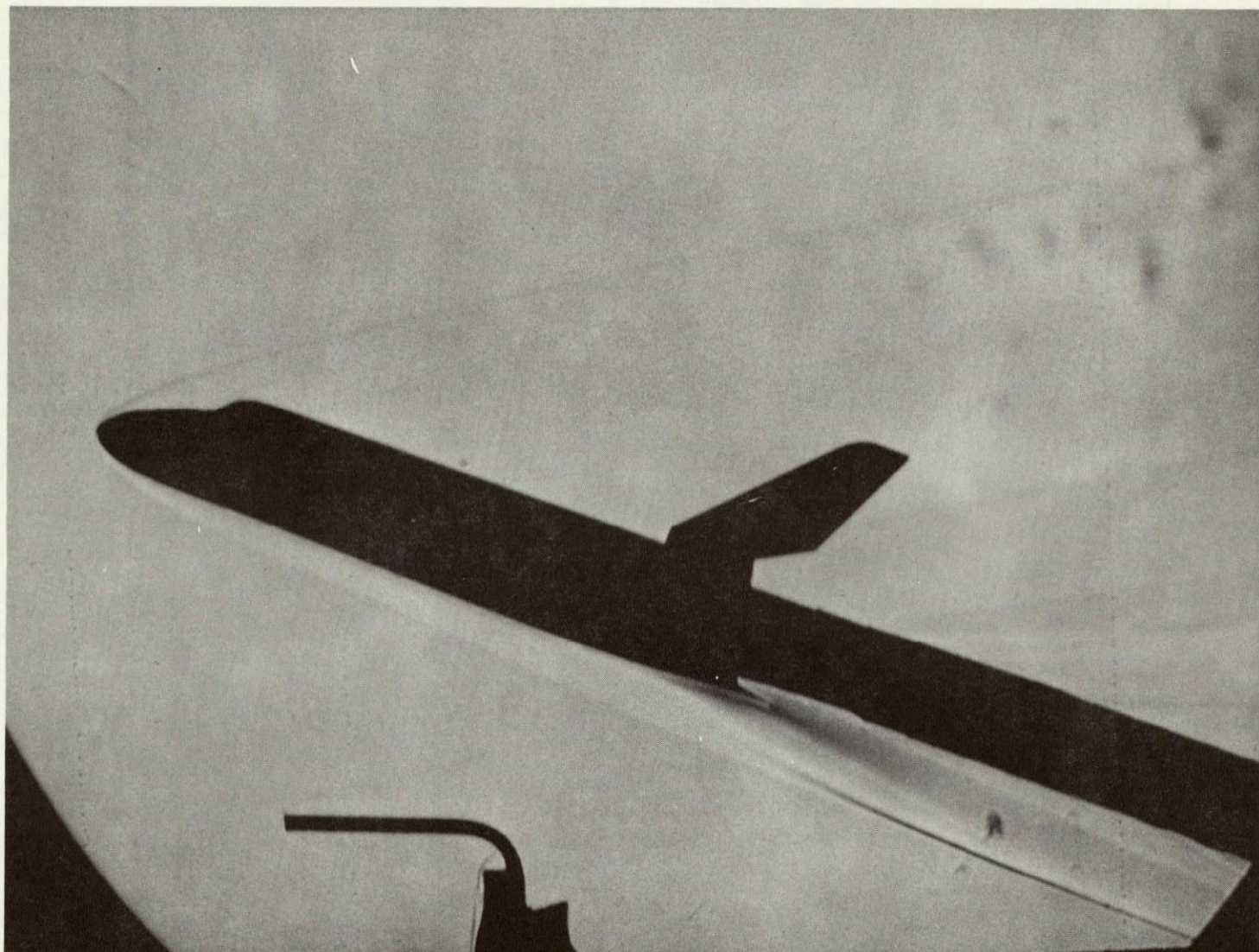


a. Electron Beam photograph, 22" Helium Tunnel, $\alpha=5^\circ$, $M=20.3$
Figure 3. - Model photographs

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b. Schlieren photograph, CF₄ Tunnel, $\alpha=10^\circ$, M=6.0
Figure 3. - Model photographs



c. Schlieren photograph, CF_4 Tunnel, $\alpha=18^\circ$, $M=6.0$
Figure 3. - Model photographs.

DATA FIGURES

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RECEIVED

(RJLW01) LARC CF4 267/273(LA78)

B58C5E18F4M3R5V5W87

SYMBOL X0 Y0 MACH
361.000
527.000 .000 6.040
782.000
982.000
1102.000
1282.000

PARAMETRIC VALUES
ELEVON .000 BOFLAP .000
SPDBRK .000

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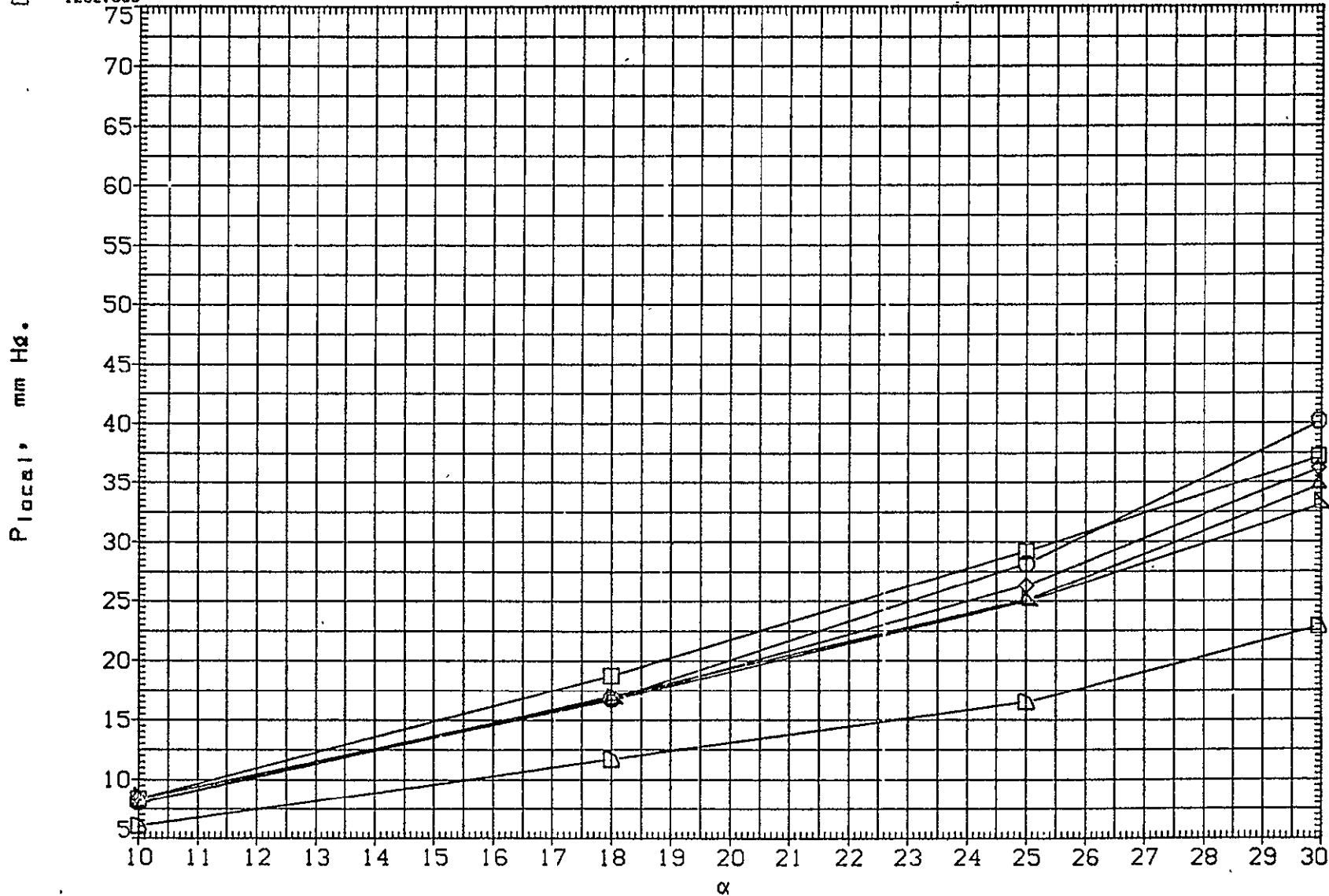


FIGURE 4. LARC CF4 267, 268, 272, 273(LA78) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

SYMBOL	X0	Y0	MACH
○	364.000	93.000	6.040

PARAMETRIC VALUES		
ELEVON	.000	BDFLAP
SPDRK	.000	.000

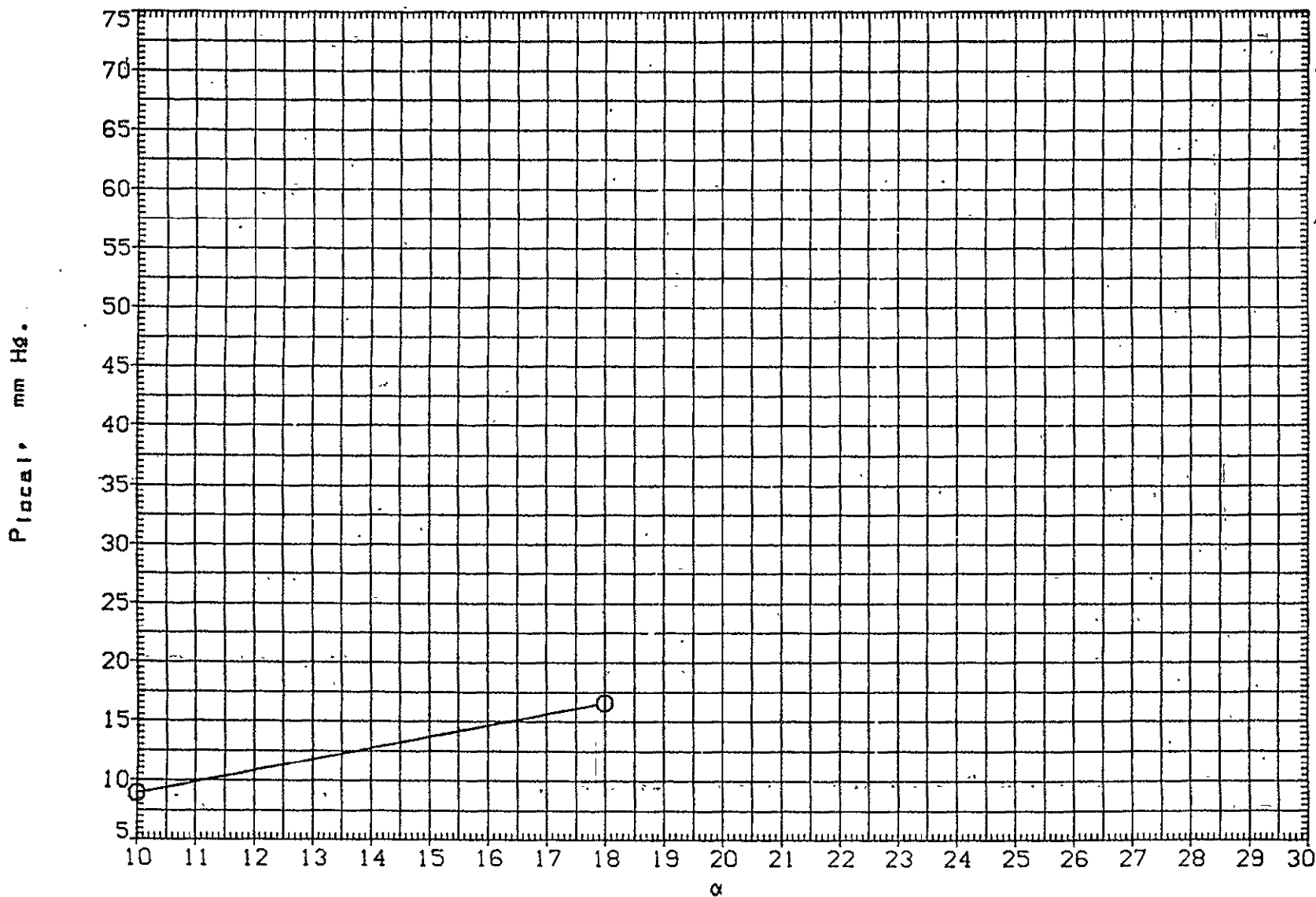


FIGURE 4. LARC CF4 267,268,272,273(LA78) LOWER SURFACE PRESSURES LOCAL PRESSURE ON LOWER WING SURFACE

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

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SYMBOL XO YO MACH
O 530.000 100.000 6.040

PARAMETRIC VALUES
ELEVON .000 BOFLAP .000
SPOBRK .000

-08-

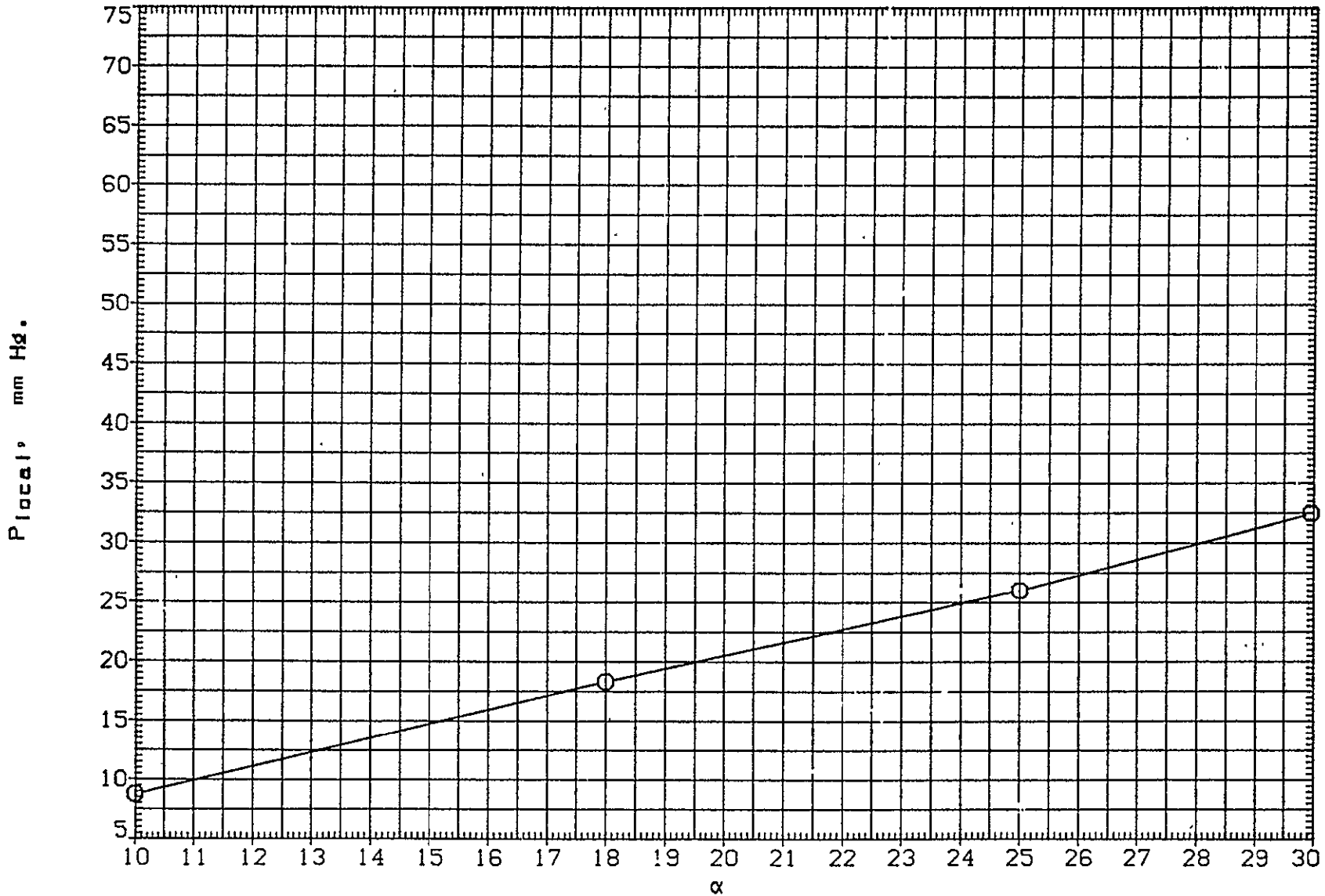


FIGURE 4. LARC CF4 267, 268, 272, 273(LA78) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

- 31 -

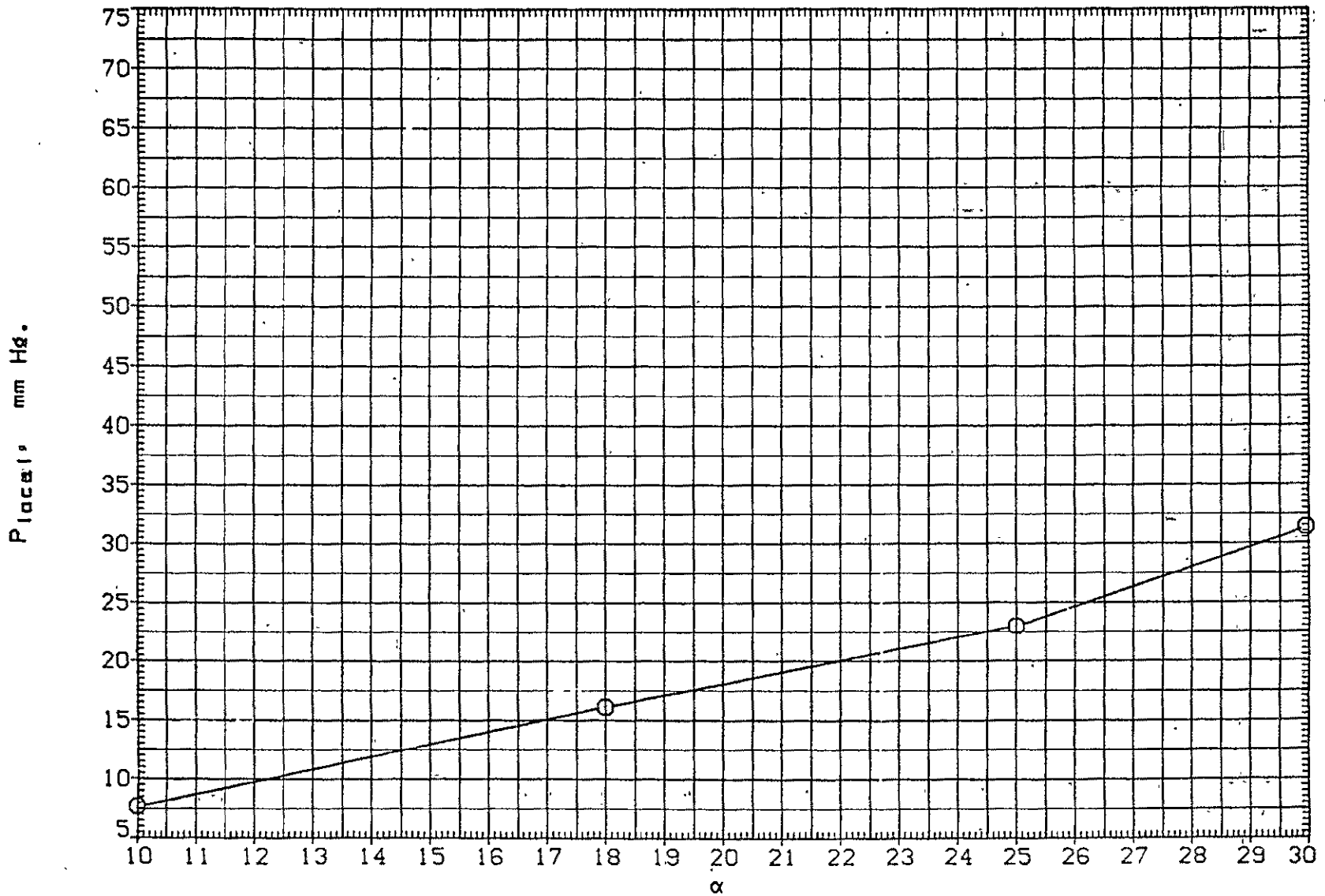


FIGURE 4. LARC CF4 267, 268, 272, 273(LA78) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

