FOREWORD

This entire report, written in three parts under separate covers, presents the results of a portion of the experimental program for the investigation of hypersonic flow separation and control characteristics being conducted by the Research Department of Grumman Aircraft Engineering Corporation, Bethpage, New York. Mr. Donald E. Hoak of the Flight Dynamics Laboratory, Aeronautical Systems Division, located at Wright-Patterson Air Force Base, Ohio, is the Air Force Project Engineer for the program, which is being supported primarily under Contract AF 33(616)-8130, Air Force Task 821902.

The Author wishes to dedicate this to the memory of his beloved Grandmother: MARY SOMERVILLE WELCH. He also wishes to express his appreciation to the staff of the von Karman Facility for their helpfulness in conducting the tests, and particularly to Messrs. Schueler and Baer for providing the machine plotted graphs of the experimental data included in this report. Ozalid reproducible copies of the tabulated data are available on loan from the Flight Control Division of the Flight Dynamics Laboratory.

The parts which constitute a complete report for this segment of the over-all program are:

Part I: Expansion Corner Flows

Part II: Flows Over a Flat Plate with and without a Partial Span Ramp

Part III: Flows Over Full Span Ramps Mounted on a Flat Plate

ABSTRACT

Pressure and heat transfer data were obtained for Mach 8 flows over a blunt pyramidal configuration composed of a 70 degree sweepback delta wing surface and two dihedral surfaces. Trailing edge flap deflections were varied up to 40 degrees on all surfaces, and the model was tested with and without canards and ventral fins. The model was pitched at angles of attack between ±54 degrees and was tested at sideslip angles of 0 and 12 degrees for free stream Reynolds numbers, based on model length, of 1.5 and 4.5 million.

This report has been reviewed and is approved.

Lawrence C. Wright

LAWRENCE C. WRIGHT
Lt. Colonel, USAF
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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

*See Table II, page 9, for figure numbers corresponding to particular test conditions.

LIST OF SYMBOLS

C_p	pressure coefficient, $C_p \equiv (p-p_\infty)/q_\infty$
M_∞	free stream Mach number
p	pressure (psia)
p_o	stagnation pressure (psia)
p_∞	free stream static pressure (psia)
q_∞	free stream dynamic pressure (psia)
Re_∞/ft	Reynolds number per foot, $Re_\infty/ft \equiv \rho_\infty U_\infty/\mu_\infty$
T_{aw}	adibatic wall temperature (°R)
T_o	stagnation temperature (°R)
T_w	wall temperature (°R)
T_∞	free stream static temperature (°R)
U_∞	free stream velocity (ft/sec)
X'	nondimensional streamwise surface distance downstream of the flat plate leading edge.
Y'	nondimensional semispan distance outboard of the model centerline.
α	angle of attack of model (deg.)
μ_∞	viscosity of air in the free stream (slugs/ft sec)
ρ_∞	density of air in the free stream (slugs/ft^3)

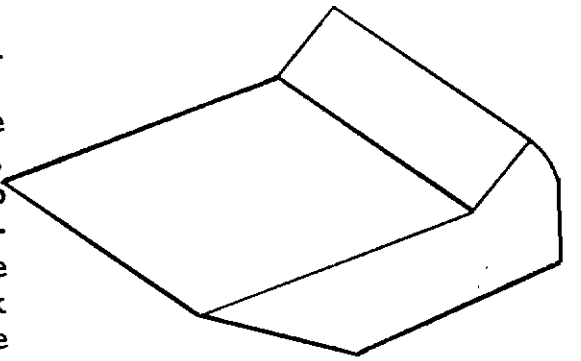
INTRODUCTION

The experimental data generated for an investigation of hypersonic flow separation and aerodynamic control characteristics are presented in a series of reports, of which this is one. Pressure, heat transfer, and force data are being obtained for hypersonic flows over "basic geometries," such as a wedge mounted on a flat plate, and for "typical" hypersonic flight configurations with aerodynamic control surfaces. The experimental portion of the program required a total of 11 models (see Fig. 1, p.13); 8 for tests in the von Karman Facility of the Arnold Engineering Development Center and 3 for tests in the Grumman Hypersonic Shock Tunnel (Refs. 1 and 2). The data obtained from AEDC tests of one of the models are given in this three-volume report (see Foreword).

Pressure distributions were obtained over a sharp expansion corner and ahead of wedge shaped ramps mounted on an internally cooled flat plate. The data are to be used in investigating the effects of wall temperature on the pressure distribution and region of separated flow ahead of ramps. These effects must be clearly understood before comprehensive conclusions can be drawn from earlier tests during which aerodynamic heating data were obtained on "cold" models and pressure data were obtained on the same models after they had reached their equilibrium temperatures. The data presented herein were obtained in the AEDC 50-inch Mach 8 Tunnel (Ref. 3). Geometrically similar models, without internal cooling but with both heat transfer and pressure instrumentation, were tested in the AEDC 40-inch and 50-inch tunnels and in the Grumman Hypersonic Shock Tunnel (see Fig. 1).

Manuscript released by author in December 1963 for publication as an ASD Technical Documentary Report.

This report (Part III) presents data obtained on the upper, flat plate, surface of the model and on the face of a 25% chord, full span, ramp mounted on the trailing edge of the flat plate. Data were obtained for three ramp angles, both with and without internal cooling of the flat plate surface, for model angles of attack from -43 to +10 degrees for free stream Reynolds numbers per foot of 1.1, 2.2 and 3.3 million.



MODEL

Photographs of the model, installed in the AEDC 50-inch Mach 8 Tunnel, are shown in Figs. 2 and 3. The model has a nominally sharp leading edge and a 12-inch square planform. The full span ramp has a 3-inch chord and can be set at 10, 20 or 30 degree wedge angles (Figs. 3 and 4). The ramp leading edge is sharp and is sealed to the flat plate surface.

The flat plate portion of the model can be cooled internally* using a mixture of low temperature nitrogen and oxygen. A 1-inch feed line leads the coolant to a settling chamber in the forward portion of the model. From there, the coolant passes through a 0.10-inch thick by 4-inch wide channel adjacent to the flat plate surface (Fig. 4). The channel extends from essentially the leading edge of the model downstream to a station aft of the ramp leading edge. Turning vanes at the trailing edge of the channel direct the coolant flow back upstream in the outboard portions of the model, adjacent to the flat plate surface. The coolant is then allowed to exhaust into the tunnel stream flow downstream of the base of the model.

Thermocouples are mounted just below the flat plate surface (0.010 inches) at various spanwise and chordwise locations (Fig. 4). These allow the surface wall temperatures to be monitored and recorded.

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*See Part II of this report for a more complete description of the cooling system.

Pressure tap locations, on the flat plate and ramp surfaces, are indicated in Fig. 4. As indicated in the figure, the true view of the ramp face is shown. The pressure taps are in a streamwise - spanwise array and are particularly closely spaced along the model centerline. The ramp leading edge is slightly notched to prevent blocking the two pressure taps at the ramp - flat plate junction (424 and 524). Two taps are located on the port side of the model (921 and 929), these allow observing and checking flow symmetry about the model centerline.

TEST CONDITIONS

Pressure data and wall temperature distributions were obtained at $M_\infty = 8$ for free stream Reynolds numbers per foot of 1.1, 2.2 and 3.3 million. The tunnel conditions corresponding to the different Reynolds numbers are shown in Table I.

The model was pitched at angles of attack (referenced to the flat plate surface) from 43 degrees nose down to 10 degrees nose up. Model angles of attack, ramp angles, and free stream Reynolds numbers are indicated in Table II.

As indicated in Table II, just two cooling flow rates (ON or OFF) were used for the data presented herein.** The coolant flow, when ON, was adjusted to yield the minimum model wall temperature just sufficient to avoid condensation and icing on the model. When OFF, the model attained its equilibrium wall temperature (which varied with angle of attack and Reynolds number). Typical temperature distributions are shown in Table III.

**Principal use of the internal cooling for the model was used for the data presented in Part II of this report (wherein the ramp was internally cooled also). Therefore, a more complete description of the different cooling flow rates and temperature distributions on the flat plate and on the ramp surfaces is presented in Part II.

DATA REDUCTION AND ACCURACY

The pressure data were reduced to standard pressure coefficient form:

$$C_p = \frac{p - p_\infty}{q_\infty}$$

where p is the measured pressure, p_∞ is the free stream static pressure, and q_∞ is the free stream dynamic pressure. The inaccuracy in the measured pressure varies from ± 0.003 psia for pressures below 0.40 psia, to 0.026 psia for pressures greater than 15 psia. Pressure coefficient uncertainties vary, for example, from 0.004 for $C_p < 0.3$ and $Re_\infty/ft = 1.1$ million, to 0.013 for $C_p = 2.0$ and $Re_\infty/ft = 3.3$ million. At the higher pressure coefficients, the greatest part of the inaccuracy is due to the deviations in the Mach 8 free stream dynamic pressure (Ref. 5).

The automatic plotting machines, used in presenting the data herein, introduce another source of possible error. The discrepancy in the plotted pressure coefficients due to this machine error should not exceed ± 0.01. Nevertheless, there is always the rare possibility that a point will be completely misplotted. Each graph has been inspected and questionable points checked with the tabulated pressure coefficients.

RESULTS

Table II summarizes the data obtained on the upper surfaces of the model and indicates the corresponding figure numbers where the sets of data are presented. The AEDC group number is presented in the last column. This number indicates the order in which the data were obtained and is to be used when referring to the tabulated data.

Shadowgraph flow photographs were obtained for the conditions indicated in Table II. These photographs show just the flow over the upper portion of the model. In order to include the entire upper surface flow in just one photograph, the camera was rotated in several instances (as apparent from the orientation of the model and the test conditions indicated on the flow photographs).

Streamwise and spanwise plots of the pressure coefficients are presented in Figs. 70 through 134. The first part of each figure presents streamwise plots of the pressure coefficients at five semispan stations, three on the cooled portion of the flat plate and two further outboard (see Fig. 4). The second part of each figure presents cross plots of the data for six streamwise stations, three ahead of the ramp leading edge. In the streamwise plots, the pressures measured by tap numbers 921 and 929 (on the port side of the model), are presented just downstream of the values obtained from the corresponding taps (numbers 221 and 229) on the starboard side of the model.

Although the accuracy of the plotted data should suffice for engineering purposes, ozalide reproducible copies of the tabulated data are available on loan (see Foreword). The plotted data may be read accurately using standard 20/inch grid, tracing graph paper overlays.

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12. Kaufman, L.G. II, Pressure Measurements for Mach Five Flows over a Blunt Pyramidal Configuration with Aerodynamic Controls, to be published as a RTD Technical Documentary Report.

13. Kaufman, L.G. II, Pressure and Heat Transfer Measurements for Mach 8 Flows over a Blunt Pyramidal Configuration with Aerodynamic Controls, to be published as a RTD Technical Documentary Report.

TABLE I

TUNNEL CONDITIONS

$\frac{Re_\infty}{10^6 ft}$	1.1	2.2	3.3
M_∞	8.04	8.08	8.09
p_∞ (psia)	0.025	0.049	0.074
q_∞ (psia)	1.13	2.24	3.37
p_o (psia)	252	510	770
T_o (°R)	1,350	1,350	1,350

TABLE II

TEST CONDITIONS

(Sheet 1 of 2)

RAMP ANGLE (deg.)	COOLANT FLOW		Re_∞ / 10^6 Ft.	α (deg.)	Figure Nos.		AEDC Group Nos.
	OFF	ON			Photo*	C_p	
30	X		1.1	-43	5	70	112
30		X	1.1	-43	6	71	115
30	X		2.2	-43	7	72	107
30	X		3.3	-43	8	73	103
30		X	3.3	-43	9	74	104
30	X		1.1	-40	10	75	108
30	X		3.3	-40	11	76	102
30	X		1.1	-35	12	77	109
30	X		3.3	-35	13	78	101
30	X		1.1	-30	14	79	111
30		X	1.1	-30	15	80	114
30	X		2.2	-30	16	81	106
30	X		3.3	-30	17	82	100
30		X	3.3	-30	18	83	105
10	X		1.1	-25	19	84	91
10	X		3.3	-25	20	85	88
20	X		1.1	-25	21	86	76
20	X		3.3	-25	22	87	74
30	X		1.1	-25	23	88	113
30	X		3.3	-25	24	89	99
10	X		1.1	-20	25	90	96
10	X		3.3	-20	26	91	89
20	X		1.1	-20	27	92	81
20	X		3.3	-20	28	93	75
30	X		1.1	-20	29	94	110
30	X		3.3	-20	30	95	98
10	X		1.1	-15	31	96	92
10	X		3.3	-15	32	97	87
20	X		1.1	-15	33	98	77
20	X		3.3	-15	34	99	73
30	X		1.1	-15	35	100	61
30	X		2.2	-15	36	101	60
30	X		3.3	-15	37	102	51

*Shadowgraph flow photographs.

TABLE II

TEST CONDITIONS

(Sheet 2 of 2)

RAMP ANGLE (deg.)	COOLANT FLOW OFF	COOLANT FLOW ON	Re_∞ / 10^6 Ft.	α (deg.)	Figure Nos. Photo*	Figure Nos. C_p	AEDC Group Nos.
10	X		1.1	-10	38	103	97
10	X		3.3	-10	39	104	86
20	X		1.1	-10	40	105	82
20	X		3.3	-10	41	106	72
30	X		1.1	-10	42	107	62
30	X		3.3	-10	43	108	52
10	X		1.1	-5	44	109	93
10	X		3.3	-5	45	110	85
20	X		1.1	-5	46	111	78
20	X		3.3	-5	47	112	71
30	X		1.1	-5	48	113	63
30	X		3.3	-5	49	114	53
10	X		1.1	0	50	115	94
10	X		2.2	0	51	116	90
10	X		3.3	0	52	117	84
20	X		1.1	0	53	118	79
20	X		2.2	0	54	119	68
20	X		3.3	0	55	120	70
30	X		1.1	0	56	121	64
30	X		2.2	0	57	122	59
30	X		3.3	0	58	123	54
30	X		1.1	+2 1/2	59	124	67
10	X		1.1	+3	60	125	95
10	X		3.3	+3	61	126	83
20	X		1.1	+3	62	127	80
20	X		3.3	+3	63	128	69
30	X		1.1	+5	64	129	65
30	X		2.2	+5	65	130	58
30	X		3.3	+5	66	131	55
30	X		3.3	+8	67	132	57
30	X		1.1	+10	68	133	66
30	X		3.3	+10	69	134	56

*Shadowgraph flow photographs.

TABLE III

TYPICAL TEMPERATURE DISTRIBUTIONS FOR 30° RAMP

COOLANT FLOW OFF		
THERMO-COUPLE NUMBER	$\alpha = +10°$ $Re_\infty/ft = 1,100,000$	$\alpha = -15°$ $Re_\infty/ft = 3,300,000$
	WALL TEMPERATURE (°R)	WALL TEMPERATURE (°R)
1	1060	1140
2	1050	1140
3	1030	1130
7	1100	1130
8	1050	1110
9	990	1090

$Re_\infty/ft = 3,300,000$		
COOLANT FLOW	α (deg)	WALL TEMPERATURE (°R) AT THERMOCOUPLE NO. 2
OFF	-30	1170
OFF	-43	1210
ON	-30	470
ON	-43	470

Notes: 1) Wall temperatures varied by as much as $\pm 10°R$ about the values shown above during the time (approximately 5 minutes) required to record the pressures for one set of test conditions.

2) See Part II of this report for more complete temperature distributions over the flat plate surface and on the face of an internally cooled, partial span, ramp.

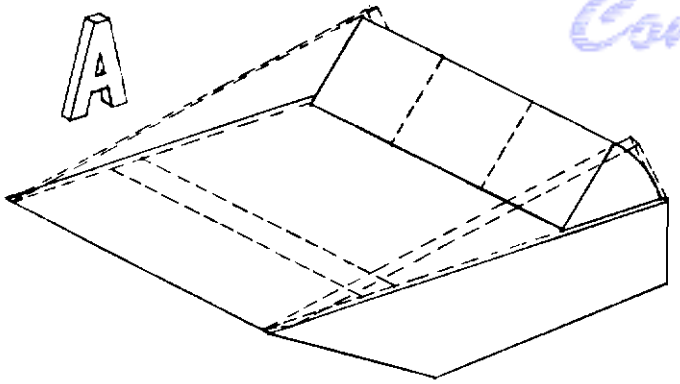
TABLE IV

COORDINATES OF PRESSURE TAPS

Pressure Tap Nos.	X'	Y'
101	0.0833	0
102	0.1250	
103	0.1667	
104	0.2083	
105	0.2500	
106	0.2917	
107	0.3333	
108	0.3750	
109	0.4167	
110	0.4583	
111	0.4792	
112	0.5000	
113	0.5208	
114	0.5417	
115	0.5625	
116	0.5833	
117	0.6042	
118	0.6250	
119	0.6458	
120	0.6667	
121	0.6875	
122	0.7083	
123	0.7292	0
125	0.7917	0
126	0.8125	
127	0.8333	
128	0.8542	
129	0.8750	
130	0.8958	
131	0.9167	
132	0.9375	
133	0.9583	0
921	0.6875	-0.1250
929	0.8750	-0.1250

Pressure Tap Nos.	X'	Y'
215	0.5625	0.1250
218	0.6250	
221	0.6875	
226	0.8125	
229	0.8750	
232	0.9375	0.1250
301	0.0833	0.2500
304	0.2083	
307	0.3333	
310	0.4583	
315	0.5625	
318	0.6250	
321	0.6875	
326	0.8125	
329	0.8750	
332	0.9375	0.2500
415	0.5625	0.4167
418	0.6250	
421	0.6875	
424	0.7500	
426	0.8125	
429	0.8750	
432	0.9375	0.4167
501	0.0833	0.5833
504	0.2083	
507	0.3333	
510	0.4583	
515	0.5625	
518	0.6250	
521	0.6875	
524	0.7500	
526	0.8125	
529	0.8750	
532	0.9375	0.5833

Note: C_p values obtained from taps 921 and 929 are plotted at X' = 0.6925 and 0.8800 for Y' = 0.1250.

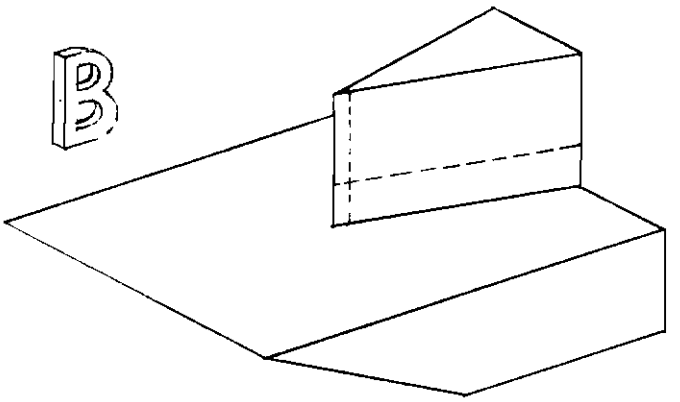


Separated Flows ahead of a Ramp
Fore and aft flaps, end plates
3 separate models:

1) Pressure and heat transfer, AEDC Tunnels A & B, M = 5 & 8, results in Refs. 4 and 5.

2) Controlled wall temperature, pressure, AEDC Tunnel B, M = 8, results in Ref. 5 and herein.

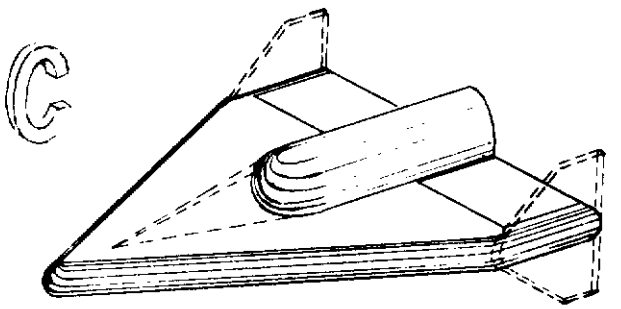
3) Pressure and heat transfer, Grumman Shock Tunnel, M 13 & 19, results not available yet.



Wedge - Plate Interaction
Small and large fins with sharp and blunt leading edges
2 separate models:

1) Pressure and heat transfer, AEDC Tunnels A & B, M = 5 & 8, results in Refs. 5, 6 and 7.

2) Pressure and heat transfer, Grumman Shock Tunnel, M 13 & 19, results not available yet.

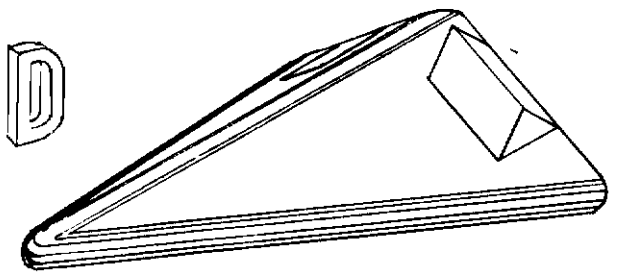


Clipped Delta, Blunt L.E.
Center body, T.E. flaps, drooped nose, spoiler, tip fins
3 separate models:

1) Pressure and heat transfer, AEDC Tunnels A & B, M = 5 & 8, results in Ref. 8.

2) Pressure, AEDC Hotshot 2, M 19, results in Refs. 9 and 10.

3) Six component force, AEDC Tunnels A & B, M = 5 & 8, results in Ref. 11.



Delta, Blunt L.E., Dihedral
T.E. flaps, canard, ventral fin
3 separate models:

1) Pressure and heat transfer, AEDC Tunnels A & B, M = 5 & 8, results in Refs. 12 and 13.

2) Pressure and heat transfer, Grumman Shock Tunnel, M 19, results not available yet.

3) Six component force, AEDC Tunnels A & B, M = 5 & 8, results not available yet.

Fig. 1 General Outline of Models and Remarks for Over-all Program

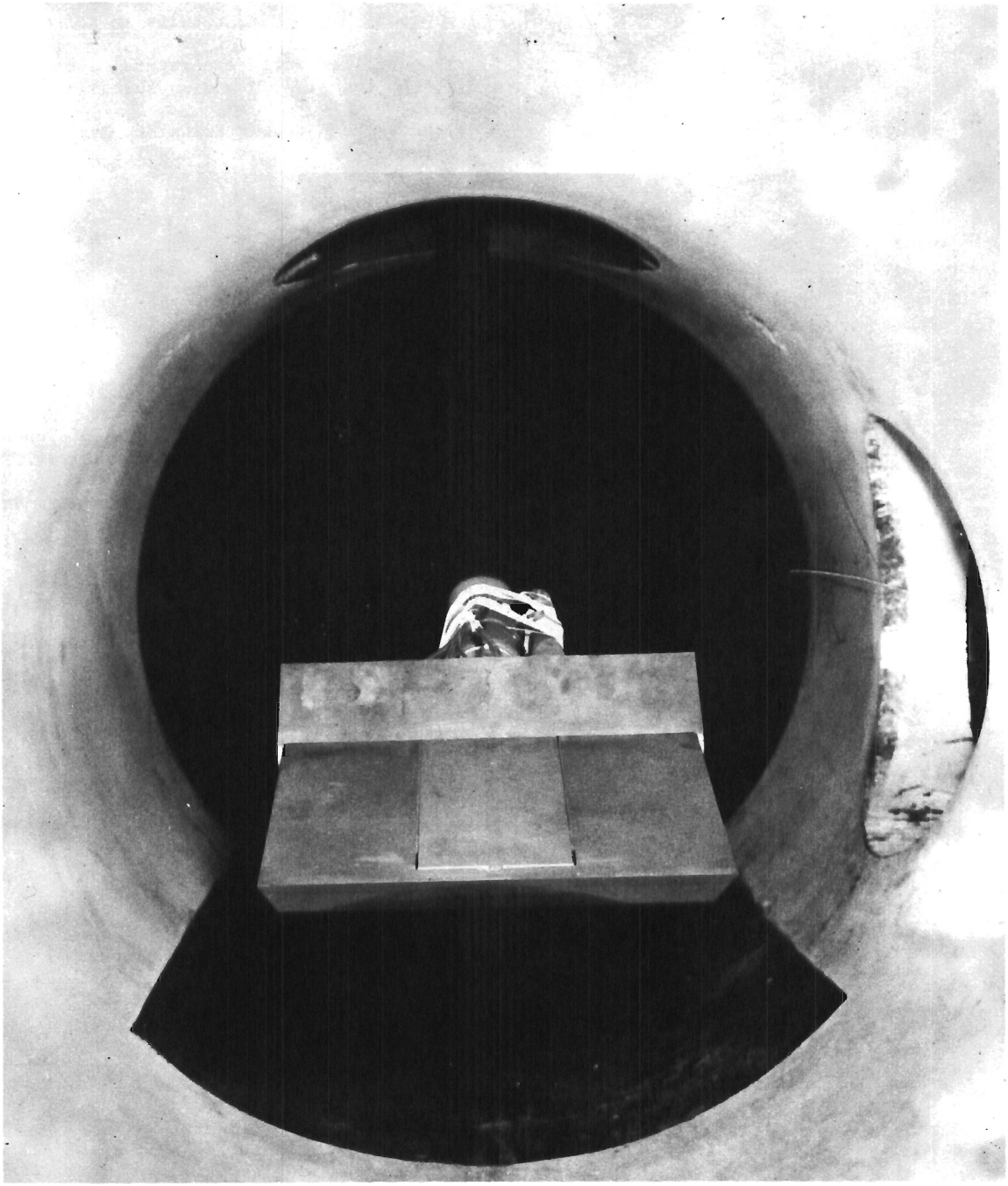


Fig. 2 Photograph of Model Installed in the AEDC 50-inch Mach 8 Tunnel

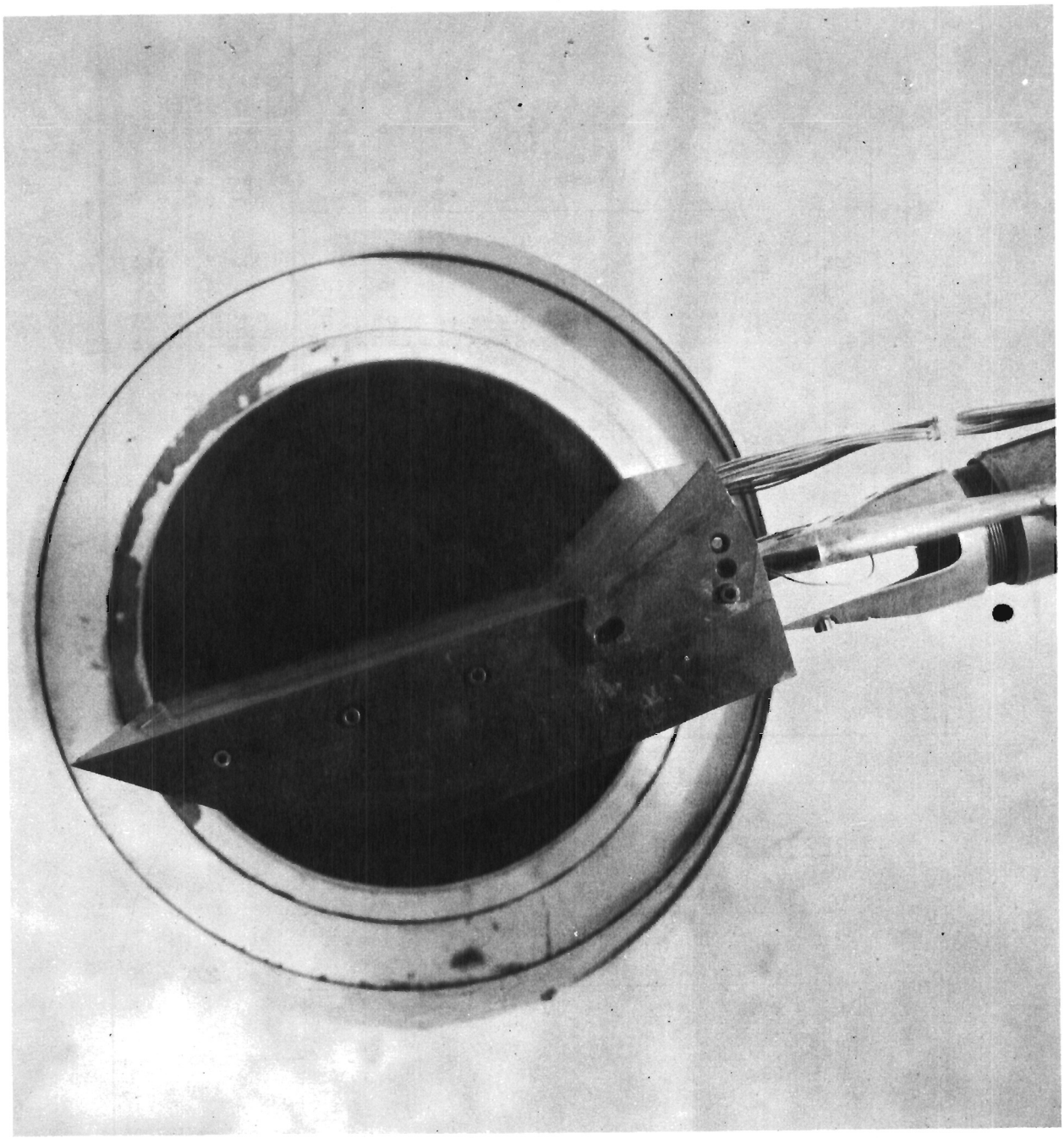


Fig. 3 Photograph of Model with 30° Ramp

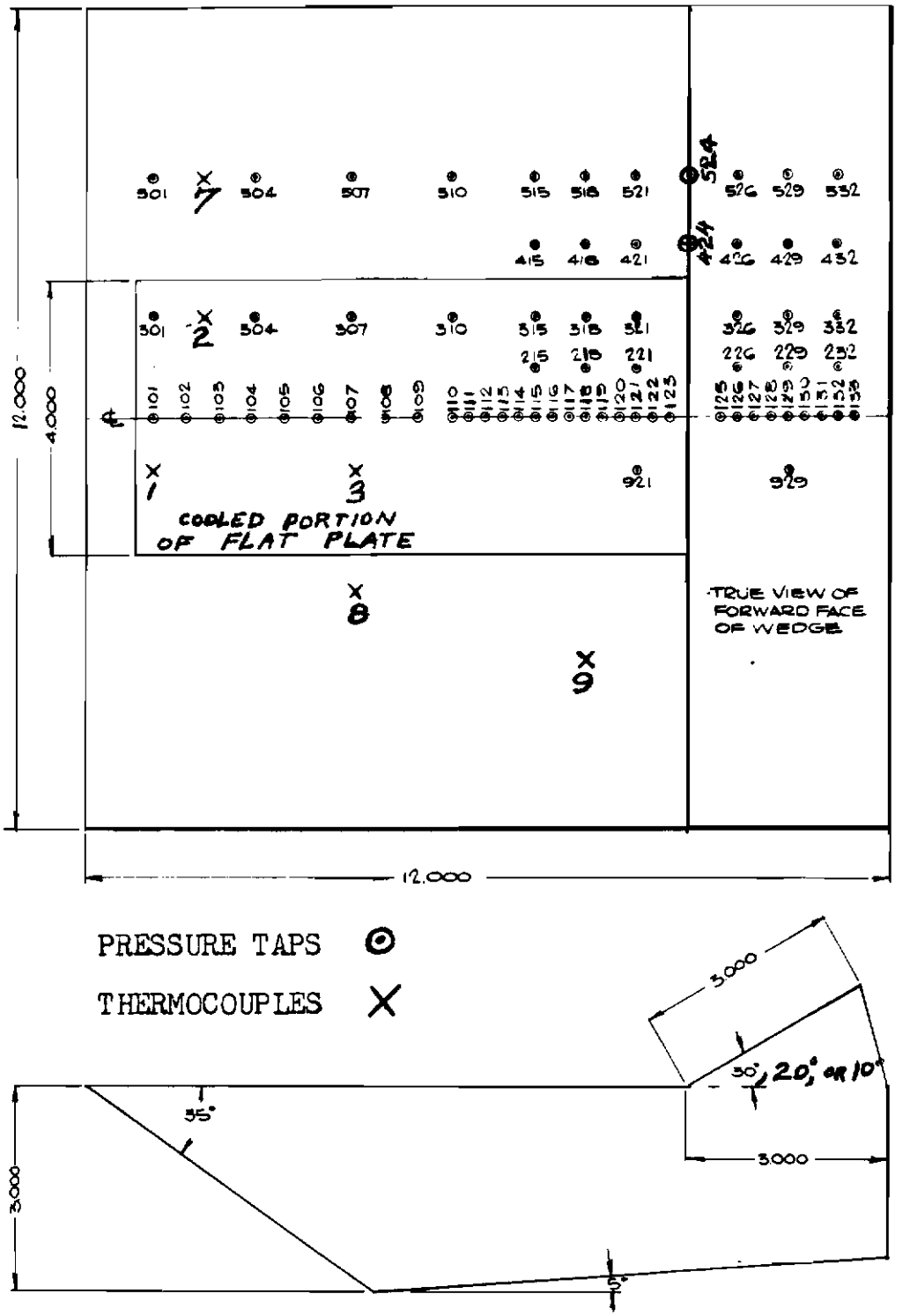


Fig. 4 Model Instrumentation

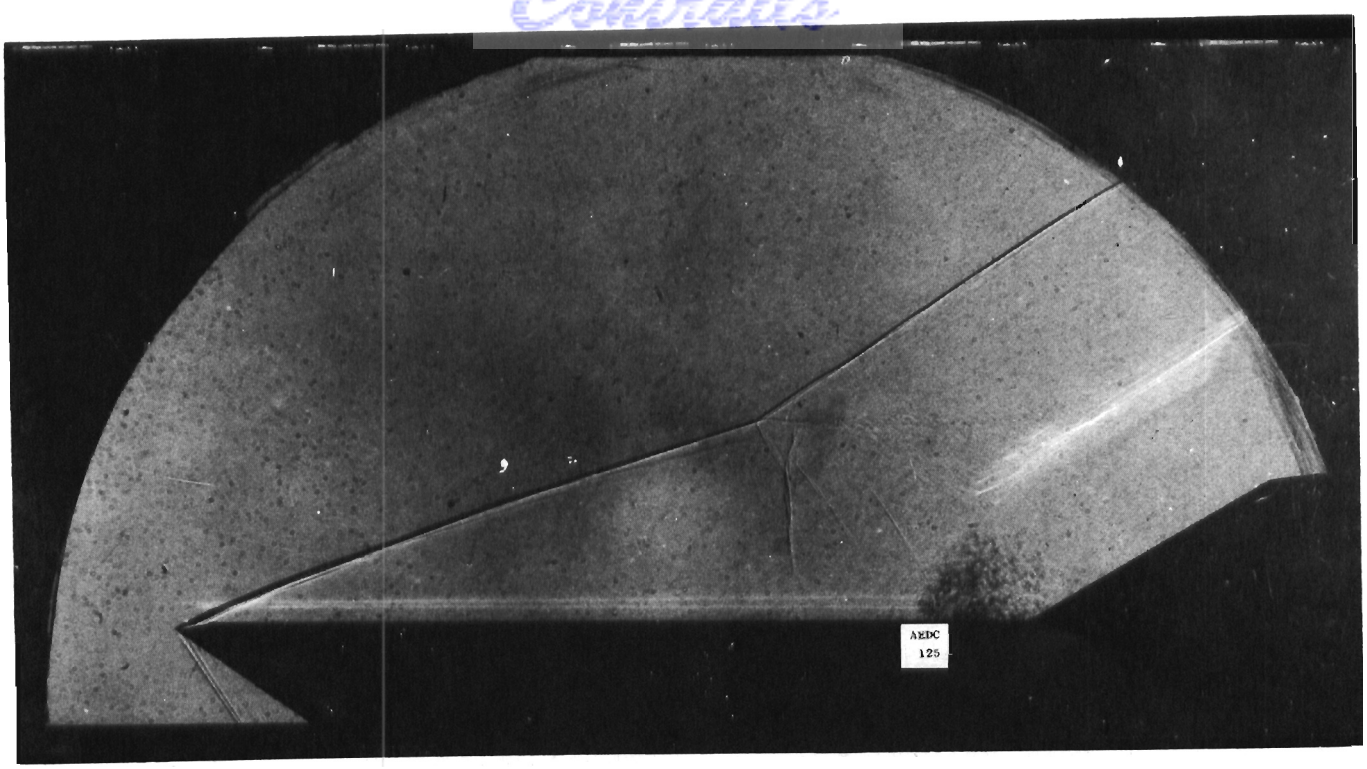


Fig. 5 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = -43^{\circ}$, $Re_{\infty}/ft = 1{,}100{,}000$

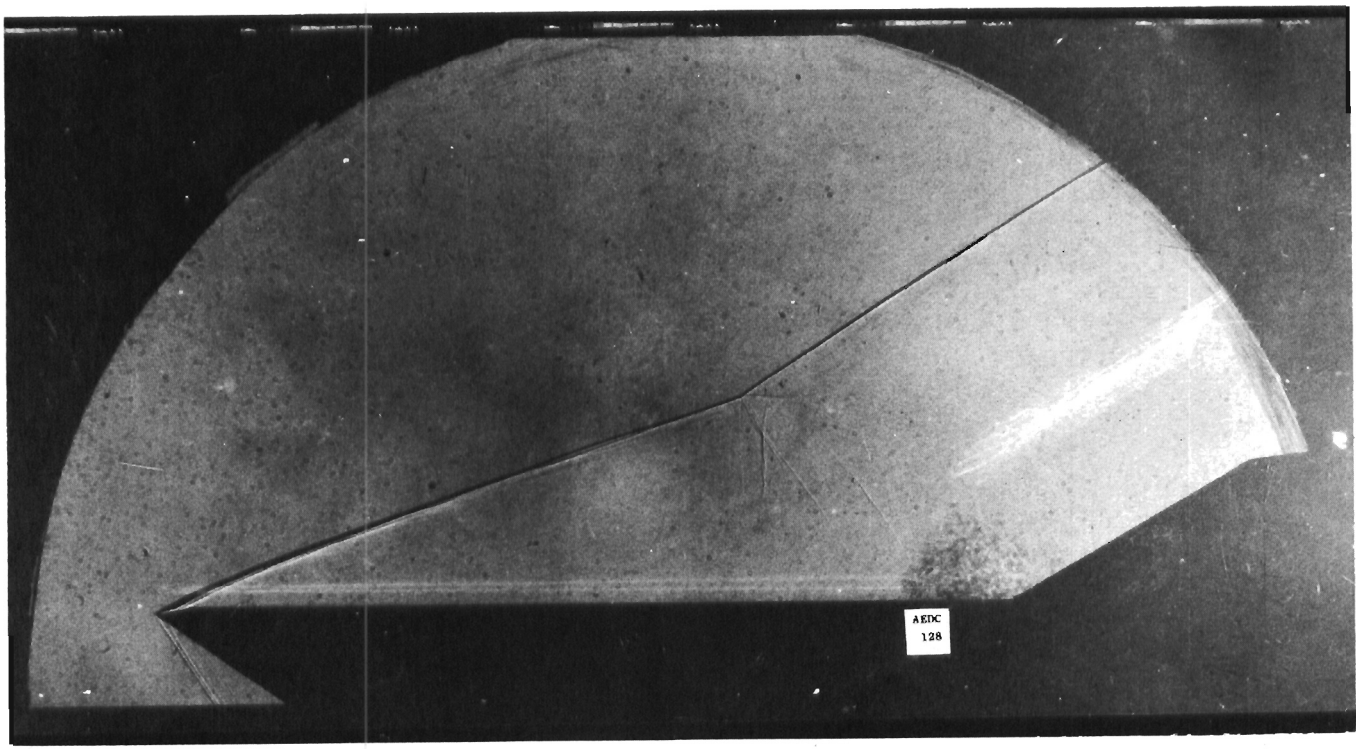


Fig. 6 Shadowgraph Flow Photograph; Coolant Flow On, 30° Ramp, $\alpha = -43^{\circ}$, $Re_{\infty}/ft = 1{,}100{,}000$

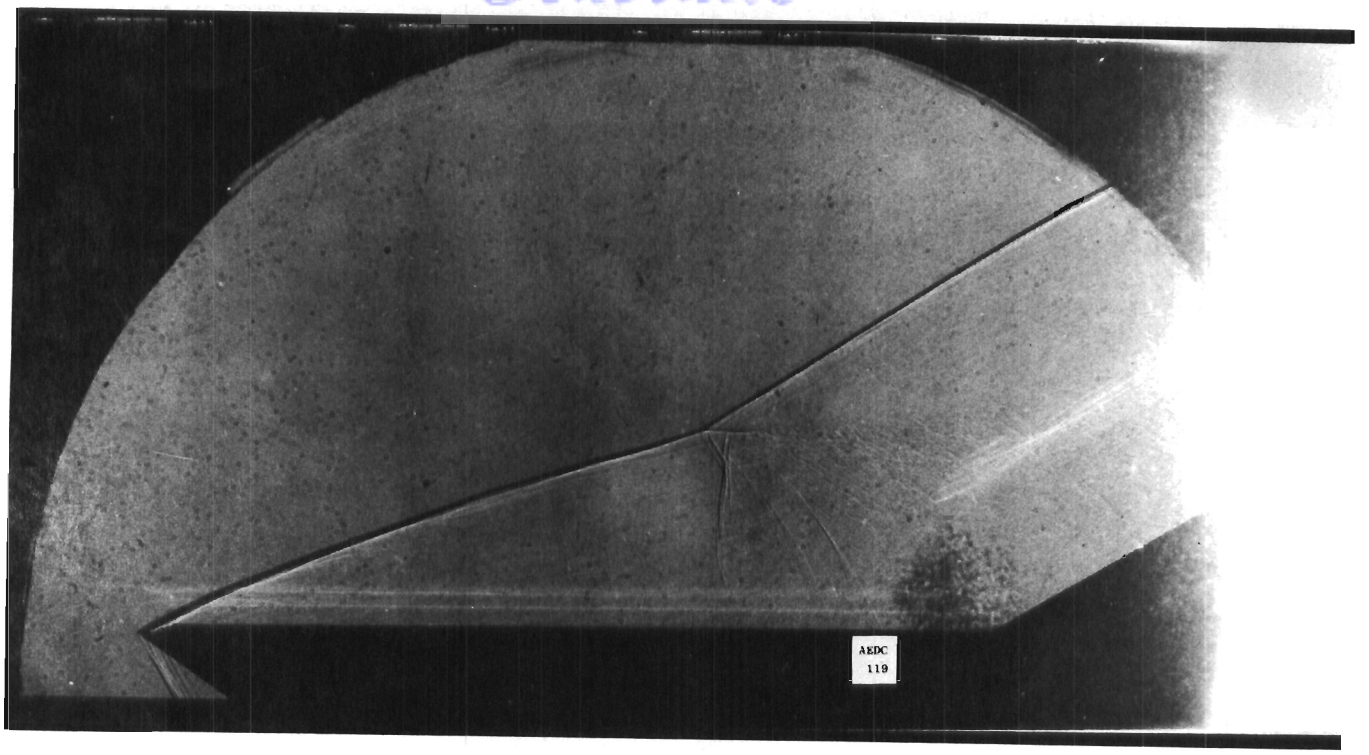


Fig. 7 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, α = -43°, Re_∞/ft = 2,200,000

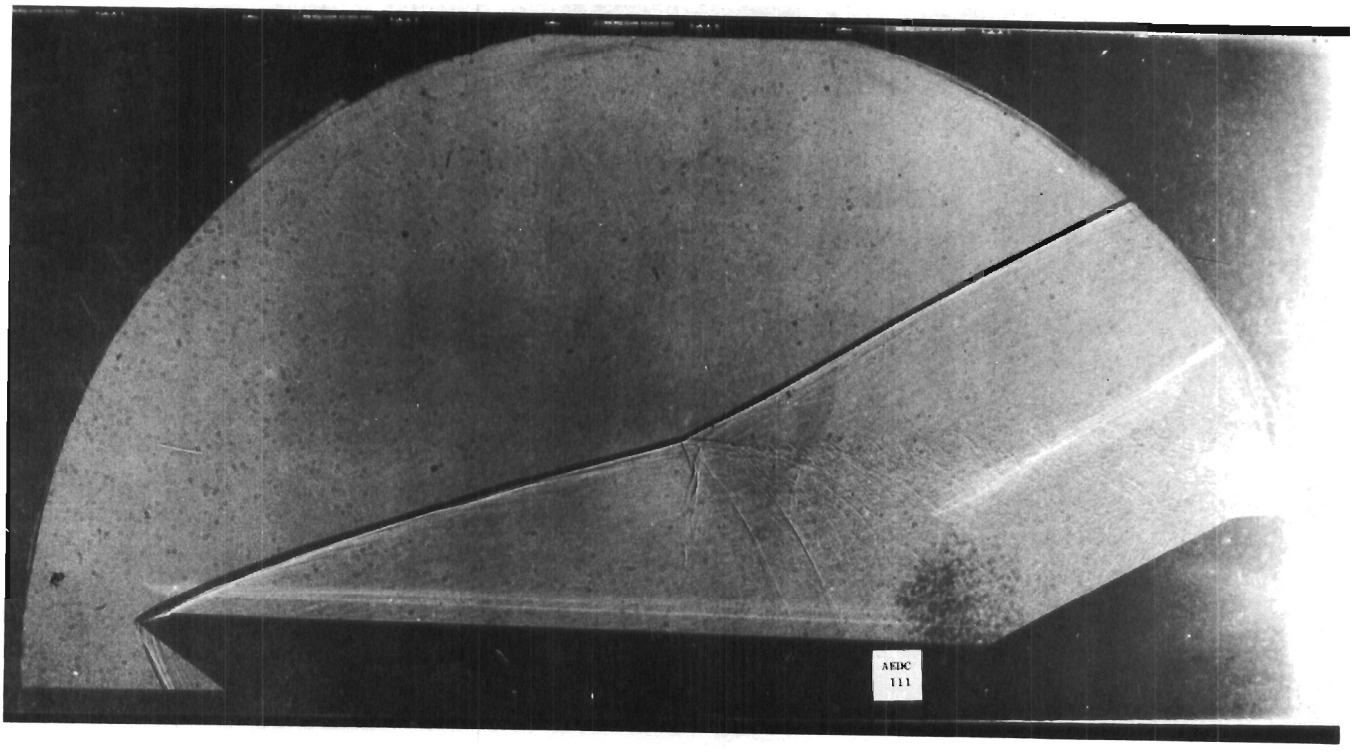


Fig. 8 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, α = -43°, Re_∞/ft = 3,300 000

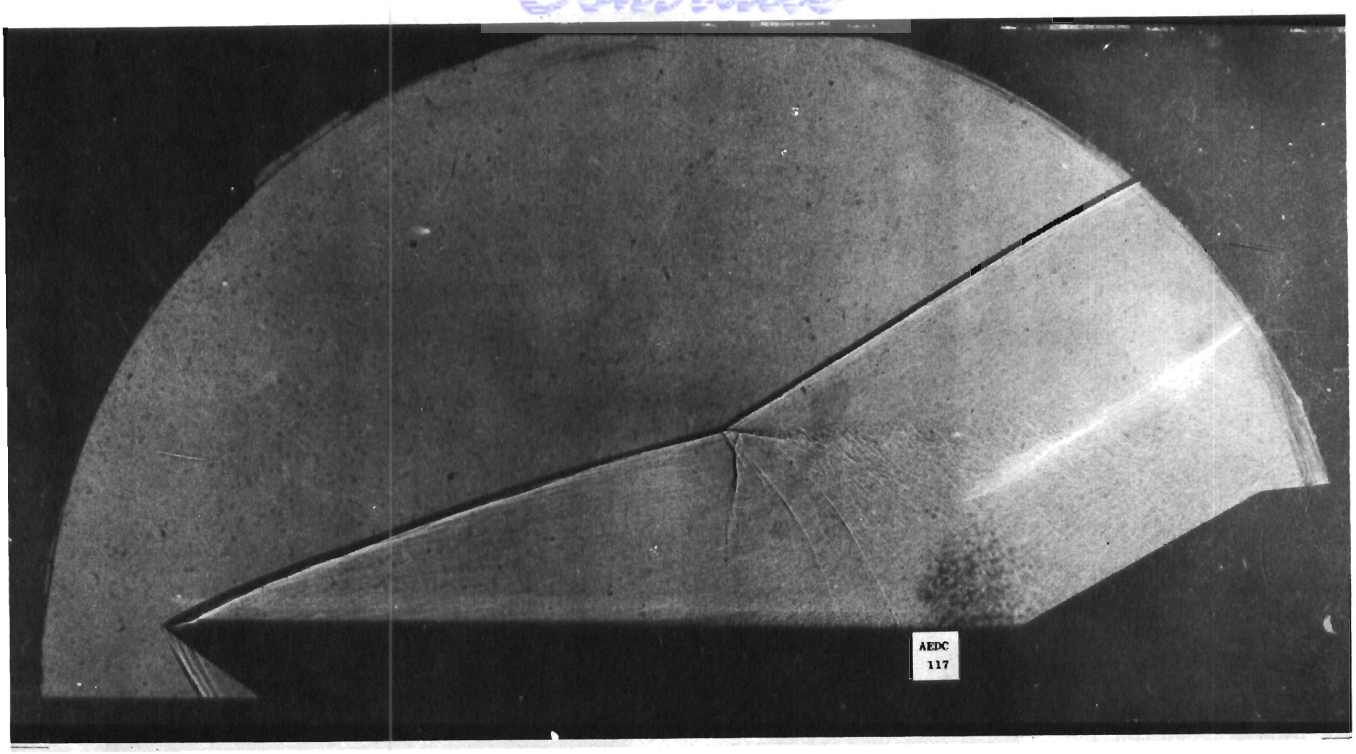


Fig. 9 Shadowgraph Flow Photograph; Coolant Flow On, 30° Ramp, $\alpha = -43^{\circ}$, $Re_{\infty}/ft = 3{,}300{,}000$

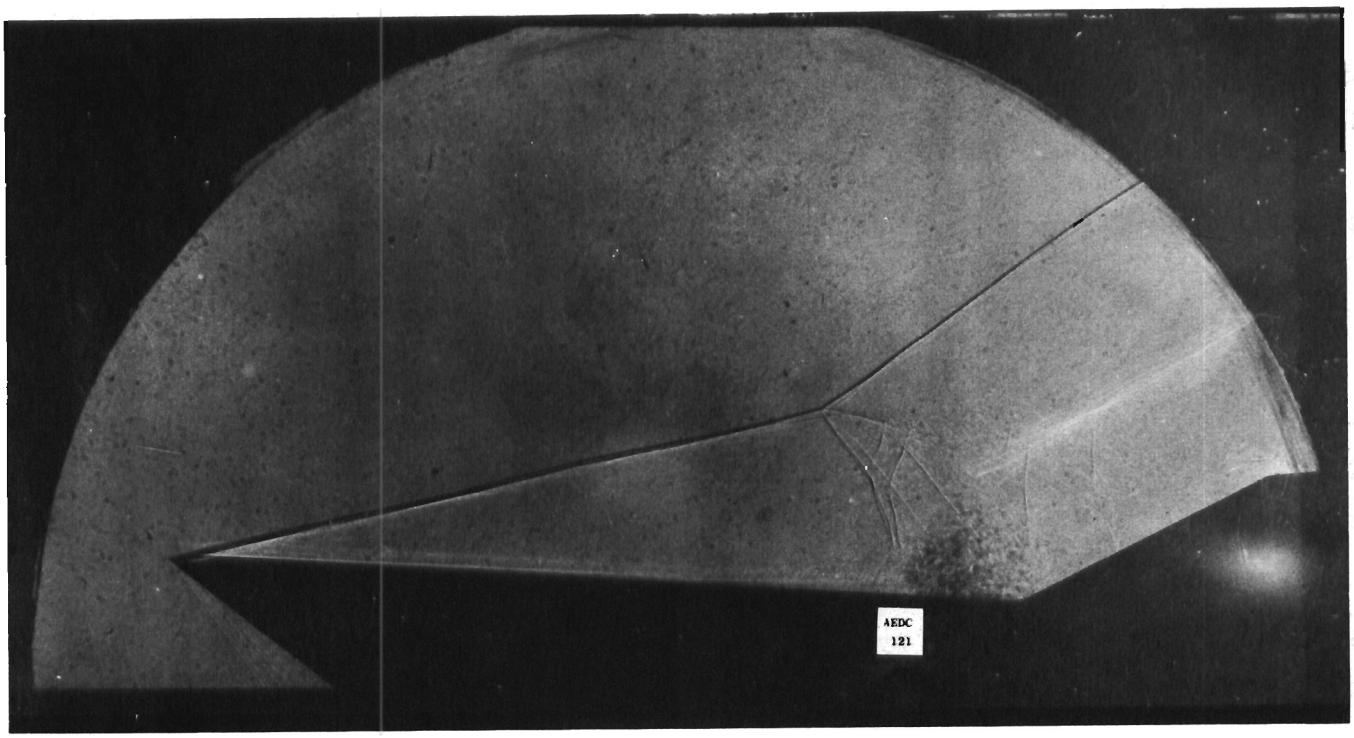


Fig. 10 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = -40^{\circ}$, $Re_{\infty}/ft = 1{,}100{,}000$

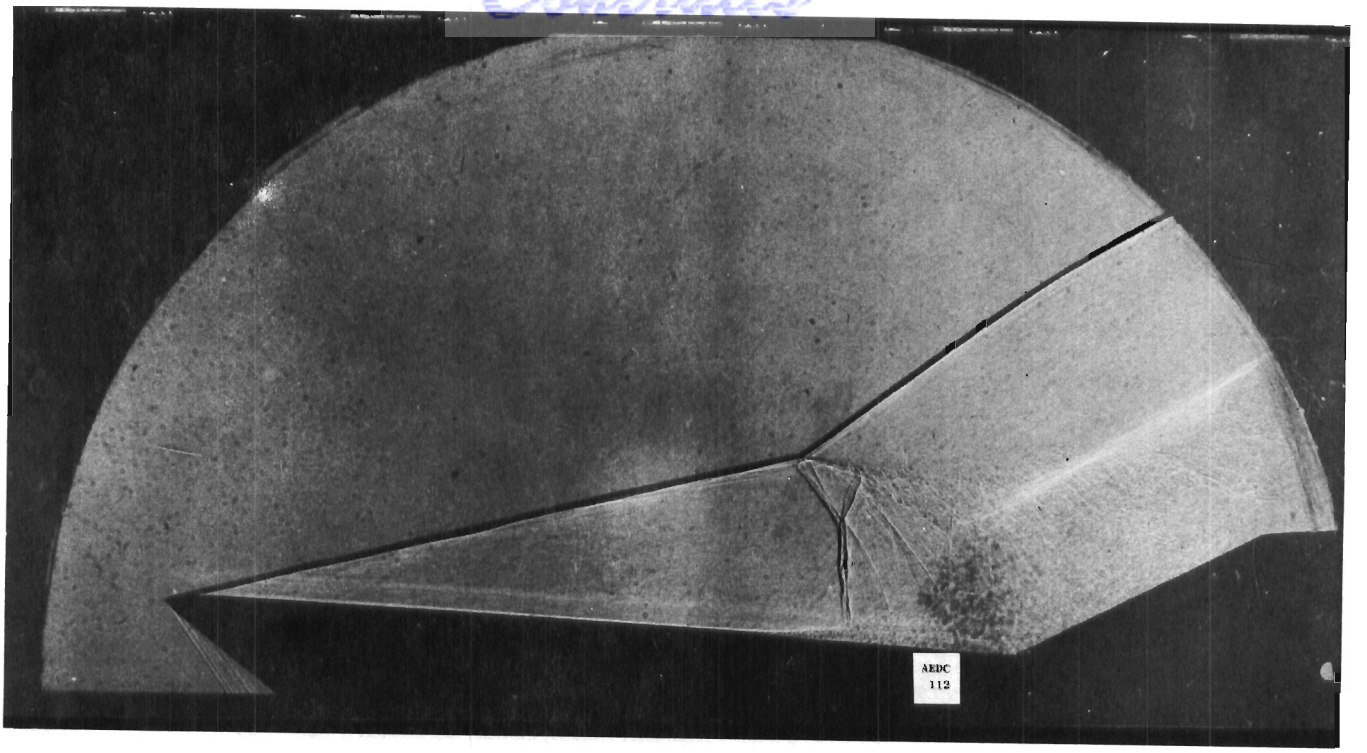


Fig. 11 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, α = -40°, Re_x/ft = 3,300,000

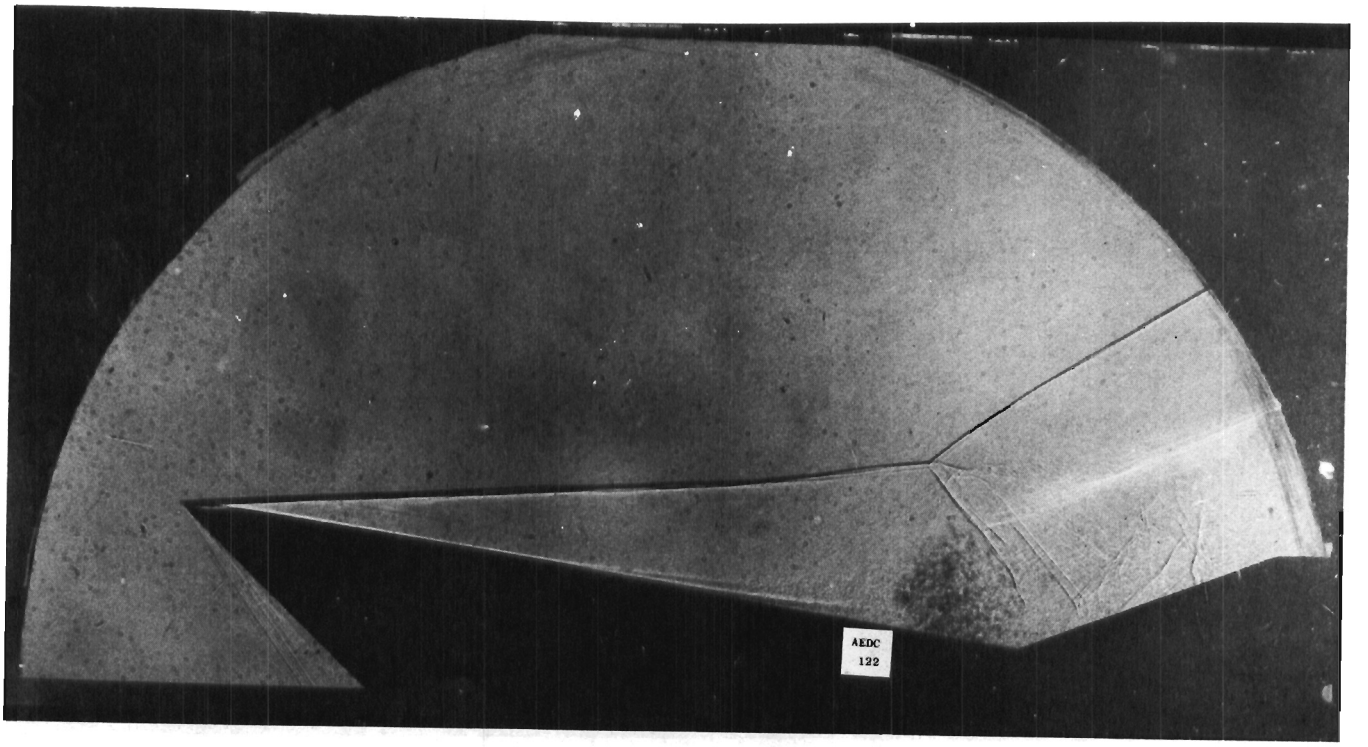


Fig. 12 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, α = -35°, Re_x/ft = 1,100,000

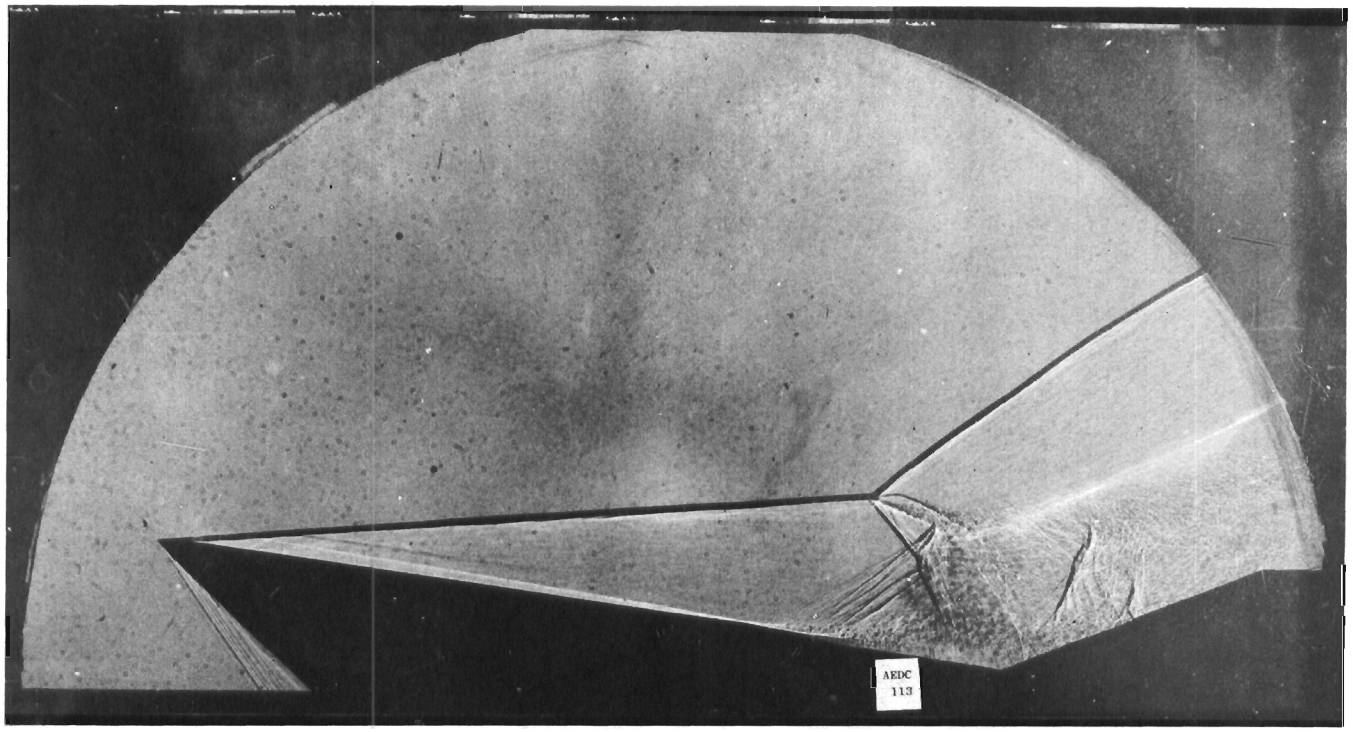


Fig. 13 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, α = -35°, Re_x/ft = 3,300,000

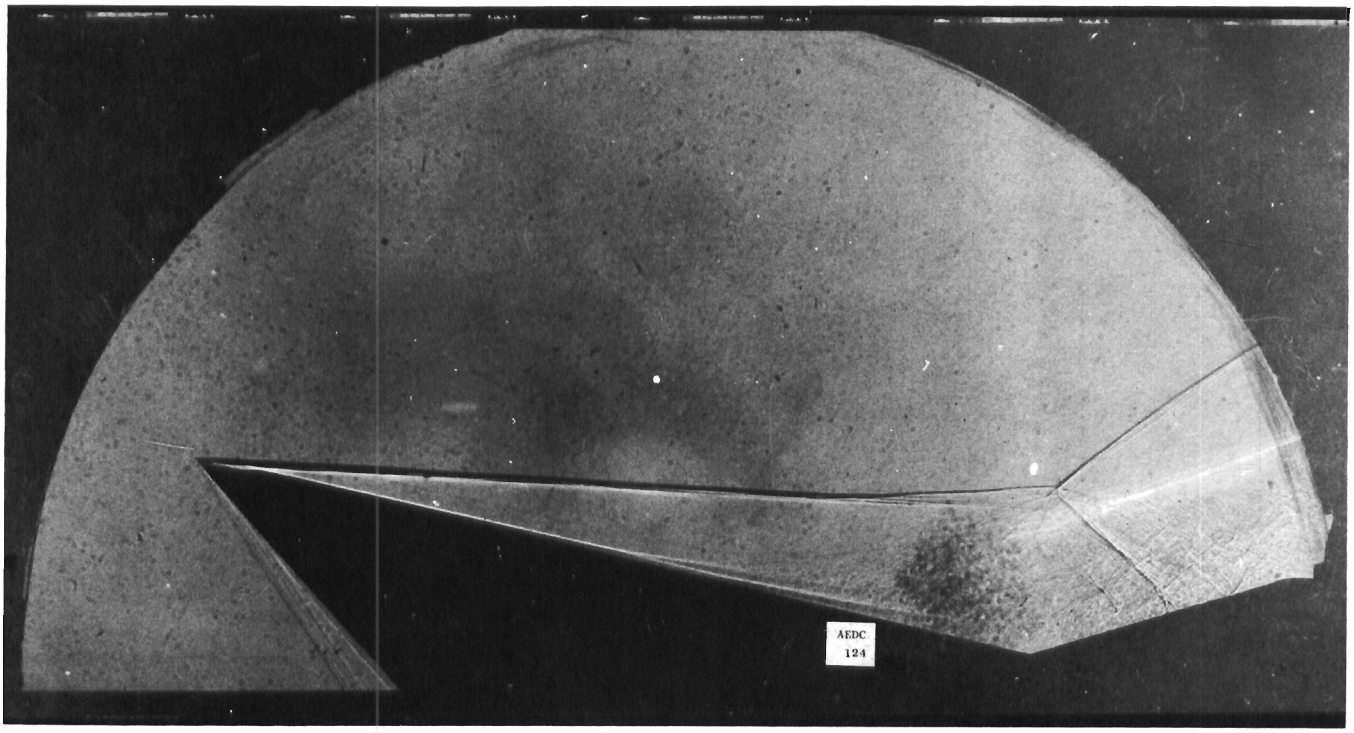


Fig. 14 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, α = -30°, Re_x/ft = 1,100,000

