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RESEARCH MEMORANDUM

CHORDWISE PRESSURE DISTRIBUTION AT HIGH SUBSONIC SPEEDS NEAR MIDSEMISPAN OF A TAPERED 35° SWEPTBACK WING OF ASPECT RATIO 4 HAVING NACA 65A006 AIRFOIL SECTIONS AND EQUIPPED WITH VARIOUS SPOILER AILERONS

By Alexander D. Hammond and Barbara M. McMullan

Langley Aeronautical Laboratory
Langley Field, Va.

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RESEARCH MEMORANDUM

CHORDWISE PRESSURE DISTRIBUTION AT HIGH SUBSONIC SPEEDS NEAR MIDSEMISPAN OF A TAPERED 35° SWEPTBACK WING OF ASPECT RATIO 4 HAVING NACA 65A006 AIRFOIL SECTIONS AND EQUIPPED WITH VARIOUS SPOILER AILERONS

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SUMMARY

An investigation was made in the Langley high-speed 7- by 10-foot tunnel through a Mach number range from 0.60 to 0.93 to determine the effects on the chordwise pressure distributions of projecting various spoiler-type ailerons on a swept wing. The semispan 35° sweptback wing had an NACA 65A006 airfoil section, an aspect ratio of 4, and a taper ratio of 0.6.

The results of the investigation are presented as curves of chordwise pressure distributions near the midspan of the spoilers (0.46-wing-semispan station).

INTRODUCTION

The use of spoiler-type ailerons for lateral control has been the subject of a number of investigations at both low and high speed. These investigations have for the most part dealt with force measurements to determine the effects of various spoiler configurations on the characteristics of both swept and unswept wings. There is, however, very little information concerning the aerodynamic loads on swept wings equipped with spoiler-type controls at high subsonic speeds. In order to obtain some information on such loads and on the flow in the vicinity of the spoiler on swept wings, chordwise pressure measurements have been made at one spanwise location on the upper and lower surfaces of a 35° sweptback semispan wing equipped with various spoiler-type controls in the Langley high-speed 7- by 10-foot tunnel.

For these tests a solid plug-type spoiler aileron was projected various heights from 3 percent of the local wing chord below the lower

wing surface to 4 percent of the local wing chord above the upper wing surface. The tests were made at Mach numbers from 0.60 to 0.93 for an angle-of-attack range from 0° to 20°. In addition three fingered-type spoiler-aileron configurations and a perforated plug-type-spoiler aileron were investigated at a projection of 4 percent of the local wing chord above the wing surface through the same angle-of-attack and Mach number range.

SYMBOLS

M	Mach number
P	pressure coefficient $\left(\frac{p_l - p}{q}\right)$
p	free-stream static pressure, lb/sq ft
p_l	local static pressure, lb/sq ft
p_a	atmospheric pressure
P_{cr}	critical-pressure coefficient, that is, the pressure coefficient corresponding to the local velocity of sound $\left(\frac{0.528p_a - p}{q}\right)$
q	free-stream dynamic pressure, lb/sq ft
α	angle of attack, deg
$\bar{c}$	mean aerodynamic chord of wing, 1.020 ft $\left(\frac{2}{S}\int_0^{b/2} c^2 dy\right)$
S	twice wing area of semispan model, 4.00 sq ft
b	wing span, ft
c	local chord, ft
x	chordwise coordinate, parallel to plane of symmetry of the pressure orifice, ft
y	spanwise distance from plane of symmetry, ft

Λ angle of sweep of the quarter-chord line, deg

δ_s projection of spoiler (projections below lower wing surface are positive), percent c

APPARATUS AND MODEL

The model used in this investigation was a semispan sweptback-wing model mounted vertically in the Langley high-speed 7- by 10-foot tunnel with the ceiling serving as a reflection plane.

The geometric characteristics and dimensions of the wing are shown in figure 1. The wing was made of steel and had 35° of sweepback of the quarter-chord line, an aspect ratio of 4, a taper ratio of 0.6, and had no twist or dihedral. The wing had NACA 65A006 airfoil sections parallel to free stream.

The pressure orifices were located on the upper and lower surfaces of the chordwise section at the 46-percent-semispan station which corresponds to approximately the midspan of the various spoiler configurations investigated. The chordwise positions of the orifice are listed in table I.

The spoiler configurations investigated (fig. 2 and table II) are as follows:

(a) Configurations A, B, and C - A fingered spoiler aileron projected -0.04c (gap unsealed)

(b) Configurations E, F, G, H, and J - A solid plug-type spoiler aileron projected -0.01c, -0.02c, -0.03c, -0.04c, and 0.03c, respectively (gap unsealed)

(c) Configuration K - A perforated plug-type spoiler aileron projected -0.04c (gap unsealed)

(d) Configurations L and D - The plain wing, gap around spoiler sealed and unsealed, respectively

TESTS

All the tests were made in the Langley high-speed 7- by 10-foot tunnel. The various spoiler configurations were investigated through

the Mach number range from 0.60 to 0.93 at angles of attack from 0° to 20°. The Reynolds number varied from about 3.1×10^{6} at $M = 0.60$ to about 4.0×10^{6} at $M = 0.93$ when based on the wing mean aerodynamic chord.

PRESENTATION OF THE DATA

Because of the interest shown in the results of this investigation, the pressure distributions over the various spoiler configurations are being presented without discussion in order to expedite the publication of the data. It is felt, however, that the pressure data as presented will be useful in the prediction of the local chordwise wing loadings and in the prediction of some of the spoiler loads for spoiler configurations similar to those of this investigation.

The chordwise pressure distributions as obtained in this investigation on a 35° sweptback tapered wing equipped with various spoiler-aileron configurations are presented in figures 3 to 13. Table II lists the figure numbers for the data corresponding to each spoiler configuration investigated. It should be noted that the angle of attack shown on the figures has not been corrected for air-stream misalinement and tunnel-wall effects.

The following discussion describes the procedure used in obtaining the data for the figures as presented. Each orifice on the upper and lower surfaces of the wing was connected to a manometer tube whose location relative to an arbitrary unit length of the manometer board corresponded to the location of the orifice relative to the wing chord. Photographs were made of the manometer board and the chordwise pressure distributions were faired on blueprints made from the negatives. These blueprints were later bleached and used for the final figures. It should be noted therefore that the vertical scale for these plots is a function of the tunnel Mach number and that the horizontal scale is, of course, the same for all figures.

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Langley Field, Va.

TABLE I

LOCATION OF PRESSURE ORIFICES

Chordwise positions of orifices on upper surface		Chordwise positions of orifices on lower surface	
Orifice	Percent chord	Orifice	Percent chord
1	0	1	2
2	1	2	6
3	4	3	10
4	8	4	$21\frac{1}{3}$
5	15	5	$30\frac{1}{3}$
6	$25\frac{1}{3}$	6	$41\frac{2}{3}$
7	$35\frac{1}{3}$	7	$50\frac{2}{3}$
8	$45\frac{2}{3}$	8	$58\frac{2}{3}$
9	$55\frac{2}{3}$	9	66
10	64	10	68
11	67	11	77
12	69	12	80
13	71	13	$90\frac{1}{3}$
14	75	14	$98\frac{1}{3}$
15	$85\frac{1}{3}$		
16	$95\frac{1}{3}$		

TABLE II

GEOMETRIC CHARACTERISTICS OF SPOILER CONFIGURATIONS

Configuration	Inboard end (percent b/2)	Outboard end (percent b/2)	Chordwise location (percent c)	Projection (percent c)	Type	Gap	Figure
A	38	54	70	-4	Fingered	Unsealed	11
B	38	54	70	-4	Fingered	Unsealed	12
C	38	55	70	-4	Fingered	Unsealed	13
D	14	98	70	0	----------	Unsealed	3
E	14	98	70	-1	Solid	Unsealed	6
F	14	98	70	-2	Solid	Unsealed	7
G	14	98	70	-3	Solid	Unsealed	8
H	14	98	70	-4	Solid	Unsealed	9
J	14	98	70	3	Solid	Unsealed	5
K	14	50	70	-4	Perforated	Unsealed	10
L	14	98	70	0	----------	Sealed	4

NACA

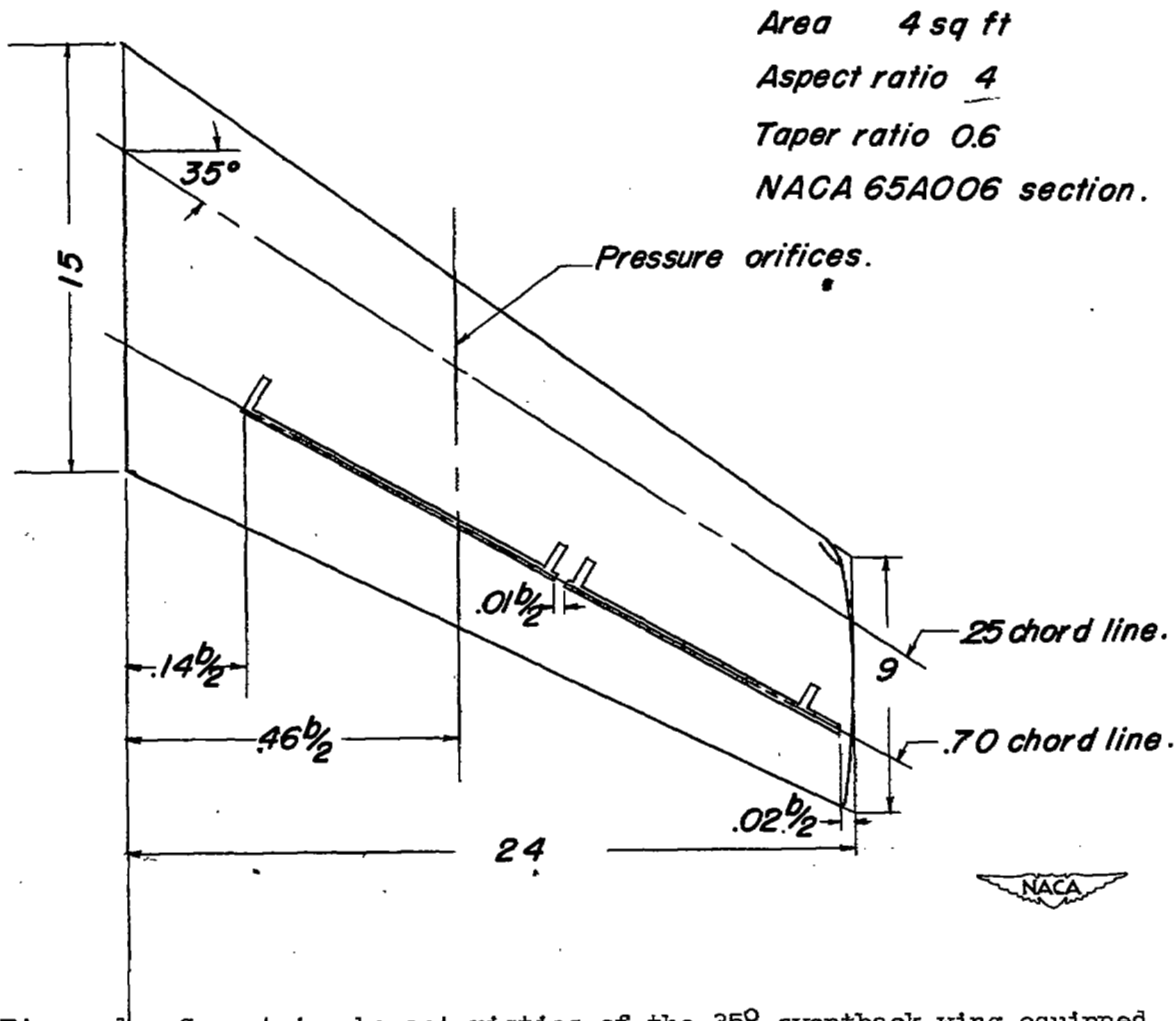


Figure 1.- Geometric characteristics of the 35° sweptback wing equipped with a plug-type spoiler aileron. (All dimensions are in inches unless otherwise noted.)

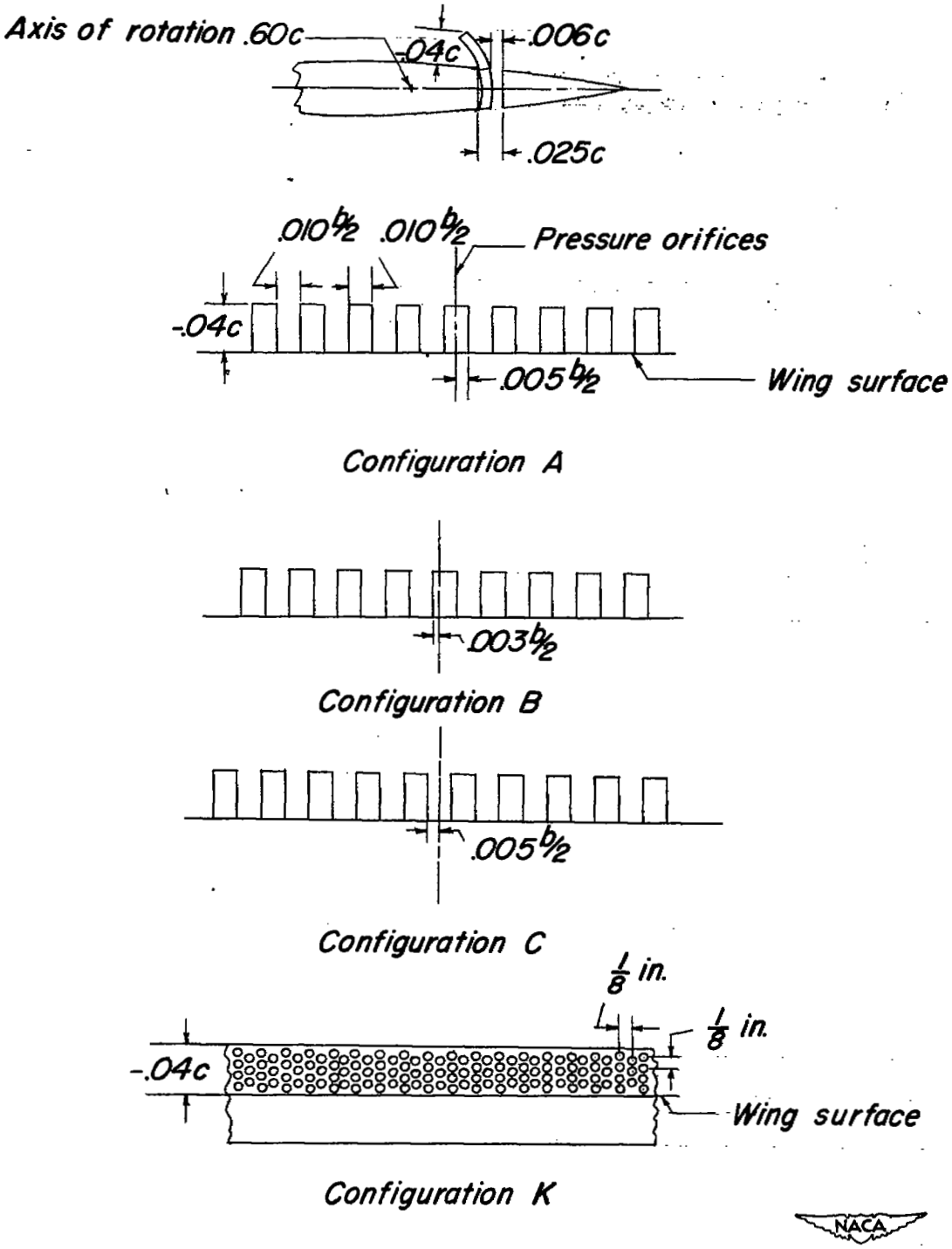
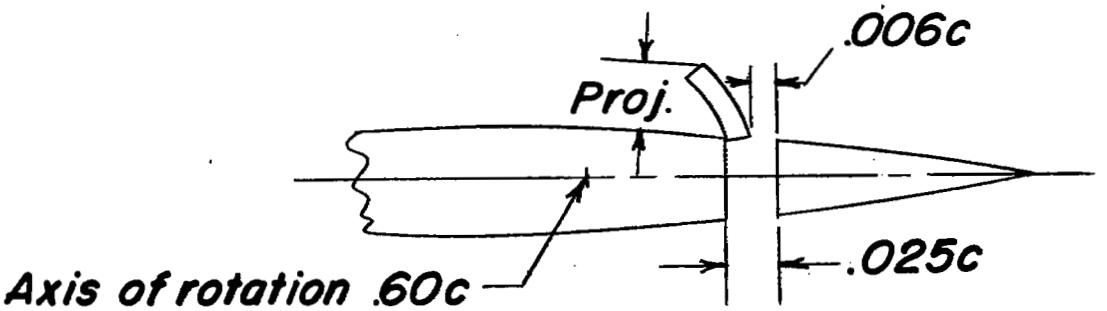
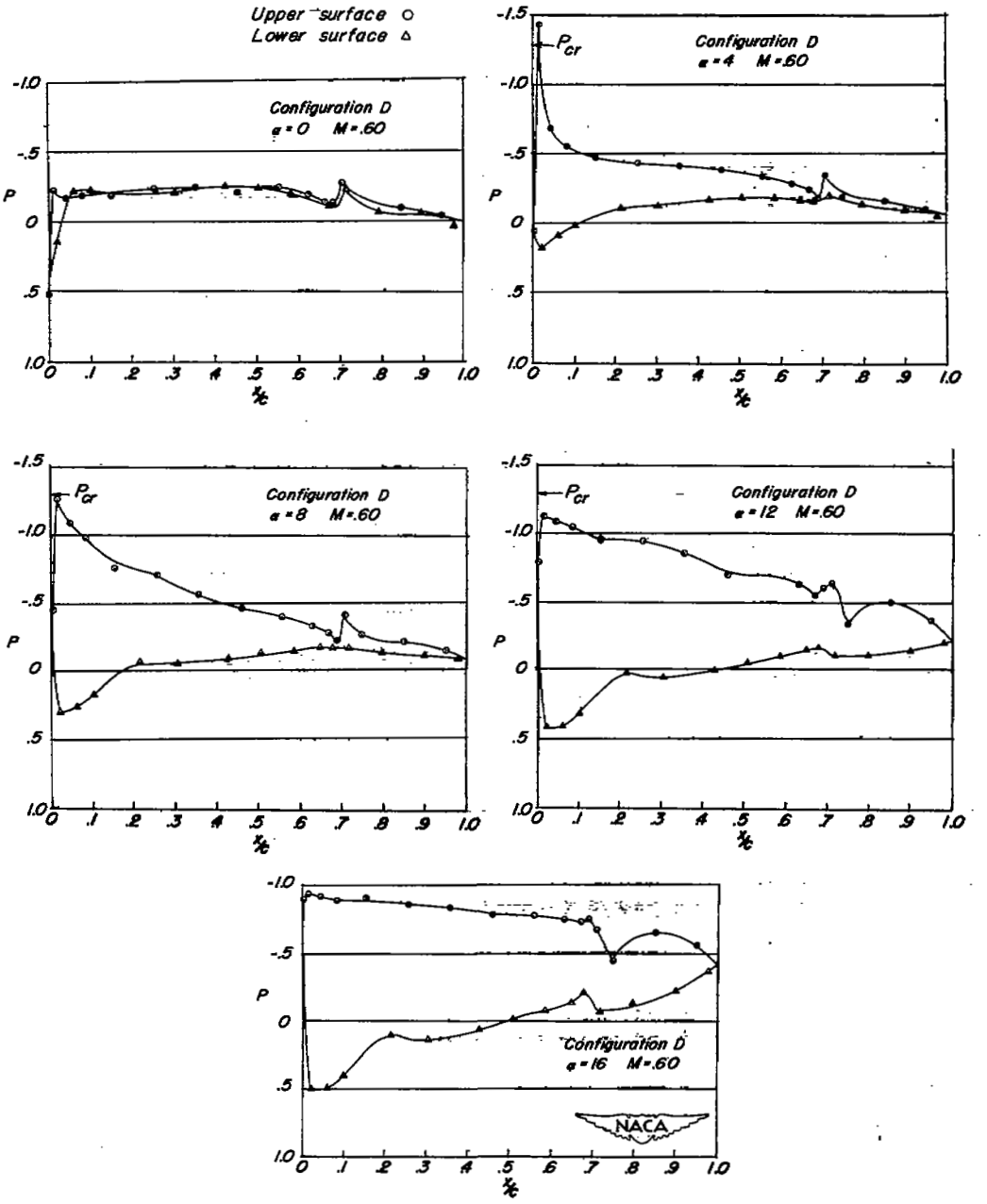


Figure 2.- Details of the various spoiler aileron configurations.



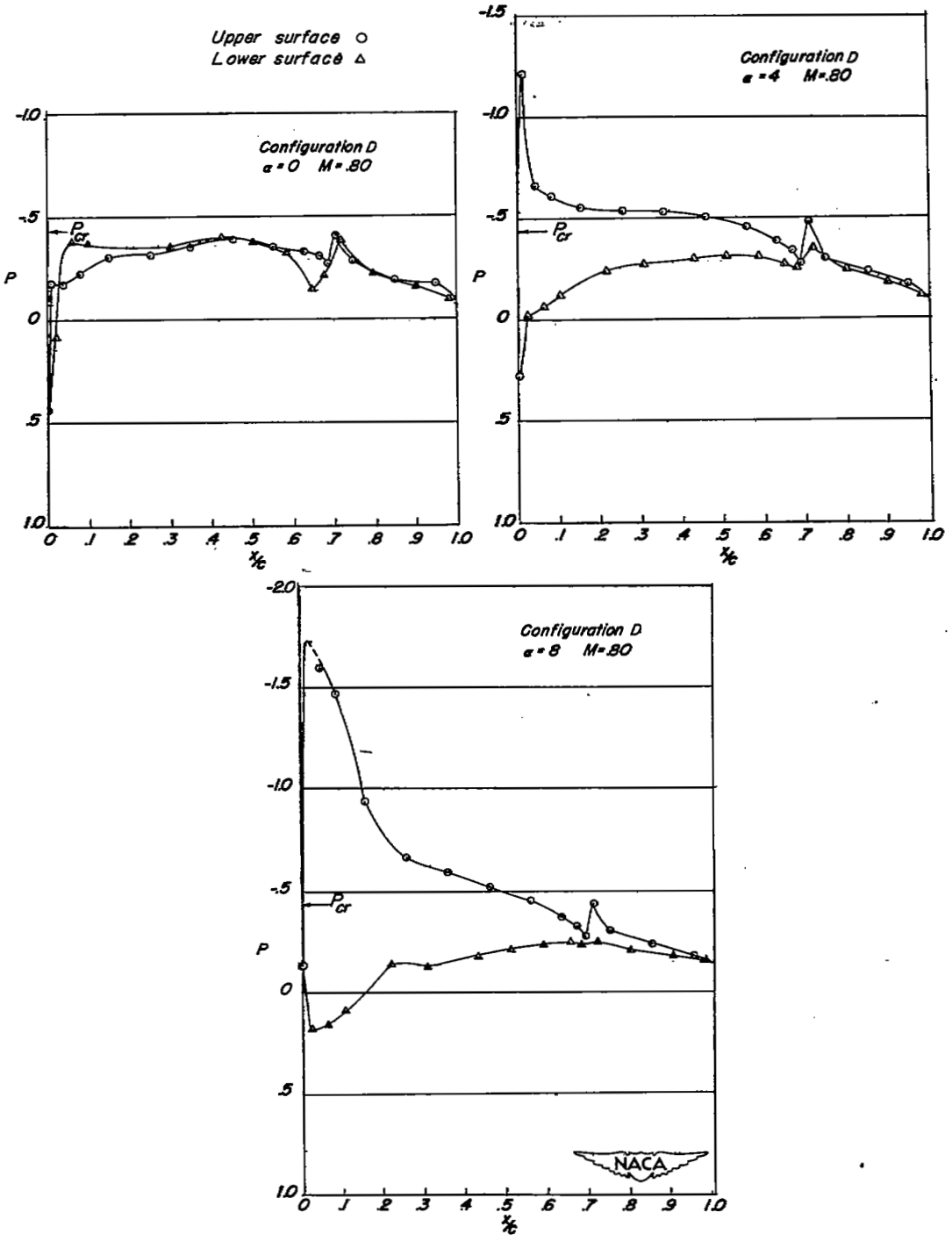
Configuration	Projection
D	0
E	-.01c
F	-.02c
G	-.03c
H	-.04c
J	.03c
L	0 (Gap sealed)

Figure 2.- Concluded.



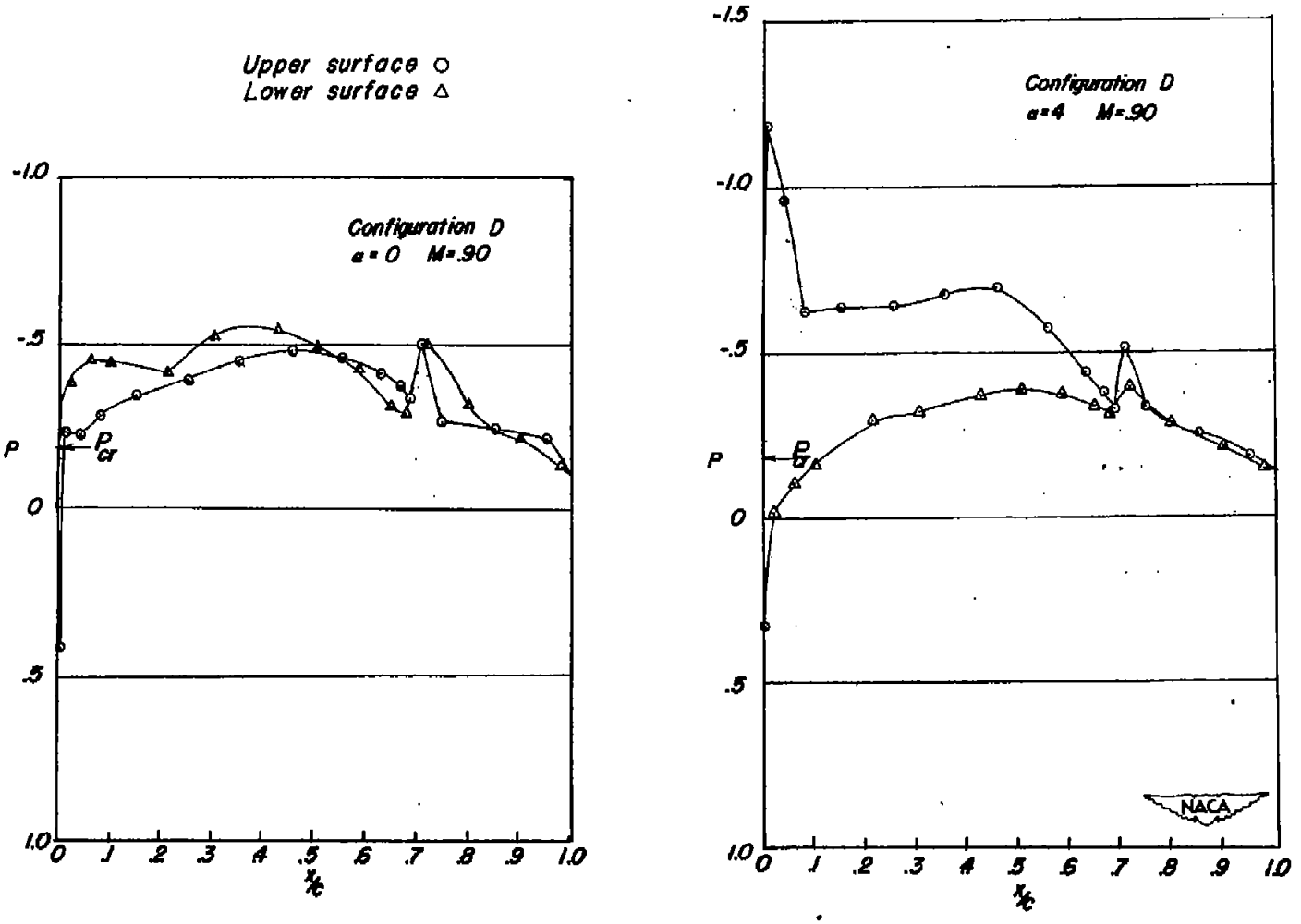
(a) M = 0.60.

Figure 3.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type-spoiler aileron. δ_s = 0; gap unsealed.



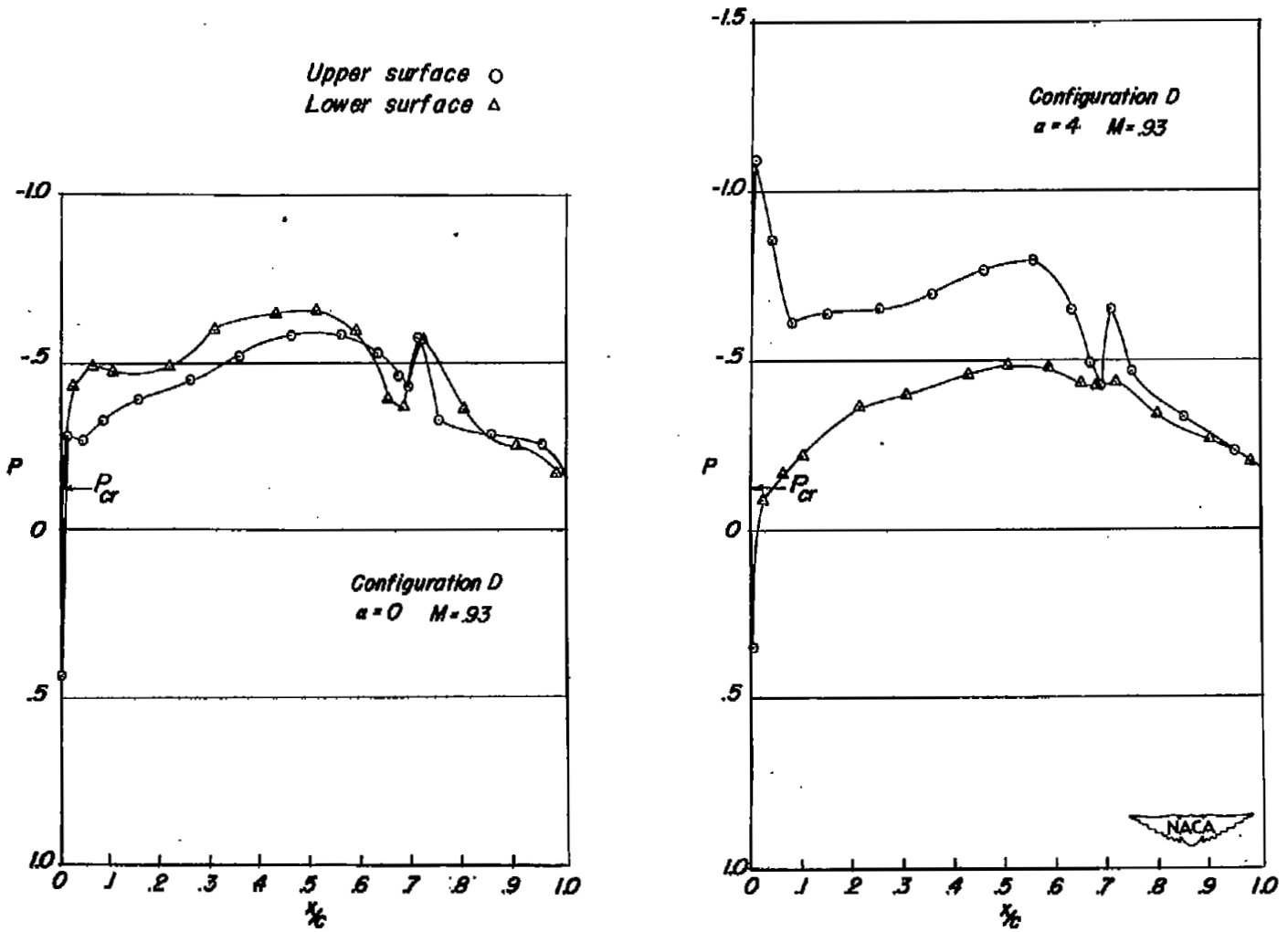
(b) M = 0.80.

Figure 3.- Continued.