(RJLW01) LARC CF4 267/273(LA78)

B58C5E18F4M3R5V5W87

SYMBOL X0 Y0 MACH
◇ 911.000 114.000 6.040
□ 1049.000
○ 1200.000

PARAMETRIC VALUES
ELEVON .000 BDFLAP .000
SPDBRK .000

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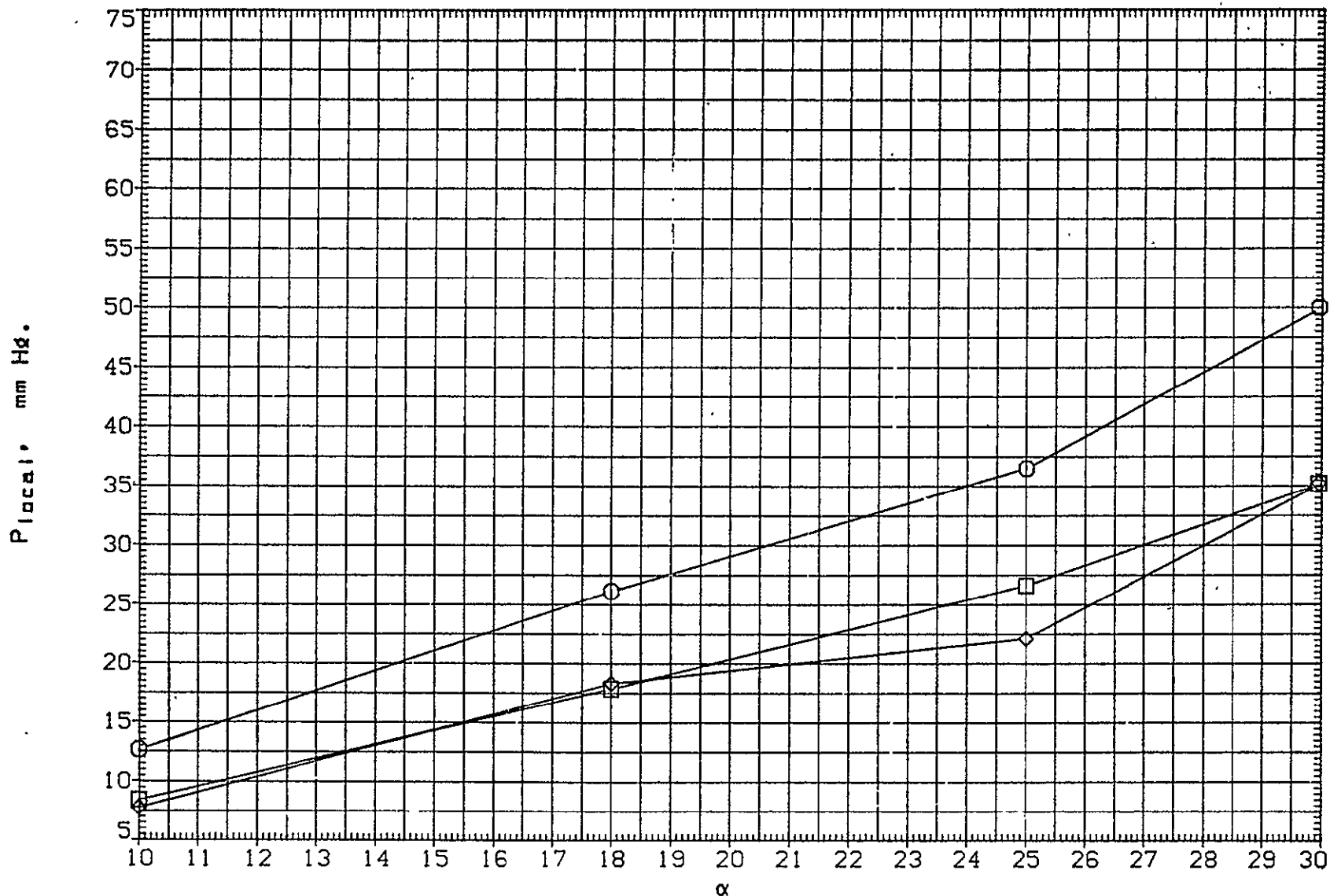


FIGURE 4. LARC CF4 267,268,272,273(LA78) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

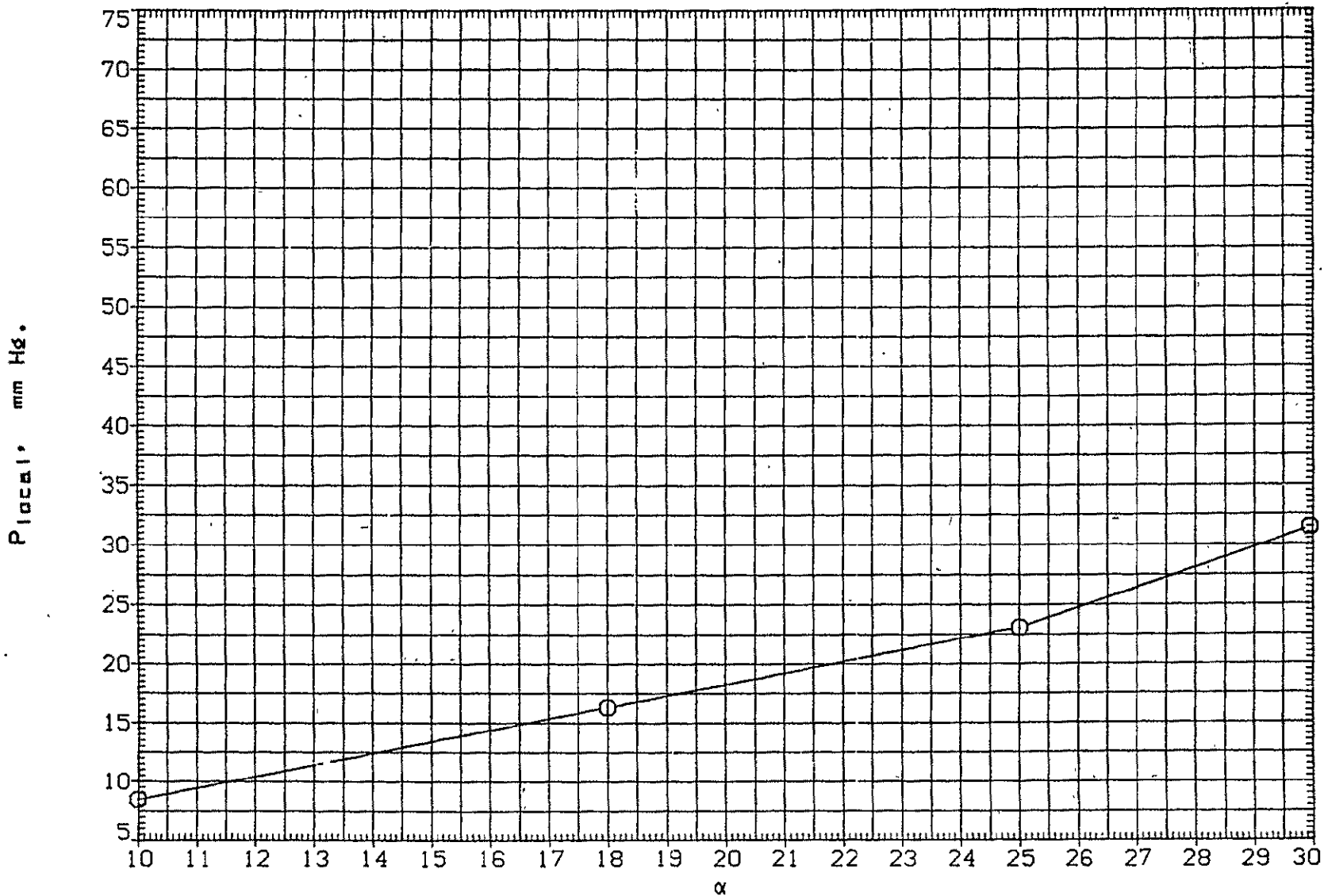


FIGURE 4. LARC CF4 267,268,272,273(LA78) LOWER SURFACE PRESSURES LOCAL PRESSURE ON LOWER WING SURFACE

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

(RJLW01) LARC CF4 267/273(LA78)

B58C5E18F4M3R5V5W87

SYMBOL XO YO MACH
O 913.000 236.000 6.040

PARAMETRIC VALUES
ELEVON .000 BDFLAP .000
SPDBRK .000

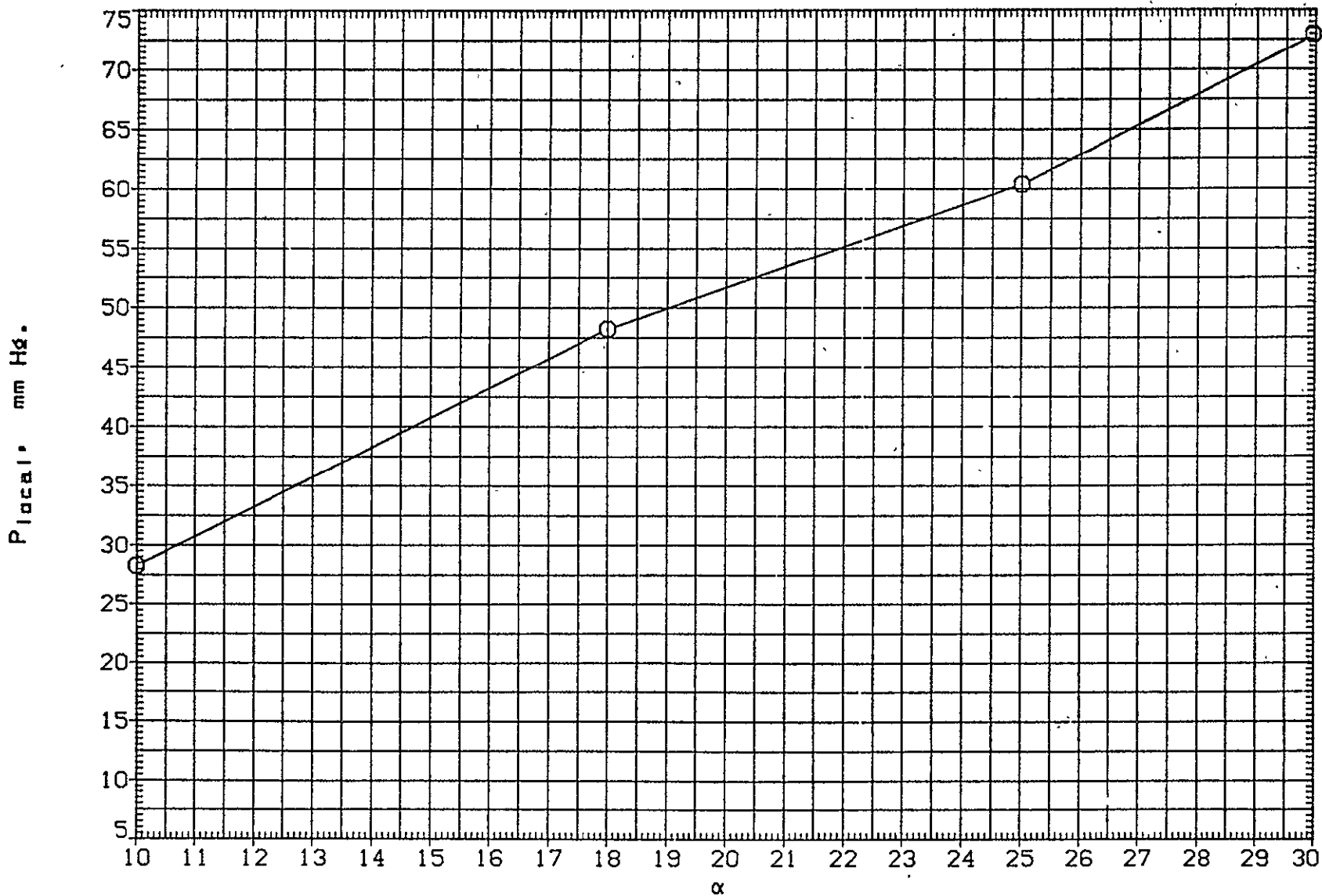


FIGURE 4. LARC CF4 267, 268, 272, 273(LA78) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

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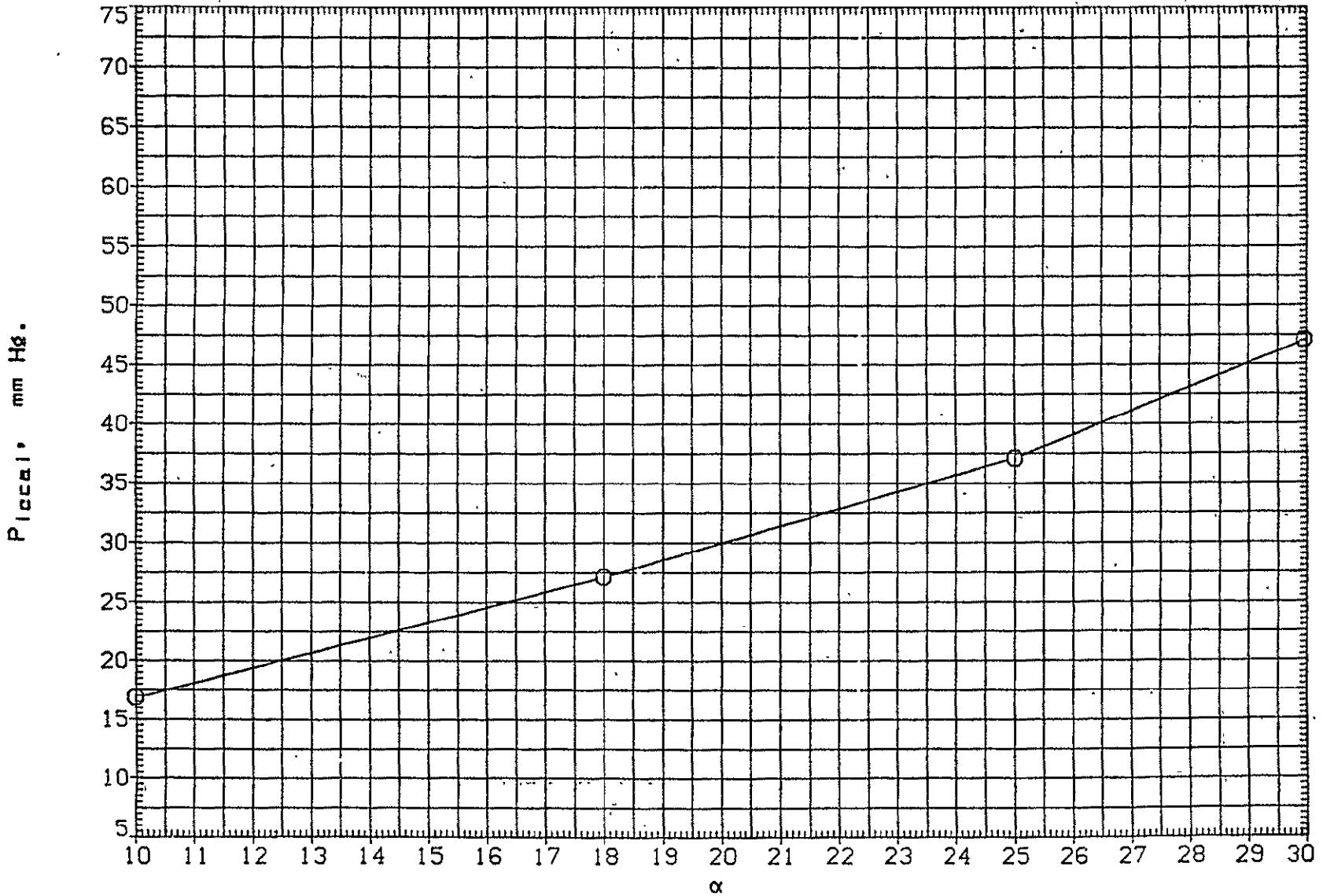


FIGURE 4. LARC CF4 267,268,272,273(LA78) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

(RJLW01) LARC CF4 267/273(LA78)

B58C5E18F4M3R5V5W87

SYMBOL X0 Y0 MACH
O 1200.000 317.000 6.040

PARAMETRIC VALUES
ELEVON .000 BOFLAP .000
SPDBRK .000

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Pressure, mm Hg.