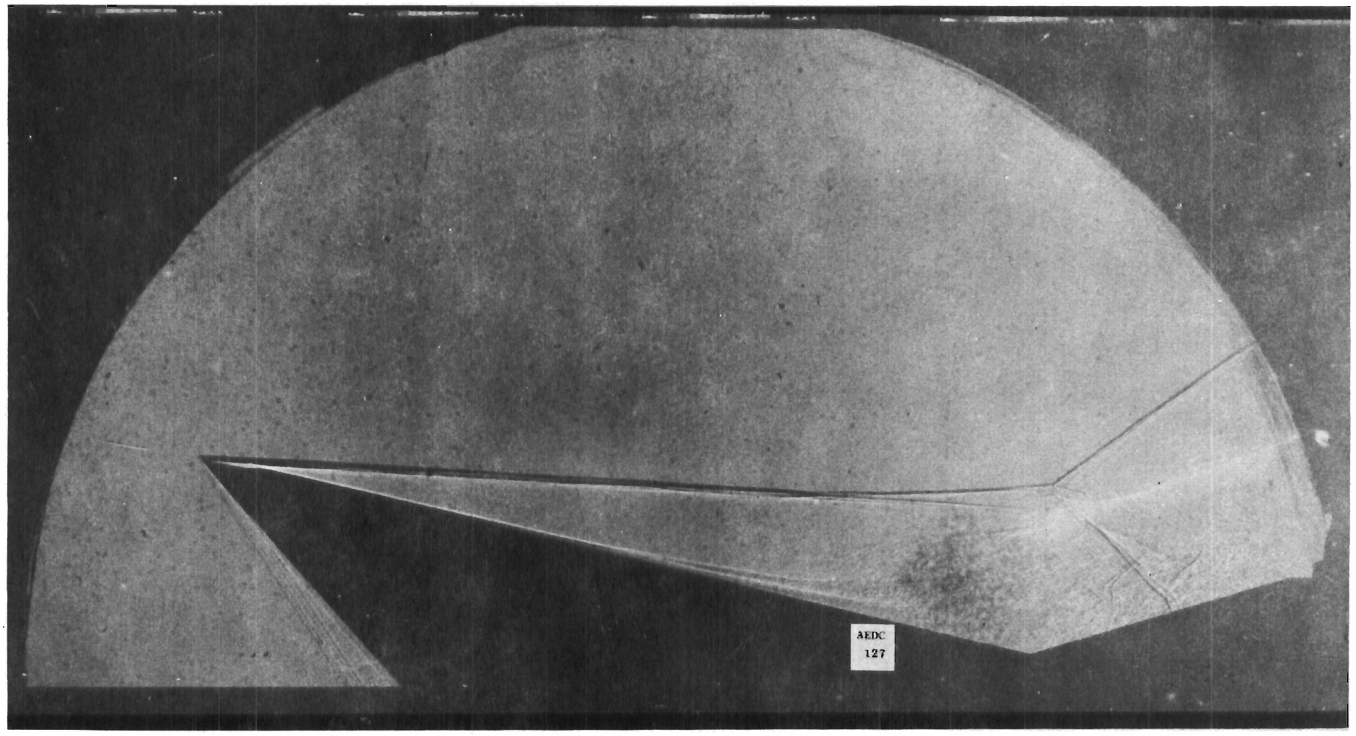


Fig. 15 Shadowgraph Flow Photograph; Coolant Flow On, 30° Ramp, $\alpha = -30^{\circ}$, $Re_{\infty}/ft = 1{,}100{,}000$

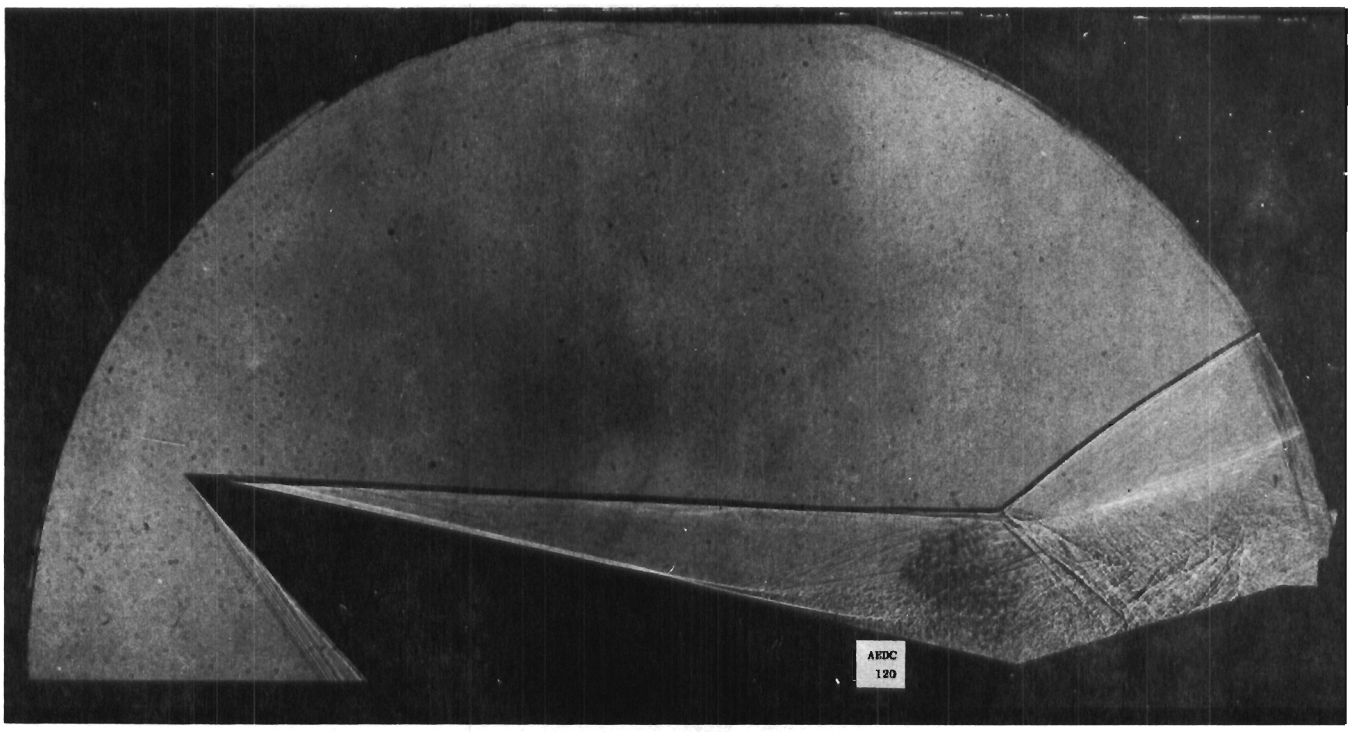


Fig. 16 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = -30^{\circ}$, $Re_{\infty}/ft = 2{,}200{,}000$

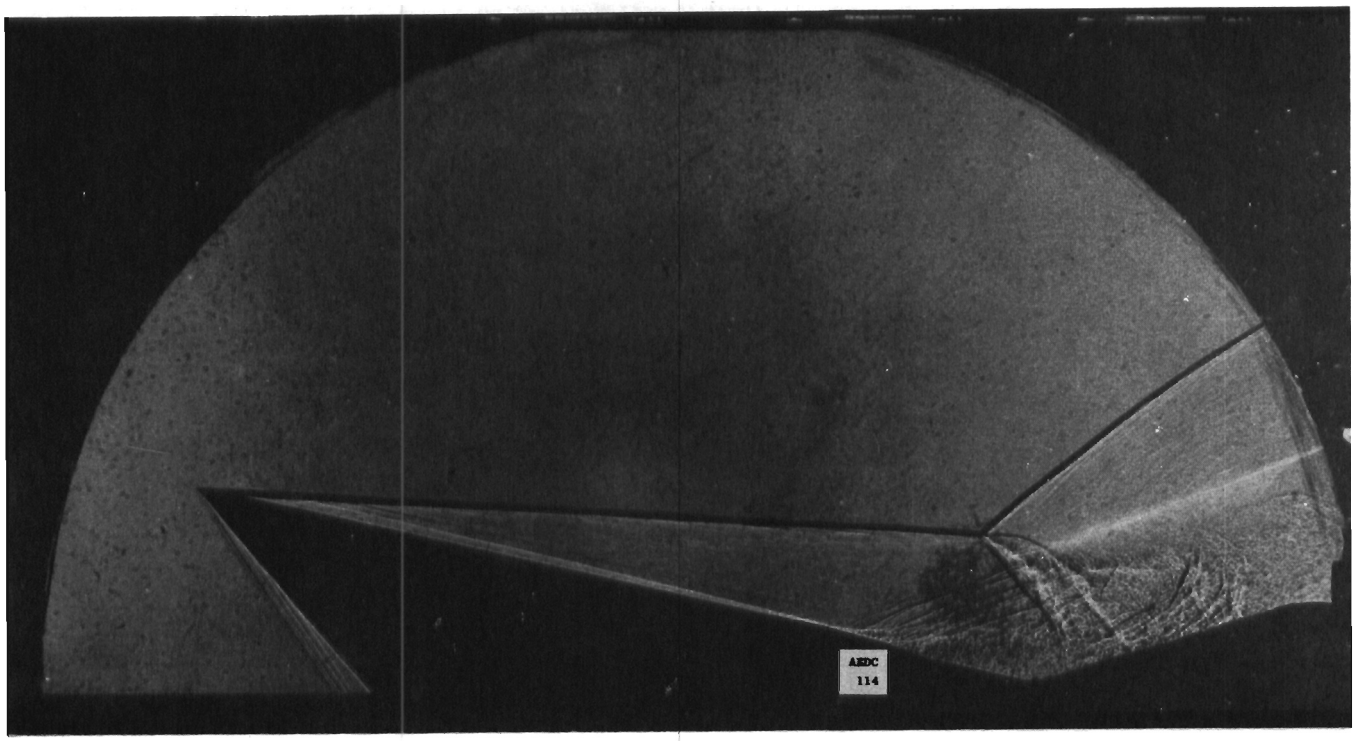


Fig. 17 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = -30^{\circ}$, $Re_{\infty}/ft = 3,300,000$

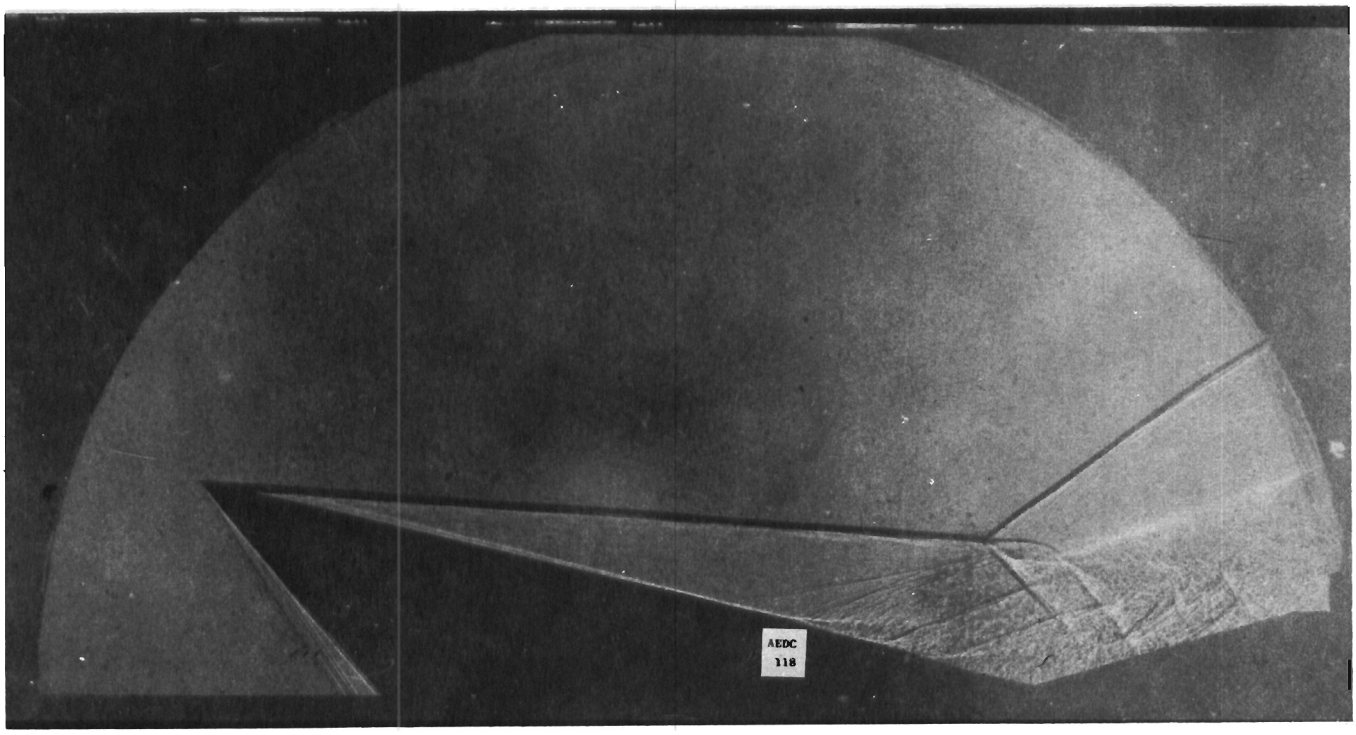


Fig. 18 Shadowgraph Flow Photograph; Coolant Flow On, 30° Ramp, $\alpha = -30^{\circ}$, $Re_{\infty}/ft = 3,300,000$

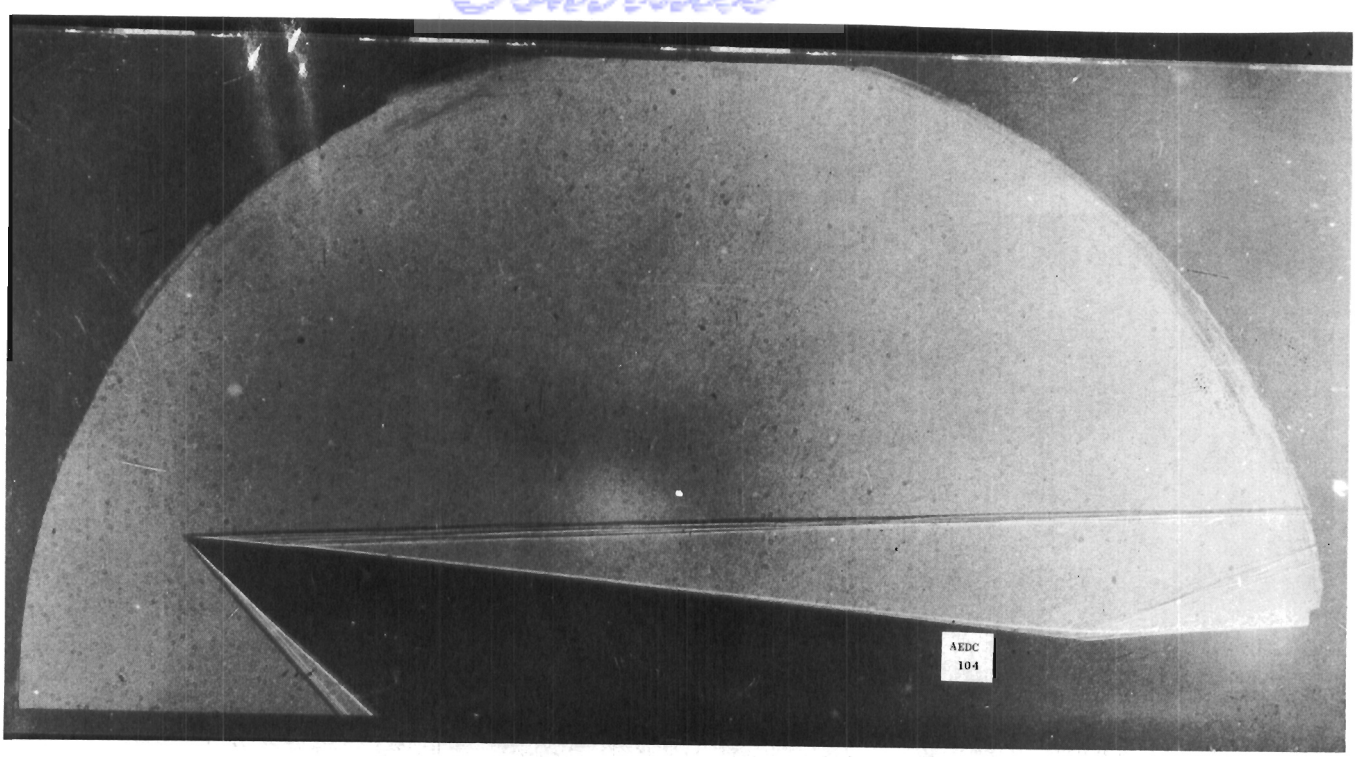


Fig. 19 Shadowgraph Flow Photograph; Coolant Flow Off, 10° Ramp, $\alpha = -25^{\circ}$, $Re_{\infty}/ft = 1{,}100{,}000$

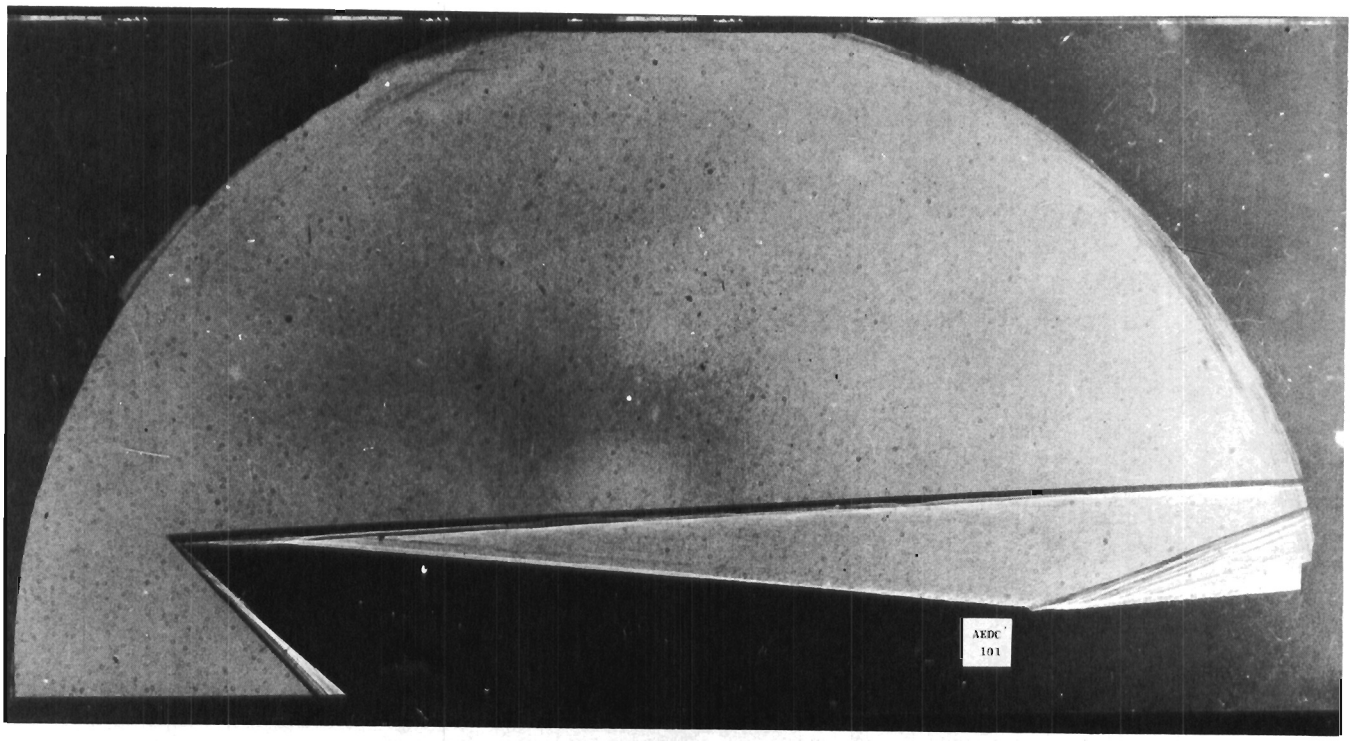


Fig. 20 Shadowgraph Flow Photograph; Coolant Flow Off, 10° Ramp, $\alpha = -25^{\circ}$, $Re_{\infty}/ft = 3{,}300{,}000$

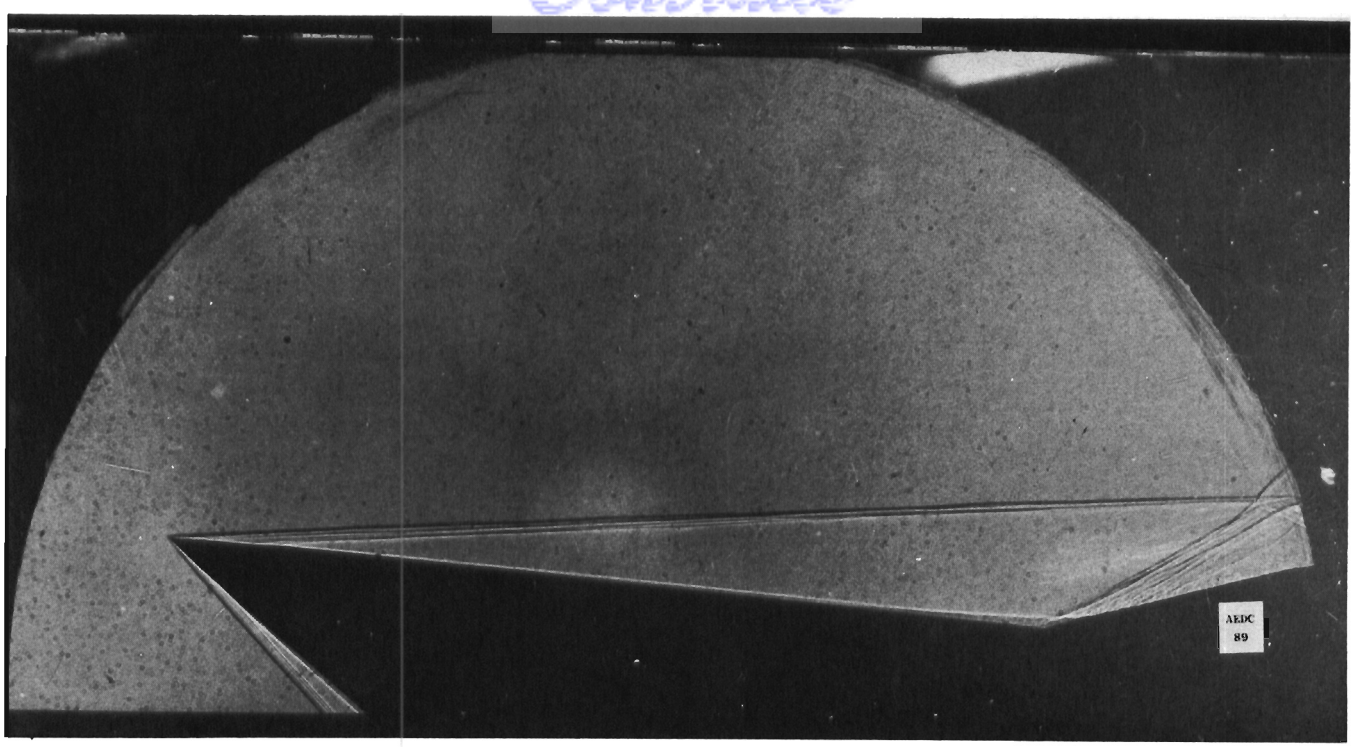


Fig. 21 Shadowgraph Flow Photograph; Coolant Flow Off, 20° Ramp, α = -25°, Re_∞/ft = 1,100,000

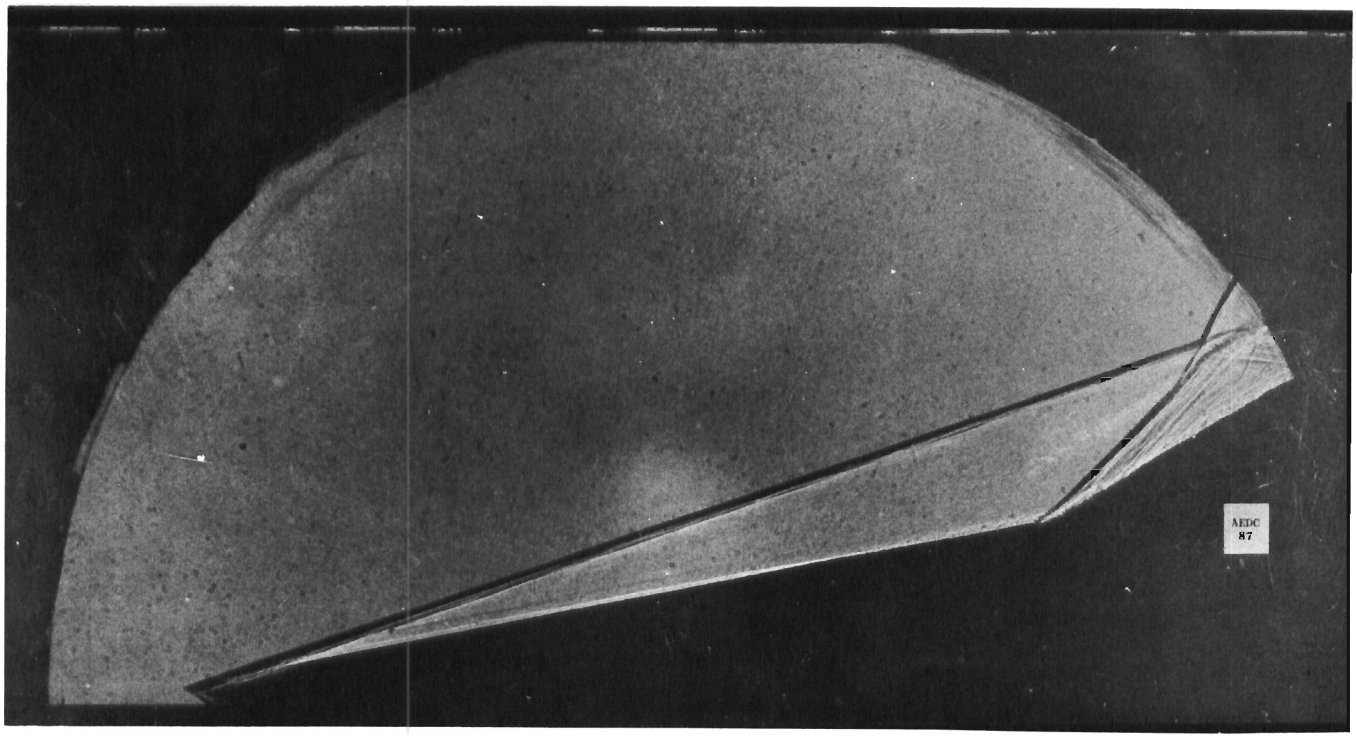


Fig. 22 Shadowgraph Flow Photograph; Coolant Flow Off, 20° Ramp, α = -25°, Re_∞/ft = 3,300,000

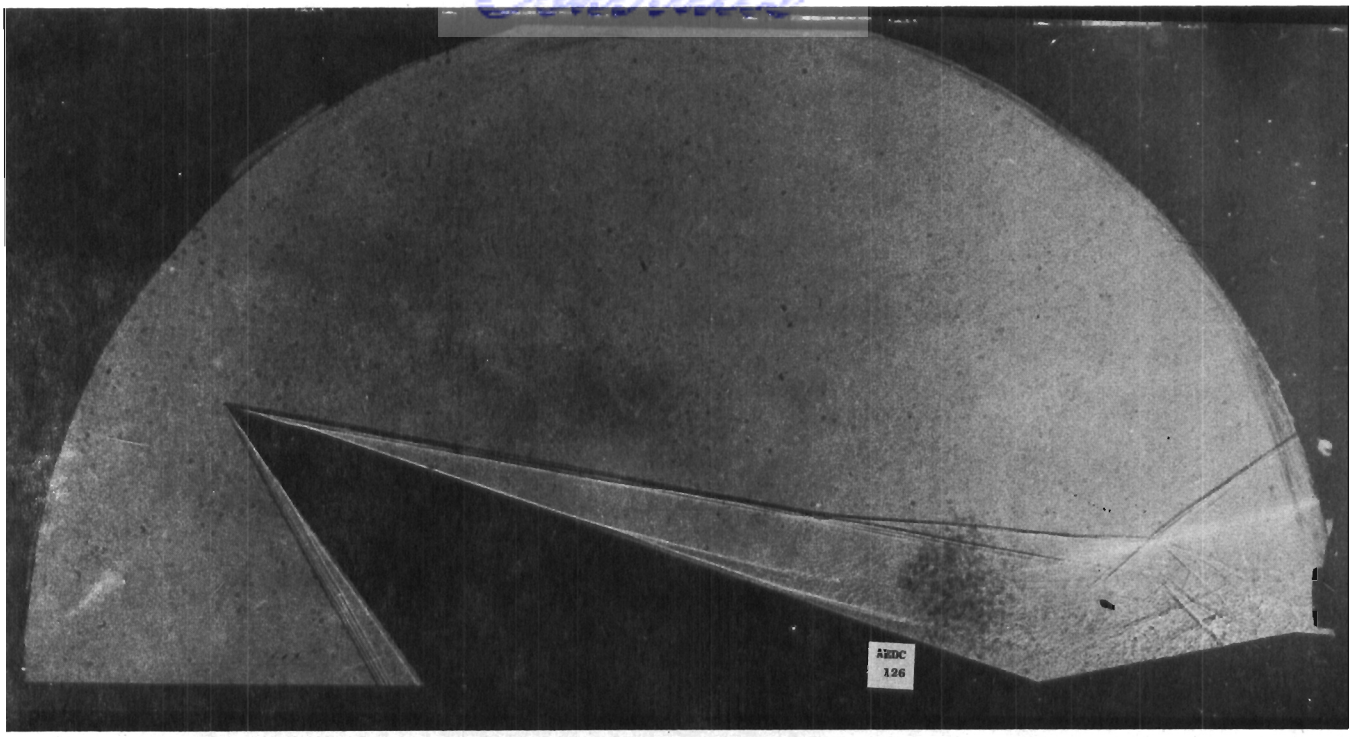


Fig. 23 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = -25^{\circ}$, $Re_{\infty}/ft = 1,100,000$

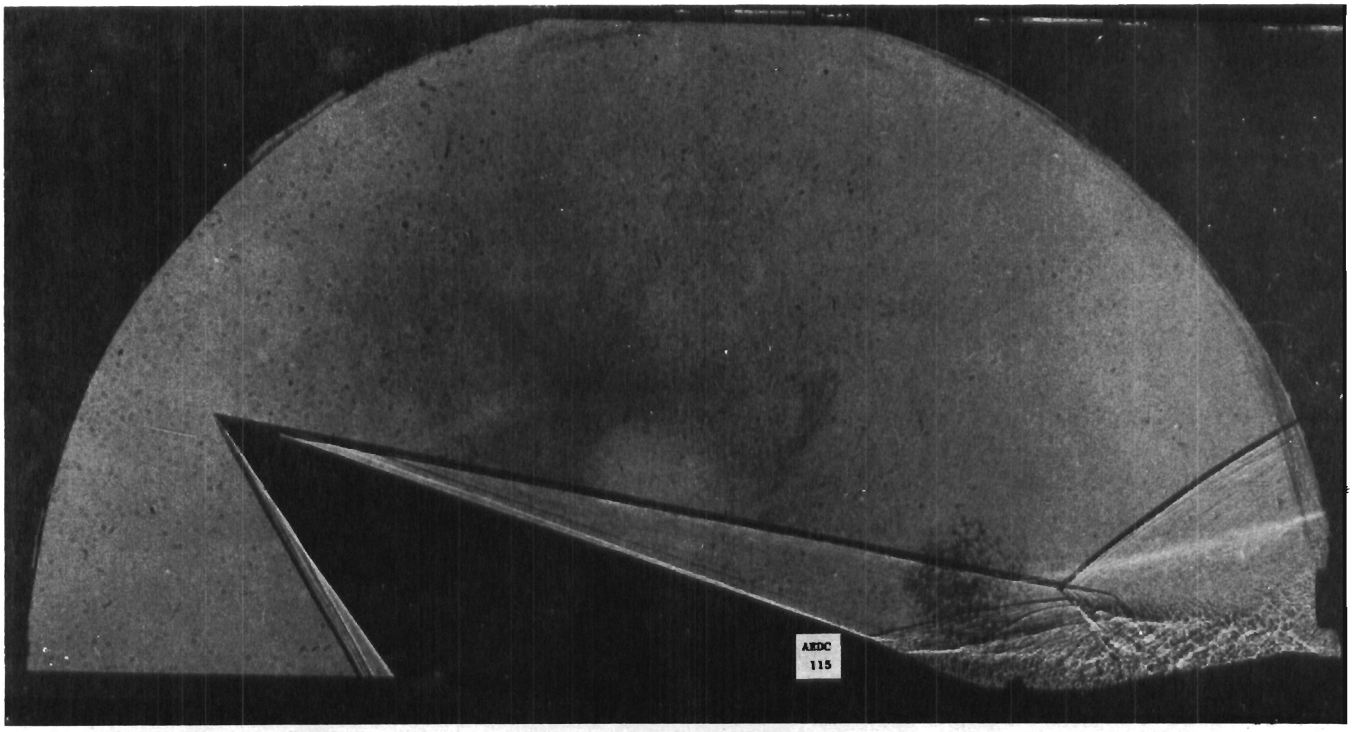


Fig. 24 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = -25^{\circ}$, $Re_{\infty}/ft = 3,300,000$

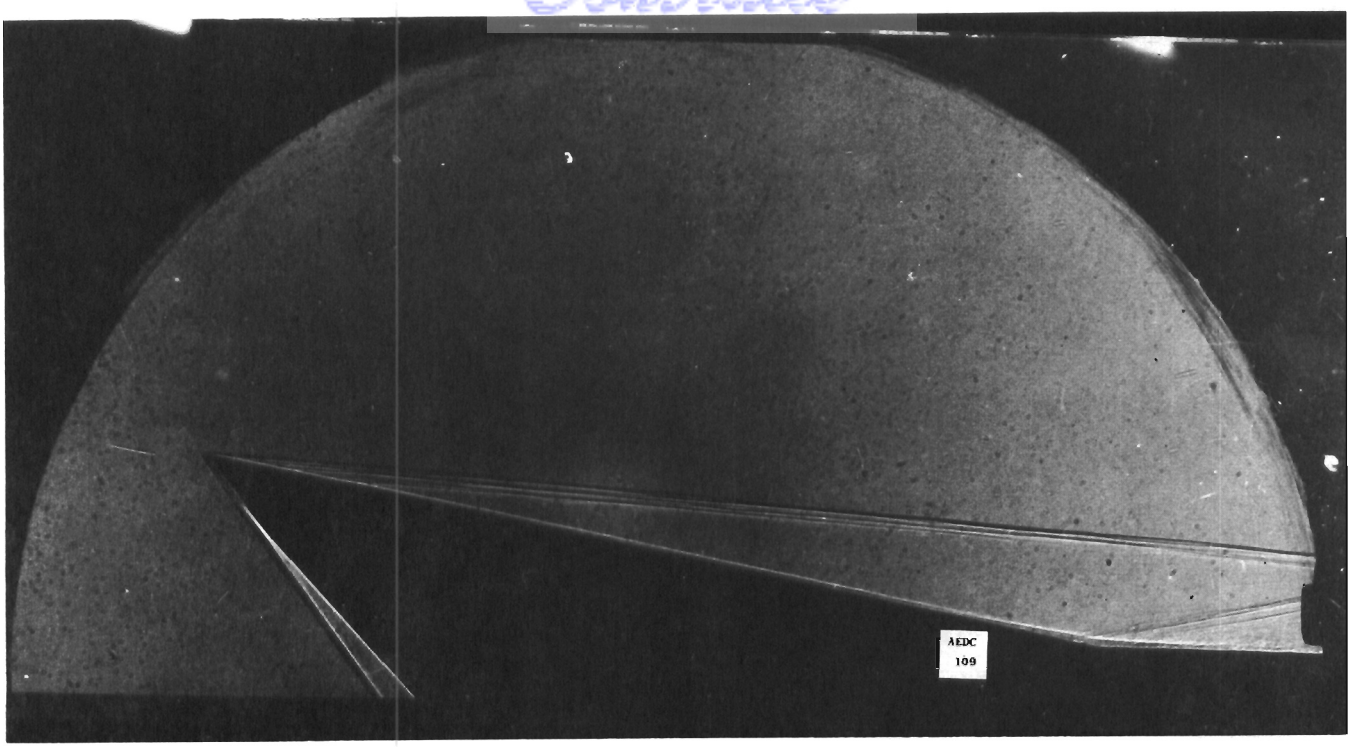


Fig. 25 Shadowgraph Flow Photograph; Coolant Flow Off, 10^{o} Ramp, $\alpha = -20^{o}$, $Re_{\infty}/ft = 1{,}100{,}000$

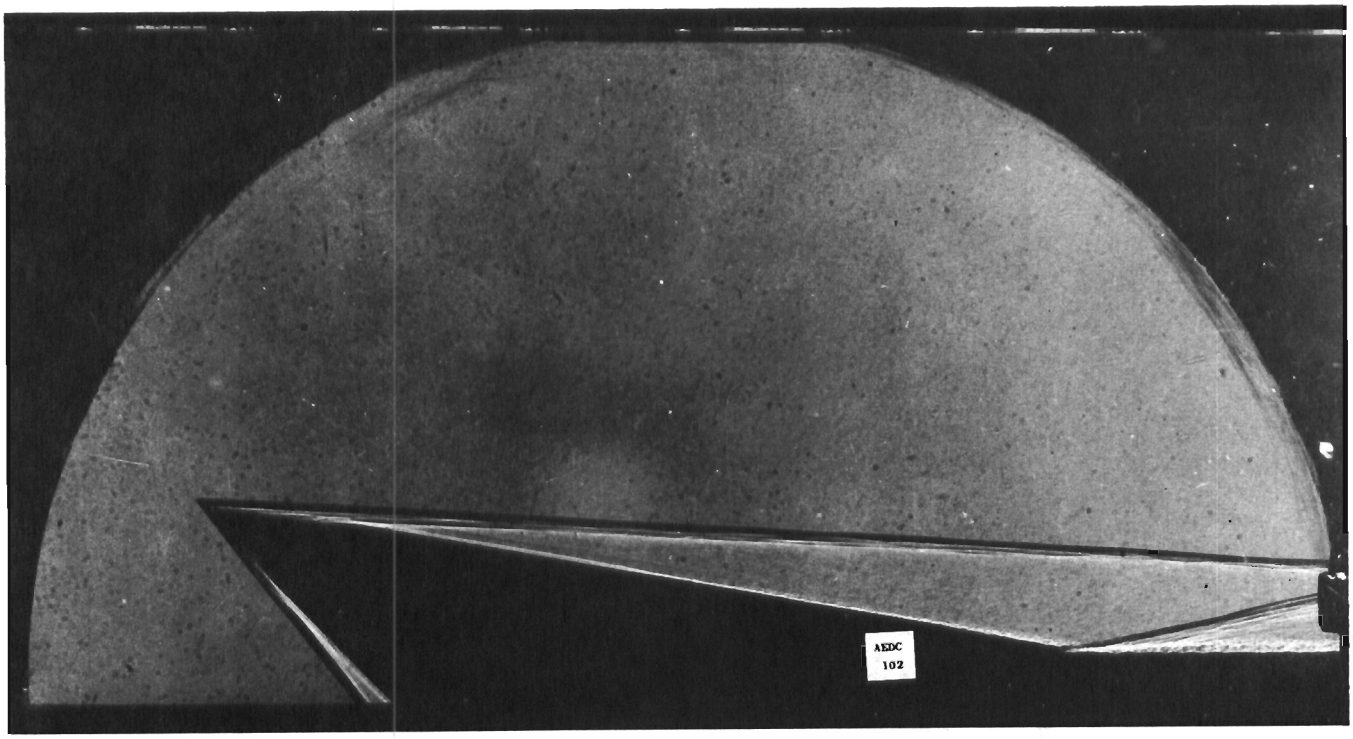


Fig. 26 Shadowgraph Flow Photograph; Coolant Flow Off, 10^{o} Ramp, $\alpha = -20^{o}$, $Re_{\infty}/ft = 3{,}300{,}000$

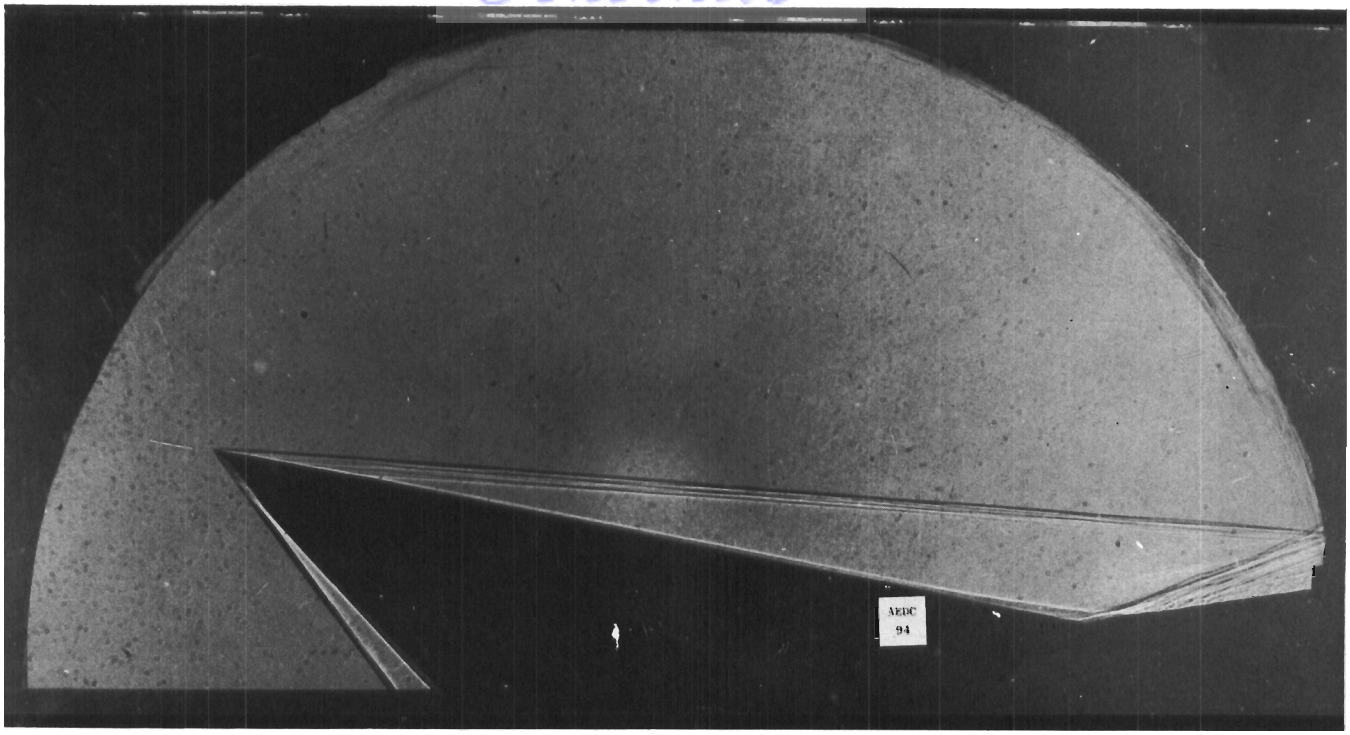


Fig. 27 Shadowgraph Flow Photograph; Coolant Flow Off, 20° Ramp, $\alpha = -20^{\circ}$, $Re_{\infty}/ft = 1{,}100{,}000$

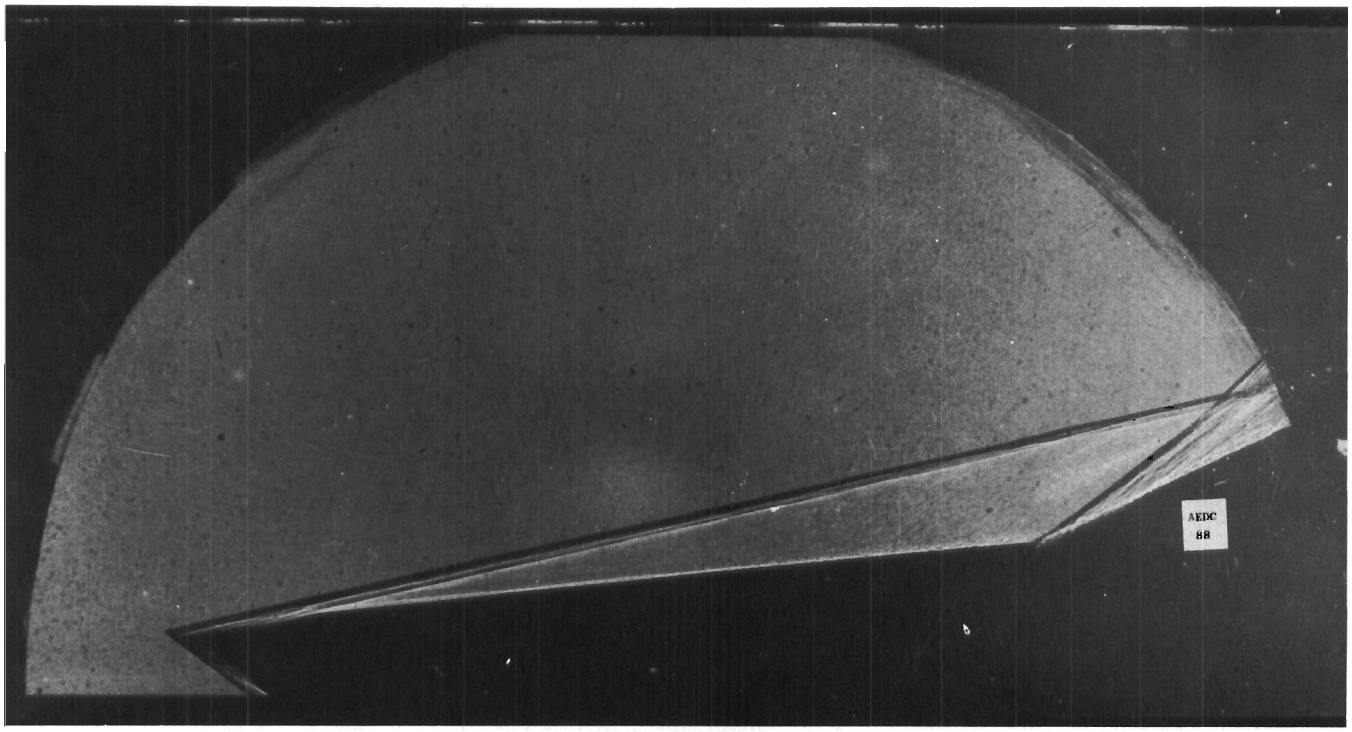


Fig. 28 Shadowgraph Flow Photograph; Coolant Flow Off, 20° Ramp, $\alpha = -20^{\circ}$, $Re_{\infty}/ft = 3{,}300{,}000$

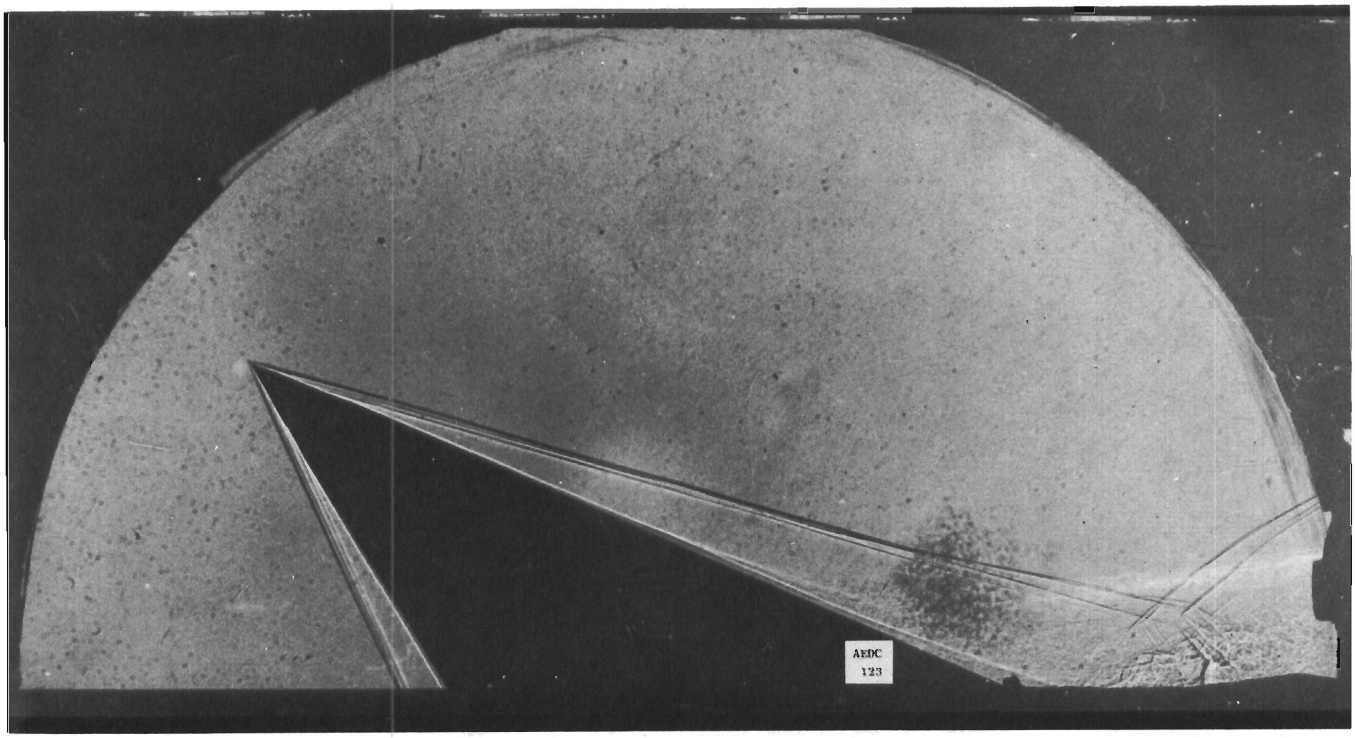


Fig. 29 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, α = -20°, Re_∞/ft = 1,100,000

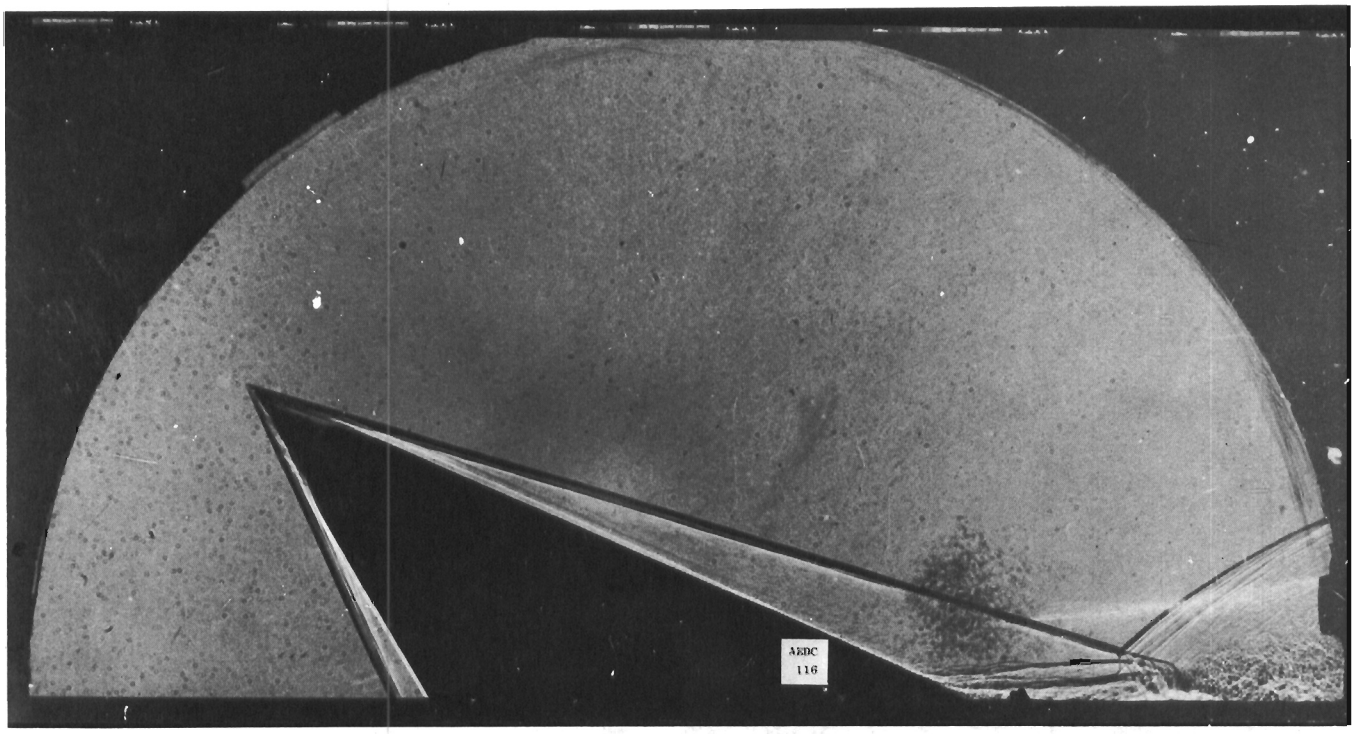


Fig. 30 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, α = -20°, Re_∞/ft = 3,300,000

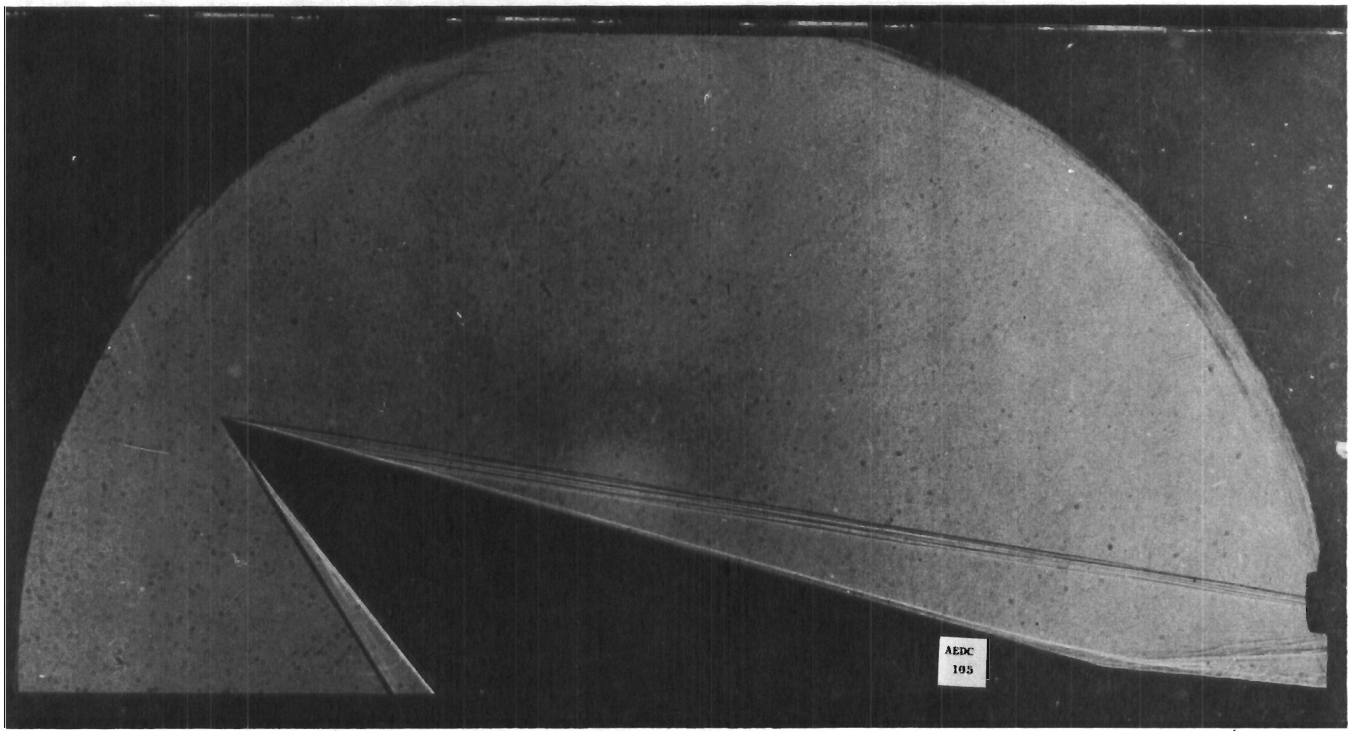


Fig. 31 Shadowgraph Flow Photograph; Coolant Flow Off, 10^{o} Ramp, $\alpha = -15^{o}$, $Re_{\infty}/ft = 1,100,000$

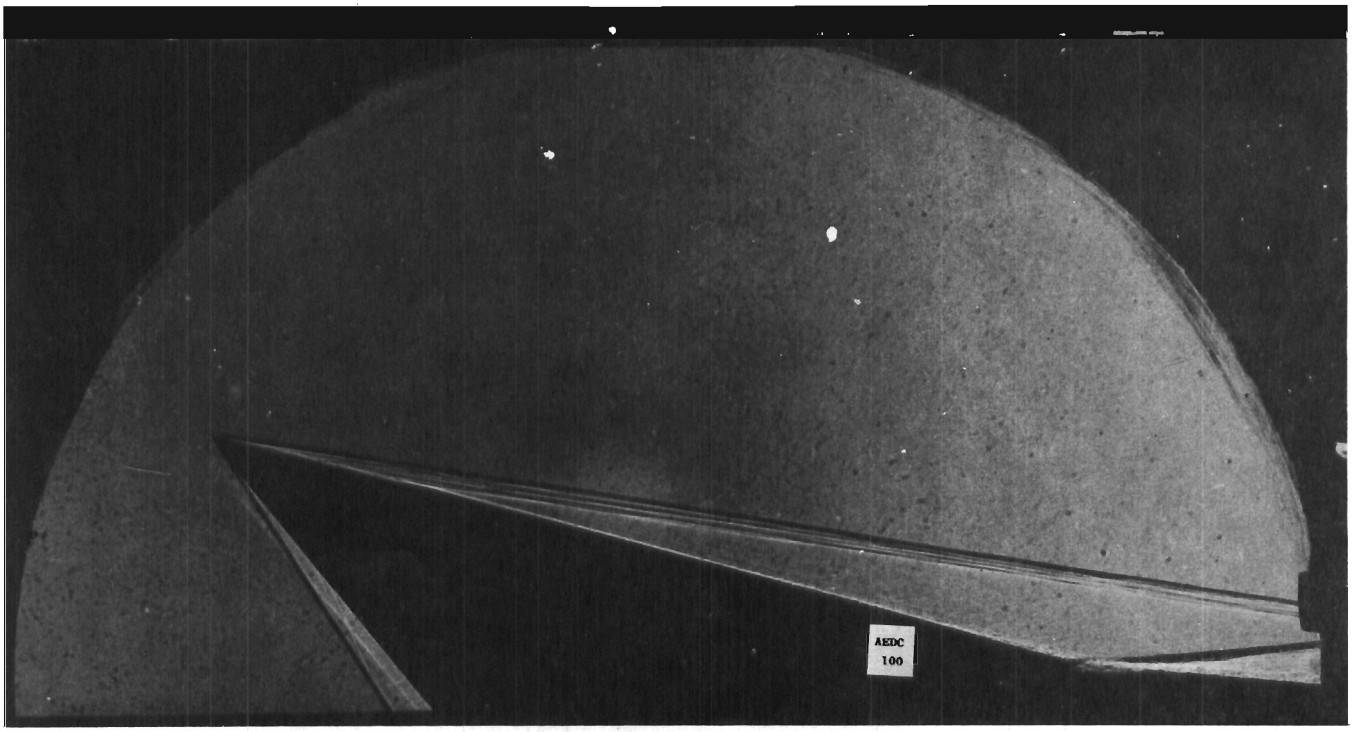


Fig. 32 Shadowgraph Flow Photograph; Coolant Flow Off, 10^{o} Ramp, $\alpha = -15^{o}$, $Re_{\infty}/ft = 3,300,000$

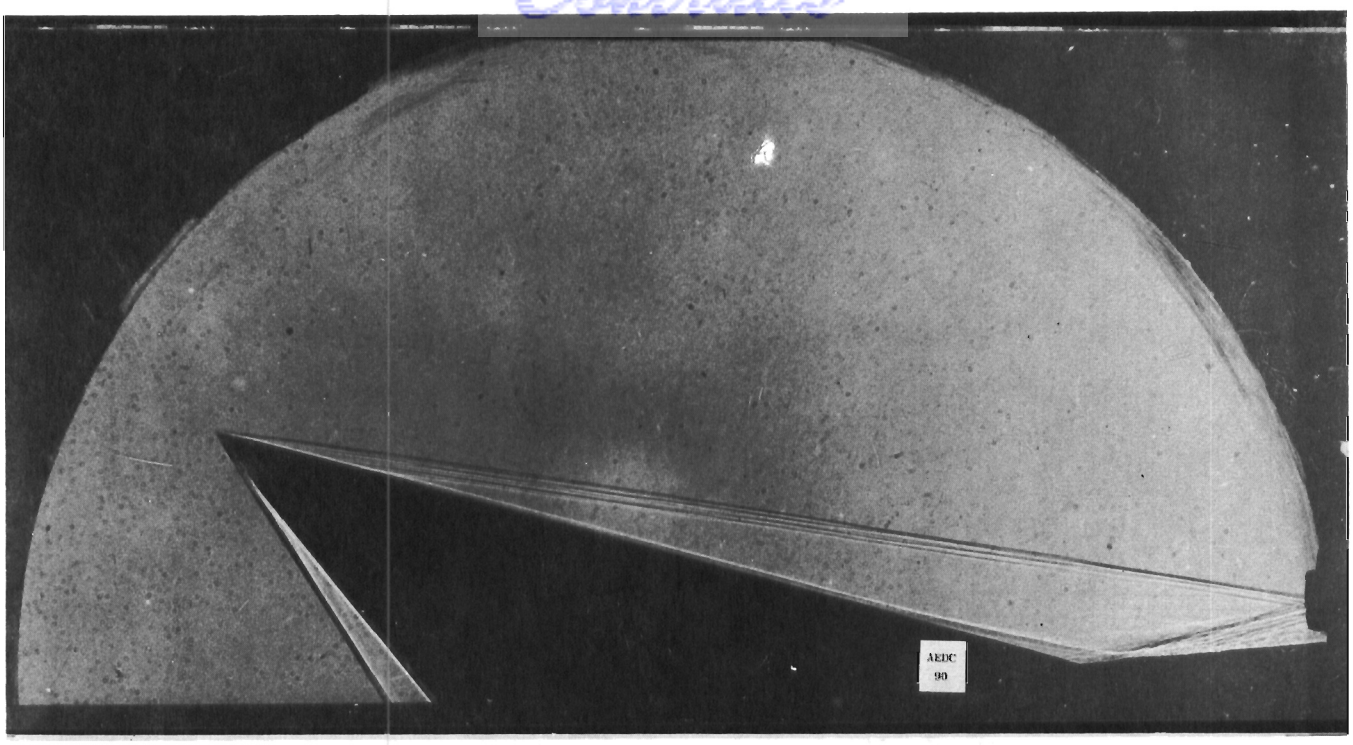


Fig. 33 Shadowgraph Flow Photograph; Coolant Flow Off, 20° Ramp, α = -15°, Re_∞/ft = 1,100,000

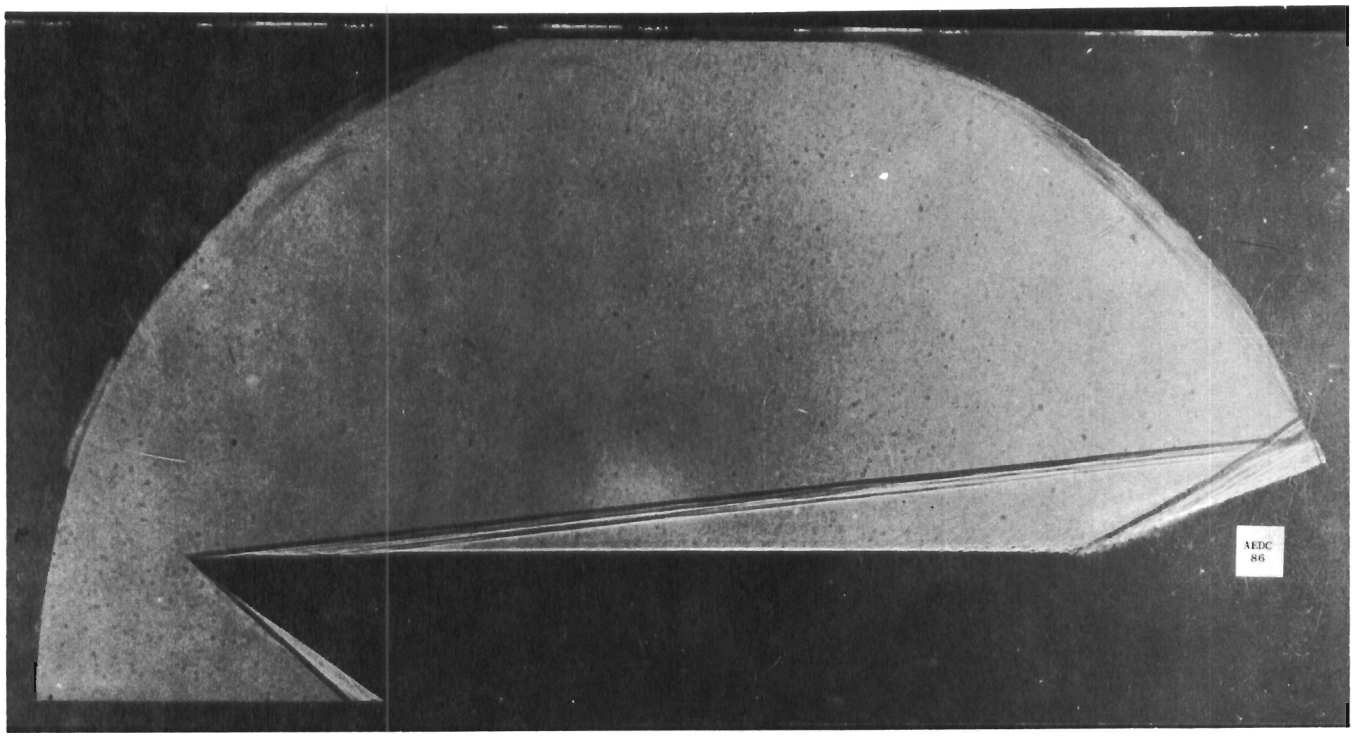


Fig. 34 Shadowgraph Flow Photograph; Coolant Flow Off, 20° Ramp, α = -15°, Re_∞/ft = 3,300,000

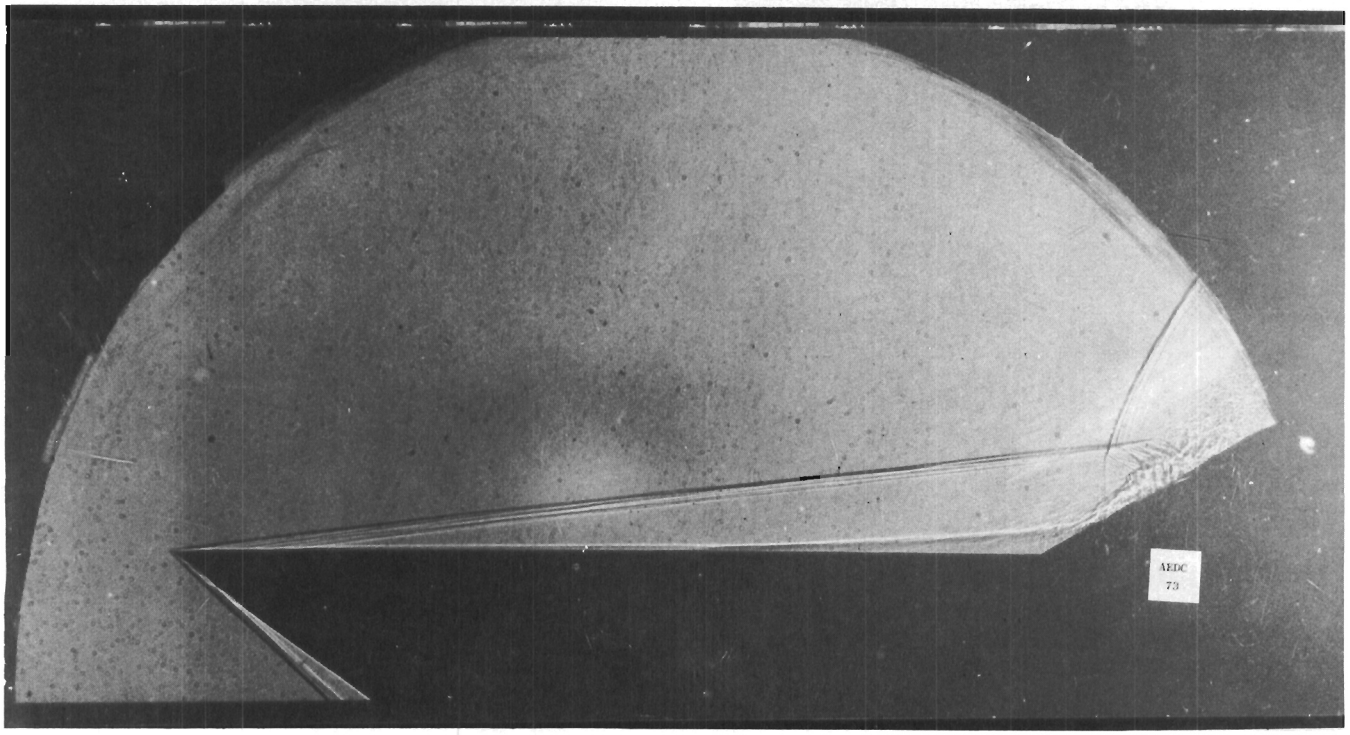


Fig. 35 Shadowgraph Flow Photograph; Coolant Off, 30° Ramp, α = -15°, Re_∞/ft = 1,100,000