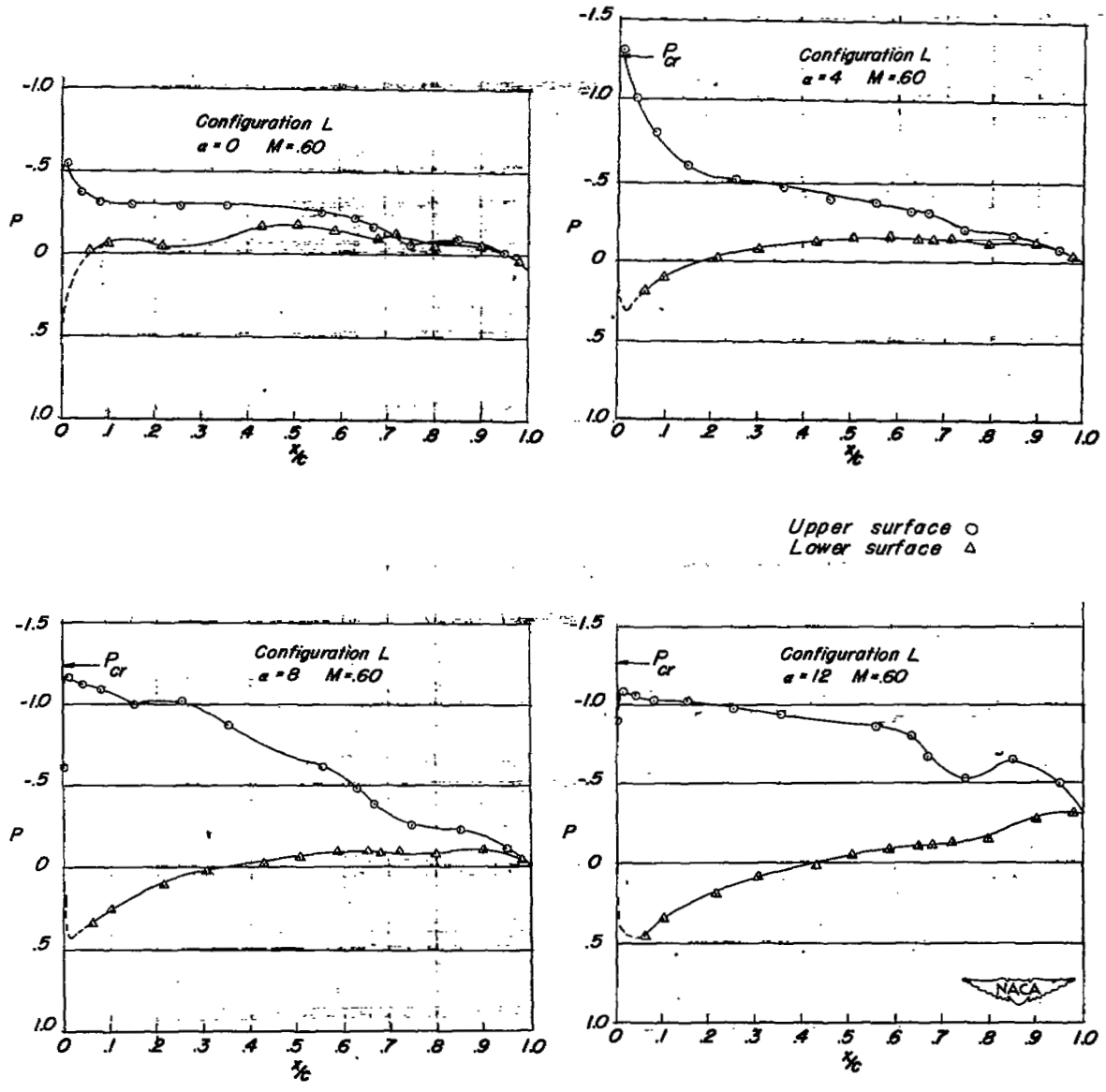
(c) M = 0.90.

Figure 3.- Continued.



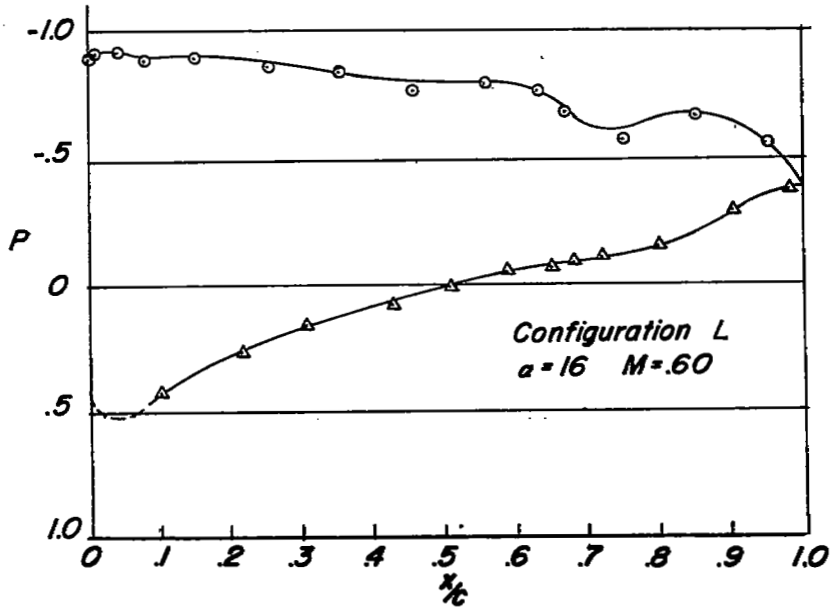
(d) M = 0.93.

Figure 3.- Concluded.

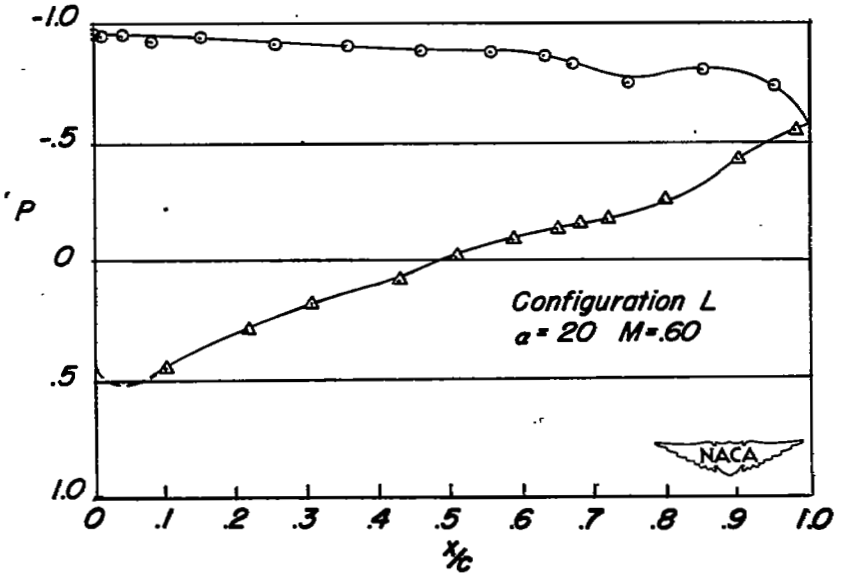


(a) M = 0.60.

Figure 4.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type spoiler aileron. $\delta_s = 0$; gap sealed.

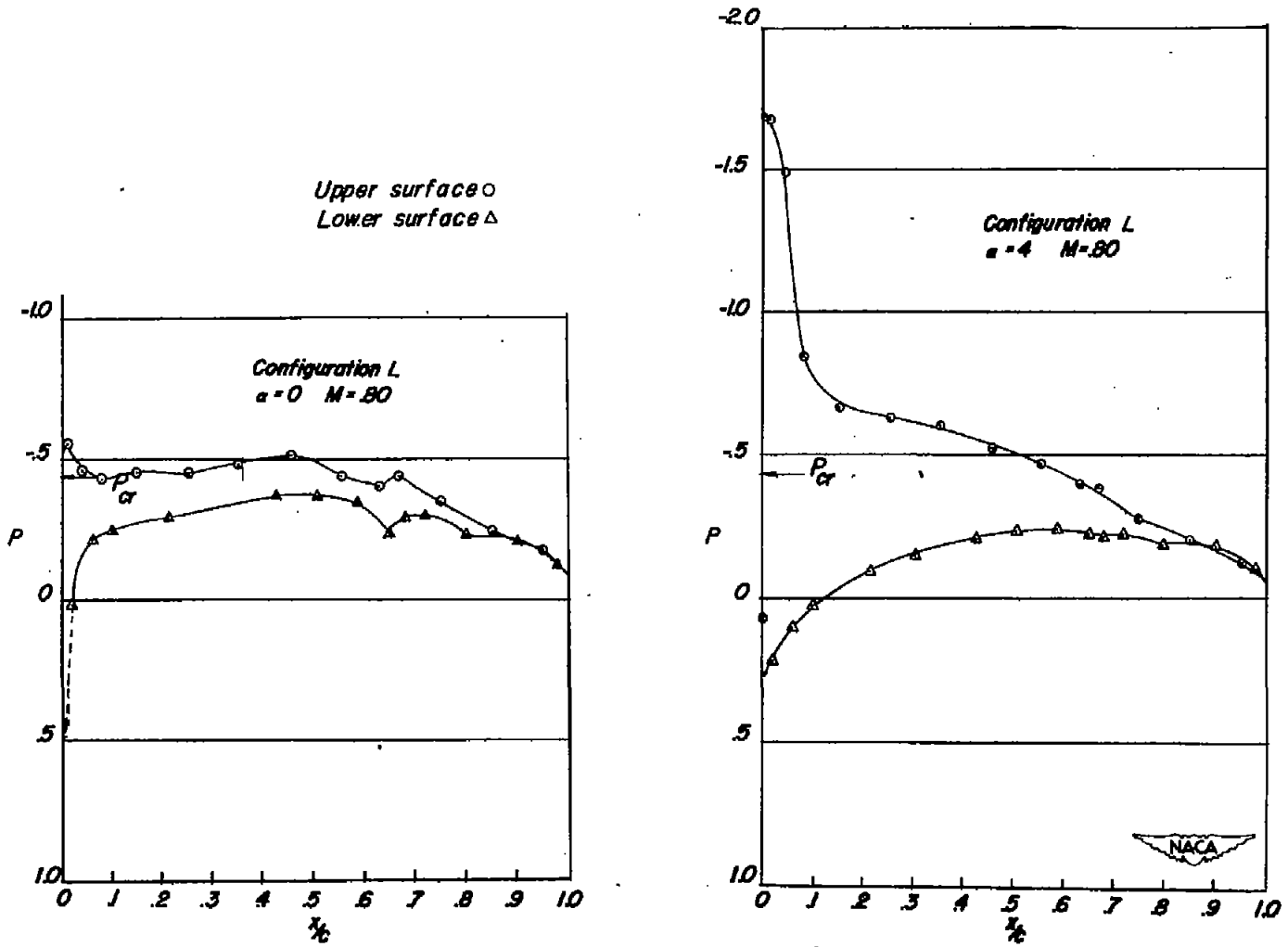


Upper surface ○
Lower surface △



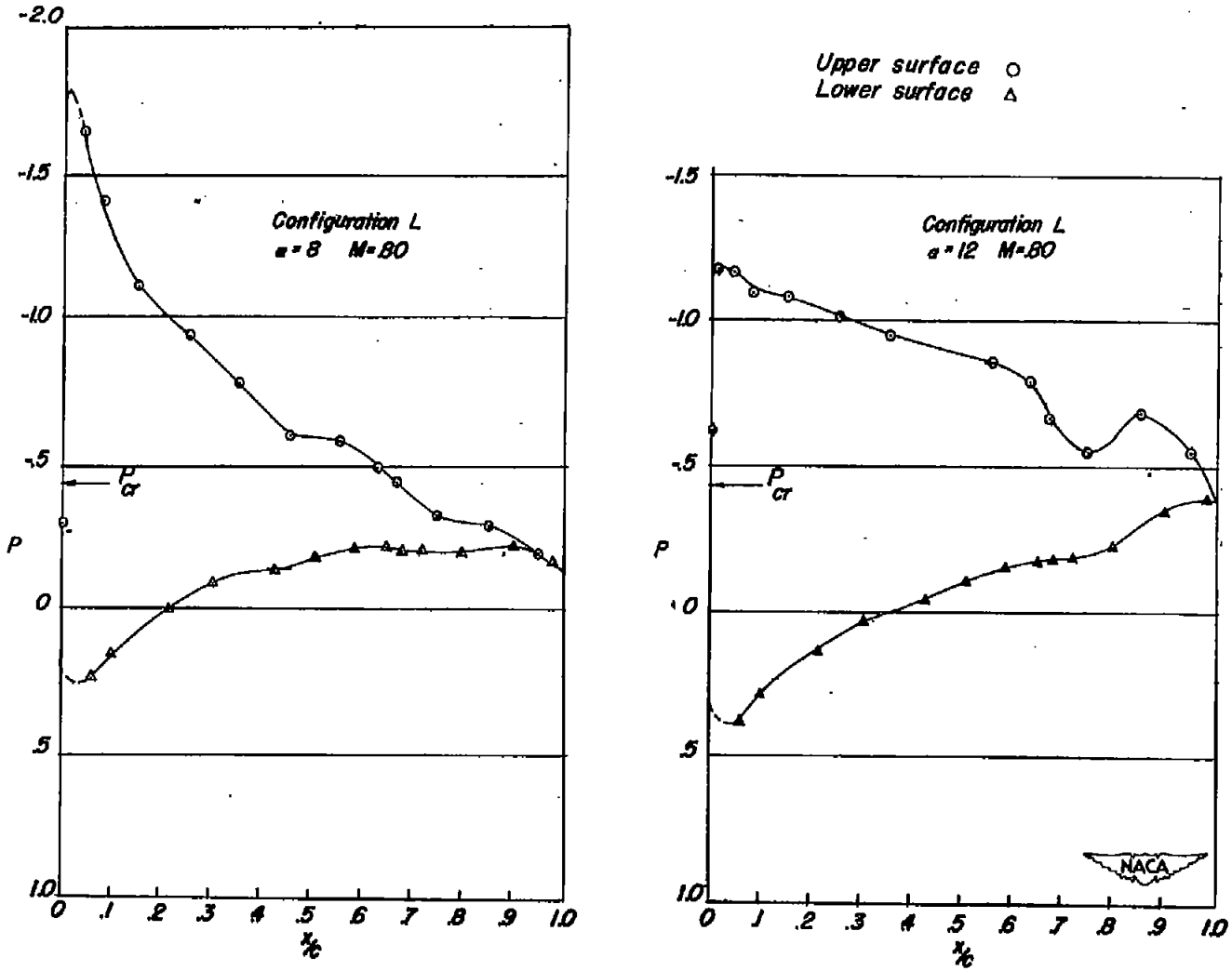
(a) M = 0.60. Concluded.

Figure 4.- Continued.



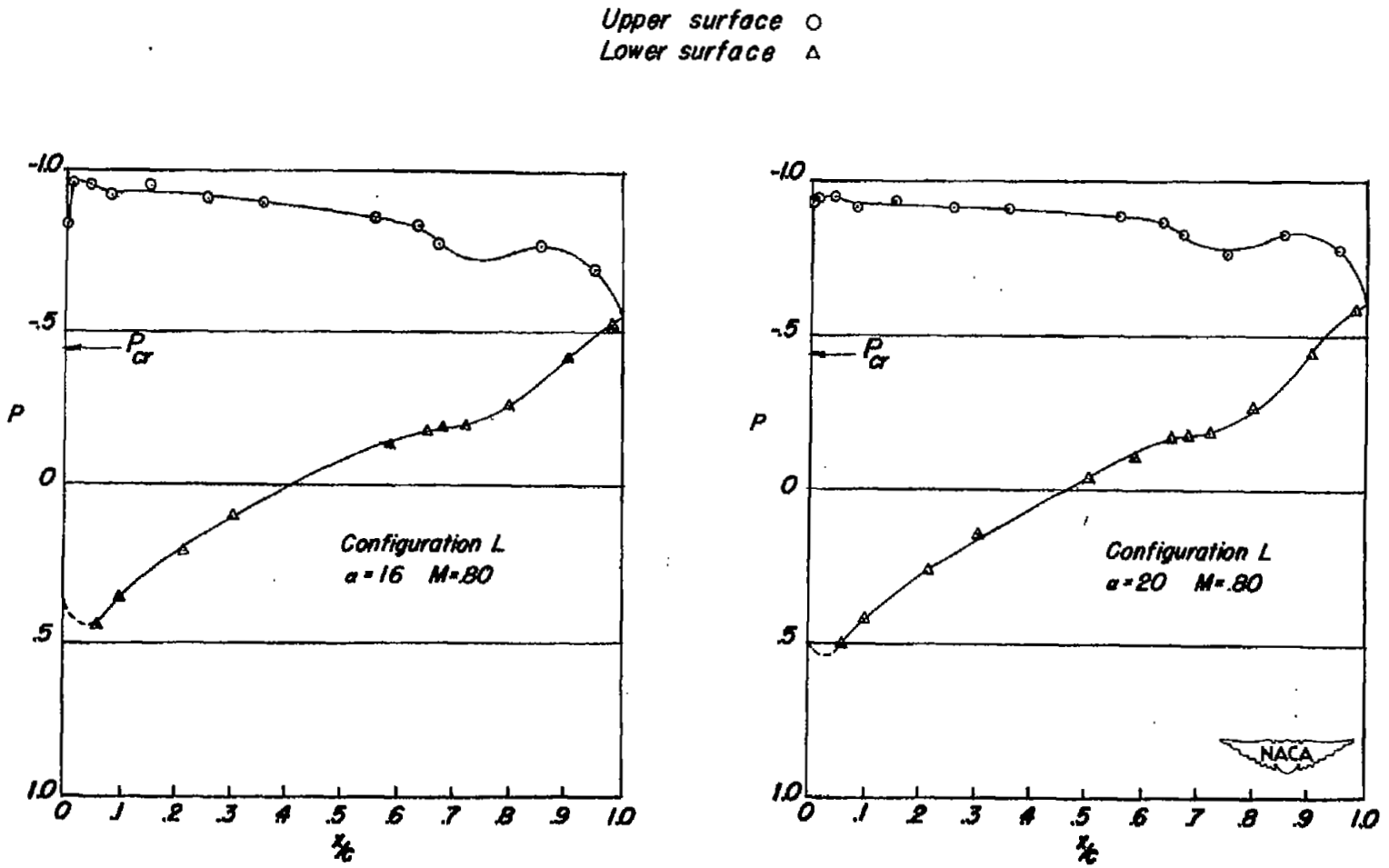
(b) M = 0.80.

Figure 4.- Continued.



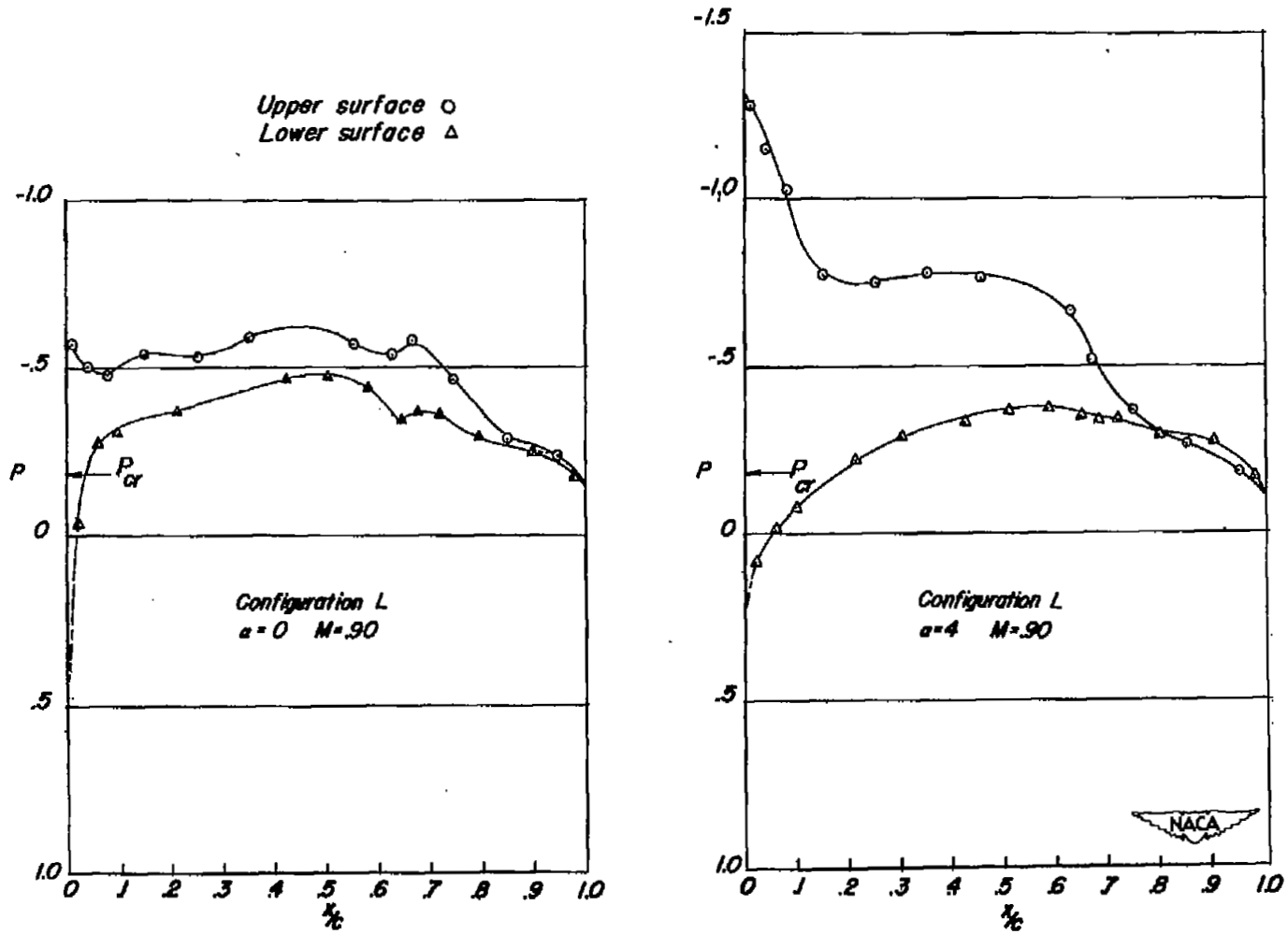
(b) M = 0.80. Continued.

Figure 4.- Continued.



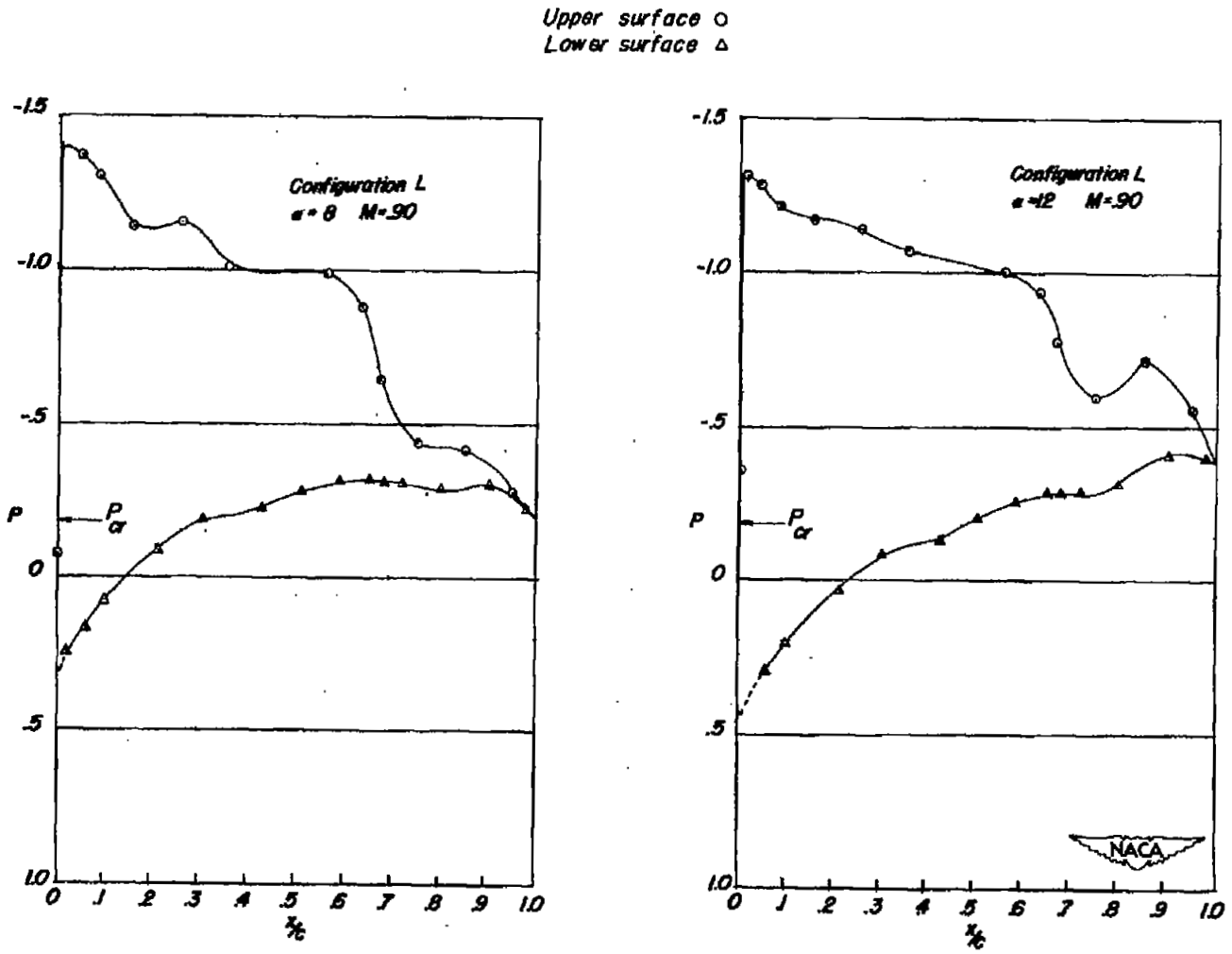
(b) M = 0.80. Concluded.

Figure 4.- Continued.



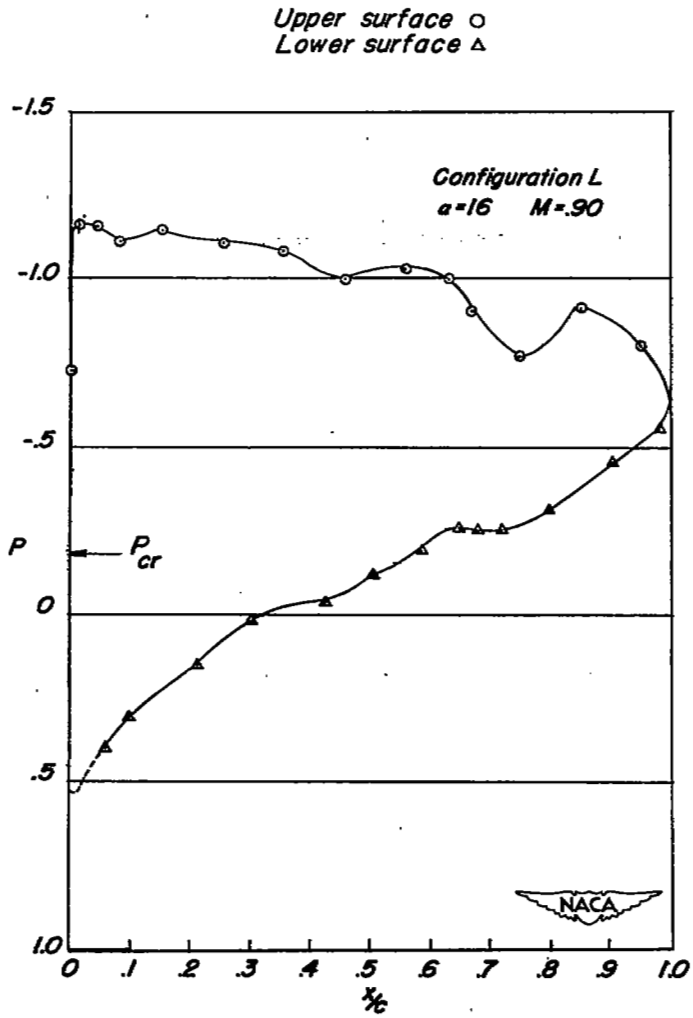
(c) M = 0.90.

Figure 4.- Continued.



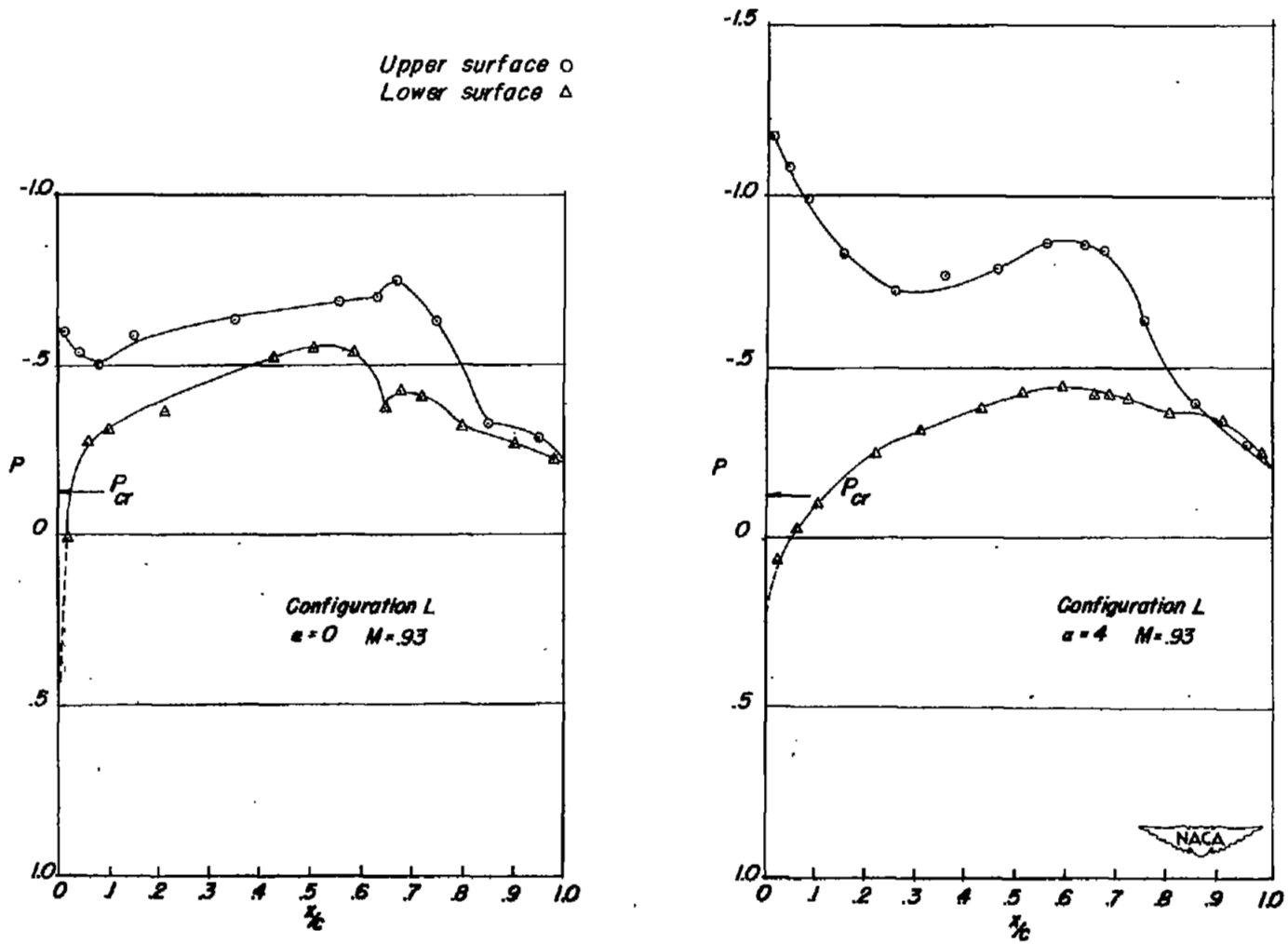
(c) M = 0.90. Continued.

Figure 4.- Continued.