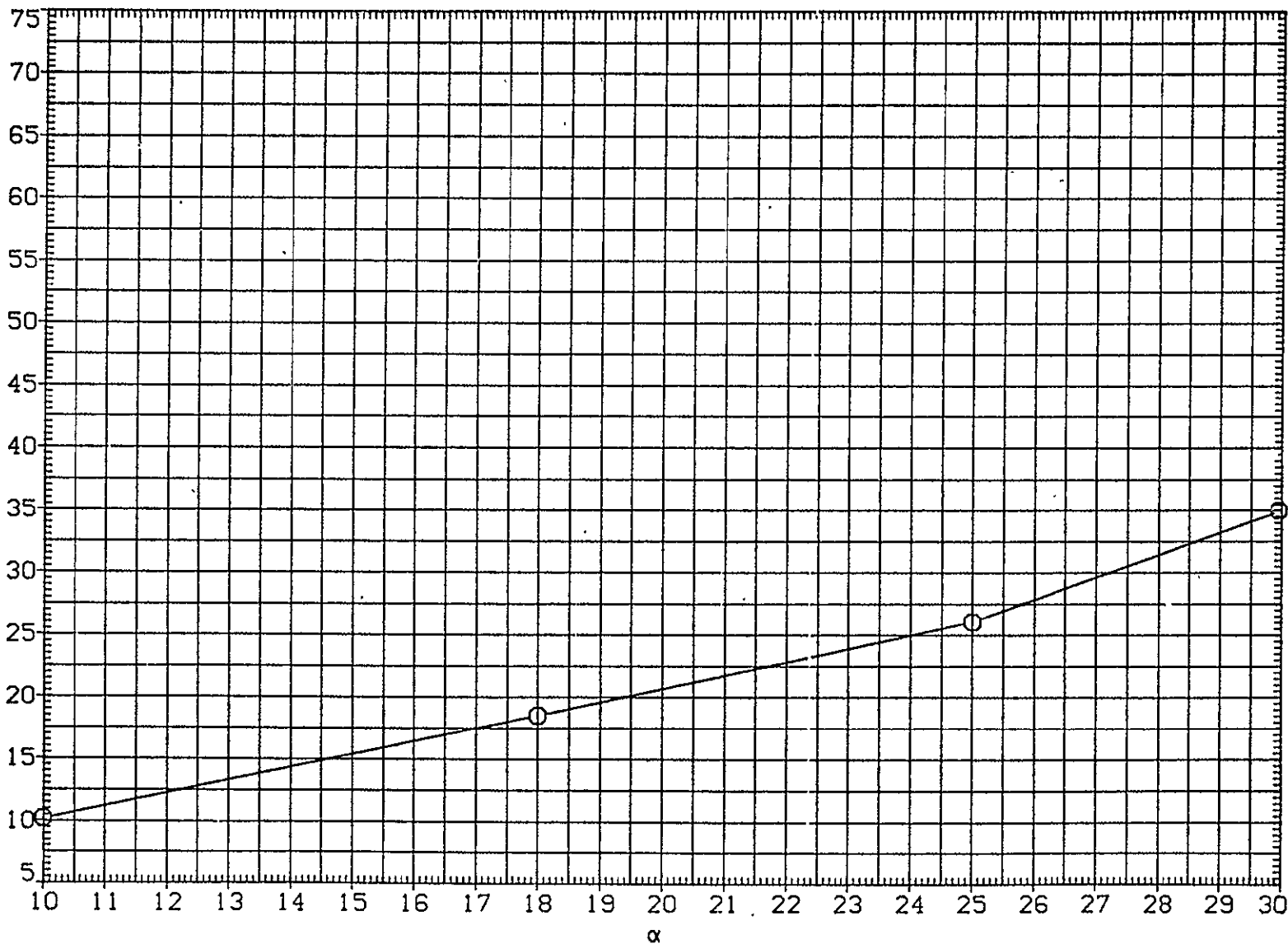


FIGURE 4. LARC CF4 267,268,272,273(LA78) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

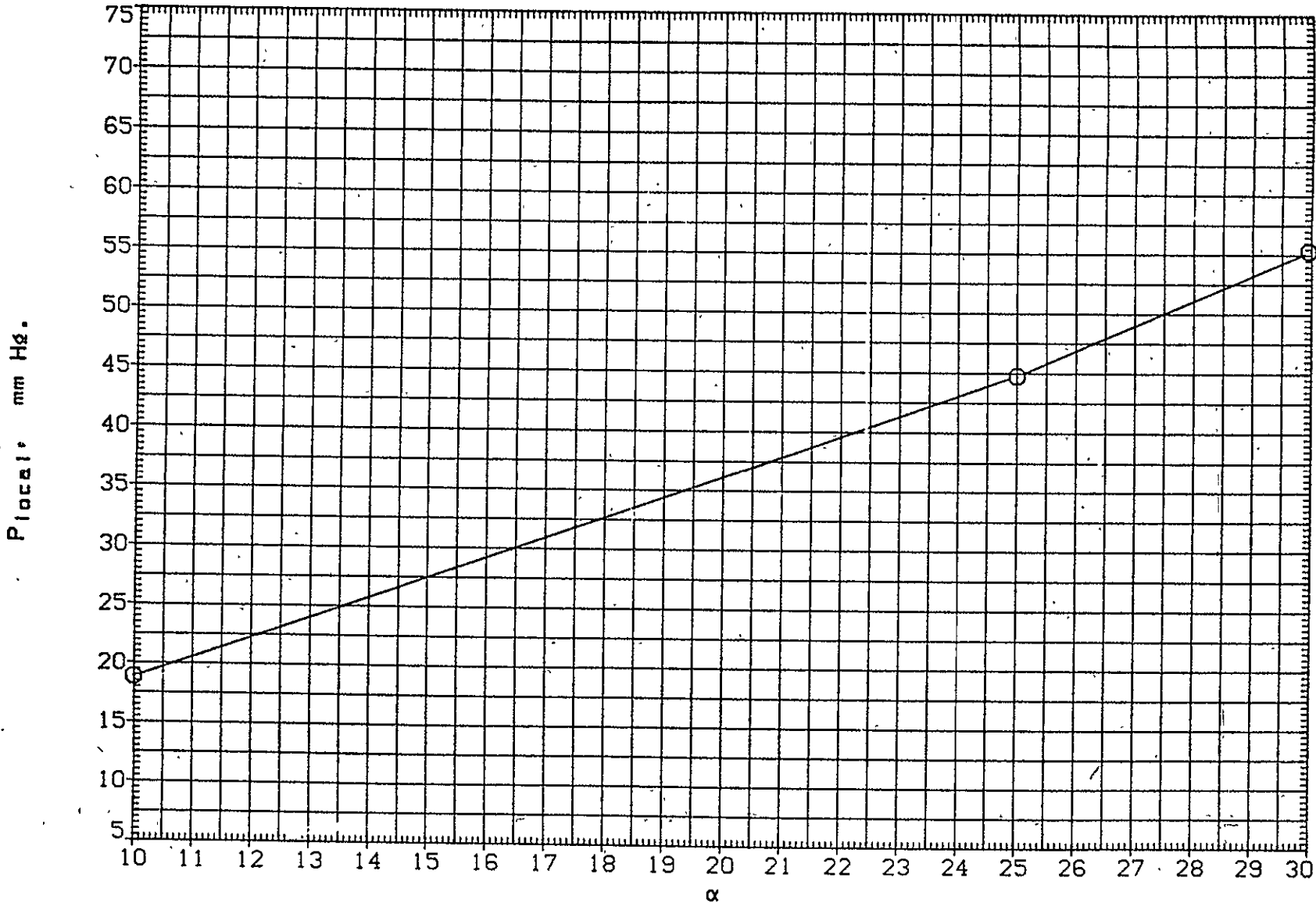


FIGURE 4. LARC CF4 267, 268, 272, 273(LA78) LOWER SURFACE PRESSURES
 LOCAL PRESSURE ON LOWER WING SURFACE

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REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

(RJLW01) LARC CF4 267/273(LA78)

B58C5E18F4M3R5V5W87

SYMBOL X0 Y0 MACH
O 1202.000 411.000 6.040

PARAMETRIC VALUES
ELEVON .000 BDFLAP .000
SPDBRK .000

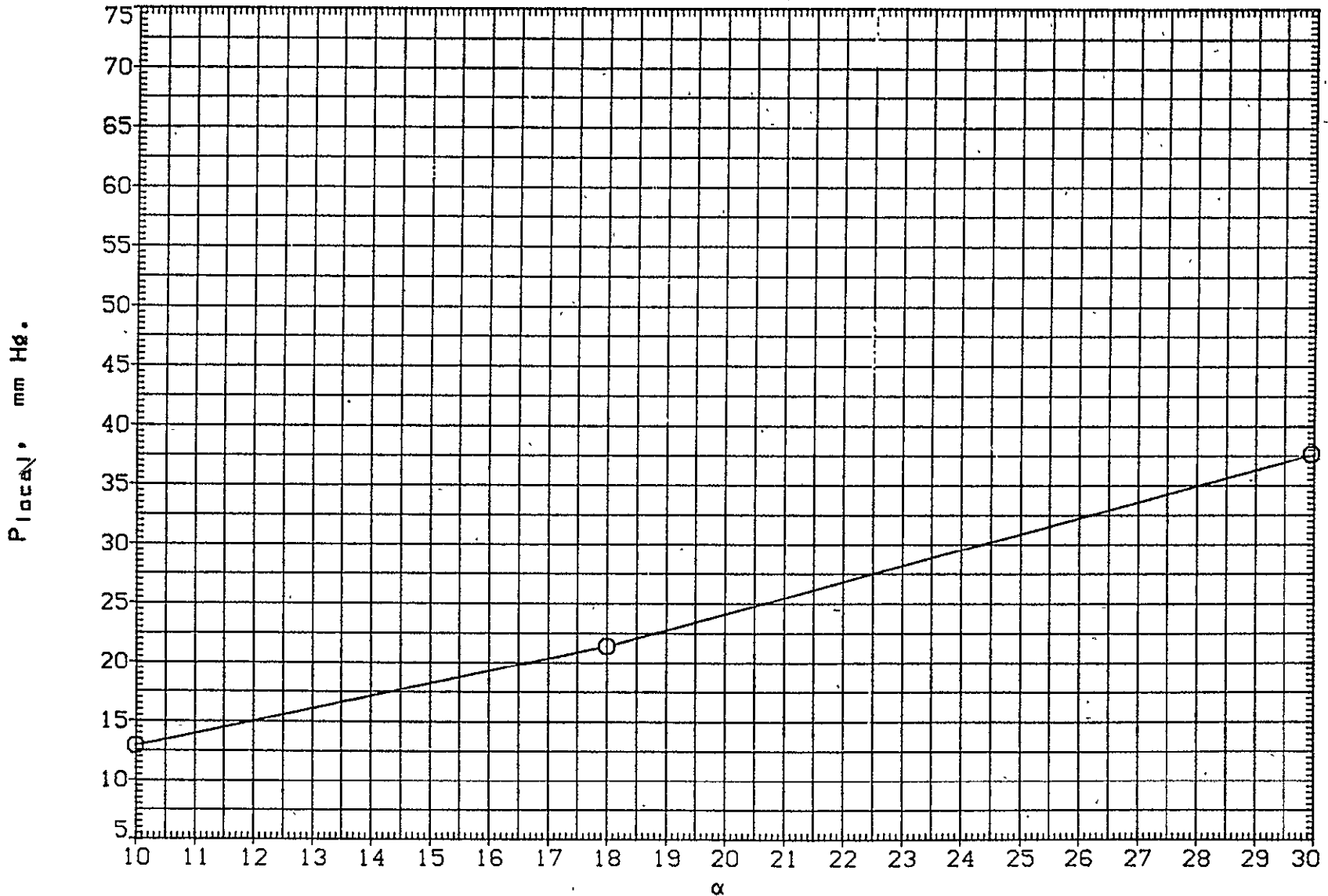


FIGURE 4. LARC CF4 267, 268, 272, 273(LA78) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

SYMBOL	X0	Y0	MACH
□	361.000	.000	20.300
◇	527.000		
○	782.000		
△	982.000		
▽	1102.000		
◇	1282.000		

PARAMETRIC VALUES			
ELEVON	.000	BDFLAP	.000
SPDRK	.000		

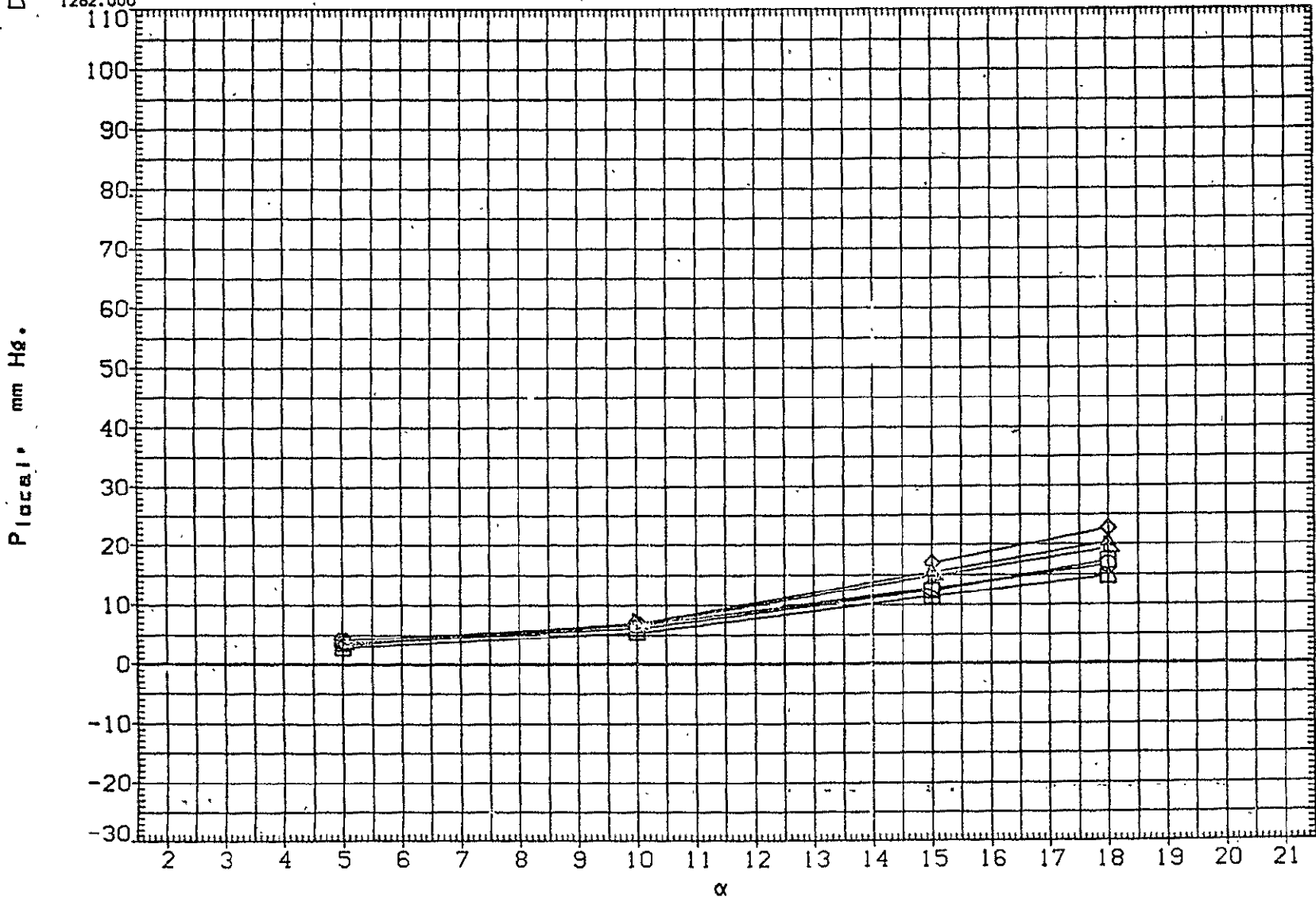


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

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(RJ5W01) LARC 22IN HELIUM 446(LA87) B58C5E18F4M3R5V5W87