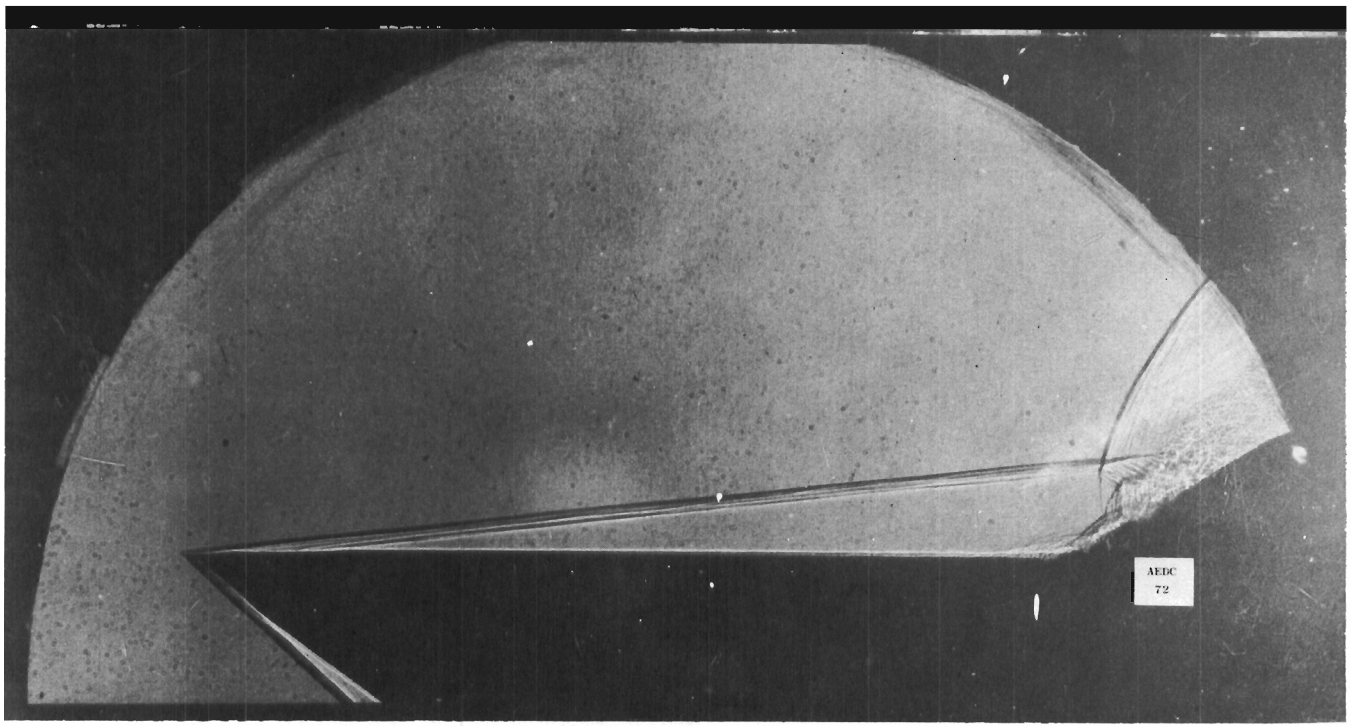


Fig. 36 Shadowgraph Flow Photograph; Coolant Off, 30° Ramp, α = -15°, Re_∞/ft = 2,200,000

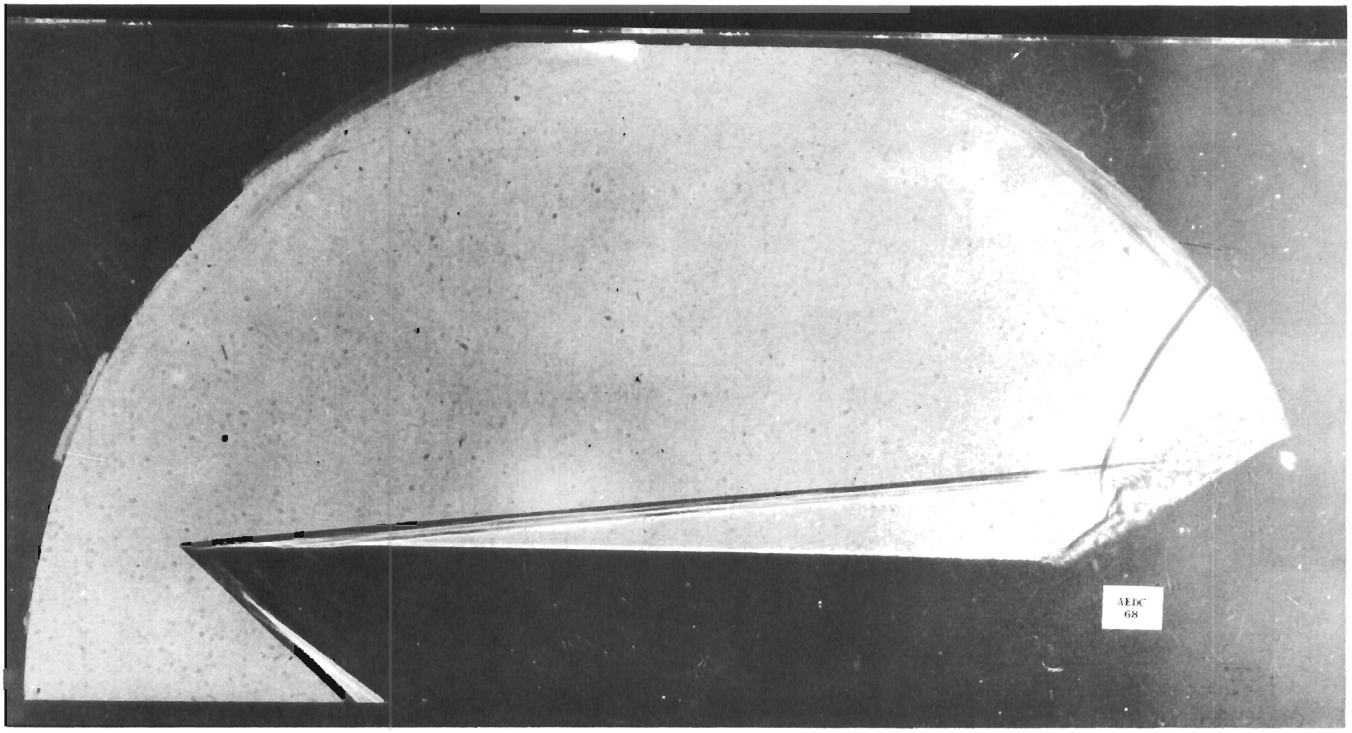


Fig. 37 Shadowgraph Flow Photograph; Coolant Flow Off, 30^{o} Ramp, $\alpha = -15^{o}$, $Re_{\infty}/ft = 3,300,000$

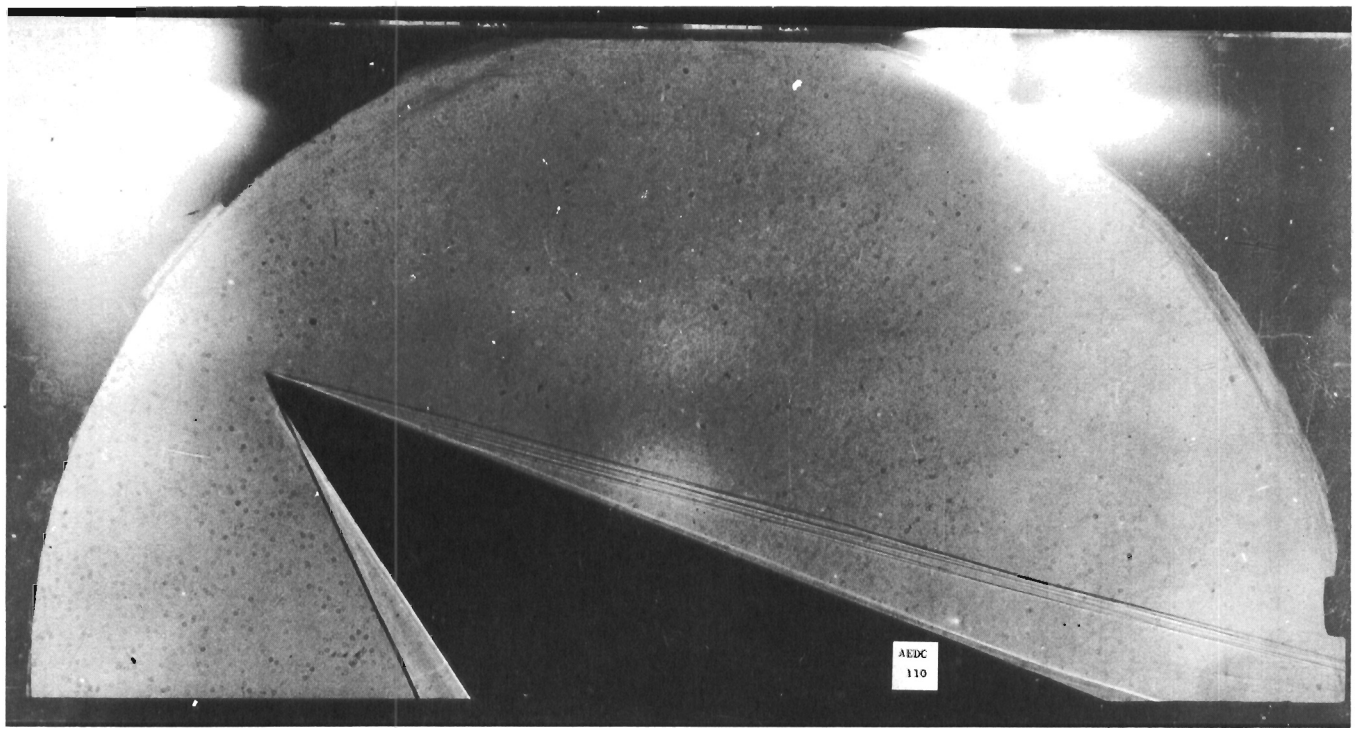


Fig. 38 Shadowgraph Flow Photograph; Coolant Off, 10^{o} Ramp, $\alpha = -10^{o}$, $Re_{\infty}/ft = 1,100,000$

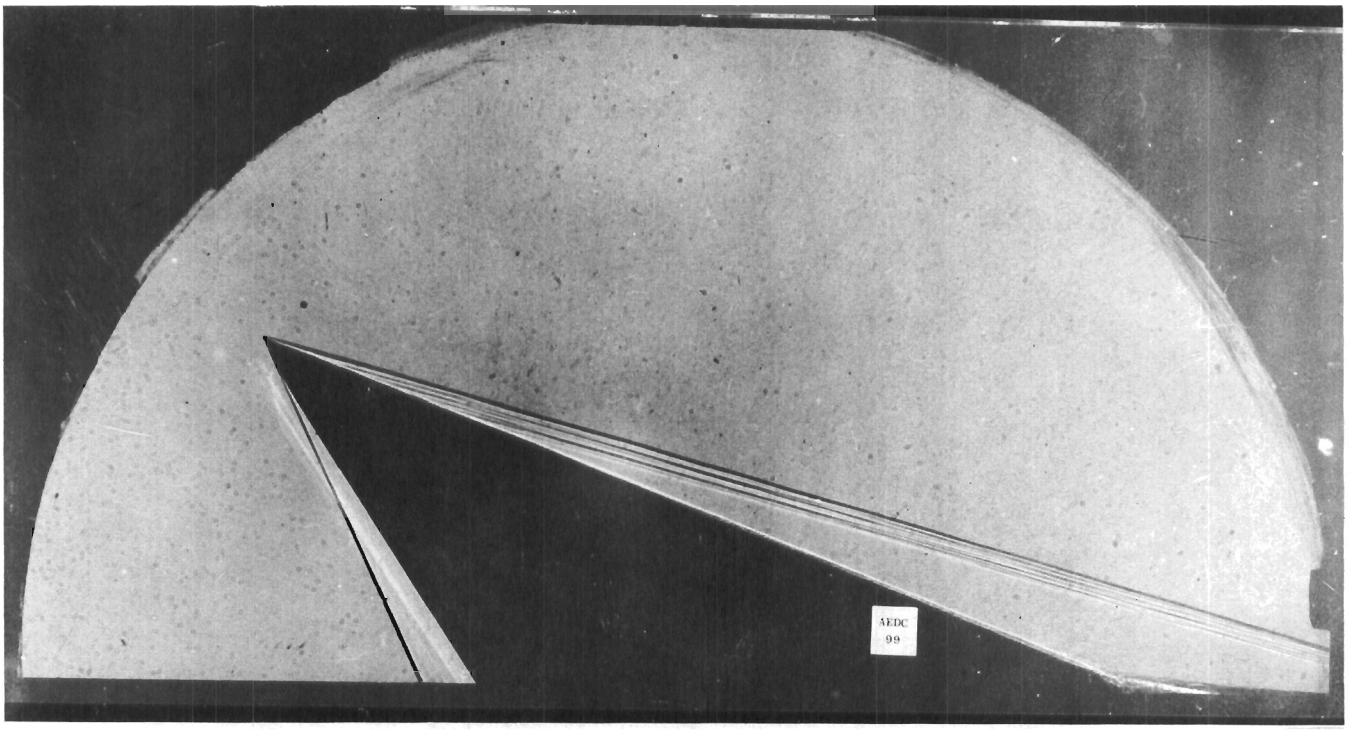


Fig. 39 Shadowgraph Flow Photograph; Coolant Off, 10° Ramp, $\alpha = -10^{\circ}$, Re_{∞}/ft = 3,300,000

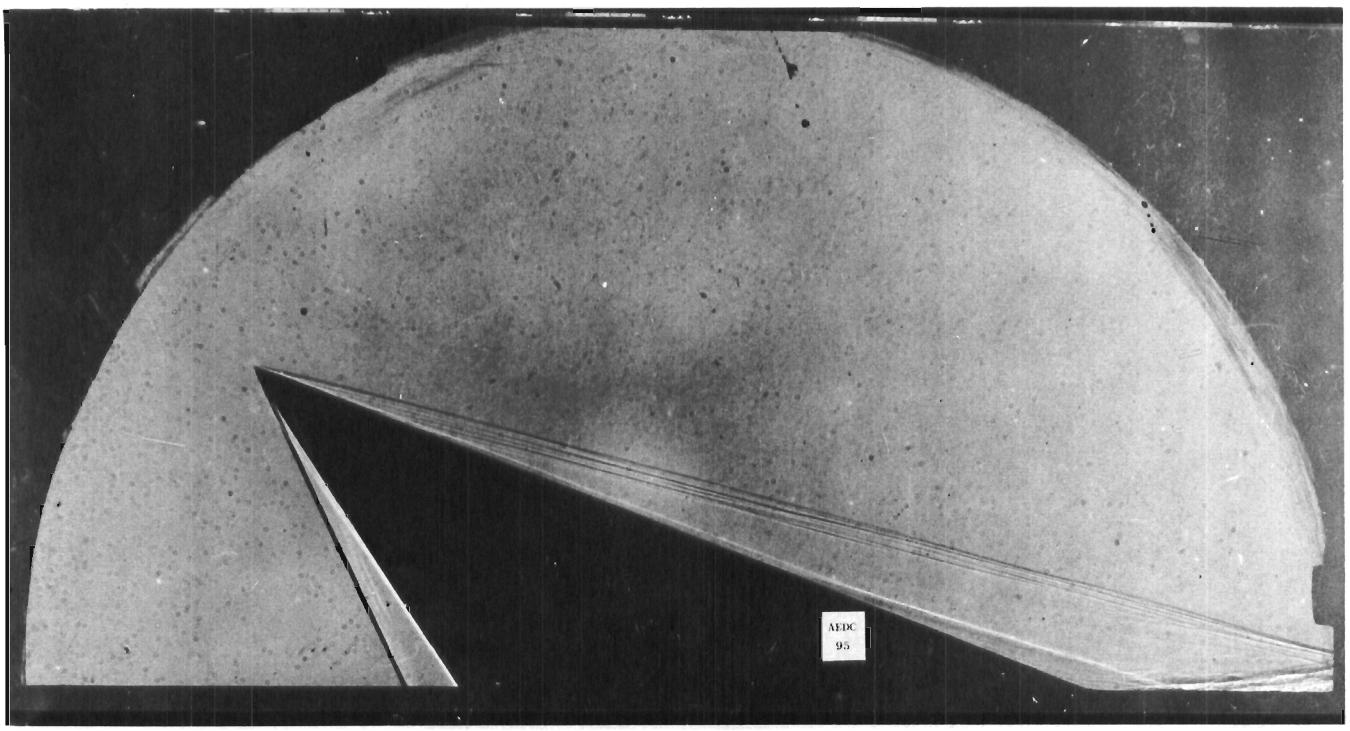


Fig. 40 Shadowgraph Flow Photograph; Coolant Off, 20° Ramp, $\alpha = -10^{\circ}$, Re_{∞}/ft = 1,100,000

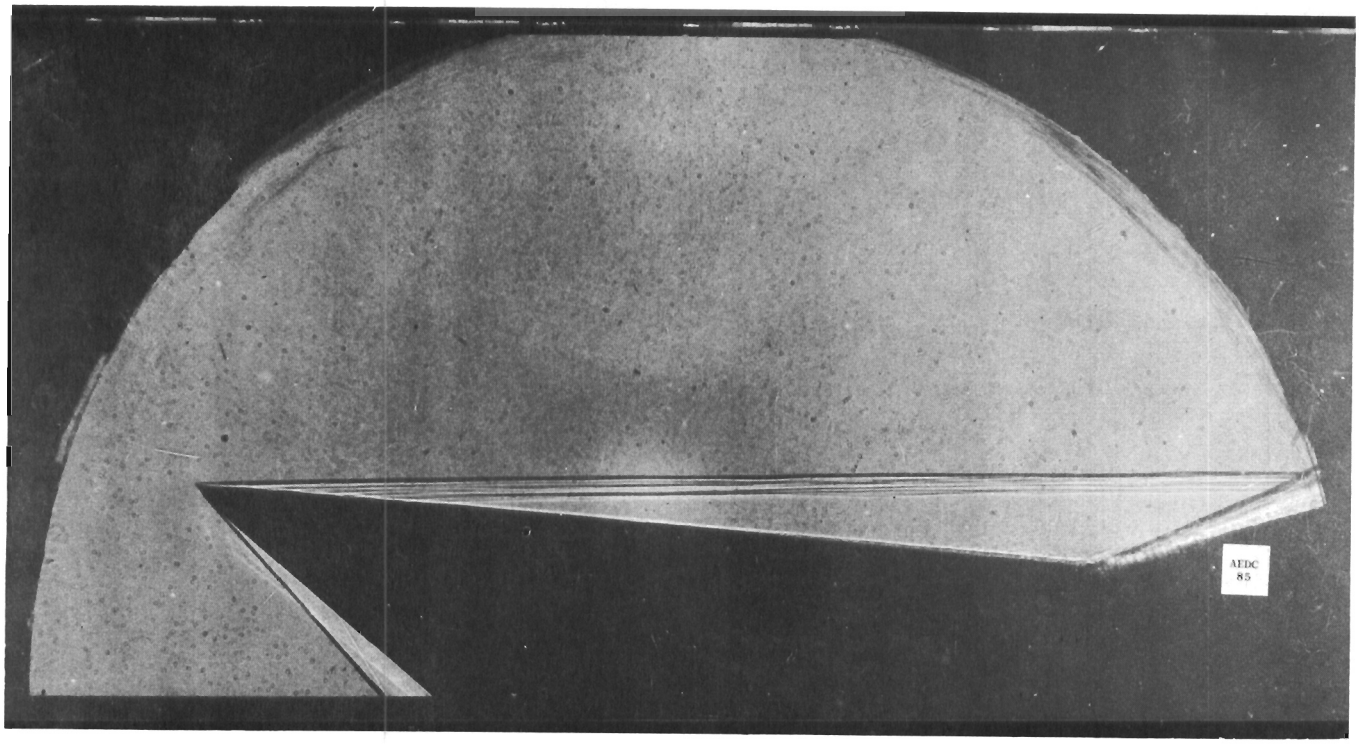


Fig. 41 Shadowgraph Flow Photograph; Coolant Off, 20° Ramp, $\alpha = -10^{\circ}$, $Re_{\infty}/ft = 3,300,000$

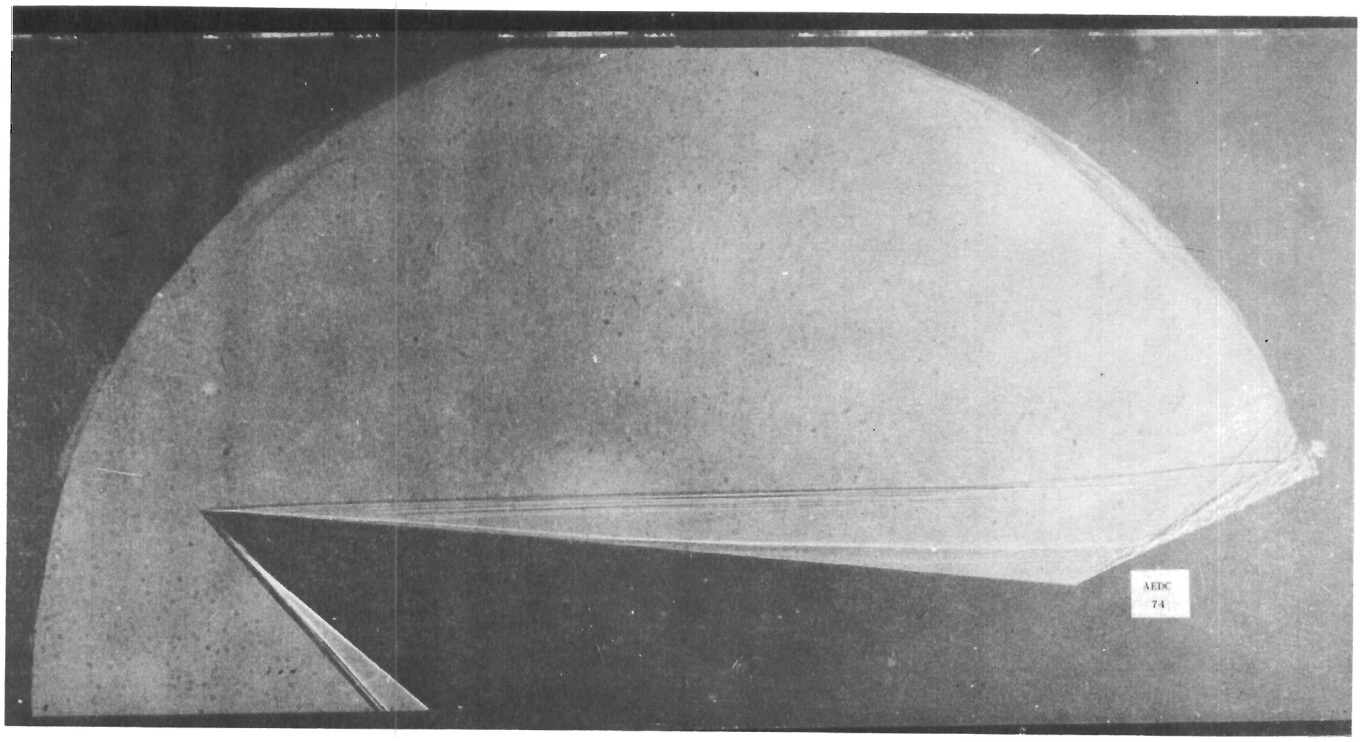


Fig. 42 Shadowgraph Flow Photograph; Coolant Off, 30° Ramp, $\alpha = -10^{\circ}$, $Re_{\infty}/ft = 1,100,000$

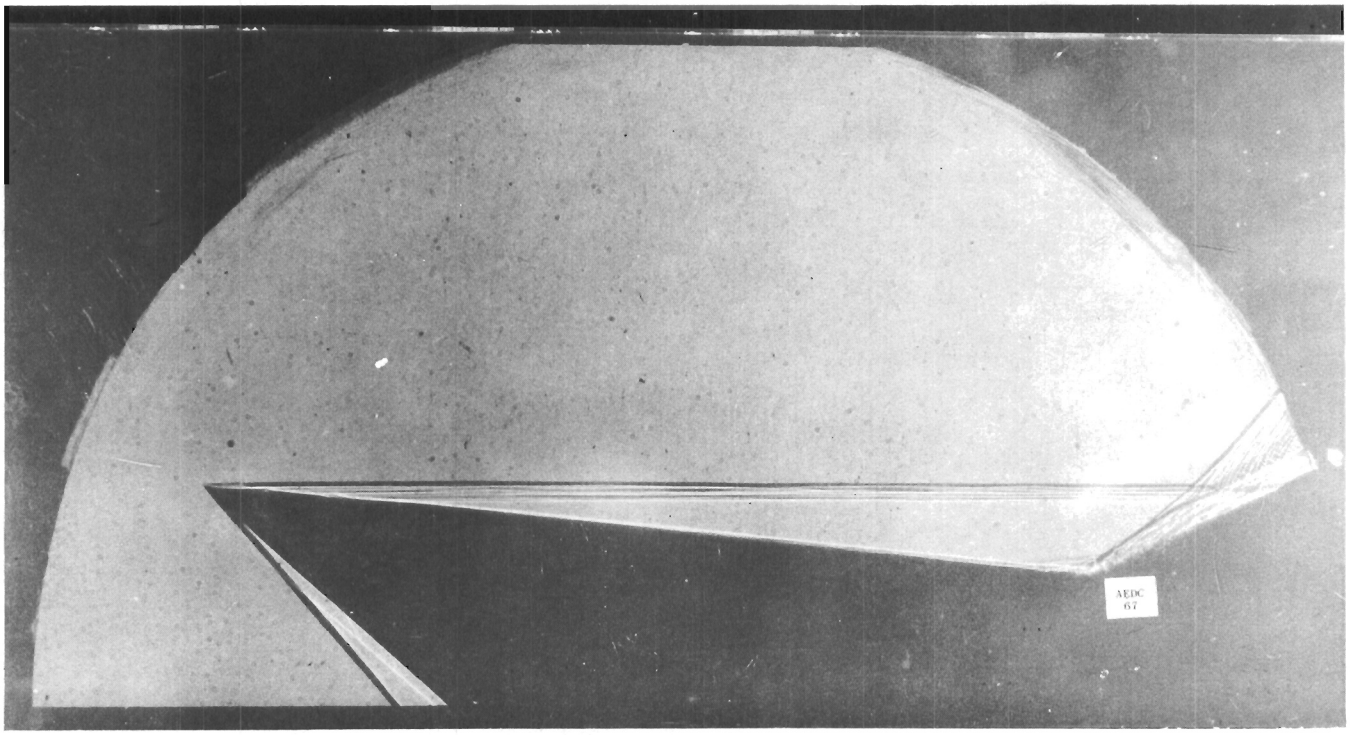


Fig. 43 Shadowgraph Flow Photograph; Coolant Off, 30° Ramp, α = -10°, Re_∞/ft = 3,300,000

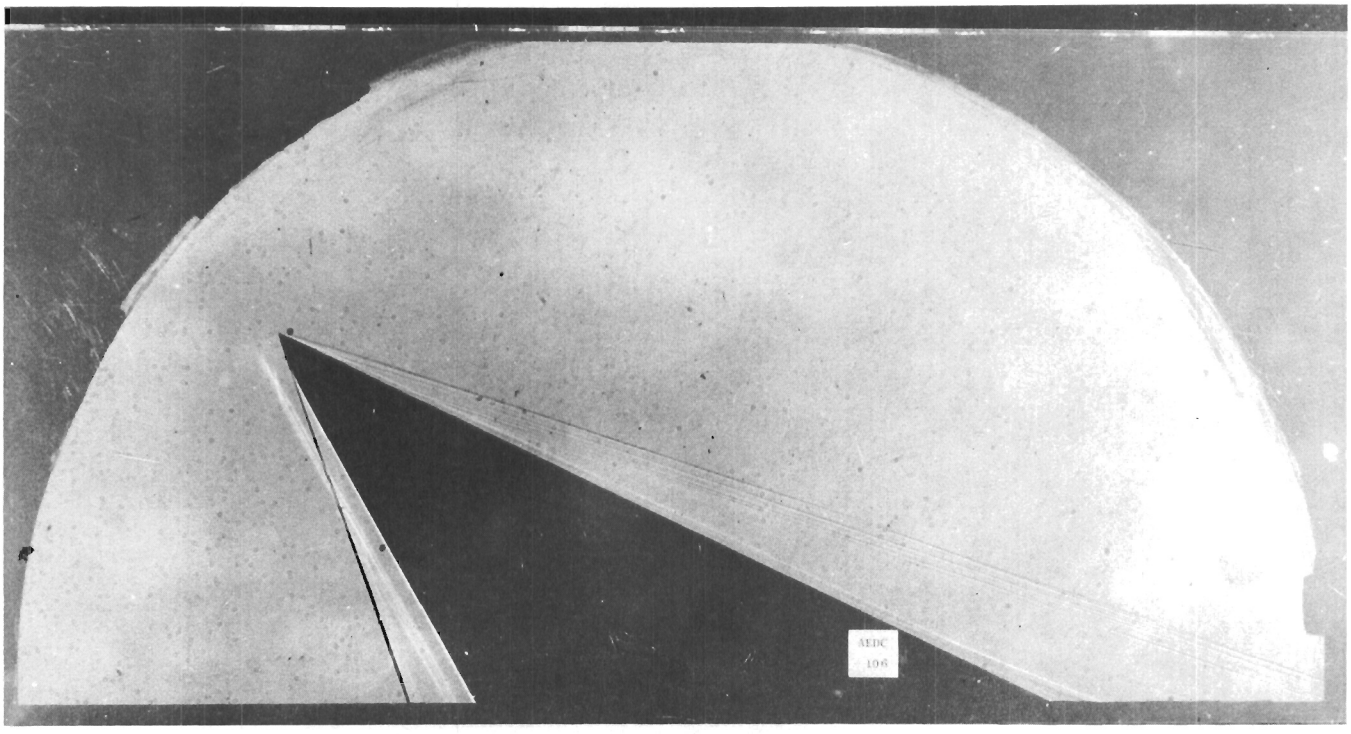


Fig. 44 Shadowgraph Flow Photograph; Coolant Off, 10° Ramp, α = -5°, Re_∞/ft = 1,100,000

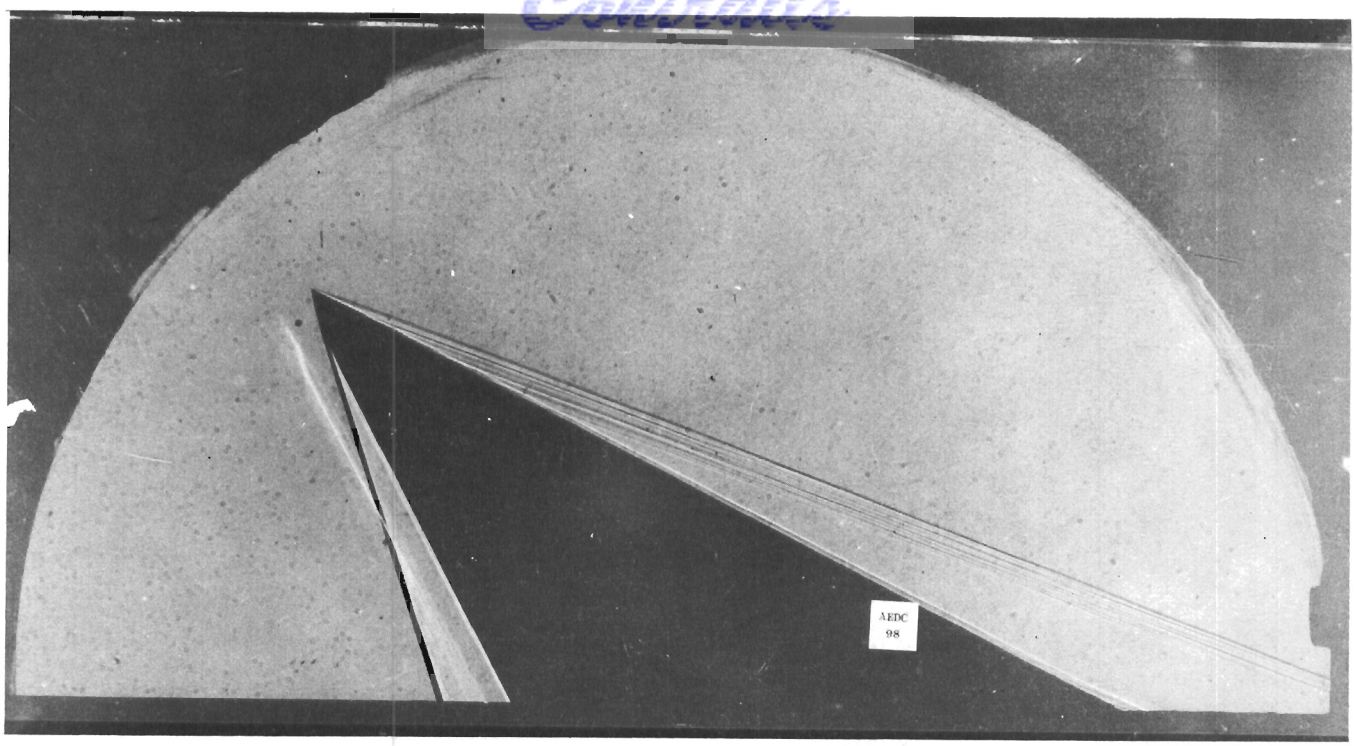


Fig. 45 Shadowgraph Flow Photograph; Coolant Off, 10° Ramp, $\alpha = -5^{\circ}$, $Re_{\infty}/ft = 3,300,000$

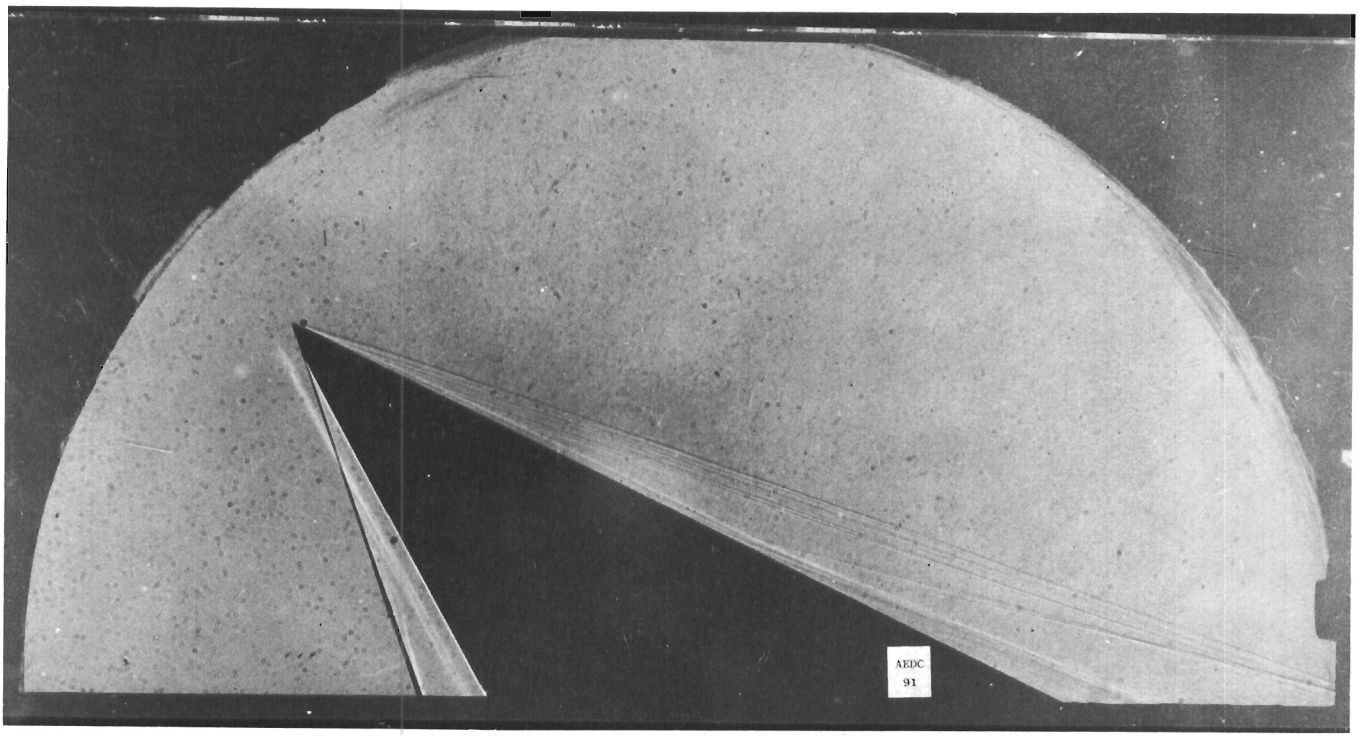


Fig. 46 Shadowgraph Flow Photograph; Coolant Off, 20° Ramp, $\alpha = -5^{\circ}$, $Re_{\infty}/ft = 1,100,000$

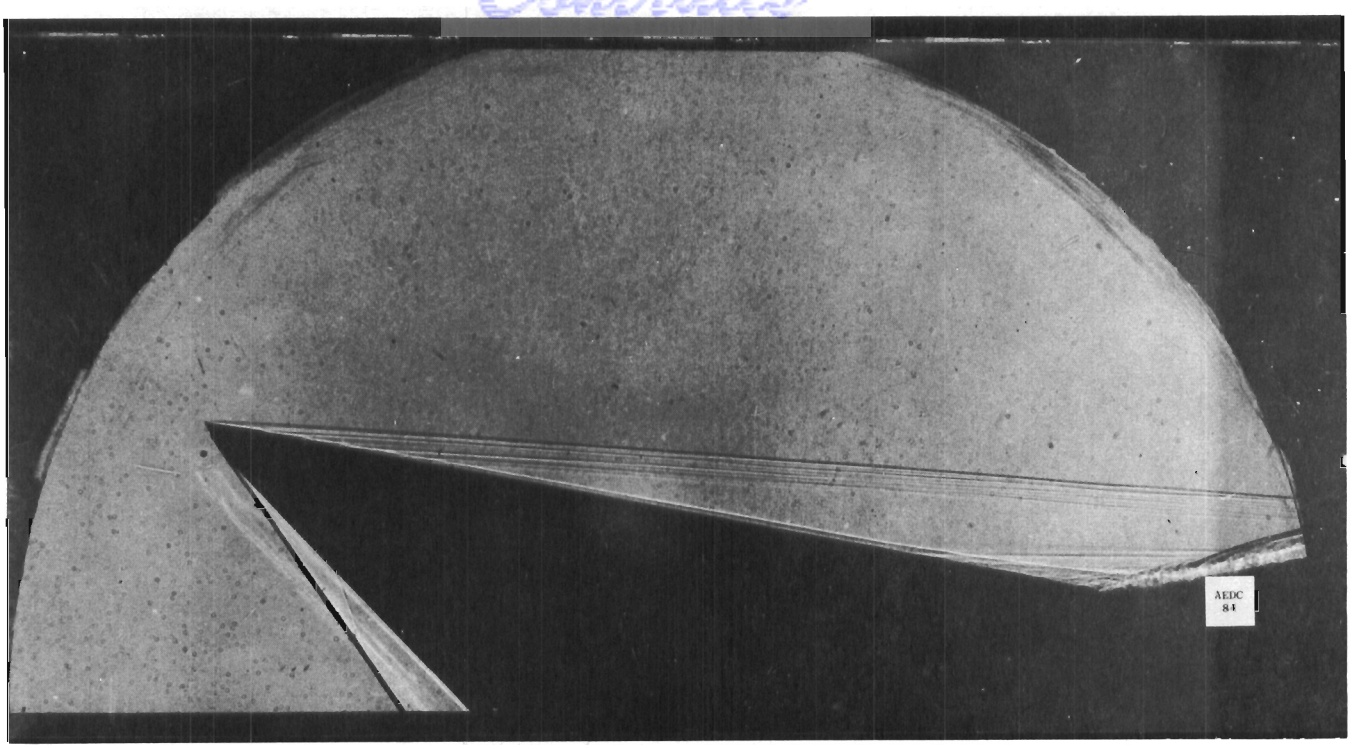


Fig. 47 Shadowgraph Flow Photograph; Coolant Off, 20^{o} Ramp, $\alpha = -5^{o}$, $Re_{\infty}/ft = 3,300,000$

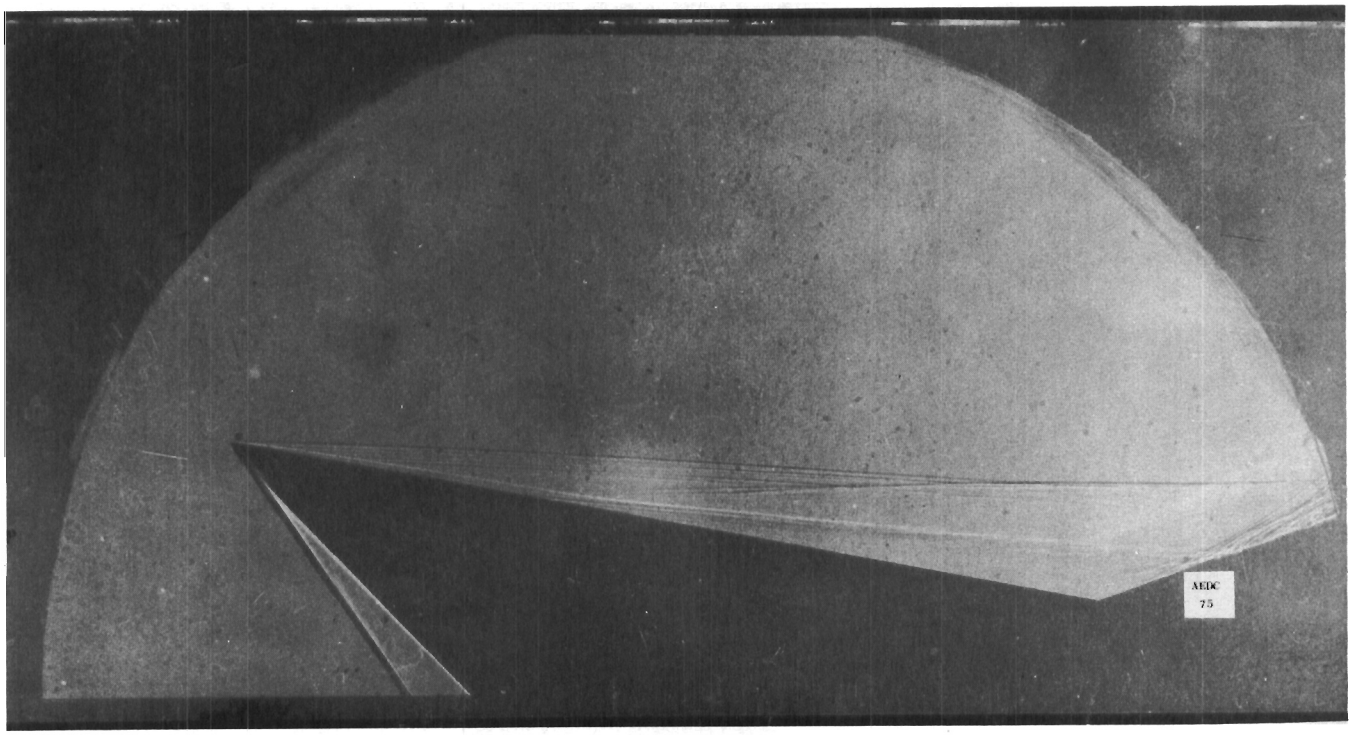


Fig. 48 Shadowgraph Flow Photograph; Coolant Off, 30^{o} Ramp, $\alpha = -5^{o}$, $Re_{\infty}/ft = 1,100,000$

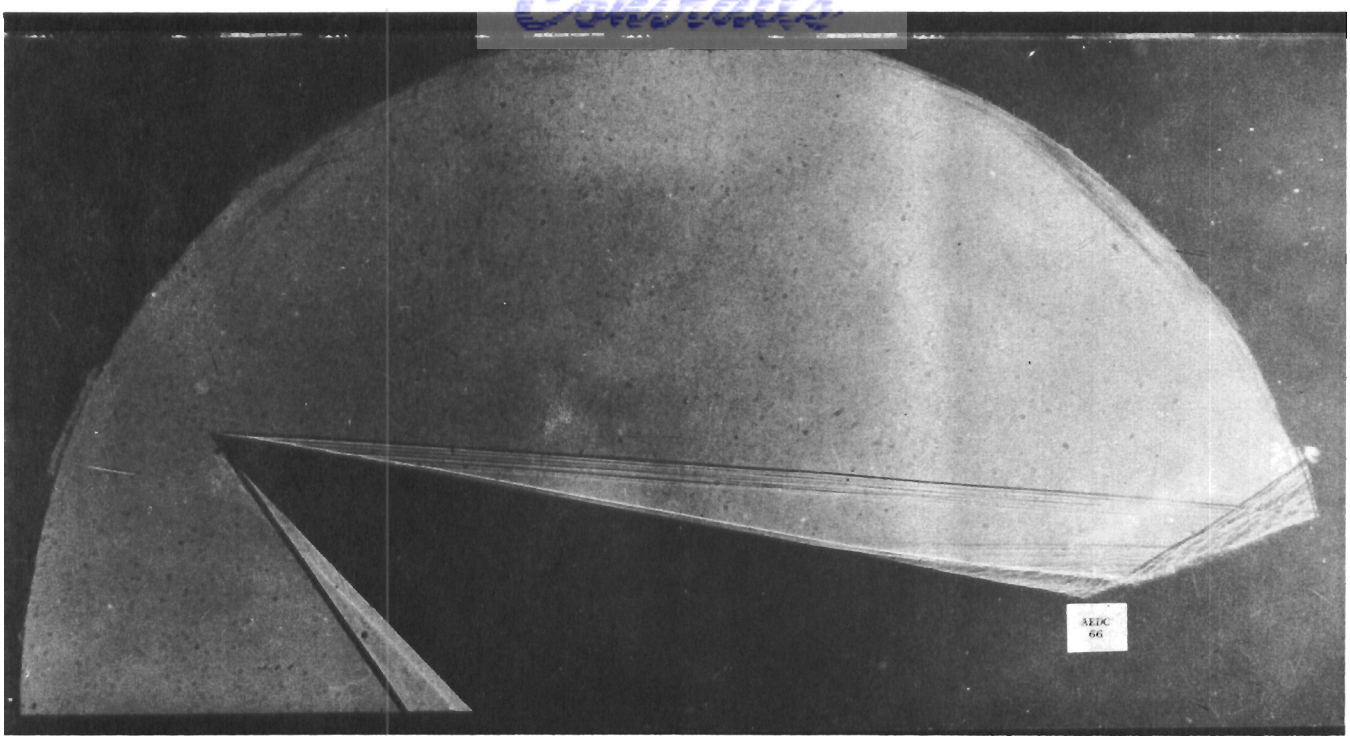


Fig. 49 Shadowgraph Flow Photograph; Coolant Off, 30^{o} Ramp, $\alpha = -5^{o}$, $Re_{\infty}/ft = 3,300,000$

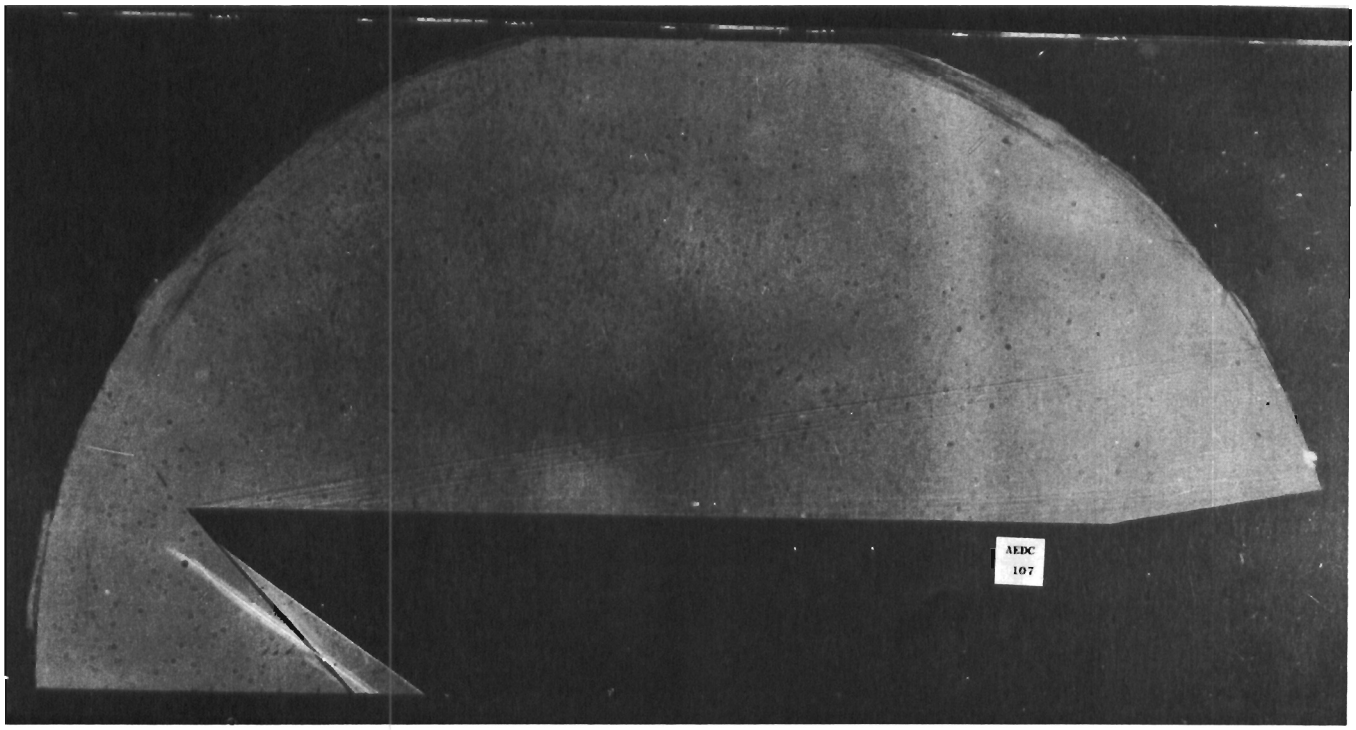


Fig. 50 Shadowgraph Flow Photograph; Coolant Off, 10^{o} Ramp, $\alpha = 0$, $Re_{\infty}/ft = 1,100,000$

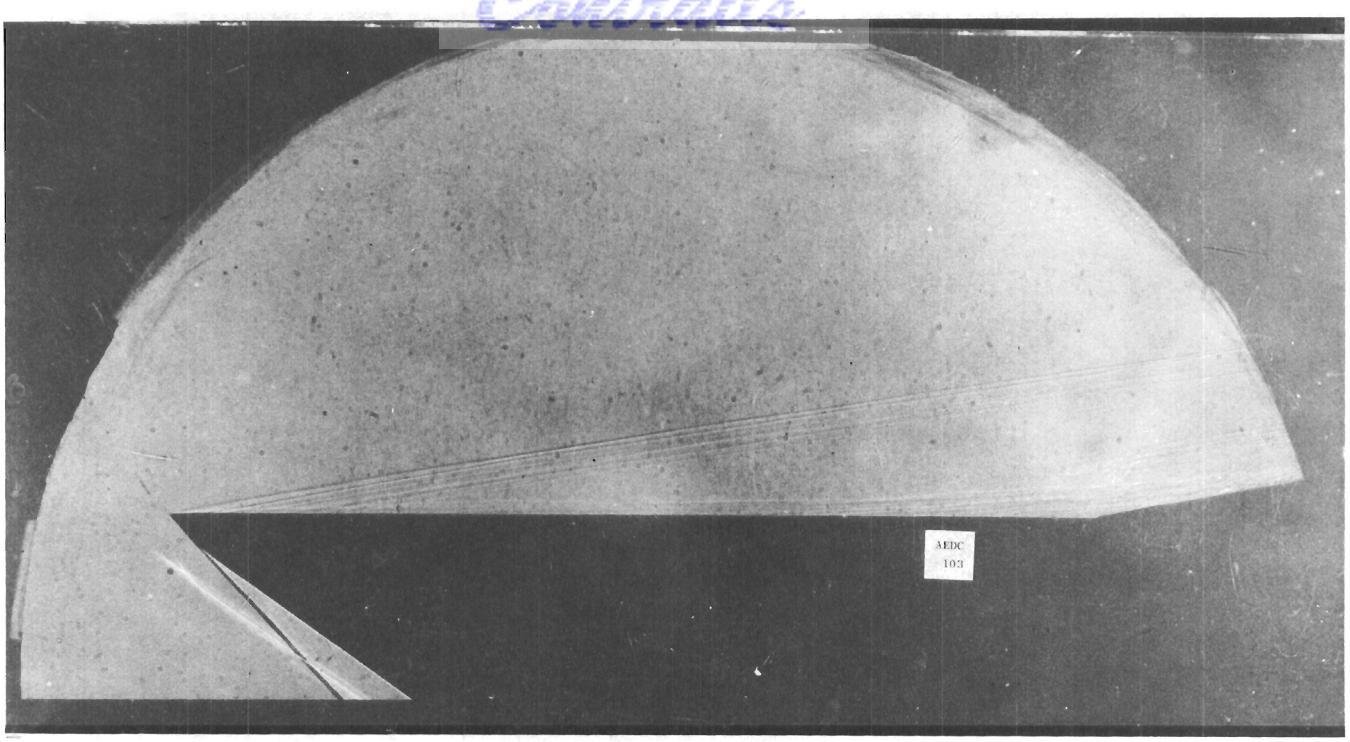


Fig. 51 Shadowgraph Flow Photograph; Coolant Flow Off, 10° Ramp, $\alpha = 0$, Re_{∞}/ft = 2,200,000

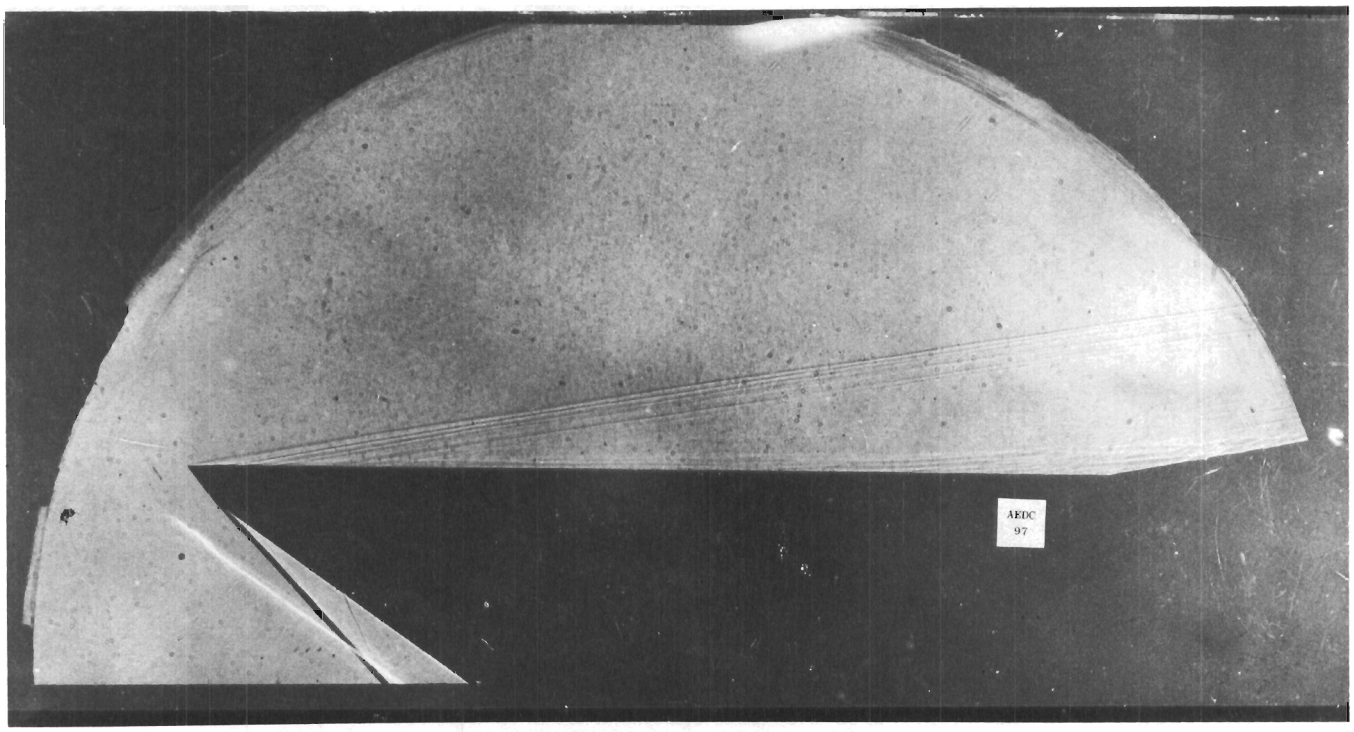


Fig. 52 Shadowgraph Flow Photograph; Coolant Flow Off, 10° Ramp, $\alpha = 0$, Re_{∞}/ft = 3,300,000

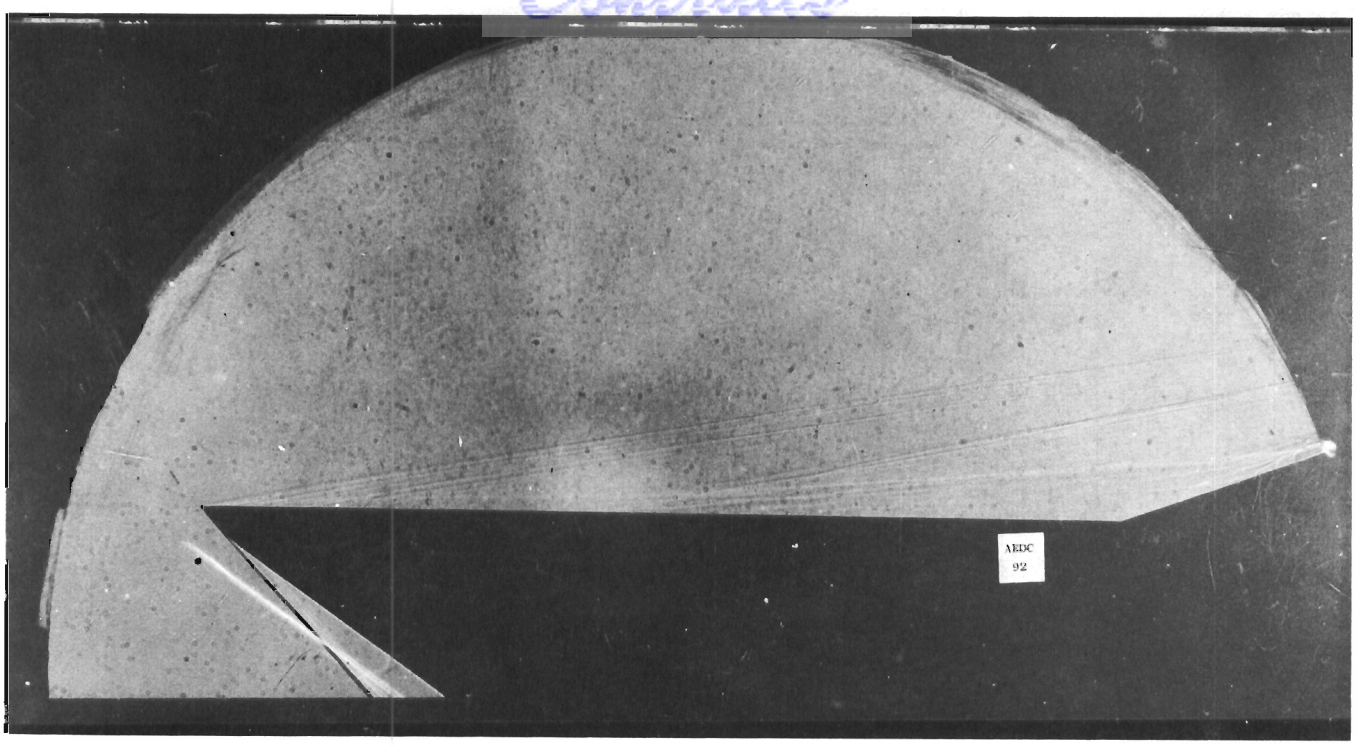


Fig. 53 Shadowgraph Flow Photograph; Coolant Flow Off, 20^{o} Ramp, $\alpha = 0$, $Re_{\infty}/ft = 1{,}100{,}000$

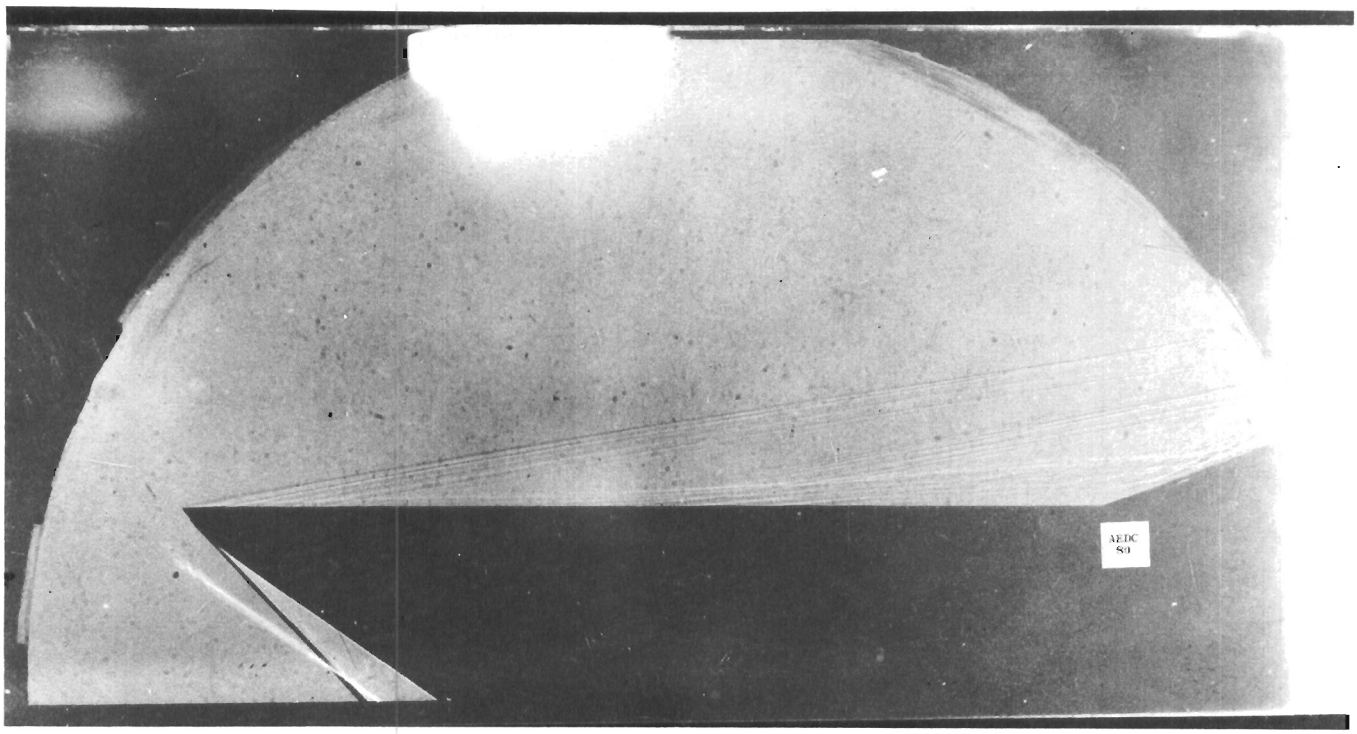


Fig. 54 Shadowgraph Flow Photograph; Coolant Flow Off, 20^{o} Ramp, $\alpha = 0$, $Re_{\infty}/ft = 2{,}200{,}000$

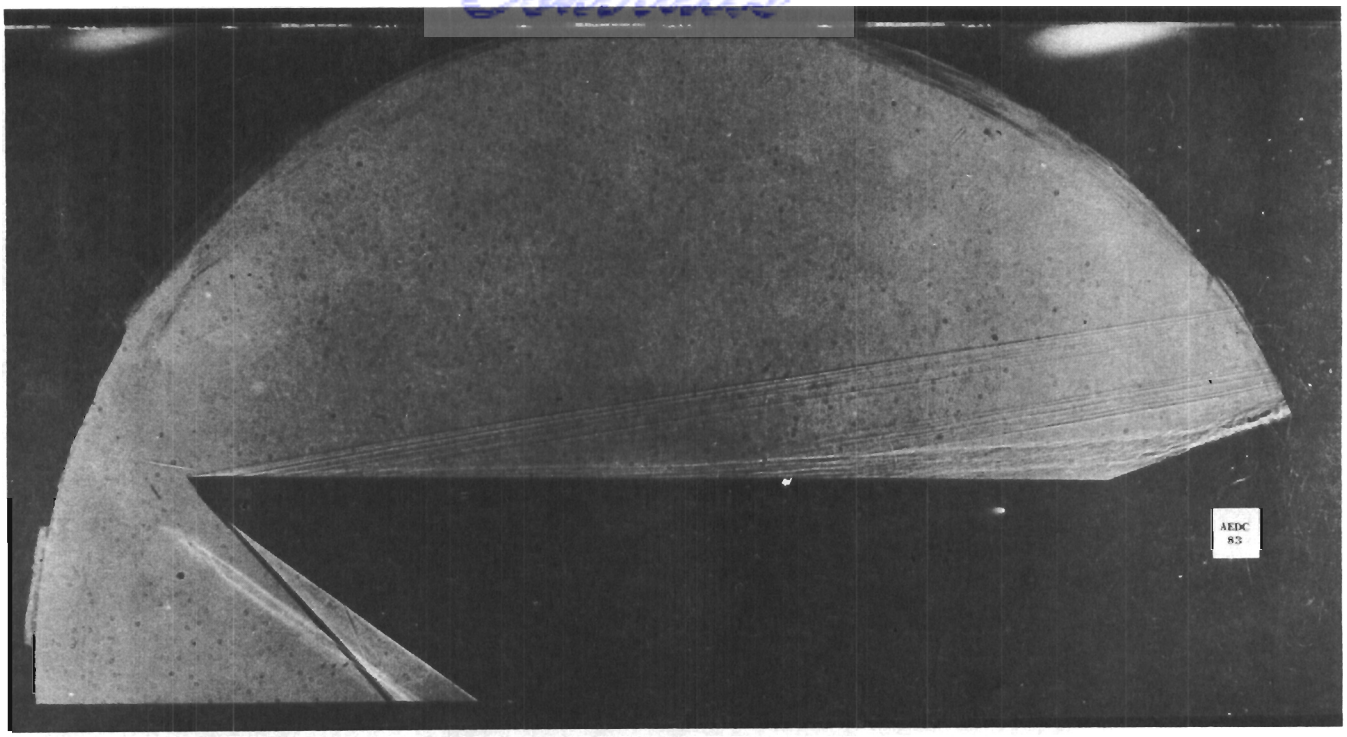


Fig. 55 Shadowgraph Flow Photograph; Coolant Flow Off, 20° Ramp, $\alpha = 0$, Re_∞/ft = 3,300,000