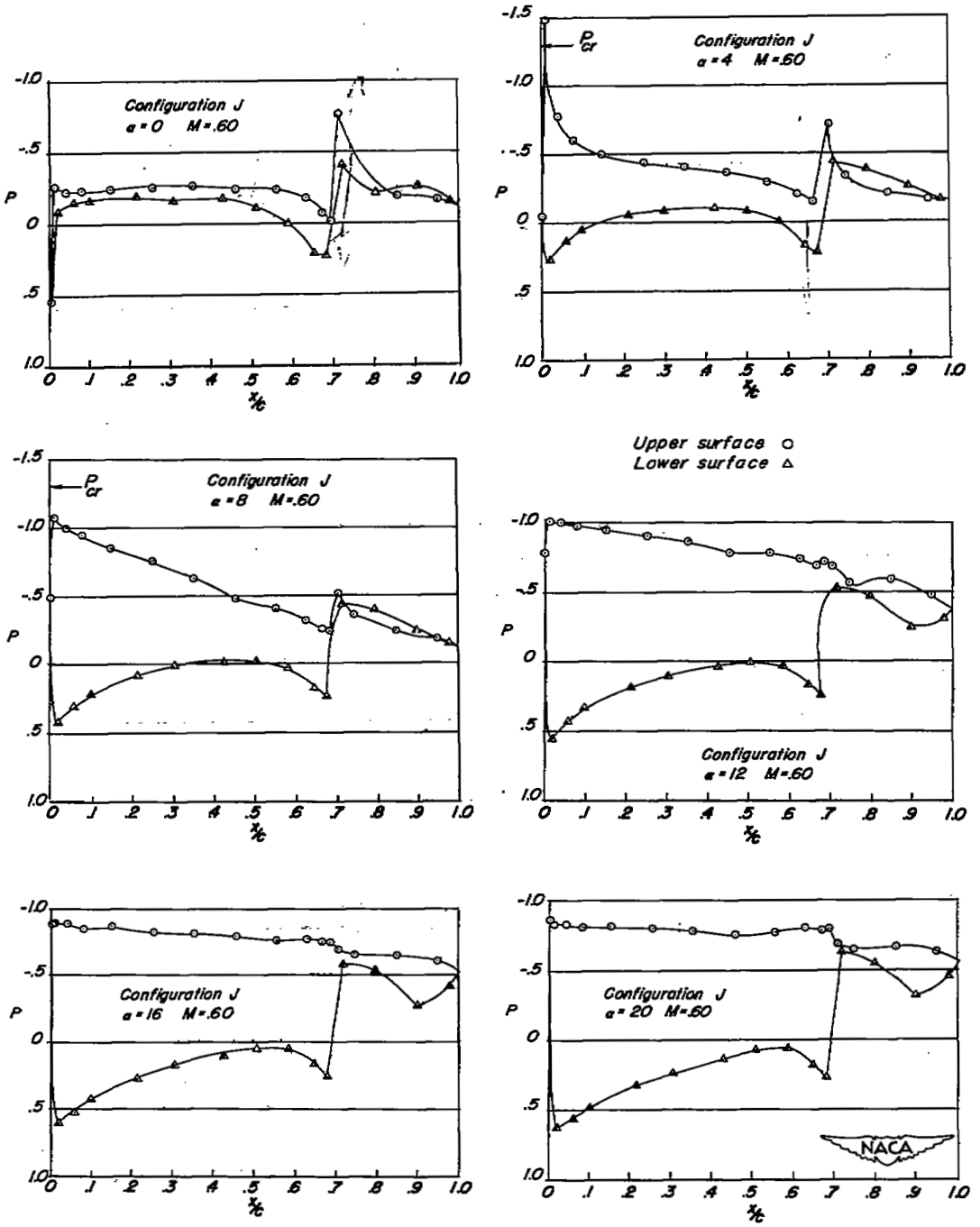
(c) M = 0.90. Concluded.

Figure 4.- Continued.



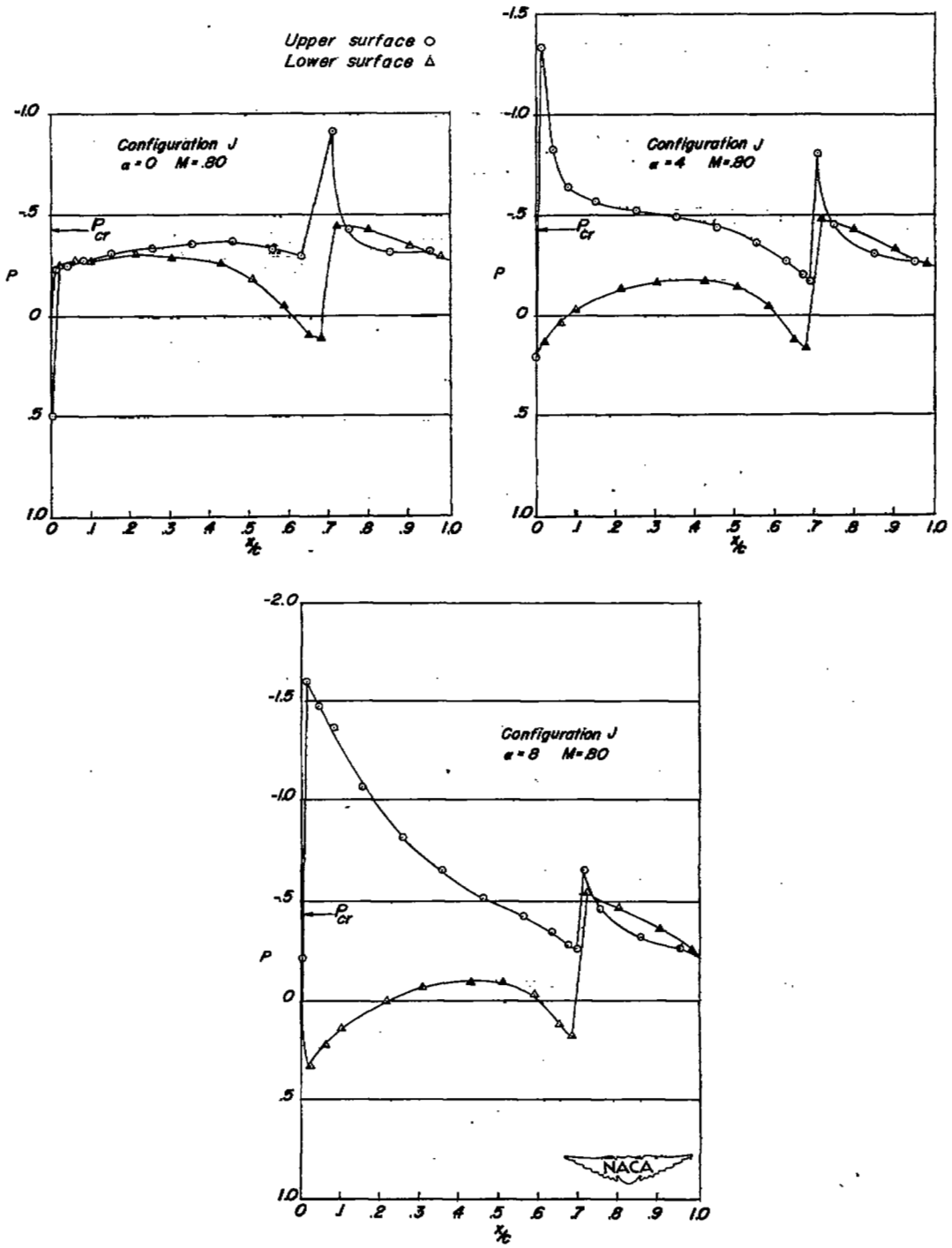
(d) M = 0.93.

Figure 4.- Concluded.



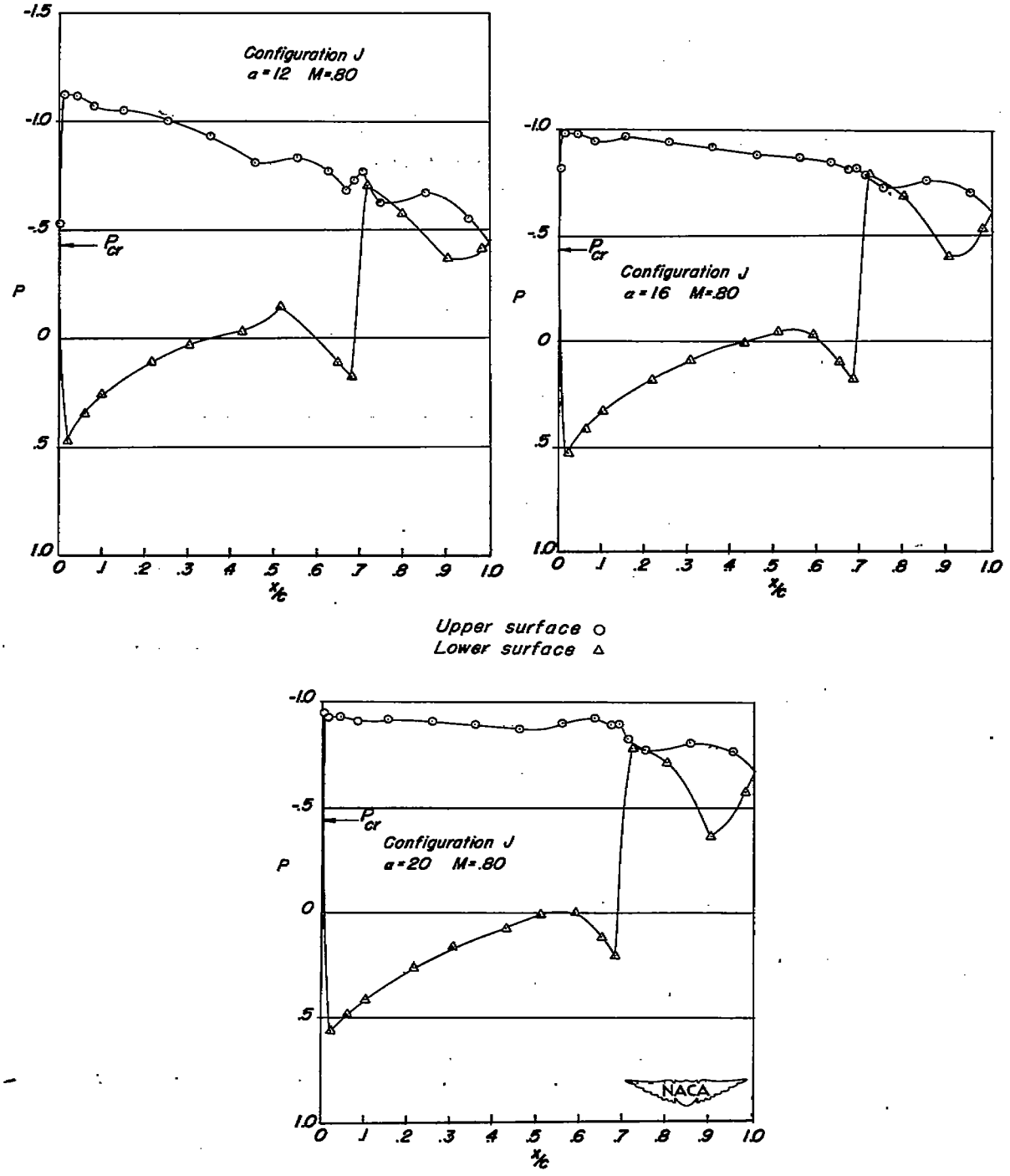
(a) M = 0.60.

Figure 5.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type spoiler aileron. δ_s = 0.03c; gap unsealed.



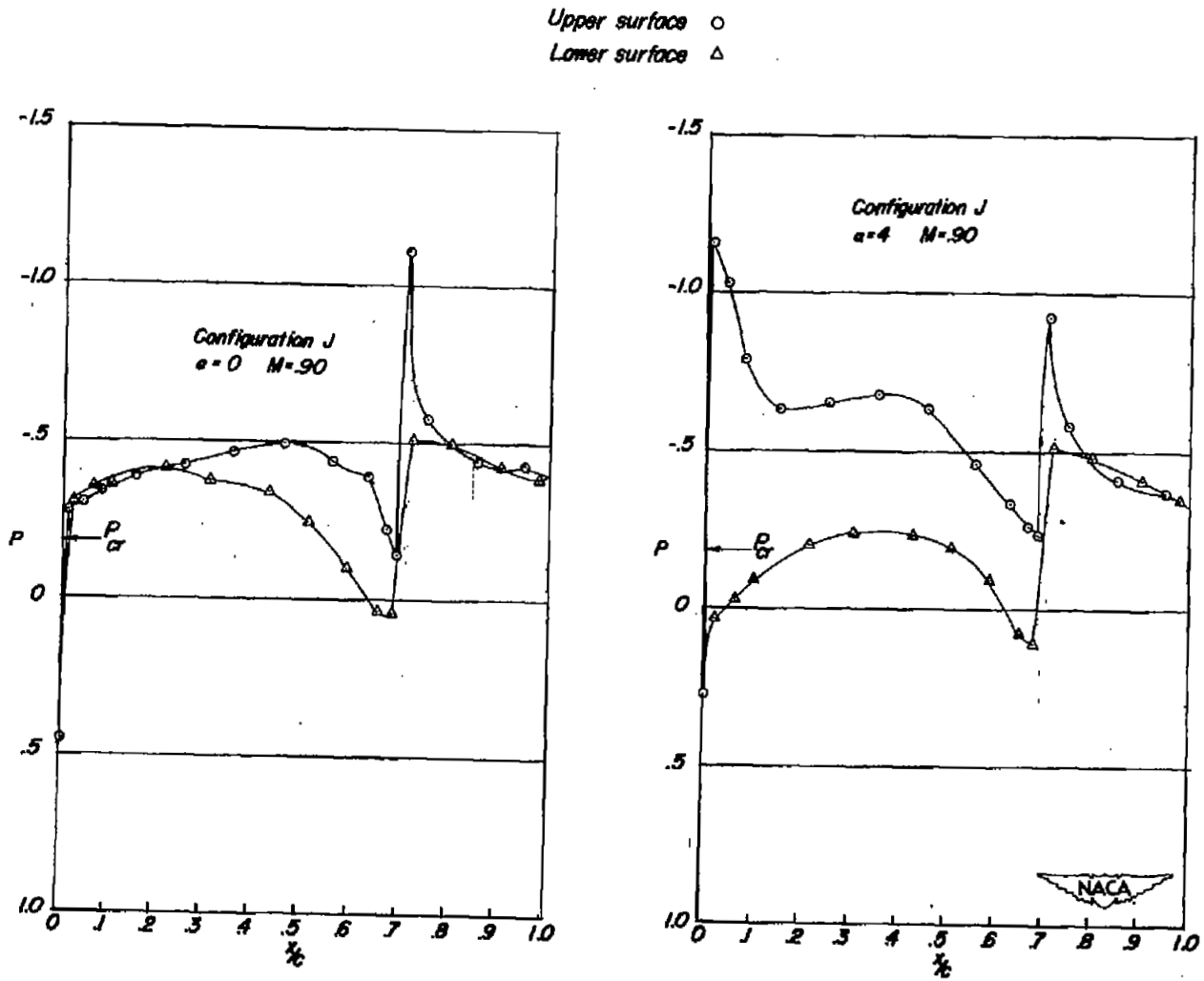
(b) M = 0.80.

Figure 5.- Continued.



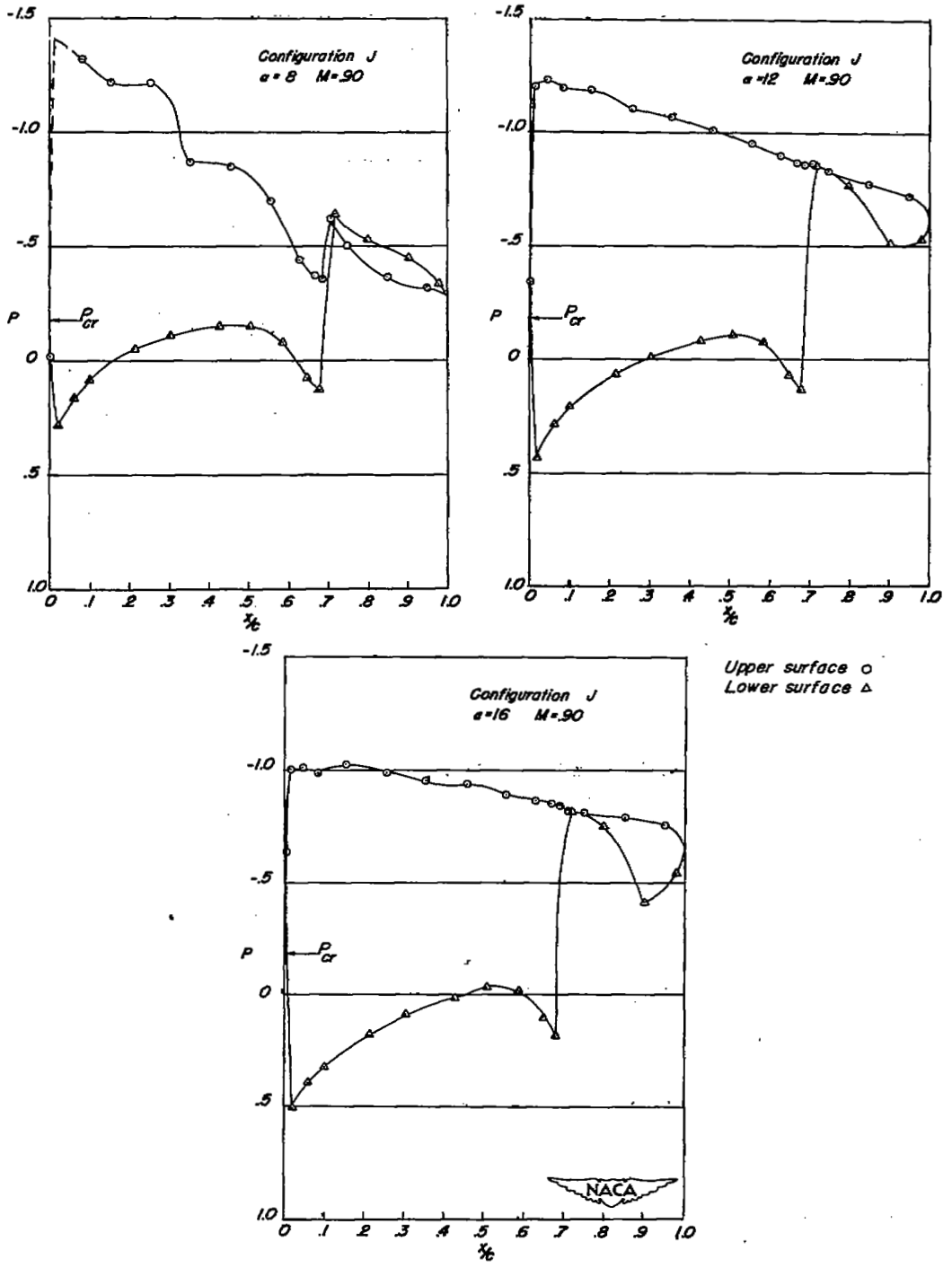
(b) M = 0.80. Concluded.

Figure 5.- Continued.



(c) M = 0.90.

Figure 5.- Continued.



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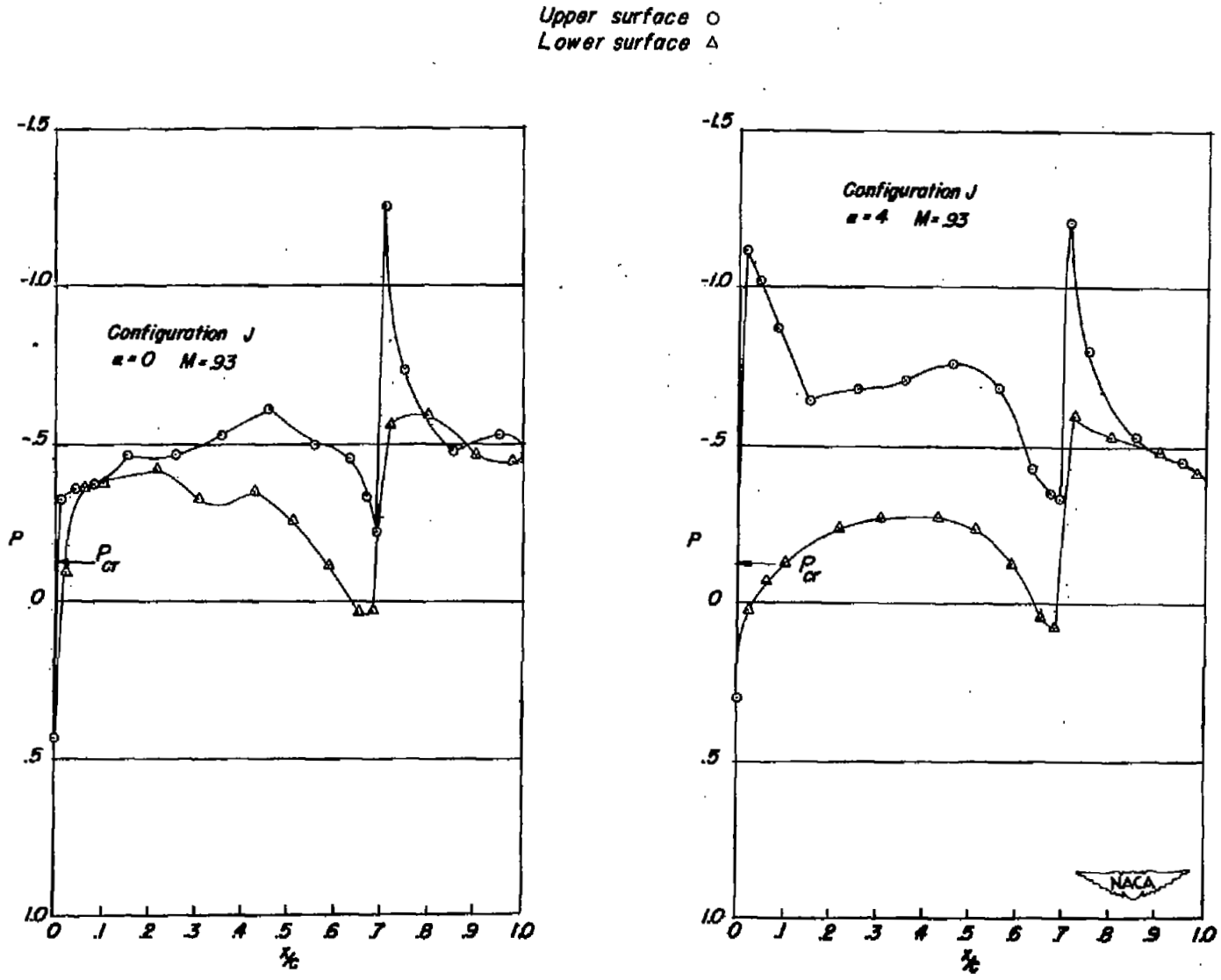

(d) M = 0.93.

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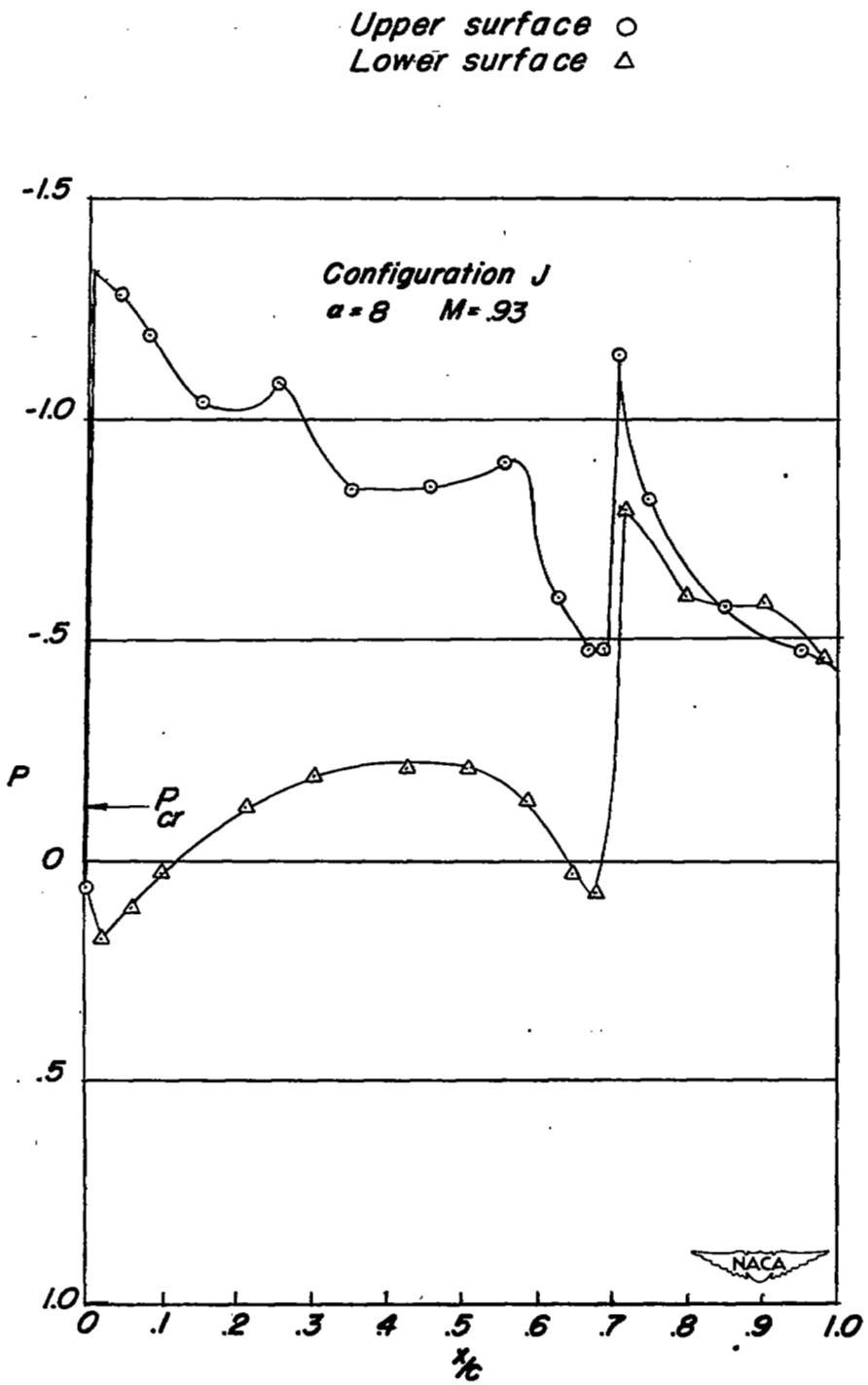
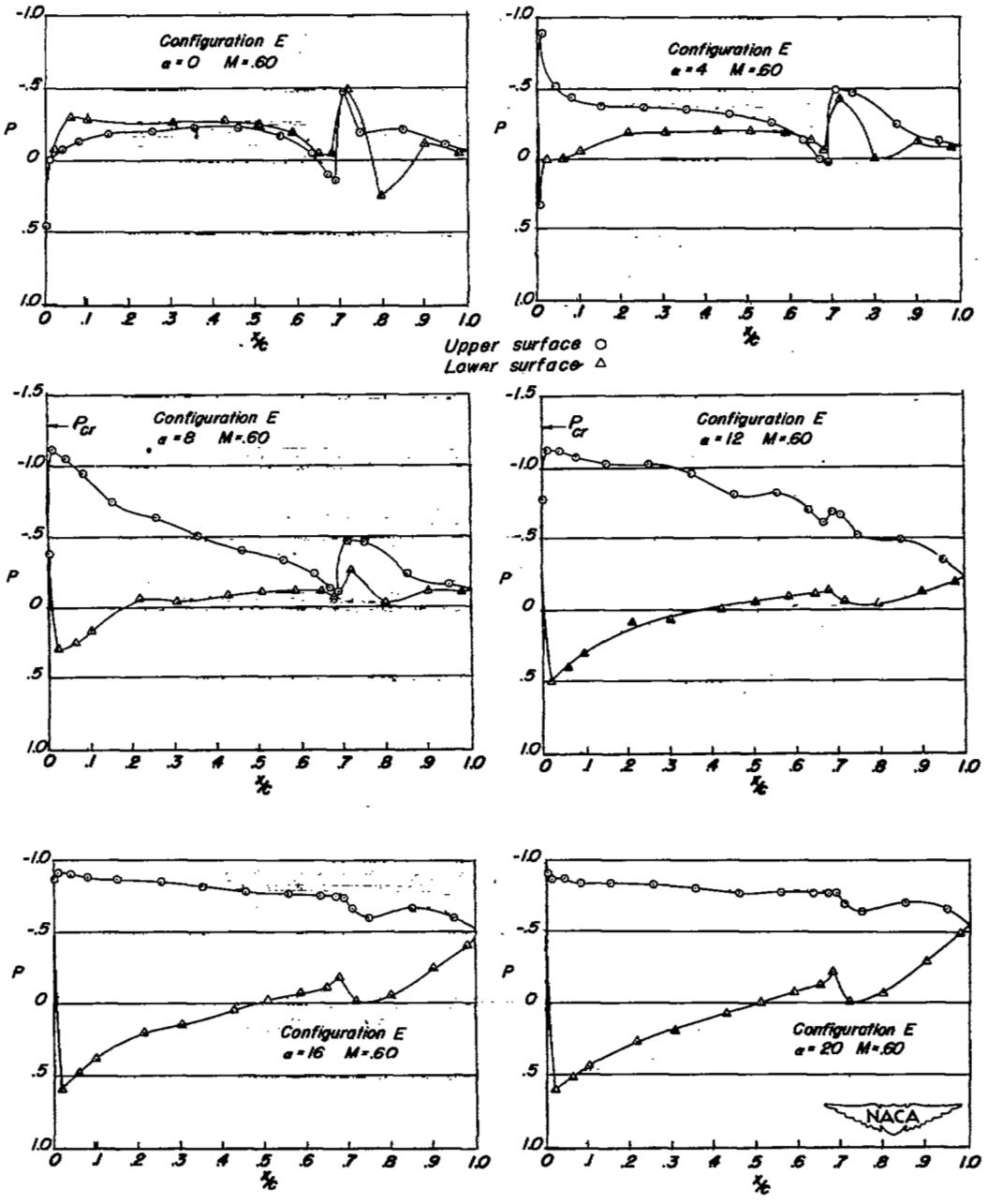


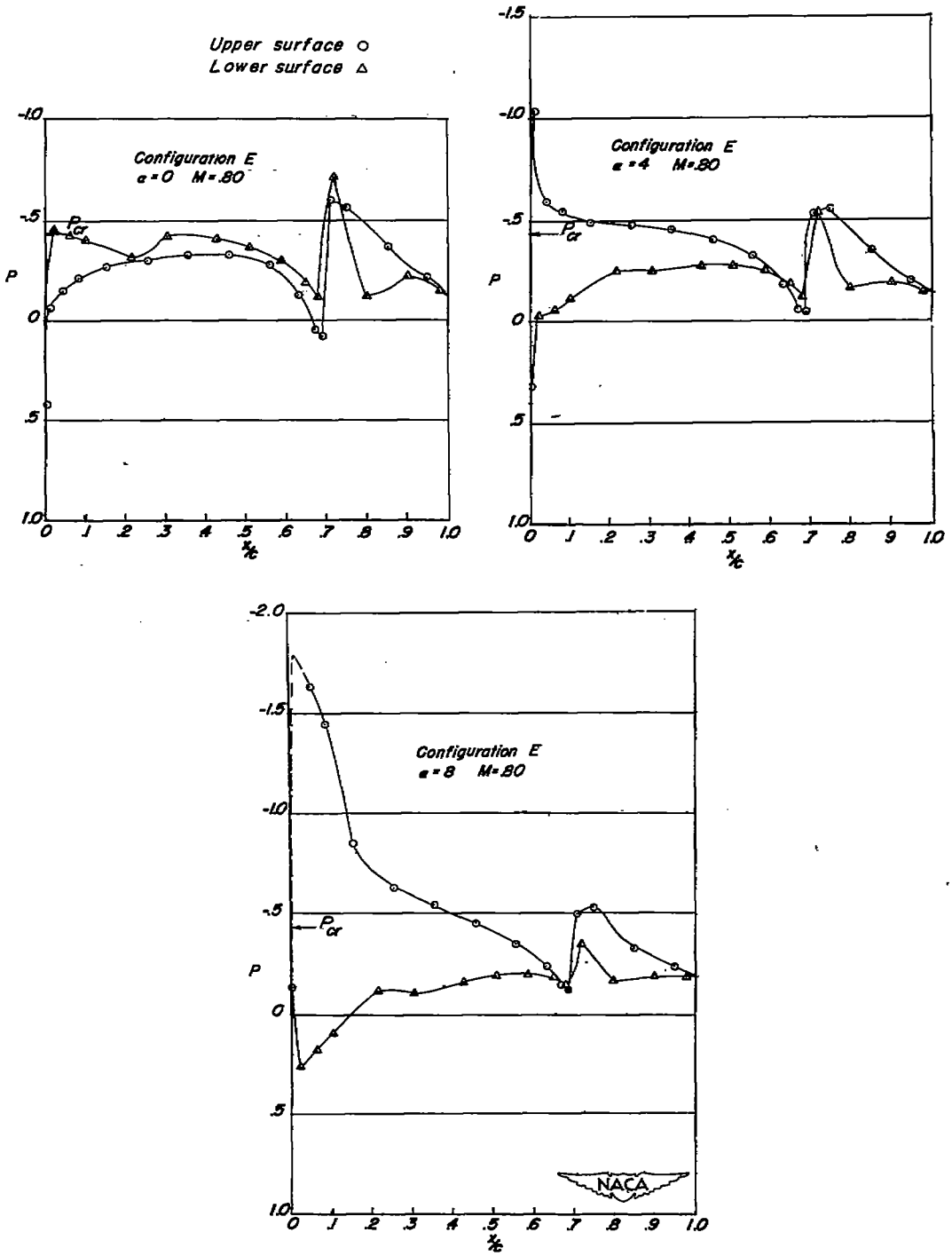
(d) M = 0.93. Concluded.

Figure 5.- Concluded.