SYMBOL XO YO MACH
O 364.000 93.000 20.300

ELEVON SPDBRK PARAMETRIC VALUES
.000 .000 BDFLAP .000

-07-

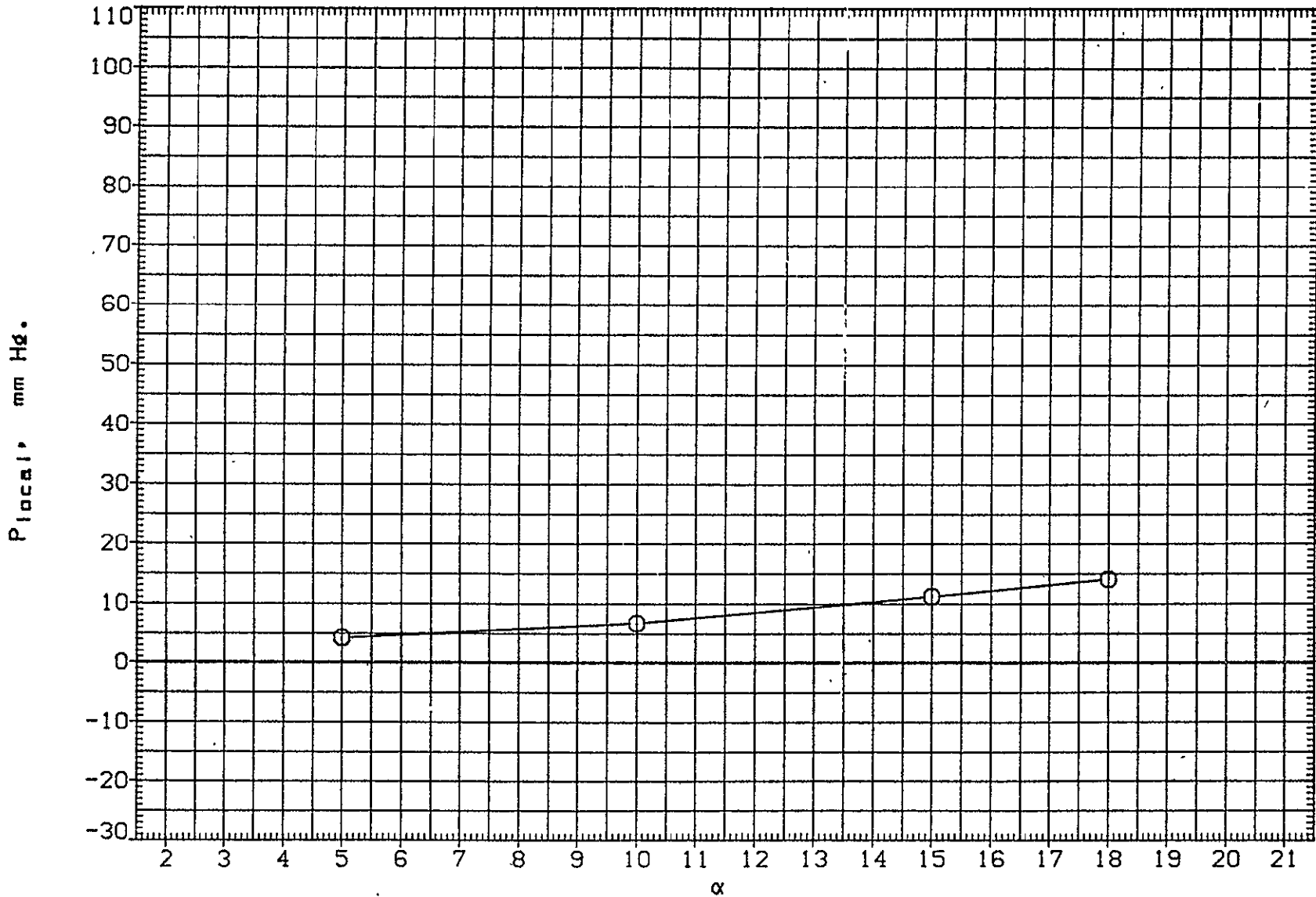


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

SYMBOL XO YO MACH
O 530.000 100.000 20.300

PARAMETRIC VALUES
ELEVON .000 BOFLAP .000
SPDBRK .000

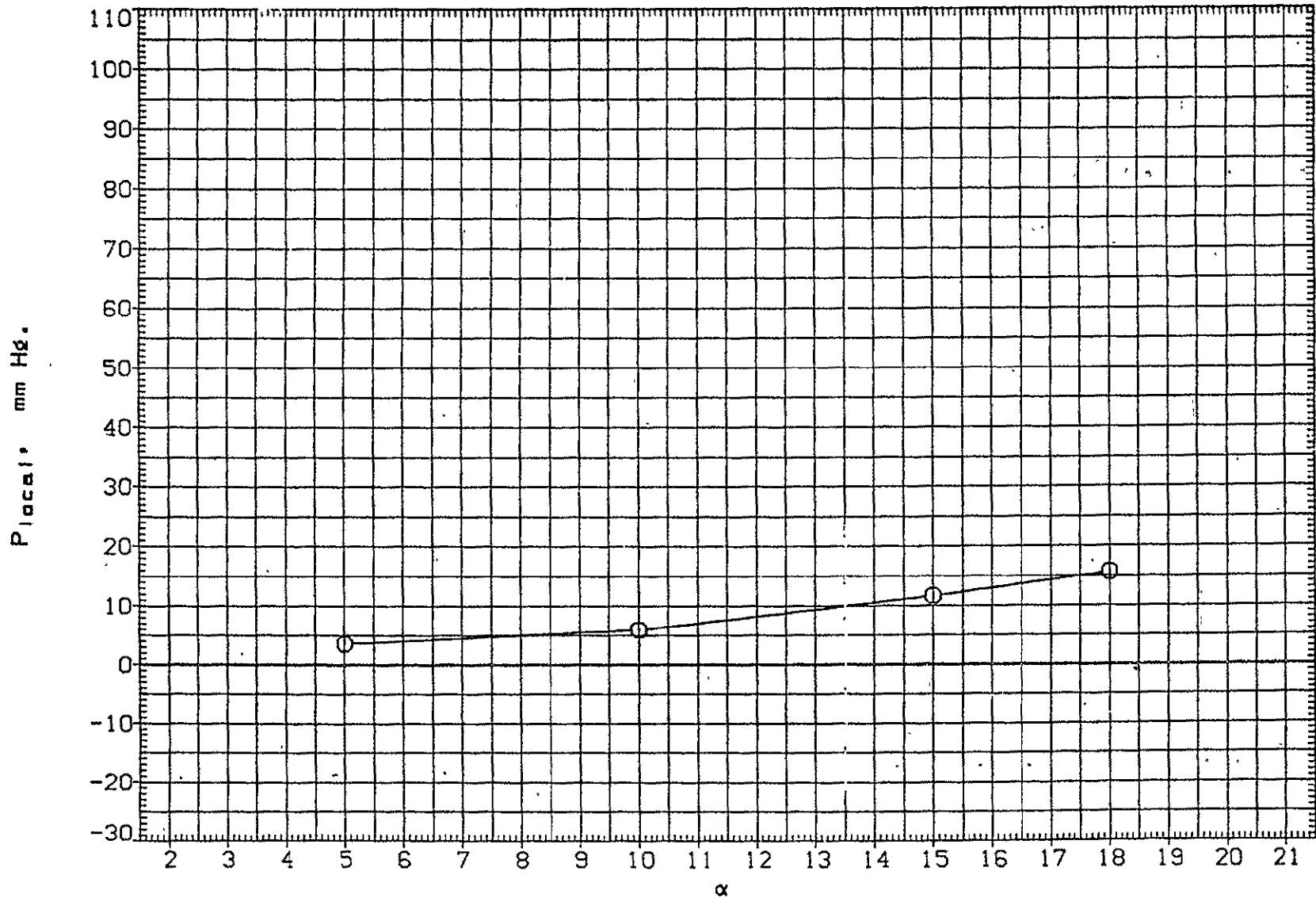


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

(RJ5W01) LARC 22IN HELIUM 446(LA87) B58C5E18F4M3R5V5W87

SYMBOL X0 Y0 MACH
O 784.000 107.000 20.300

PARAMETRIC VALUES
ELEVON .000 BDFLAP .000
SPDBRK .000

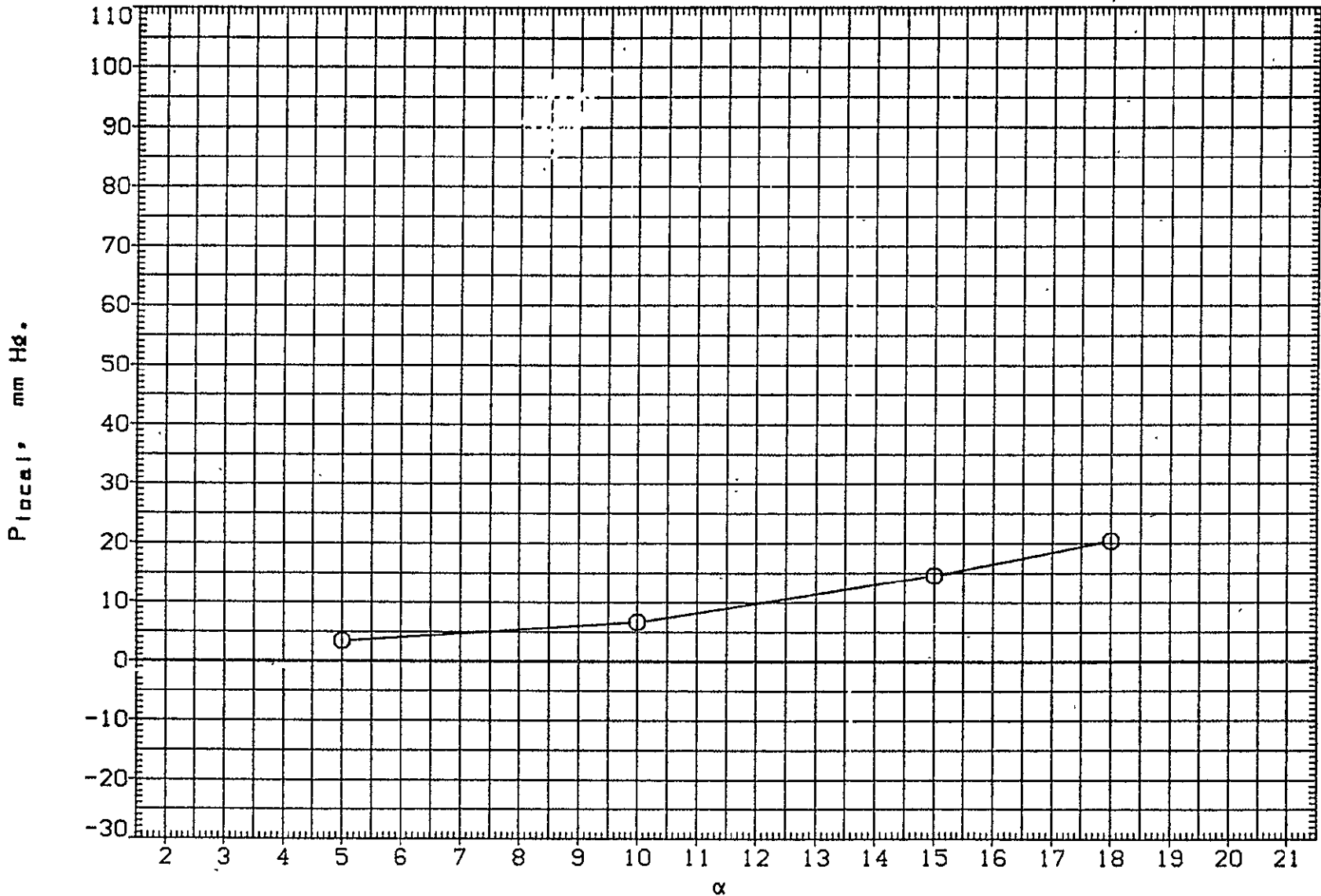


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

SYMBOL	X0	Y0	MACH
□	911.000	114.000	20.300
◇	1049.000		
	1200.000		

PARAMETRIC VALUES		
ELEVON	.000	BDFLAP
SPOBRK	.000	.000

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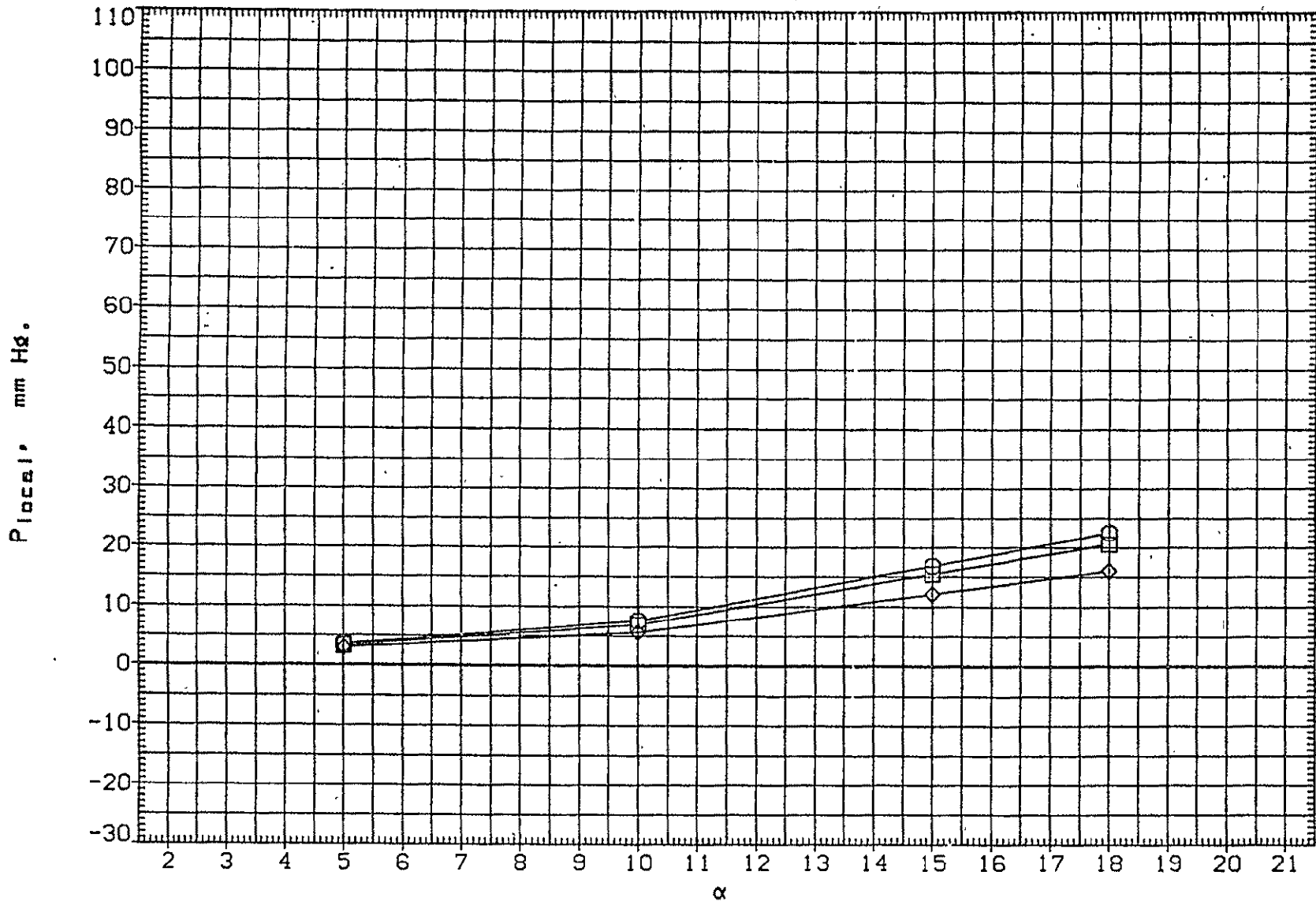


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

SYMBOL X0 Y0 MACH
O 1200.000 202.000 20.300

PARAMETRIC VALUES
ELEVON .000 BDFLAP .000
SPDBRK .000

-hh-

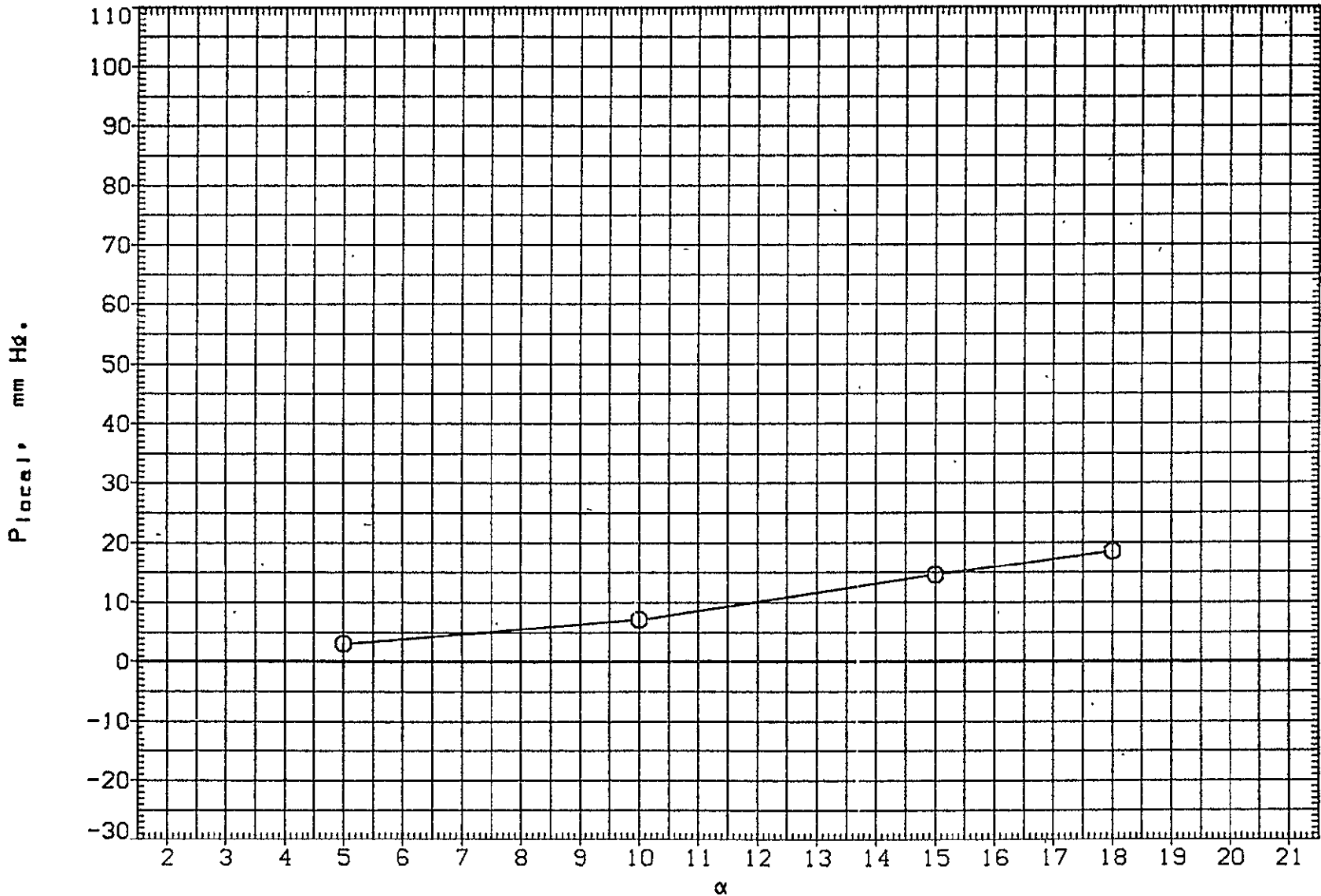


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

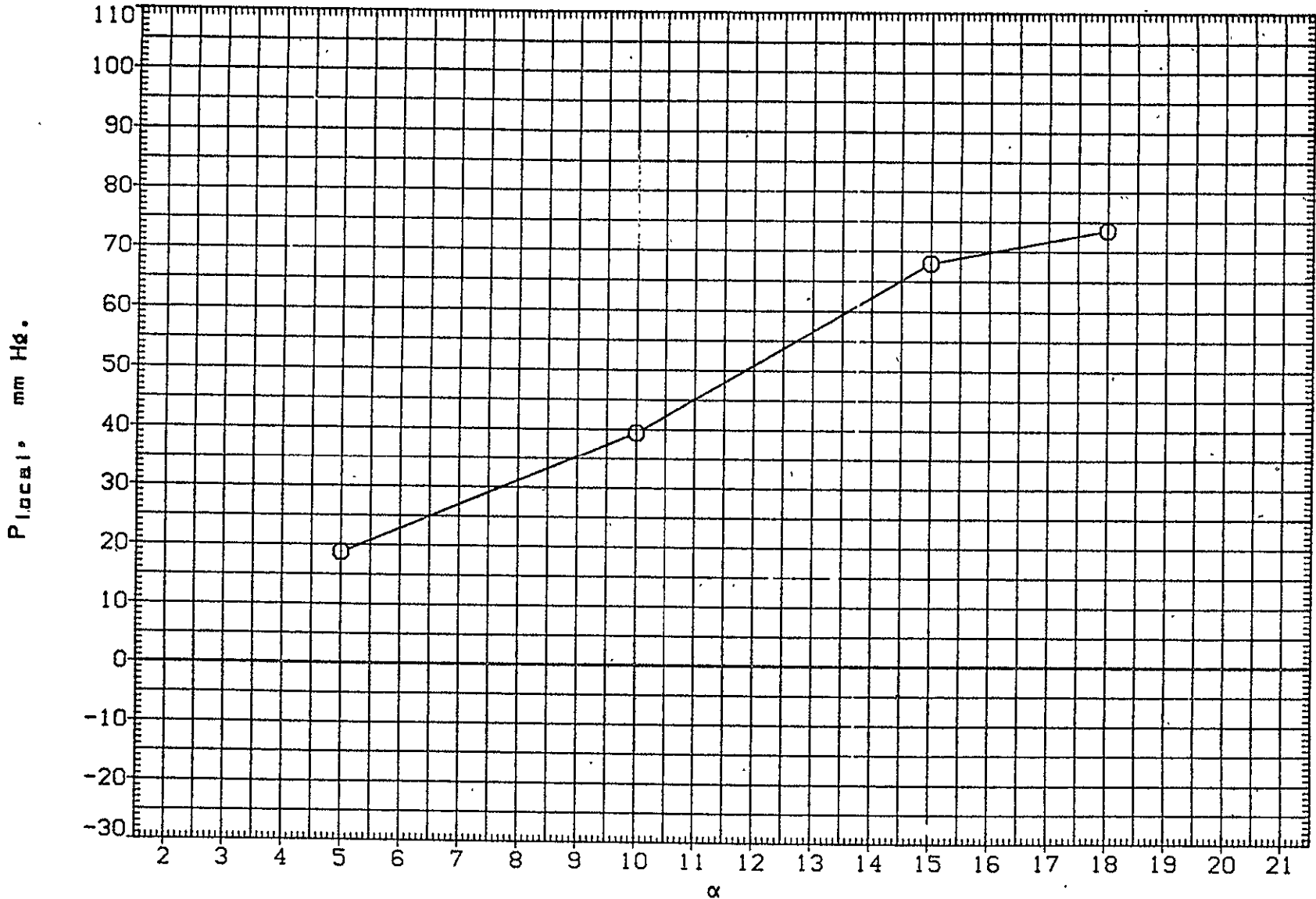


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

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(RJ5W01) LARC 22IN HELIUM 446(LA87) B58C5E18F4M3R5V5W87

SYMBOL XO YO MACH
O 1046.000 251.000 20.300

PARAMETRIC VALUES
ELEVON .000
SPOBRK .000
BDFLAP .000

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P_{local}, mm Hg.