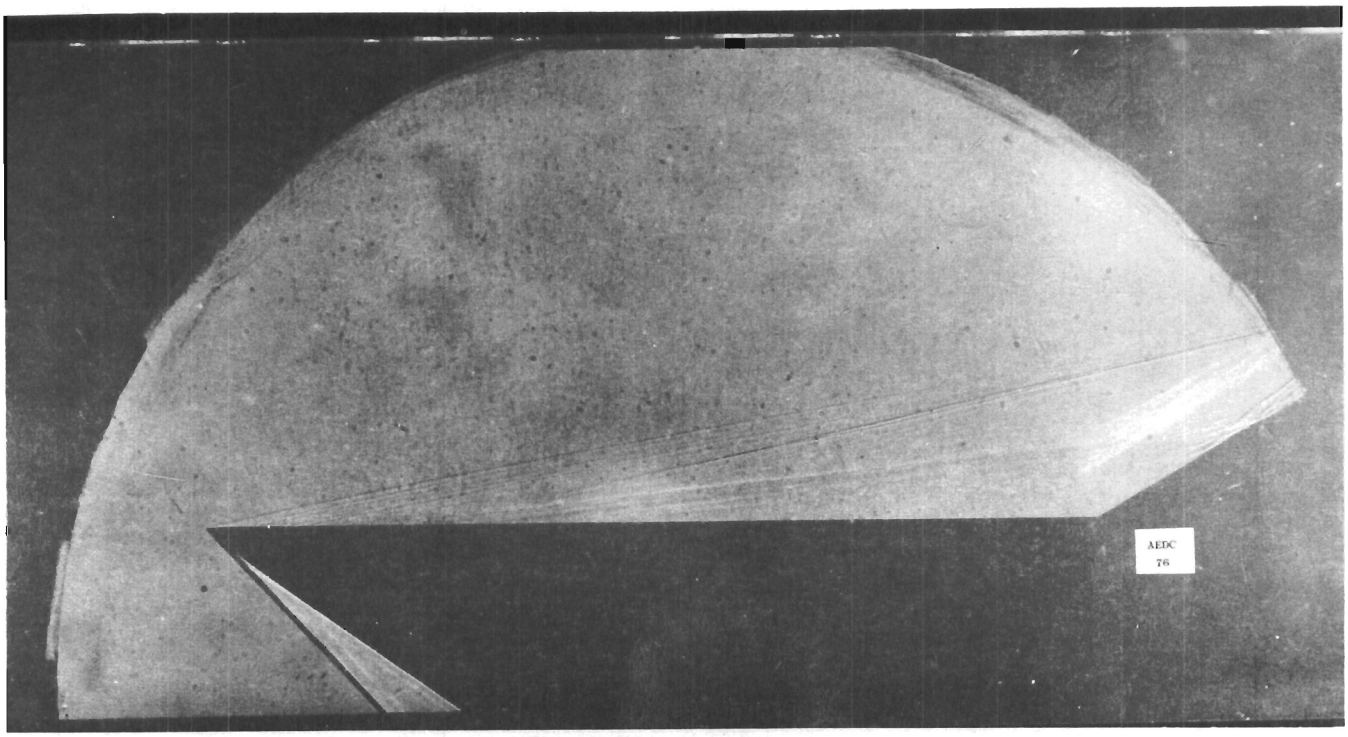


Fig. 56 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = 0$, Re_∞/ft = 1,100,000

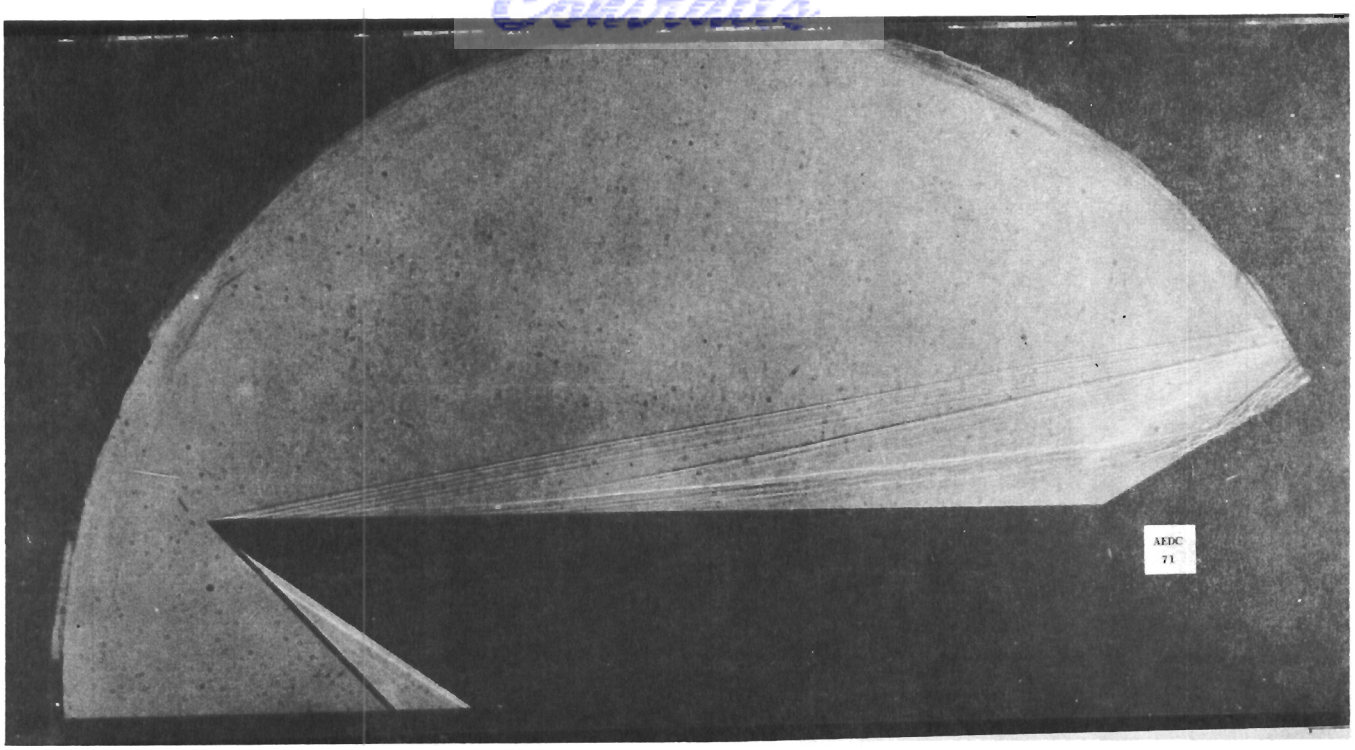


Fig. 57 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = 0$, $Re_\infty/ft = 2{,}200{,}000$

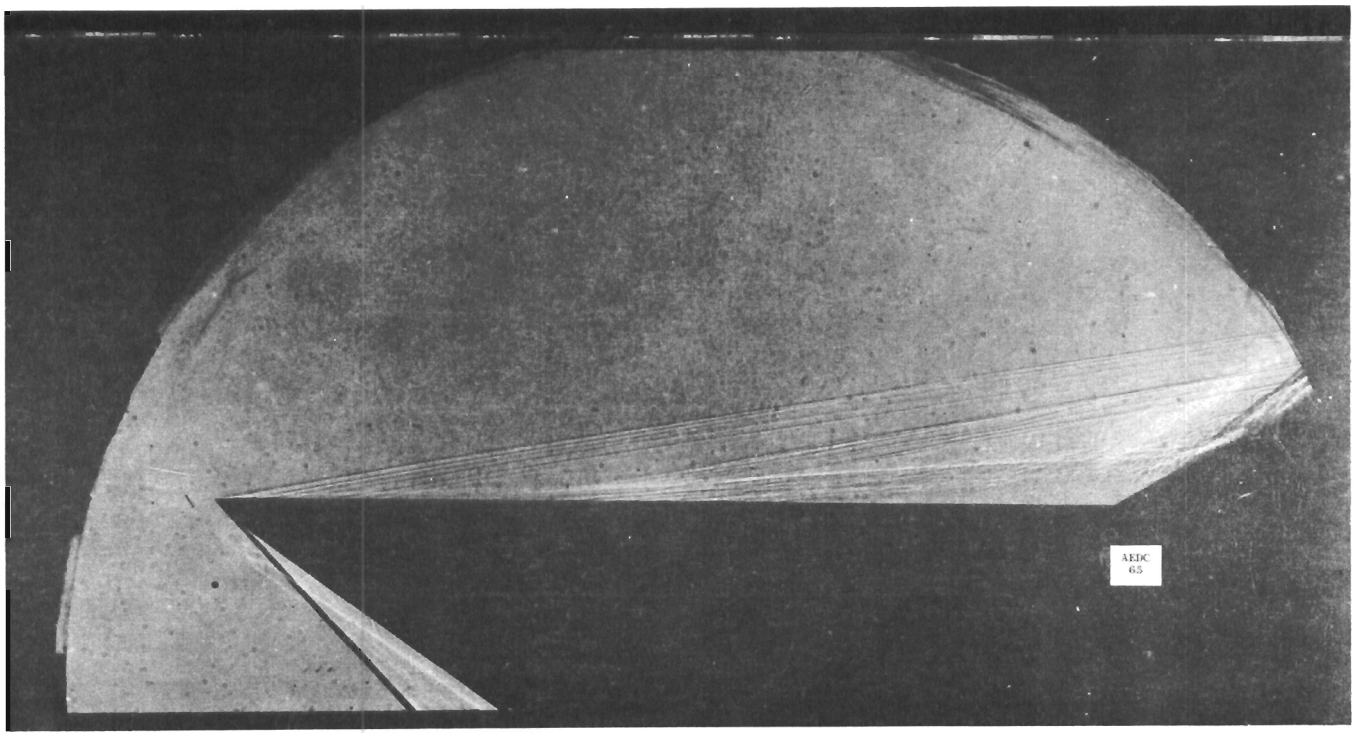


Fig. 58 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = 0$, $Re_\infty/ft = 3{,}300{,}000$

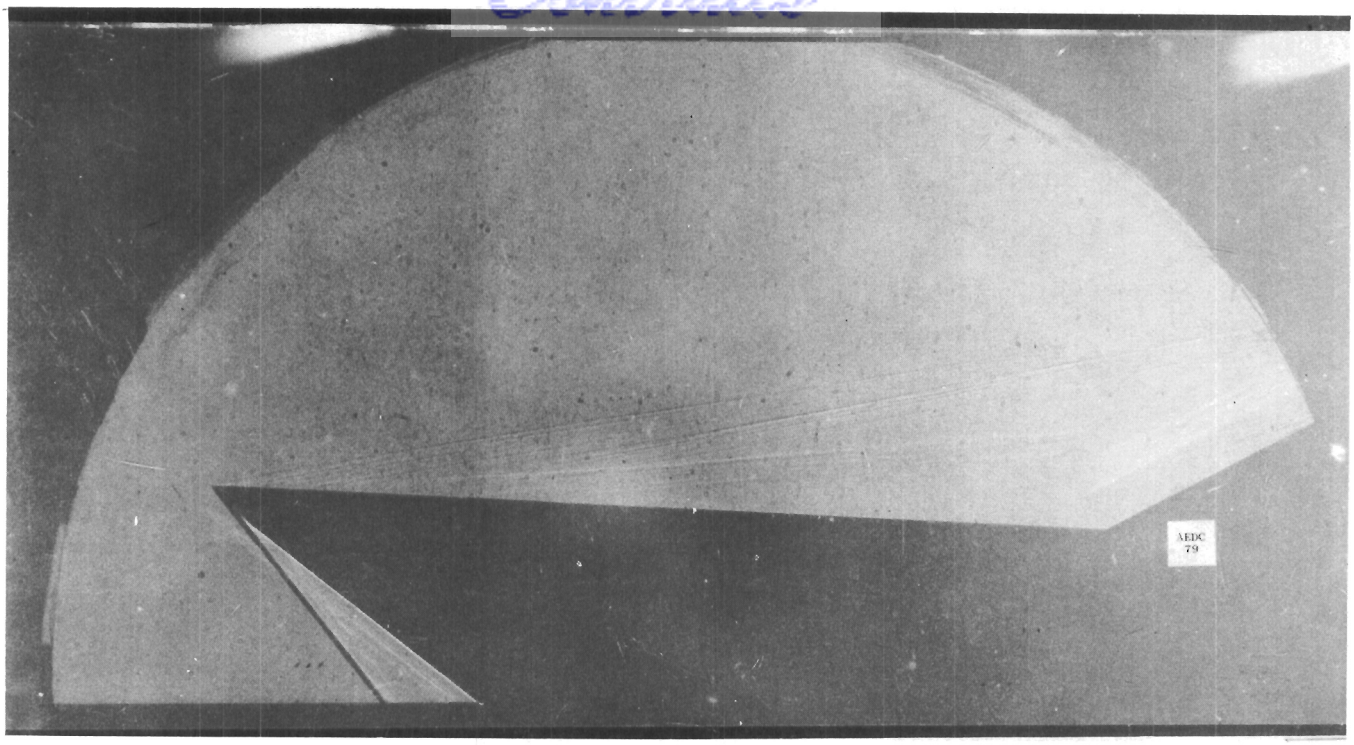


Fig. 59 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = +2\frac{1}{2}^{\circ}$, $Re_{\infty}/ft = 1{,}100{,}000$

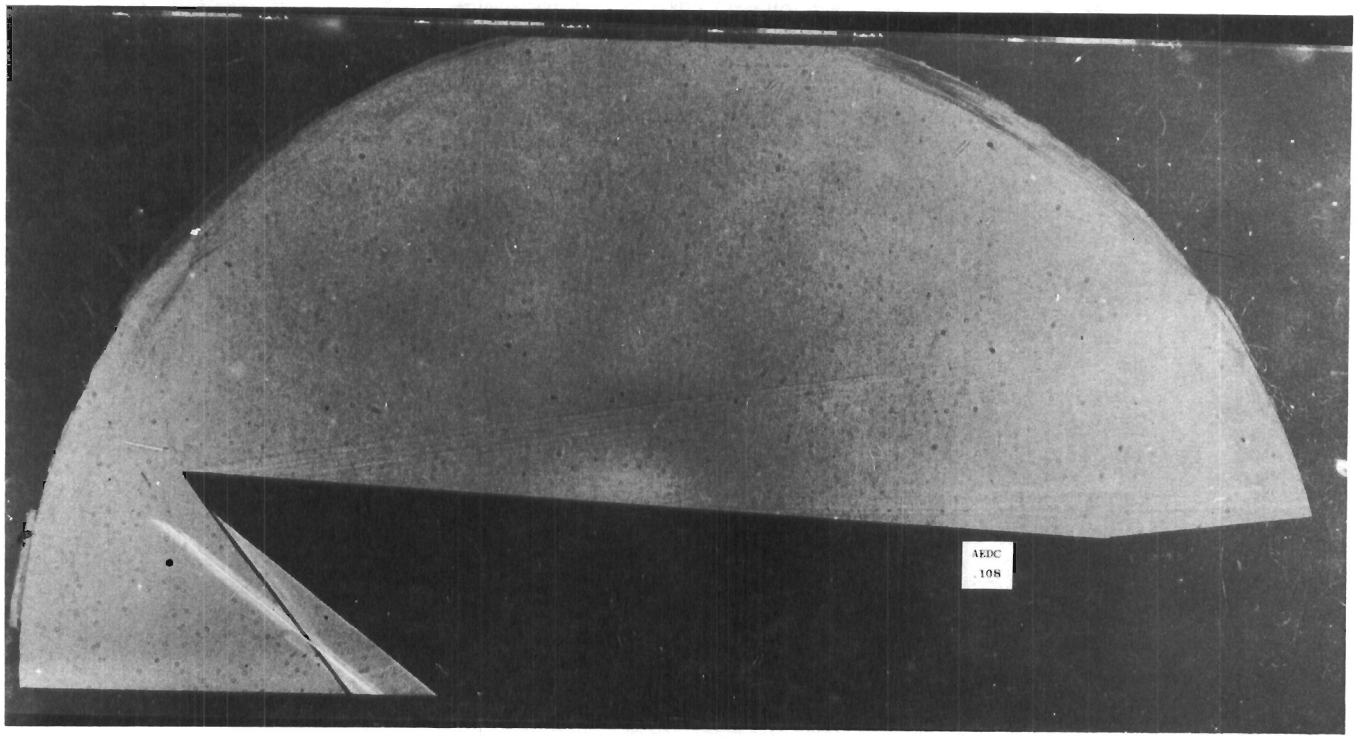


Fig. 60 Shadowgraph Flow Photograph; Coolant Flow Off, 10° Ramp, $\alpha = +3^{\circ}$, $Re_{\infty}/ft = 1{,}100{,}000$

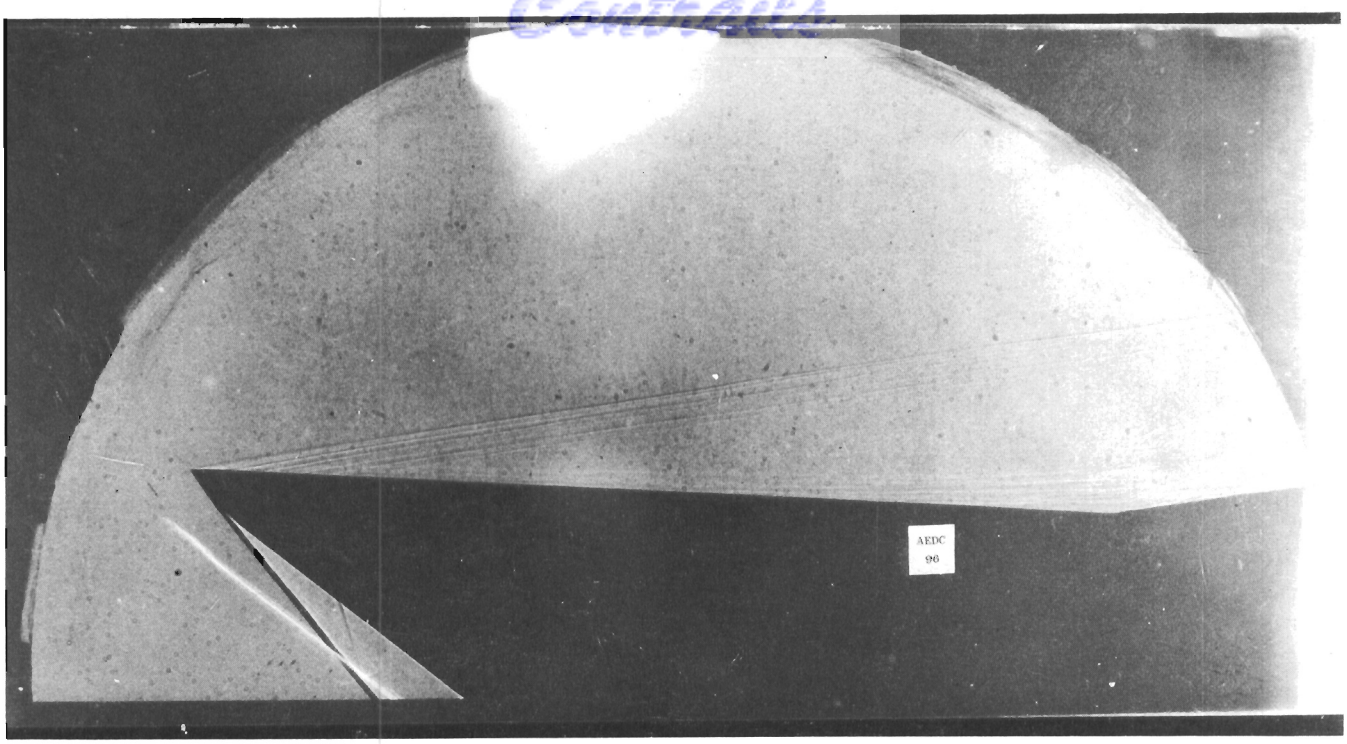


Fig. 61 Shadowgraph Flow Photograph; Coolant Flow Off, 10° Ramp, $\alpha = +3^{\circ}$, $Re_{\infty}/ft = 3,300,000$

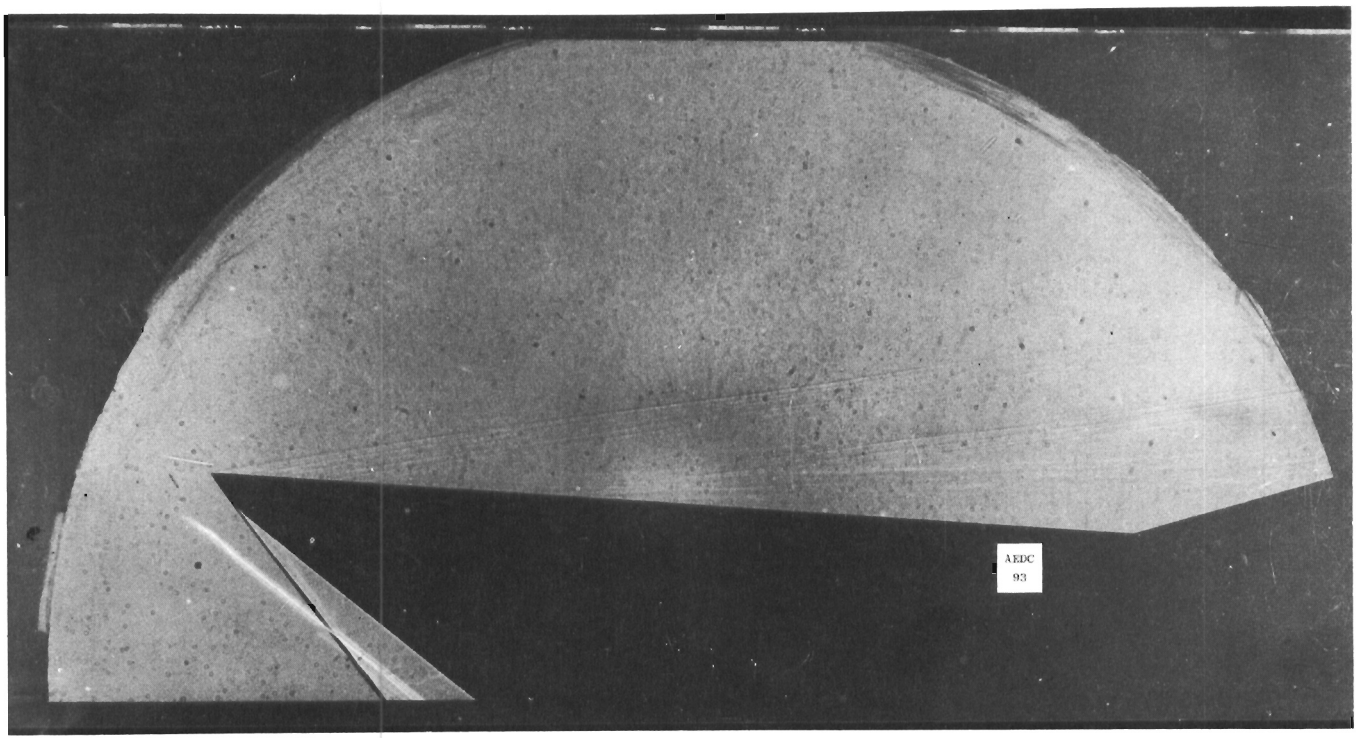


Fig. 62 Shadowgraph Flow Photograph; Coolant Flow Off, 20° Ramp, $\alpha = +3^{\circ}$, $Re_{\infty}/ft = 1,100,000$

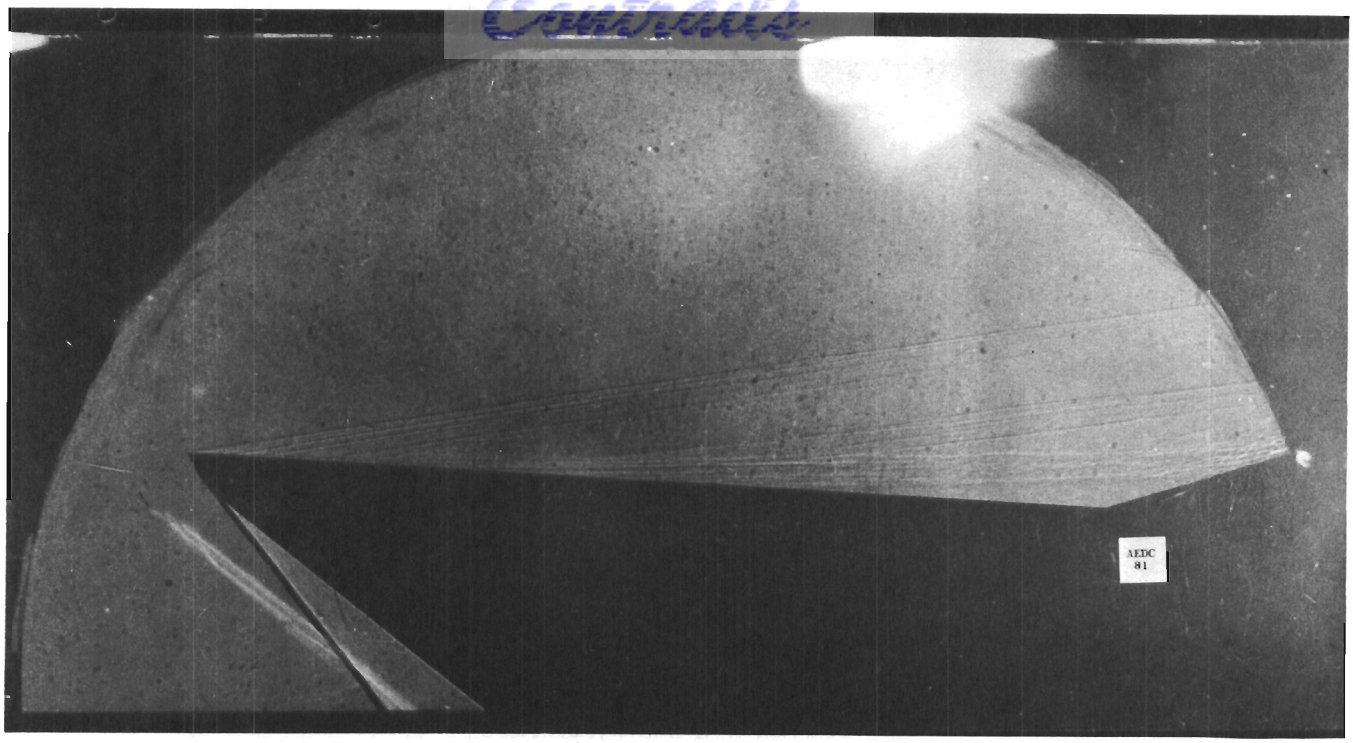


Fig. 63 Shadowgraph Flow Photograph; Coolant Flow Off, 20° Ramp, $\alpha = +3^{\circ}$, $Re_{\infty}/ft = 3,300,000$

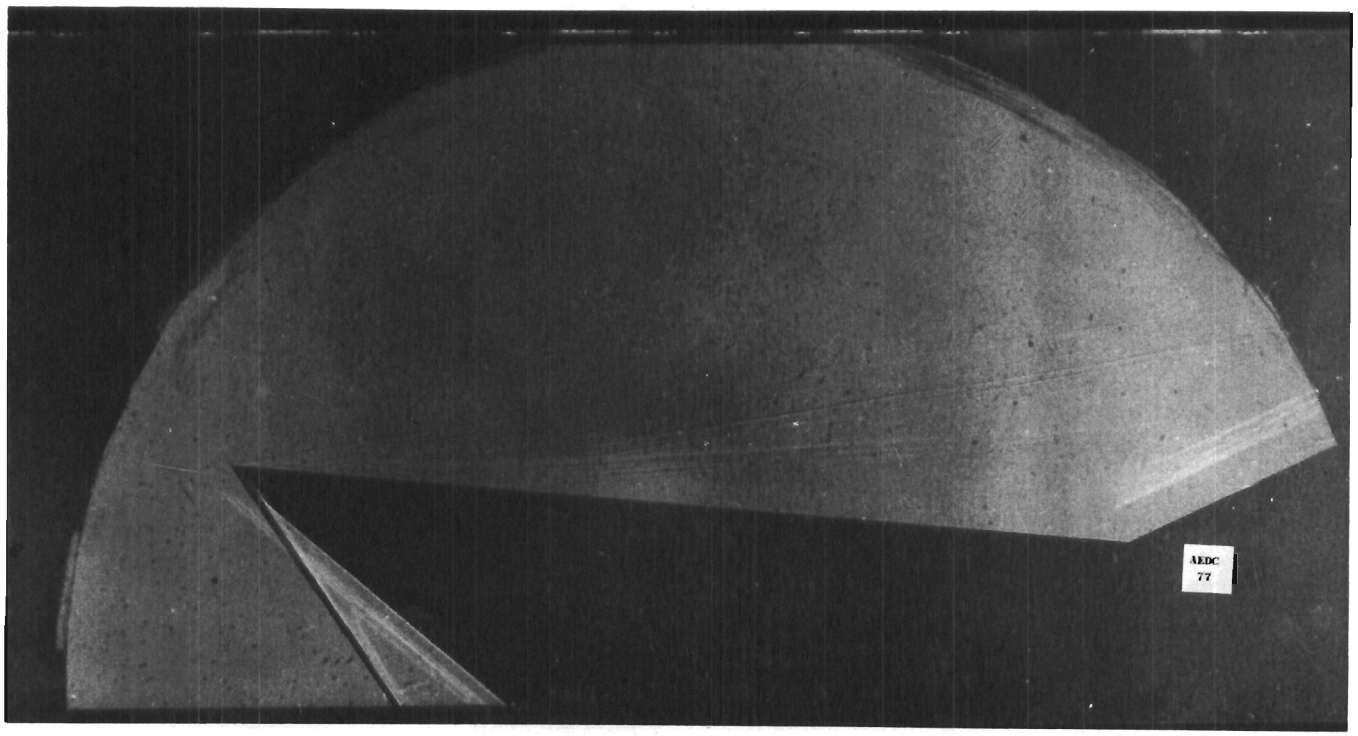


Fig. 64 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = +5^{\circ}$, $Re_{\infty}/ft = 1,100,000$

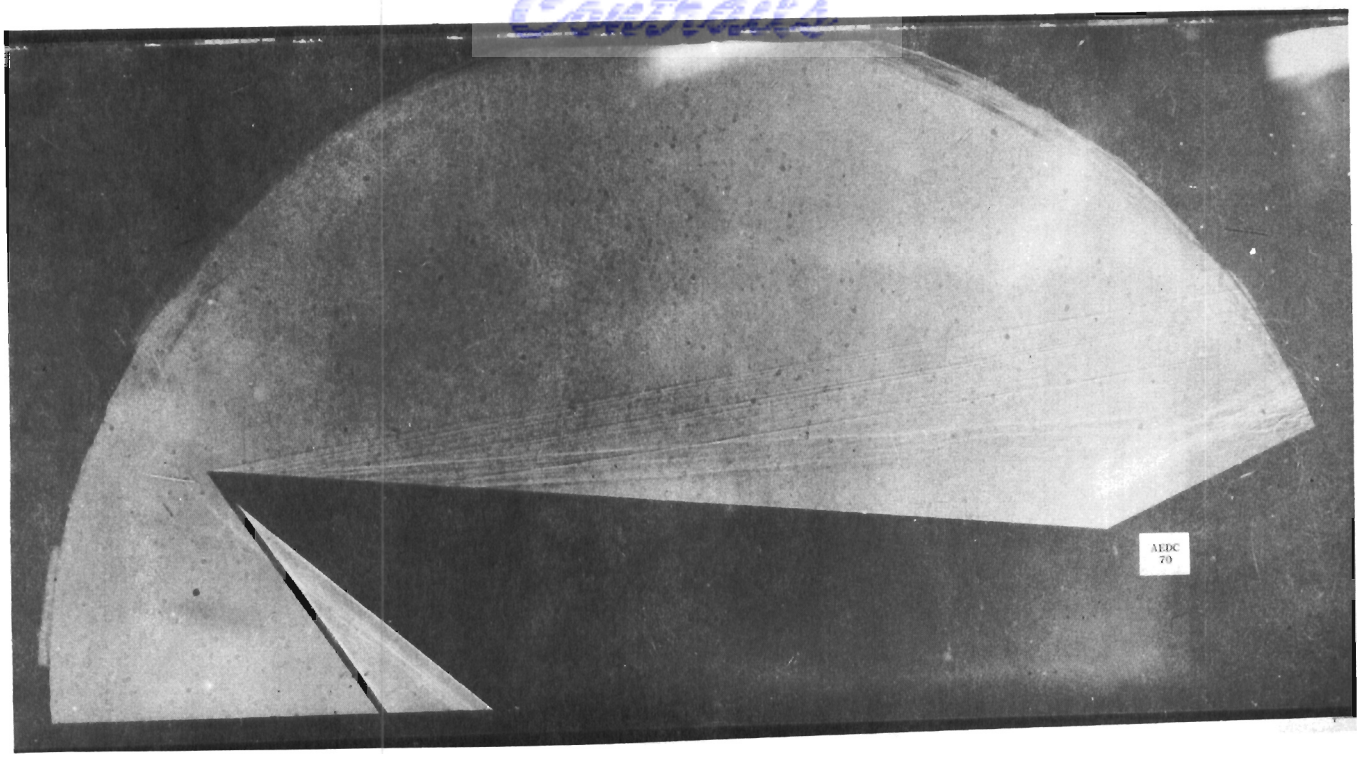


Fig. 65 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = +5^{\circ}$, $Re_{\infty}/ft = 2{,}200{,}000$

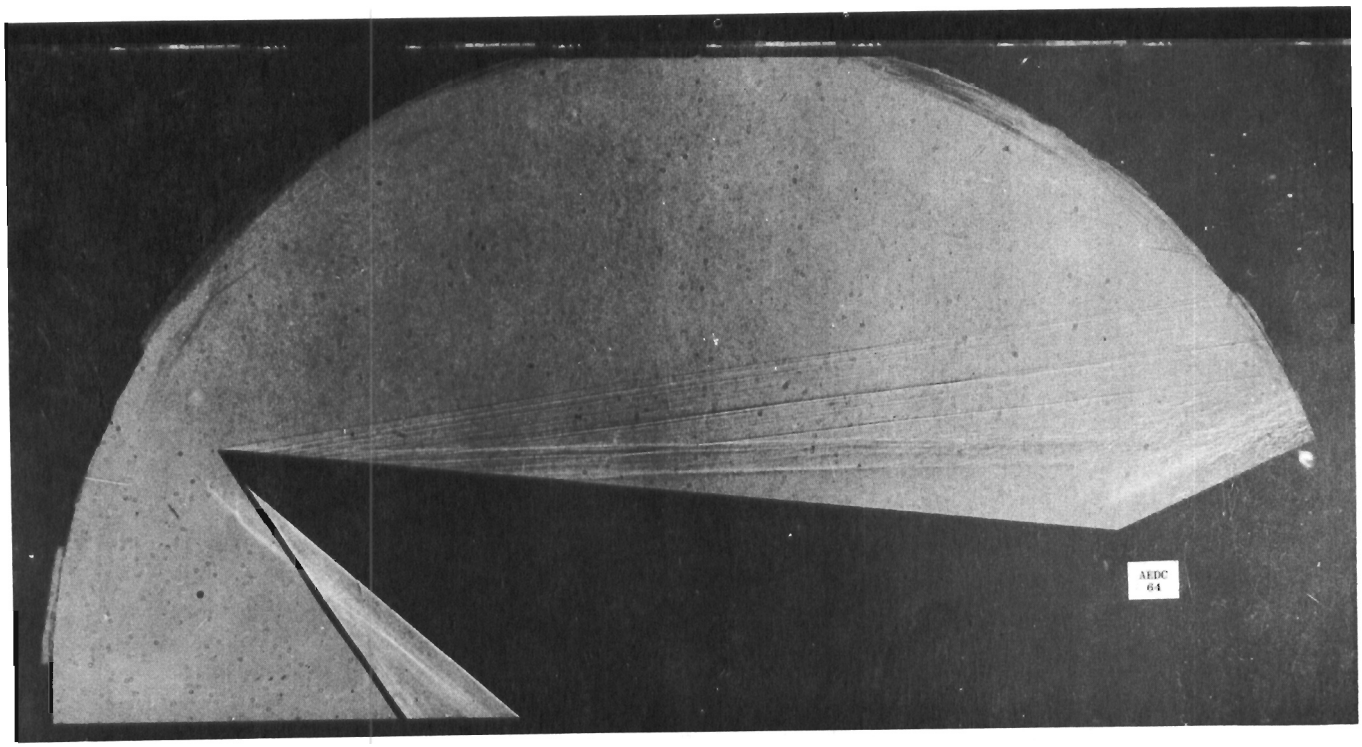


Fig. 66 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = +5^{\circ}$, $Re_{\infty}/ft = 3{,}300{,}000$

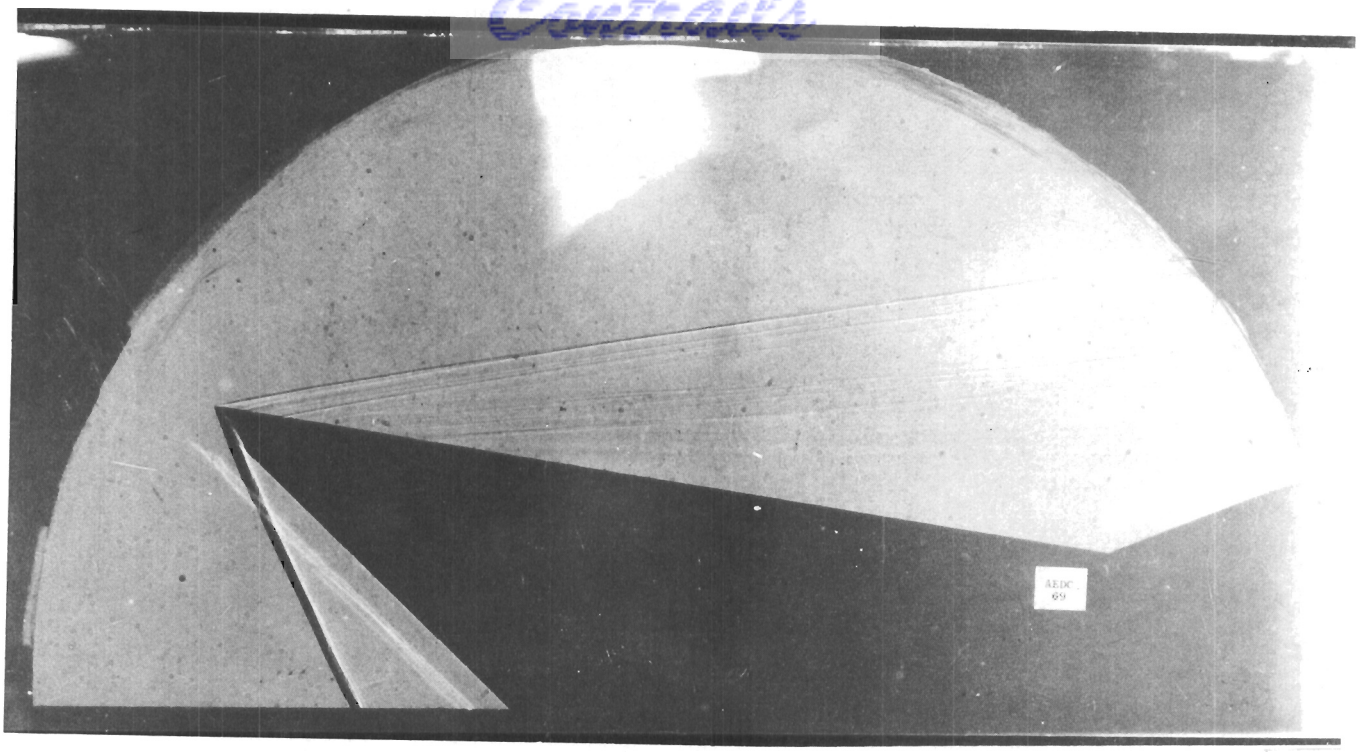


Fig. 67 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = +8^{\circ}$, $Re_{\infty}/ft = 3,300,000$

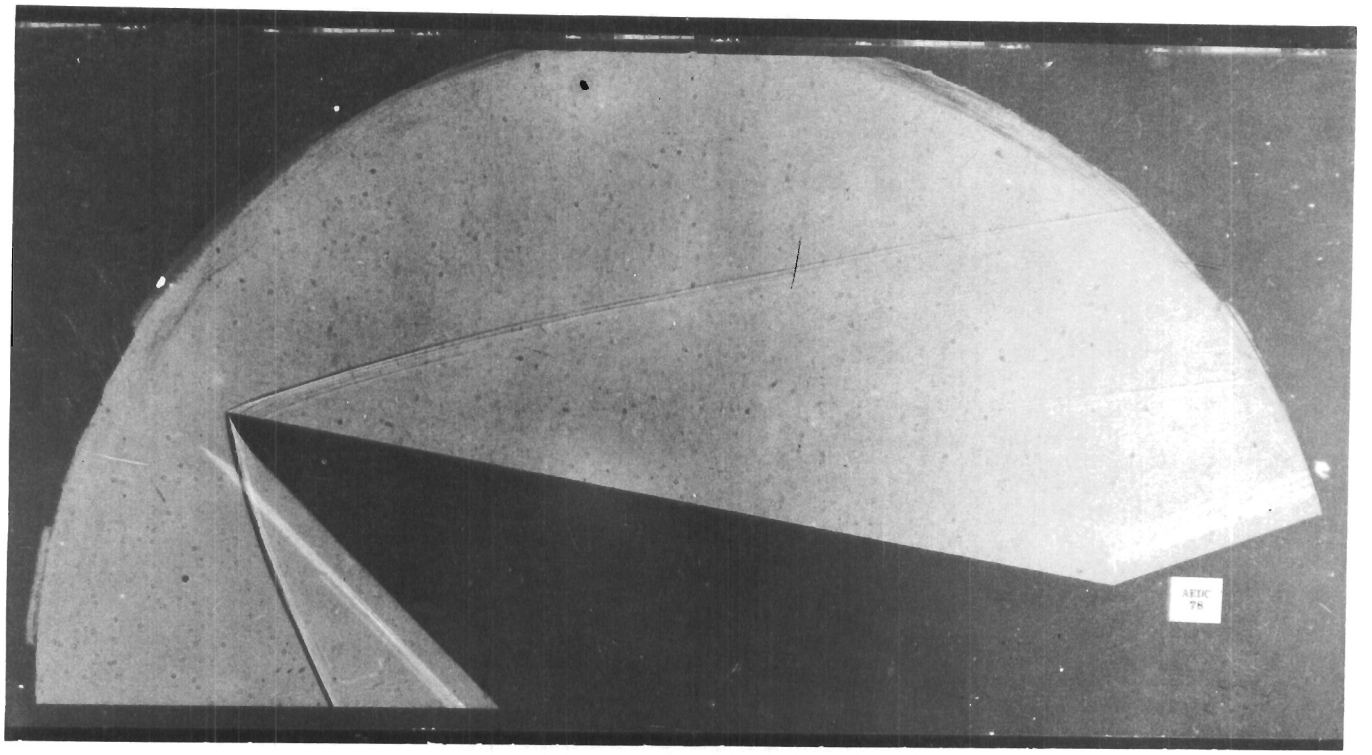


Fig. 68 Shadowgraph Flow Photograph; Coolant Flow Off, 30° Ramp, $\alpha = +10^{\circ}$, $Re_{\infty}/ft = 1,100,000$

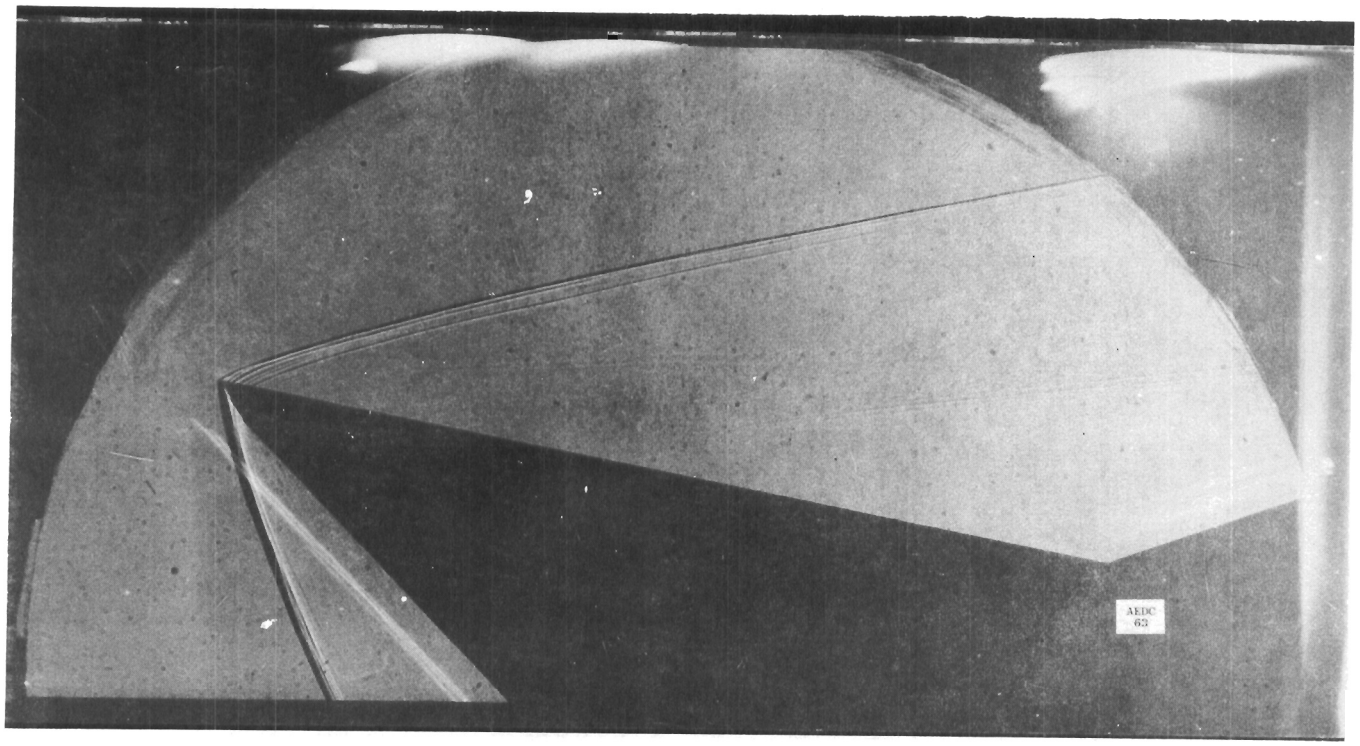


Fig. 69 Shadowgraph Flow Photograph; Coolant Flow Off, 30^{o} Ramp, $\alpha = +10^{o}$, $Re_{\infty}/ft = 3{,}300{,}000$

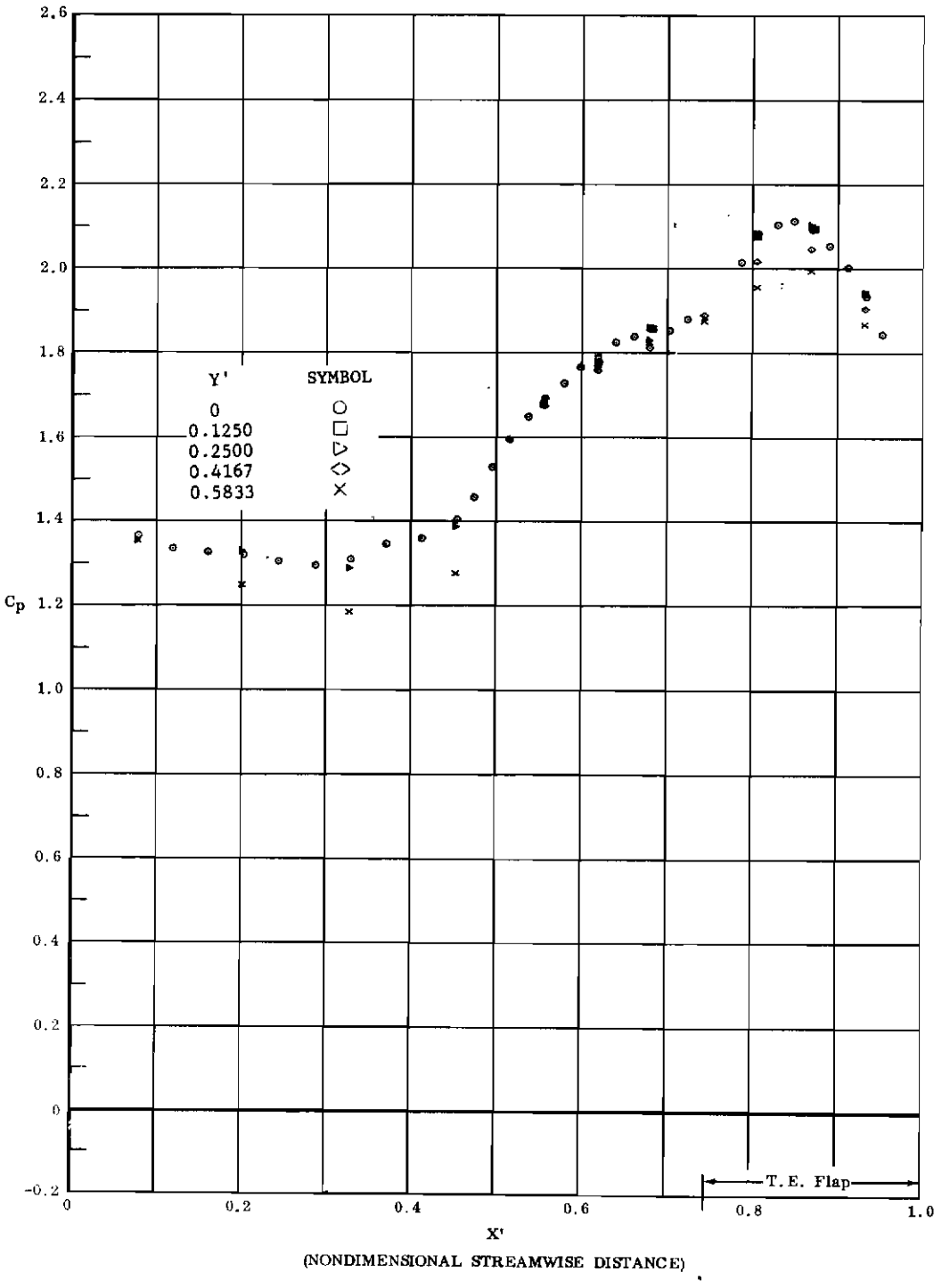


Fig. 70 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -43°$, $Re_\infty/ft = 1{,}100{,}000$.

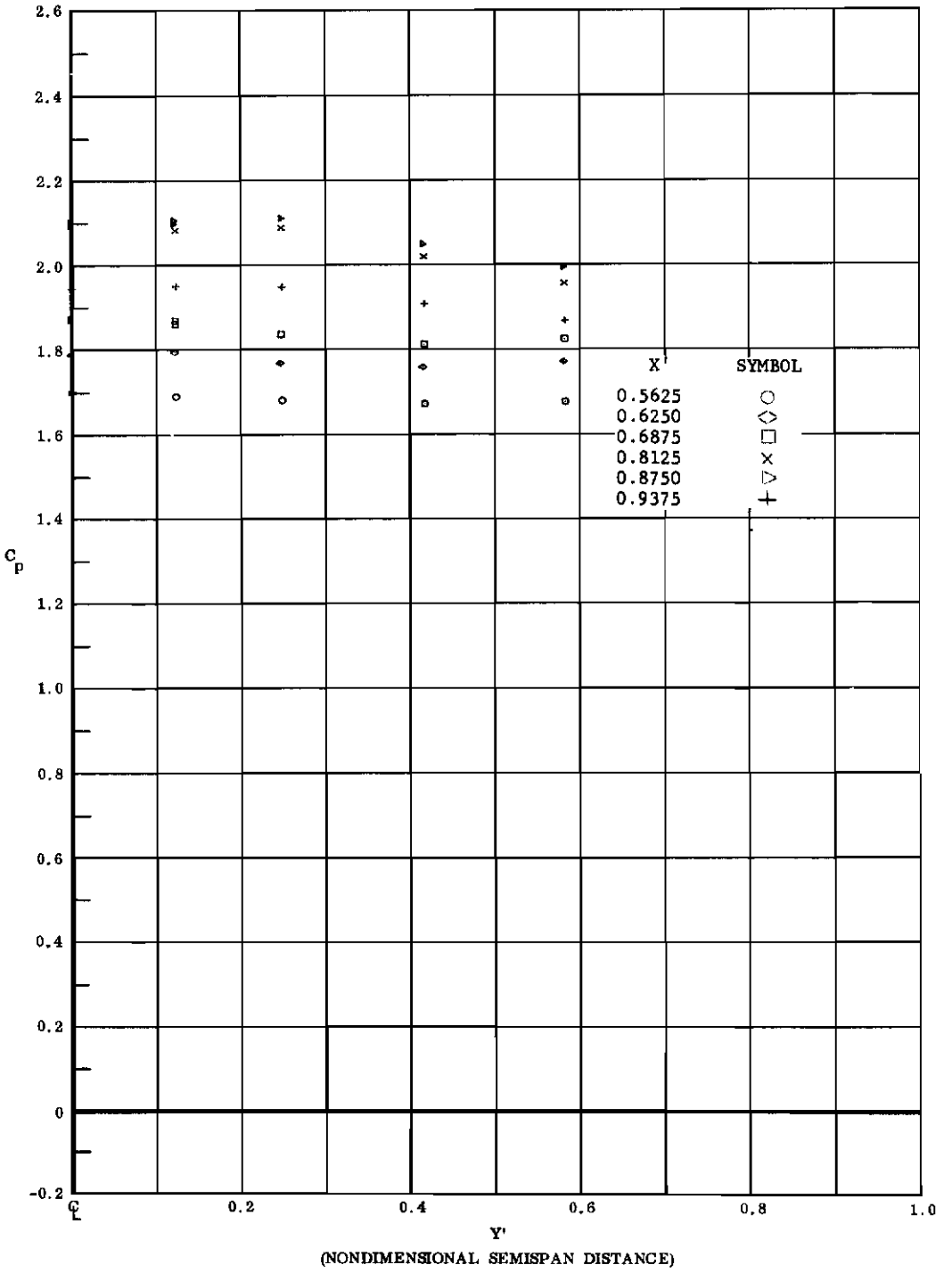


Fig. 70 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -43°, Re_∞/ft = 1,100,000.

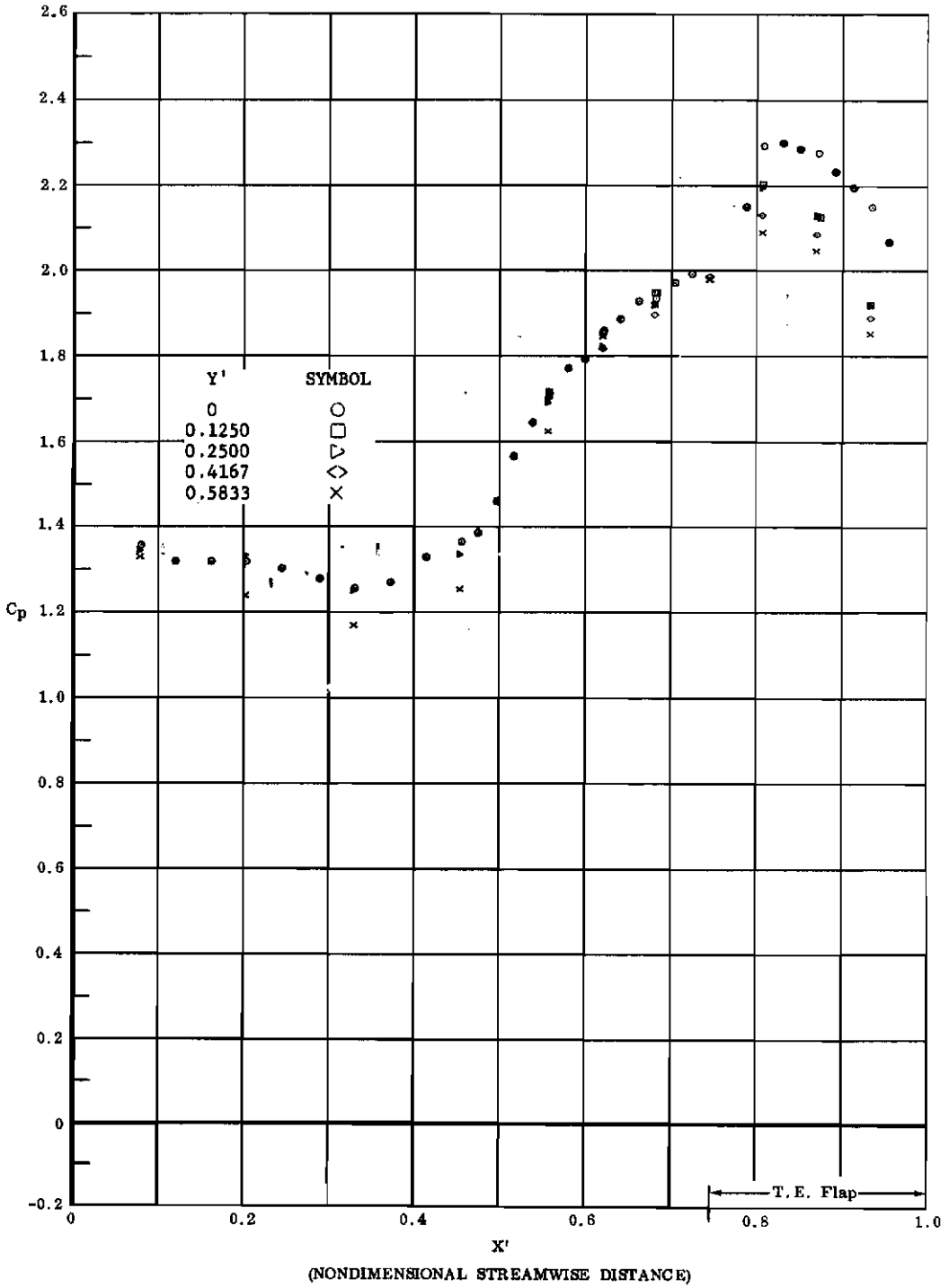


Fig. 71 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow On, $\alpha = -43°$, $Re_\infty/ft = 1{,}100{,}000$.

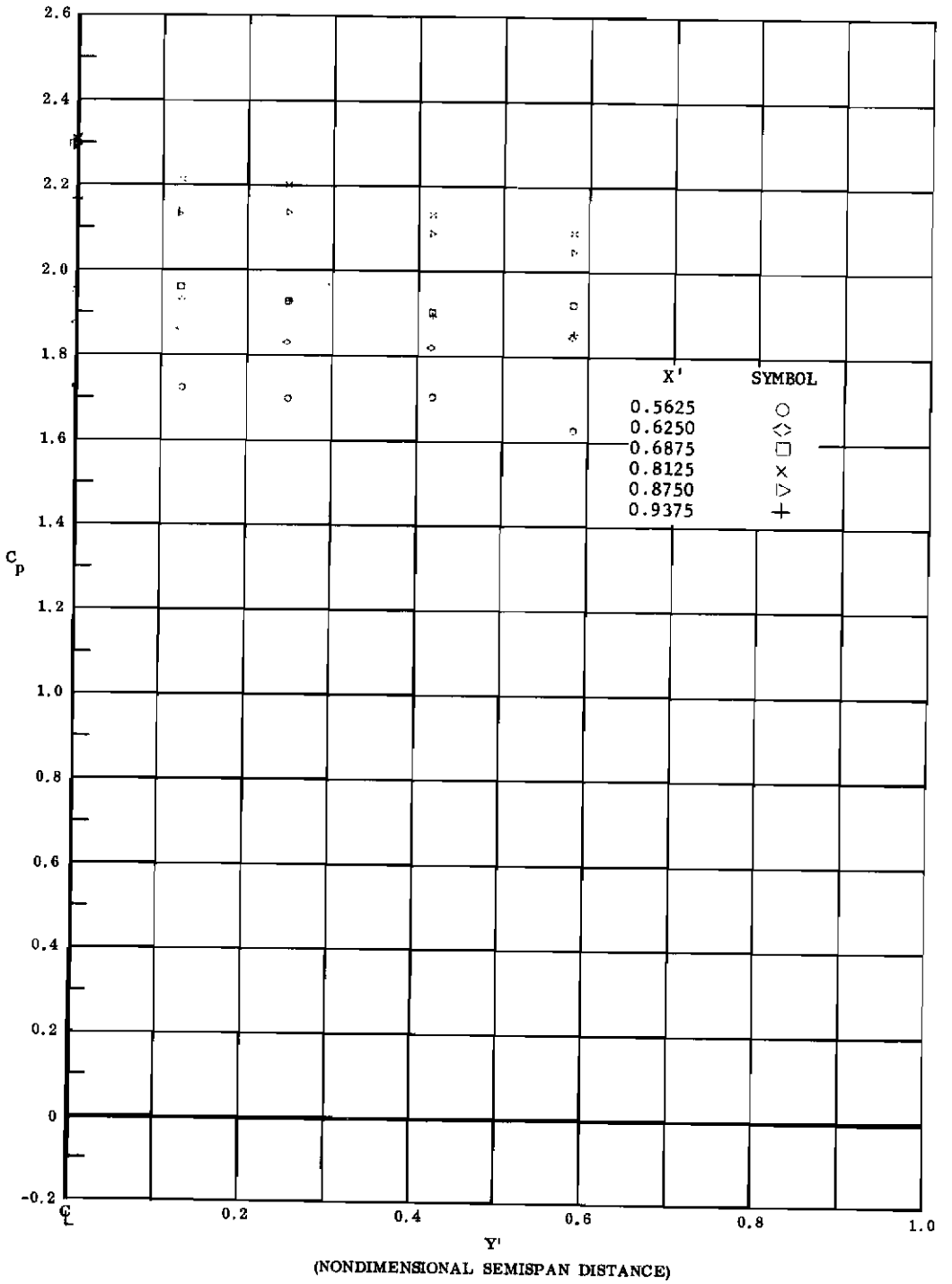


Fig. 71 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow On, α = -43°, Re_∞/ft = 1,100,000.

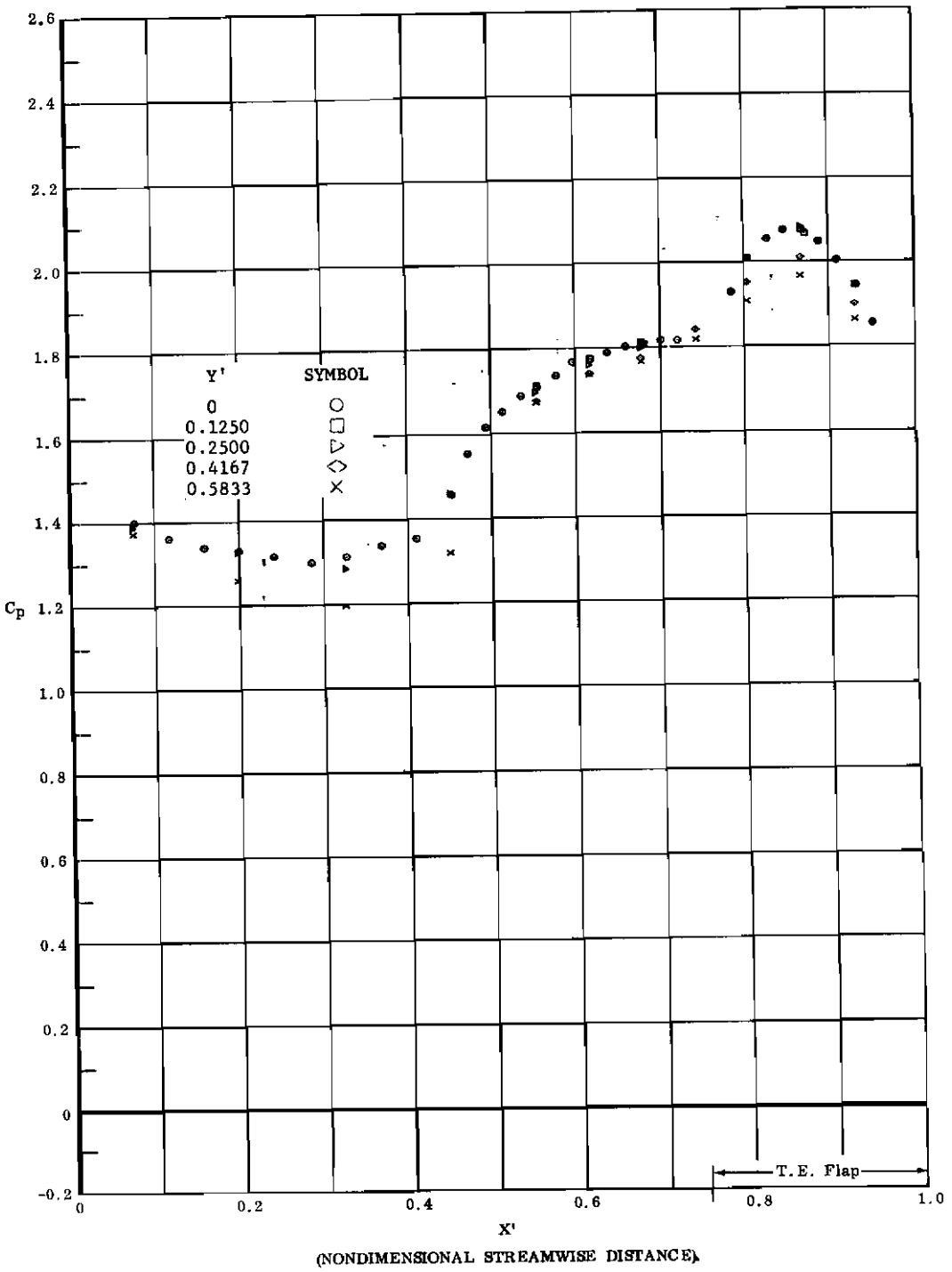


Fig. 72 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -43°, Re_∞/ft = 2,200,000.