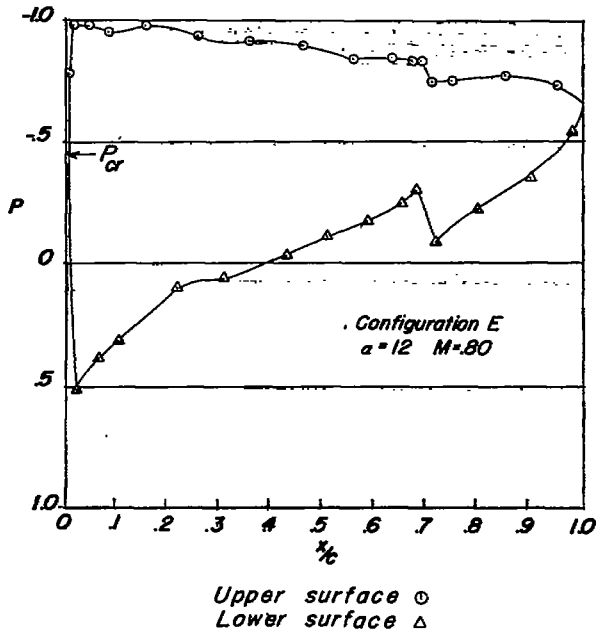
(a) M = 0.60.

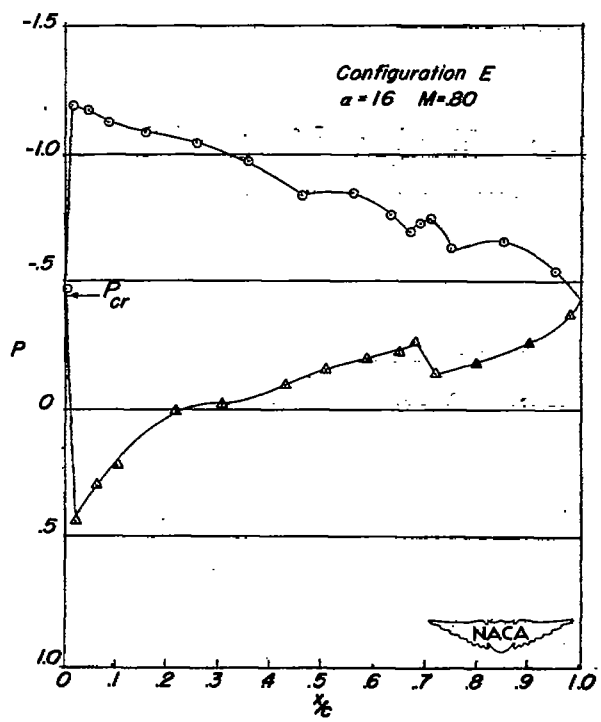
Figure 6.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type spoiler aileron. δ_s = -0.01c; gap unsealed.



(b) M = 0.80.

Figure 6.- Continued.





(b) M = 0.80. Concluded.

Figure 6.- Continued.

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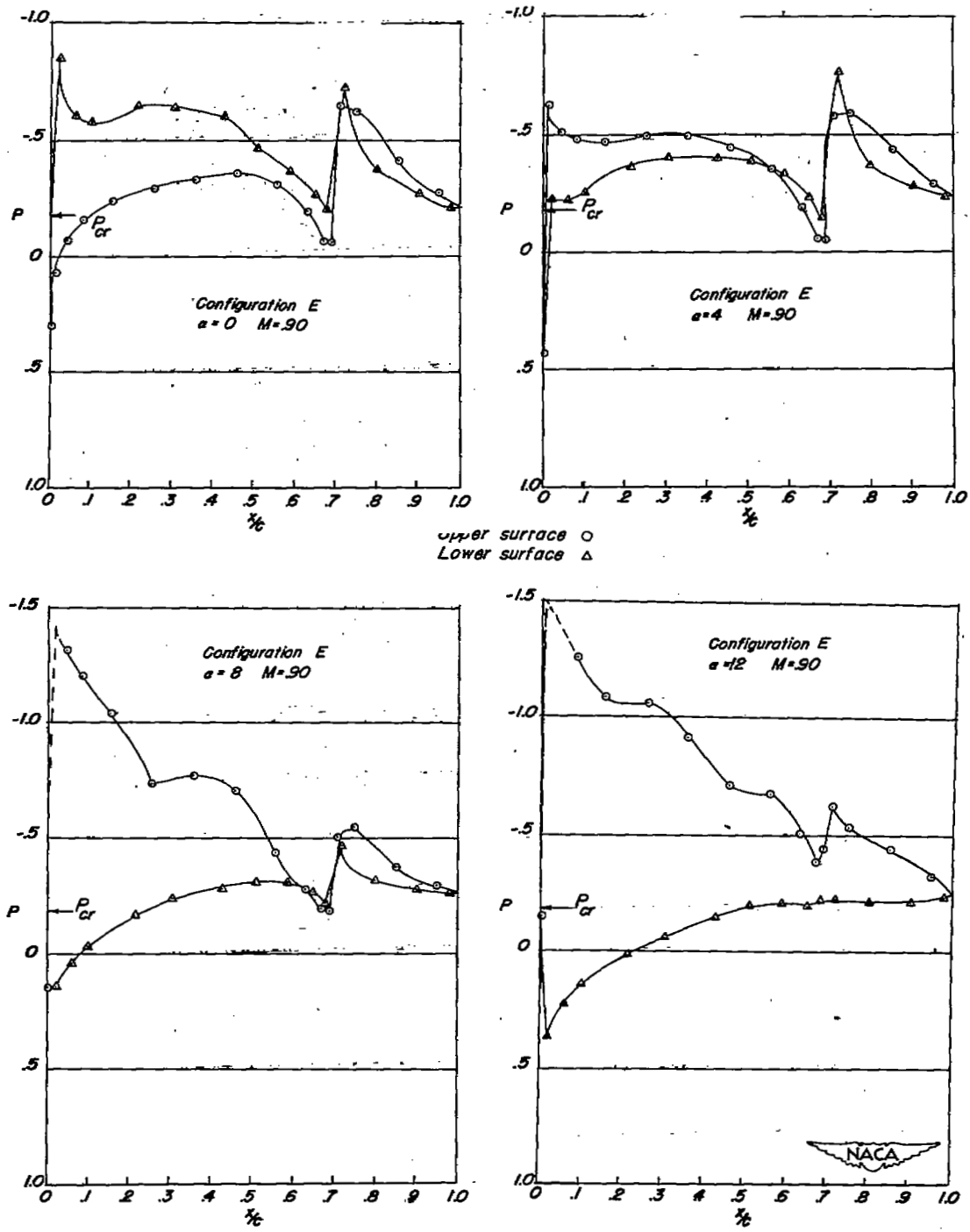

(c) M = 0.90.

Figure 6.- Concluded.

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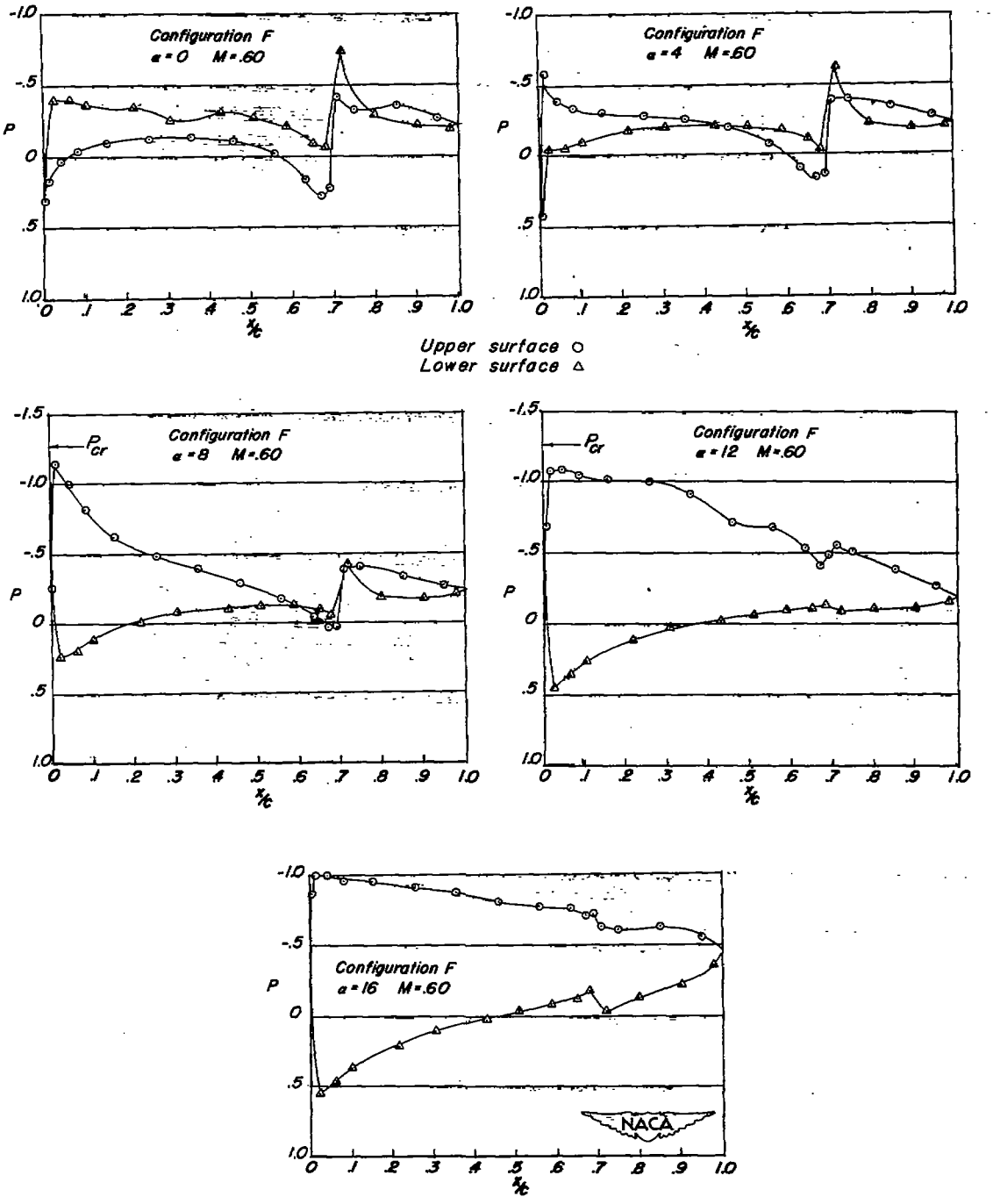
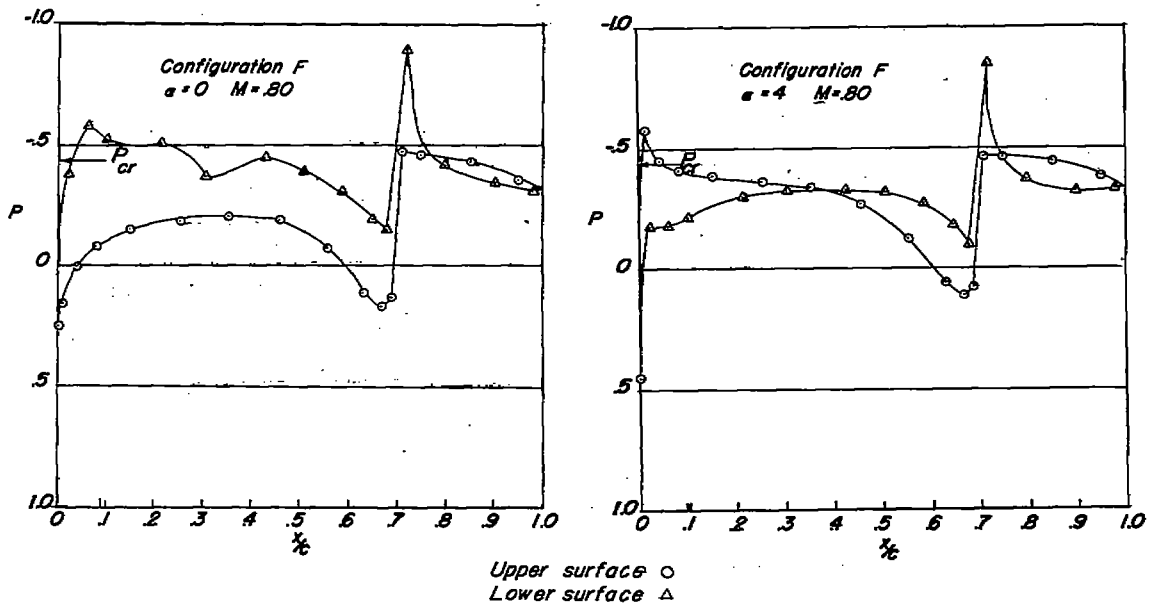
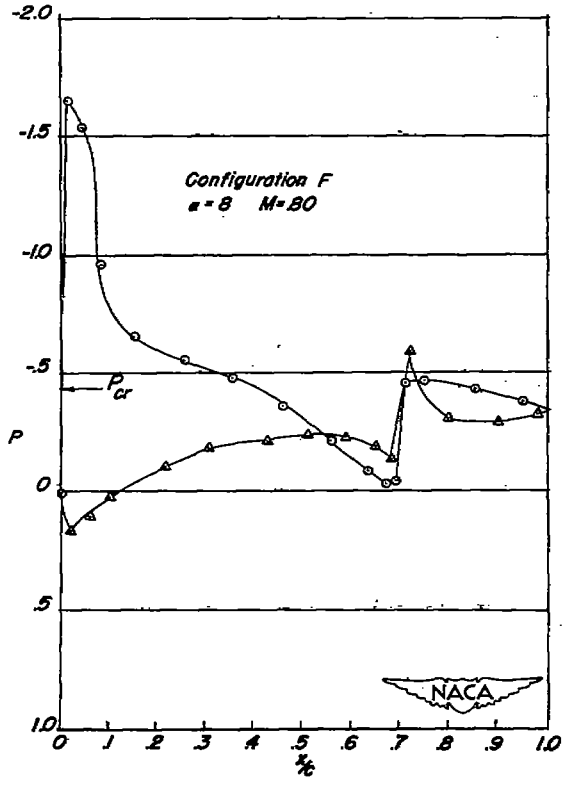


(a) M = 0.60.

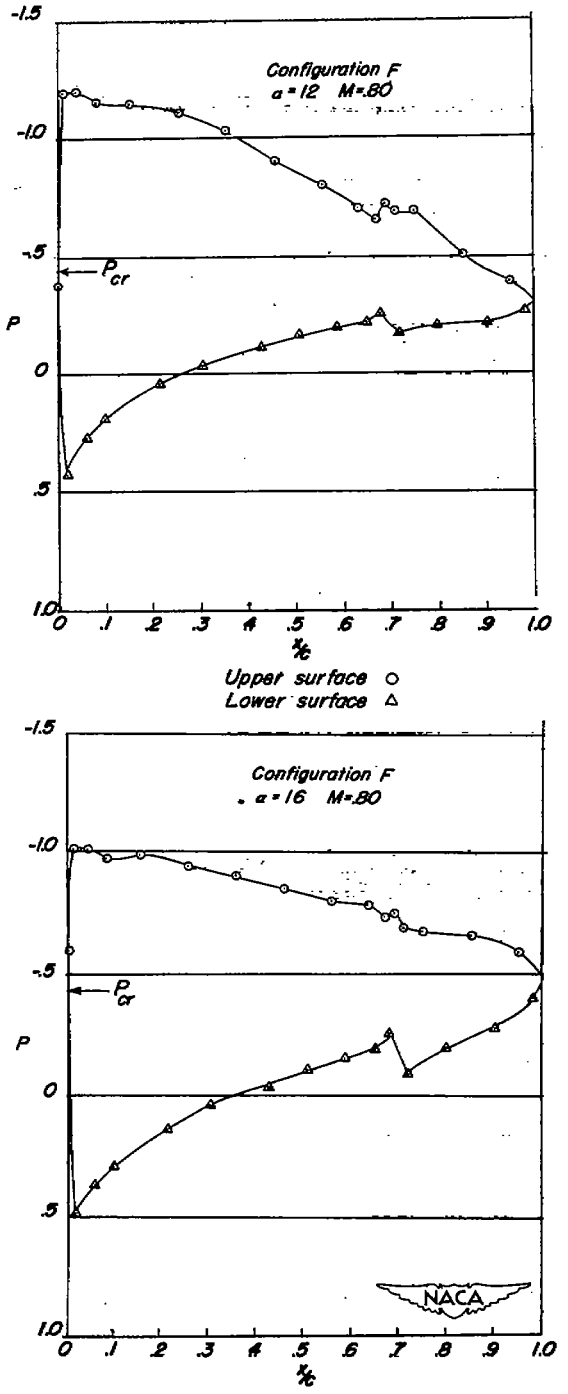
Figure 7.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type spoiler aileron. $\delta_s = -0.02c$; gap unsealed.





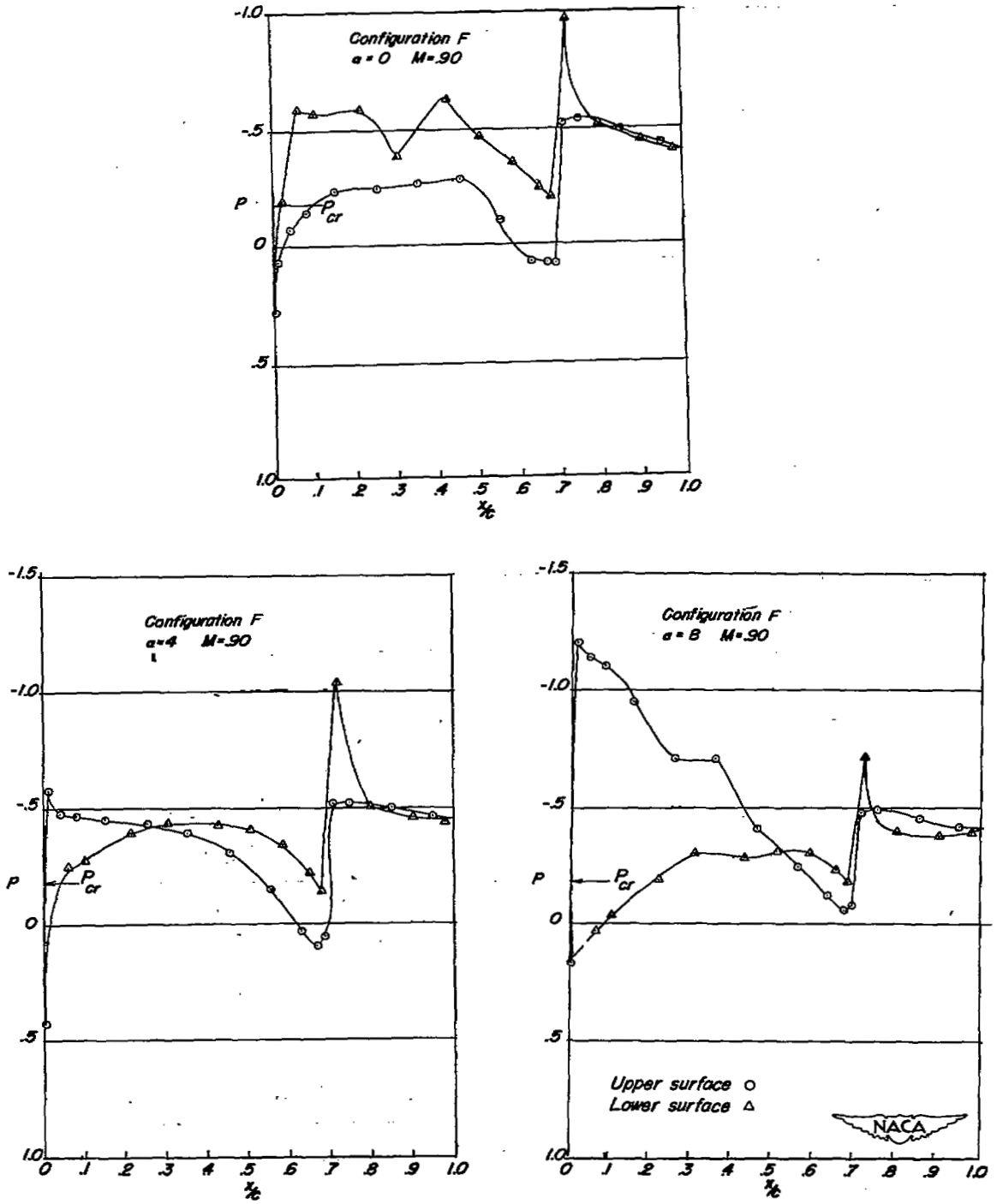
(b) M = 0.80.

Figure 7.- Continued.



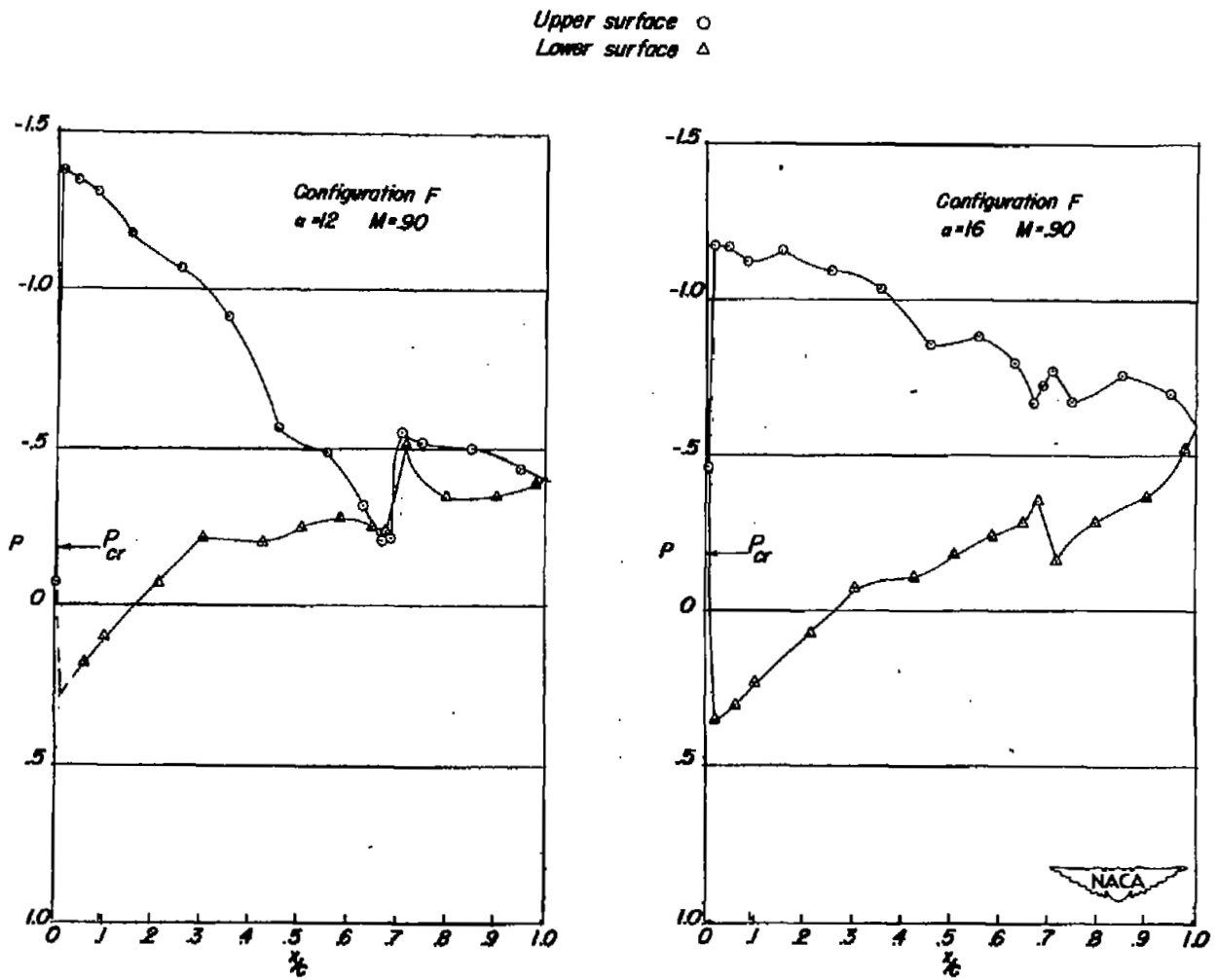
(b) M = 0.80. Concluded.

Figure 7.- Continued.



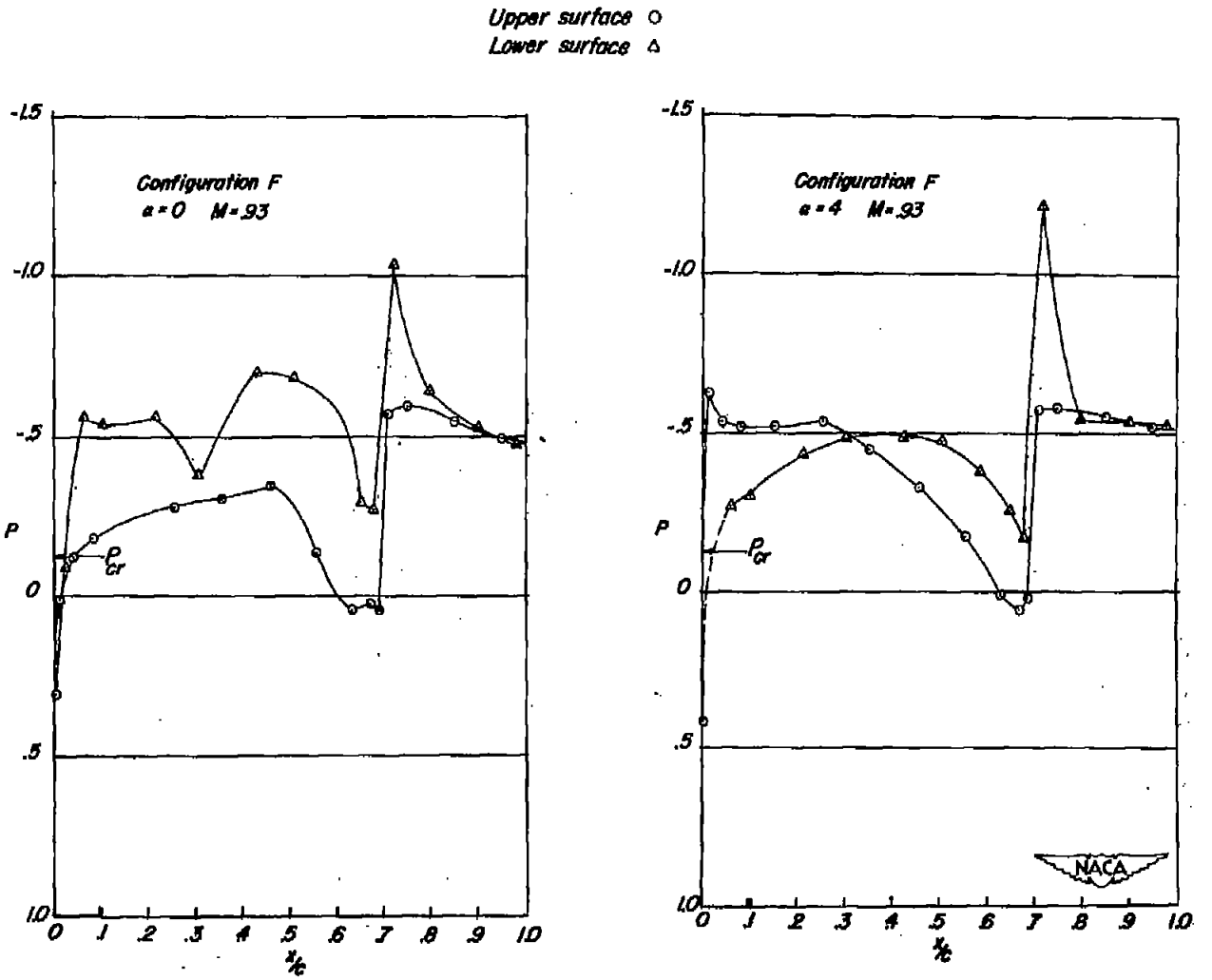
(c) M = 0.90.

Figure 7.- Continued.



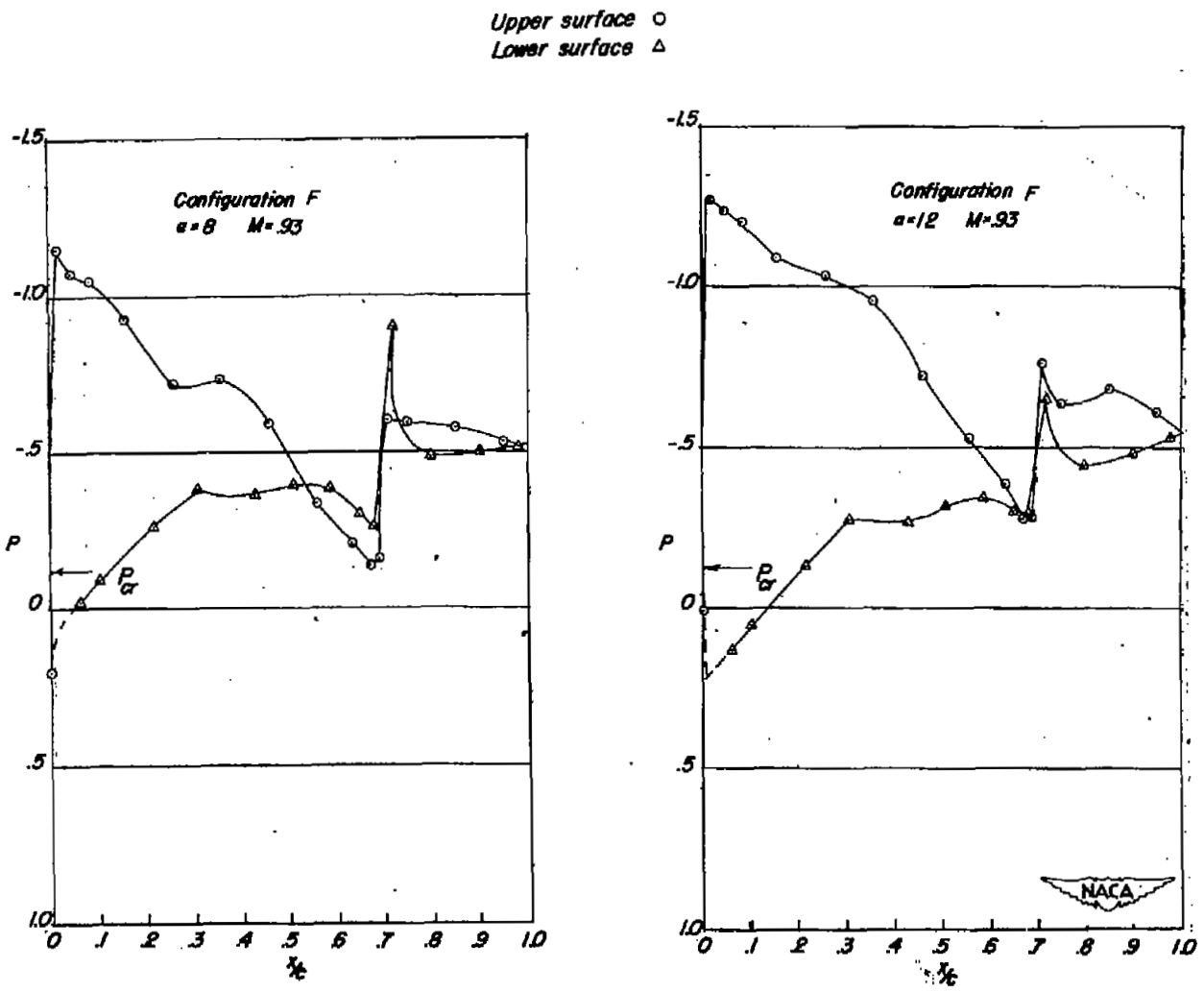
(c) M = 0.90. Concluded.

Figure 7.- Continued.