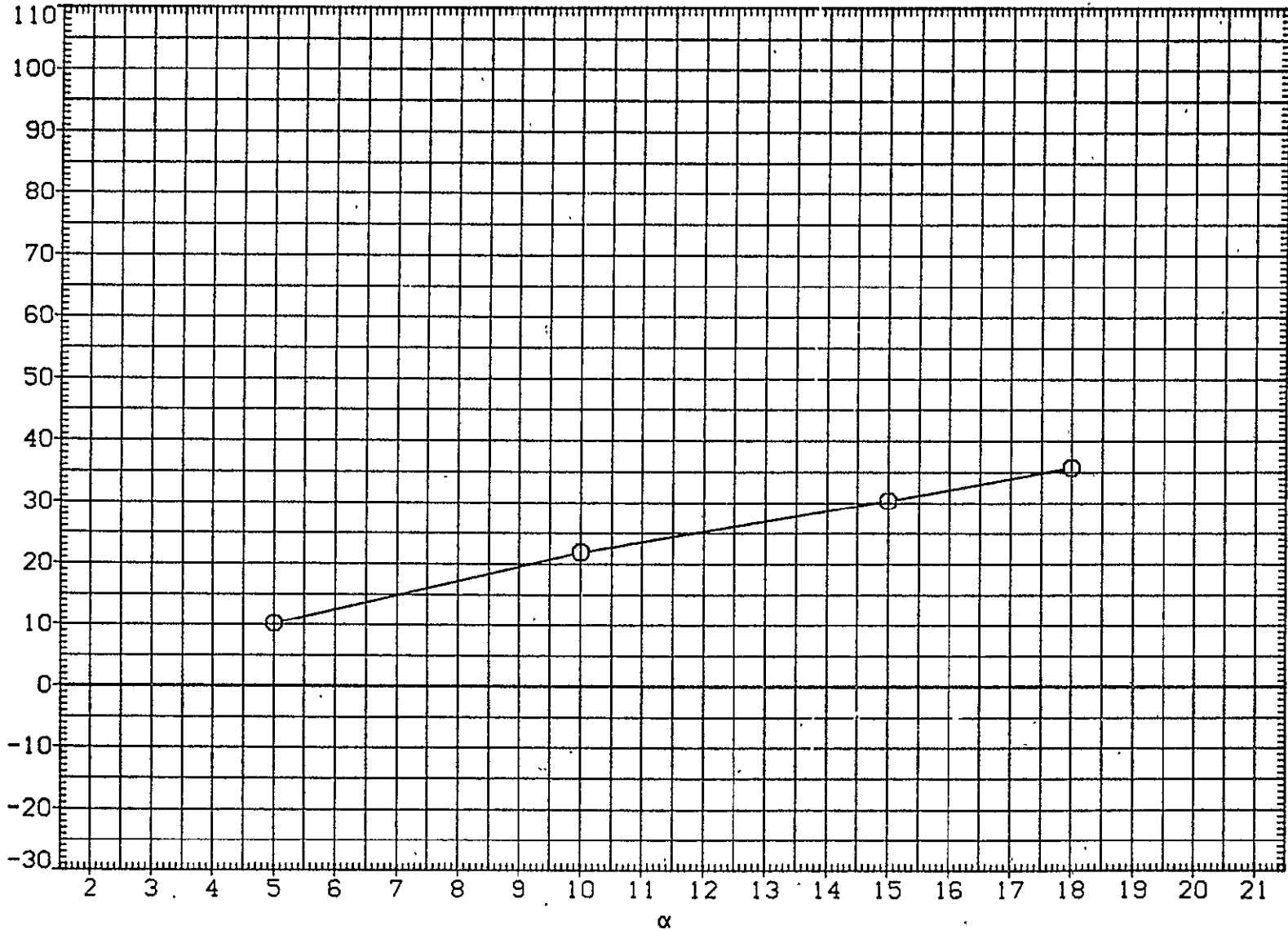


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

SYMBOL X0 Y0 MACH
O 1200.000 317.000 20.300

PARAMETRIC VALUES
ELEVON .000 BDFLAP .000
SPDBRK .000

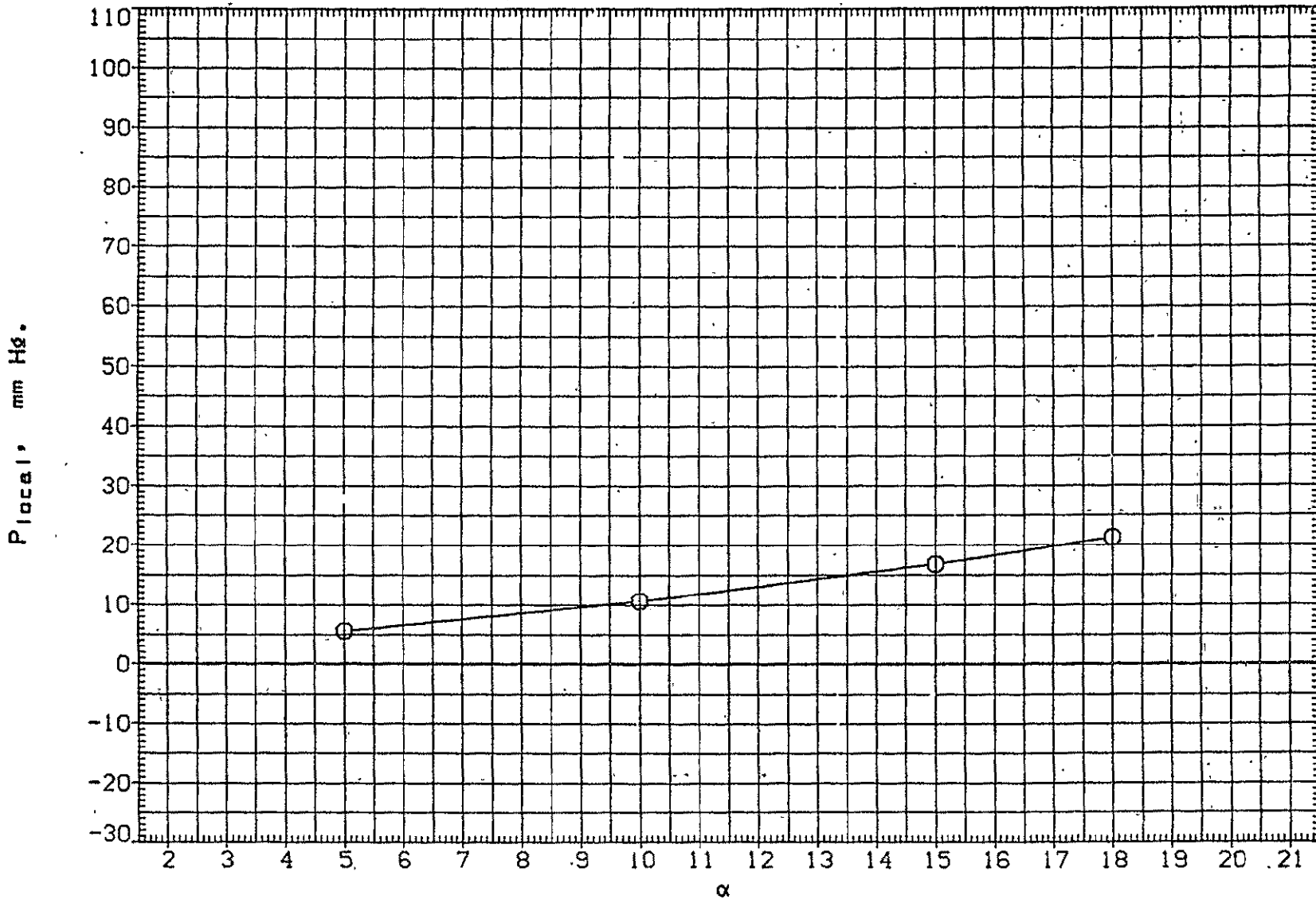


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

SYMBOL XO YO MACH
 O 1041.000 365.000 20.300

PARAMETRIC VALUES
 ELEVON .000 BDFLAP .000
 SPDBRK .000

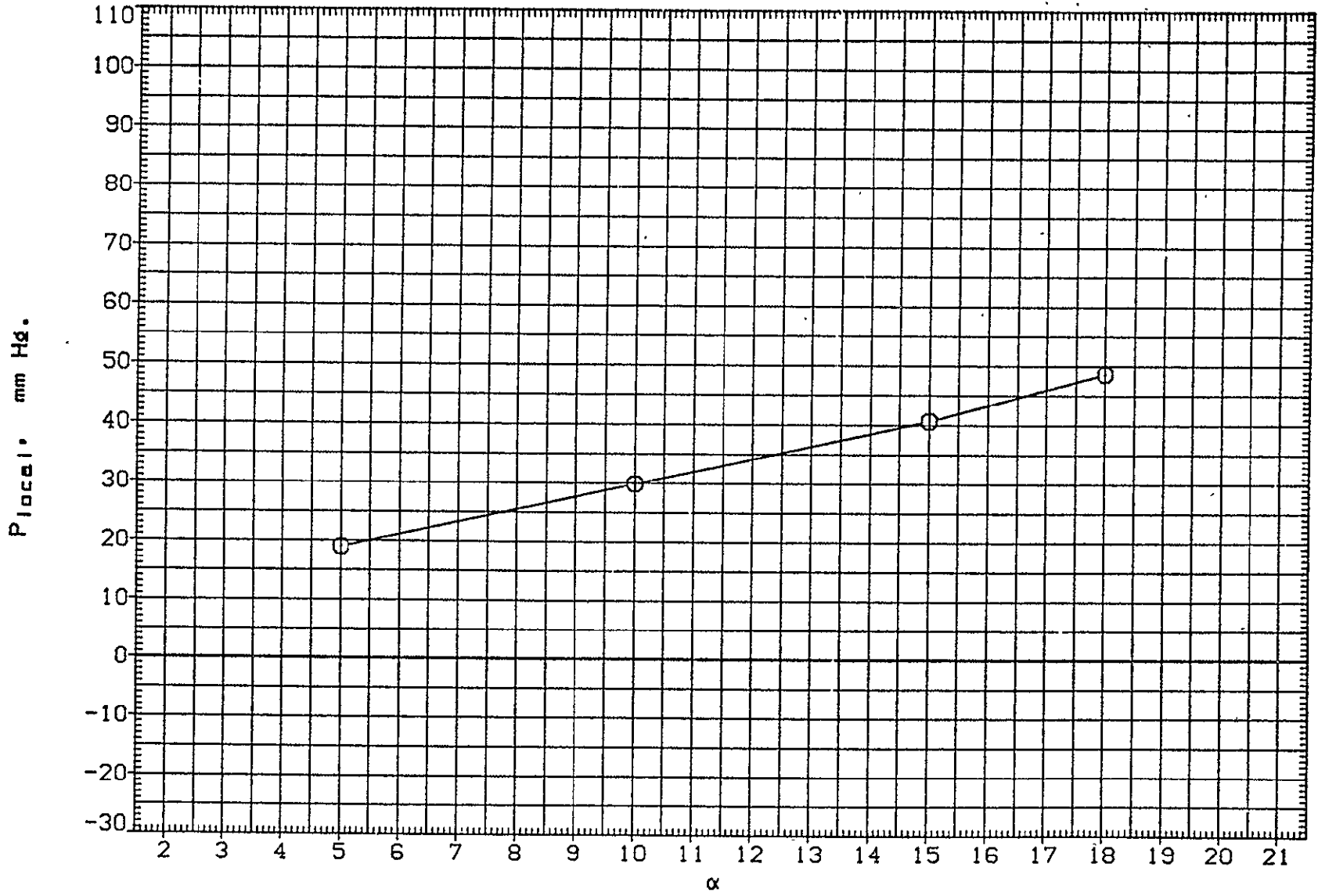


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
 LOCAL PRESSURE ON LOWER WING SURFACE

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-bH-

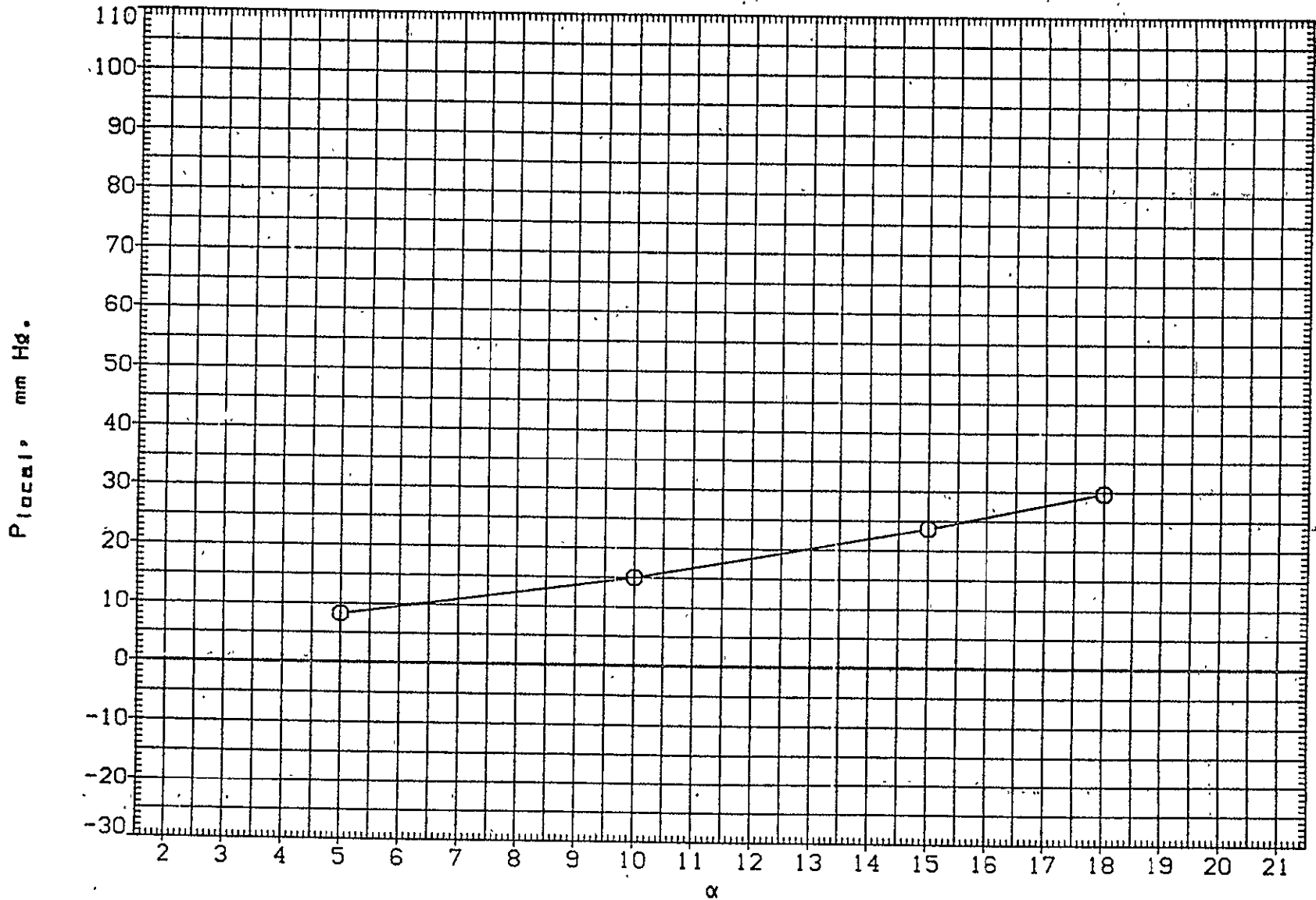


FIGURE 5. LARC 22IN. HE. 446(LA87) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

(RJVW01) LARC 20IN M6 6468(LA88)