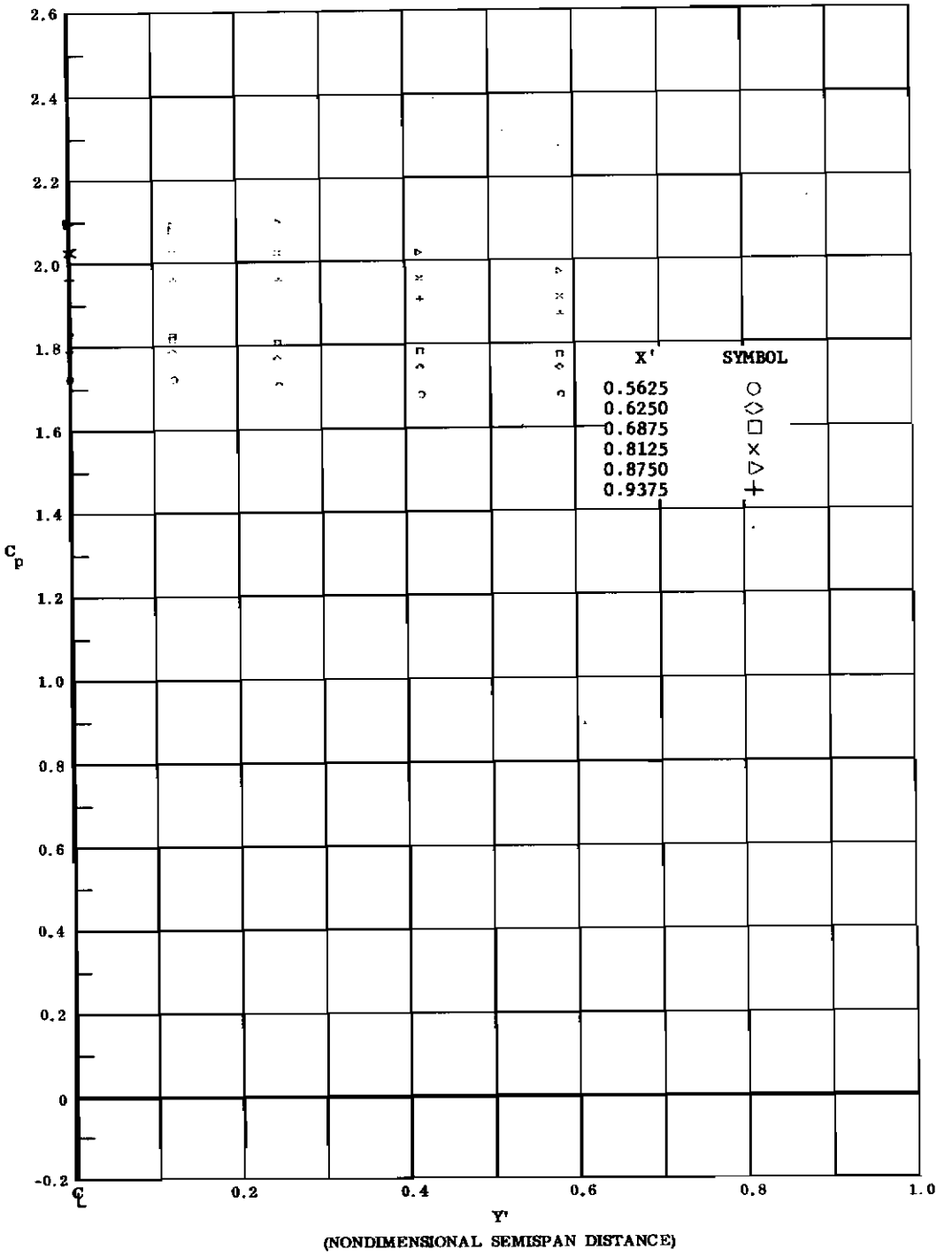


Fig. 72 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -43°, Re_∞/ft = 2,200,000.

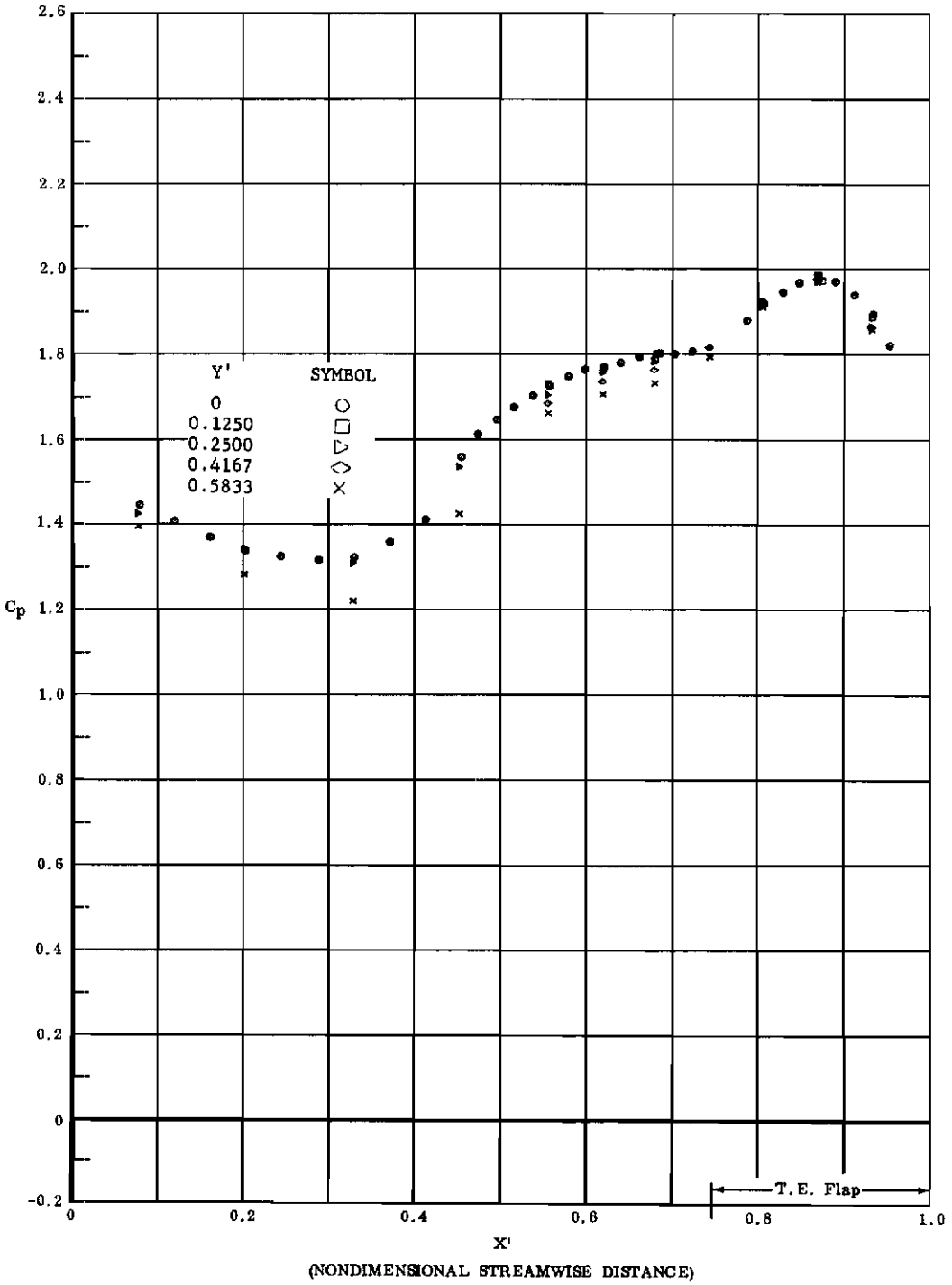


Fig. 73 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -43°$, $Re_\infty/ft = 3,300,000$.

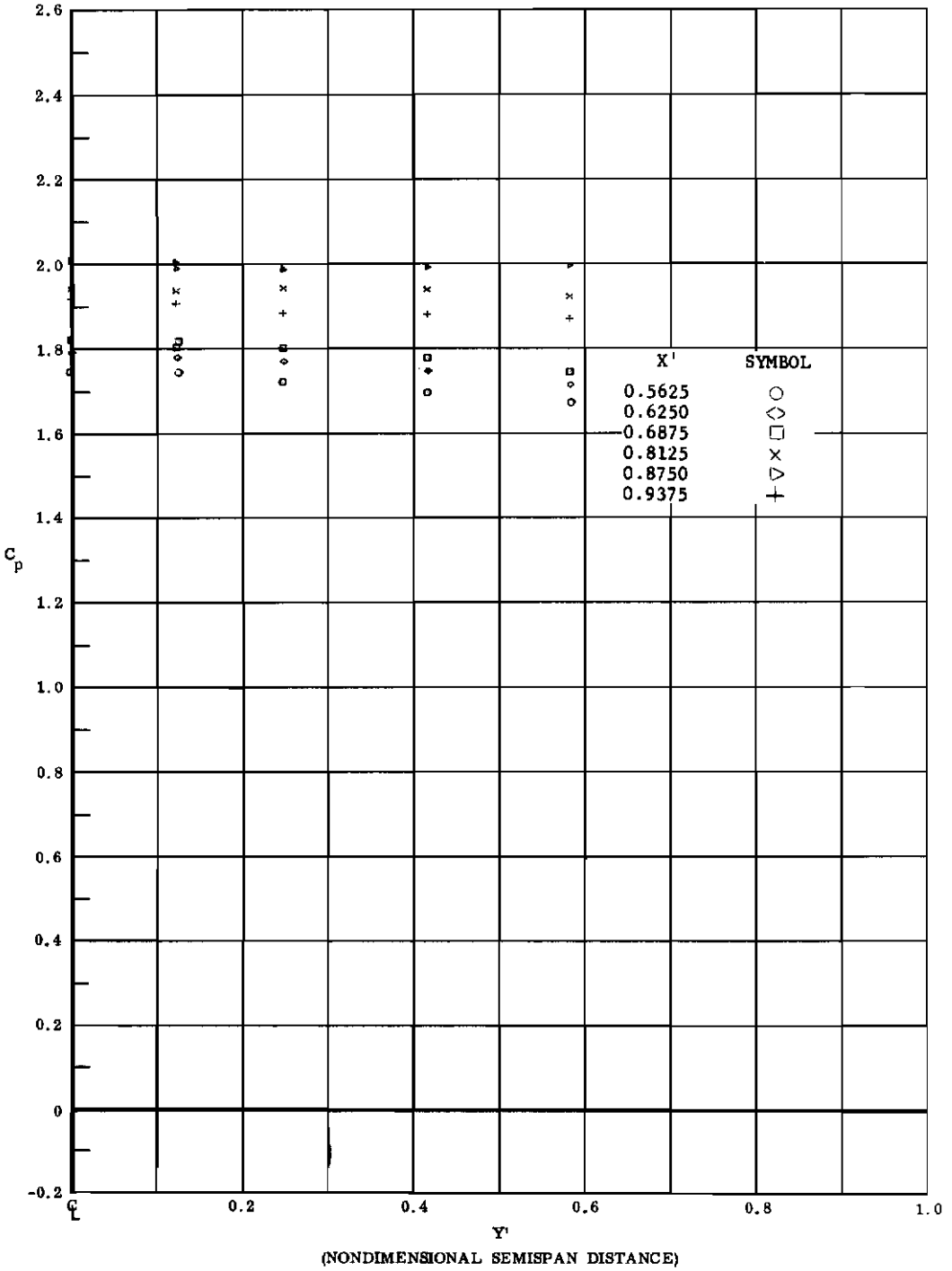


Fig. 73 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -43°, Re_∞/ft = 3,300,000.

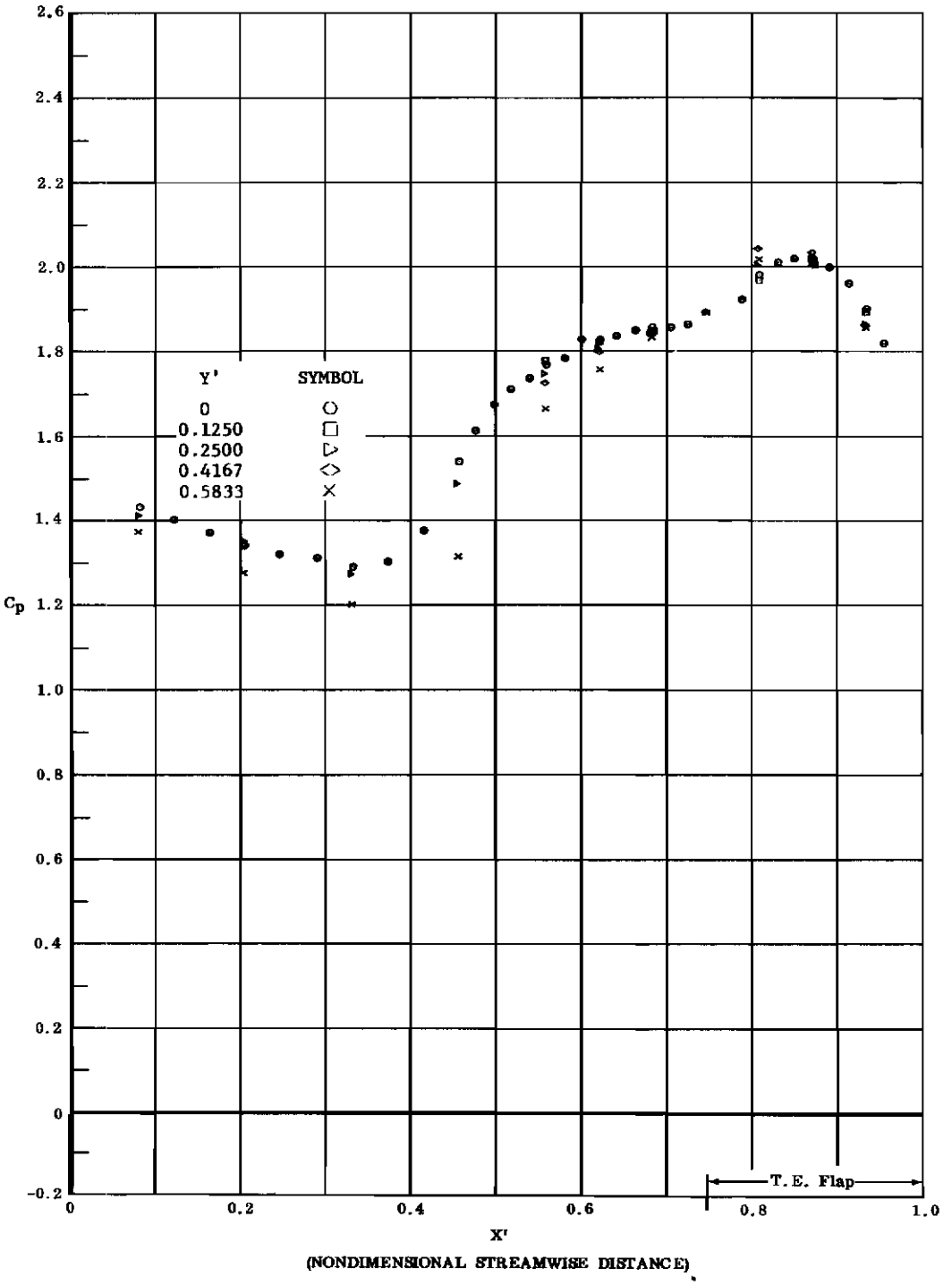


Fig. 74 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow On, α = -43°, Re_∞/ft = 3,300,000.

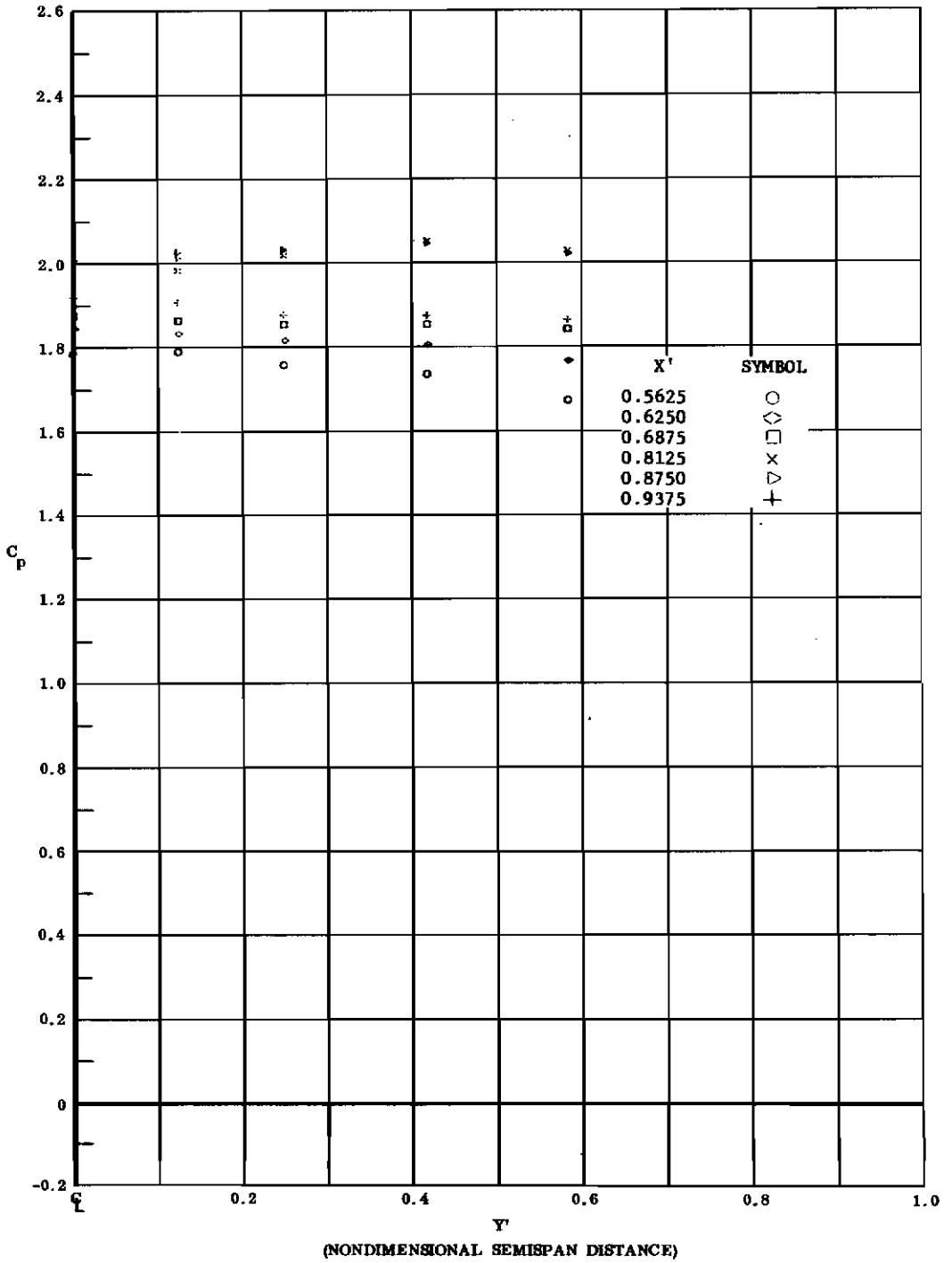


Fig. 74 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow On, α = -43°, Re_∞/ft = 3,300,000.

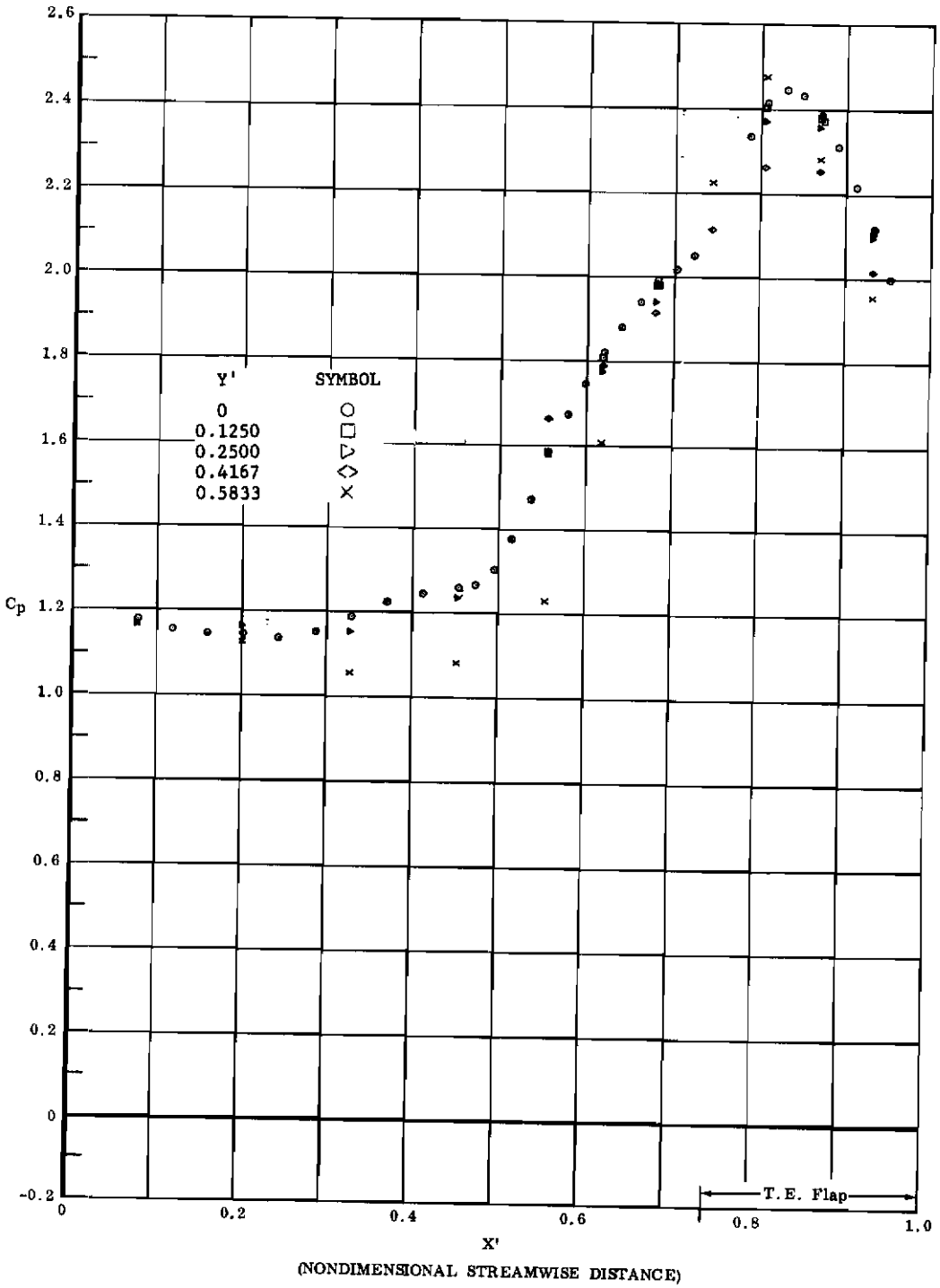


Fig. 75 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -40°$, $Re_\infty/ft = 1{,}100{,}000$.

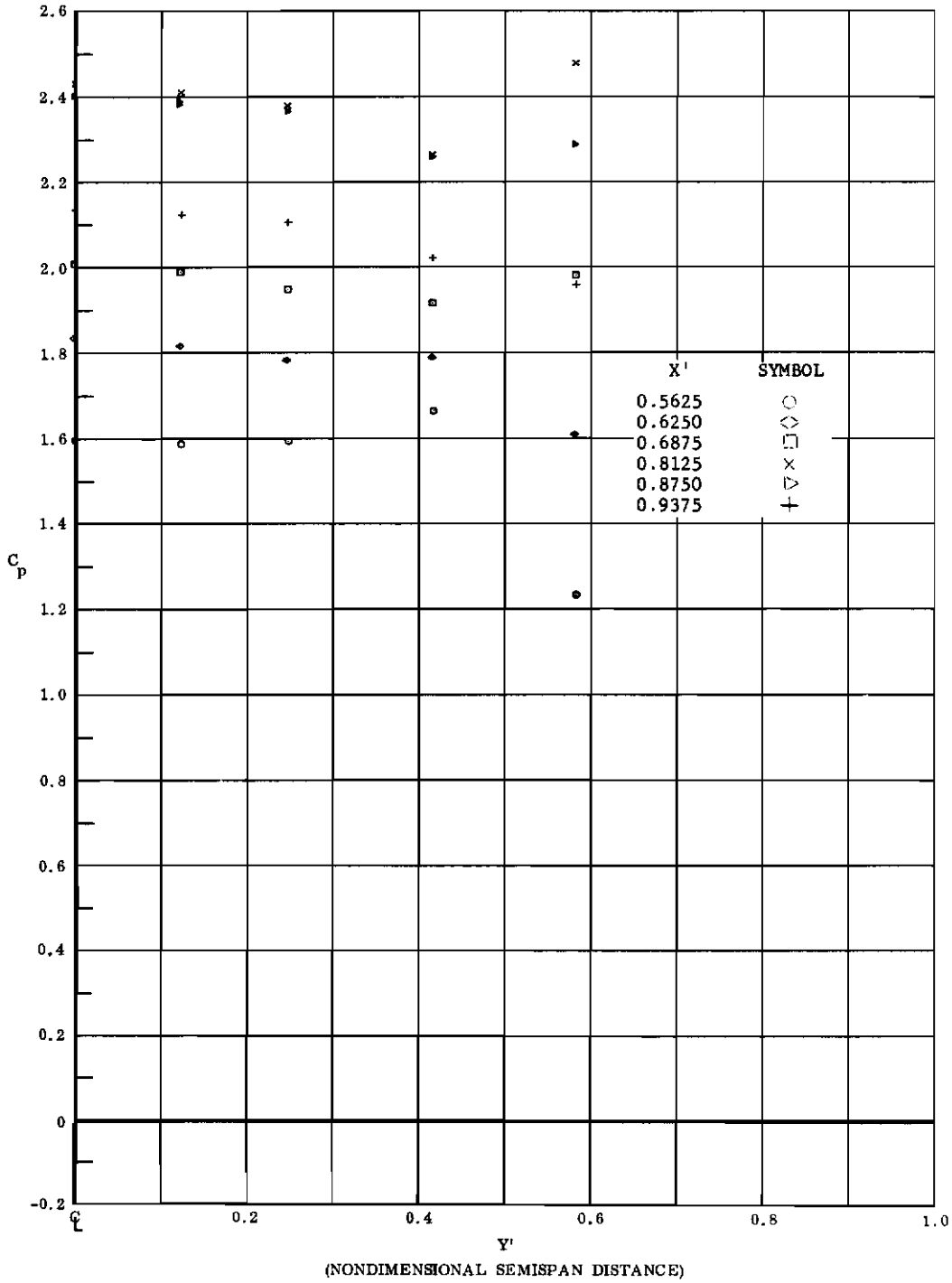


Fig. 75 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -40°, Re_∞/ft = 1,100,000.

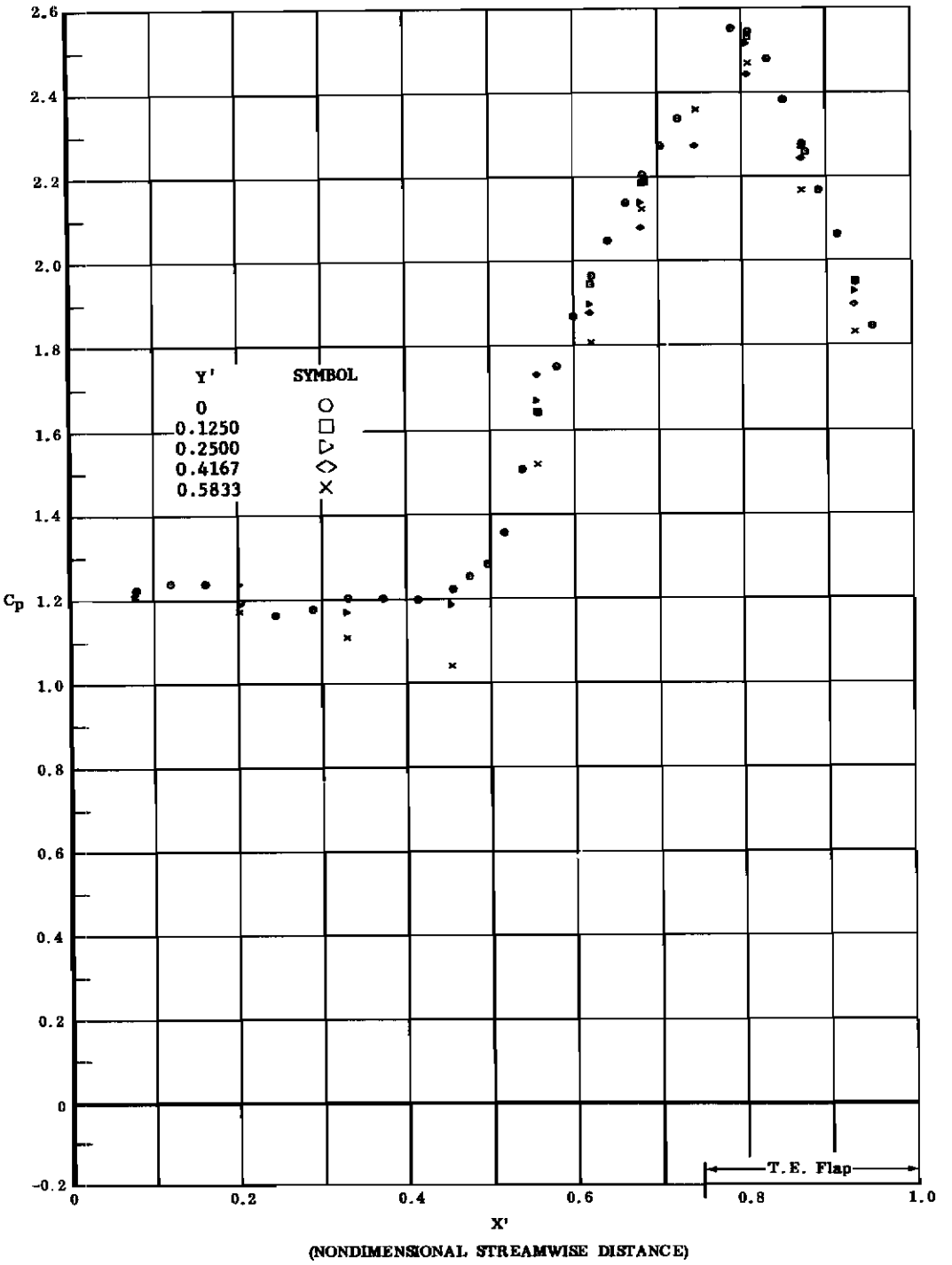


Fig. 76 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -40°$, $Re_\infty/ft = 3{,}300{,}000$.

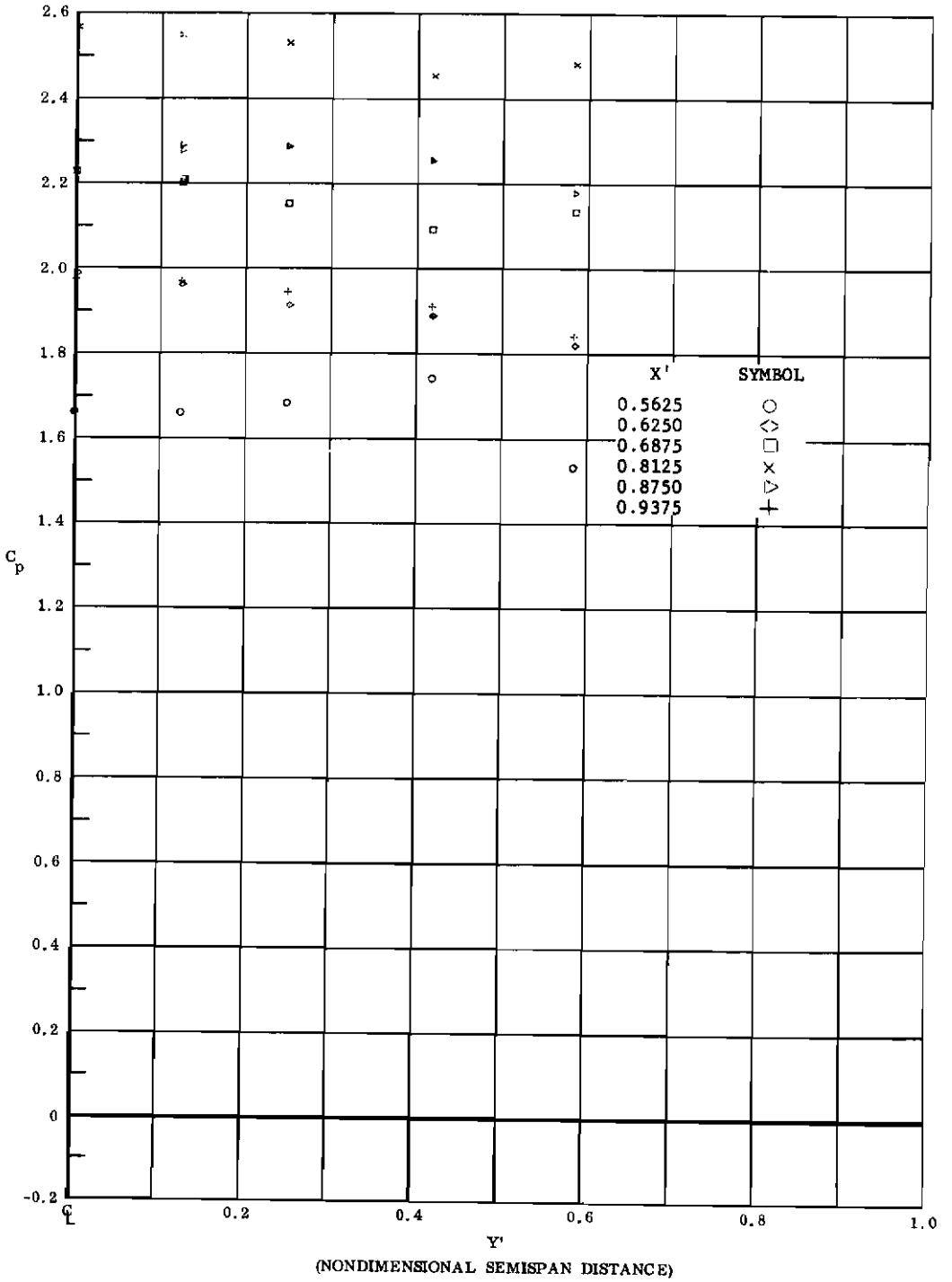


Fig. 76 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -40°, Re_∞/ft = 3,300,000.

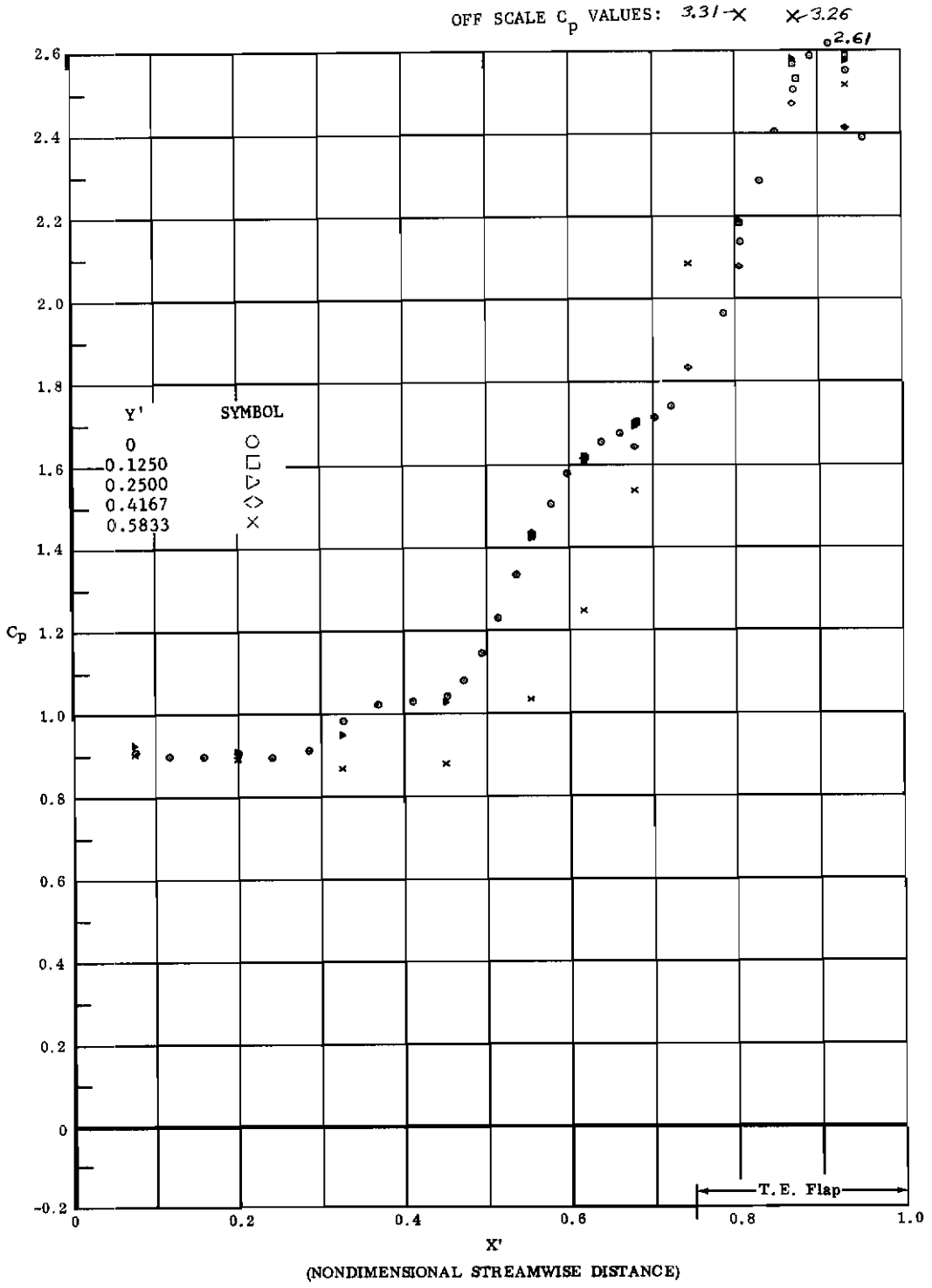


Fig. 77 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -35°$, $Re_\infty/ft = 1,100,000$.

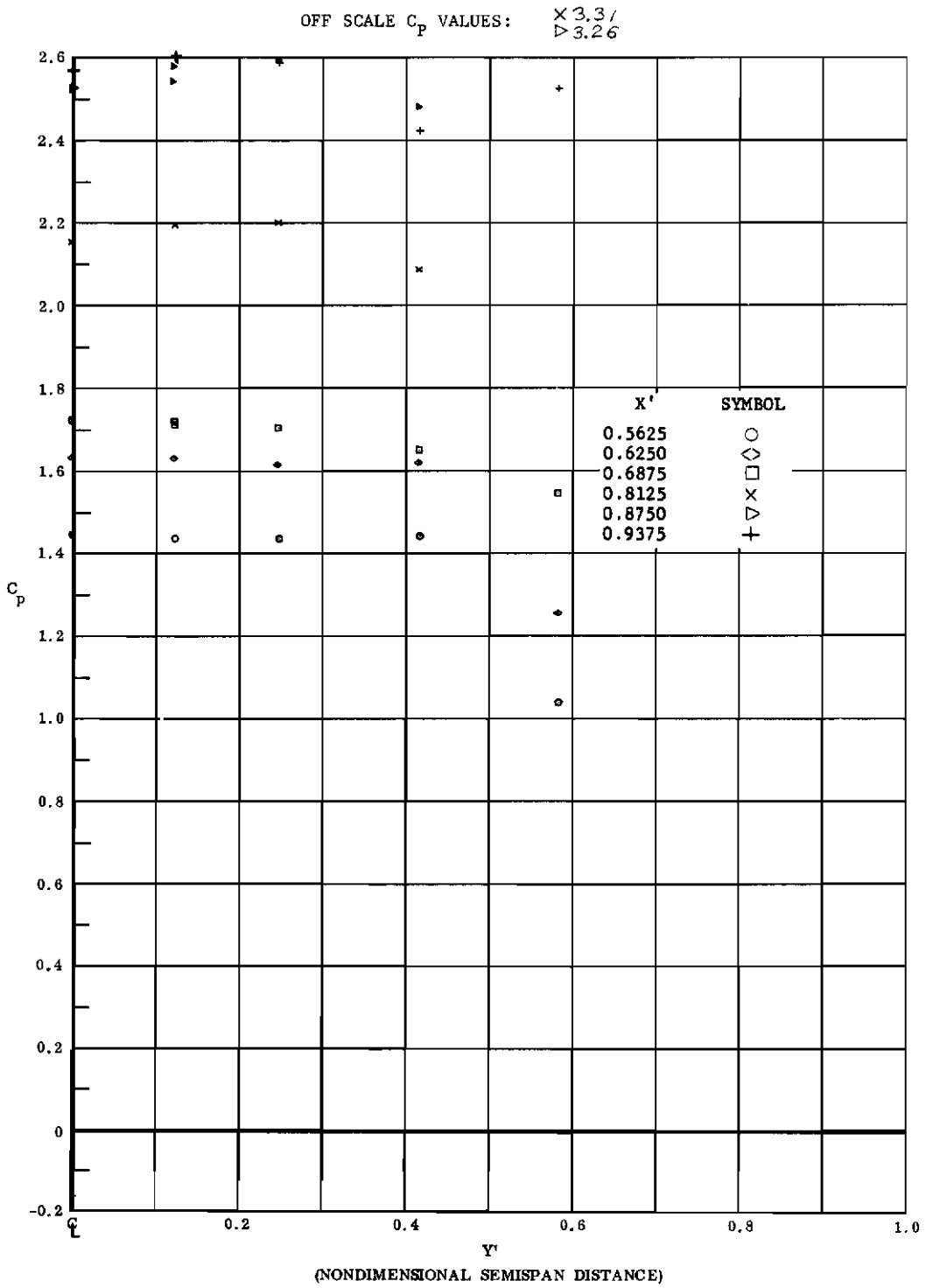


Fig. 77 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -35°, Re_∞/ft = 1,100,000.

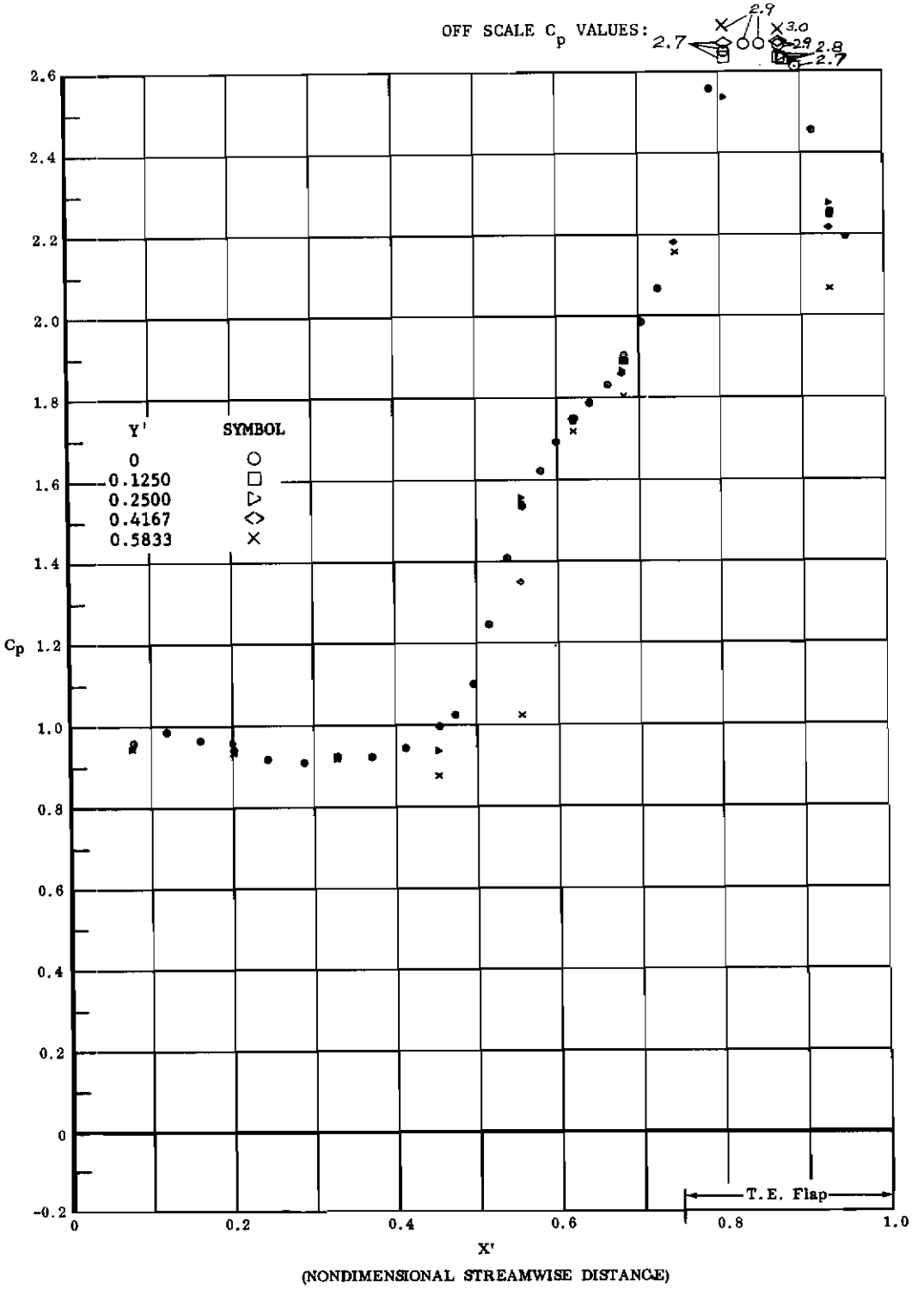


Fig. 78 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -35°, Re_∞/ft = 3,300,000.

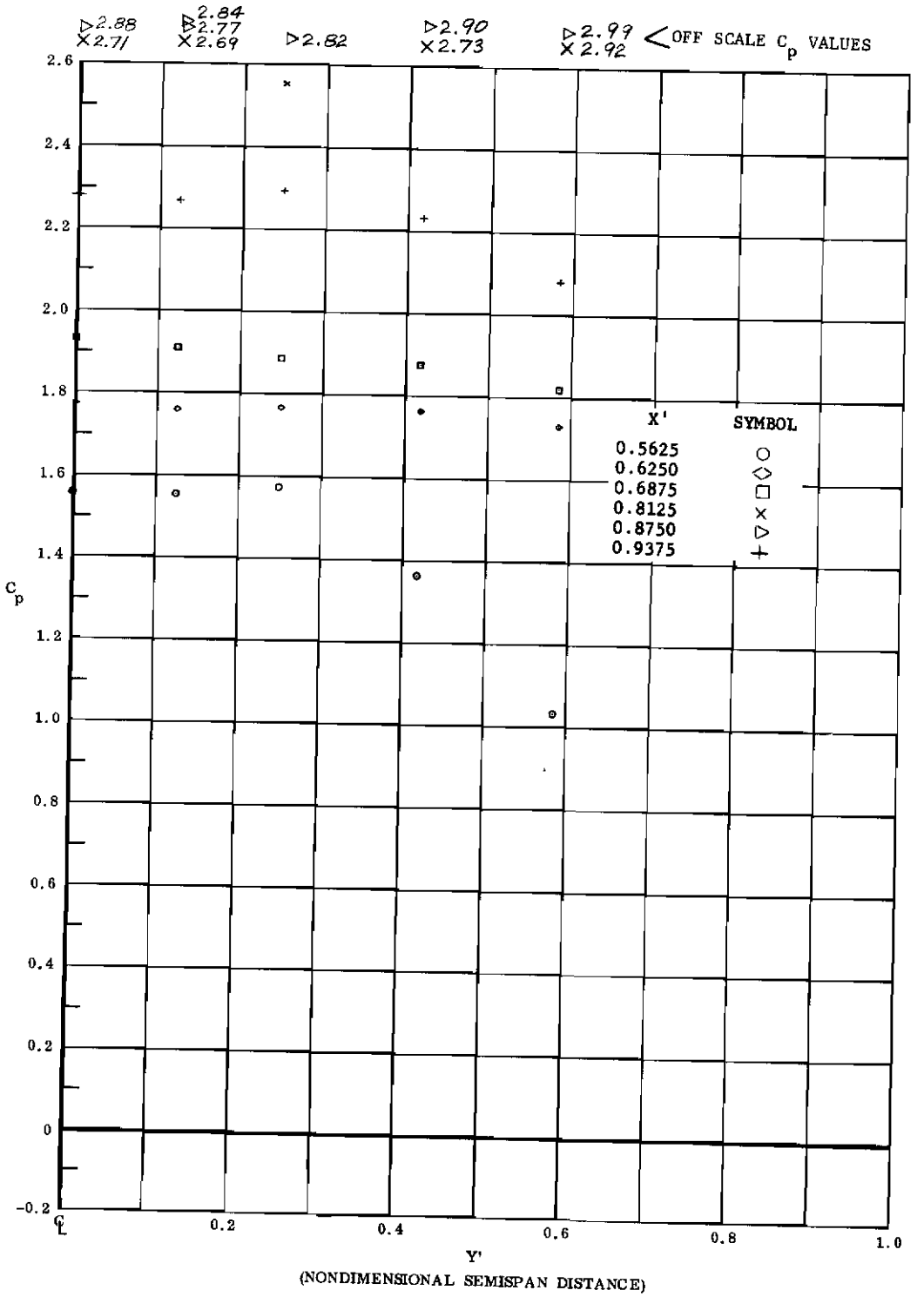


Fig. 78 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -35°, Re_∞/ft = 3,300,000.

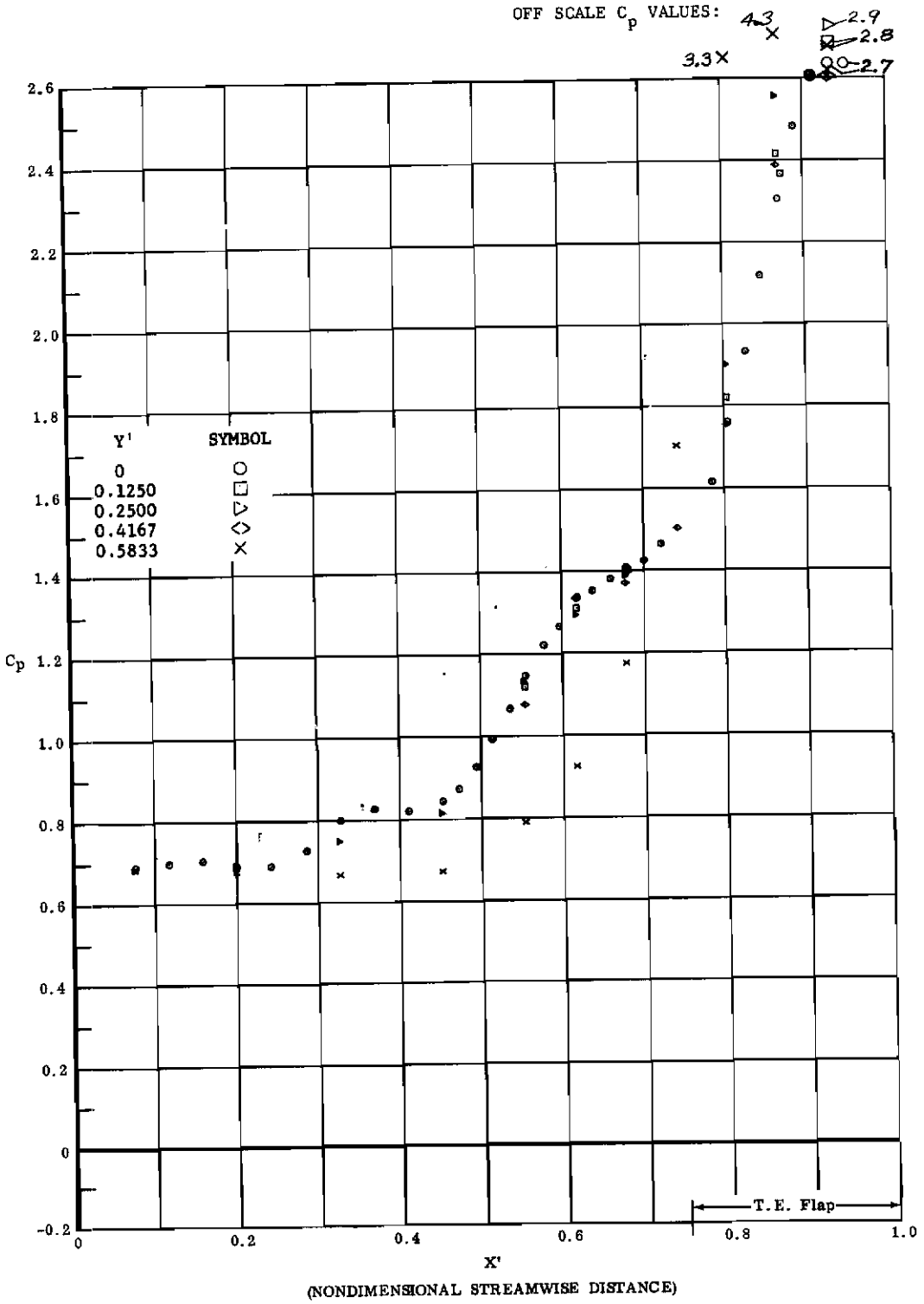


Fig. 79 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -30°$, $Re_\infty/ft = 1{,}100{,}000$.

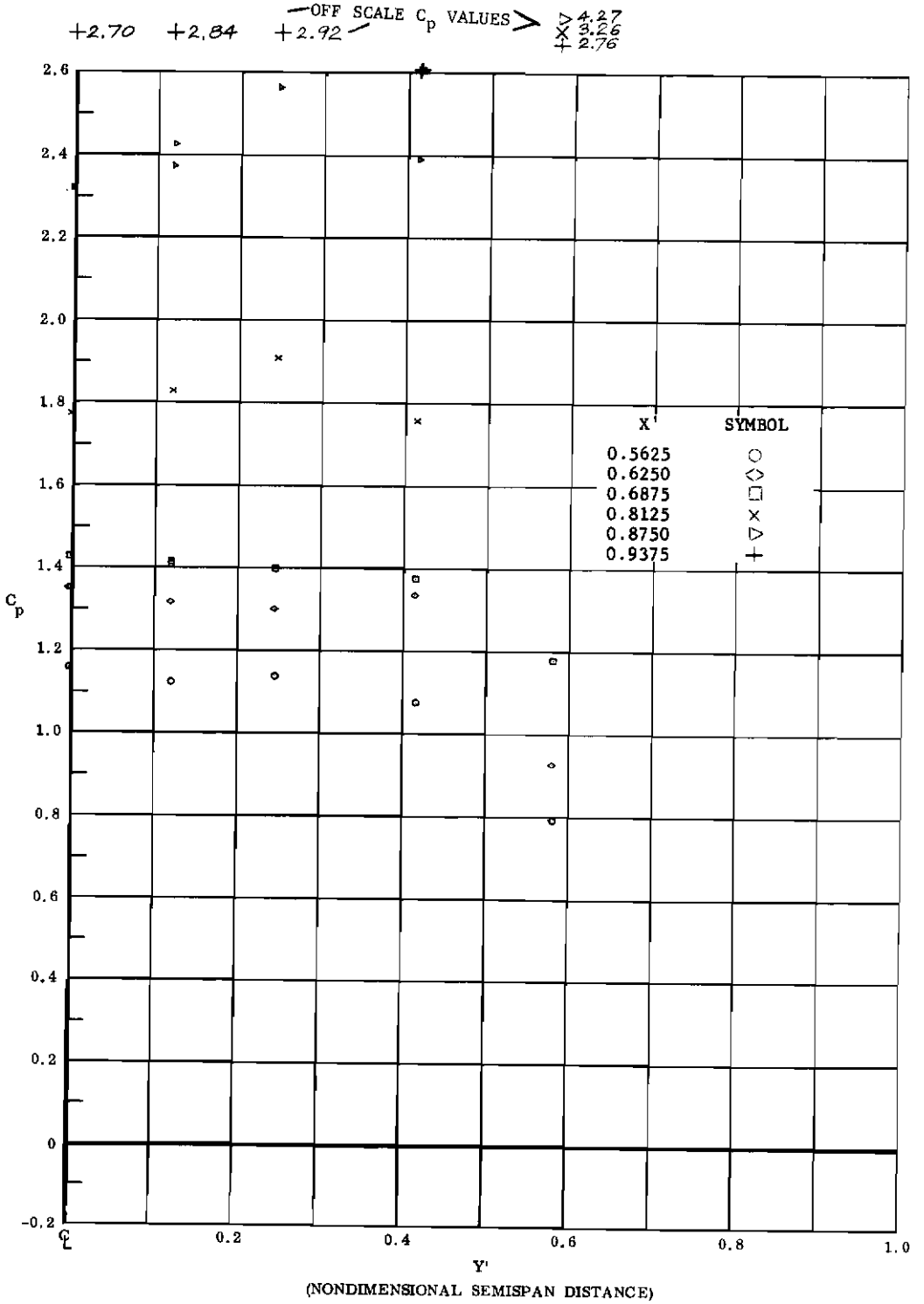


Fig. 79 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -30°$, $Re_\infty/ft = 1{,}100{,}000$.

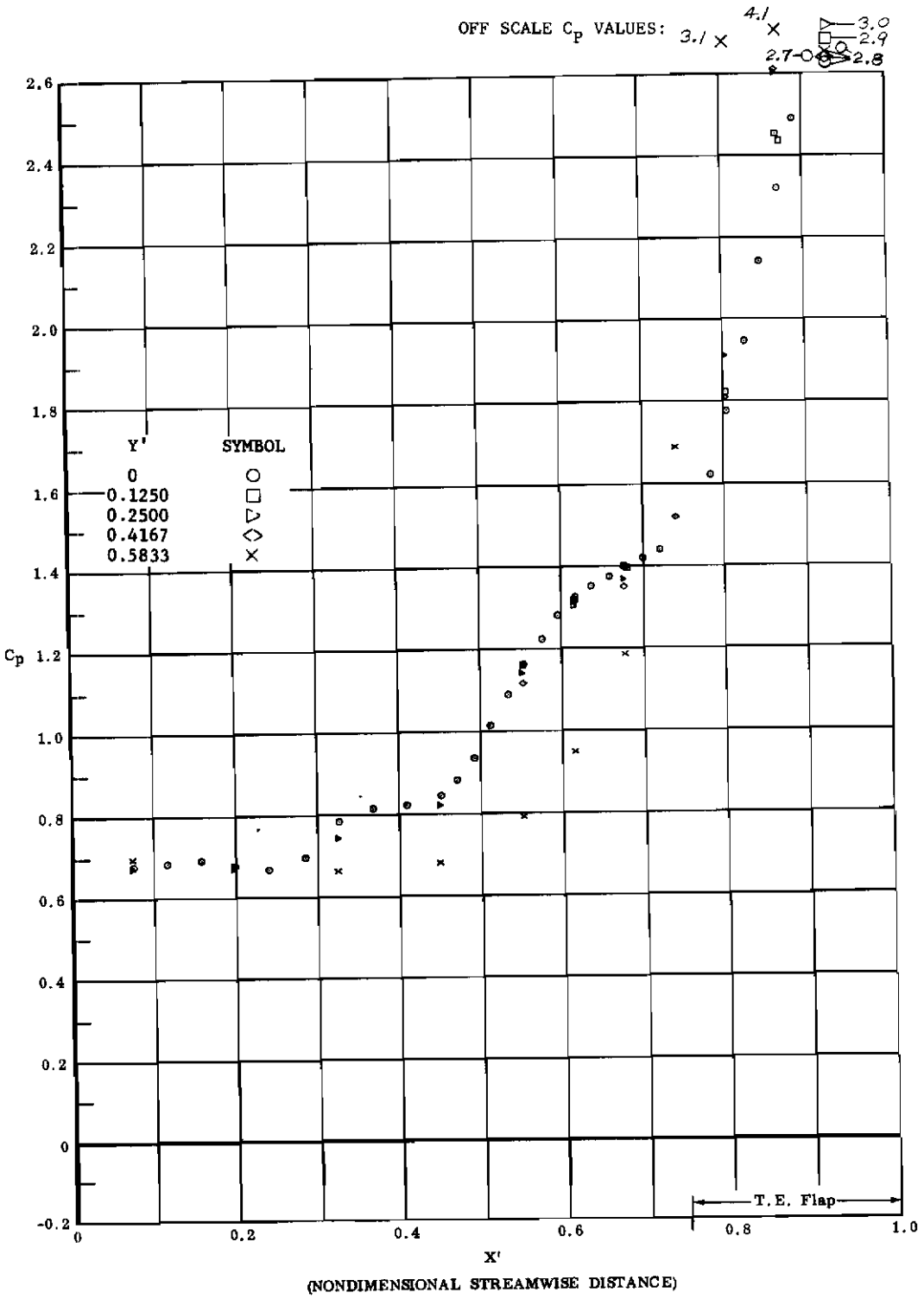


Fig. 80 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow On, $\alpha = -30°$, $Re_\infty/ft = 1{,}100{,}000$.

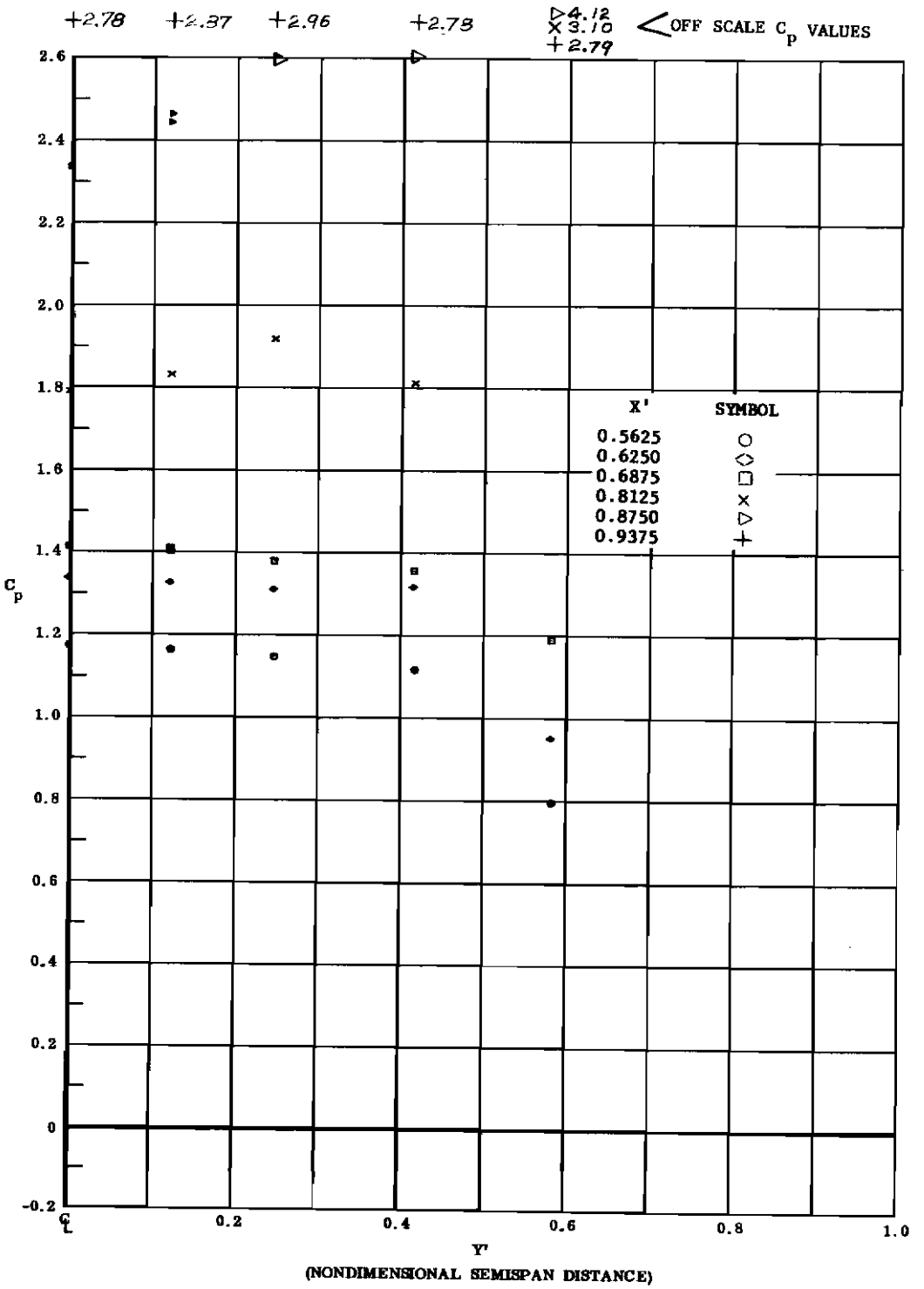
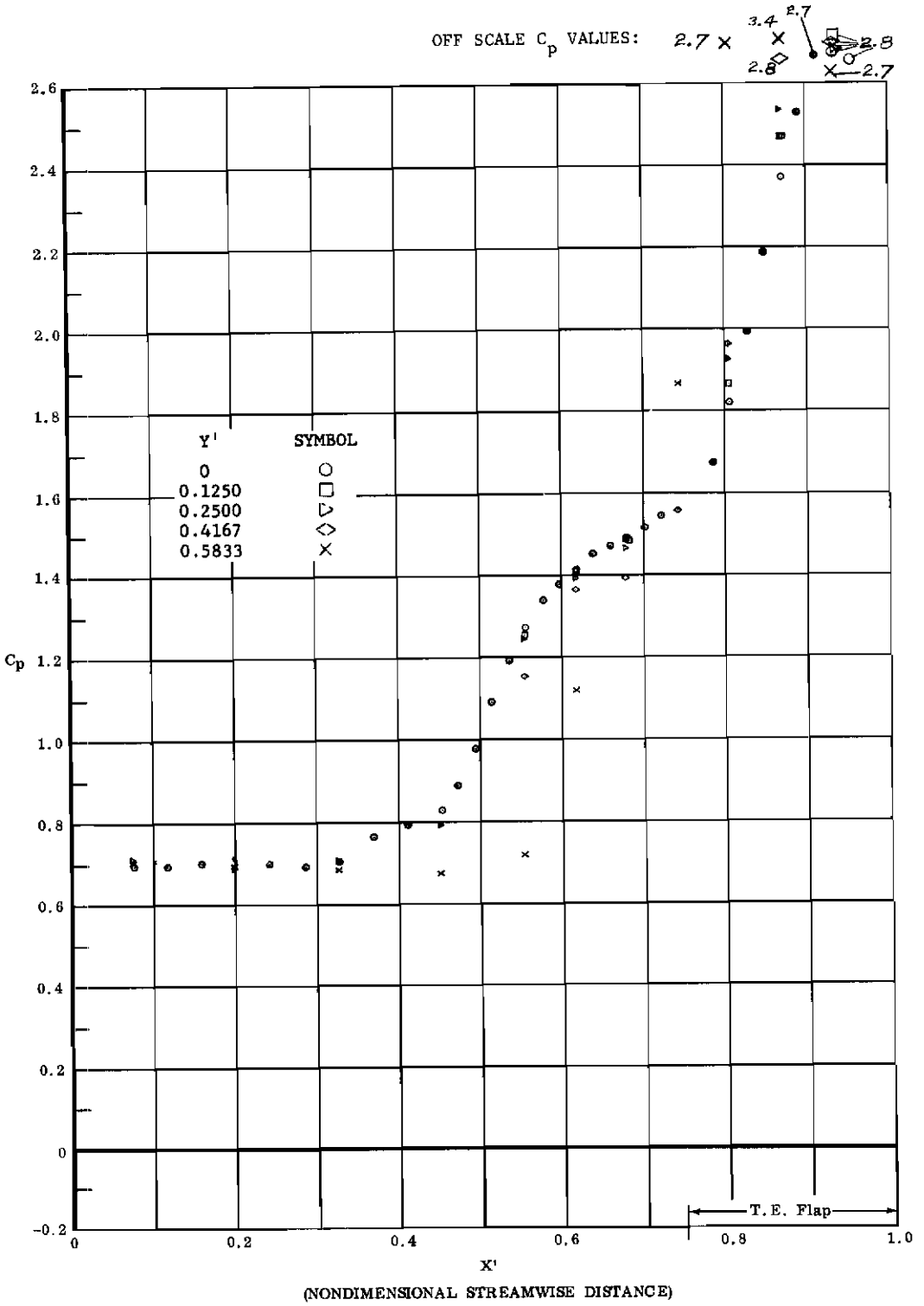


Fig. 80 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow On, $\alpha = -30°$, $Re_\infty/ft = 1{,}100{,}000$.