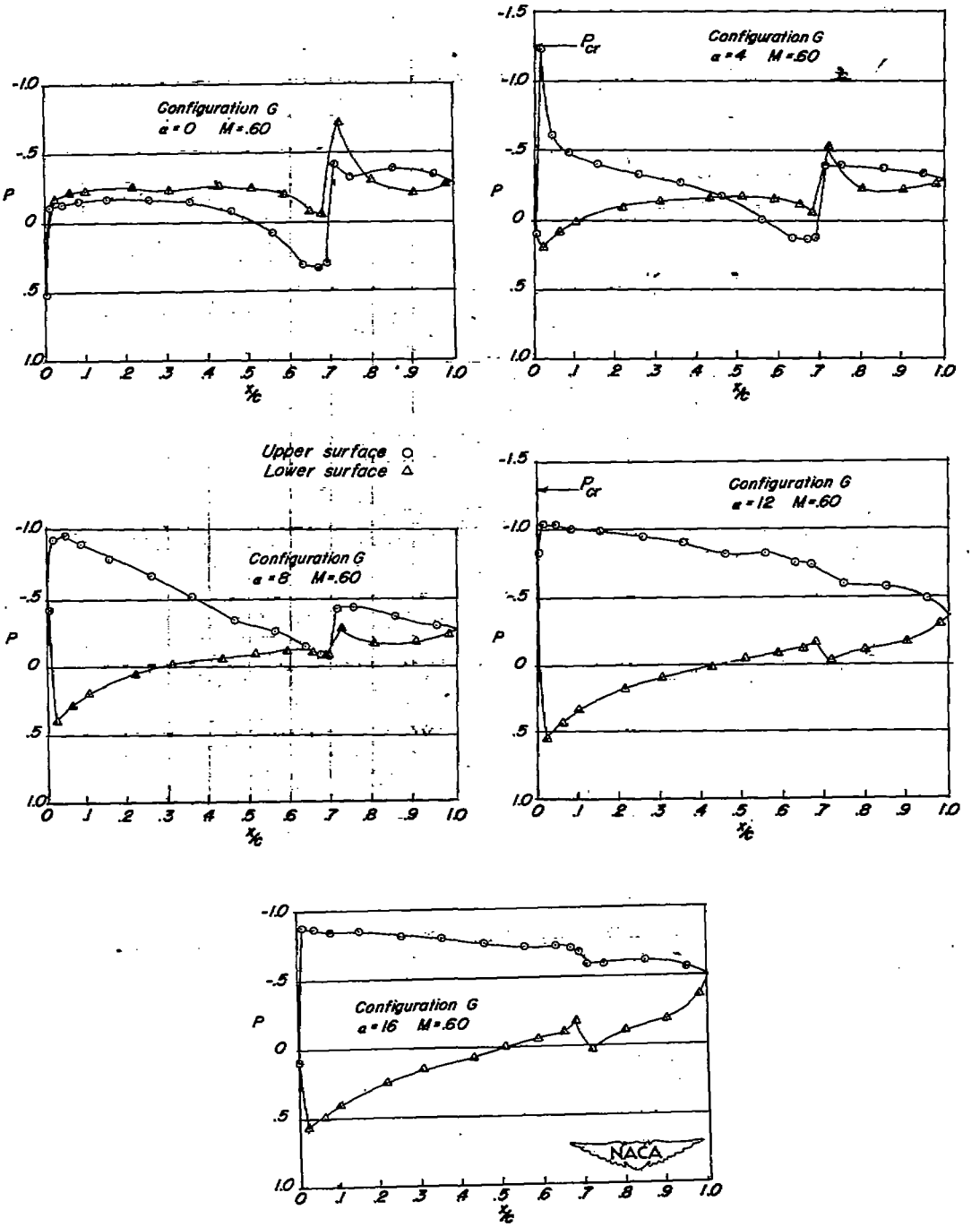
(d) M = 0.93.

Figure 7.- Continued.



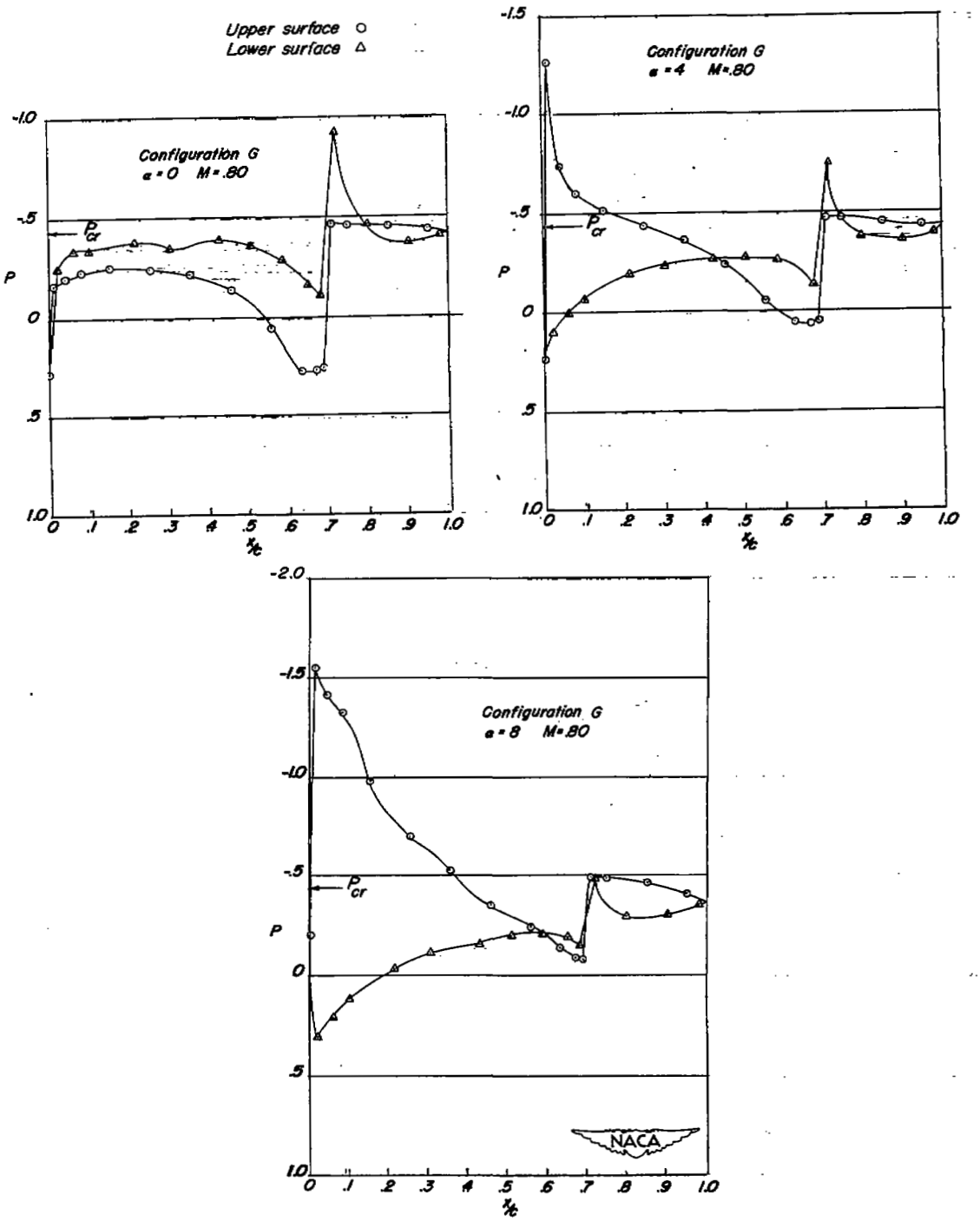
(d) M = 0.93. Concluded

Figure 7.- Concluded.



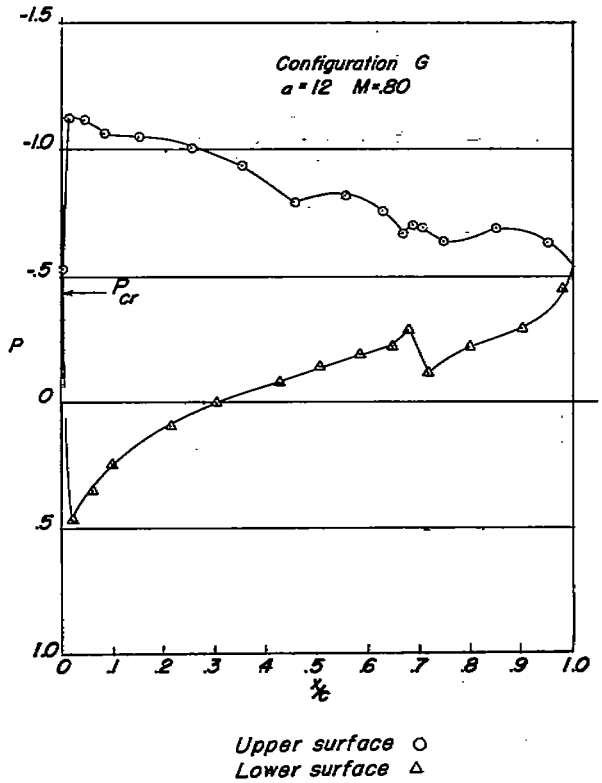
(a) M = 0.60.

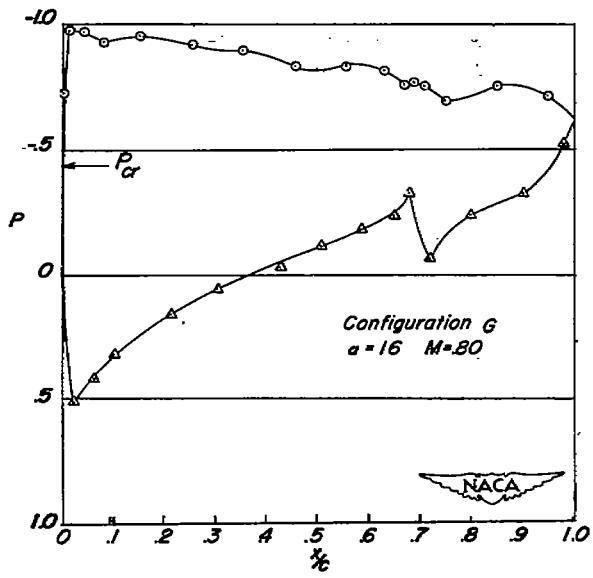
Figure 8.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type spoiler aileron. δ_s = -0.03c; gap unsealed.



(b) M = 0.80.

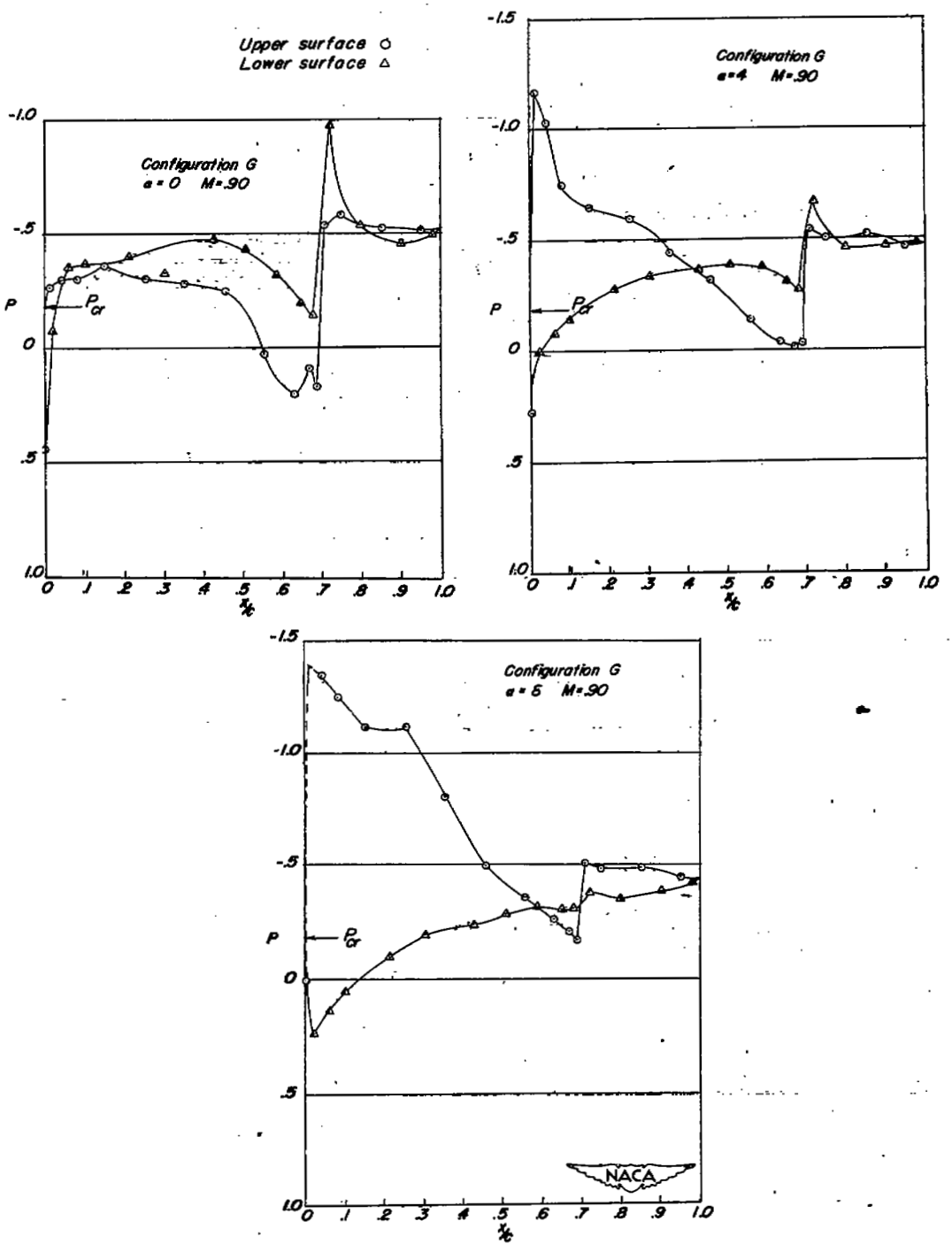
Figure 8.- Continued.





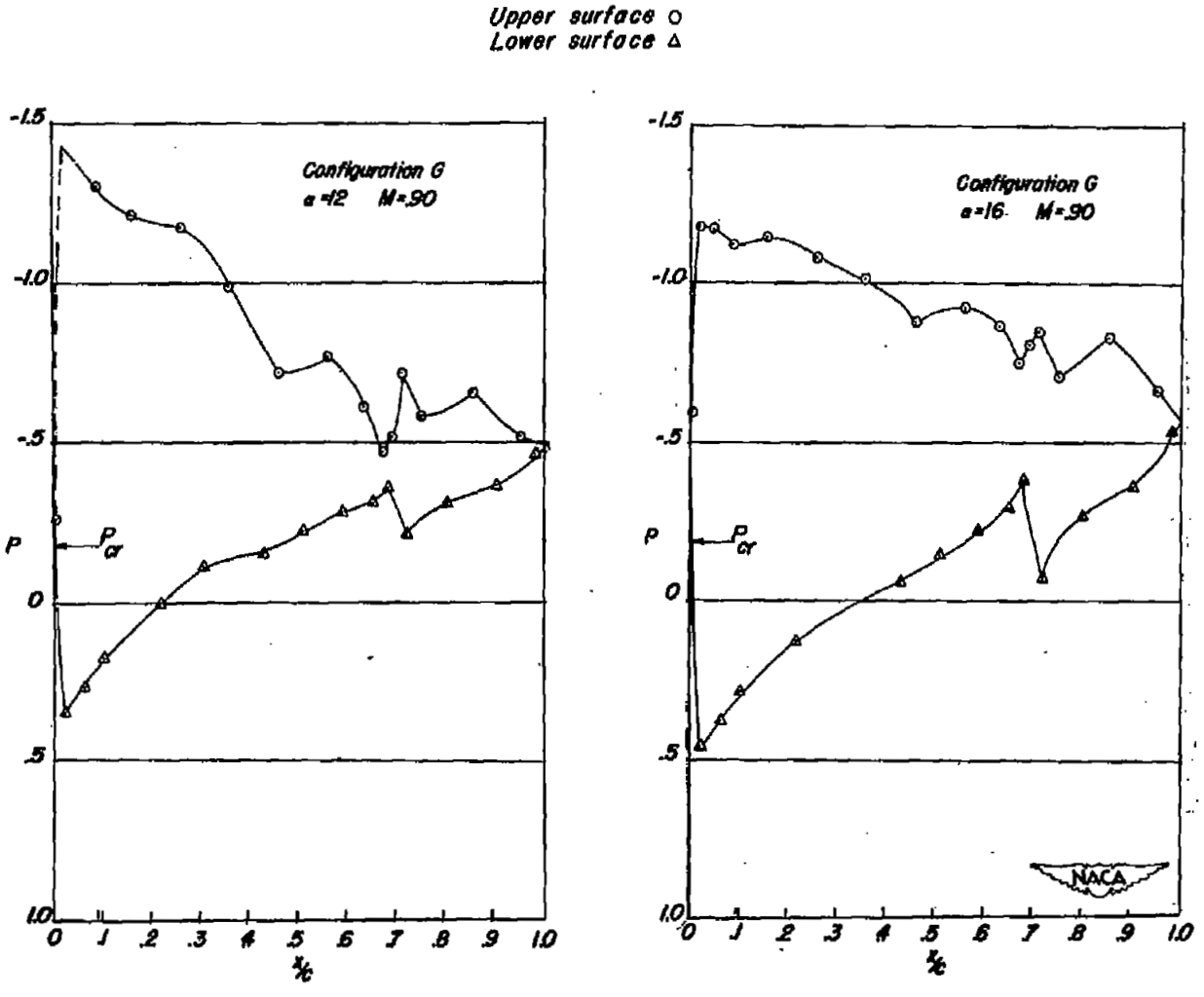
(b) M = 0.80. Concluded.

Figure 8.- Continued.



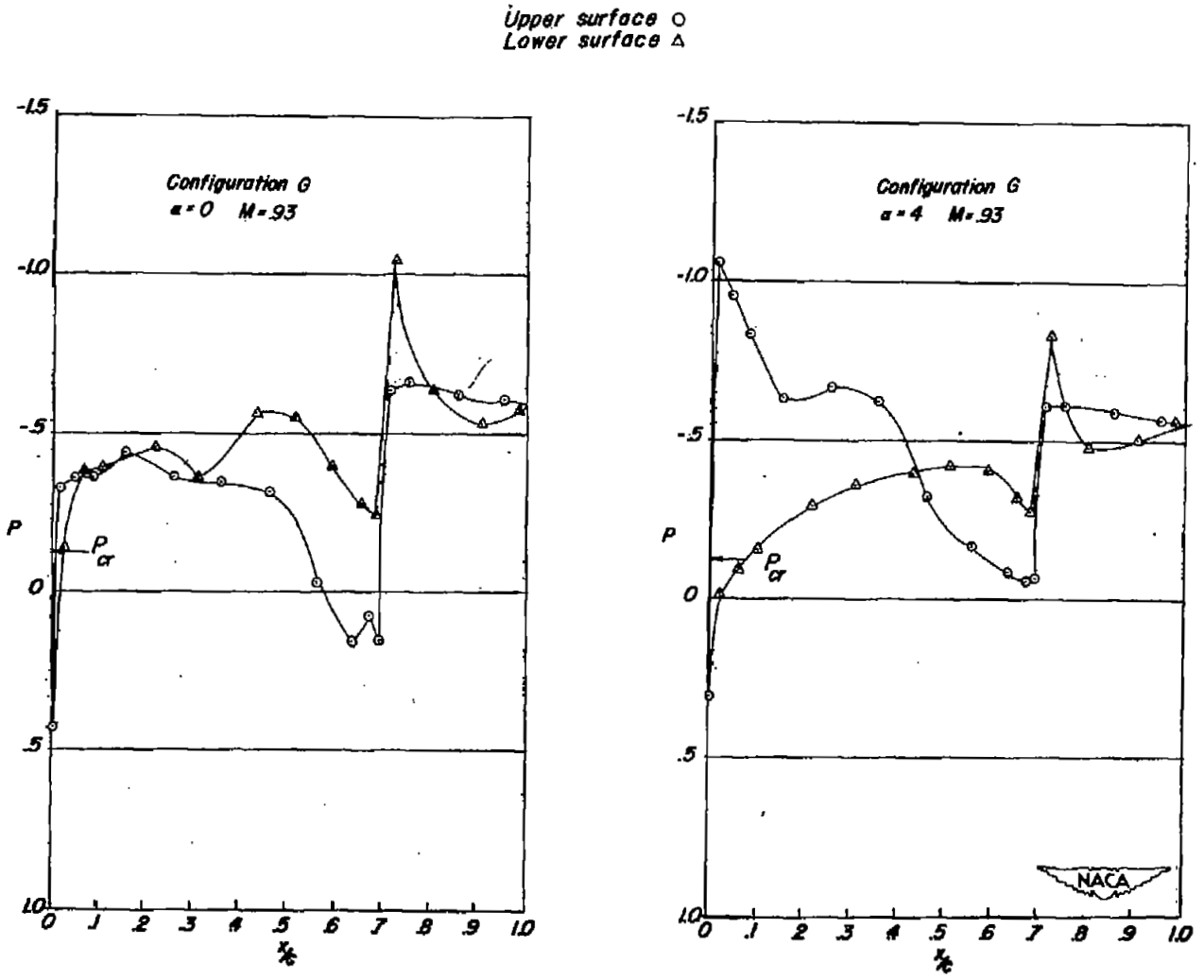
(c) M = 0.90.

Figure 8.- Continued.



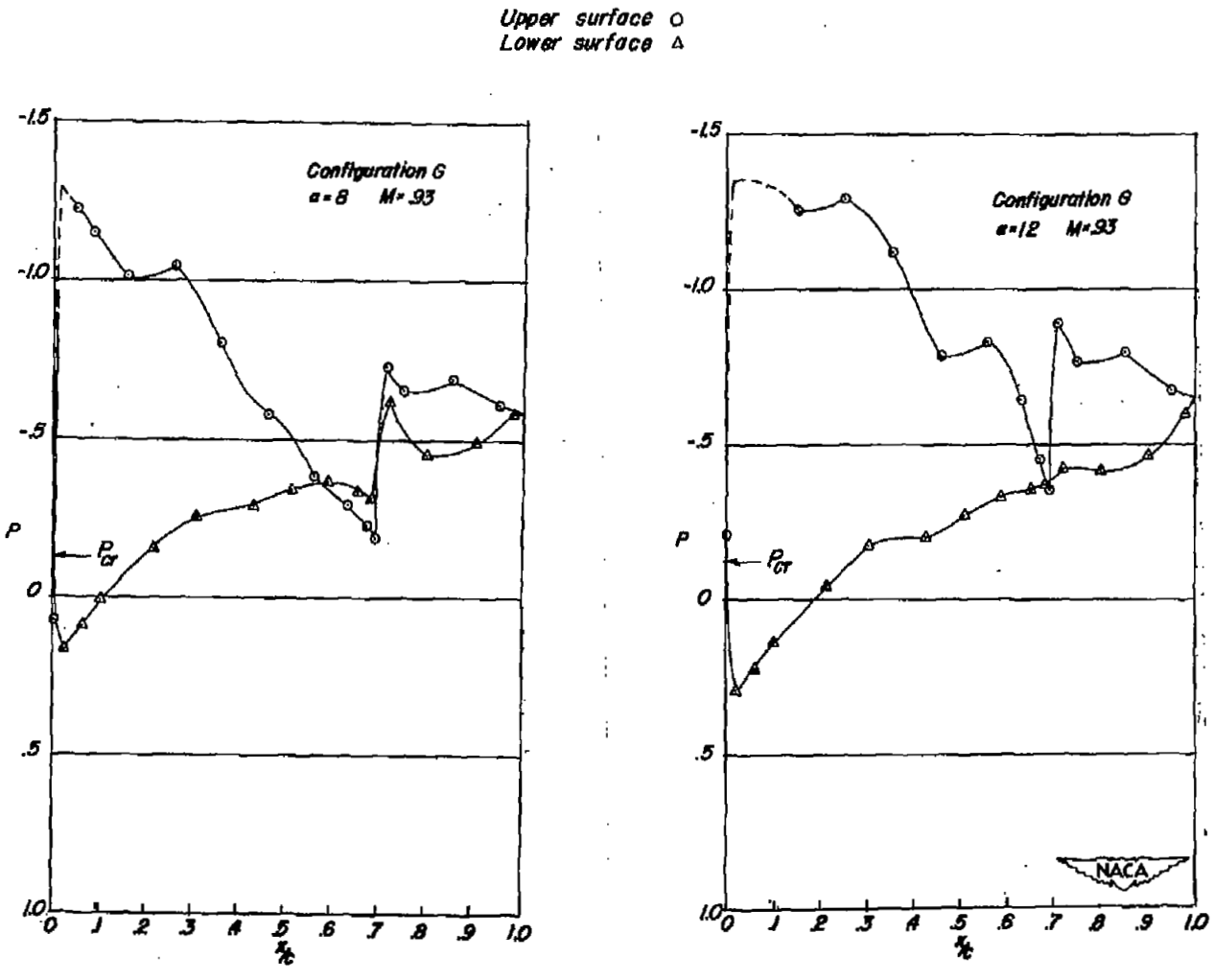
(c) M = 0.90. Concluded.

Figure 8.- Continued.



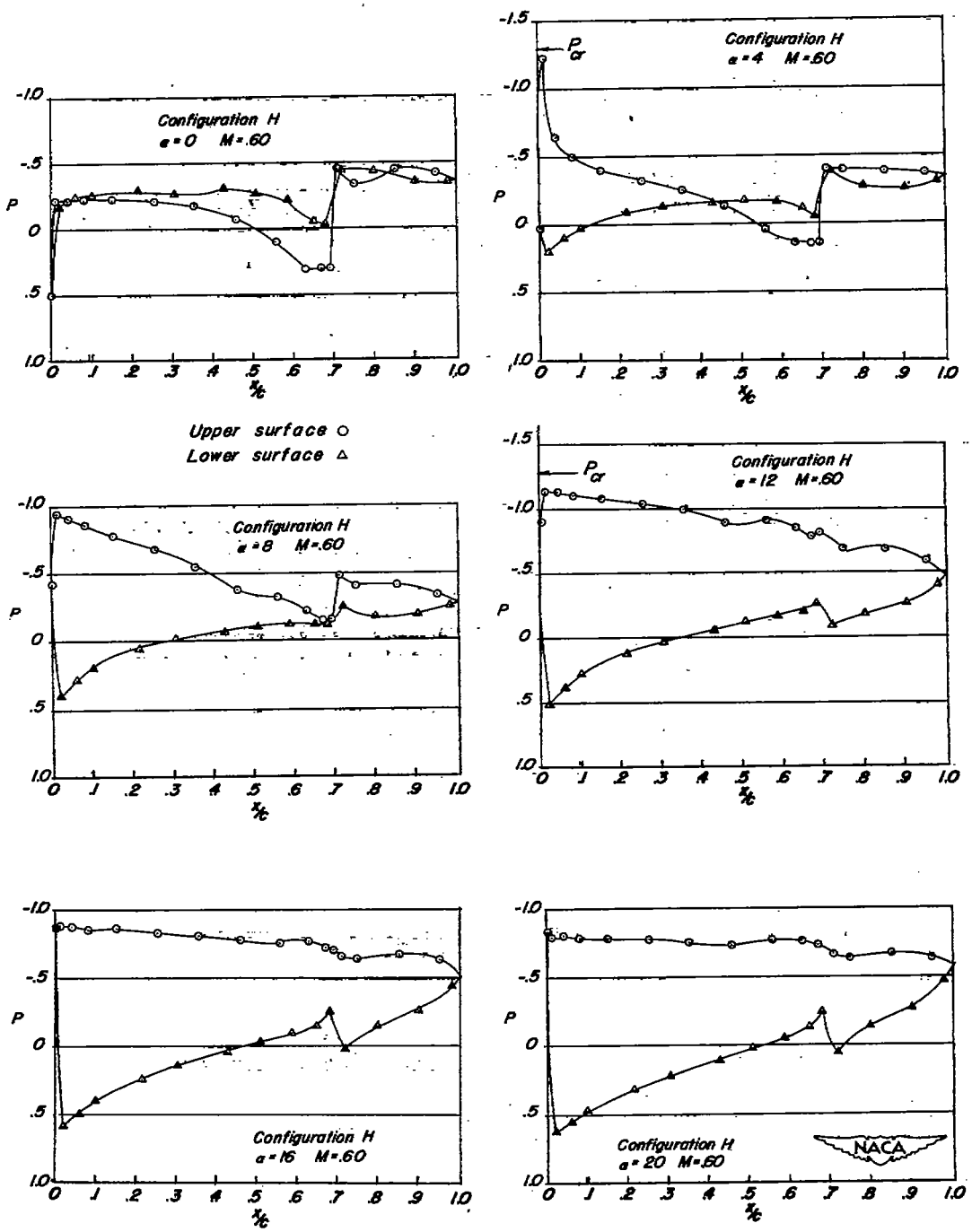
(d) M = 0.93.

Figure 8.- Continued.



(d) M = 0.93. Concluded.

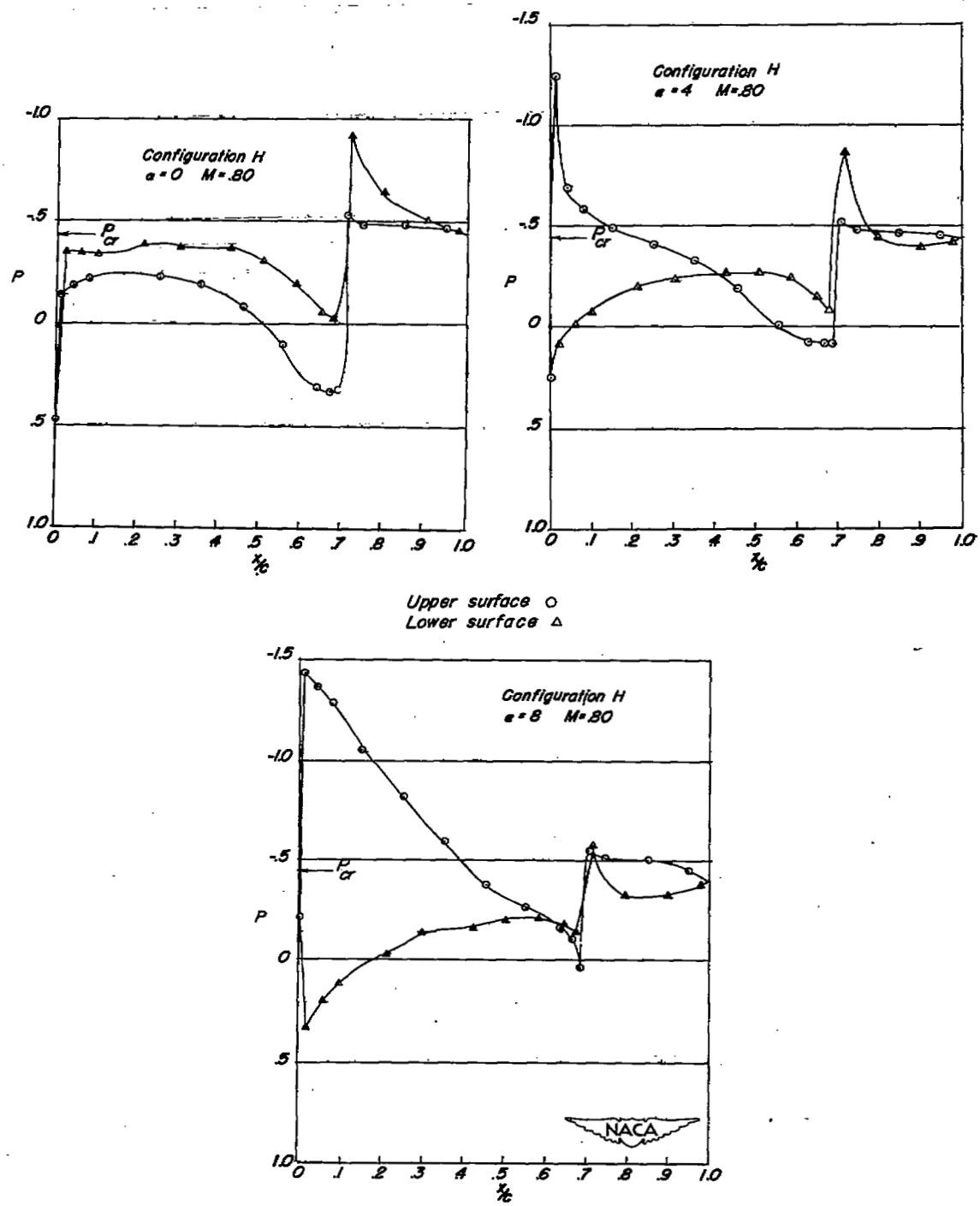
Figure 8.- Concluded.



(a) M = 0.60.