B58C5E18F4M3R5V5W87

SYMBOL

X0
361.000
527.000
782.000
982.000
1102.000
1282.000

Y0
.000

MACH
5.940

PARAMETRIC VALUES
ELEVON .000
SPDRBK .000
BOFLAP .000

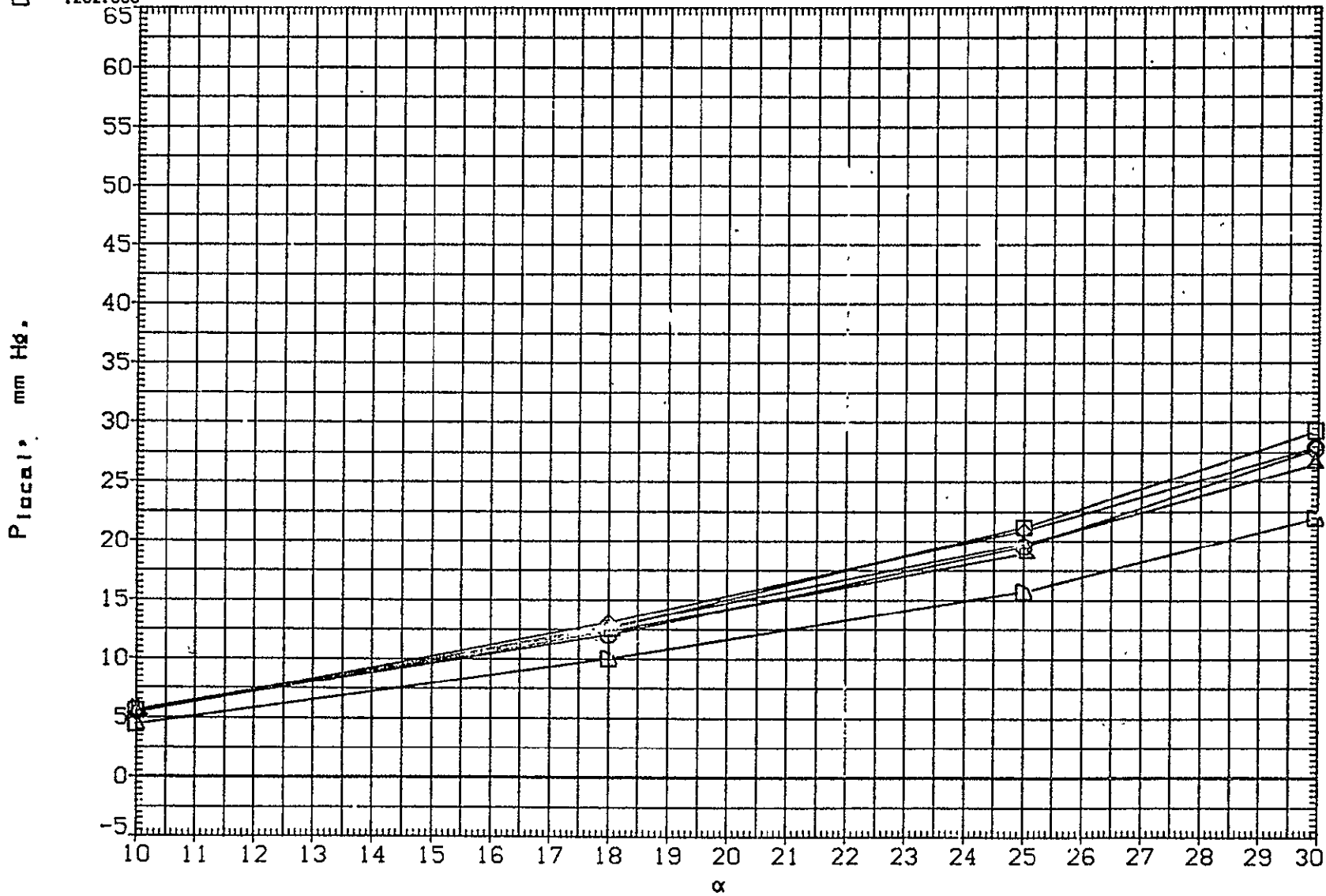


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

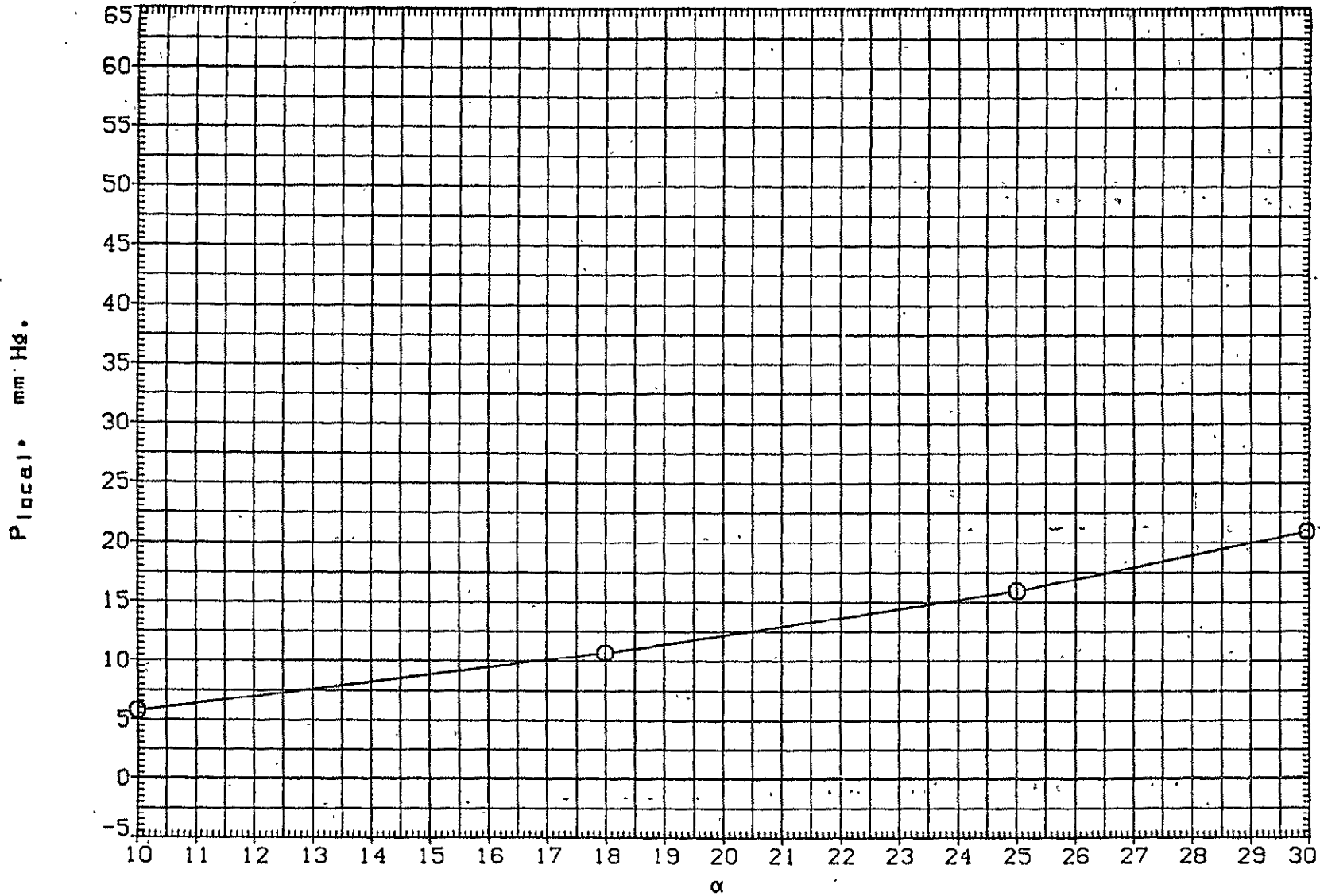


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

SYMBOL XO YO MACH
O 530.000 100.000 5.940

PARAMETRIC VALUES
ELEVON .000 BOFLAP .000
SPDBRK .000

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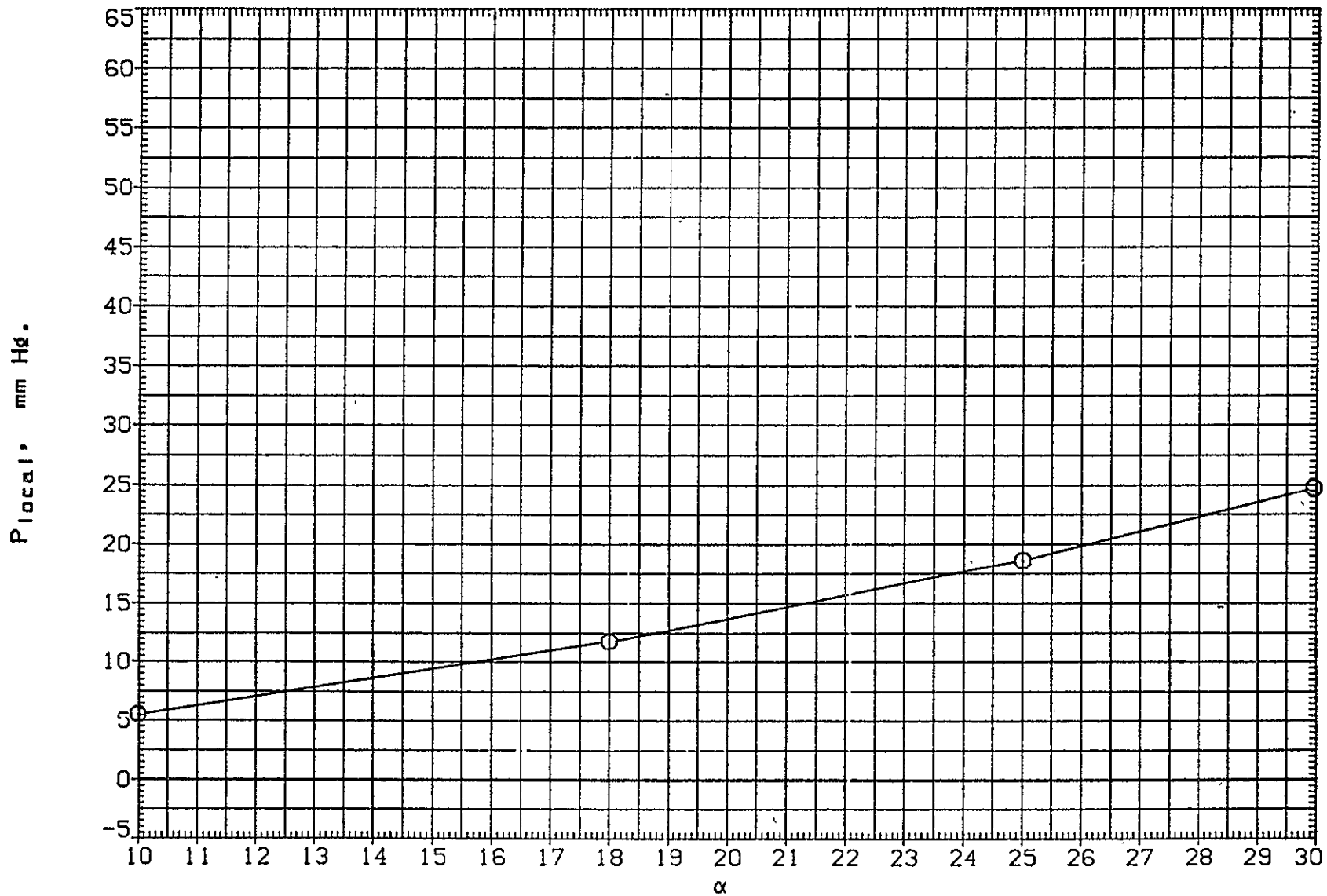


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

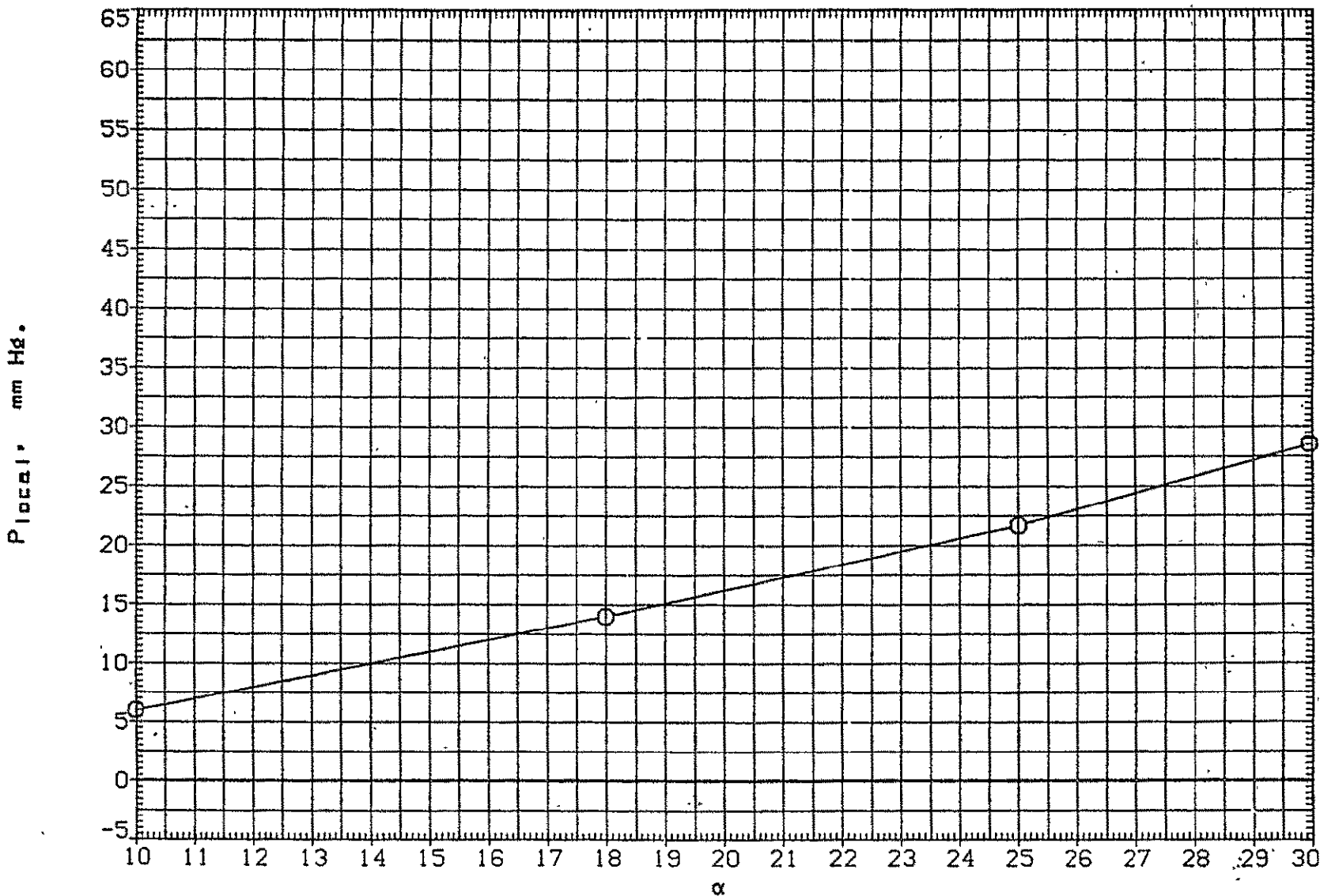


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
 LOCAL PRESSURE ON LOWER WING SURFACE

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REPRODUCIBILITY OF THE
 ORIGINAL PAGE IS POOR

(RJVV01) LARC 20IN M6 6468(LA88)