(NONDIMENSIONAL STREAMWISE DISTANCE)

Fig. 81 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -30°$, $Re_\infty/ft = 2,200,000$.

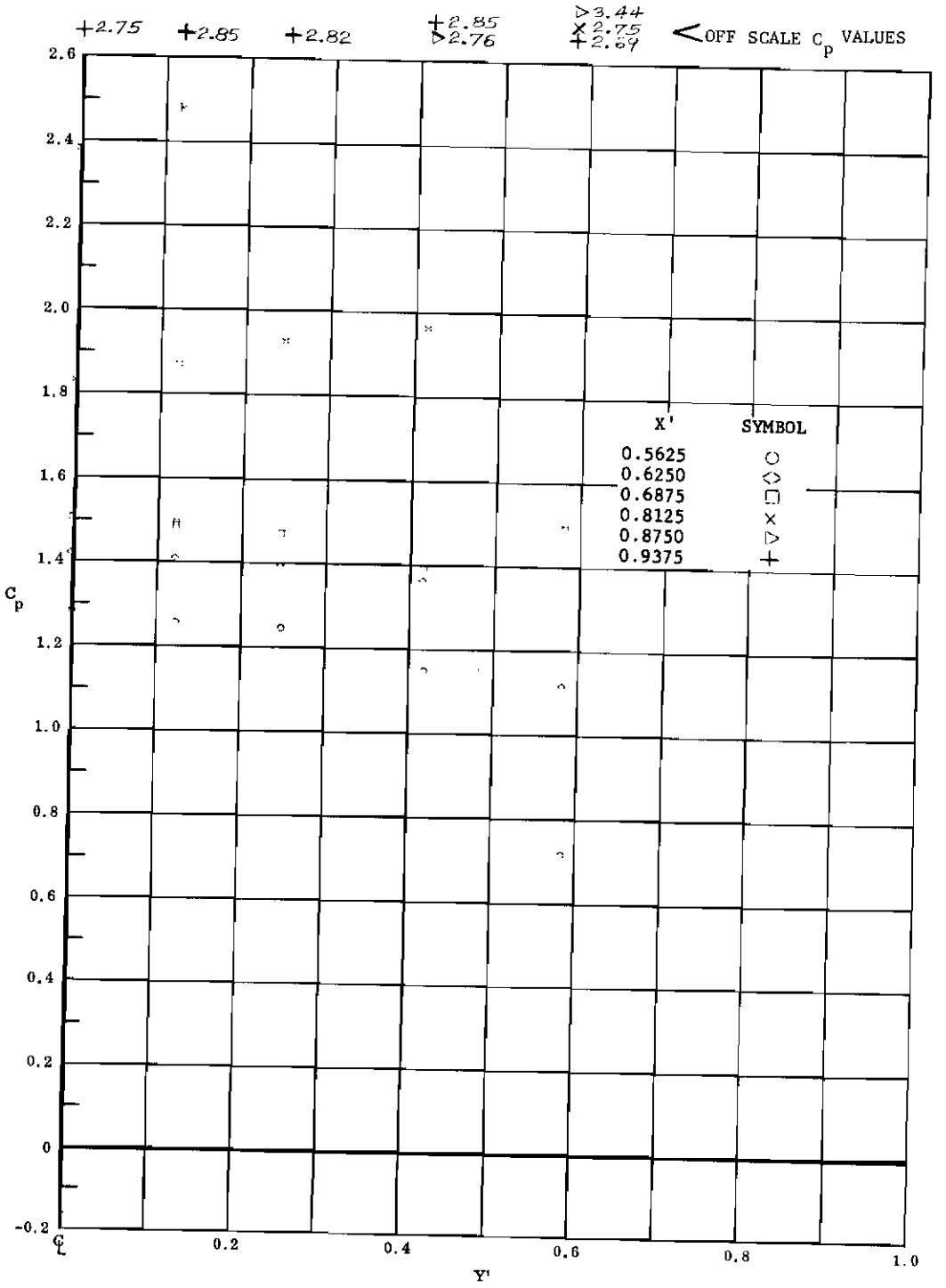


Fig. 81 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -30°, Re_∞/ft = 2,200,000.

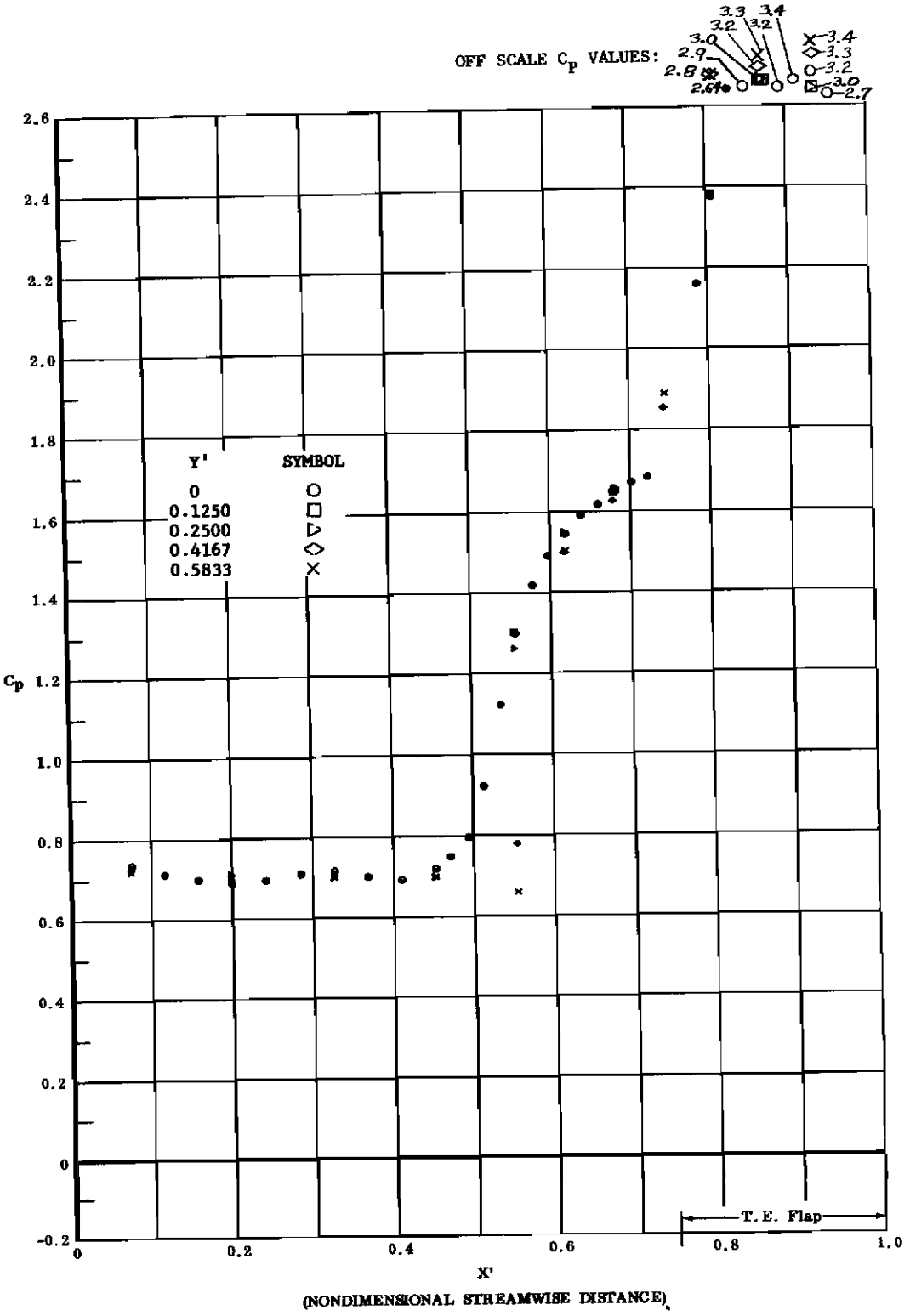


Fig. 82 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -30°$, $Re_\infty/ft = 3{,}300{,}000$.

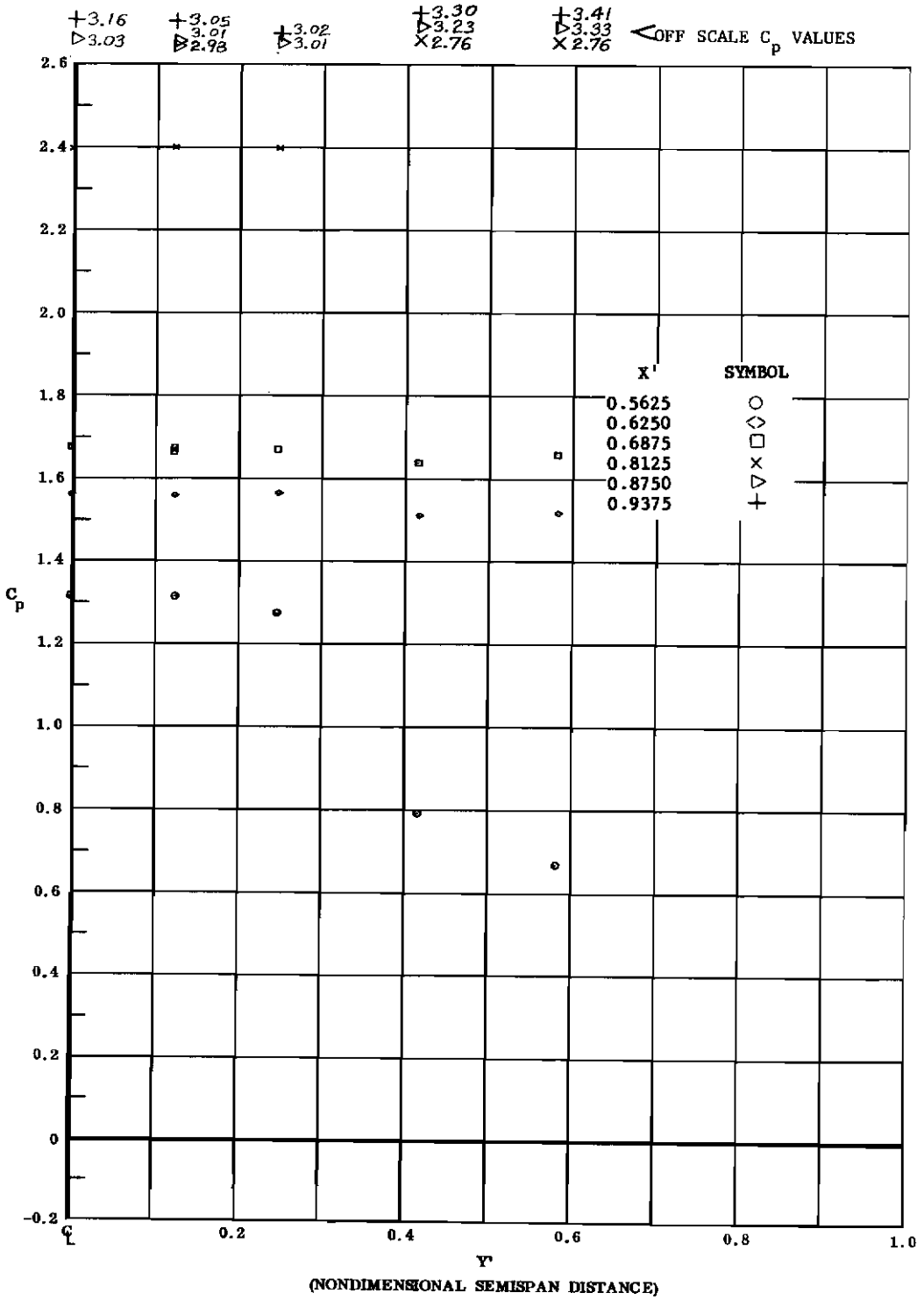


Fig. 82 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -30°$, $Re_\infty/ft = 3{,}300{,}000$.

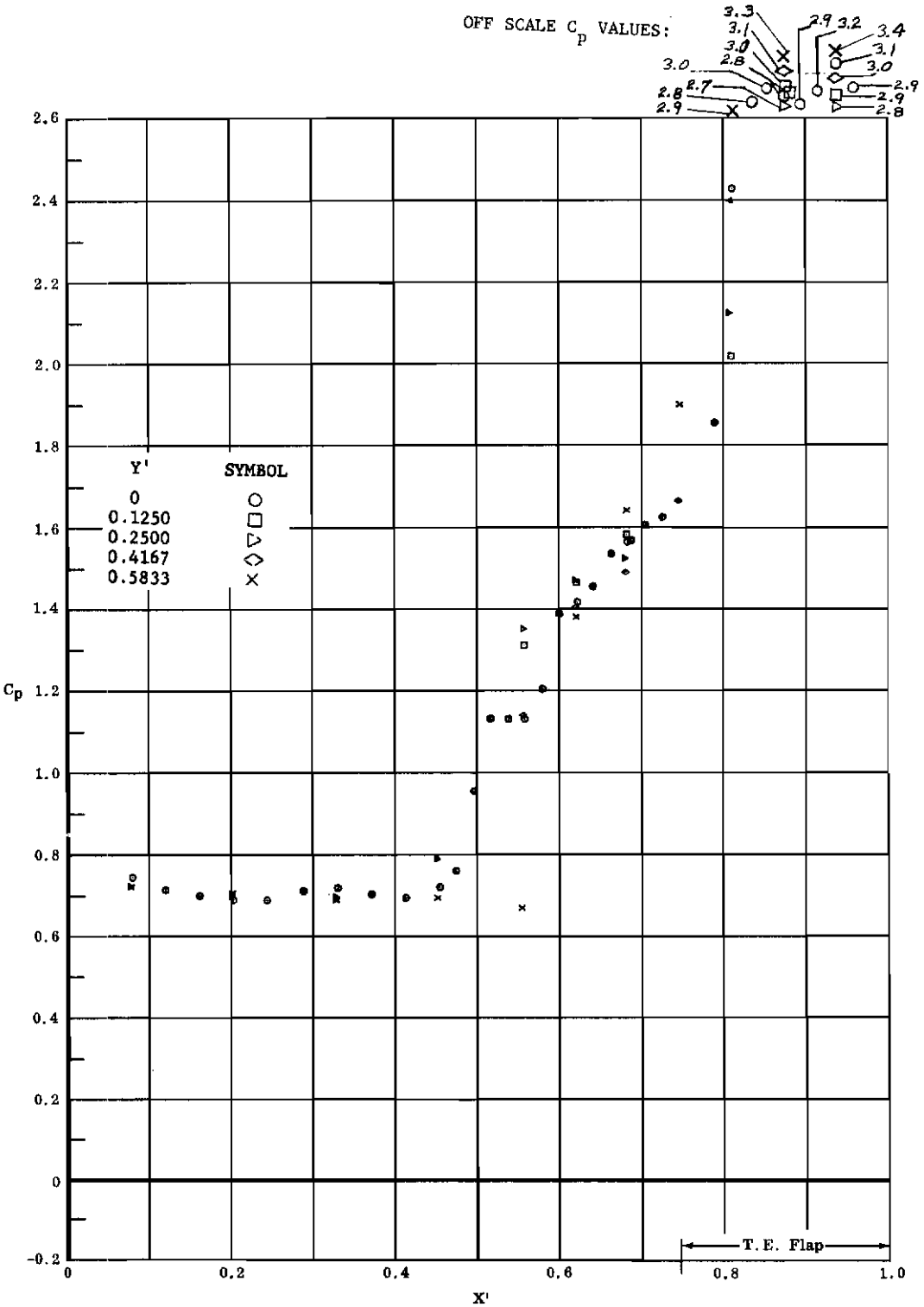


Fig. 83 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow On, $\alpha = -30°$, $Re_\infty/ft = 3{,}300{,}000$.

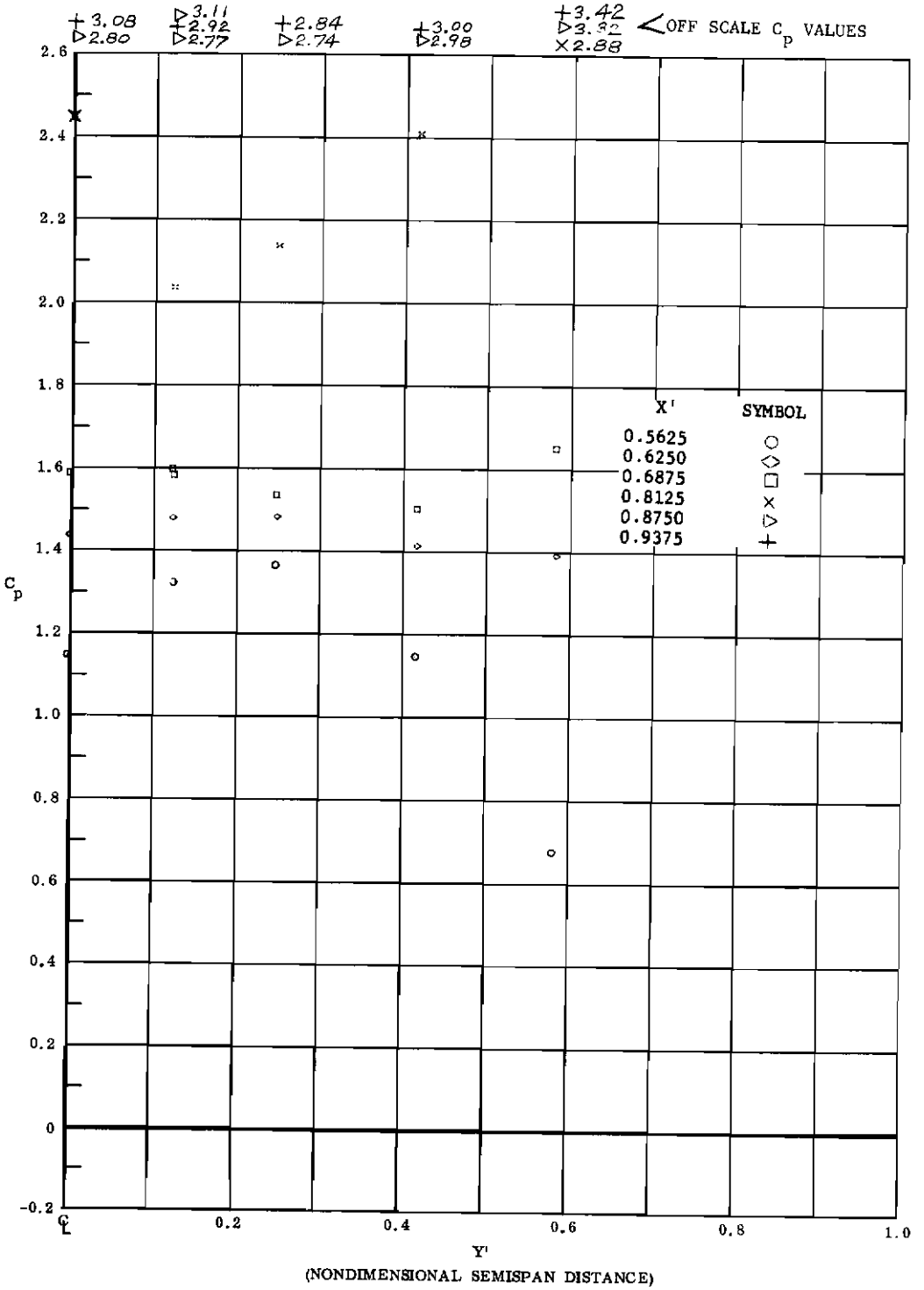


Fig. 83 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow On, $\alpha = -30°$, $Re_\infty/ft = 3,300,000$.

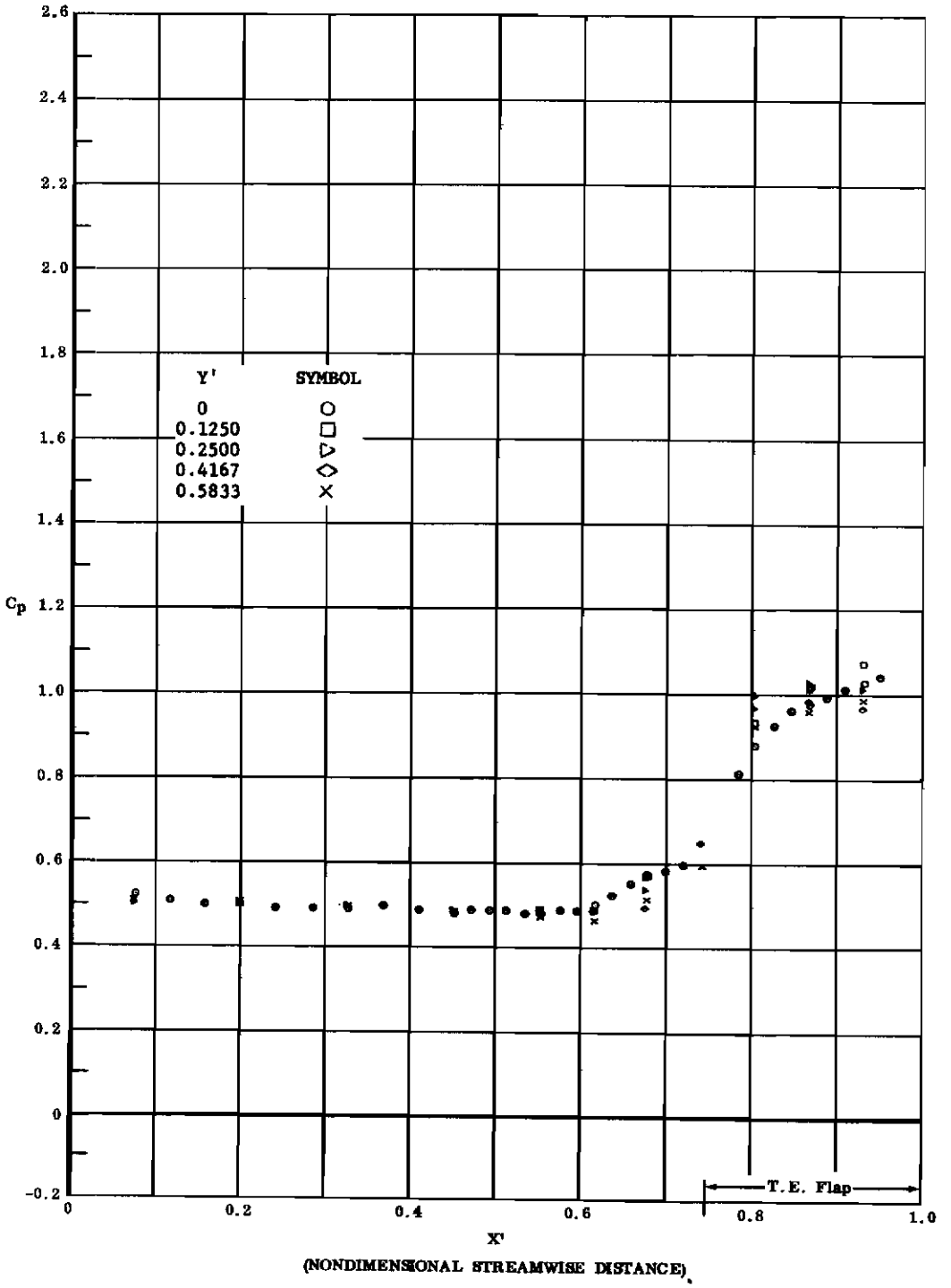


Fig. 84 Streamwise Pressure Distributions; 10° Ramp, Coolant Flow Off, $\alpha = -25°$, $Re_\infty/ft = 1{,}100{,}000$.

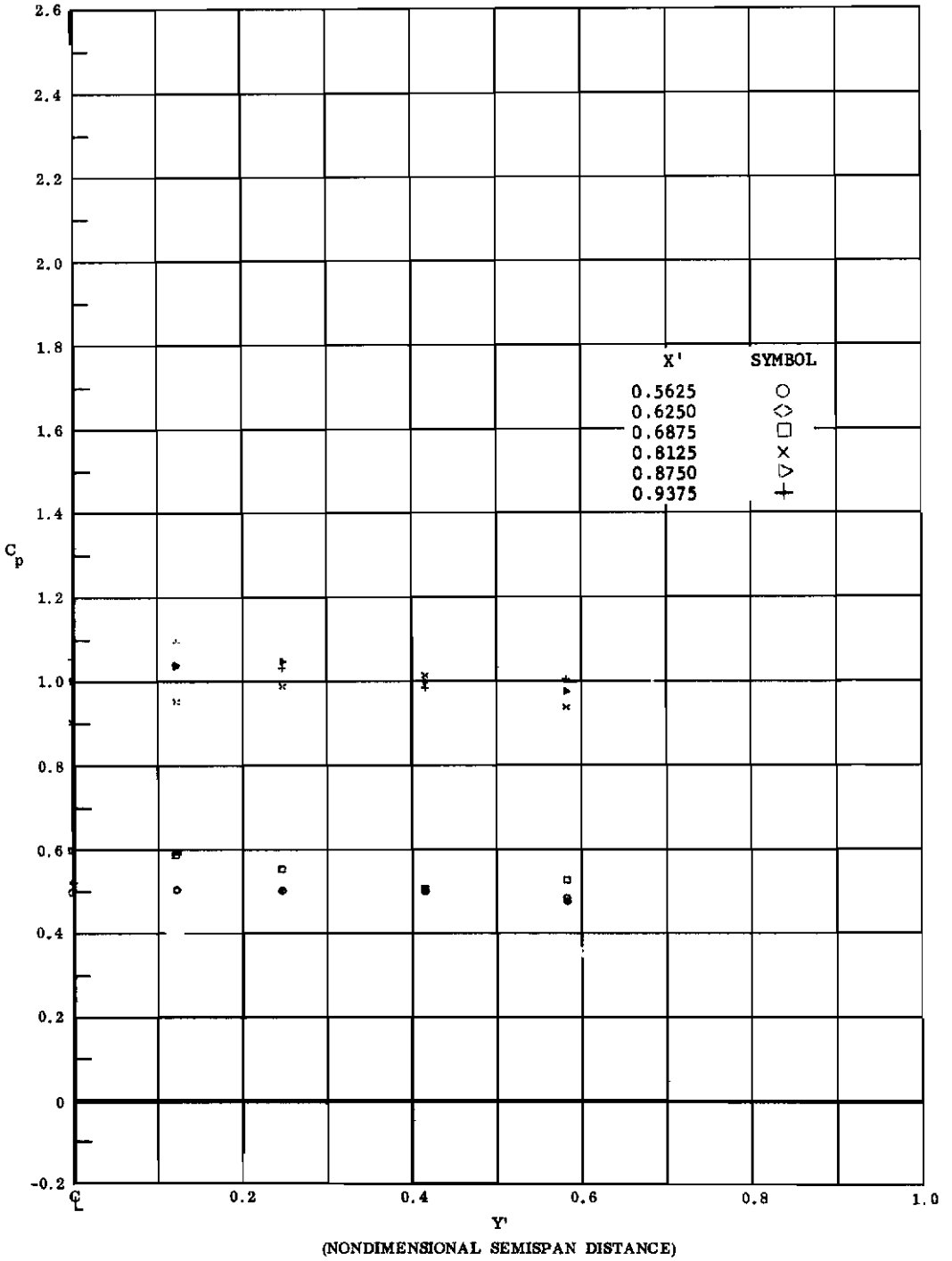


Fig. 84 Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, $\alpha = -25°$, $Re_\infty/ft = 1{,}100{,}000$.

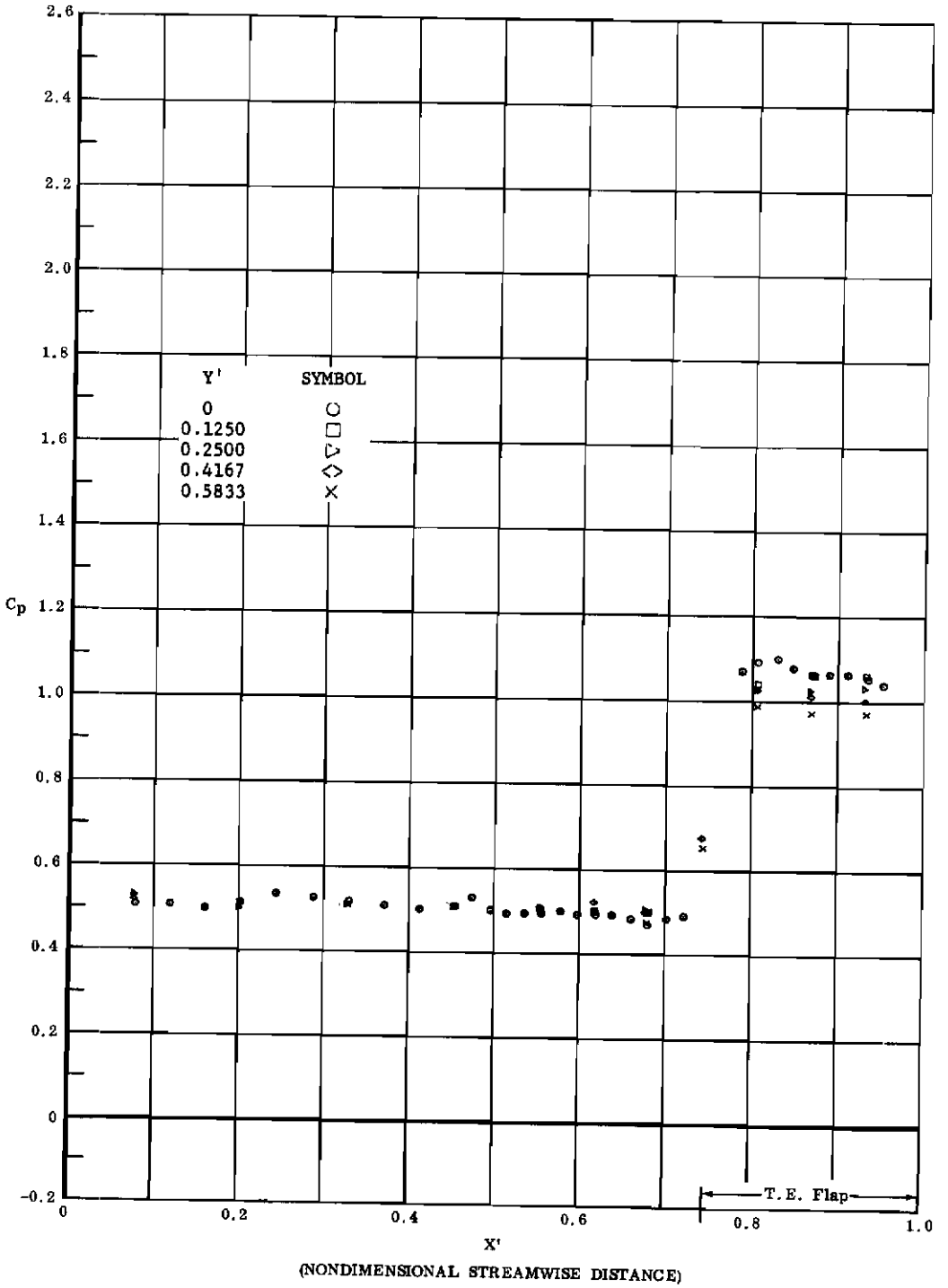


Fig. 85 Streamwise Pressure Distributions; 10° Ramp, Coolant Flow Off, $\alpha = -25°$, $Re_\infty/ft = 3{,}300{,}000$.

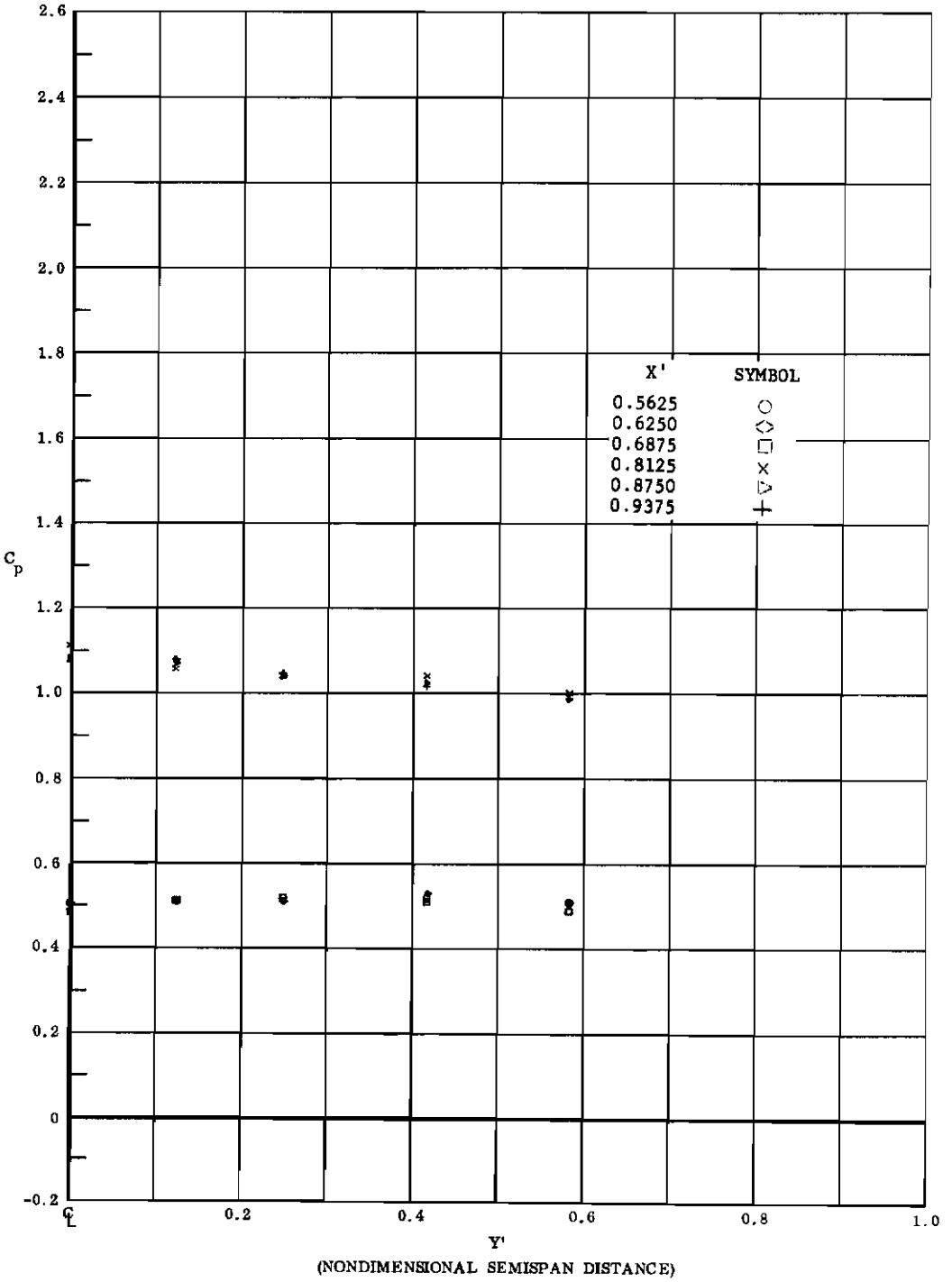


Fig. 85 Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = -25°, Re_∞/ft = 3,300,000.

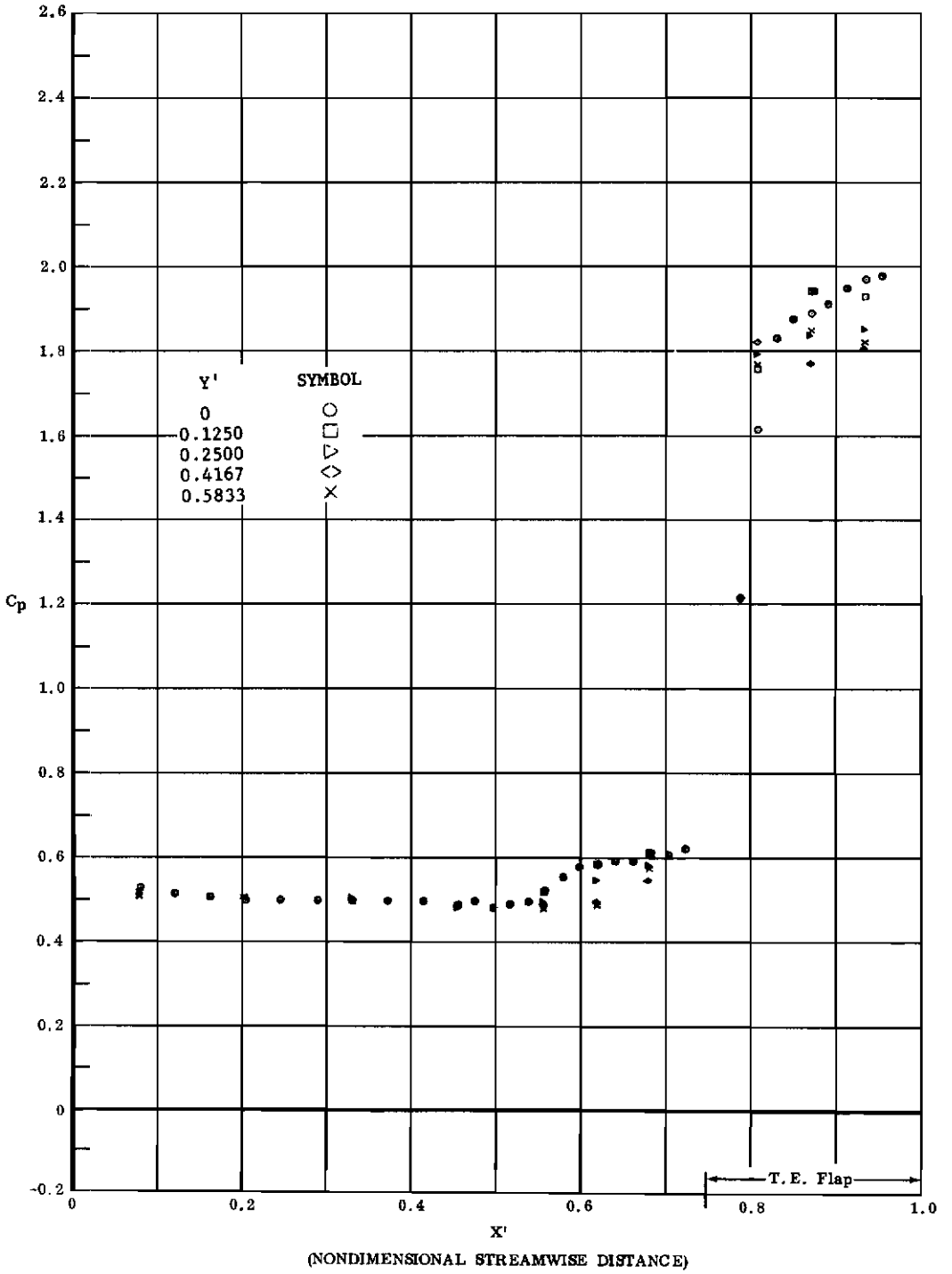


Fig. 86 Streamwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = -25°, Re_∞/ft = 1,100,000.

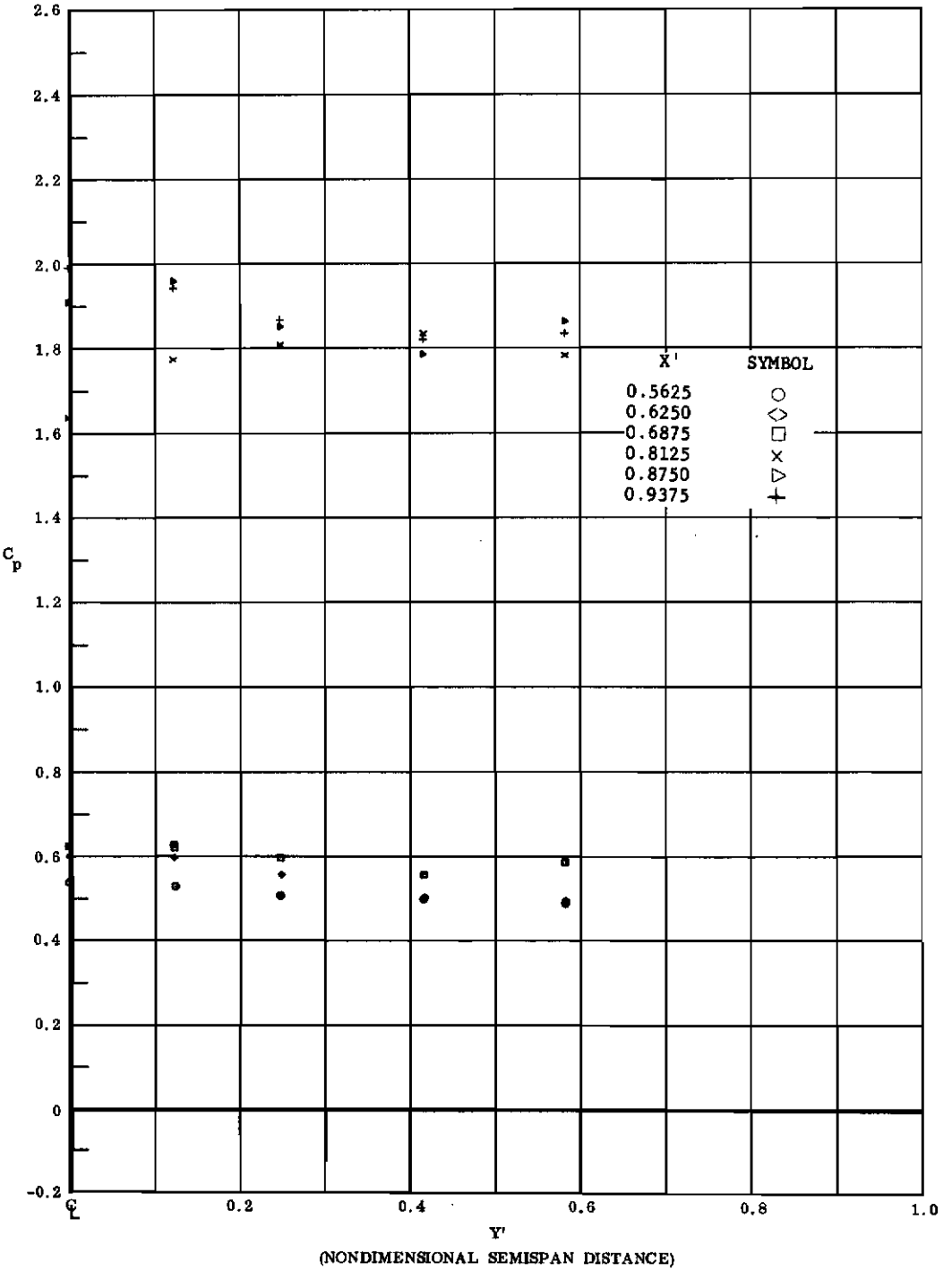


Fig. 86 Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -25°$, $Re_\infty/ft = 1{,}100{,}000$.

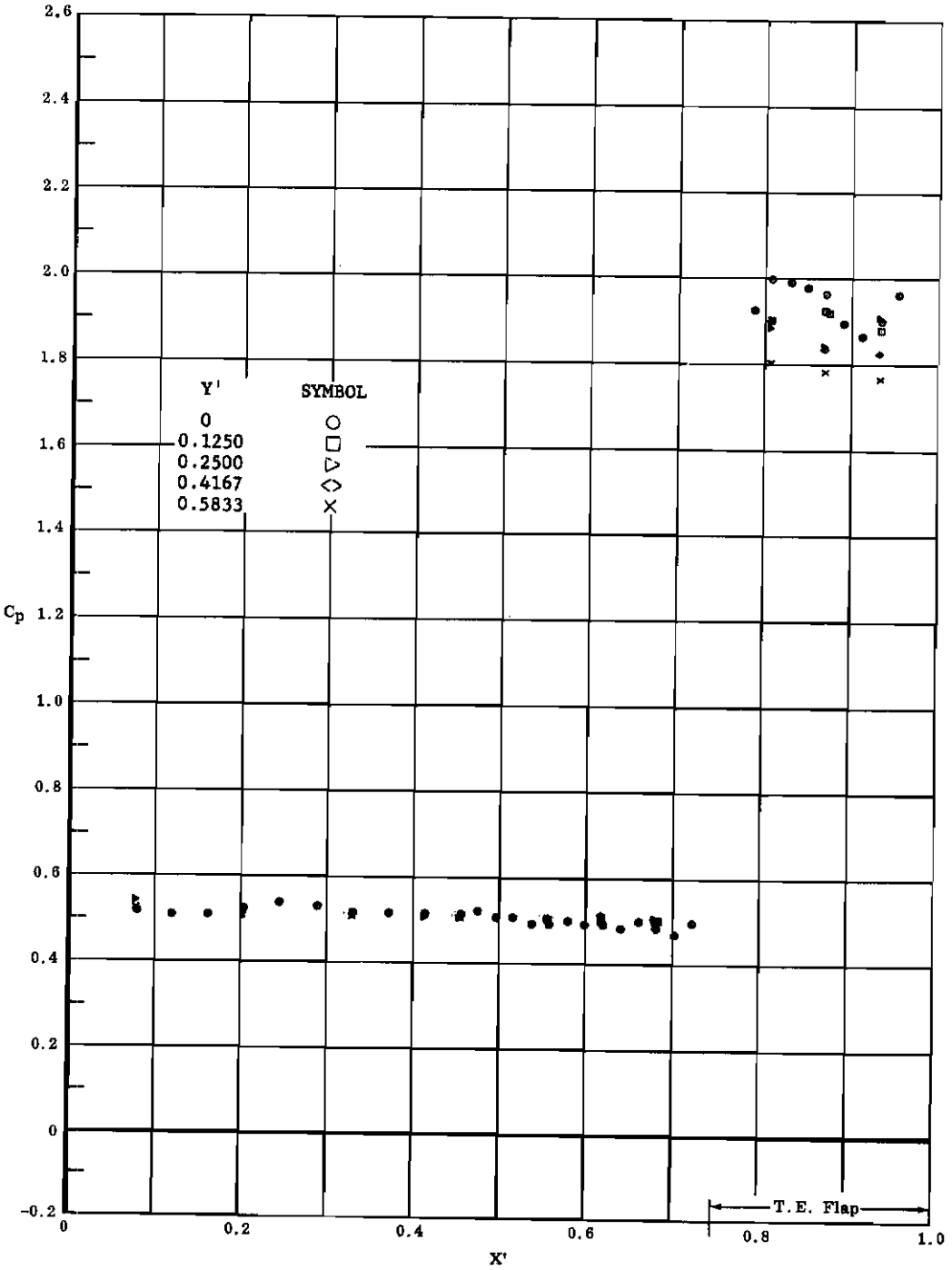


Fig. 87 Streamwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = -25°, Re_∞/ft = 3,300,000.

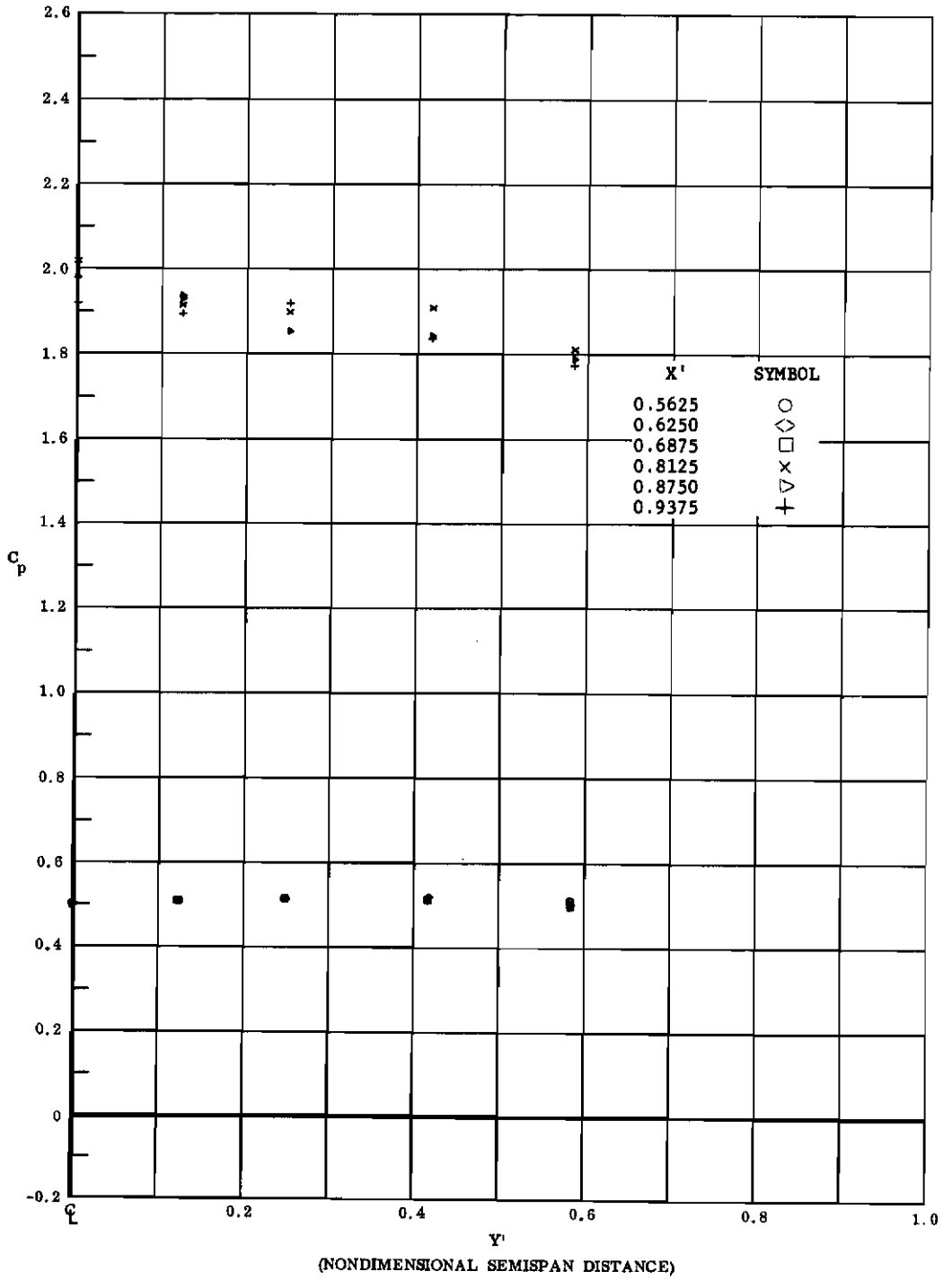


Fig. 87 Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = -25°, Re_∞/ft = 3,300,000.

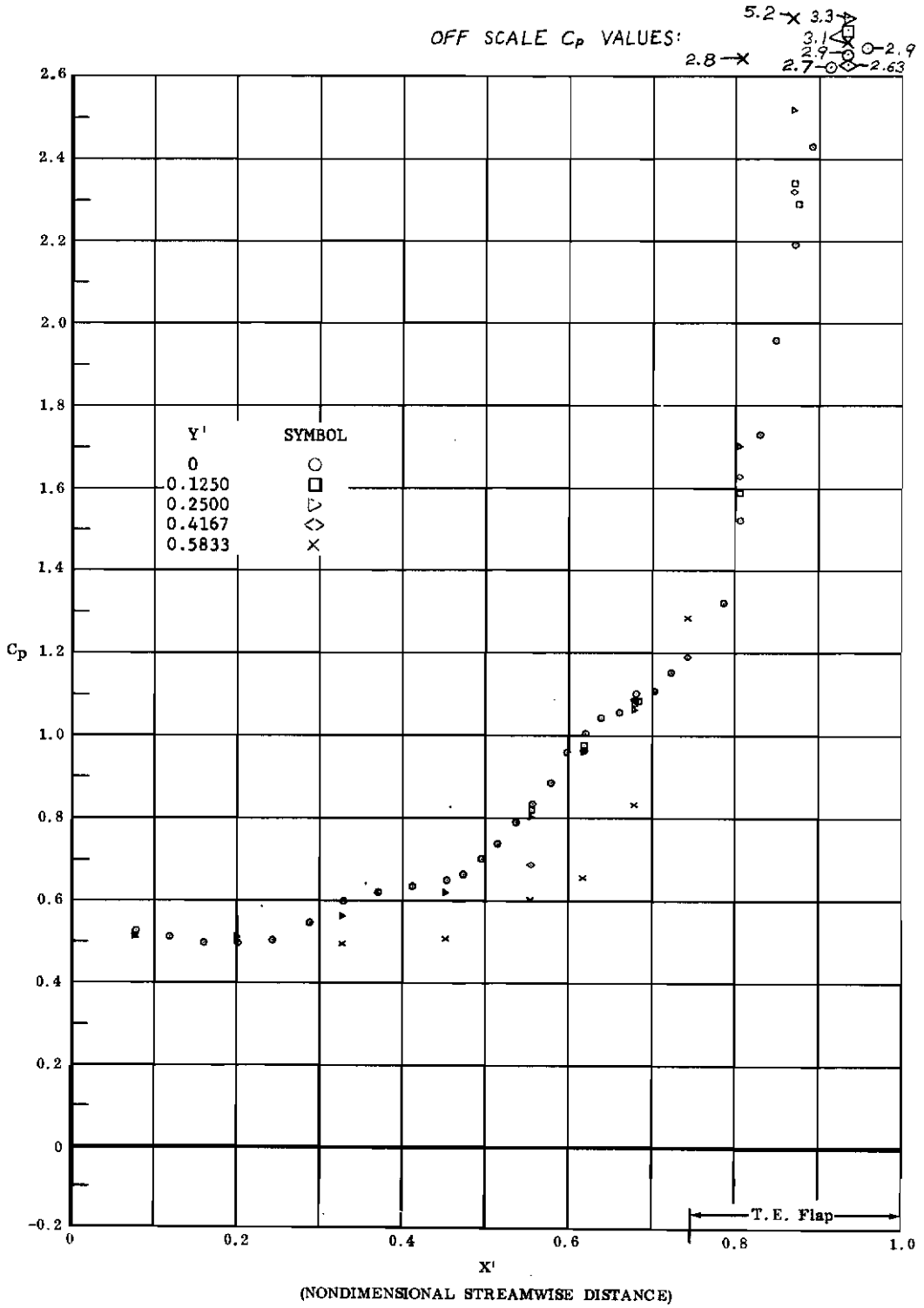


Fig. 88 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -25°$, $Re_\infty/ft = 1{,}100{,}000$.

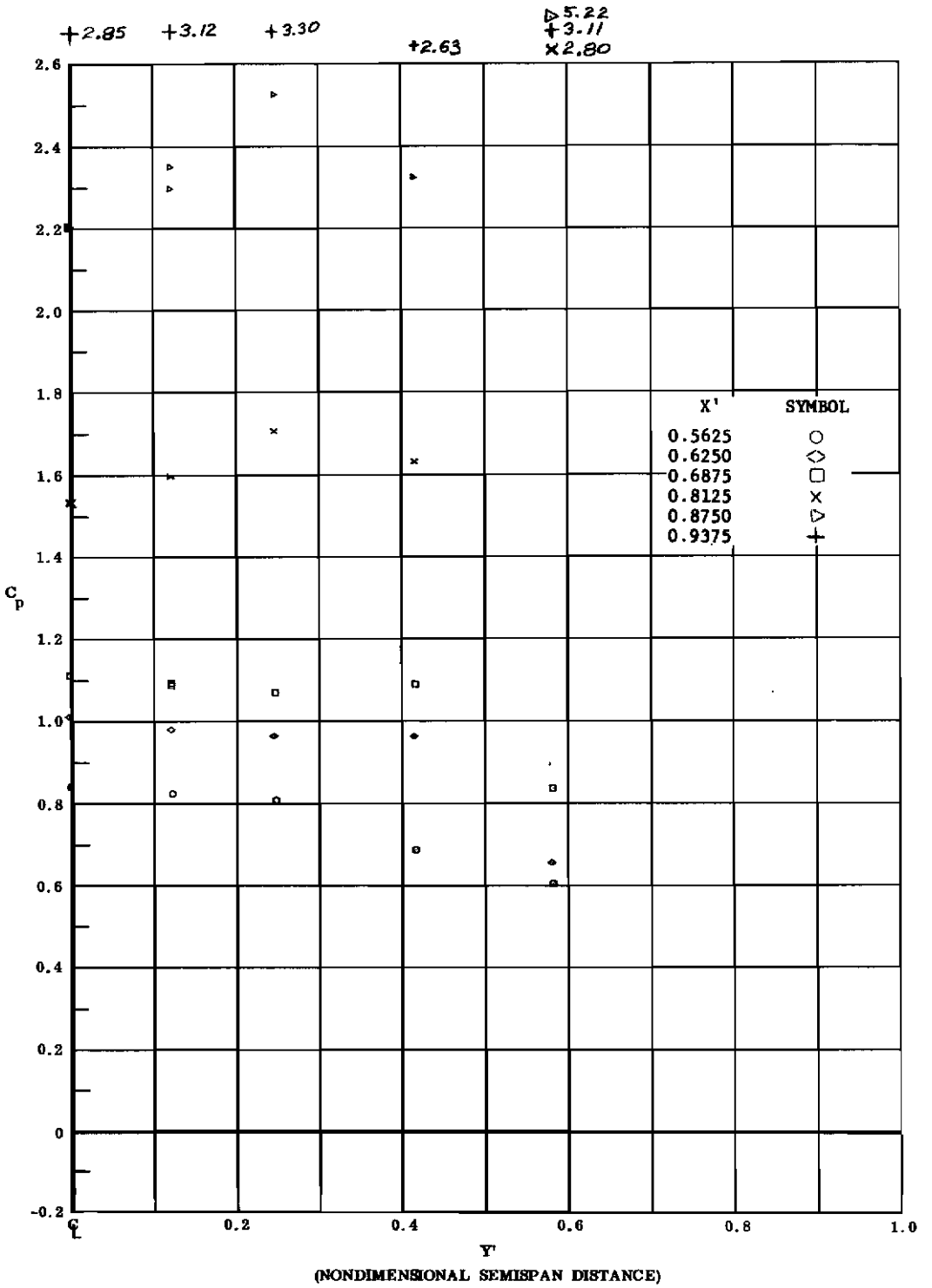


Fig. 88 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -25°$, $Re_\infty/ft = 1{,}100{,}000$.

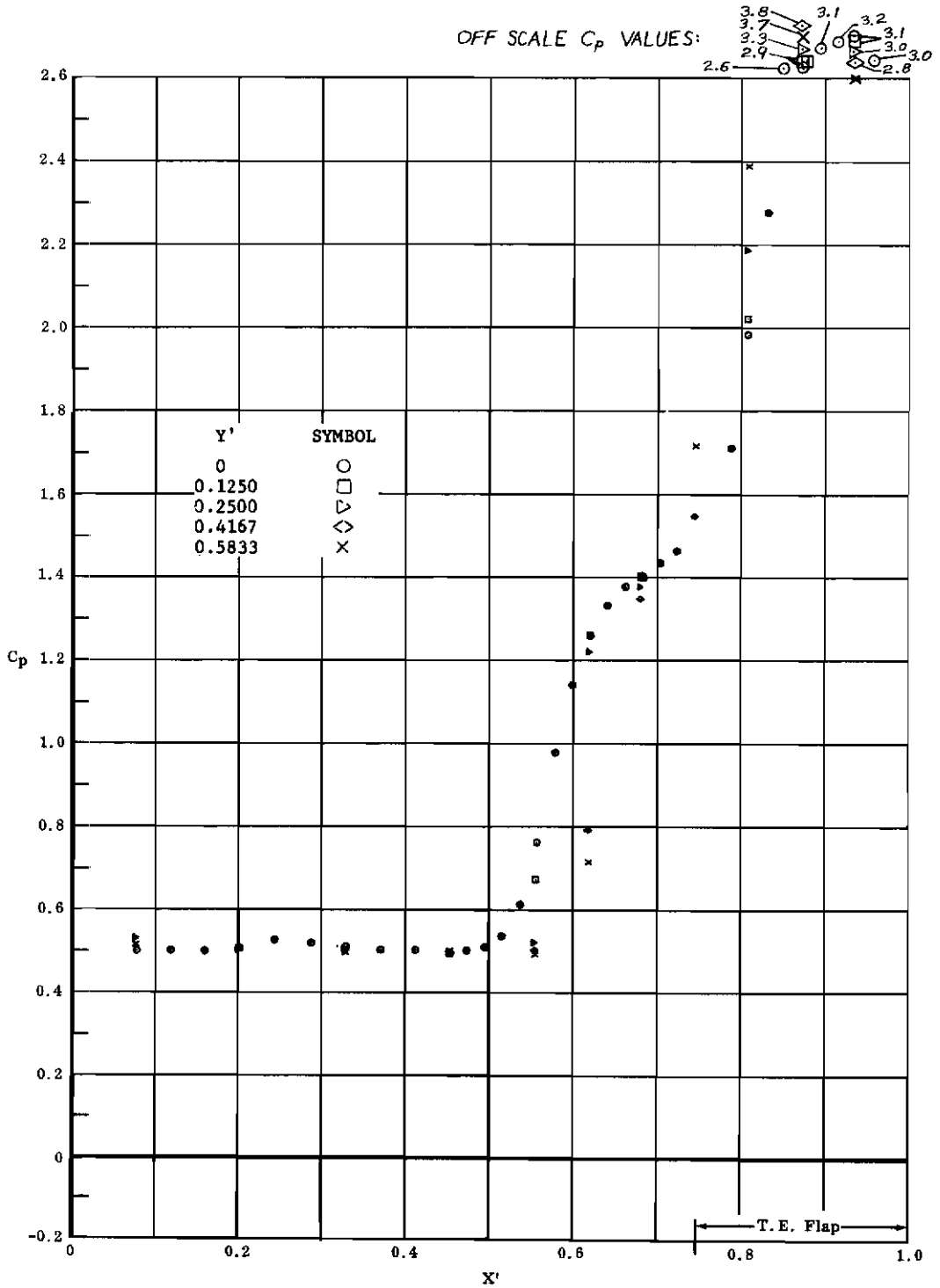


Fig. 89 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -25°$, $Re_\infty/ft = 3,300,000$.

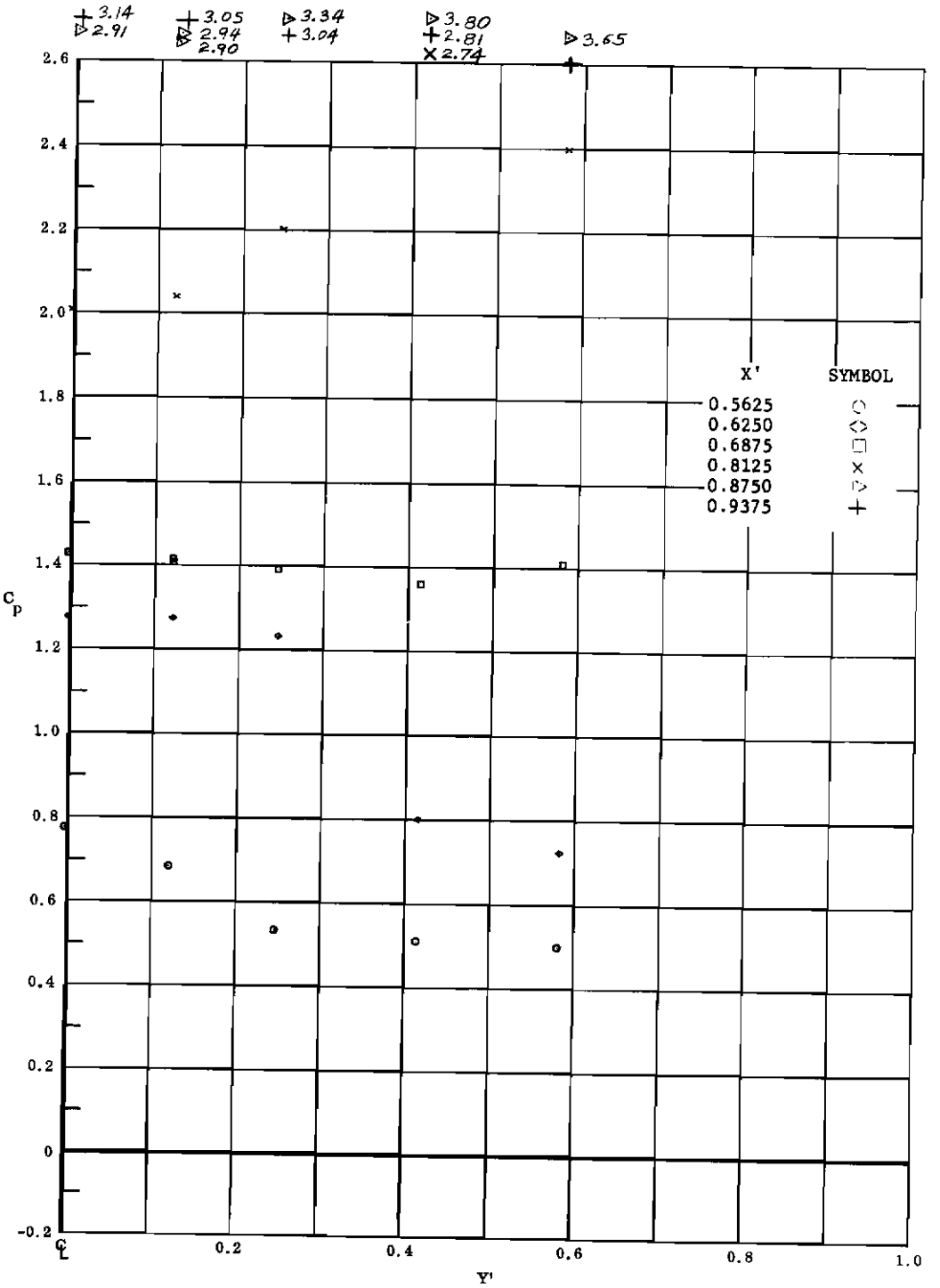
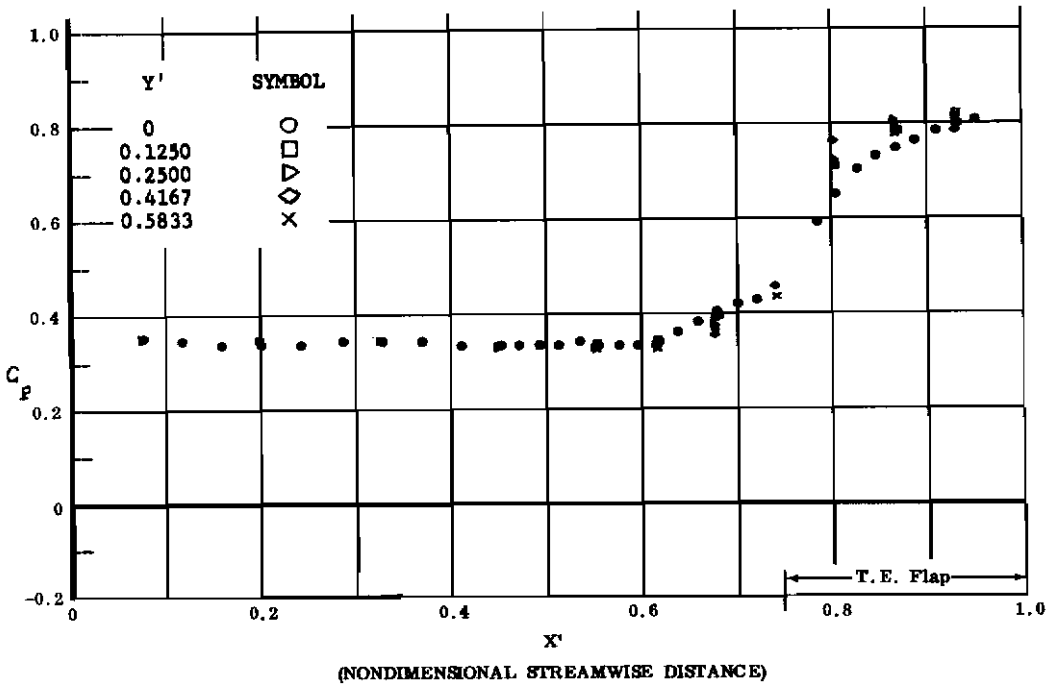


Fig. 89 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -25°$, $Re_\infty/ft = 3{,}300{,}000$.