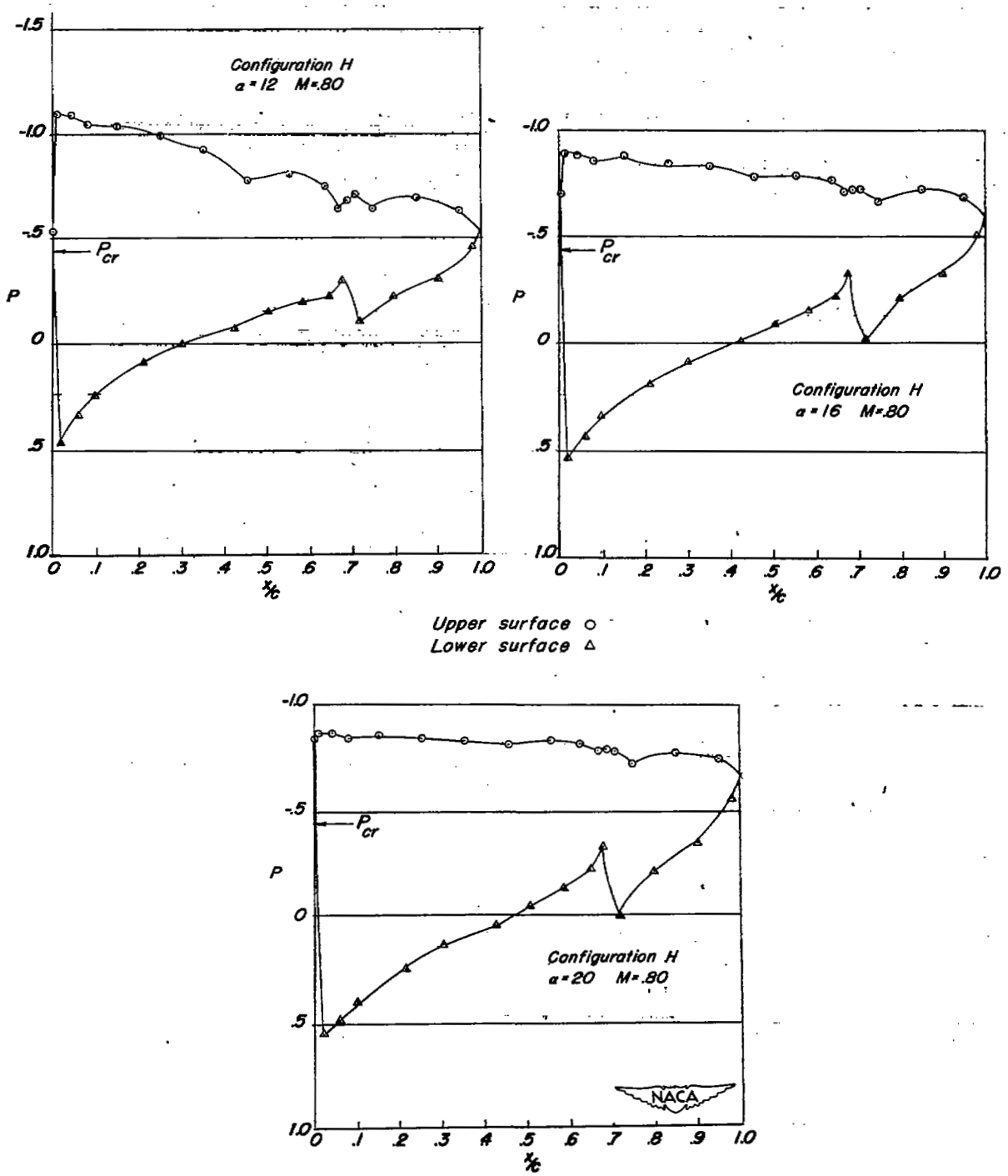
Figure 9.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type spoiler aileron. δ_s = -0.04c; gap unsealed.

7X



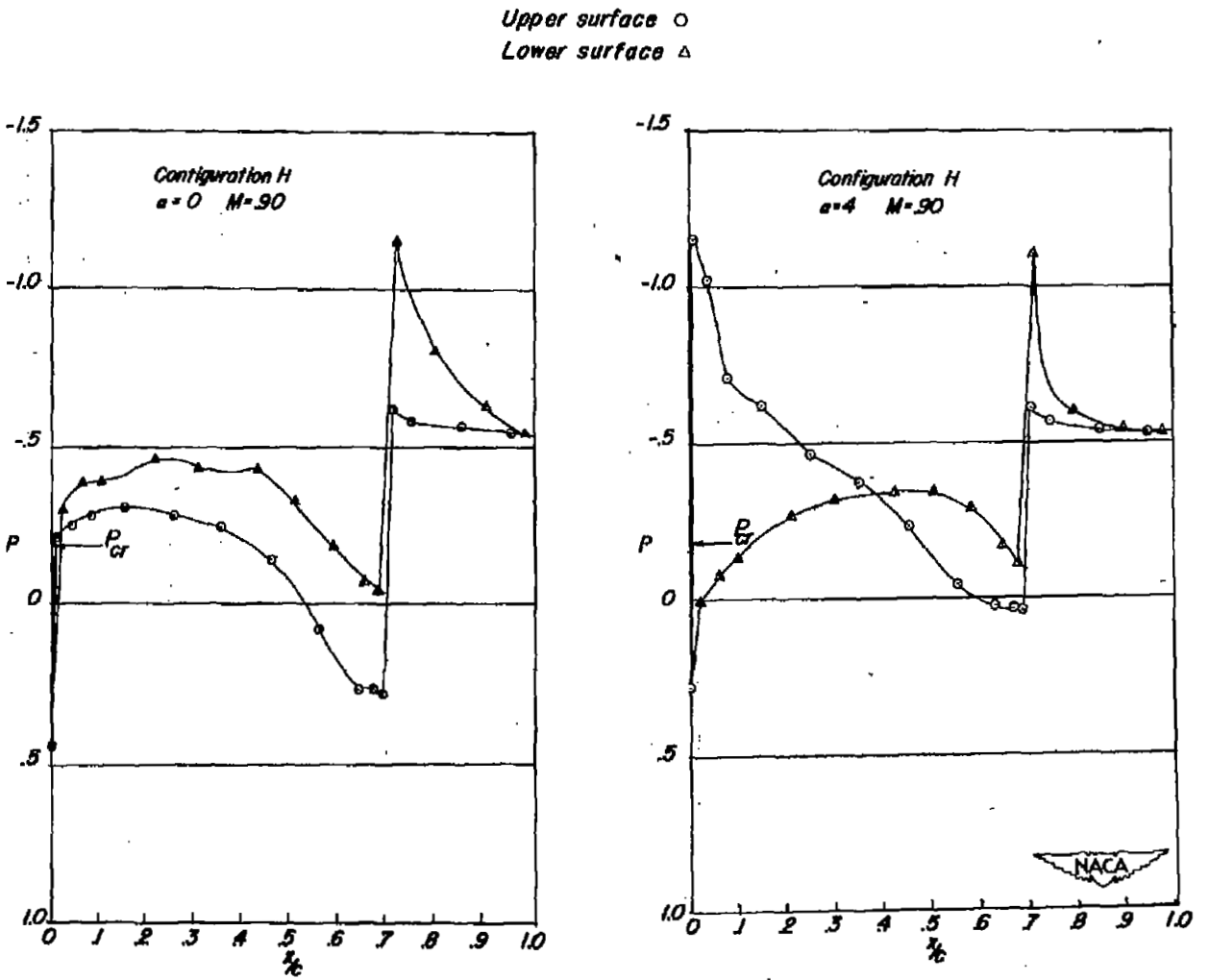
(b) M = 0.80.

Figure 9.- Continued.



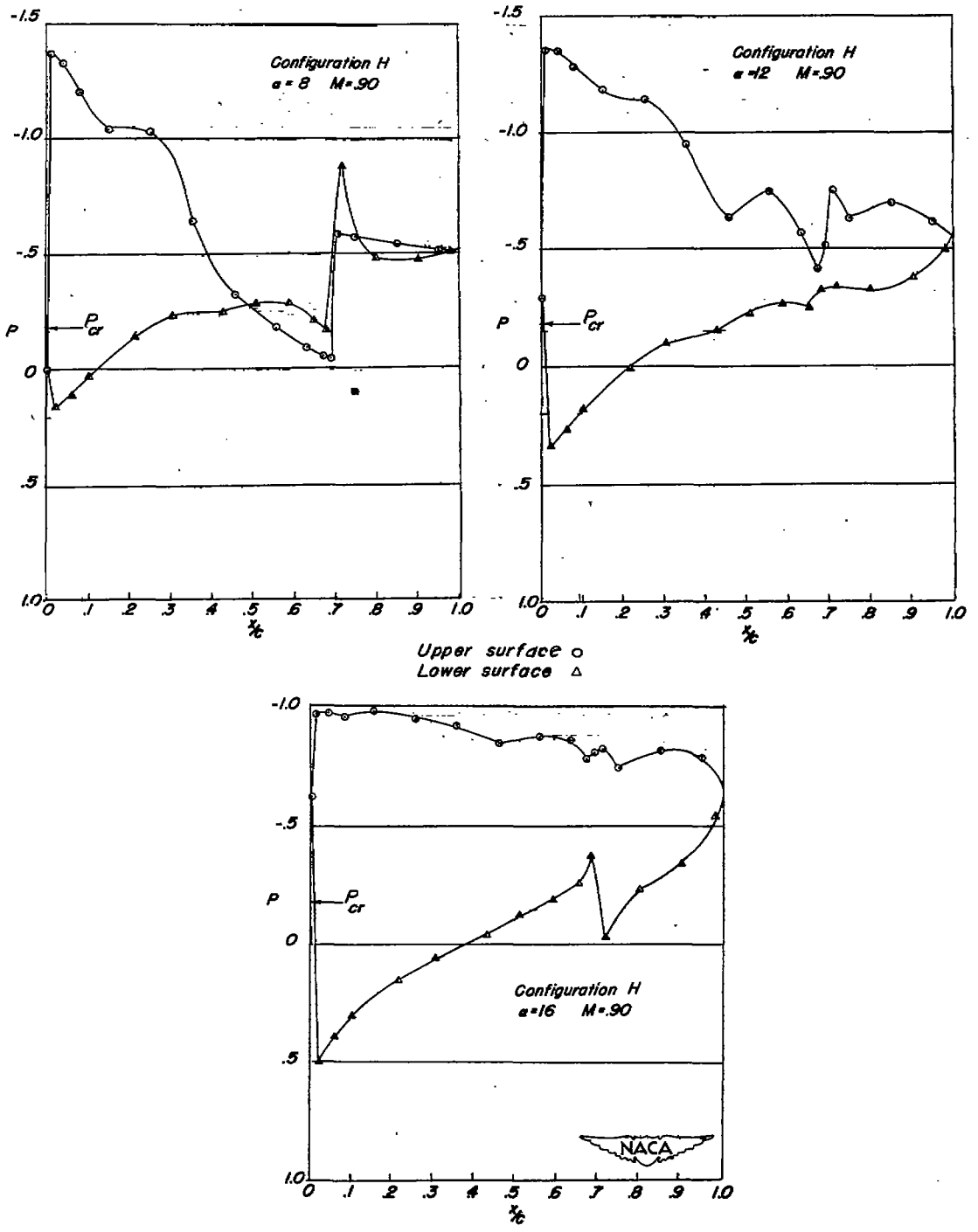
(b) M = 0.80. Concluded.

Figure 9.- Continued.



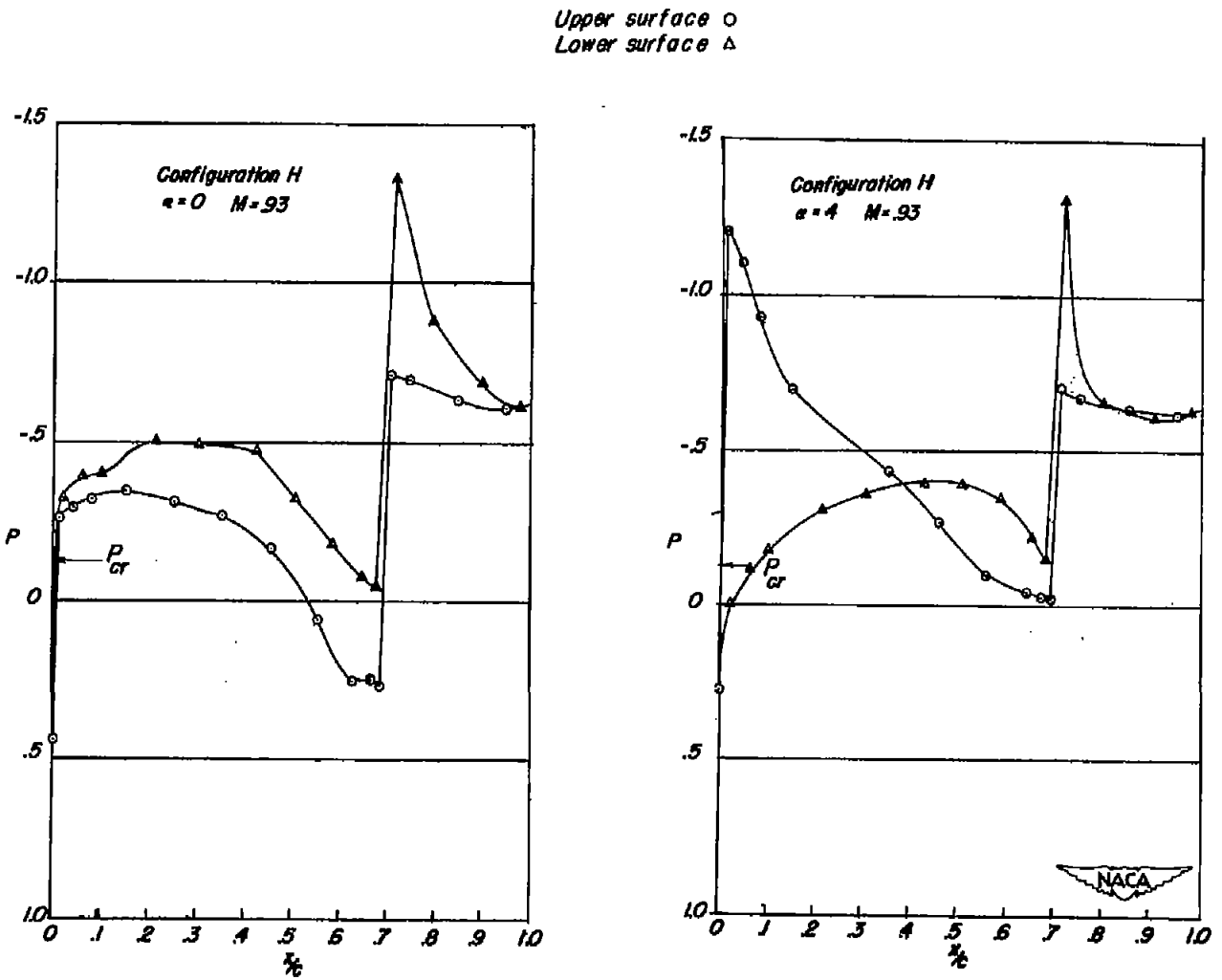
(c) M = 0.90.

Figure 9.- Continued.



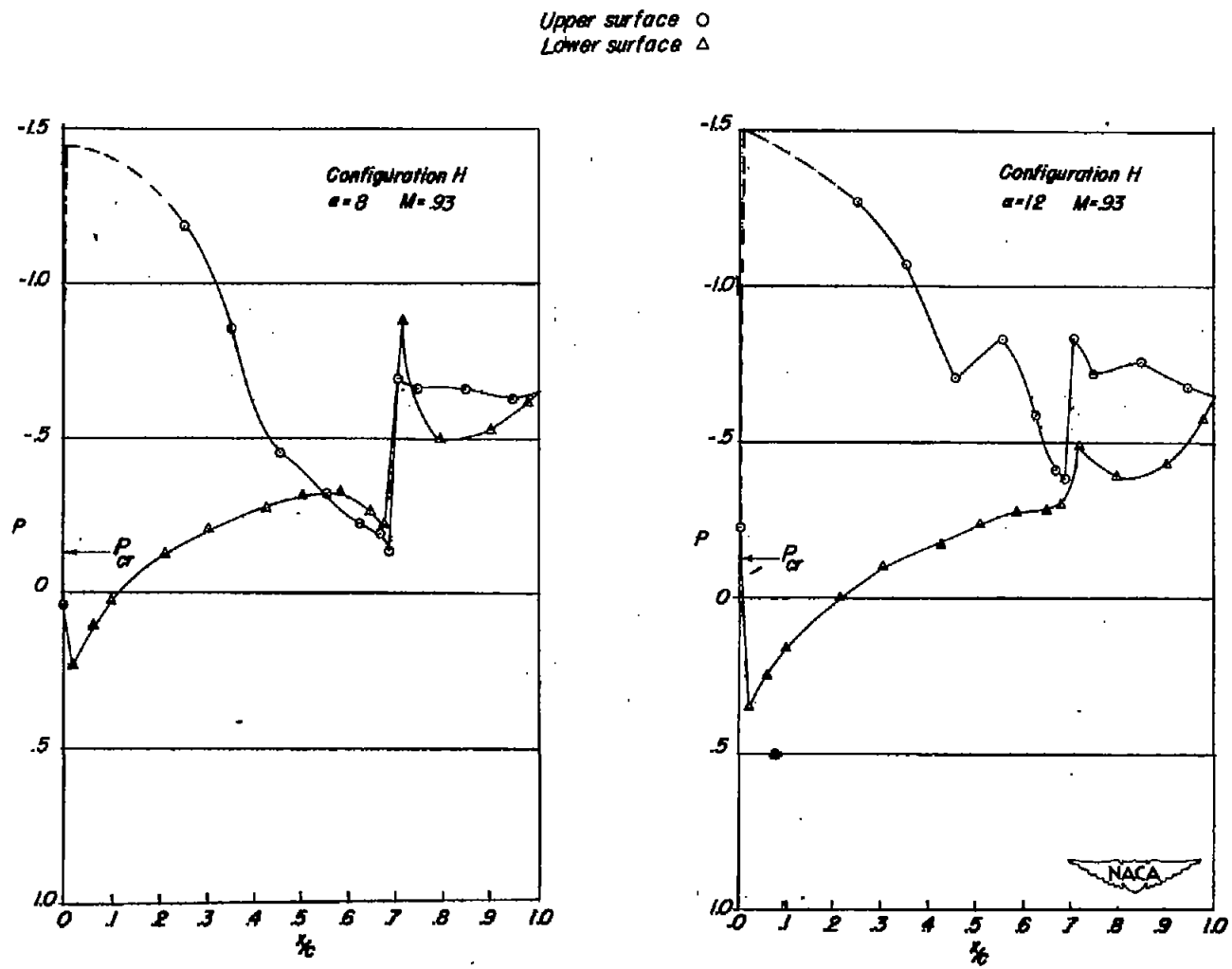
(c) M = 0.90. Concluded.

Figure 9.- Continued.



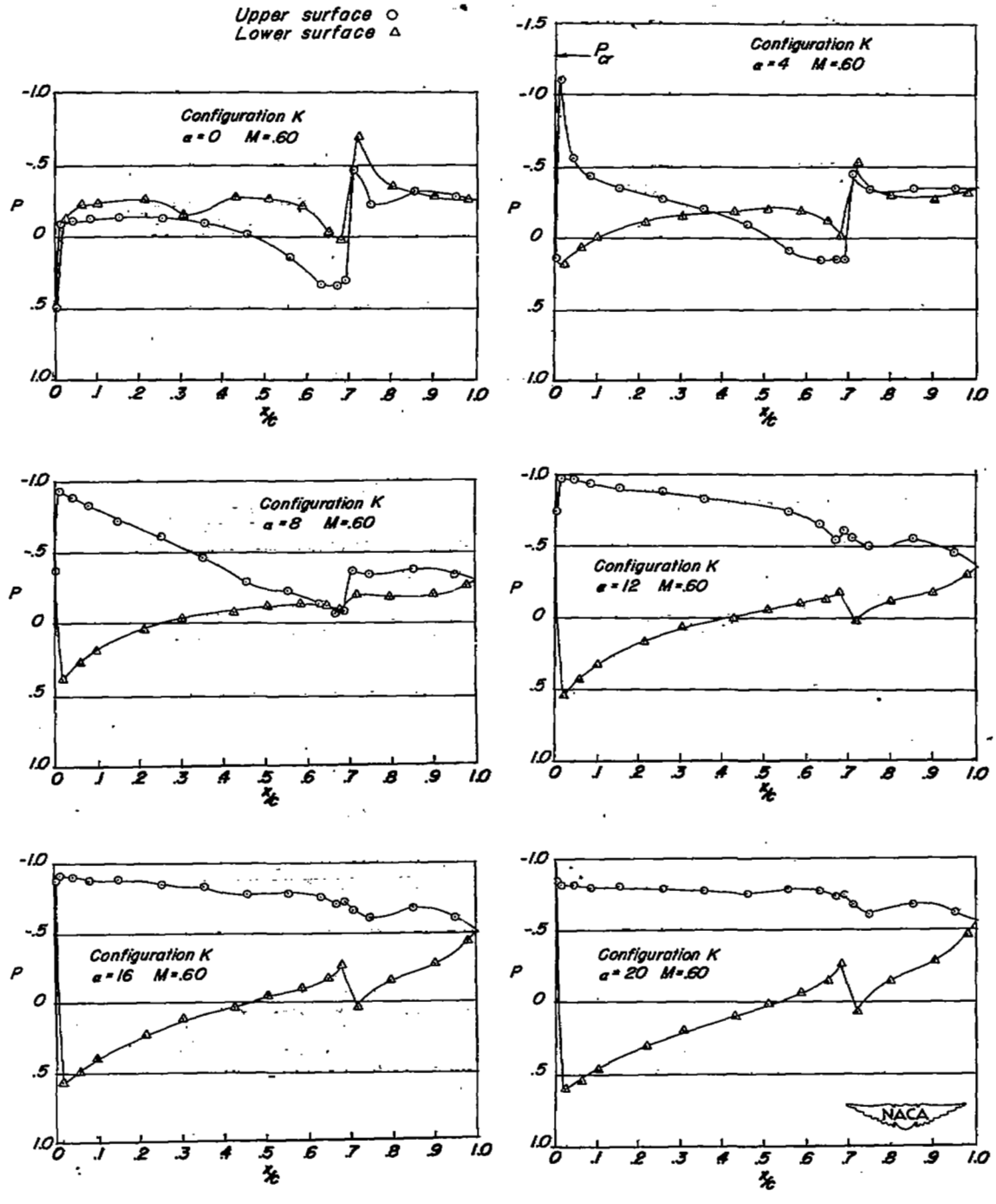
(d) M = 0.93.

Figure 9.- Continued.



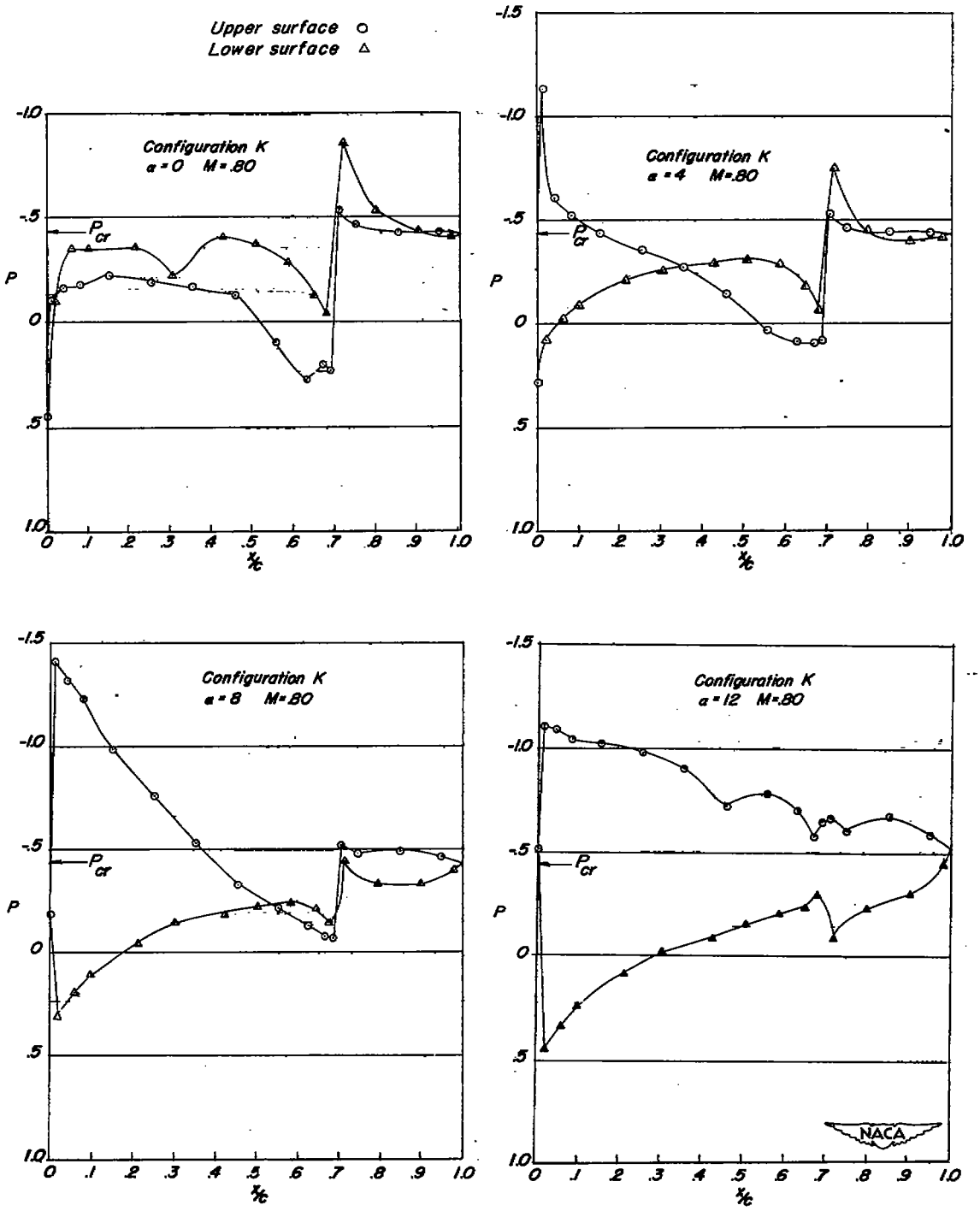
(d) M = 0.93. Concluded.

Figure 9.- Concluded.



(a) M = 0.60.

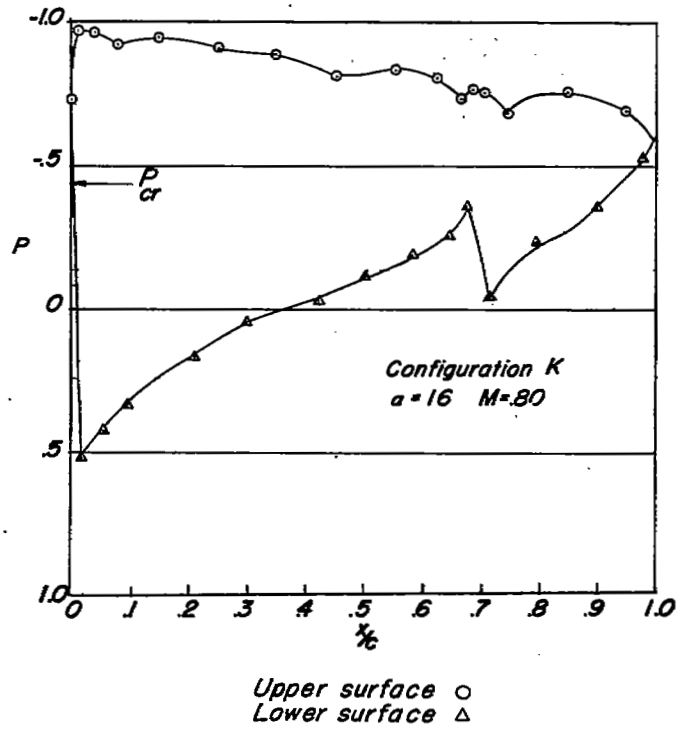
Figure 10.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station equipped with a plug-type perforated spoiler aileron. δ_s = -0.04c; gap unsealed.

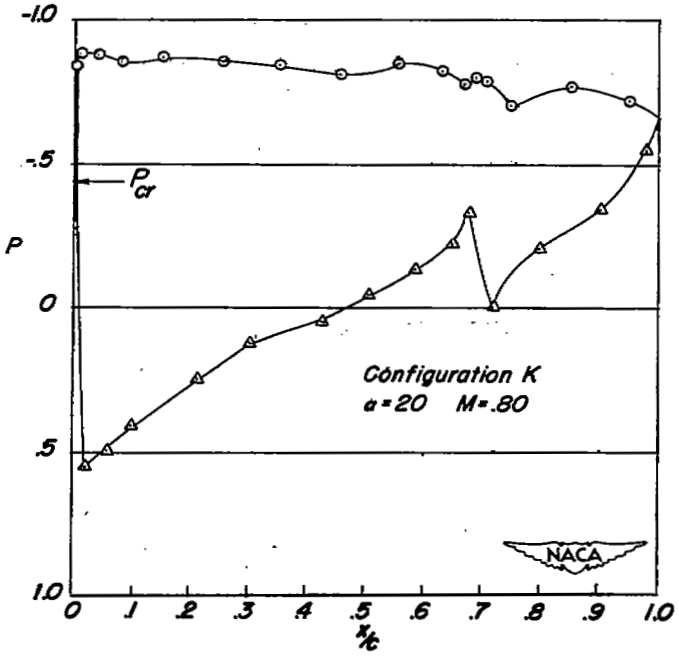


(b) M = 0.80.

Figure 10.- Continued.

8X

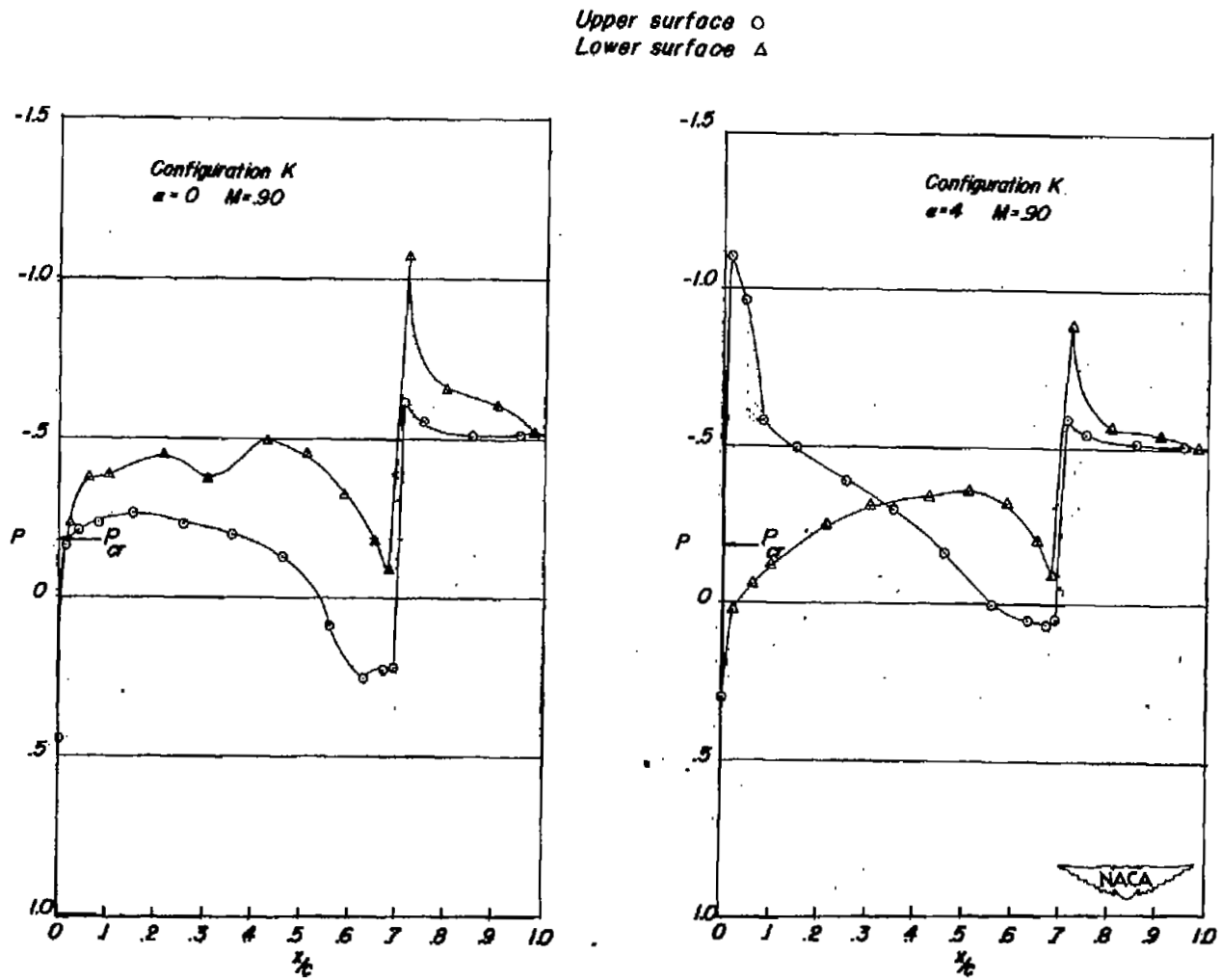




(b) M = 0.80. Concluded.