B58C5E18F4M3R5V5W87

SYMBOL	X0	Y0	MACH
○	911.000	114.000	5.940
□	1049.000		
◇	1200.000		

PARAMETRIC VALUES			
ELEVON	.000	BDFLAP	.000
SPDBRK	.000		

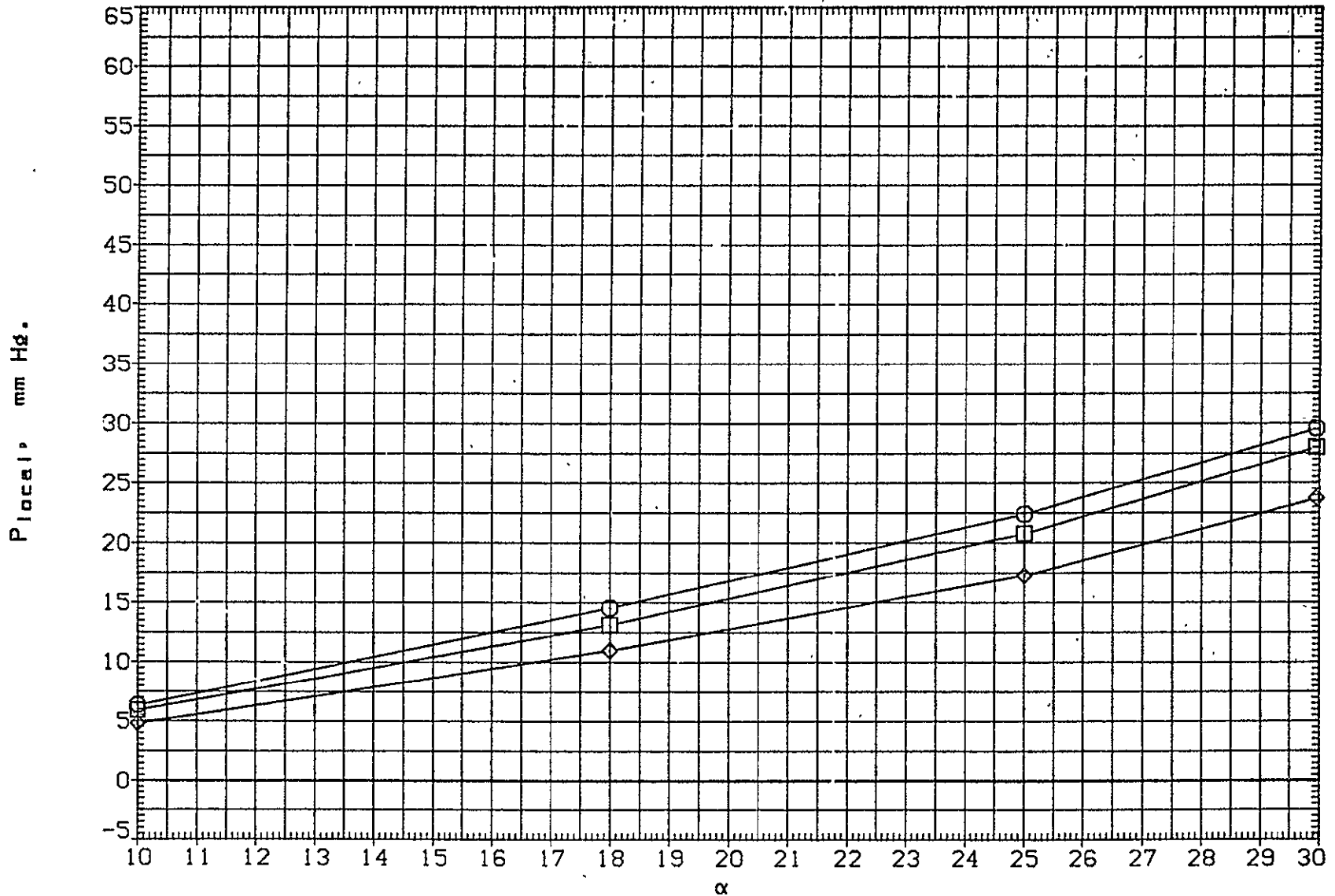


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

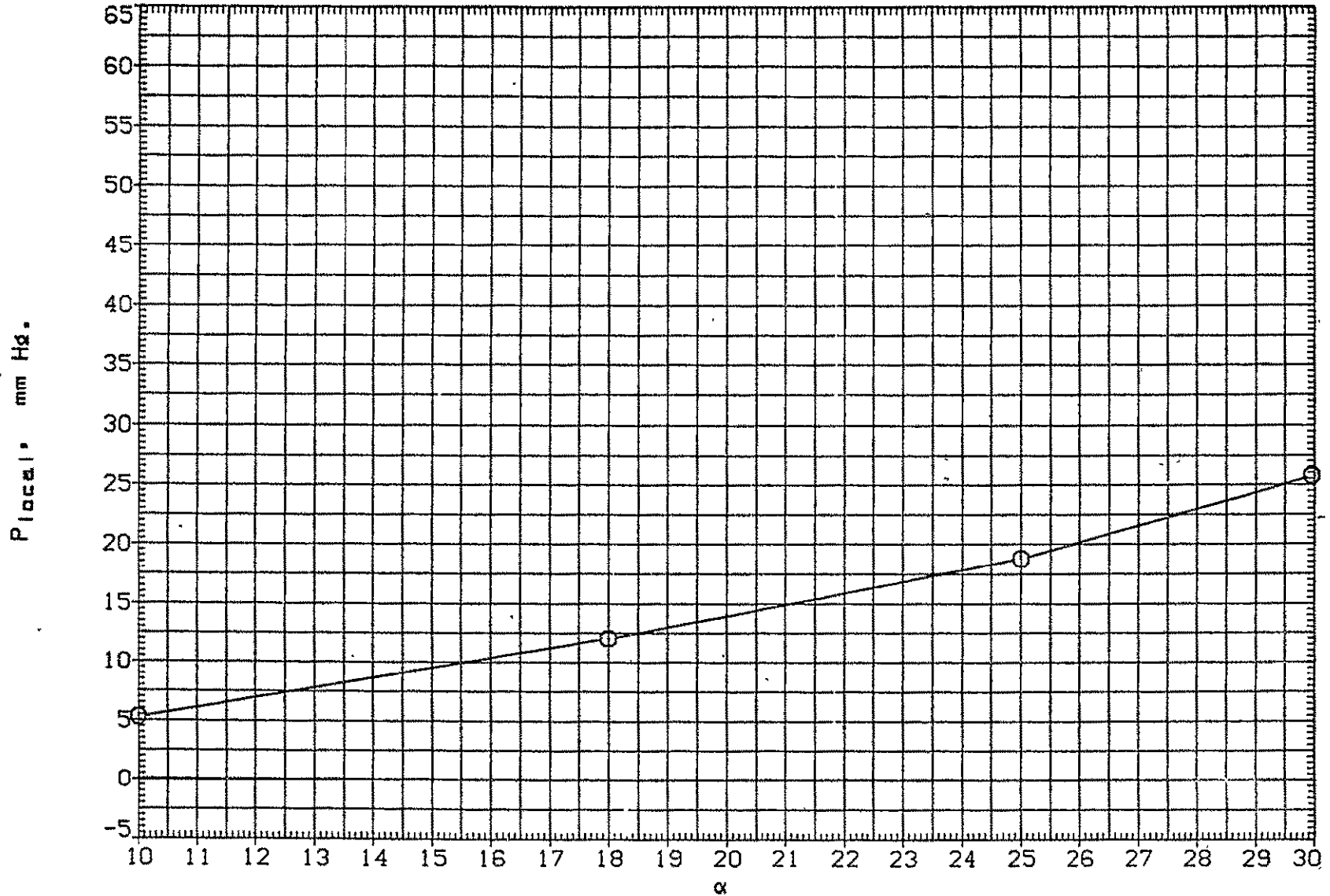


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

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(RJW01) LARC 20IN M6 6468(LA88)

B58C5E18F4M3R5V5W87

SYMBOL X0 Y0 MACH
O 913.000 236.000 5.940

PARAMETRIC VALUES
ELEVON .000 BDFLAP .000
SPDBRK .000

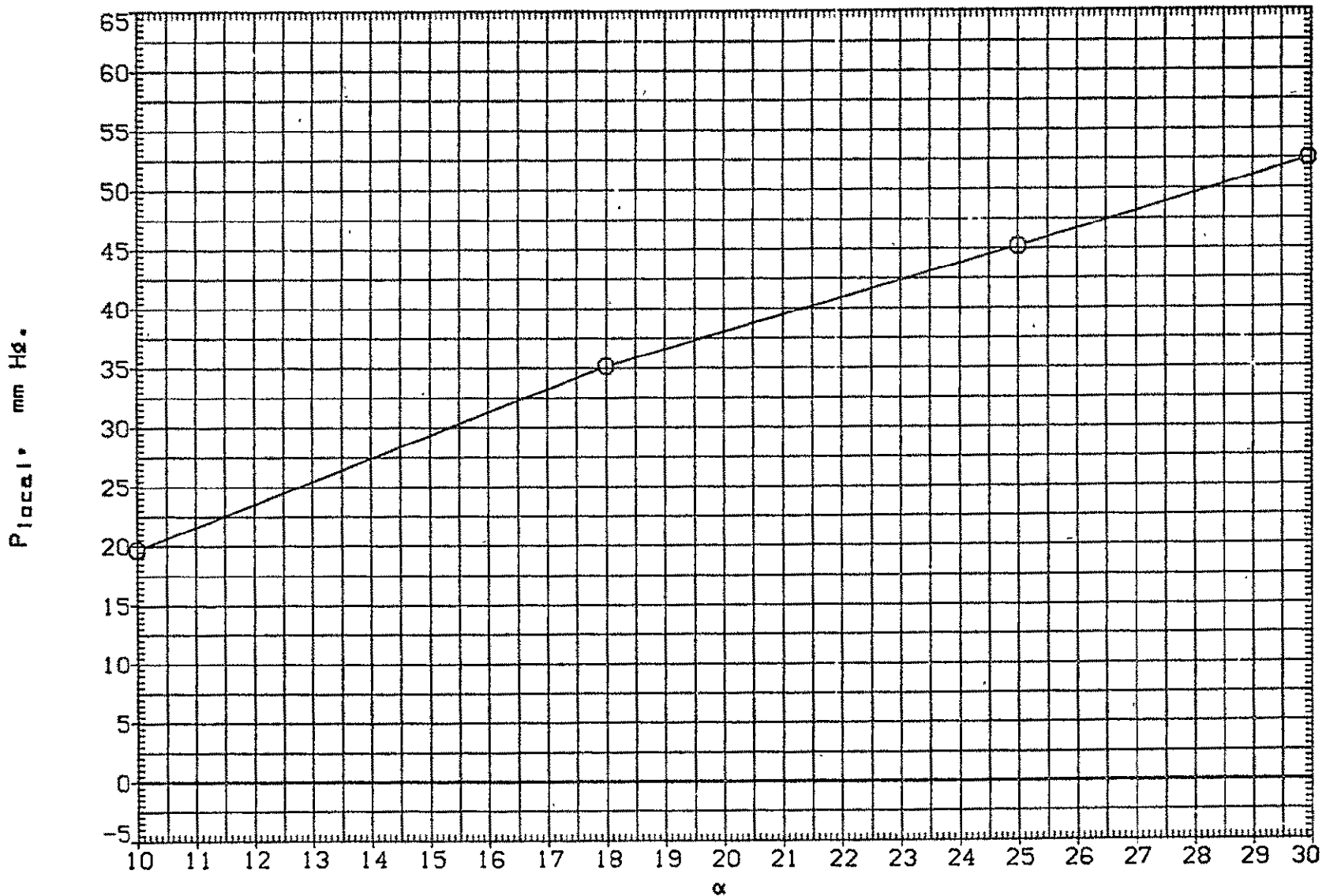


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

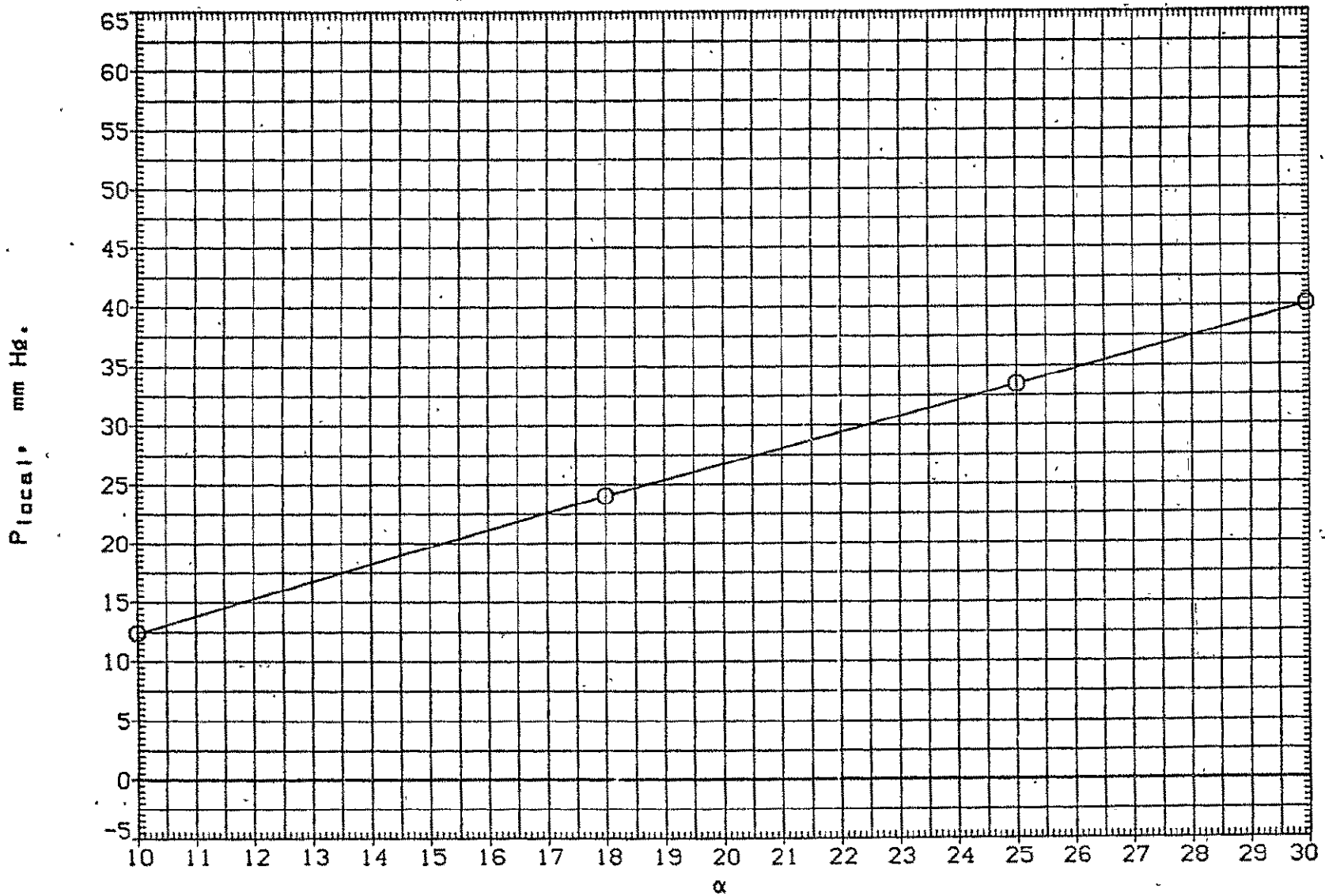


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

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(RJVW01) LARC 20IN M6 6468(LA88)

B58C5E18F4M3R5V5W87

SYMBOL X0 Y0 MACH
O 1200.000 317.000 5.940

PARAMETRIC VALUES
ELEVON .000 BOFLAP .000
SPOBRK .000

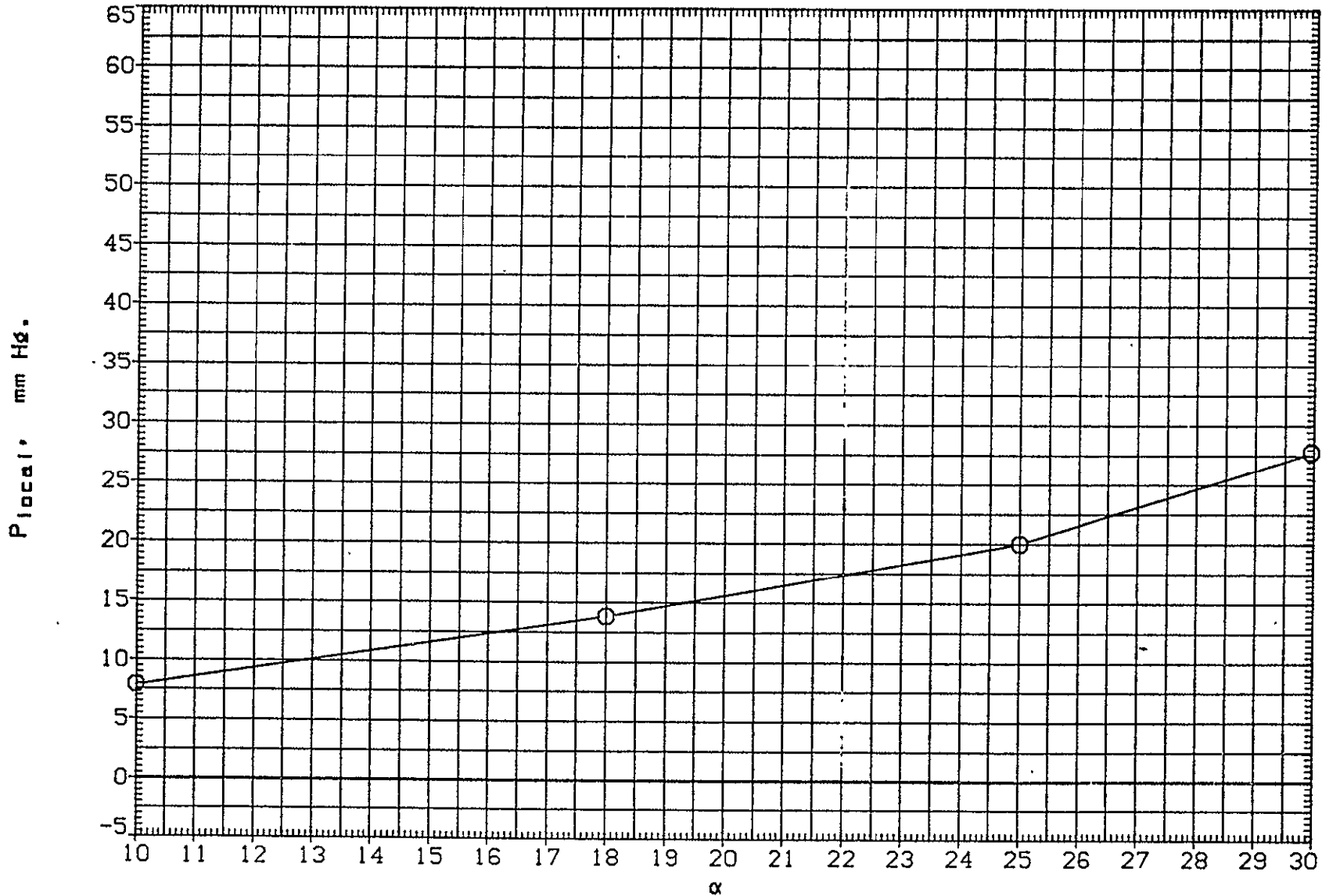


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

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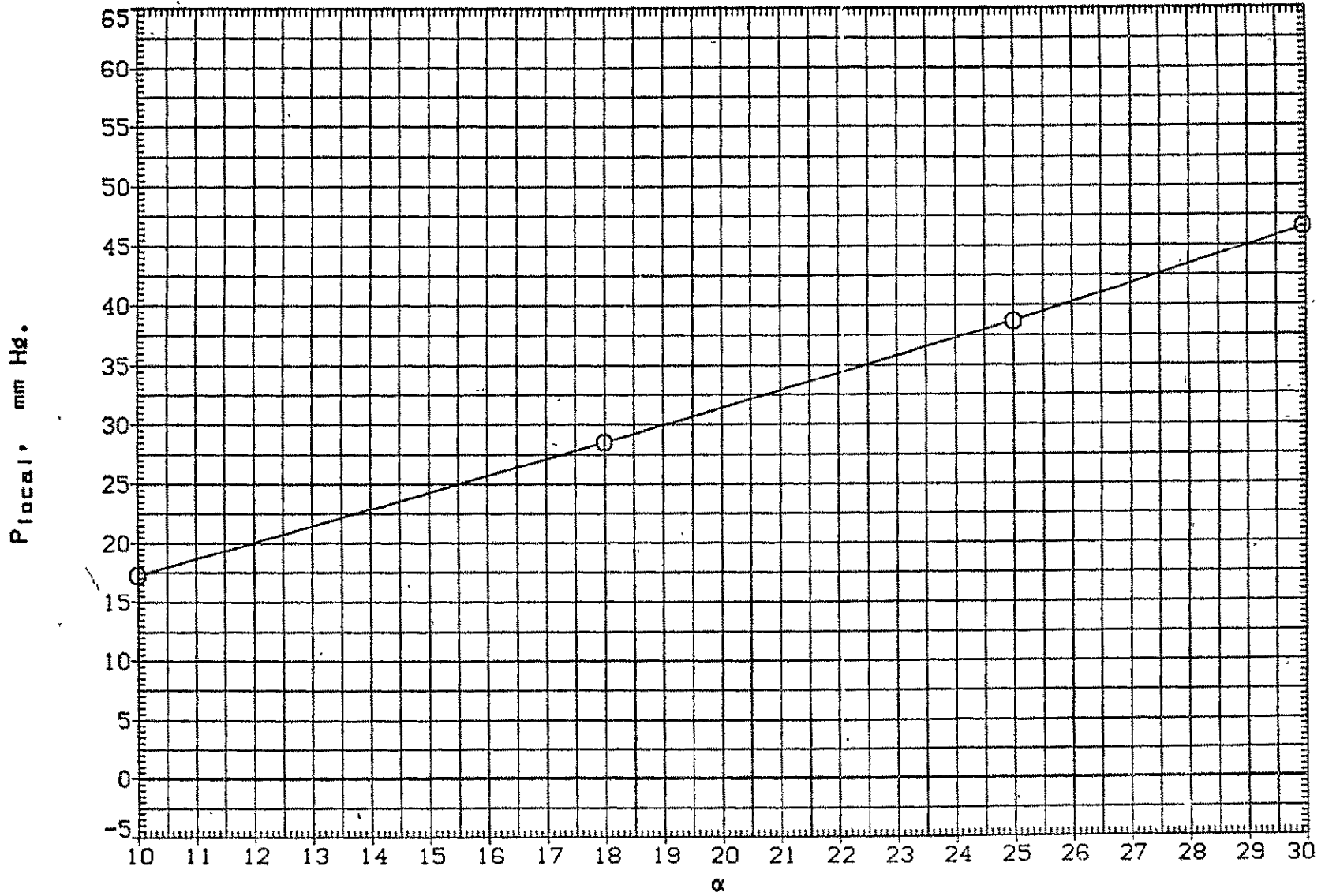