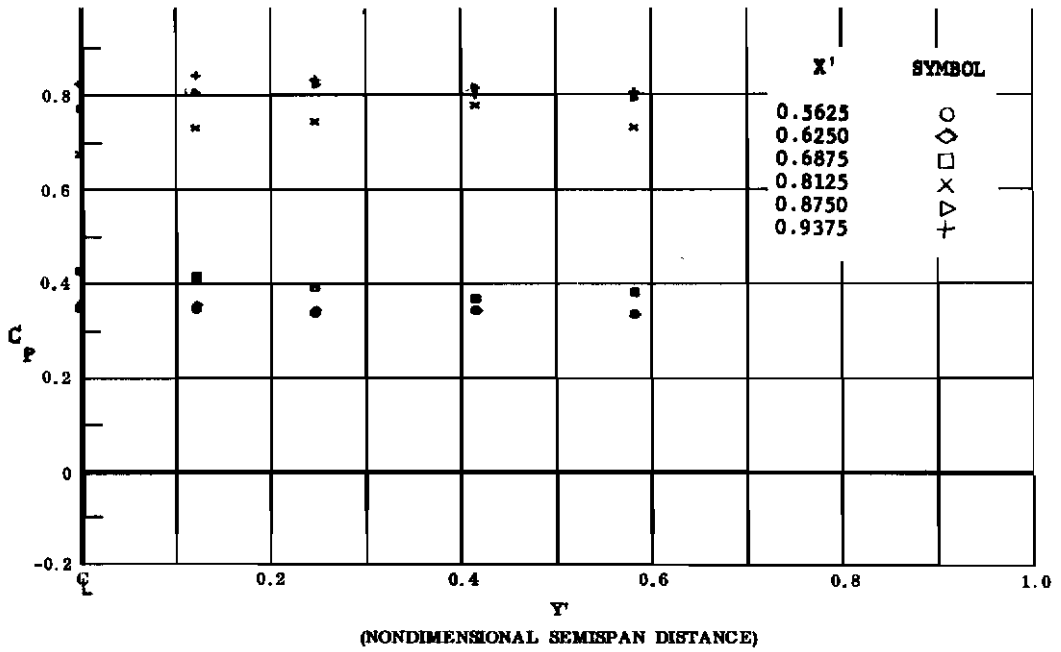
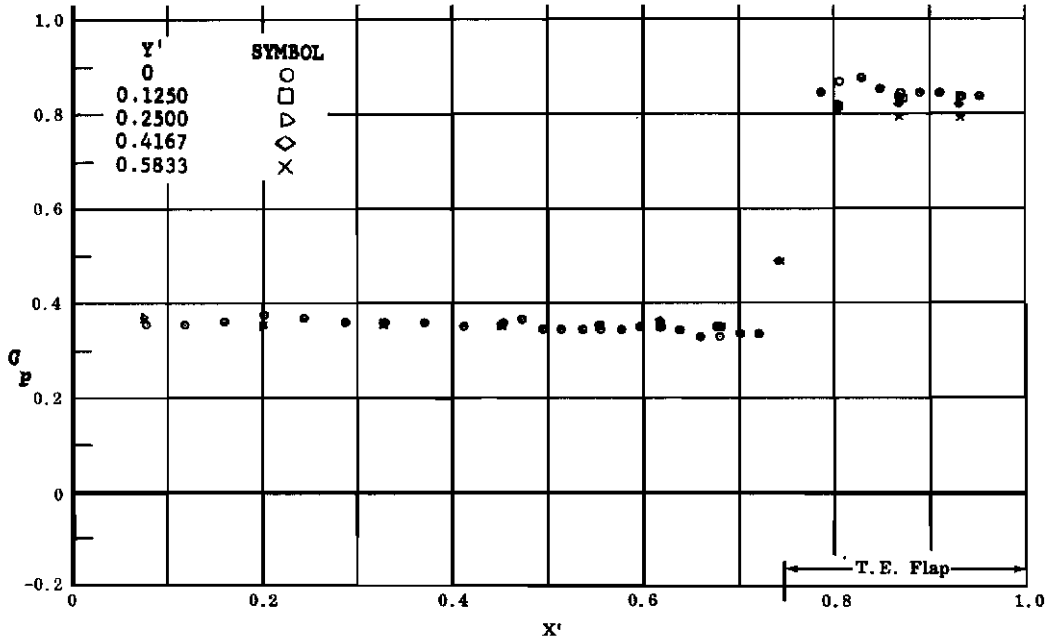


Fig. 90 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = -20°, Re_∞/ft = 1,100,000.



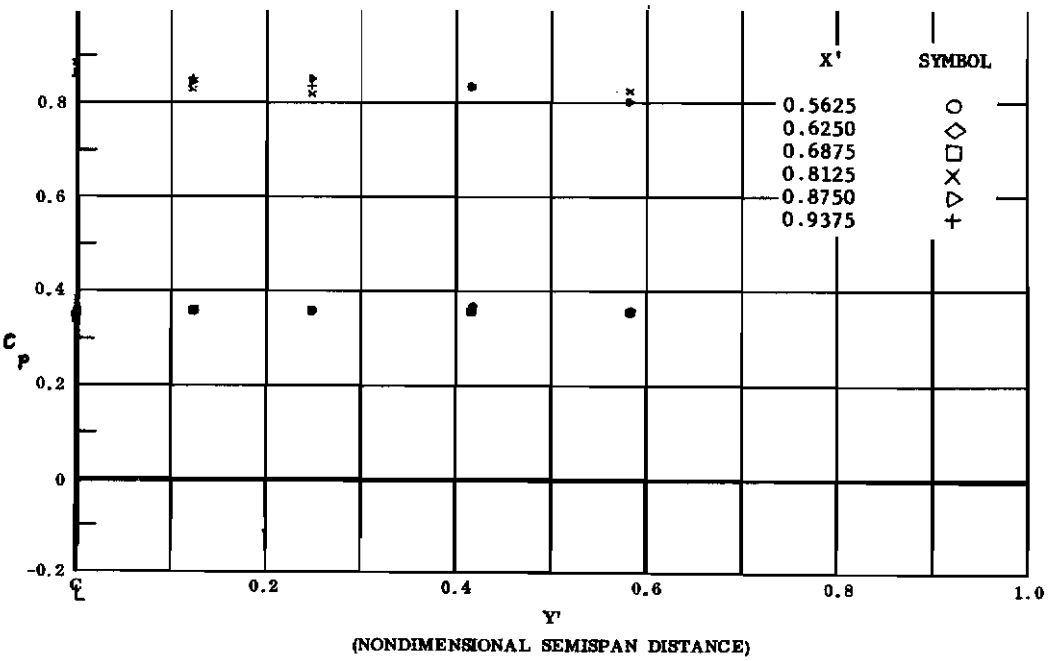


Fig. 91 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = -20°, Re_∞/ft = 3,300,000.

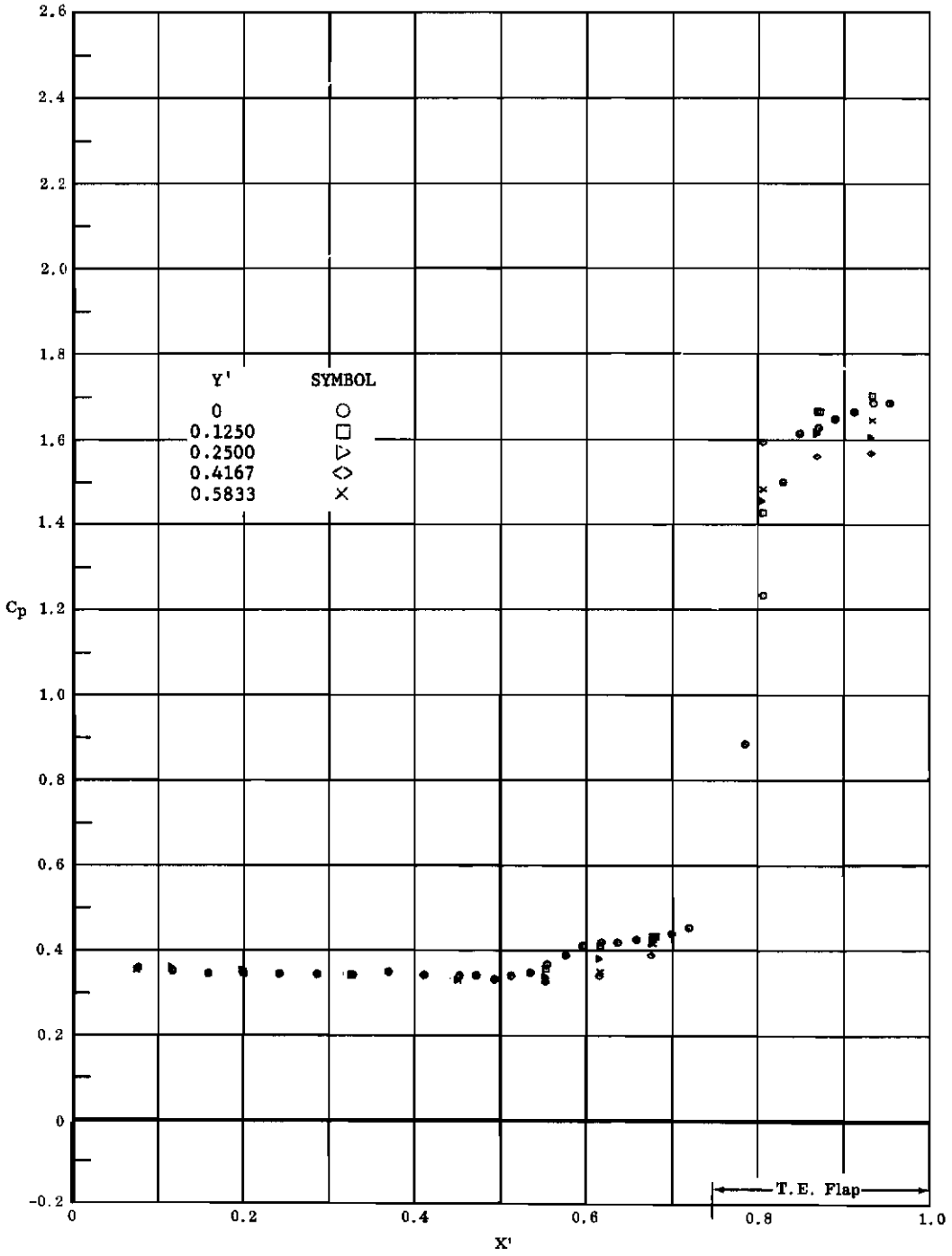


Fig. 92 Streamwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = -20°, Re_∞/ft = 1,100,000.

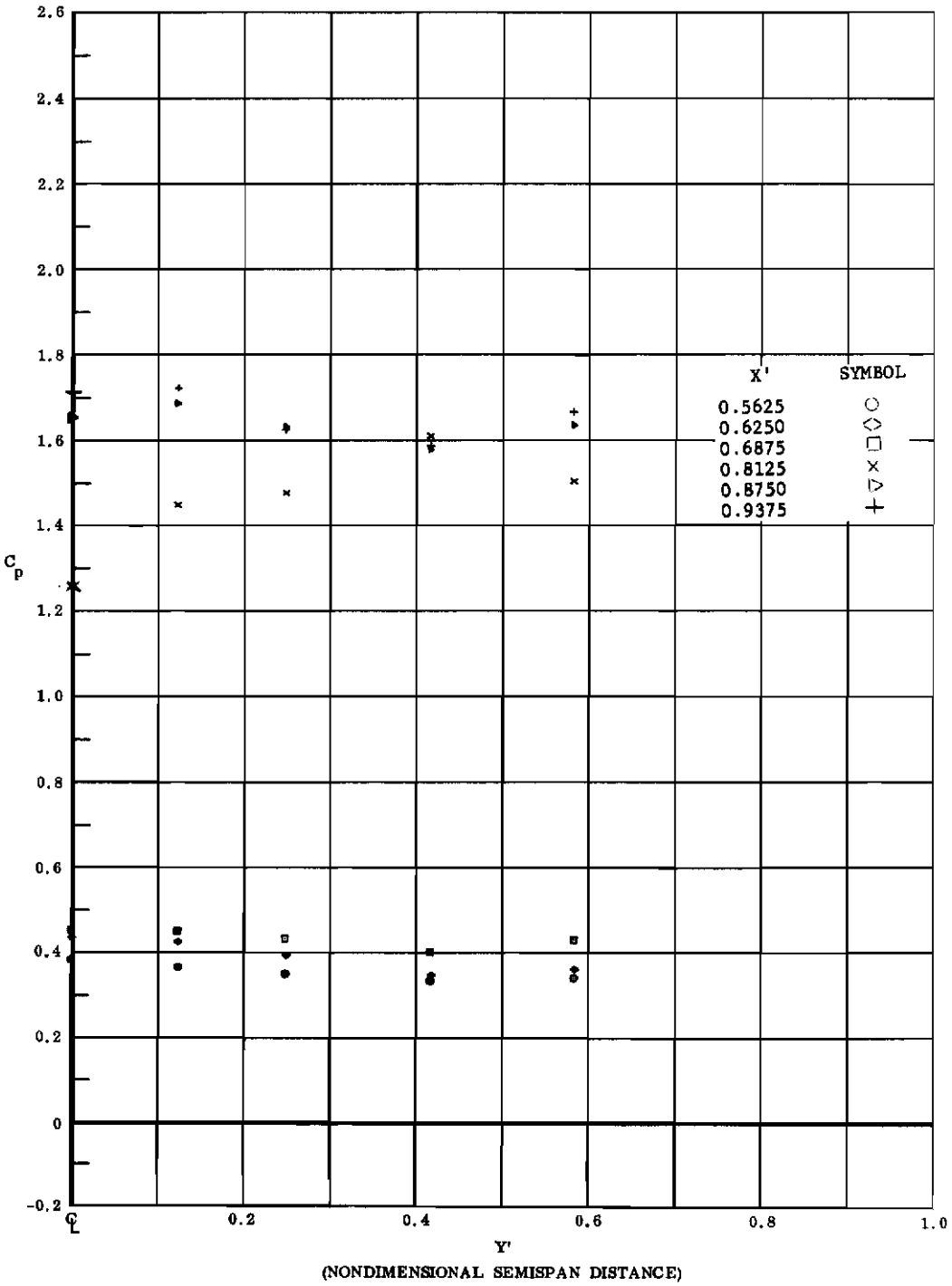


Fig. 92 Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -20°$, $Re_\infty/ft = 1{,}100{,}000$.

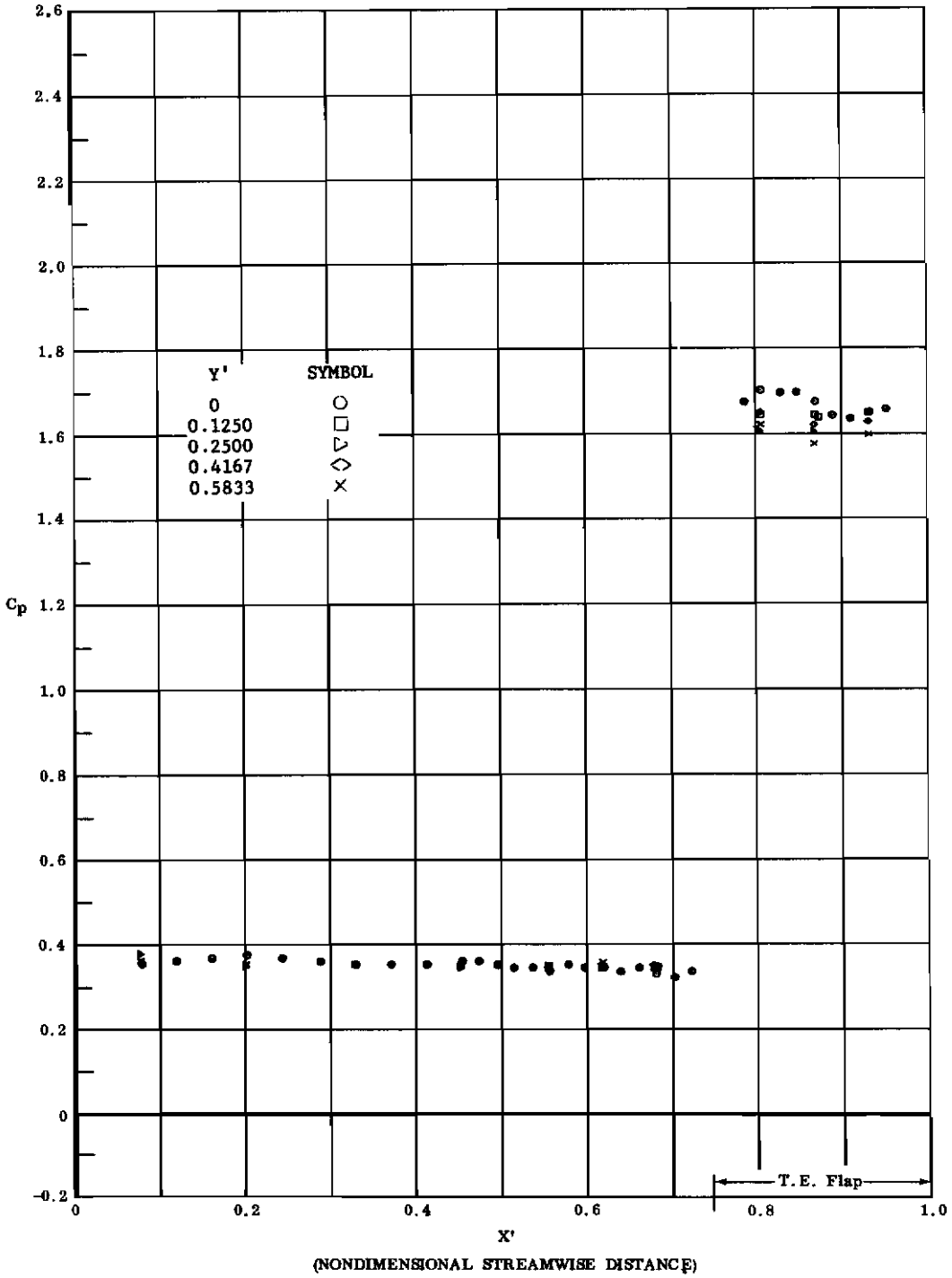


Fig. 93 Streamwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -20°$, $Re_\infty/ft = 3{,}300{,}000$.

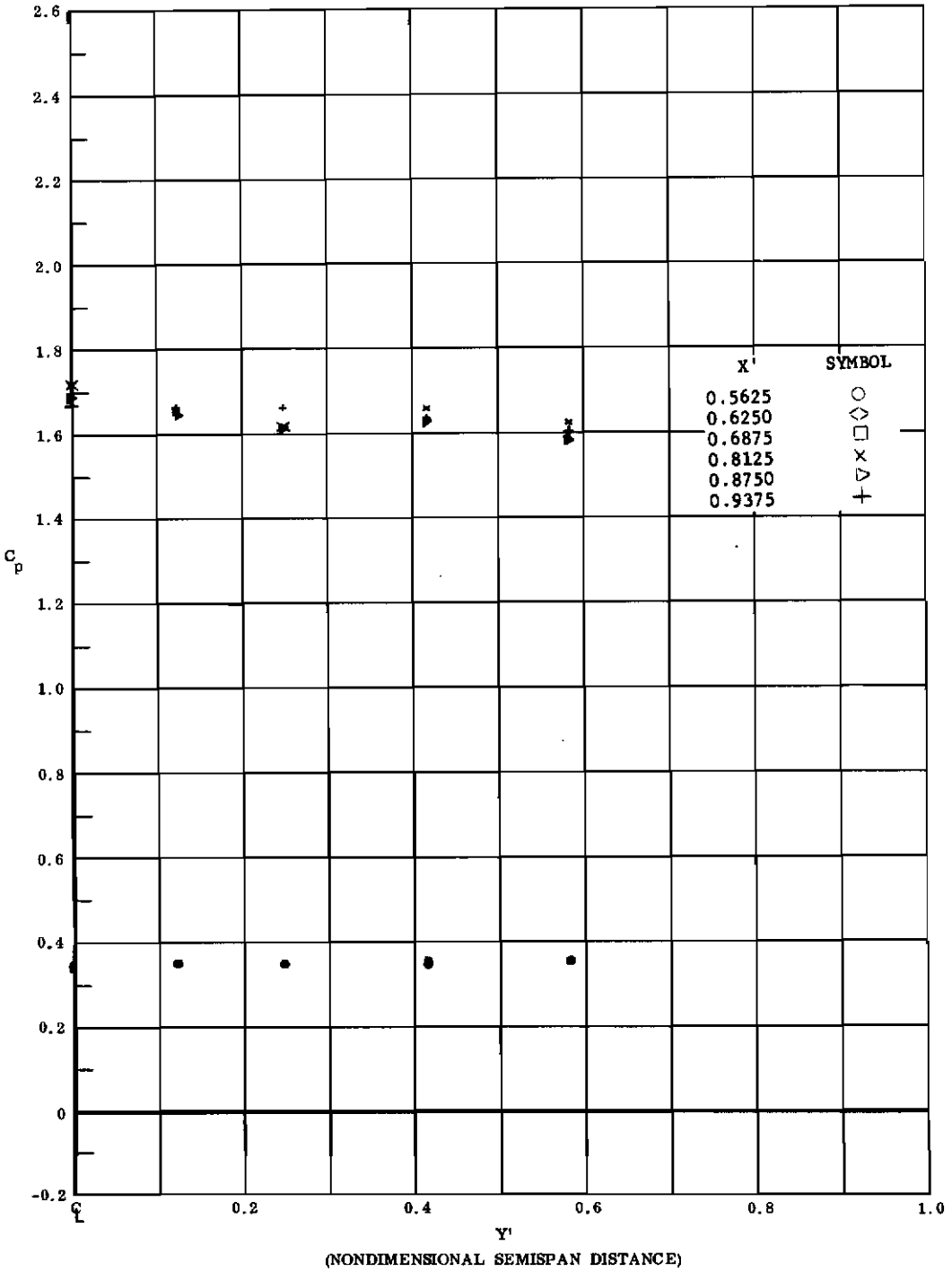


Fig. 93 Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -20°$, $Re_\infty/ft = 3{,}300{,}000$.

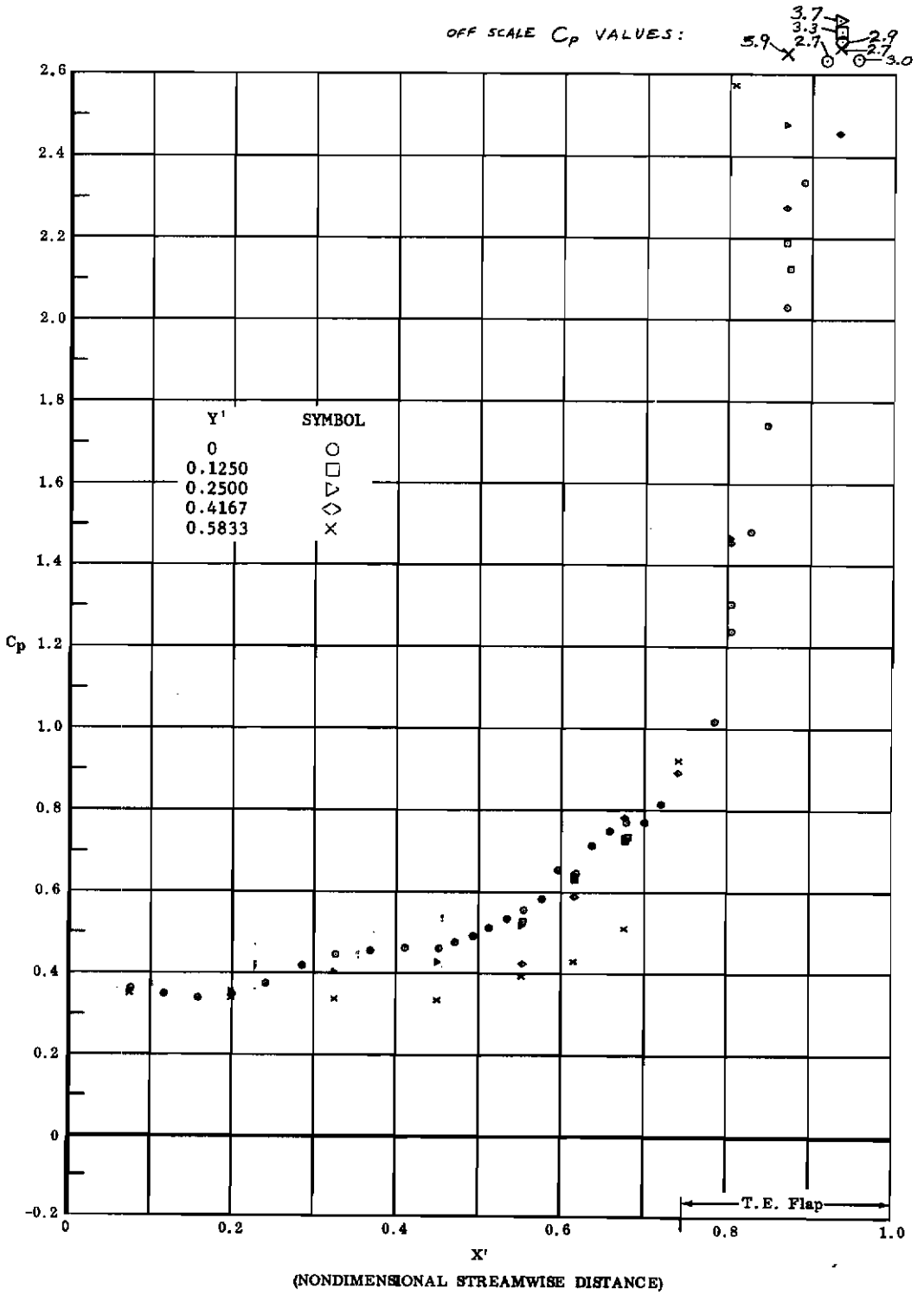


Fig. 94 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -20°$, $Re_\infty/ft = 1{,}100{,}000$.

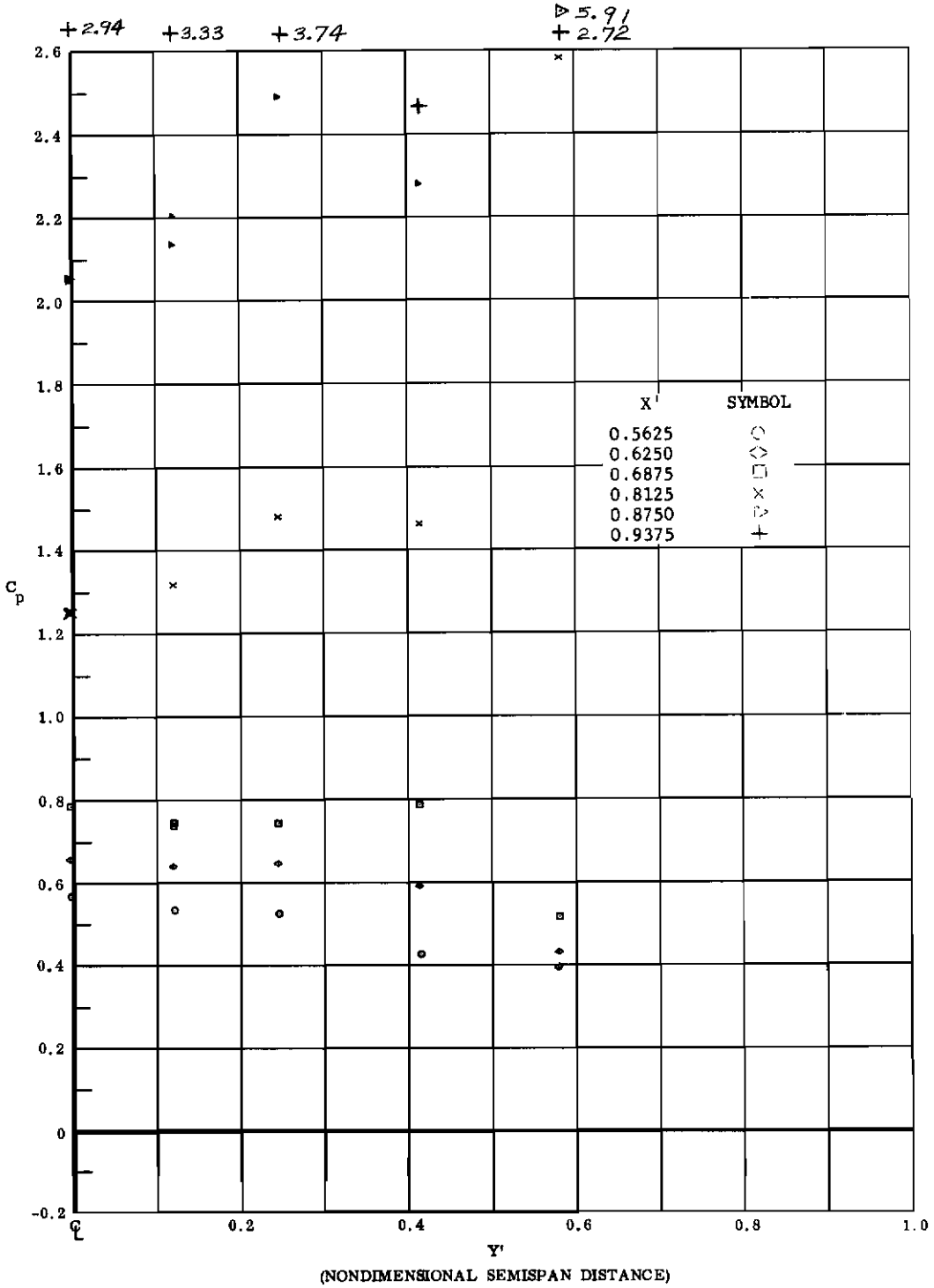


Fig. 94 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -20°$, $Re_\infty/ft = 1{,}100{,}000$.

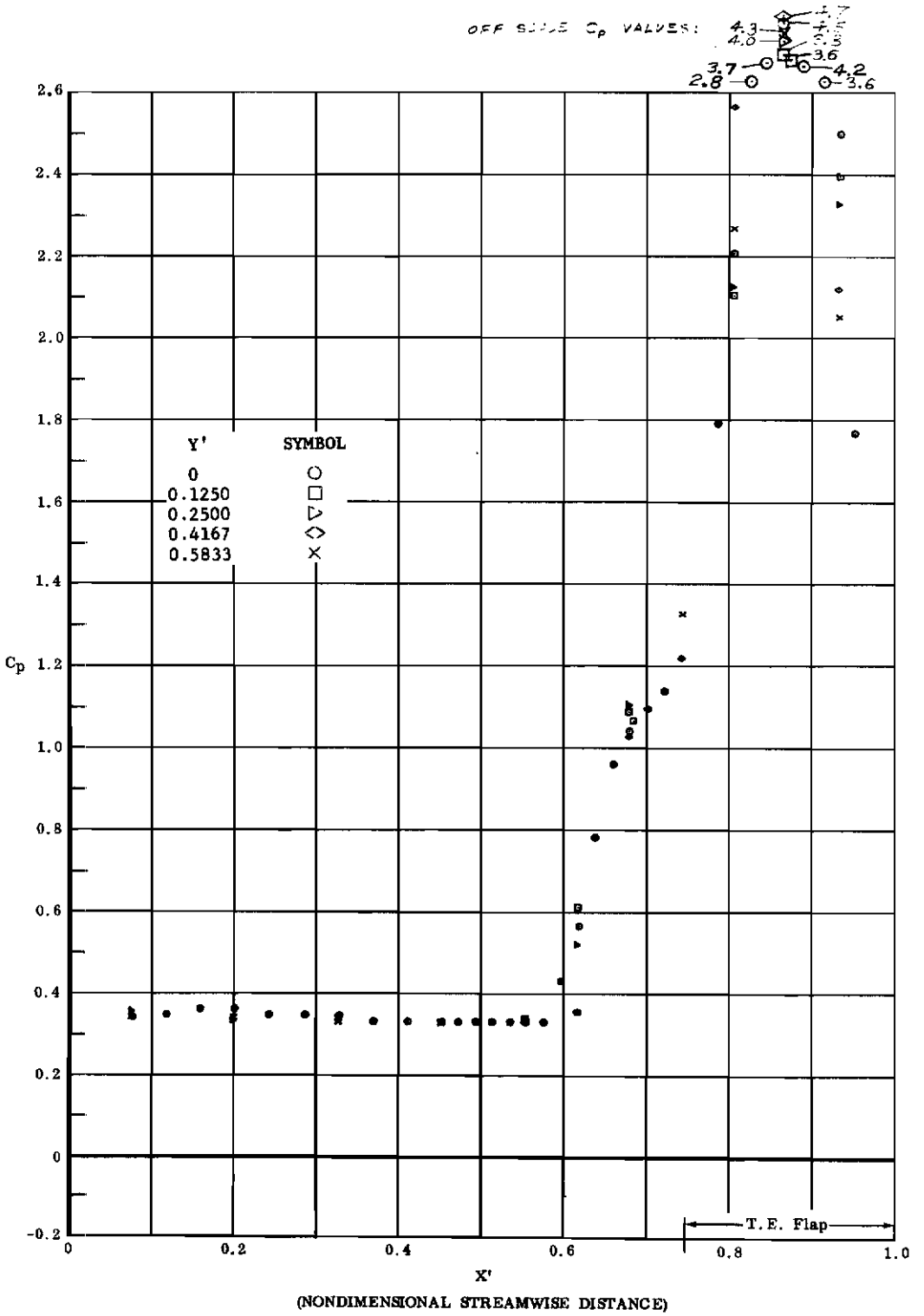


Fig. 95 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -20°, Re_∞/ft = 3,300,000.

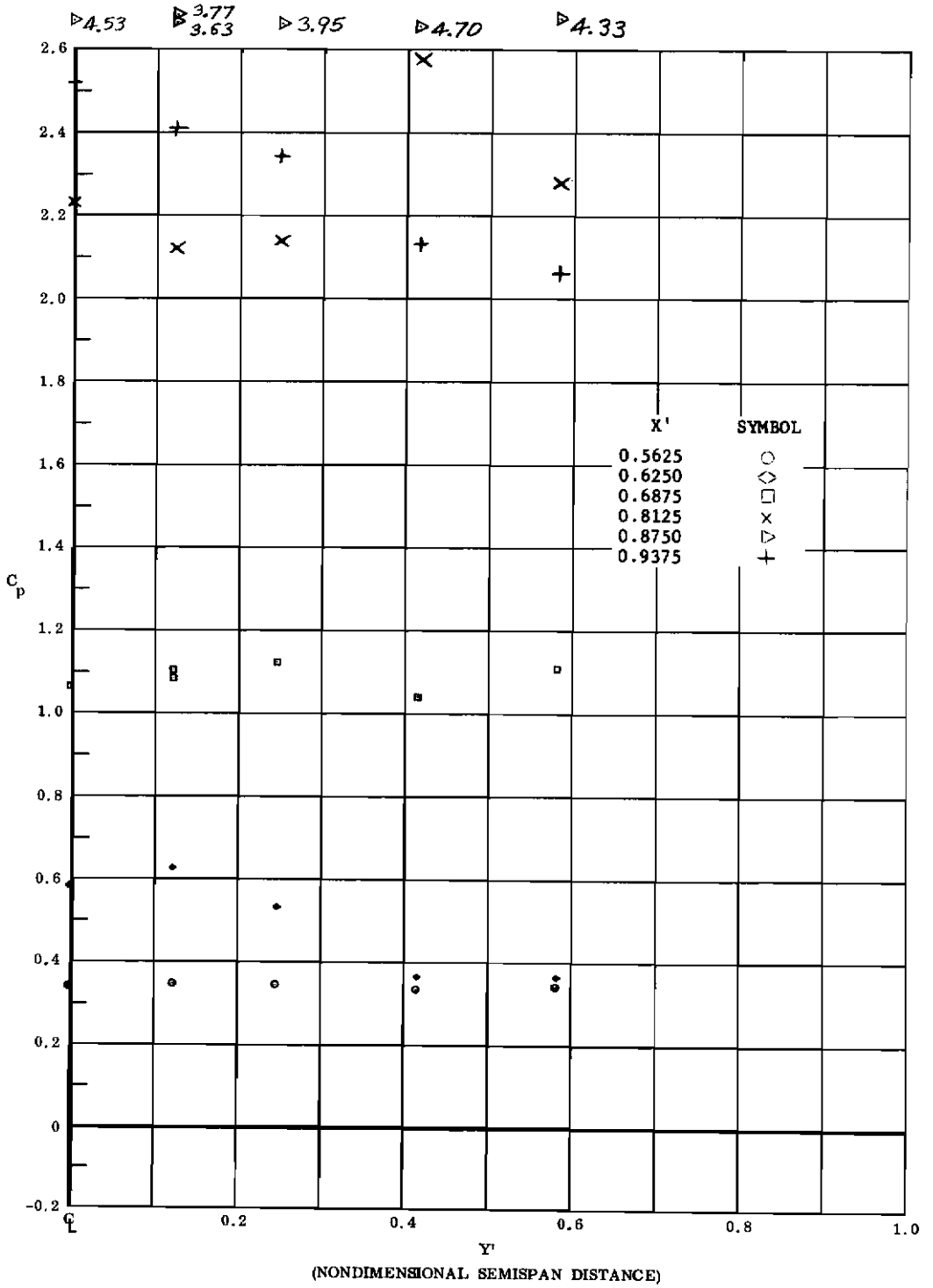
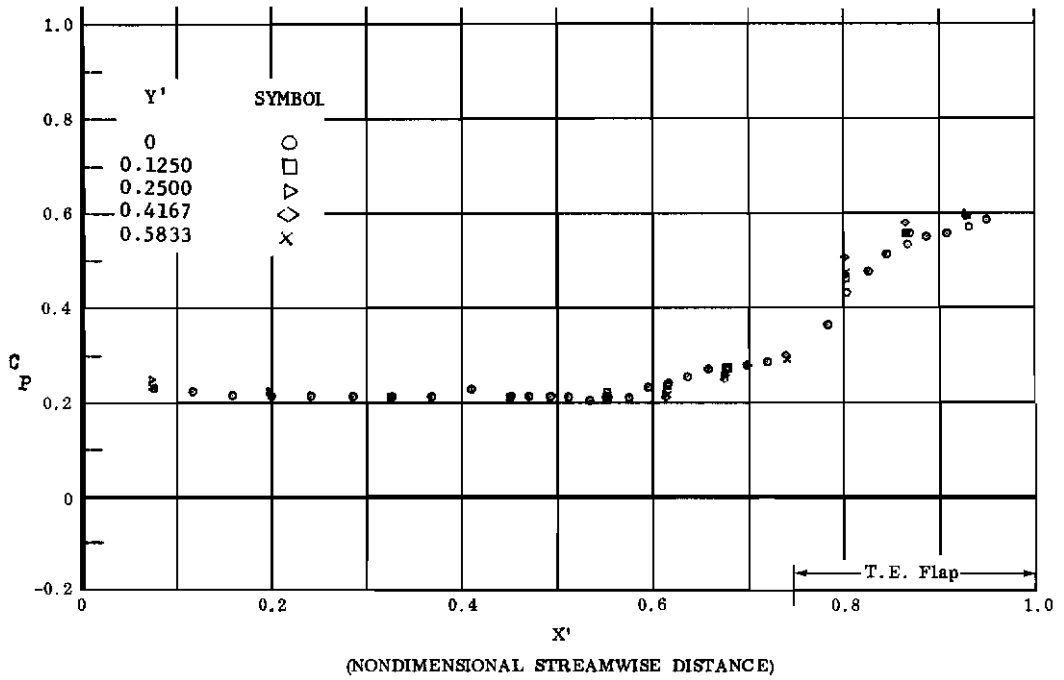


Fig. 5 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -20°$, $Re_\infty/ft = 3,300,000$.



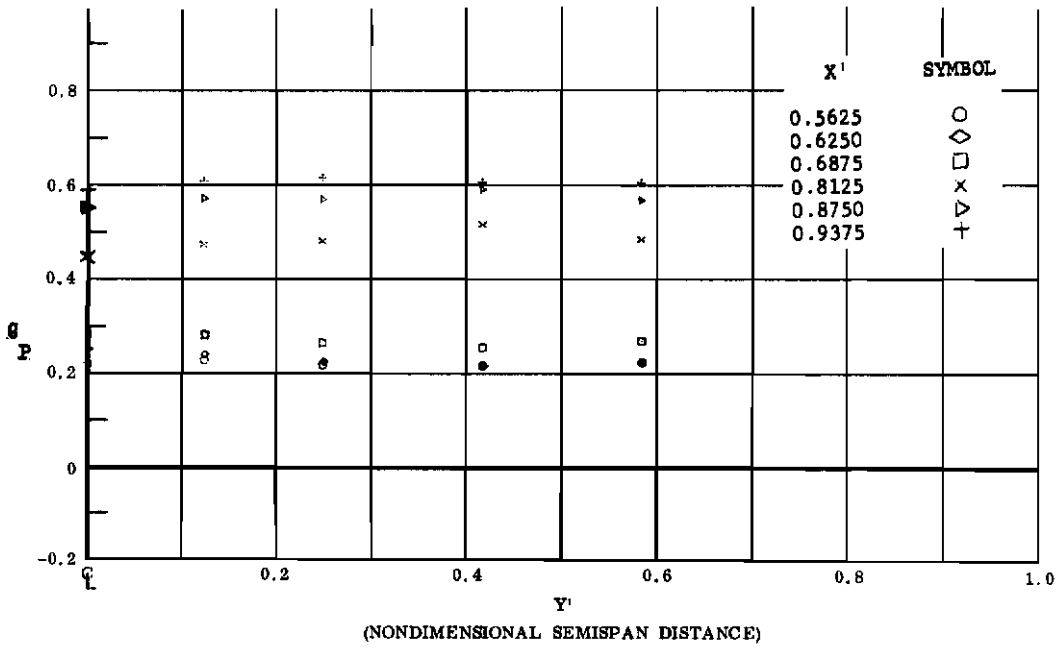
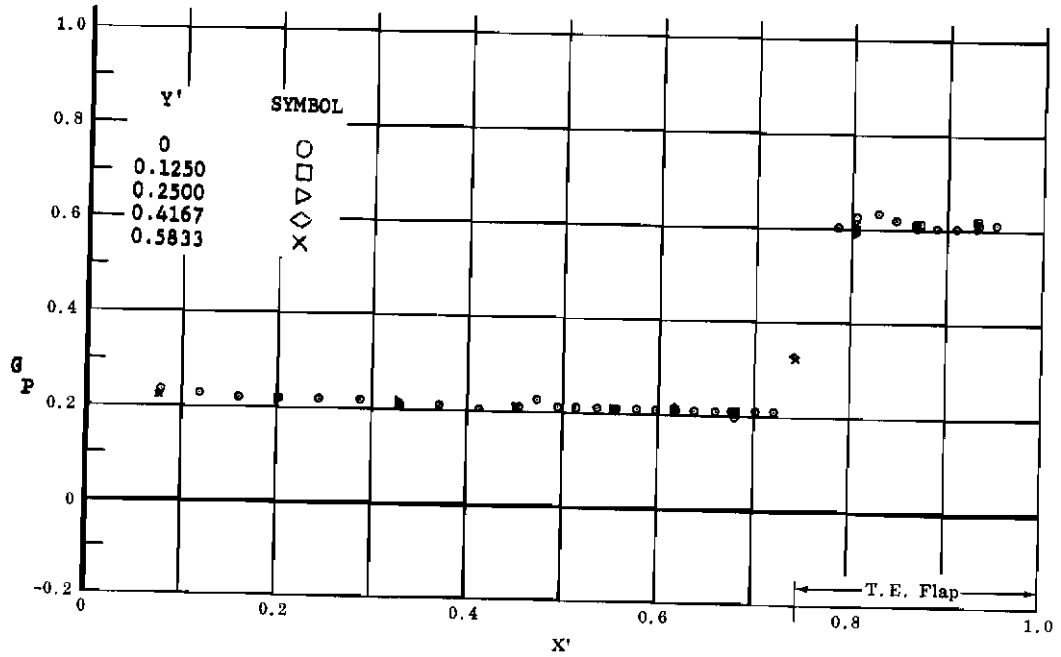


Fig. 96 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, $\alpha = -15°$, $Re_\infty/ft = 1{,}100{,}000$.



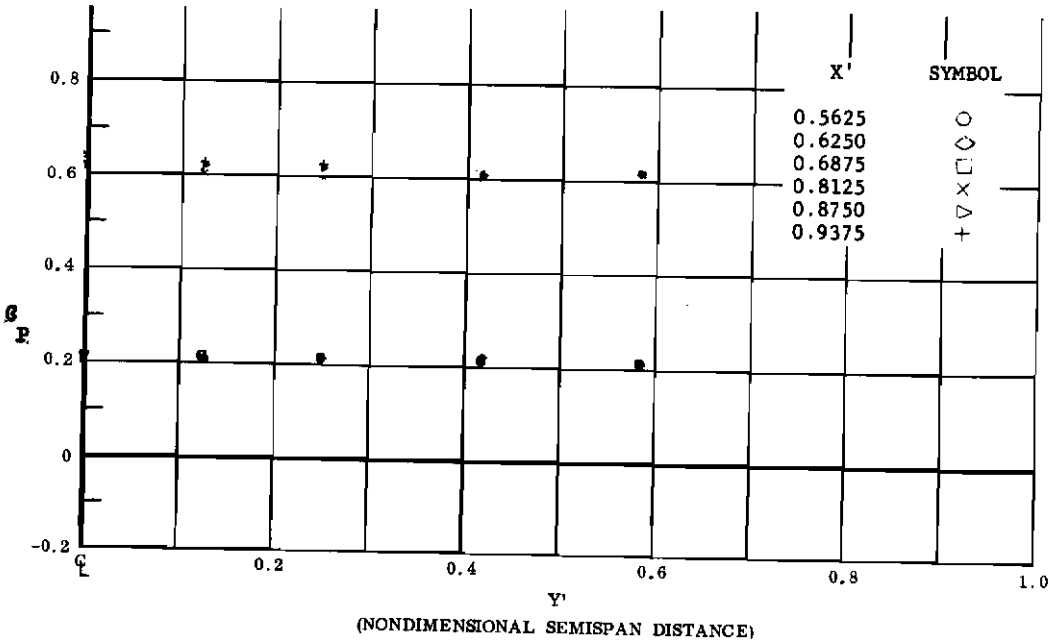


Fig. 97 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = -15°, Re_∞/ft = 3,300,000.

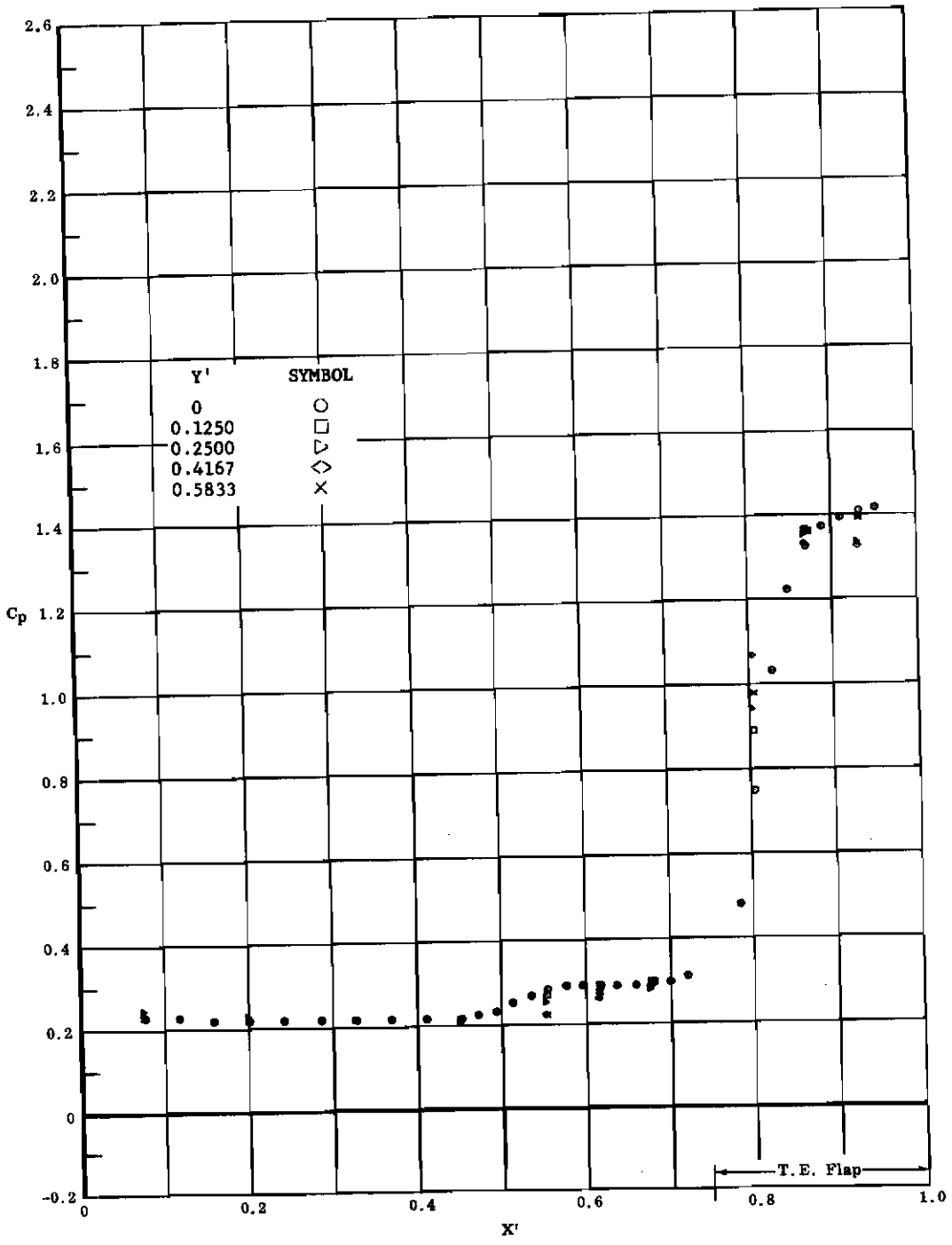


Fig. 98 Streamwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = -15°, Re_∞/ft = 1,100,000.

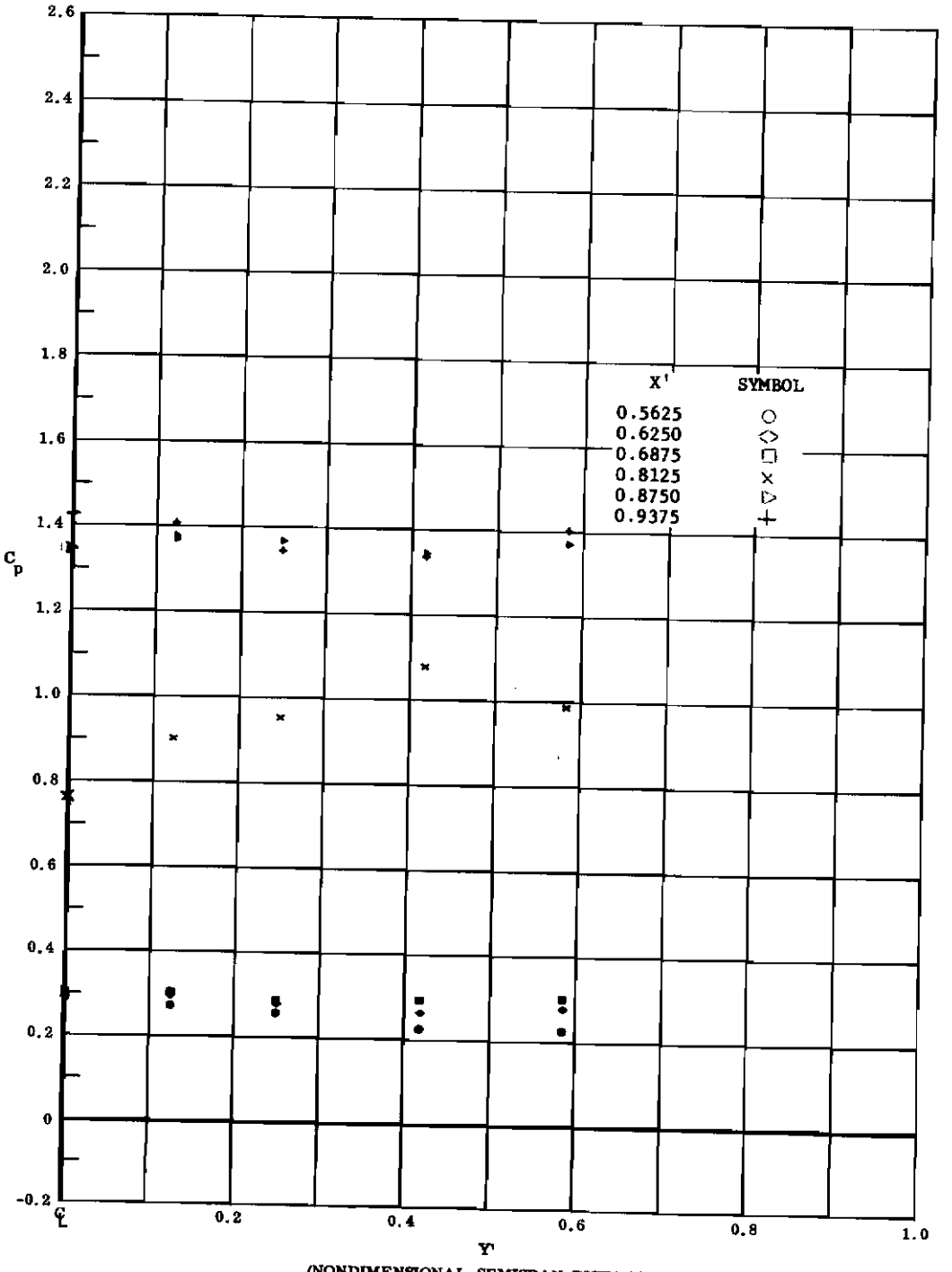


Fig. 98 Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -15°$, $Re_\infty/ft = 1{,}100{,}000$.

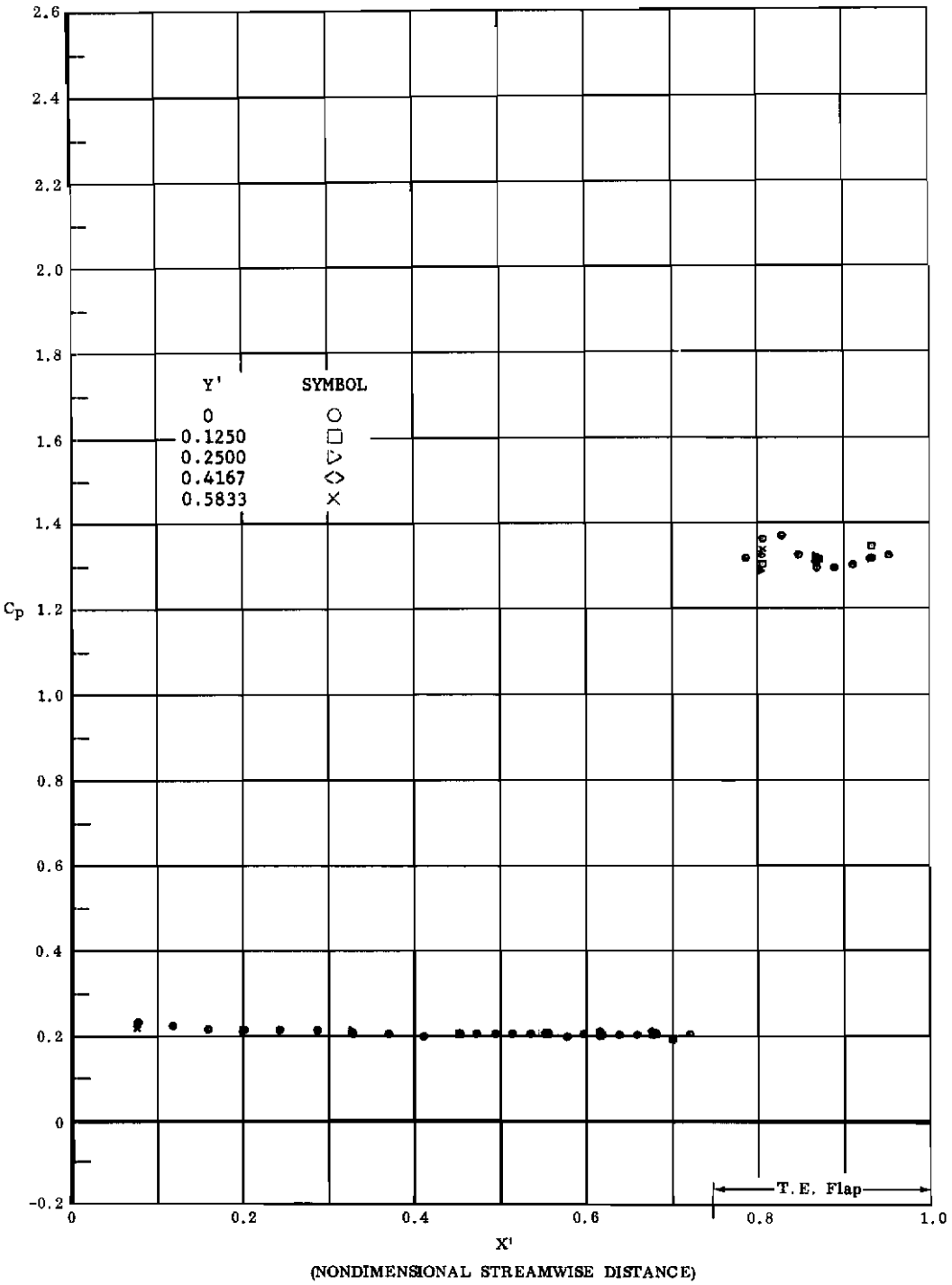


Fig. 99 Streamwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = -15°, Re_∞/ft = 3,300,000.

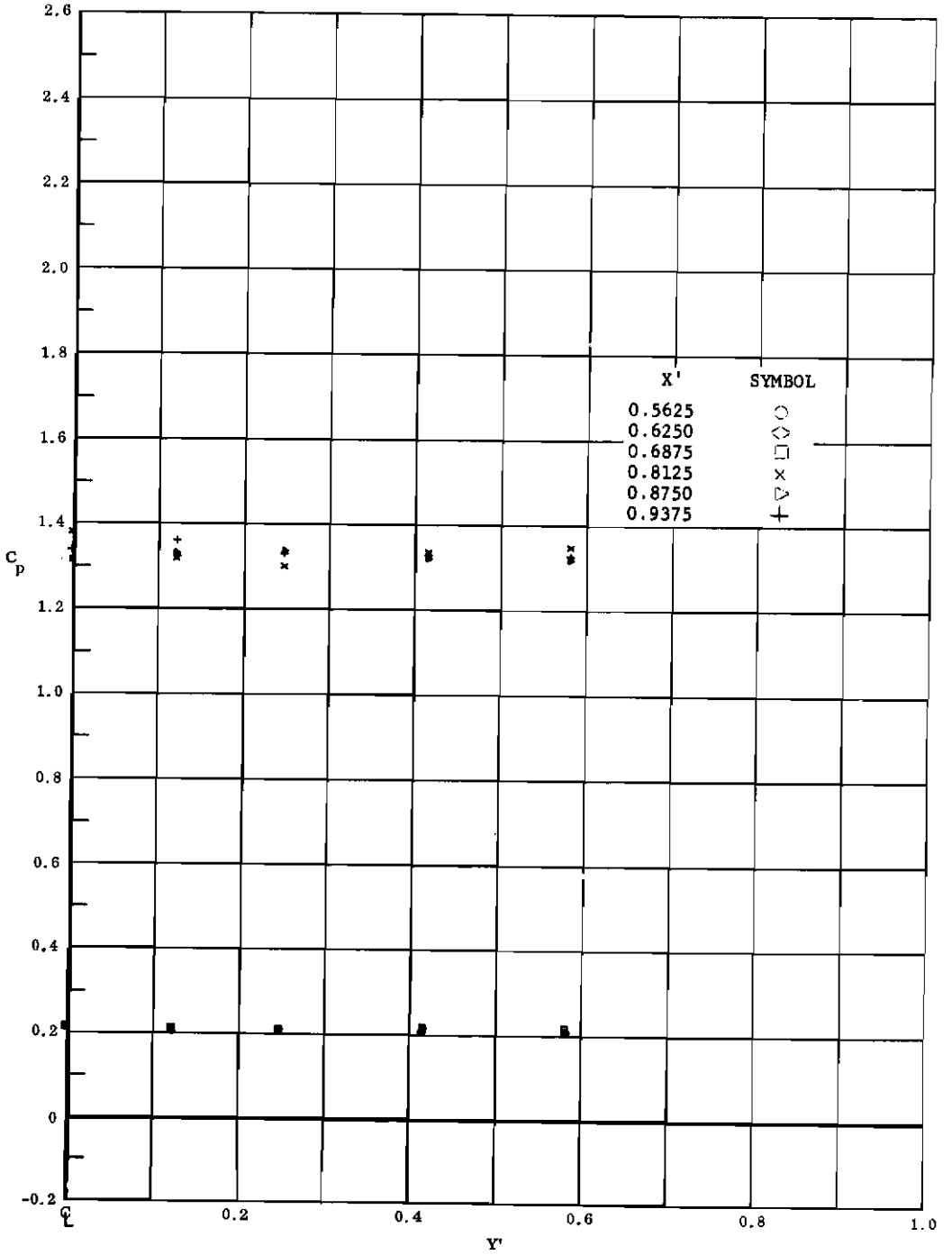


Fig. 99 Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = -15°, Re_∞/ft = 3,300,000.

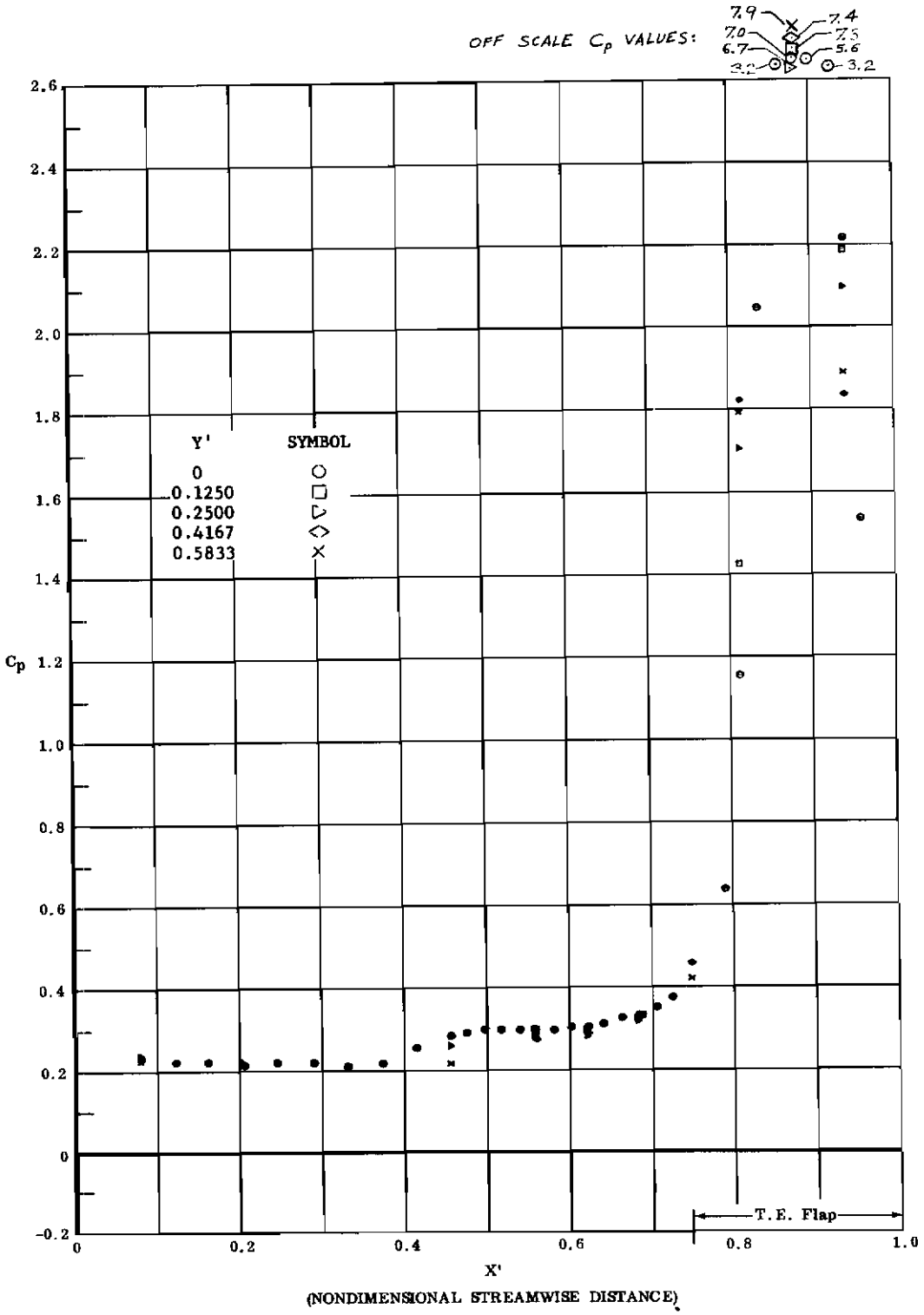


Fig. 100 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -15°, Re_∞/ft = 1,100,000.