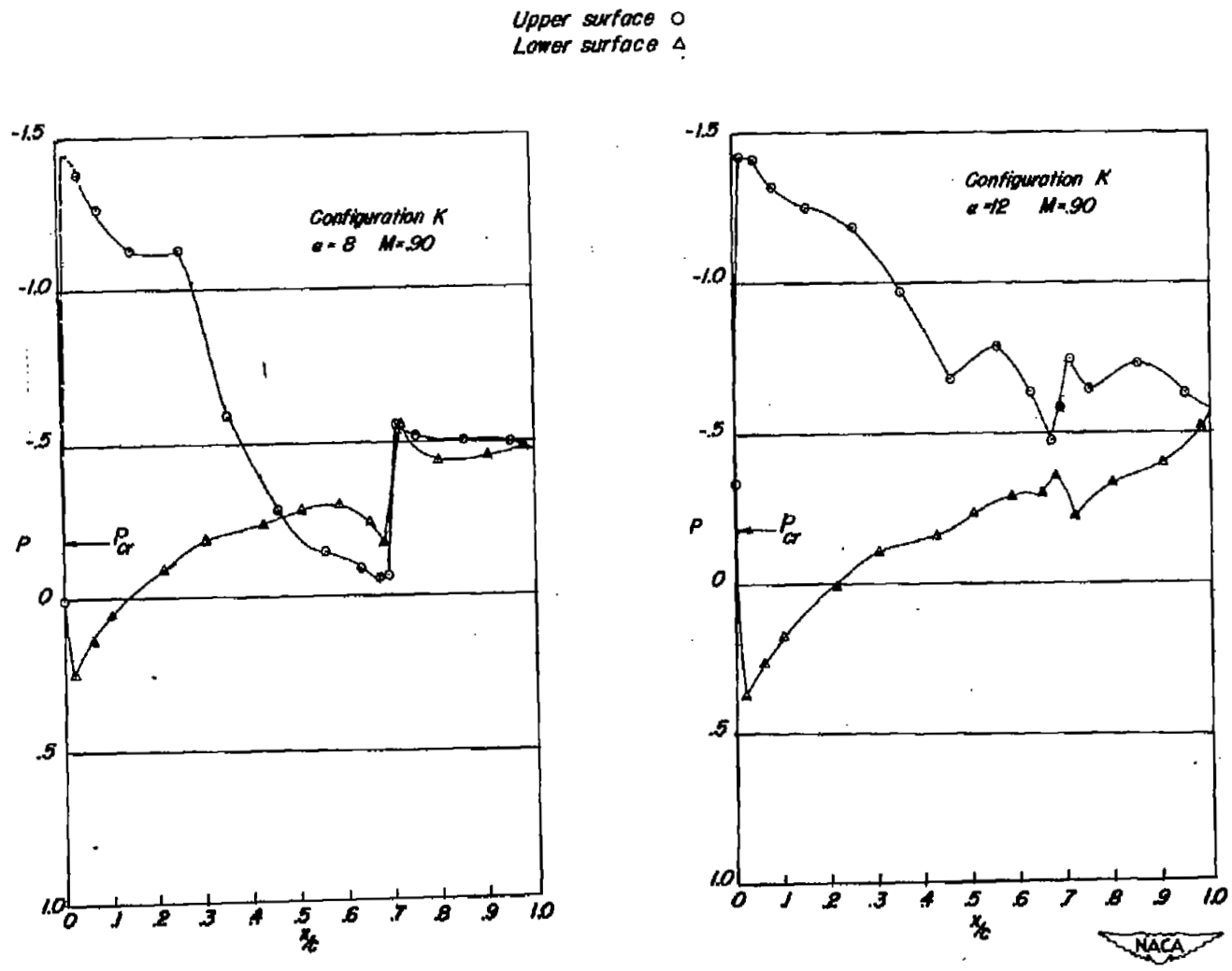
Figure 10.- Continued.

[redacted]



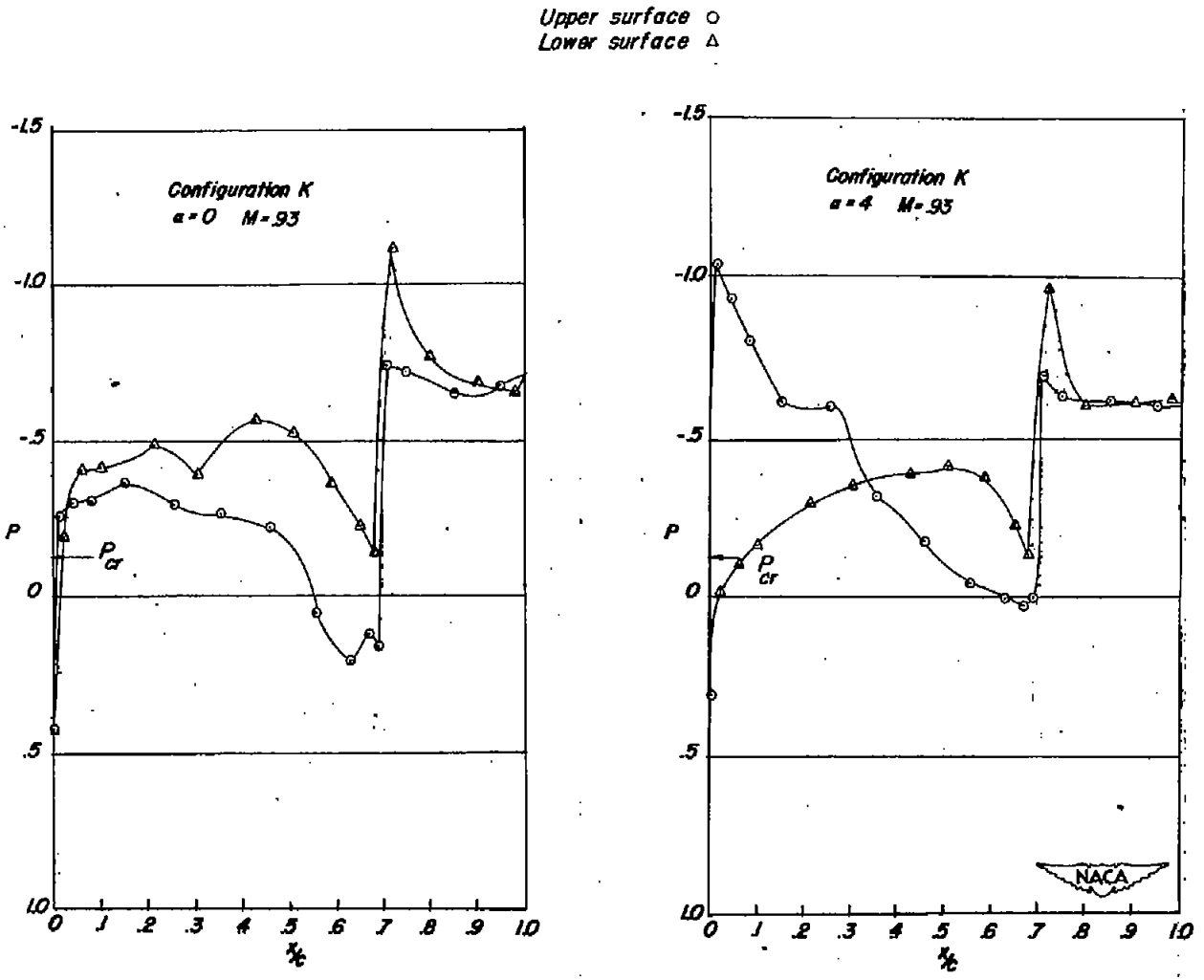
(c) M = 0.90.

Figure 10.- Continued.



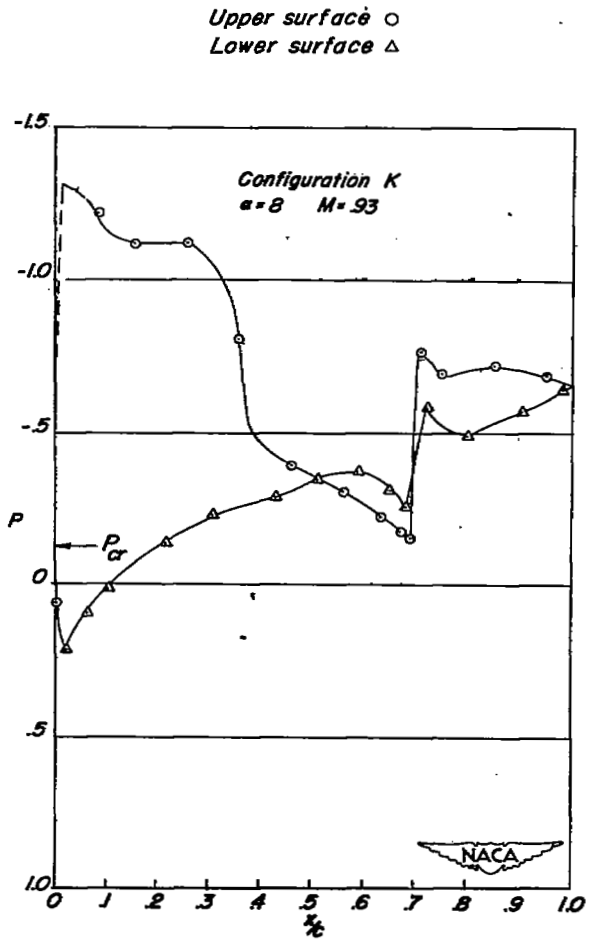
(c) M = 0.90. Concluded.

Figure 10.- Continued.



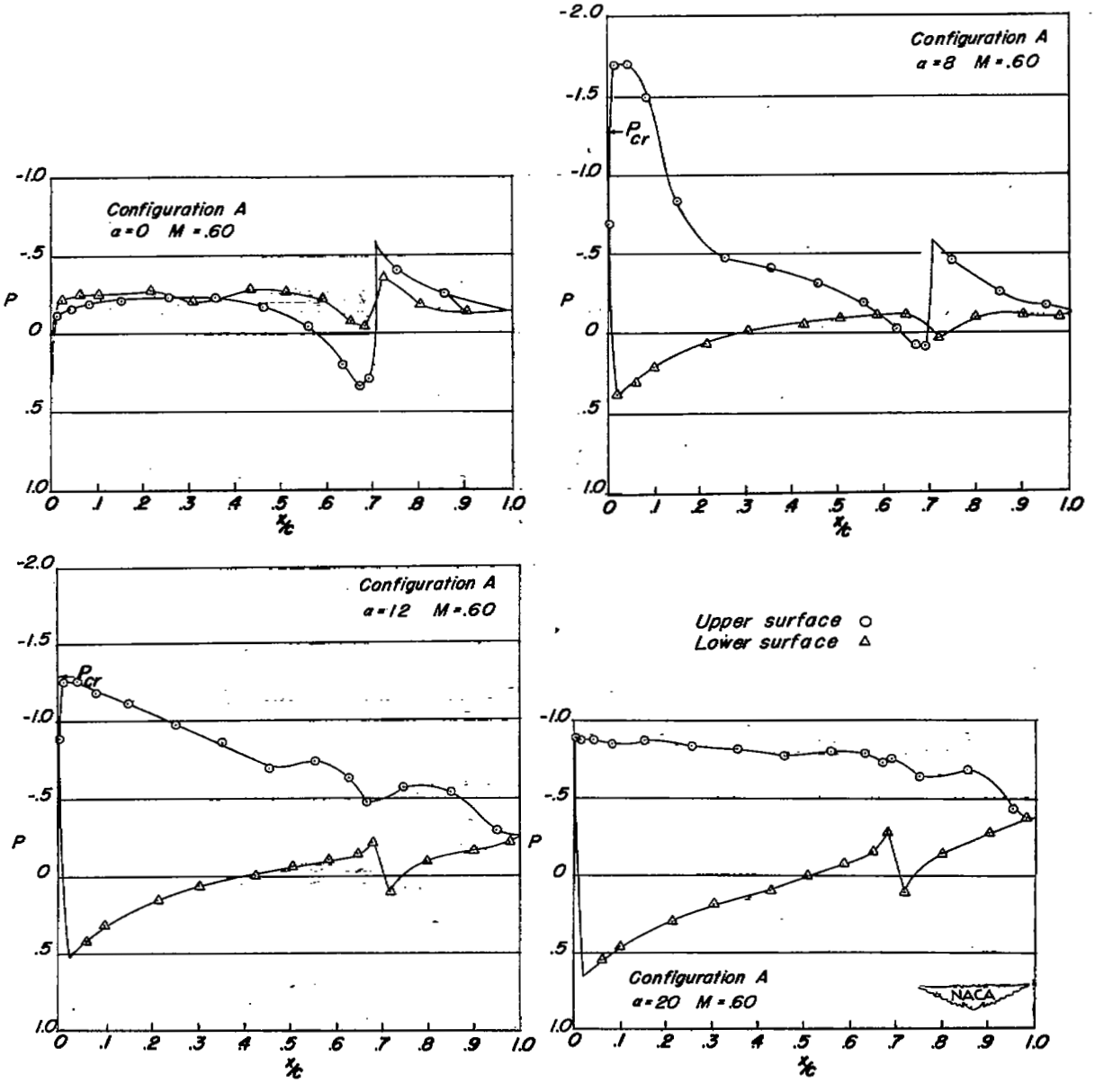
(d) M = 0.93.

Figure 10.- Continued.



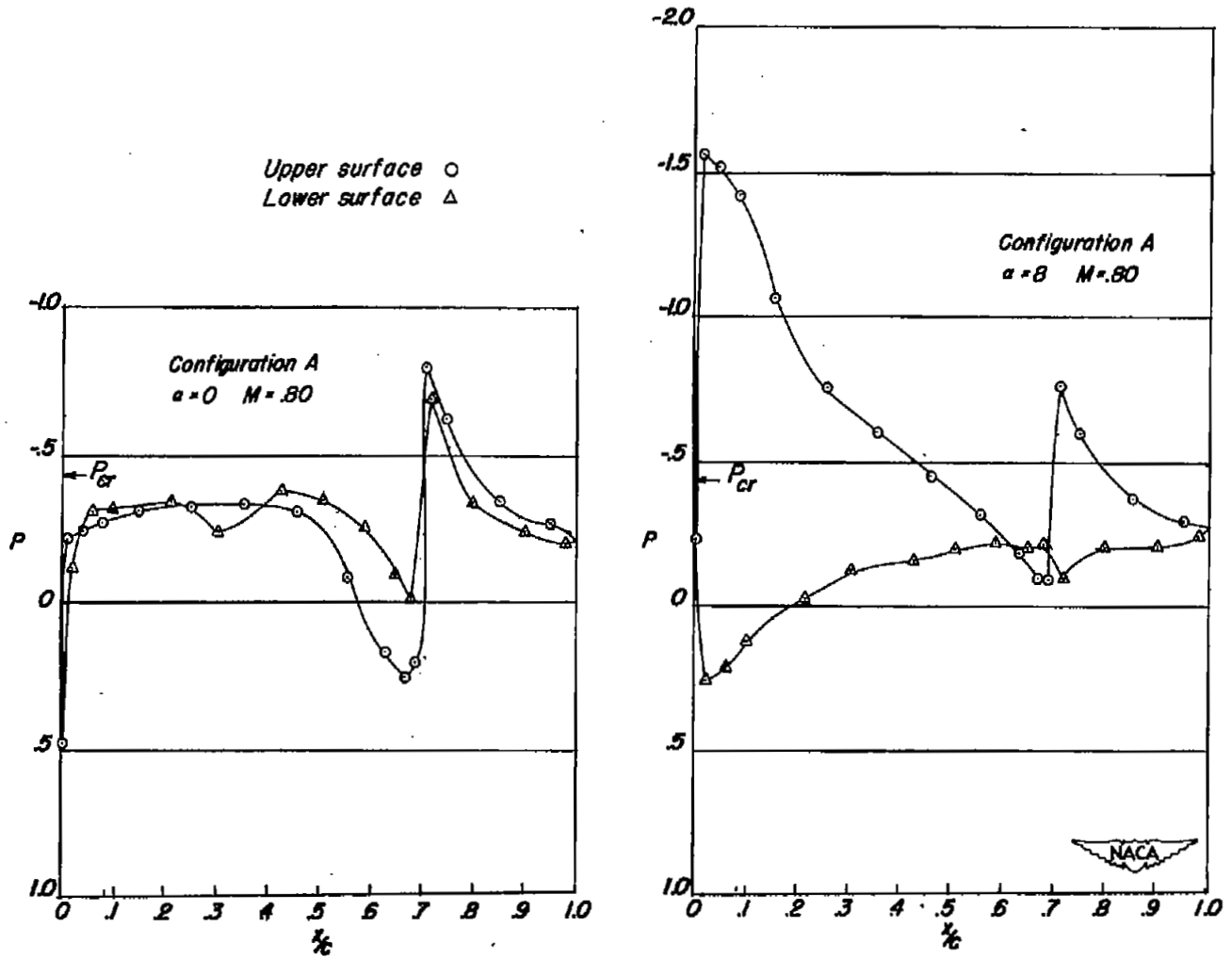
(d) M = 0.93. Concluded.

Figure 10.- Concluded.



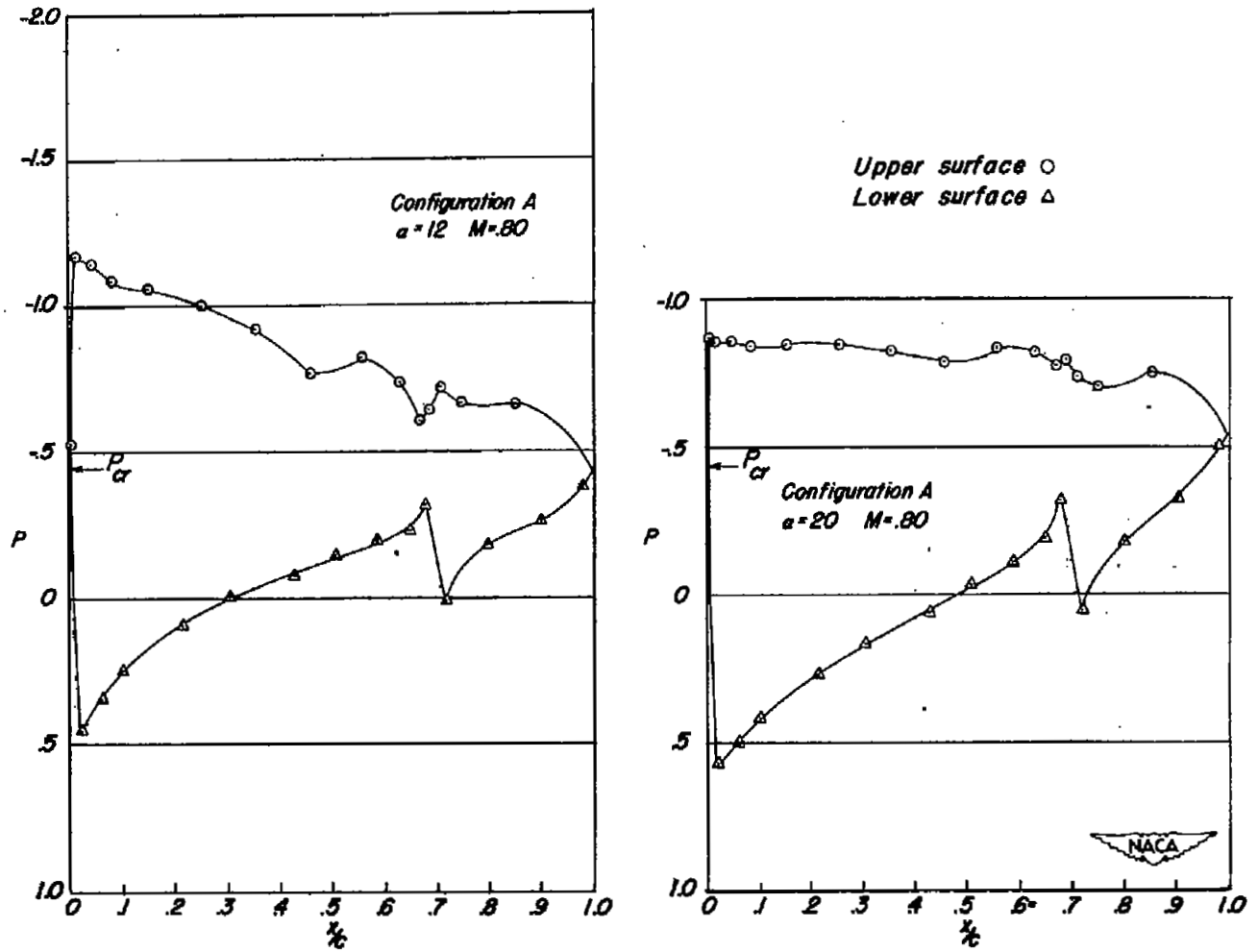
(a) M = 0.60.

Figure 11.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type fingered spoiler aileron. Configuration A; δ_s = -0.04c; gap unsealed.



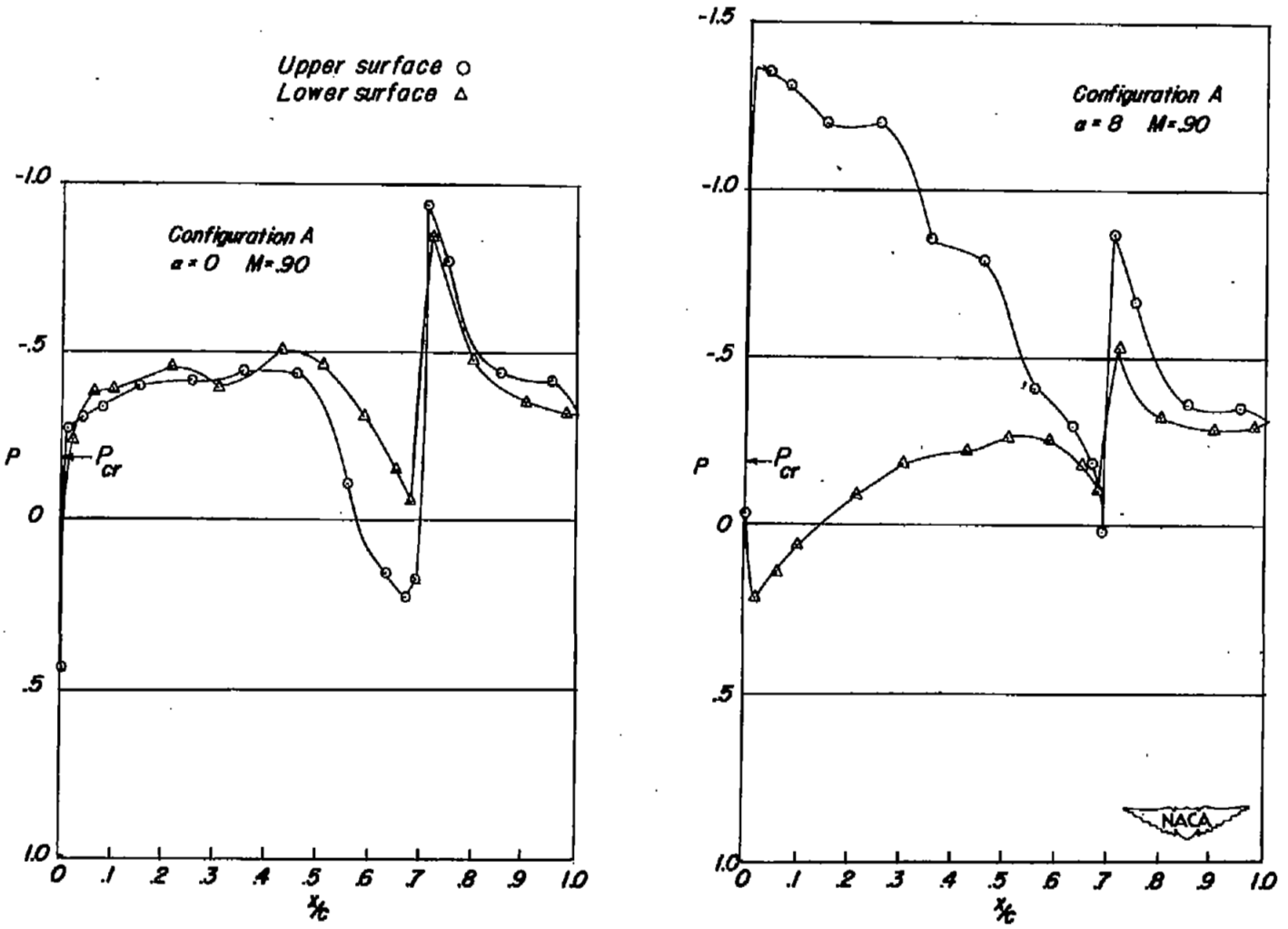
(b) M = 0.80.

Figure 11.- Continued.



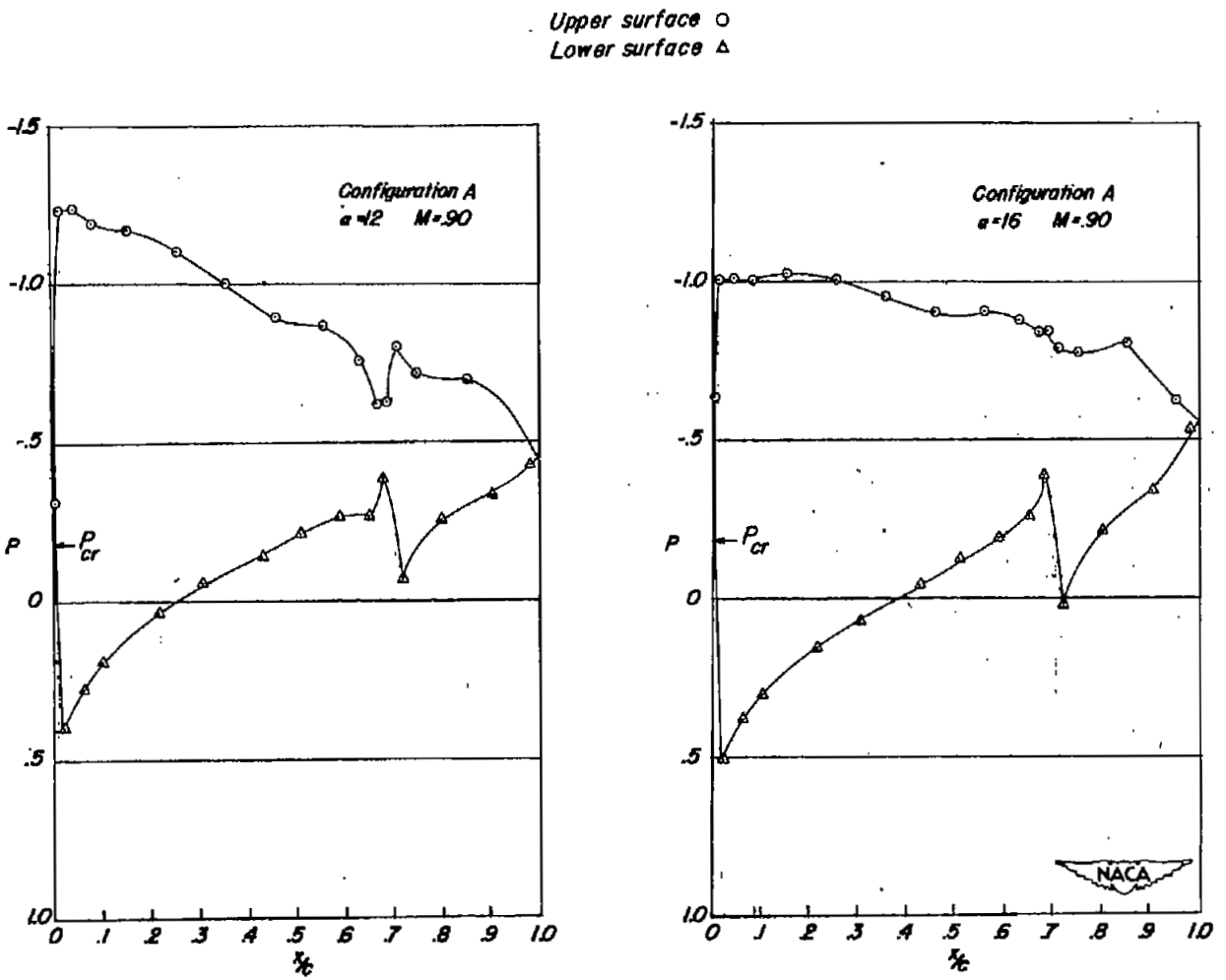
(b) M = 0.80. Concluded.

Figure 11.- Continued.



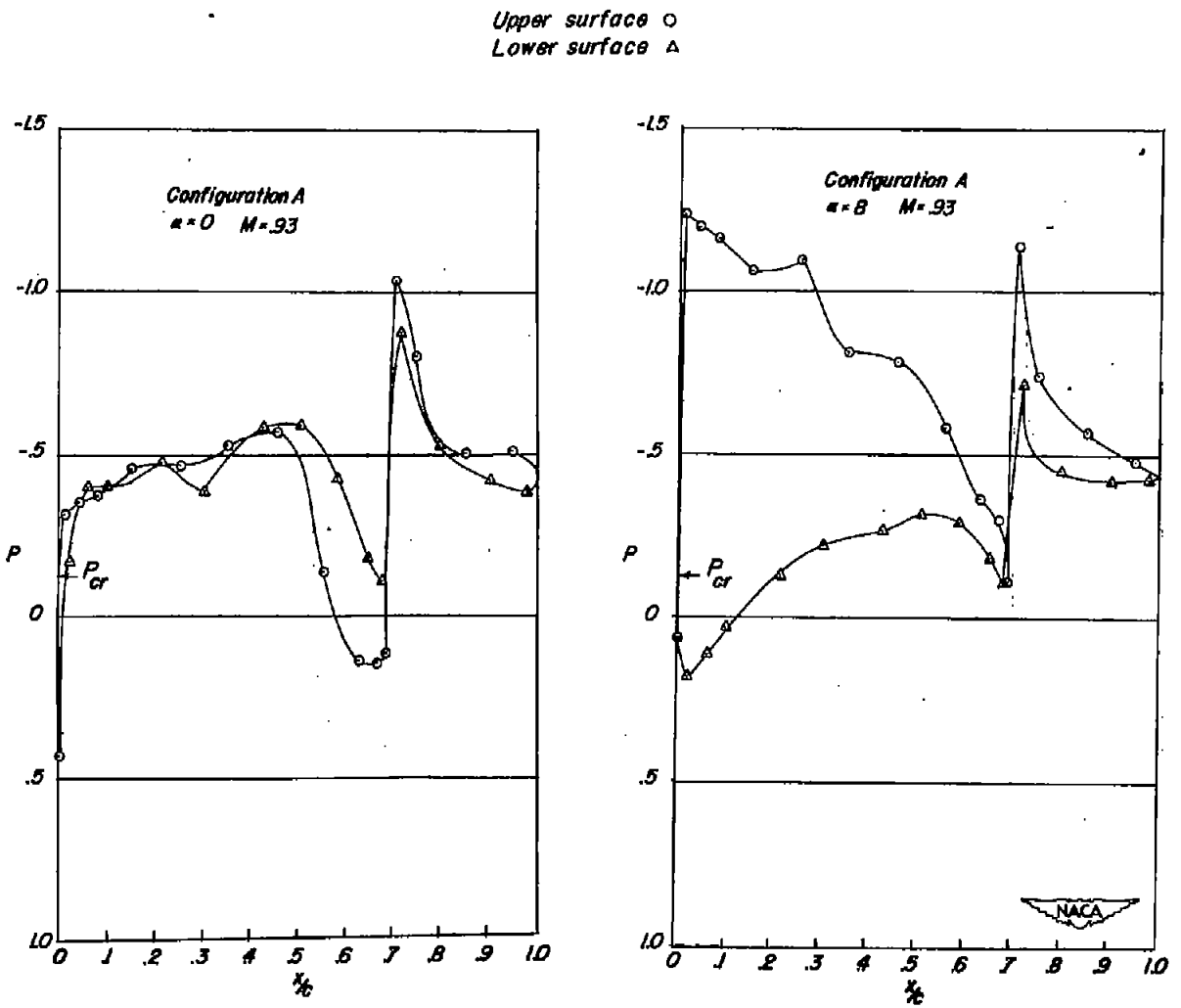
(c) M = 0.90.

Figure 11.- Continued.