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

(RJVV01) LARC 20IN M6 6468(LA88)

B58C5E18F4M3R5V5W87

SYMBOL X0 Y0 MACH
O 1202.000 411.000 5.940

PARAMETRIC VALUES
ELEVON .000 BOFLAP .000
SPDBRK .000

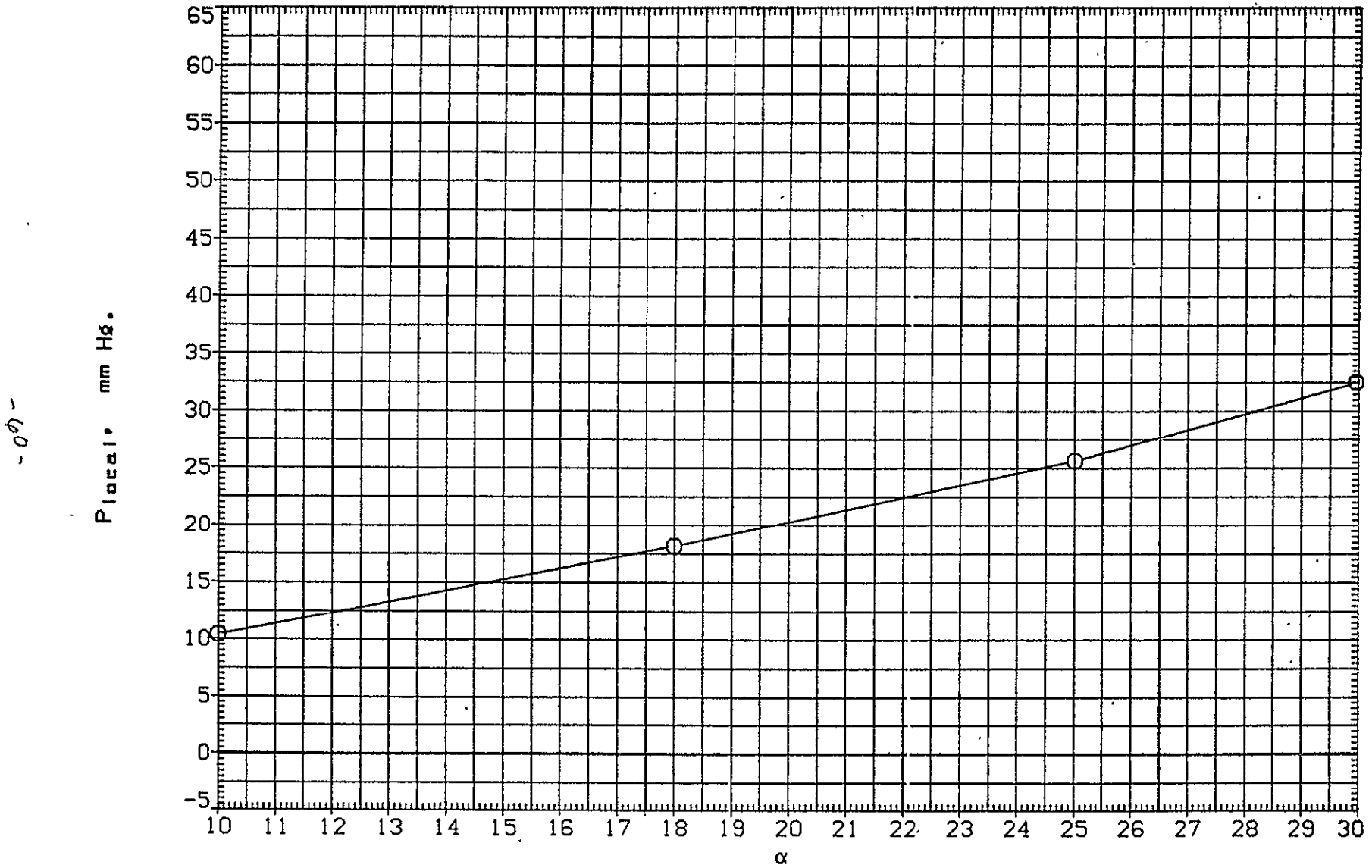


FIGURE 6. LARC 20IN. M6 6468(LA88) LOWER SURFACE PRESSURES
LOCAL PRESSURE ON LOWER WING SURFACE

APPENDIX

TABULATED SOURCE DATA

Tabulations of plotted data are available on request from Data Management Services.

DATE 14 JUN 76

LA7B, LA87, LA88 - PRESSURE SOURCE DATA TABULATION

PAGE 1

LARC CF4 267/E73(LA7B)

858C5E18F4M3R5V5W87

(RJLW01) (27 APR 76)

REFERENCE DATA

PARAMETRIC DATA

SREF = 2690.0000 SQ.FT. XMRP = 1076.7000 IN. XO
 LREF = 474.8000 INCHES YMRP = .0000 IN. YO
 BREF = 936.6800 INCHES ZMRP = 375.0000 IN. ZO
 SCALE = .0040

ELEVON = .000 BDFLAP = .000
 SPDBRK = .000

MACH (1) = 6.040 ALPHA (1) = 10.000 PTOT = 96868. TTOT = 438.52 Q(MMH) = 58.955

SECTION (1) WING

DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO
 361.000 8.0789
 364.000 8.9332
 527.000 8.3714
 530.000 8.7826
 782.000 8.4024
 784.000 7.7019
 911.000 12.6530
 913.000 28.2400
 982.000 7.9859
 1041.000 18.8480
 1046.000 16.8530
 1049.000 8.4361
 1102.000 8.3811
 1200.000 7.7811 8.4716 10.2050
 1202.000 12.9010
 1282.000 6.0819

MACH (1) = 6.040 ALPHA (2) = 18.000 PTOT = 96868. TTOT = 438.52 Q(MMH) = 58.955

SECTION (1) WING

DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO
 361.000 16.8110
 364.000 16.5750
 527.000 18.7900
 530.000 18.3340
 782.000 16.6940
 784.000 16.1370
 911.000 26.1690
 913.000 48.2040
 982.000 17.0280
 1041.000 .0000
 1046.000 27.1180
 1049.000 17.9010
 1102.000 16.7340
 1200.000 18.3350 16.3480 18.5130

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 REPRODUCIBILITY OF THIS ORIGINAL PAGE IS POOR

LARC CF4 267/273(LA78)

B58C5E18F4M3R5V5W87

(RJLW01)

MACH (1) = 6.040 ALPHA (2) = 18.000

SECTION (1) WING DEPENDENT VARIABLE PL

YO .0000 93.0000100.0000107.0000114.0000202.0000236.0000251.0000317.0000365.0000411.0000

XO
1202.000
1282.000 11.7360 21.4270

MACH (1) = 6.040 ALPHA (3) = 25.000 PTOT = 96868. TTOT = 438.52 Q(MMH) = 58.955

SECTION (1) WING DEPENDENT VARIABLE PL

YO .0000 93.0000100.0000107.0000114.0000202.0000236.0000251.0000317.0000365.0000411.0000

XO
361.000 28.1750
364.000 .0000
527.000 29.1930
530.000 26.0140
782.000 26.3260
784.000 23.0280
911.000 36.5350
913.000 60.3620
982.000 25.0840
1041.000 44.7660
1046.000 37.1100
1049.000 26.6530
1102.000 24.9600
1200.000 22.1380 23.1060 26.0630
1202.000 .0000
1282.000 16.5050

MACH (1) = 6.040 ALPHA (4) = 30.000 PTOT = 96868. TTOT = 438.52 Q(MMH) = 58.955

SECTION (1) WING DEPENDENT VARIABLE PL

YO .0000 93.0000100.0000107.0000114.0000202.0000236.0000251.0000317.0000365.0000411.0000

XO
361.000 40.1670
364.000 .0000
527.000 37.2020
530.000 32.4930
782.000 36.2290
784.000 31.3800
911.000 19.9990
913.000 72.9080
982.000 34.7610
1041.000 55.3140
1046.000 47.0780

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LA78, LA87, LA88 - PRESSURE SOURCE DATA TABULATION

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LARC CF4 267/273(LA78)

B58C5E18F4M3R5V5W87

(RJLW01)

MACH (1) = 6.040 ALPHA (4) = 30.000

SECTION (1) WING

DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO

1049.000

35.2090

1102.000 33.0970

1200.000

35.2420 31.4160

35.0050

1202.000

37.6410

1282.000 22.8600

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LARC 201N M6 6468(LA88)

858C5E18F4M3R5V5W87

(RJVVW01) (27 APR 76)

REFERENCE DATA

PARAMETRIC DATA

SREF = 2690.0000 SQ.FT.	XMRP = 1076.7000 IN. XO	ELEVON = .000	BDFLAP = .000
LREF = 474.8000 INCHES	YMRP = .0000 IN. YO	SPDBRK = .000	
BREF = 936.6800 INCHES	ZMRP = 375.0000 IN. ZO		
SCALE = .0040			

MACH (1) = 5.940 ALPHA (1) = 10.000 PTOT = 2678.5 TTOT = 176.87 Q(MMH) = 44.545

SECTION (1) WING

DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO										
361.000	5.6602									
364.000		5.7872								
527.000	5.5917									
530.000			5.5693							
782.000	5.4472									
784.000			5.9996							
911.000				6.3425						
913.000										
982.000	5.4740				19.6900					
1041.000										
1046.000									17.2290	
1049.000										
1102.000	5.4908			5.9329		12.4010				
1200.000					4.7944	5.2864			7.9183	
1202.000										
1282.000	4.4555									10.4290

MACH (1) = 5.940 ALPHA (2) = 18.000 PTOT = 2678.5 TTOT = 176.87 Q(MMH) = 44.545

SECTION (1) WING

DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO										
361.000	12.0670									
364.000		10.7350								
527.000	12.6010									
530.000			11.7850							
782.000	13.1380									
784.000			14.0540							
911.000				14.5720						
913.000										
982.000	12.7920				35.1780					
1041.000										
1046.000									28.5090	
1049.000							24.0550			
1102.000	12.3610			13.1430						
1200.000					11.0180	12.0360			13.8540	

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LA78, LA87, LA88 - PRESSURE SOURCE DATA TABULATION

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LARC 201N M6 6468(LA88)

B58C5E18F4M3R5V5W87

(RJVV01)

MACH (1) = 5.940 ALPHA (2) = 18.000

SECTION (1) WING DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO
1202.000 18.1910
1282.000 10.0560

MACH (1) = 5.940 ALPHA (3) = 25.000 PTOT = 2678.5 TTOT = 176.87 Q(MMH) = 44.545

SECTION (1) WING DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO
361.000 19.5370
364.000 15.9530
527.000 21.2070
530.000 18.6700
782.000 20.9300
784.000 21.7460
911.000 22.4250
913.000 45.2250
982.000 19.7530
1041.000 38.6970
1046.000 33.4580
1049.000 20.7720
1102.000 18.9320
1200.000 17.2630 18.7680 20.0230
1202.000 25.6780
1282.000 15.7460

MACH (1) = 5.940 ALPHA (4) = 30.000 PTOT = 2678.5 TTOT = 176.87 Q(MMH) = 44.545

SECTION (1) WING DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO
361.000 27.8540
364.000 20.9650
527.000 29.2990
530.000 24.7380
782.000 27.9920
784.000 28.5730
911.000 29.5850
913.000 52.5440
982.000 26.5890
1041.000 46.5340
1046.000 40.1420

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DATE 14 JUN 76

LA78, LA87, LA88 - PRESSURE SOURCE DATA TABULATION

LARC 201N M6 6488(LA88)

B58C5E16F4M3R5V5W87

(RJVV01)

MACH (1) = 5.940 ALPHA (4) = 30.000

SECTION (1) WING

DEPENDENT VARIABLE PL

YO .0000 93.0000109.0000107.0000114.0000202.0000236.0000251.0000317.0000365.0000411.0000

XO

1049.000

28.0290

1102.000 .0000

1200.000

23.7470 25.7250

27.7800

1202.000

1282.000 21.9820

32.5450

-67-

REFERENCE DATA

PARAMETRIC DATA

SREF = 2690.0000 SQ.FT. XMRP = 1076.7000 IN. XO
 LREF = 474.8000 INCHES YMRP = .0000 IN. YO
 BREF = 936.6800 INCHES ZMRP = 375.0000 IN. ZO
 SCALE = .0040

ELEVON = .000 BDFLAP = .000
 SPDBRK = .000

MACH (1) = 20.300 ALPHA (1) = 5.000 PTOT = 51598. TTOT = 28.725 Q(MMH) = 81.010

SECTION (1) WING

DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO
 361.000 4.1104
 364.000 4.2987
 527.000 3.6135
 530.000 3.6034
 782.000 .0000
 784.000 3.4969
 911.000 3.6032
 913.000 18.7360
 982.000 3.4116
 1041.000 18.9960
 1046.000 10.2320
 1049.000 3.3989
 1102.000 3.2757
 1200.000 3.0627 3.1373 5.6288
 1202.000 8.3321
 1282.000 2.8504

MACH (1) = 20.300 ALPHA (2) = 10.000 PTOT = 51598. TTOT = 28.725 Q(MMH) = 81.010

SECTION (1) WING

DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO
 361.000 6.7102
 364.000 6.7650
 527.000 6.1979
 530.000 5.9933
 782.000 .0000
 784.000 6.7221
 911.000 7.5815
 913.000 39.4650
 982.000 6.9740
 1041.000 29.8720
 1046.000 21.9780
 1049.000 7.0116
 1102.000 6.7452
 1200.000 5.6711 7.1529 10.7120

- 6 0 -

LARC 22IN HELIUM 446(LA87) B58C5E18F4M3R5V5W87

(RJ5W01)

MACH (1) = 20.300 ALPHA (2) = 10.000

SECTION (1) WING DEPENDENT VARIABLE PL

YO .0000 93.0000100.0000107.0000114.0000202.0000236.0000251.0000317.0000365.0000411.0000

XO
1202.000
1282.000 5.4312 15.0540

MACH (1) = 20.300 ALPHA (3) = 15.000 PTOT = 51598. TTOT = 28.725 Q(MMH) = 81.010

SECTION (1) WING DEPENDENT VARIABLE PL

YO .0000 93.0000100.0000107.0000114.0000202.0000236.0000251.0000317.0000365.0000411.0000

XO
361.000 12.7310
364.000 11.2270
527.000 12.3610
530.000 11.6390
782.000 16.9310
784.000 14.6000
911.000 - 16.8990
913.000 67.9810
982.000 15.4170
1041.000 40.6540
1046.000 30.3810
1049.000 15.5440
1102.000 14.7980
1200.000 12.1380 14.5750 16.8330
1202.000 23.7710
1282.000 11.4290

MACH (1) = 20.300 ALPHA (4) = 18.000 PTOT = 51598. TTOT = 28.725 Q(MMH) = 81.010

SECTION (1) WING DEPENDENT VARIABLE PL

YO .0000 93.0000100.0000107.0000114.0000202.0000236.0000251.0000317.0000365.0000411.0000

XO
361.000 16.6780
364.000 14.0660
527.000 17.2740
530.000 15.6720
782.000 22.7600
784.000 20.4120
911.000 22.5930
913.000 73.6050
982.000 20.3350
1041.000 48.6530
1046.000 35.7930

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DATE 14 JUN 76

LA78, LA87, LA88 - PRESSURE SOURCE DATA TABULATION

PAGE 9

LARC 221N HELIUM 446(LA87) B58C5E18F4M3R5V5W87

(RJ5W01)

MACH (1) = 20.300 ALPHA (4) = 18.000

SECTION (1) WING

DEPENDENT VARIABLE PL

YO .0000 93.0000 100.0000 107.0000 114.0000 202.0000 236.0000 251.0000 317.0000 365.0000 411.0000

XO										
1049.000				20.6080						
1102.000	19.2970									
1200.000				16.0460	18.6080			21.3000		
1202.000									29.8100	
1282.000	14.8220									

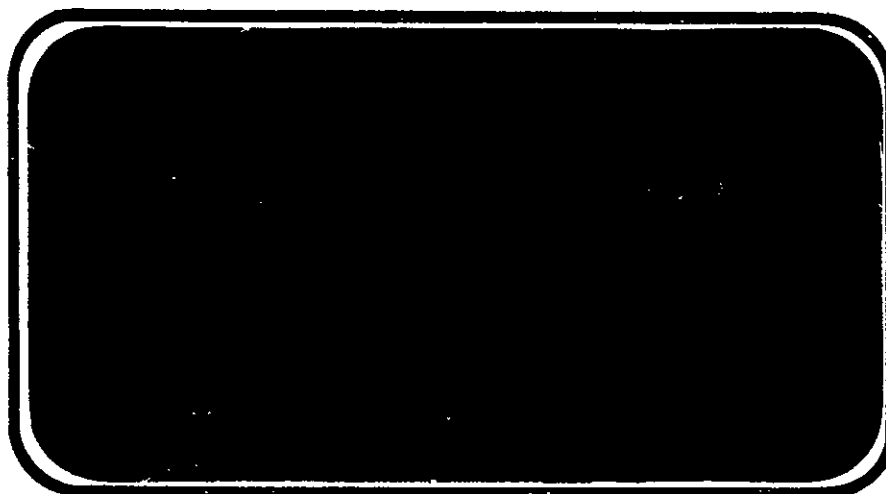
-70-



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA CR:

147620



(NASA-CR-147620) RESULTS FROM
 INVESTIGATIONS IN THREE NASA/LARC HYPERSONIC
 WIND TUNNELS ON A .004 SCALE MODEL SPACE
 SHUTTLE ORBITER (MODEL 13P-0) TO DETERMINE
 REAL GAS EFFECTS (LA78, LA87, LA88)

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SPACE SHUTTLE

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