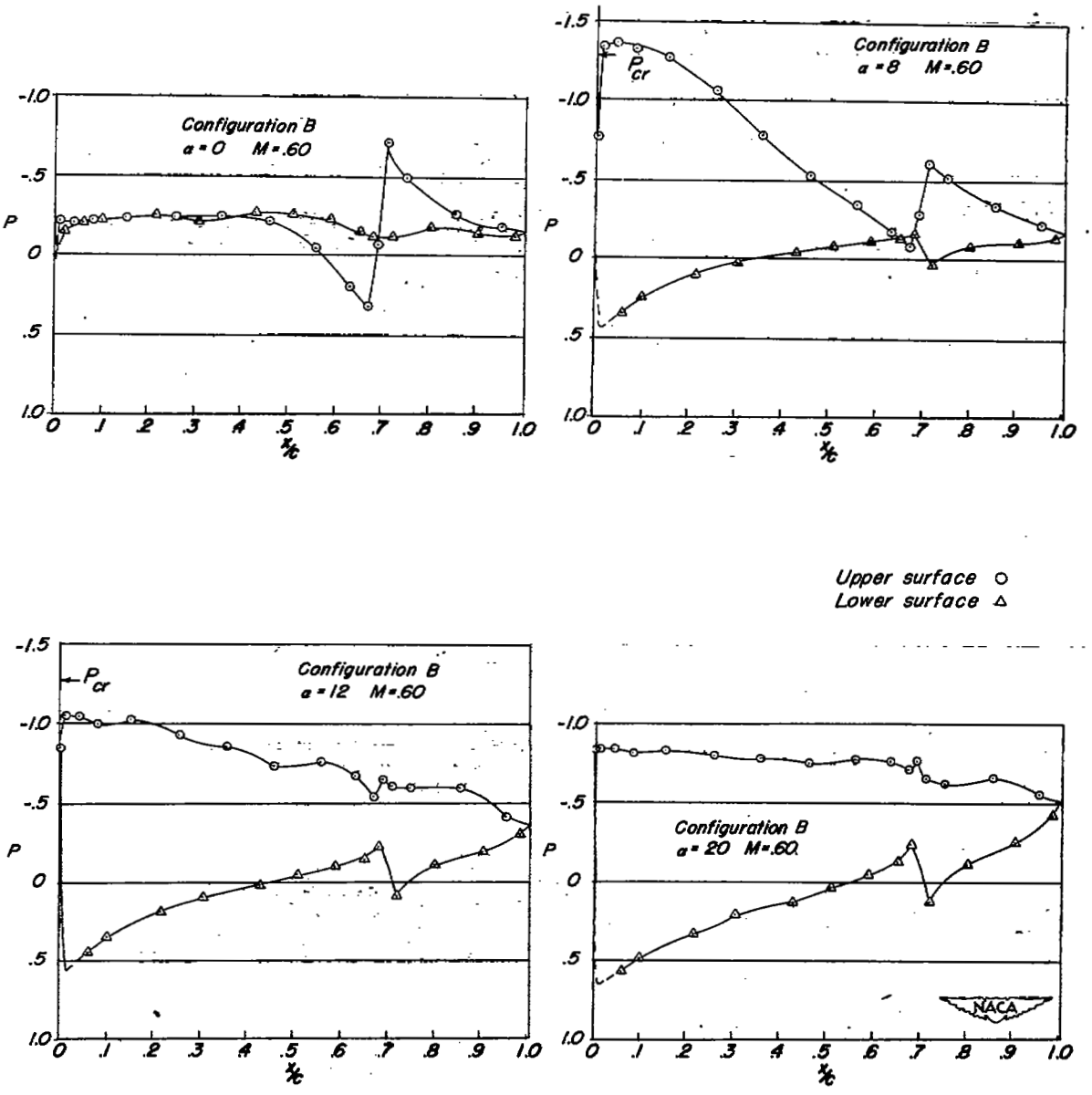
(c) M = 0.90. Concluded.

Figure 11.- Continued.



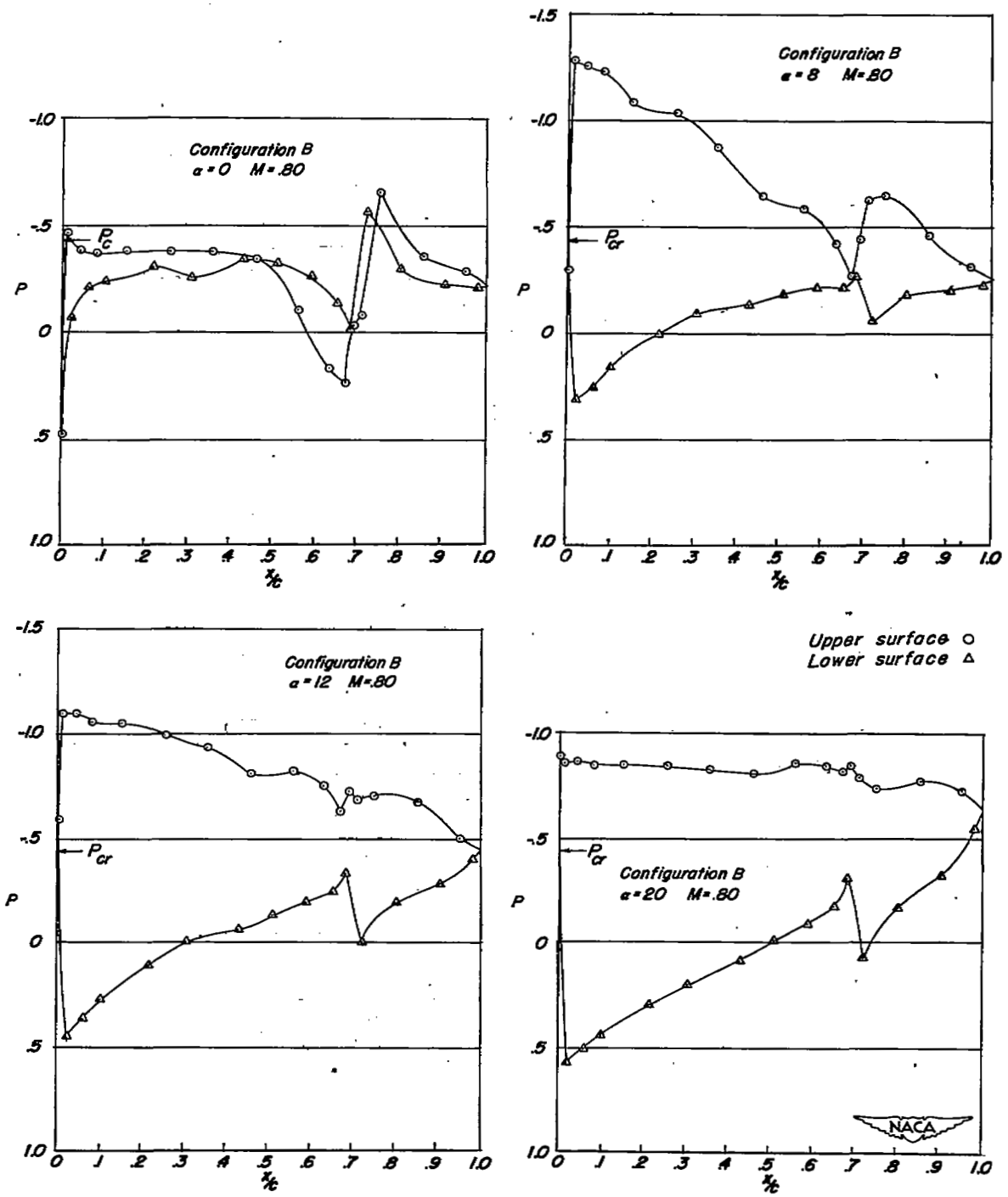
(d) M = 0.93.

Figure 11.- Concluded.



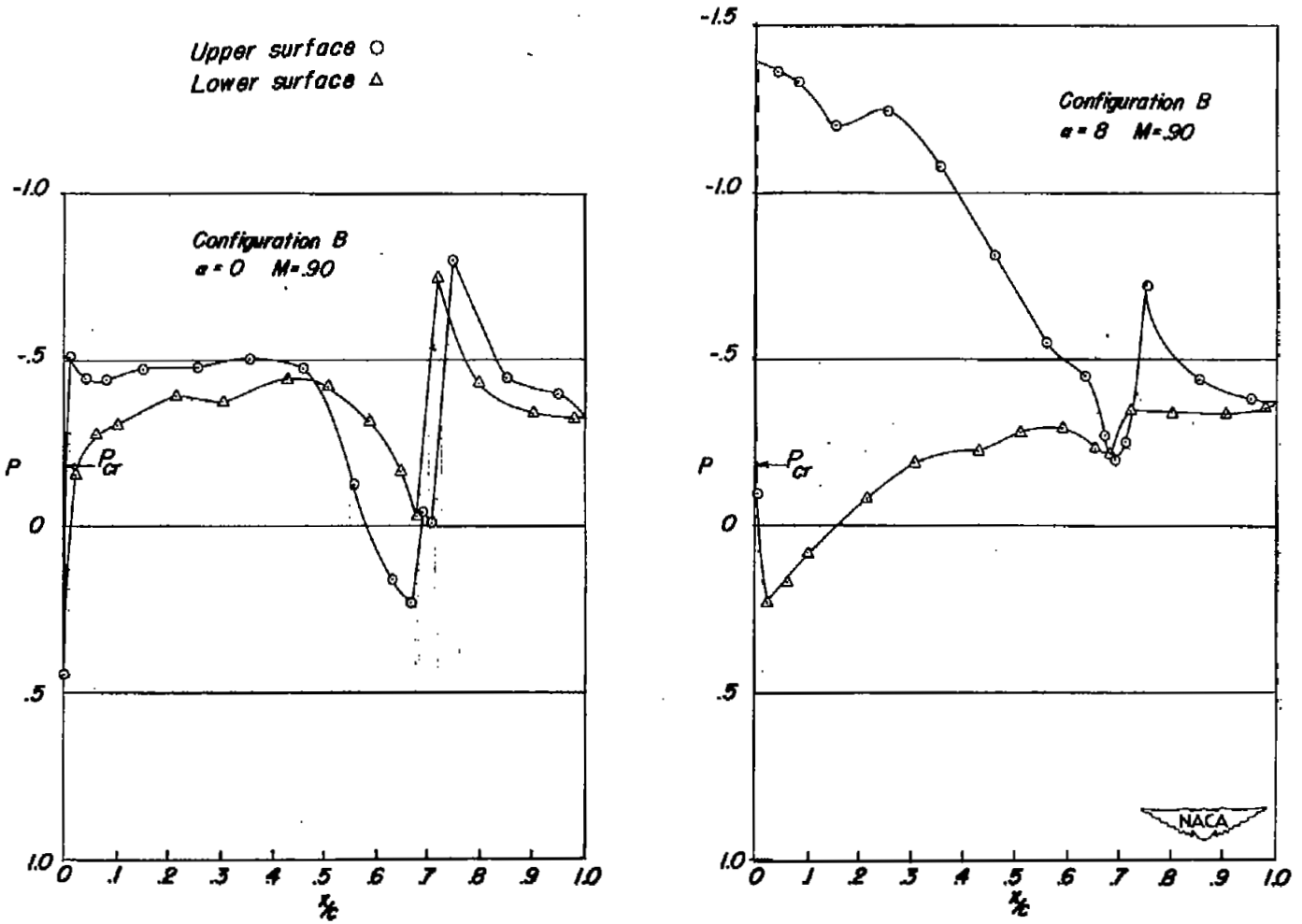
(a) M = 0.60.

Figure 12.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type fingered spoiler aileron. Configuration B; δ_s = -0.04c; gap unsealed.



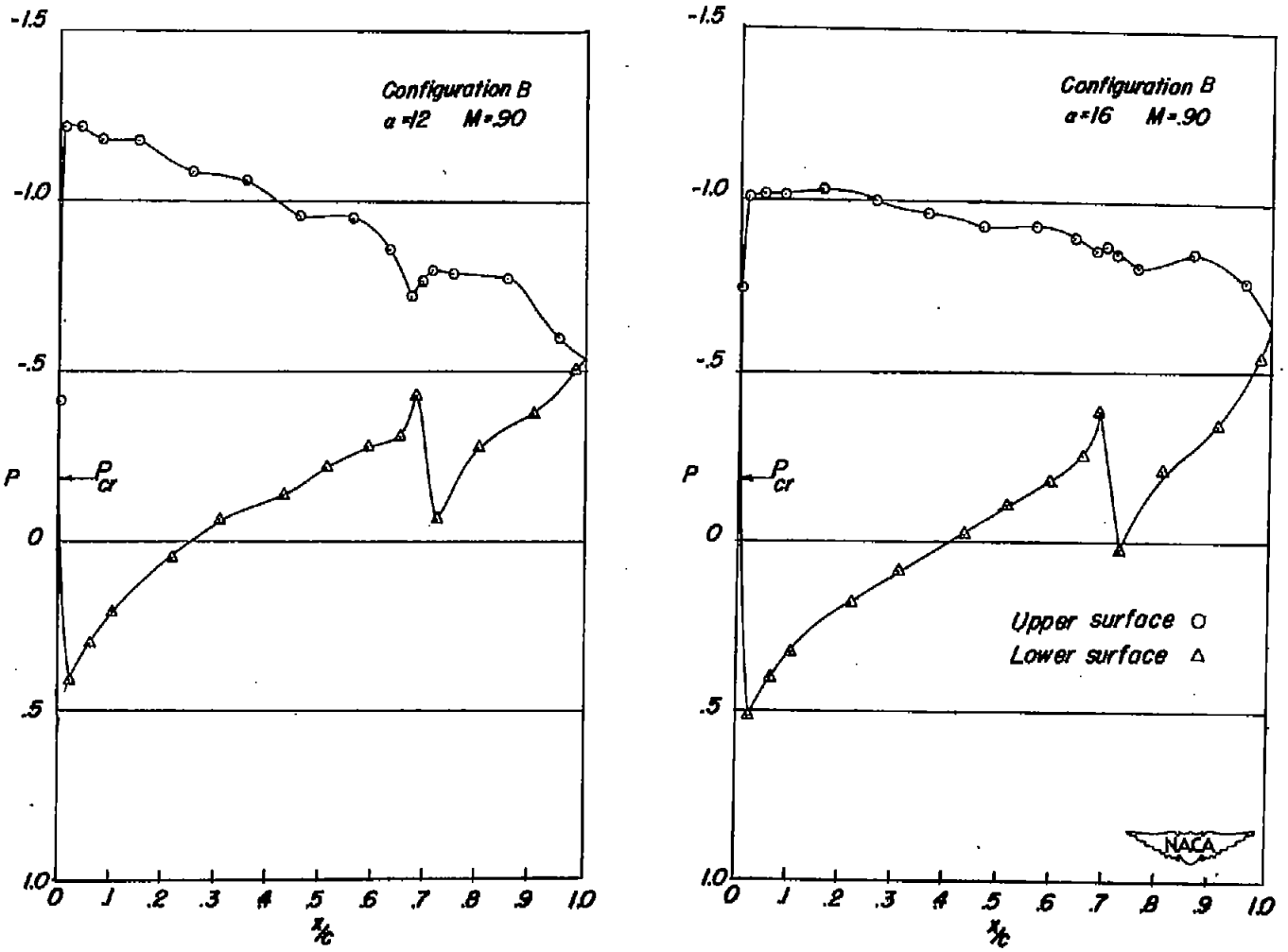
(b) M = 0.80.

Figure 12.- Continued.



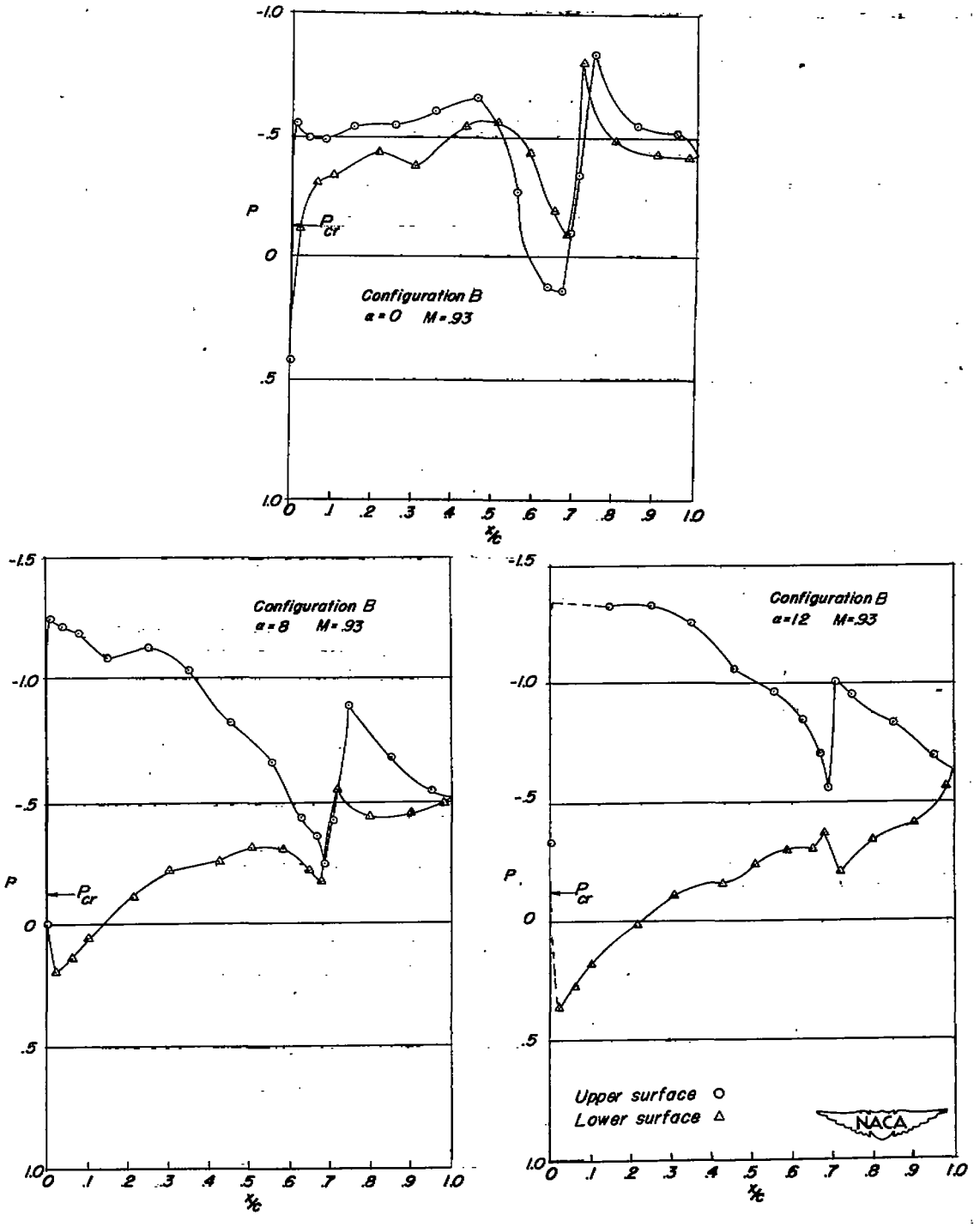
(c) M = 0.90.

Figure 12.- Continued.



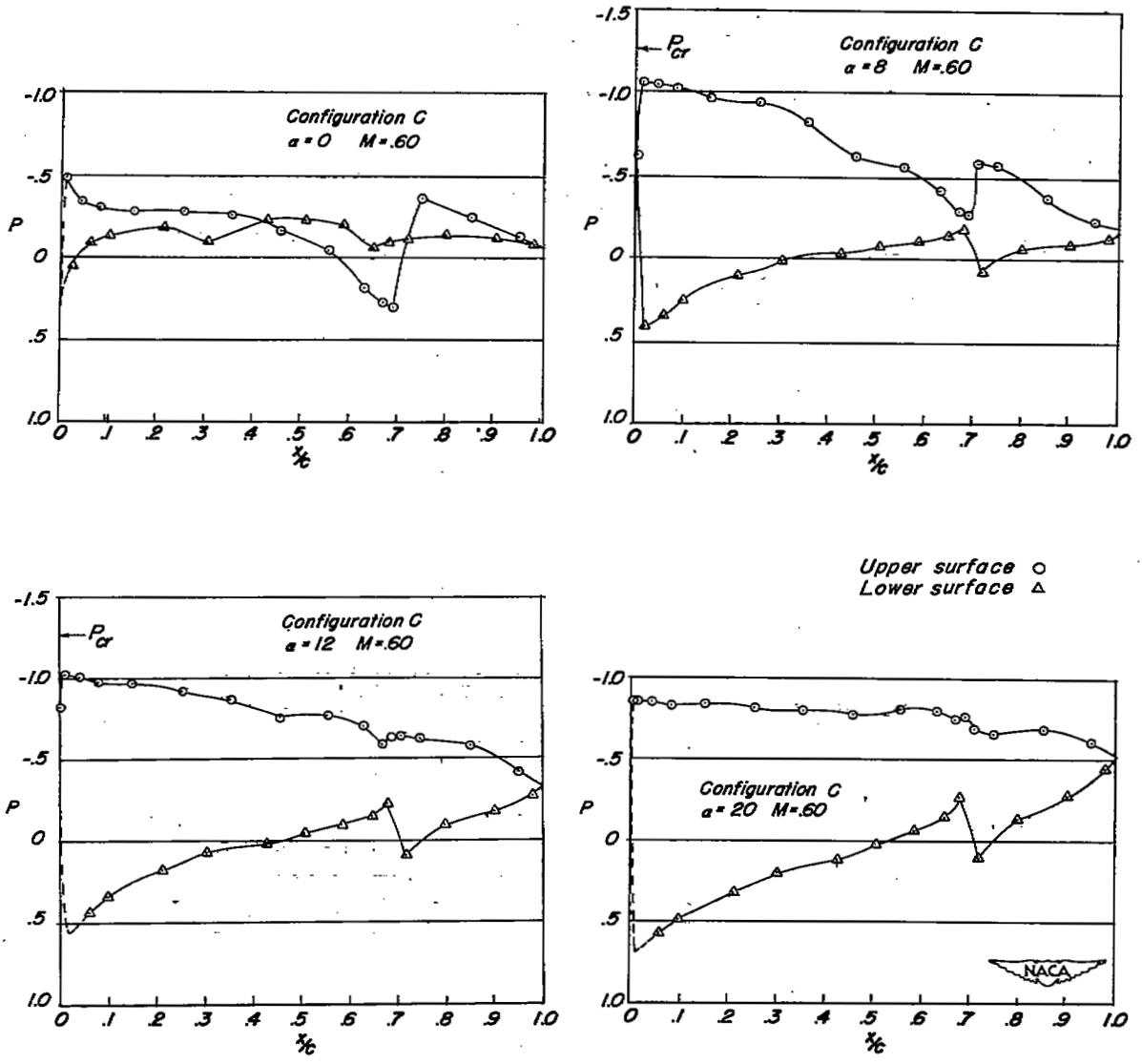
(c) M = 0.90. Concluded.

Figure 12.- Continued.



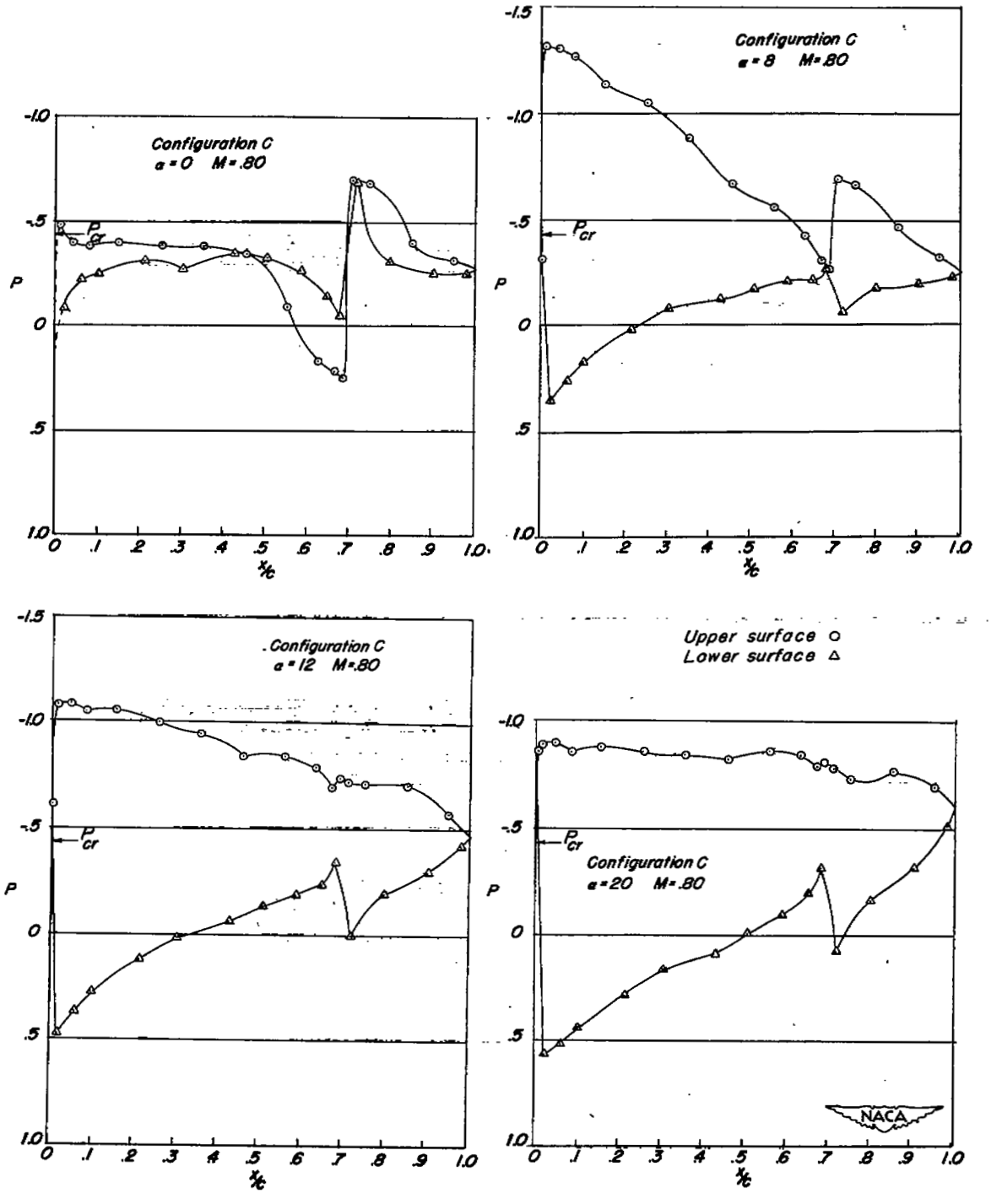
(d) M = 0.93.

Figure 12.- Concluded.



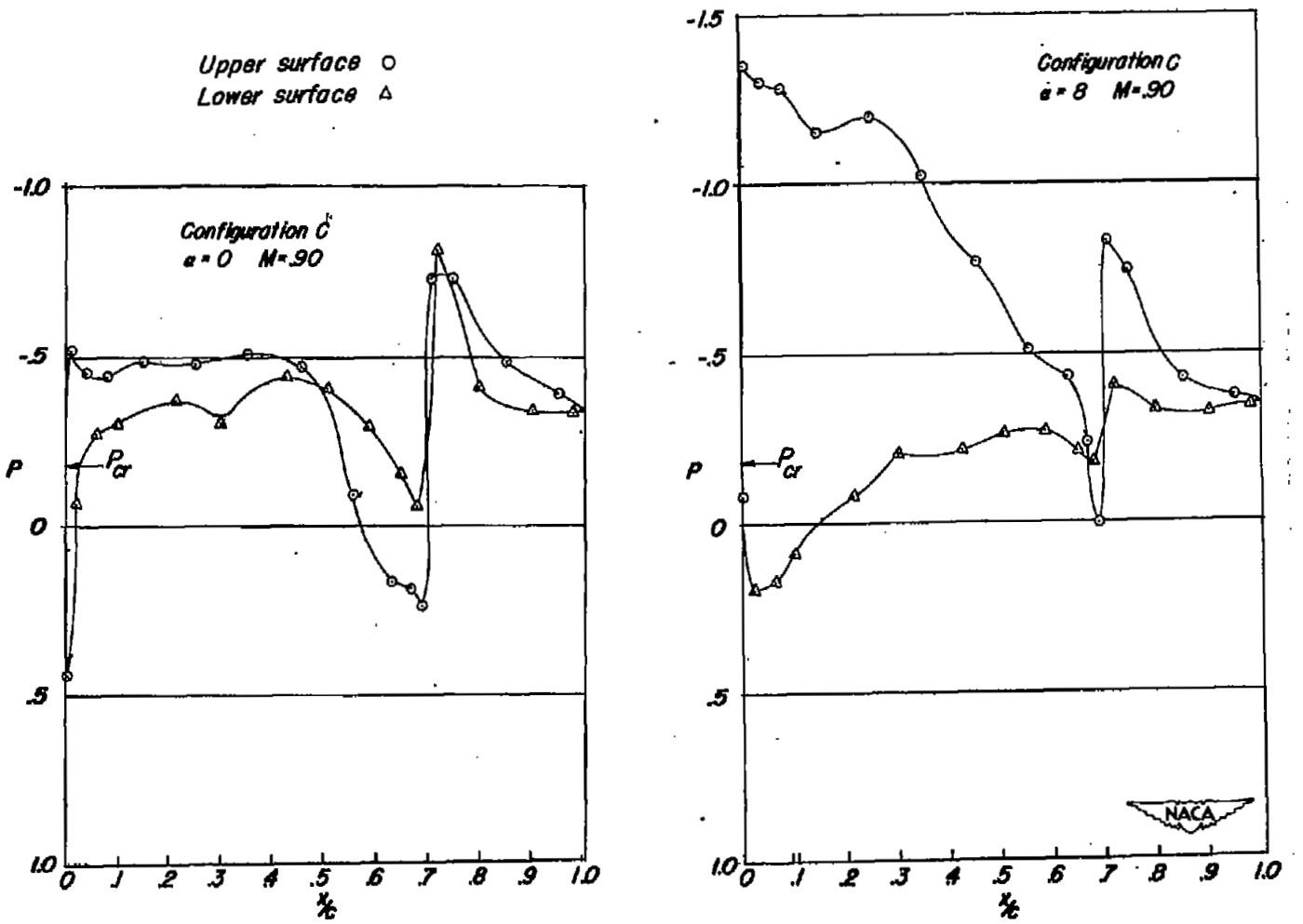
(a) M = 0.60.

Figure 13.- Chordwise pressure distribution over a 35° sweptback wing, at the 46-percent-semispan station, equipped with a plug-type fingered spoiler aileron. Configuration C; $\delta_s = -0.04c$; gap unsealed.



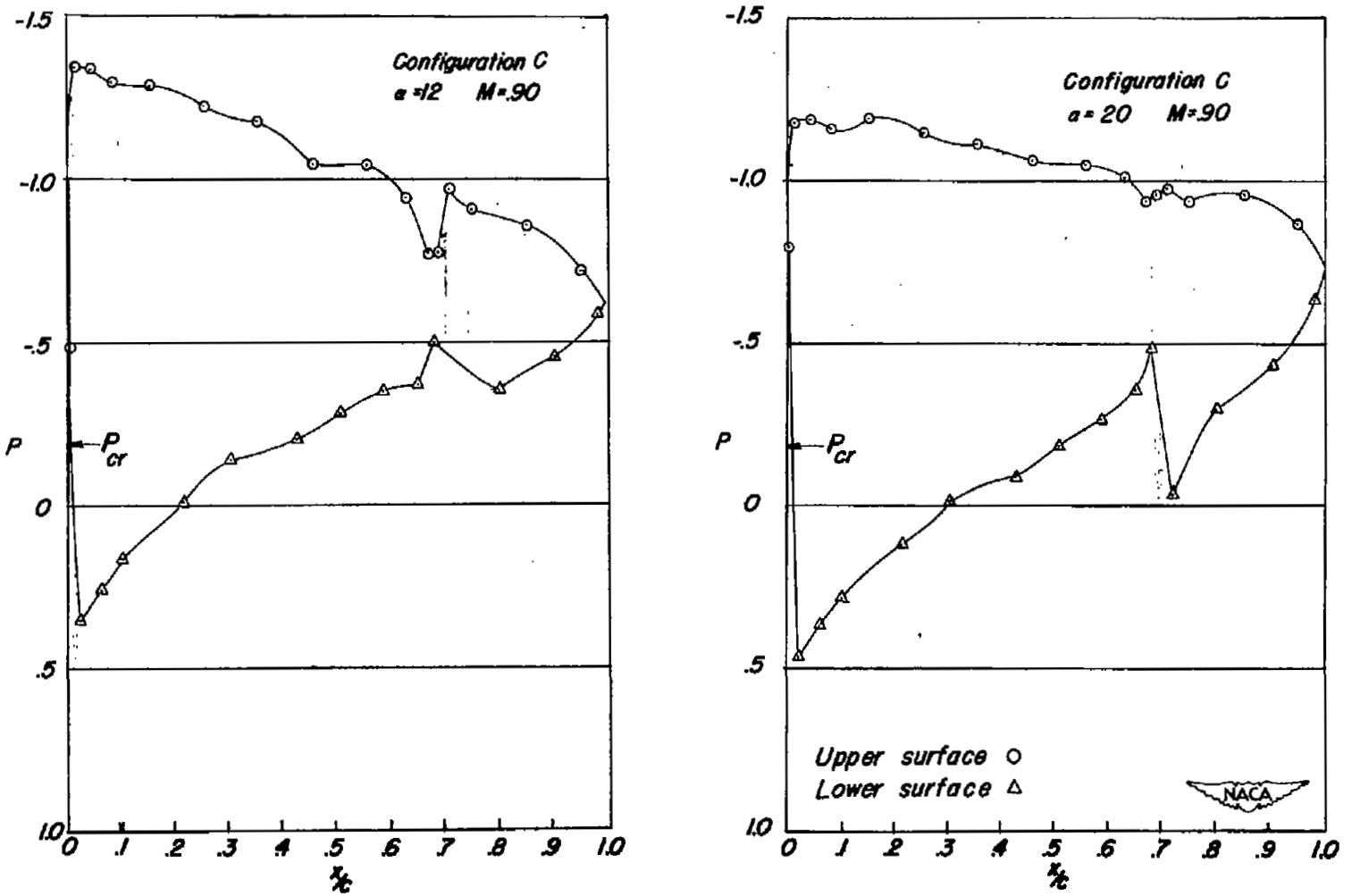
(b) M = 0.80.

Figure 13.- Continued.



(c) M = 0.90.

Figure 13.- Continued.



(c) M = 0.90. Concluded.

Figure 13.- Concluded.

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