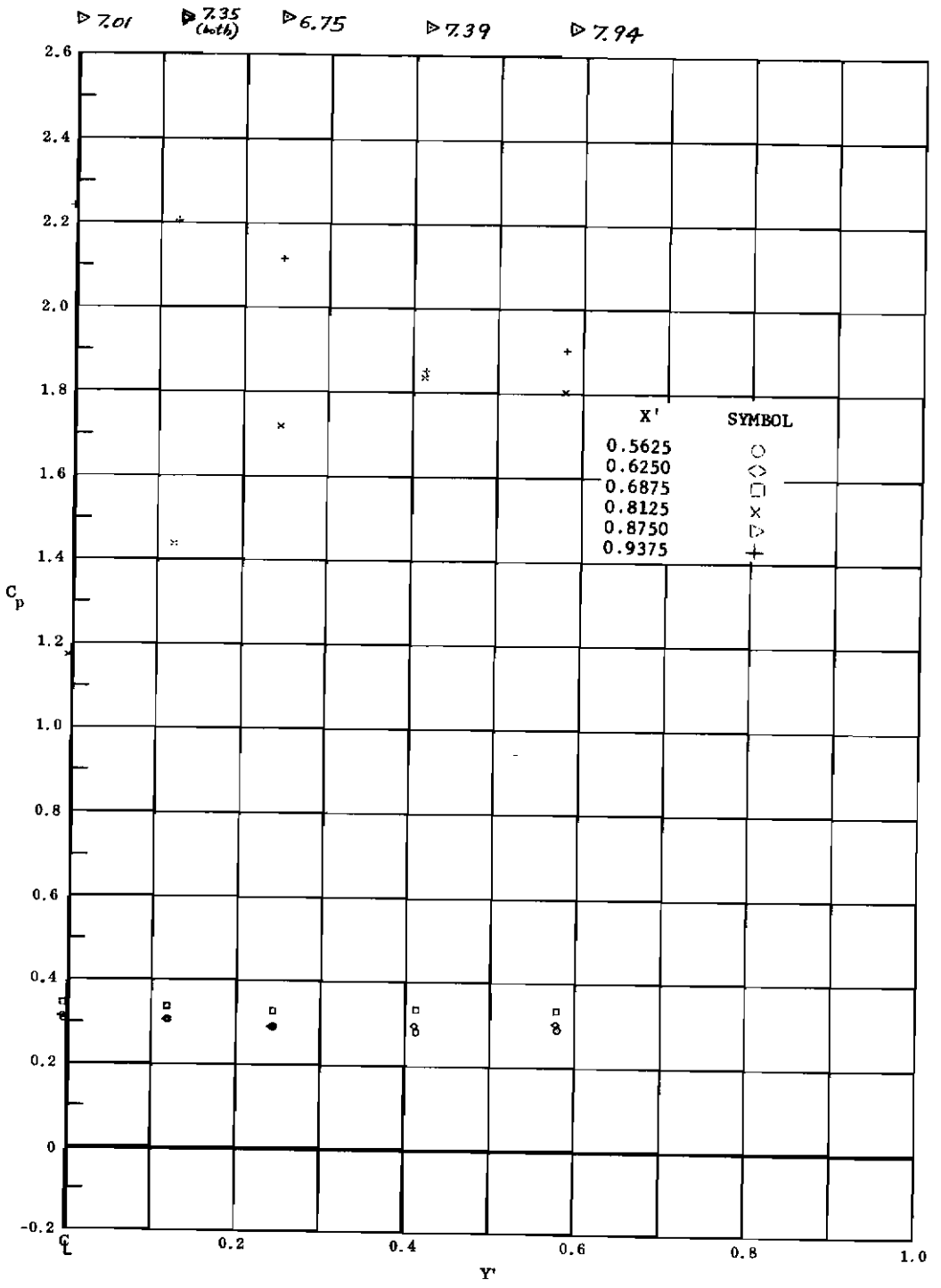


Fig. 100 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -15°$, $Re_\infty/ft = 1{,}100{,}000$.

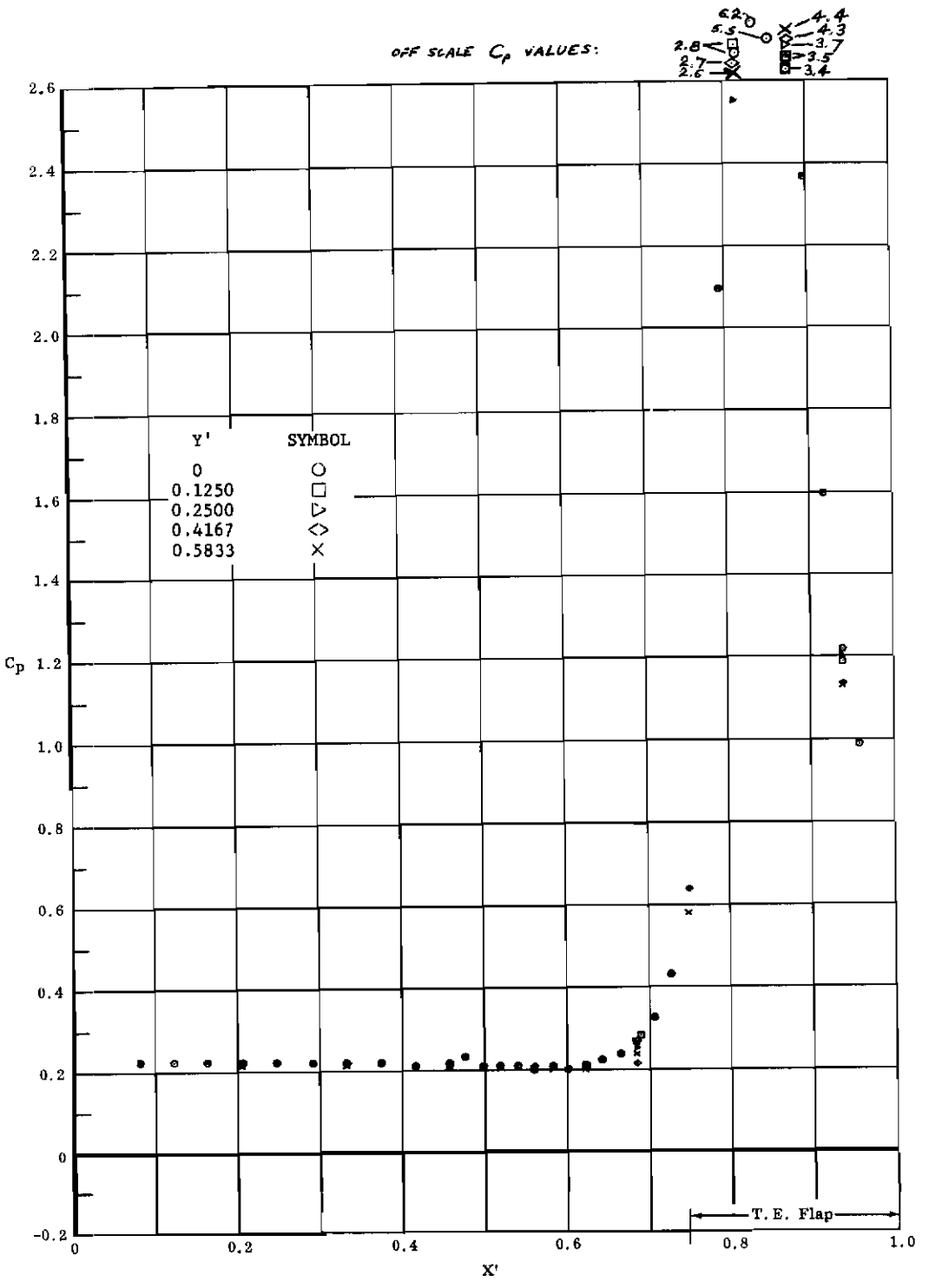


Fig. 101 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -15°, Re_∞/ft = 2,200,000.

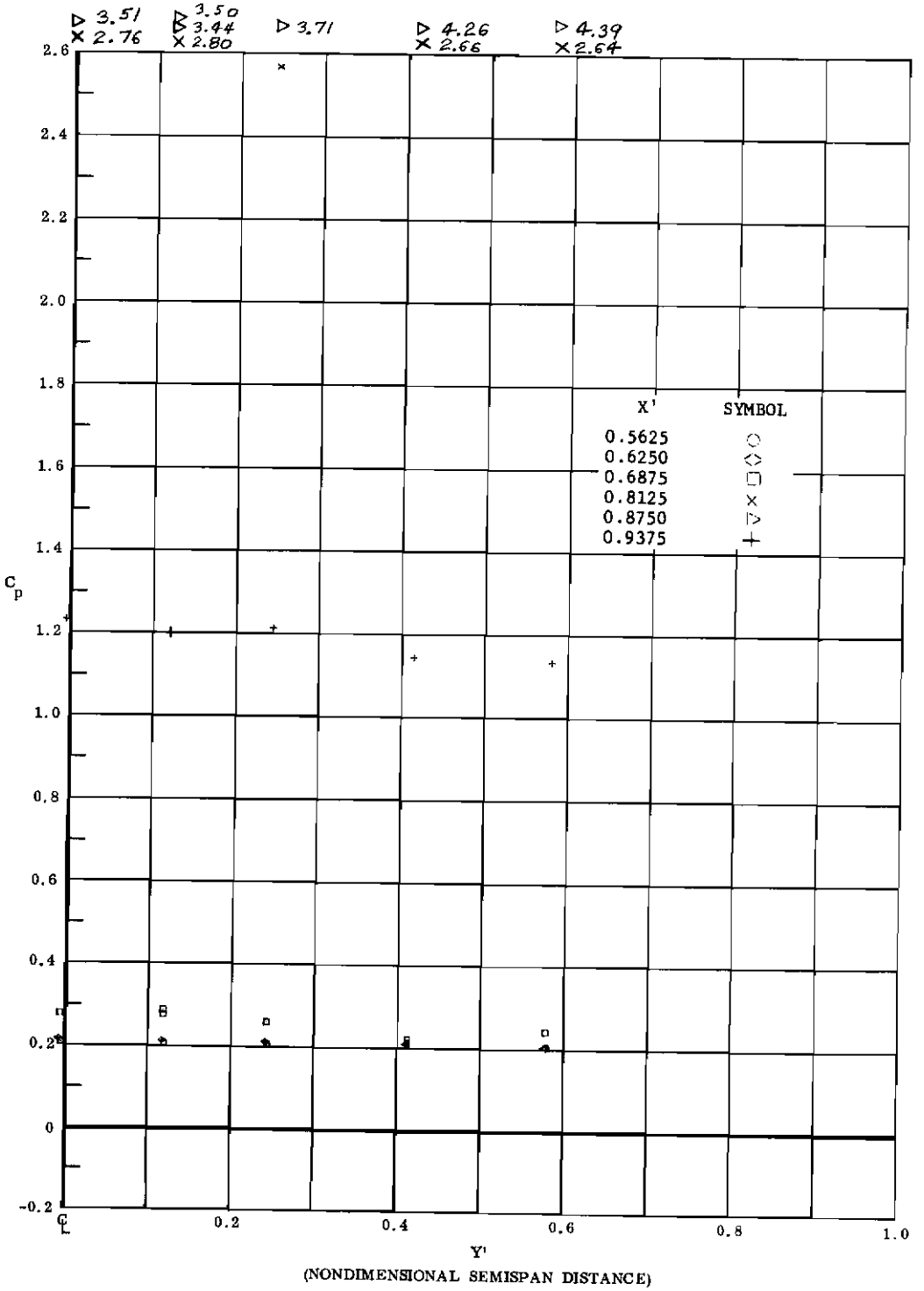


Fig. 101 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -15°, Re_∞/ft = 2,200,000.

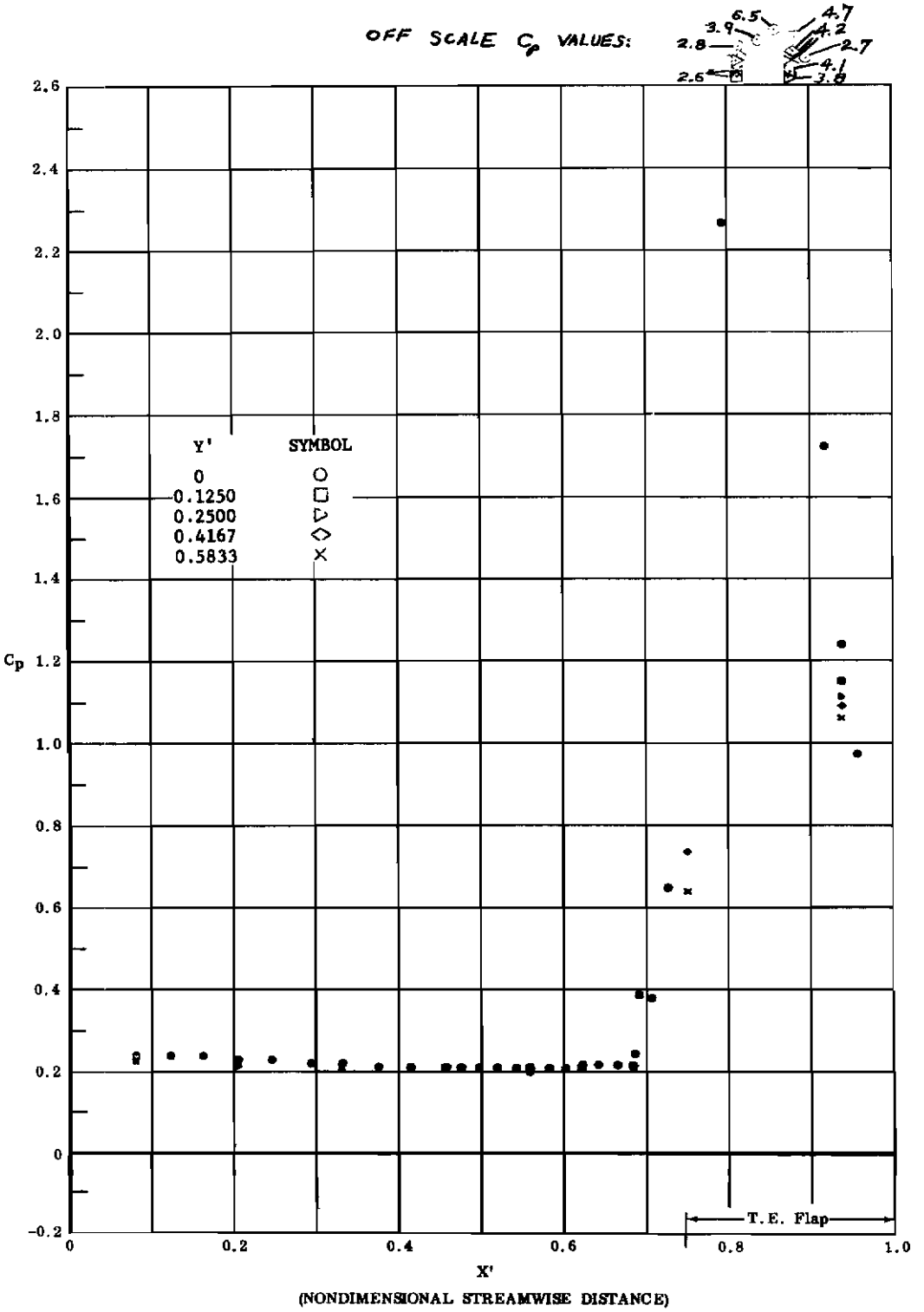


Fig. 102 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -15°$, $Re_\infty/ft = 3,300,000$.

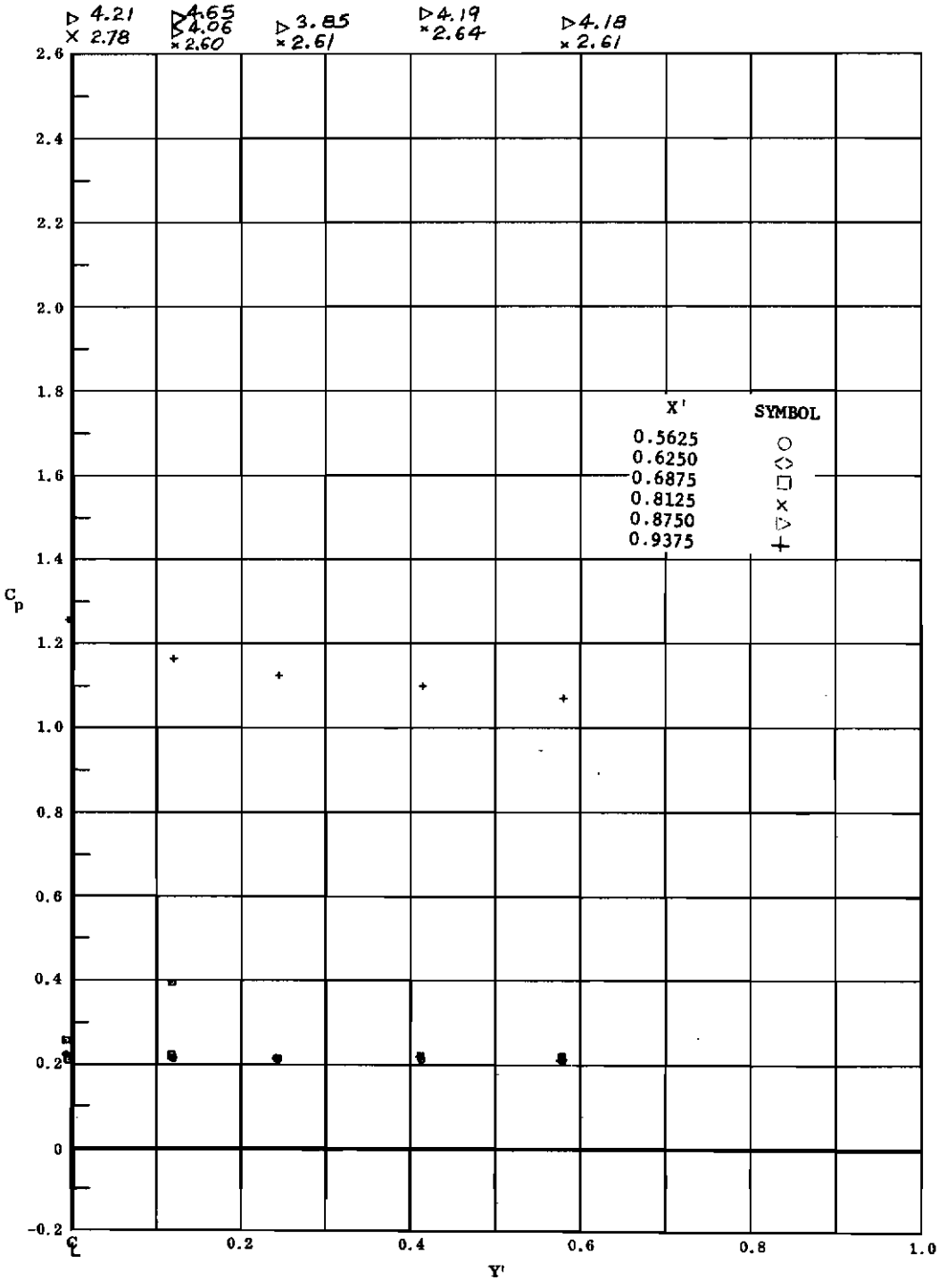
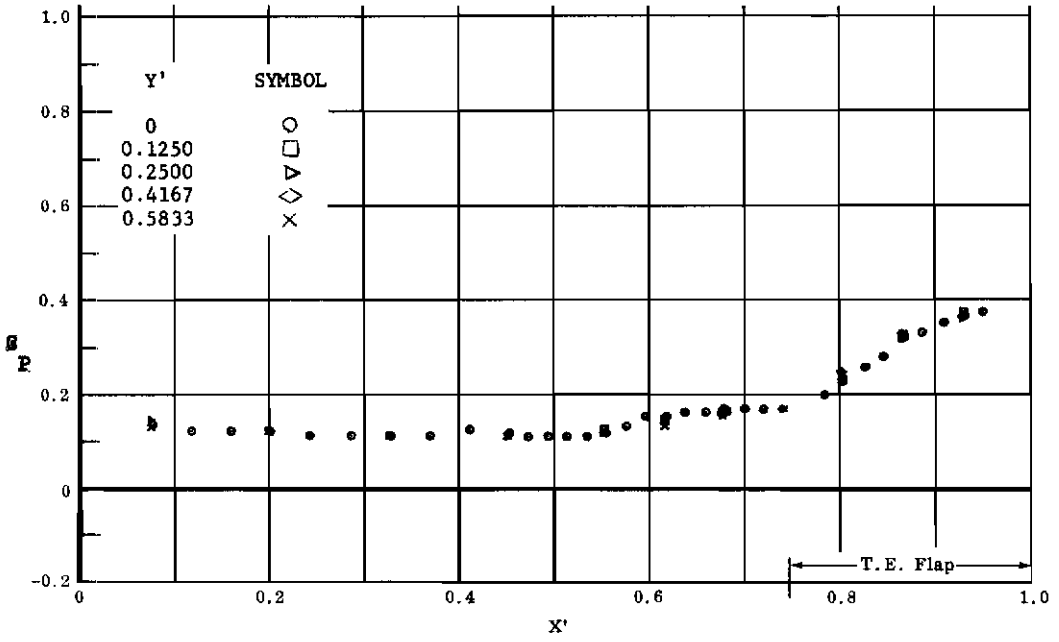


Fig. 102 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -15°, Re_∞/ft = 3,300,000.



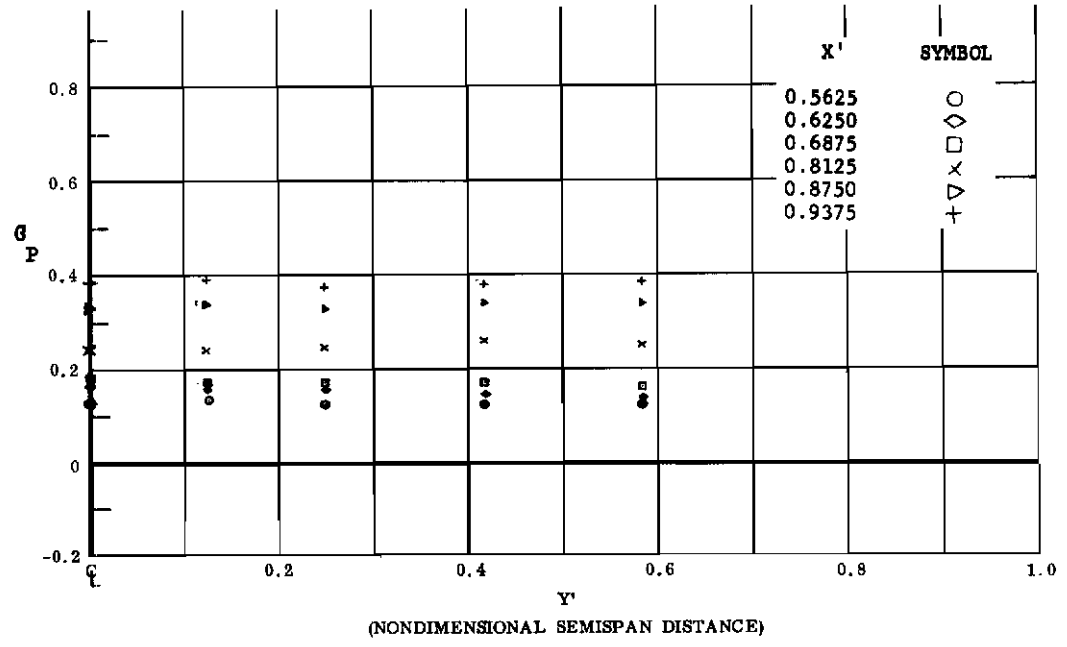
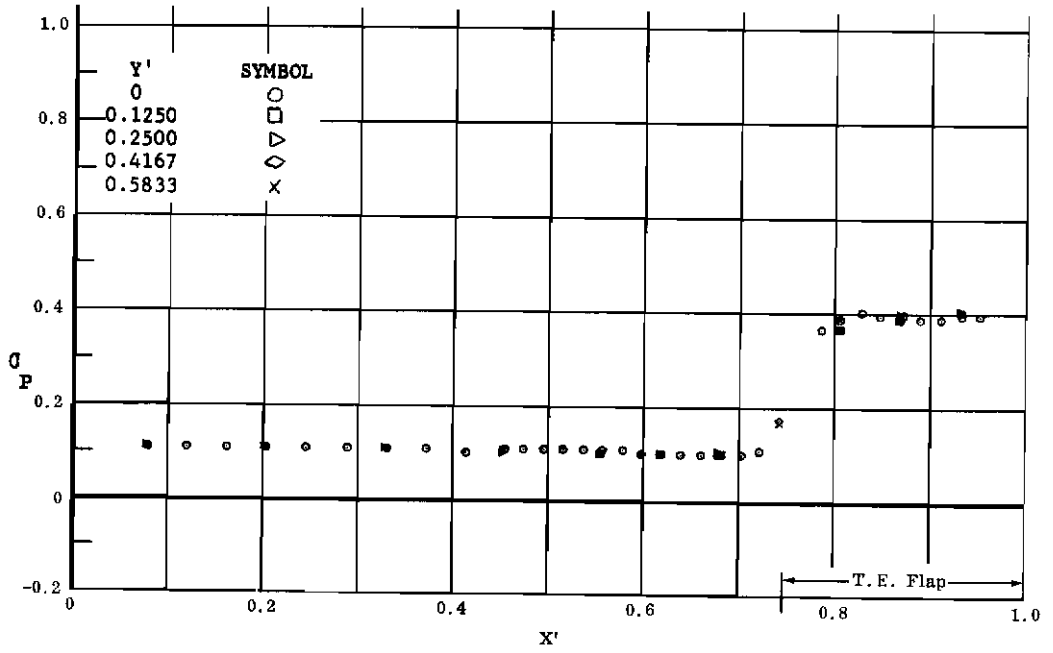


Fig. 103 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = -10°, Re_∞/ft = 1,100,000.



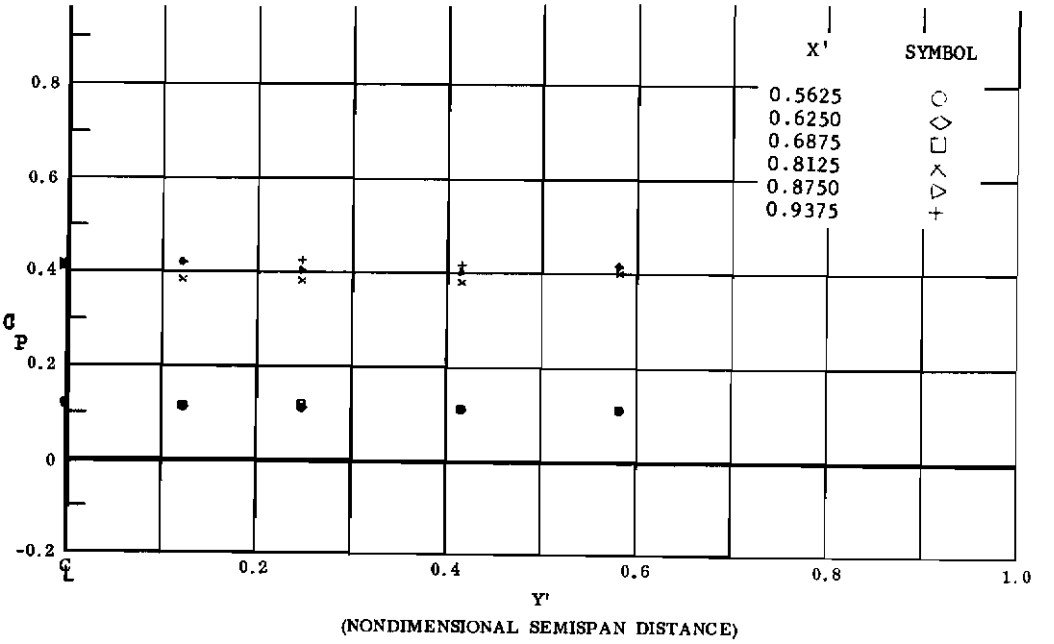


Fig. 104 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = -10°, Re_∞/ft = 3,306,000.

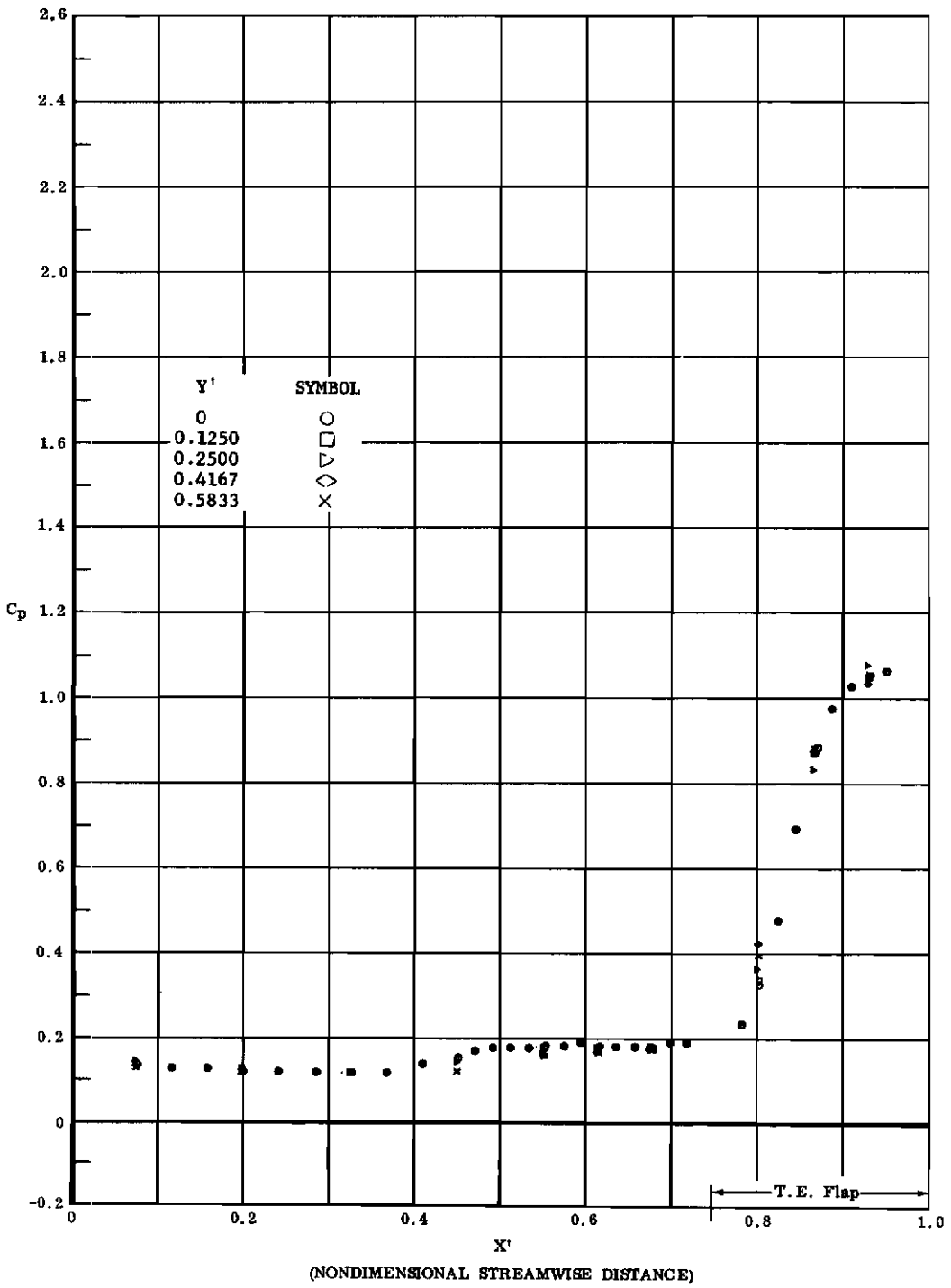


Fig. 105 Streamwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -10°$, $Re_\infty/ft = 1{,}100{,}000$.

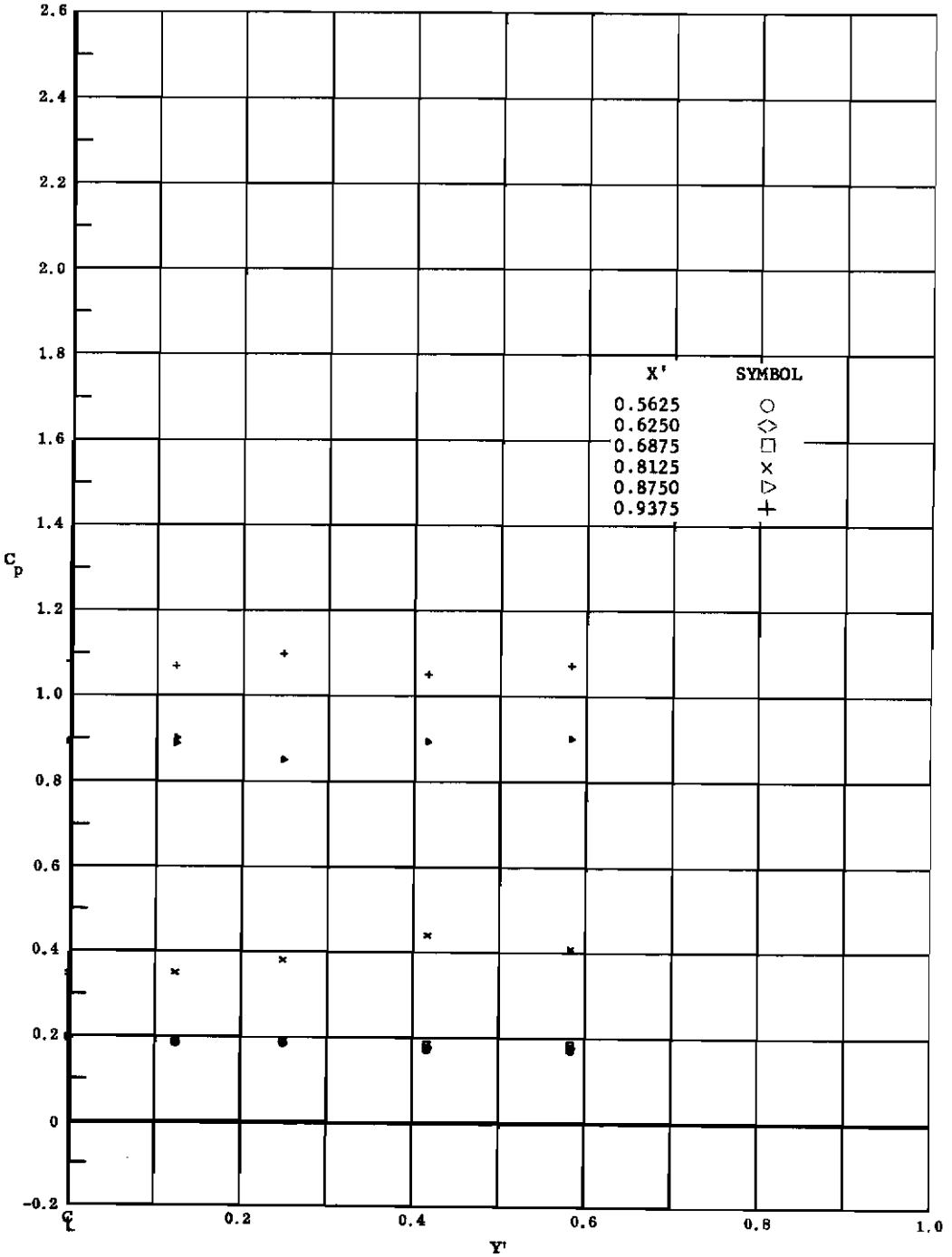


Fig. 105 Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -10°$, $Re_\infty/ft = 1{,}100{,}000$.

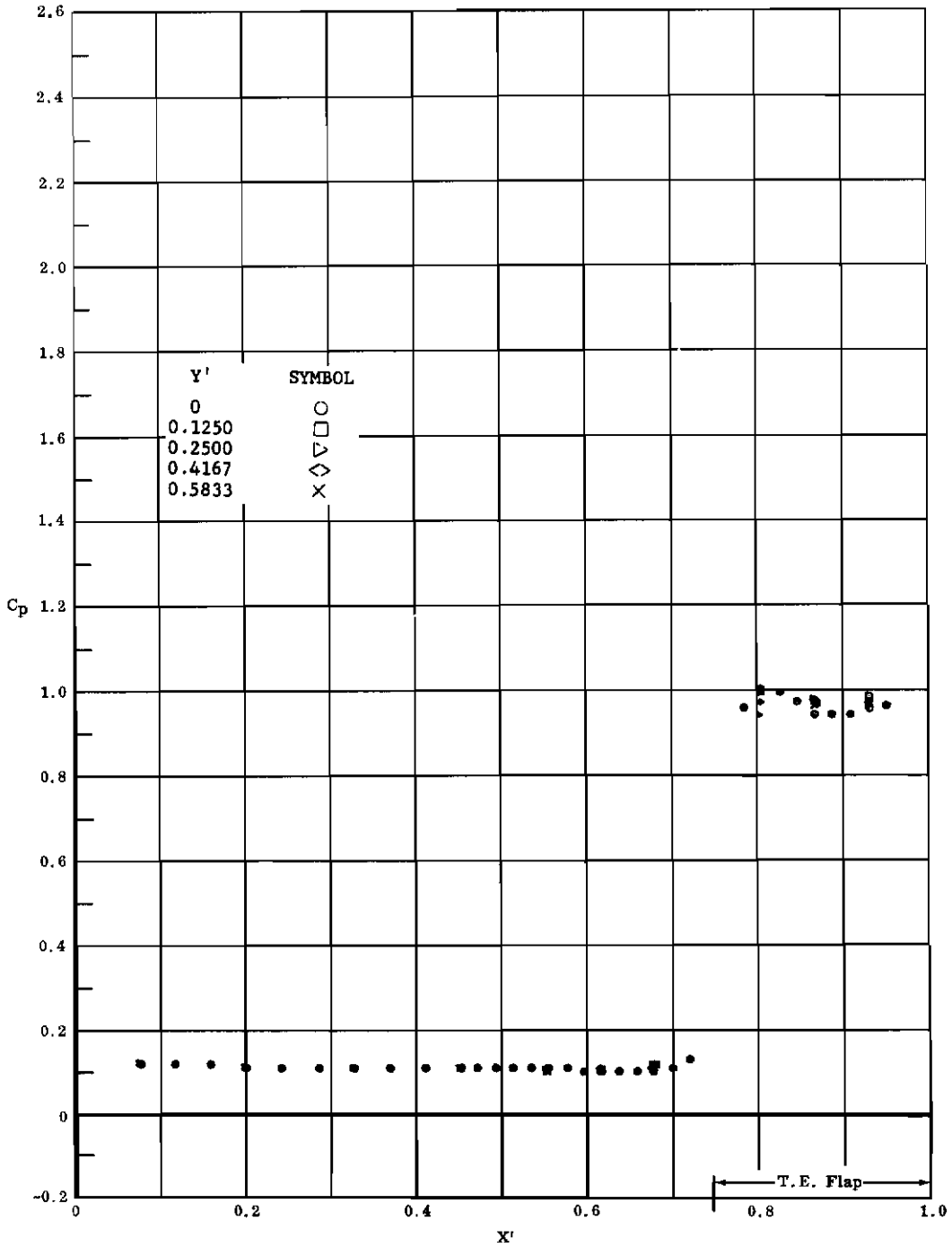


Fig. 106 Streamwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -10°$, $Re_\infty/ft = 3{,}300{,}000$.

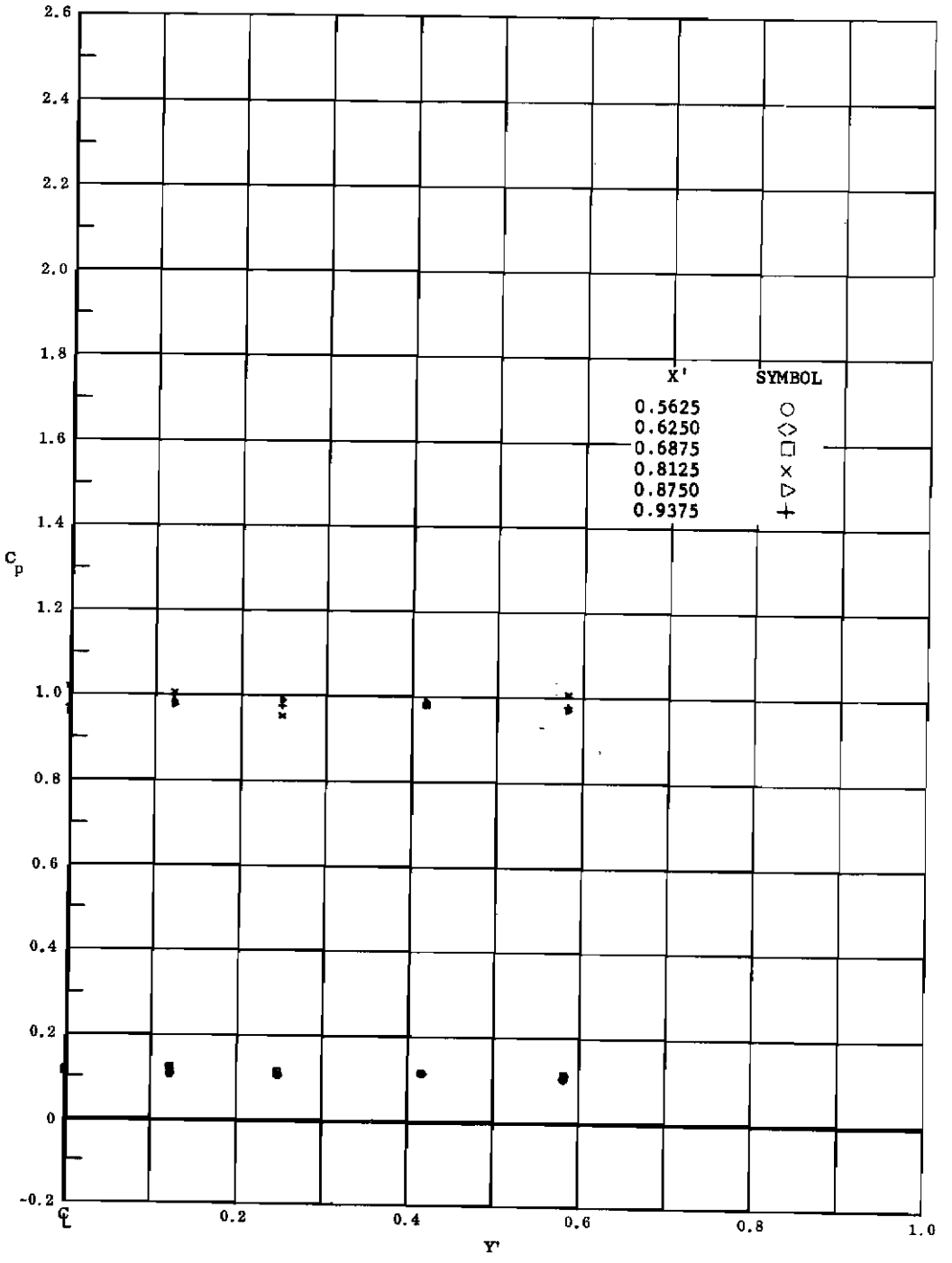


Fig. 106 Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -10°$, $Re_\infty/ft = 3,300,000$.

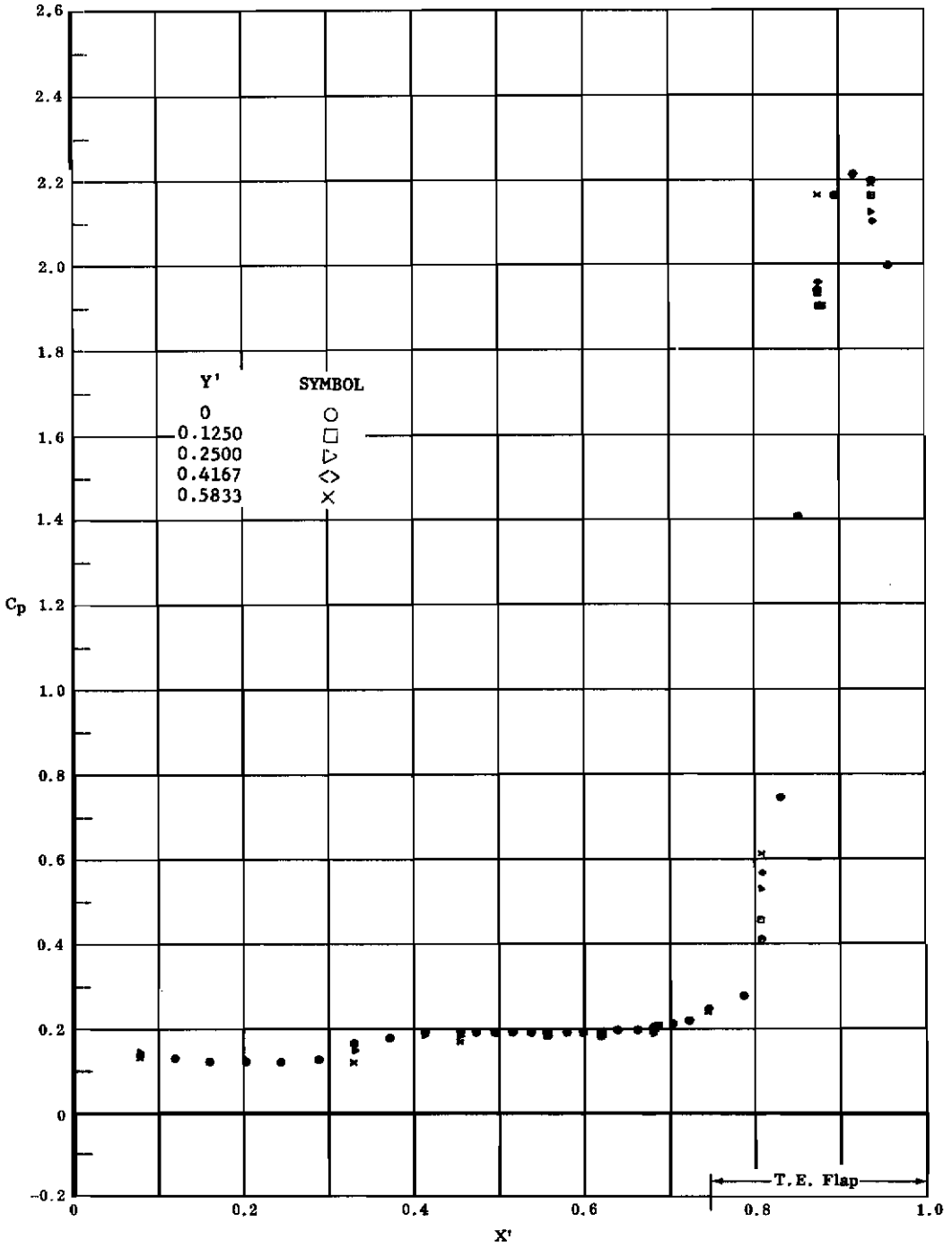


Fig. 107 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -10°$, $Re_\infty/ft = 1{,}100{,}000$.

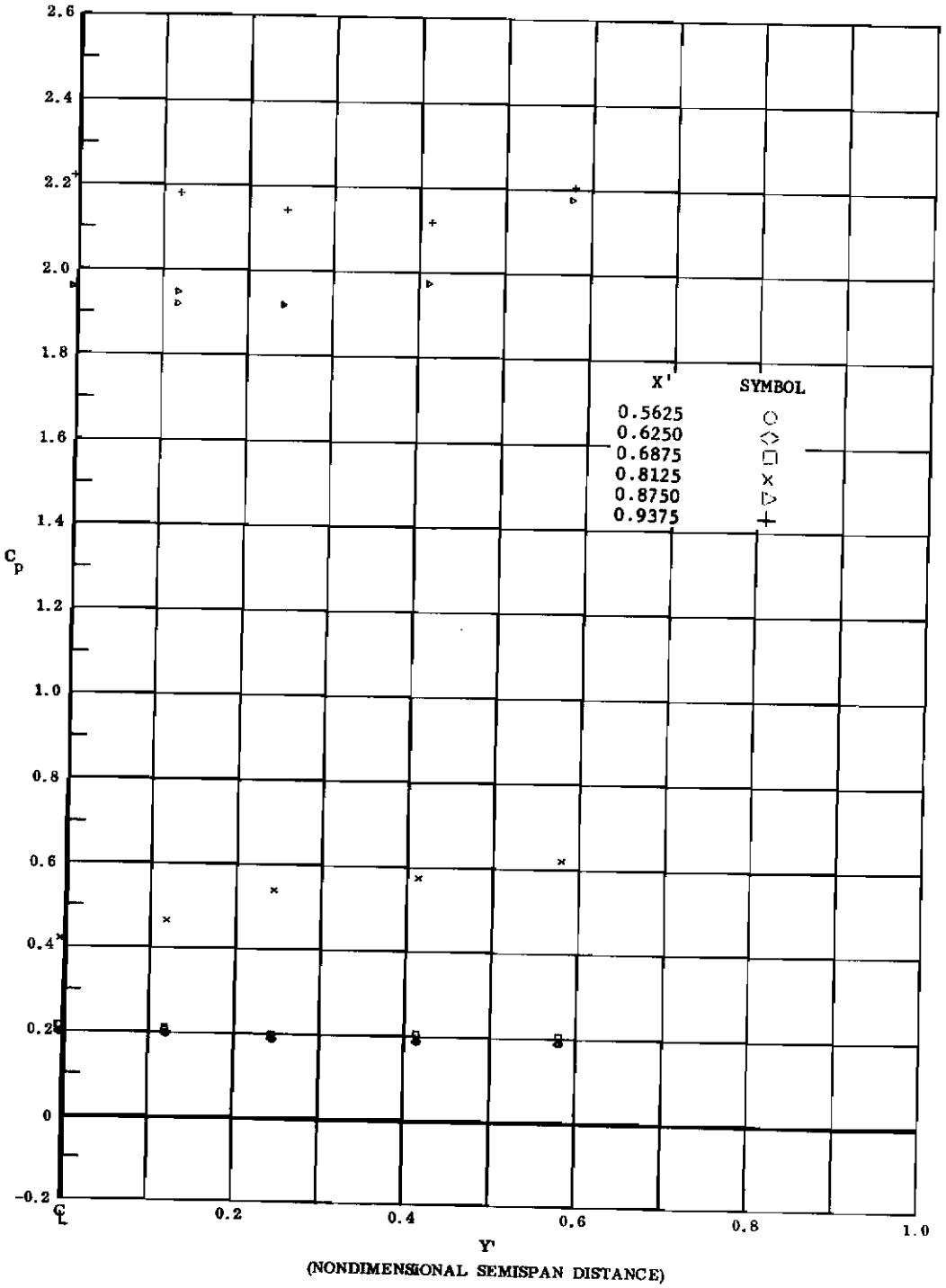


Fig. 107 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -10°$, $Re_\infty/ft = 1{,}100{,}000$.

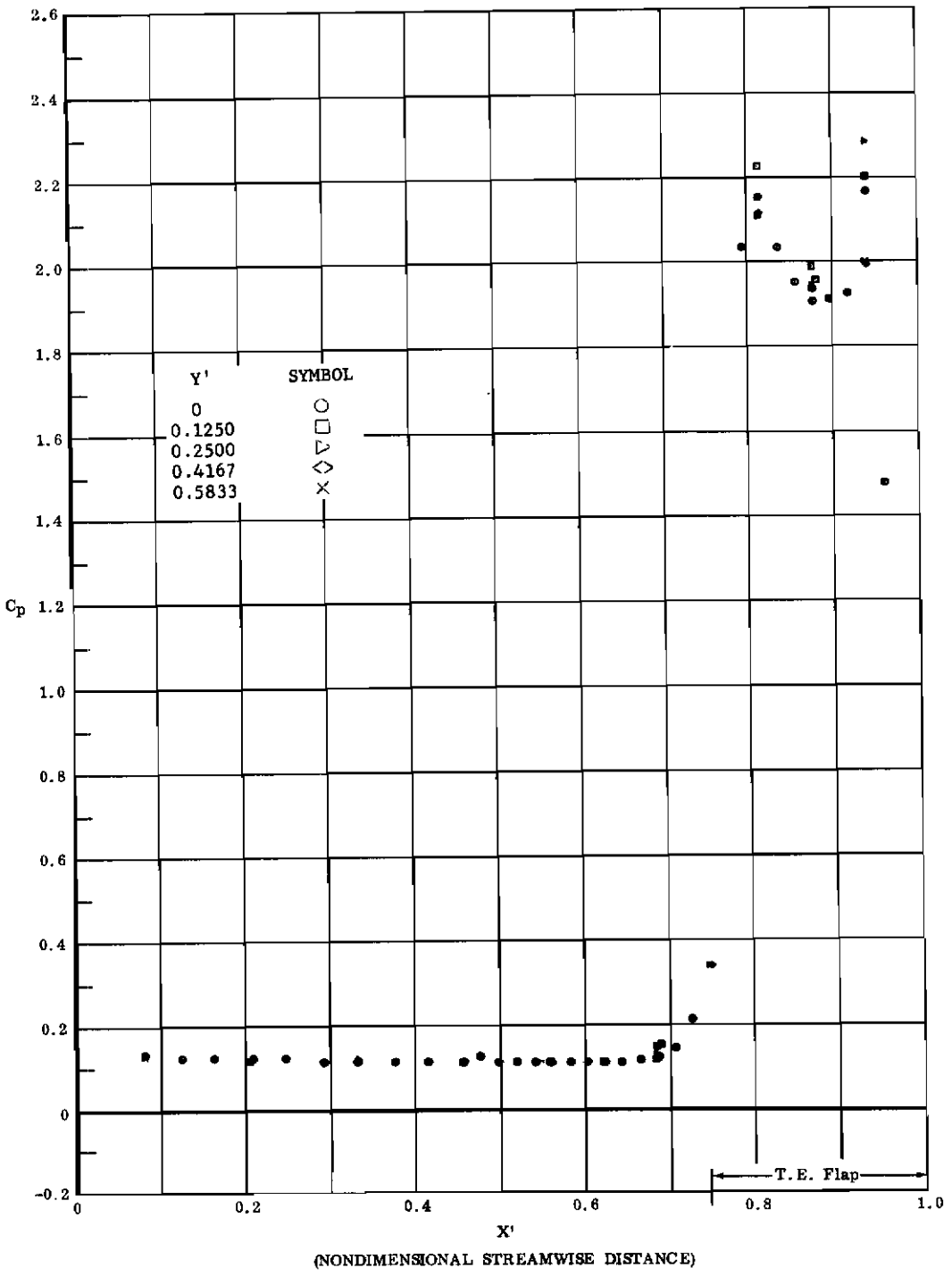


Fig. 108 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -10°$, $Re_\infty/ft = 3{,}300{,}000$.

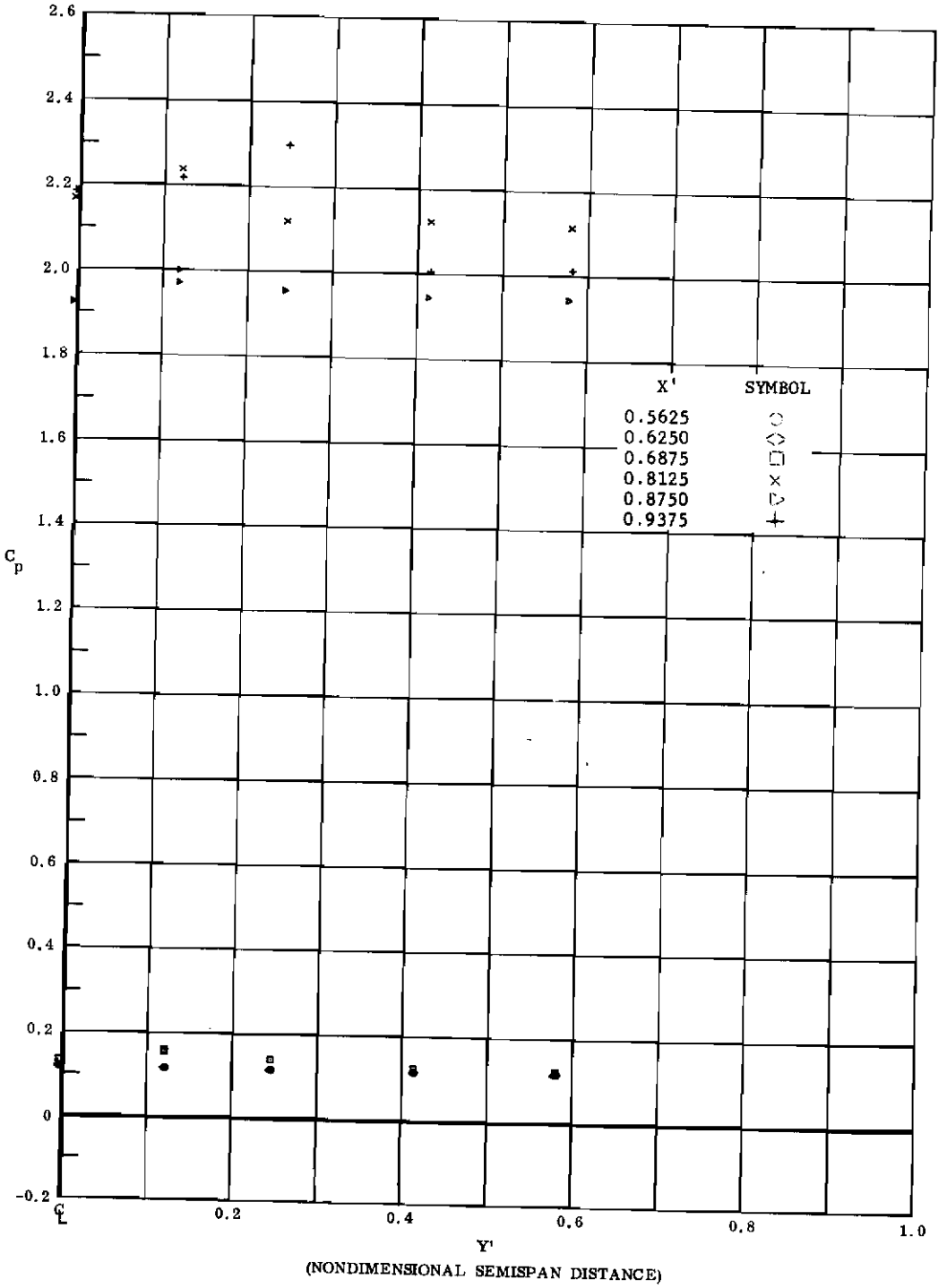
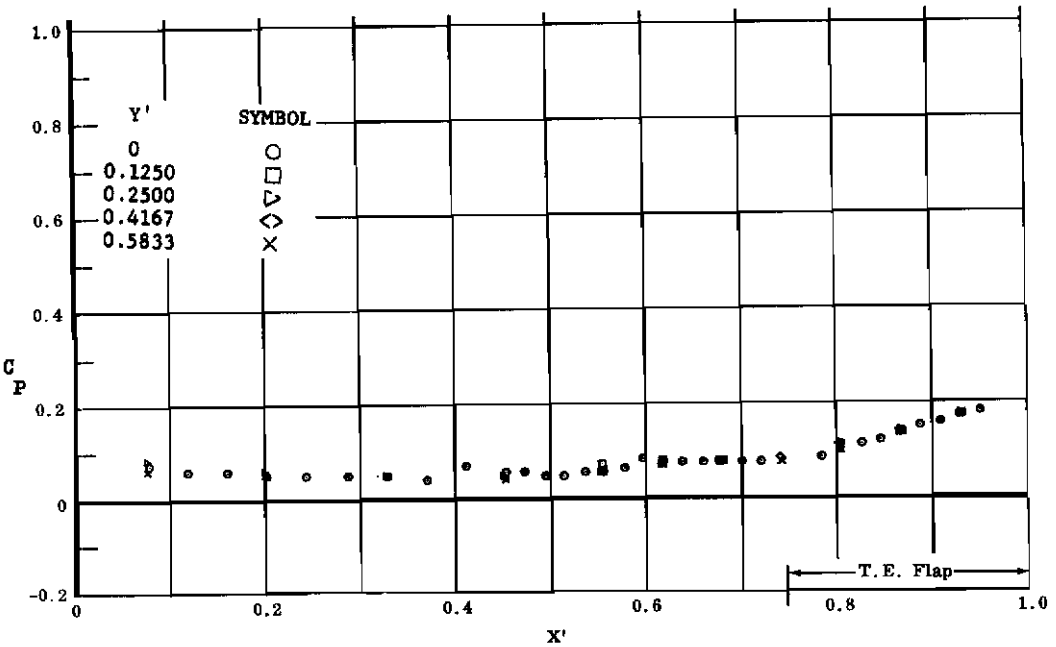


Fig. 108 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -10°, Re_∞/ft = 3,300,000.



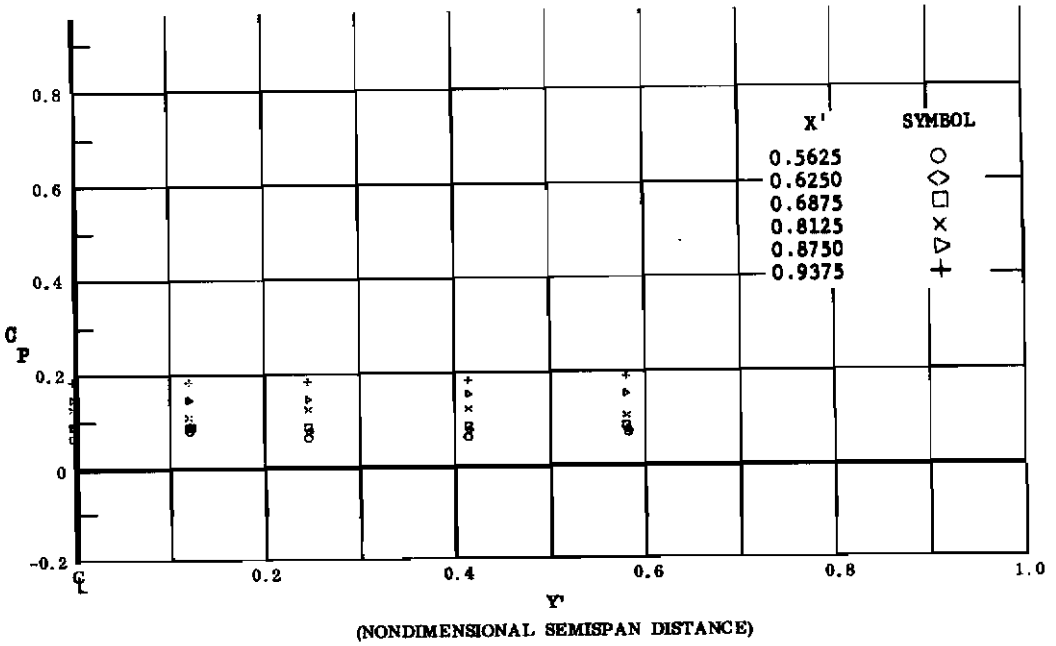
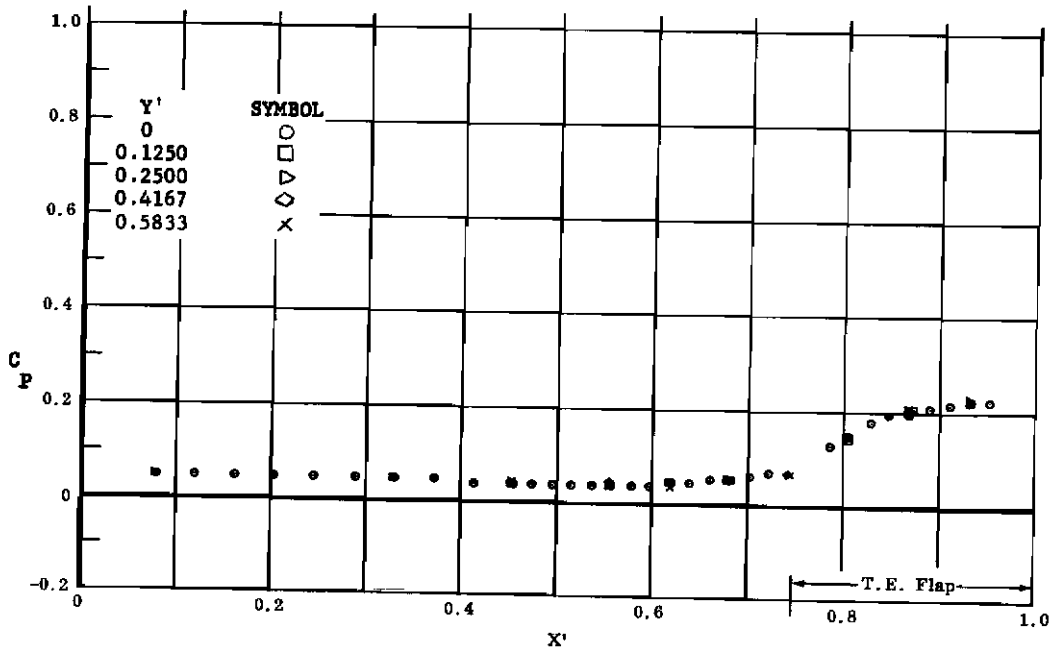


Fig. 109 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, $\alpha = -5°$, $Re_\infty/ft = 1{,}100{,}000$.



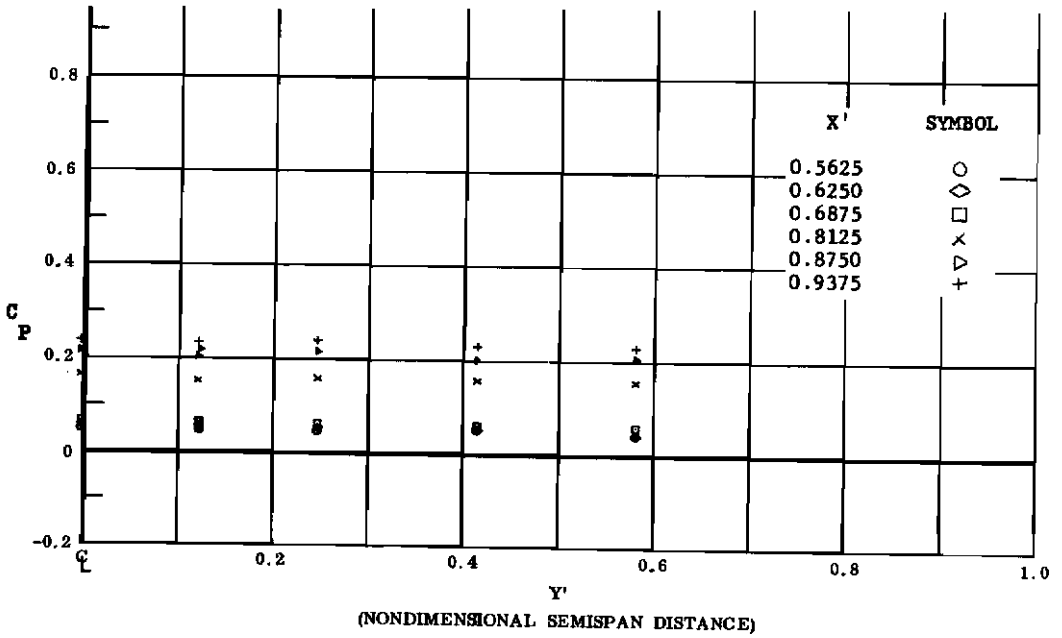
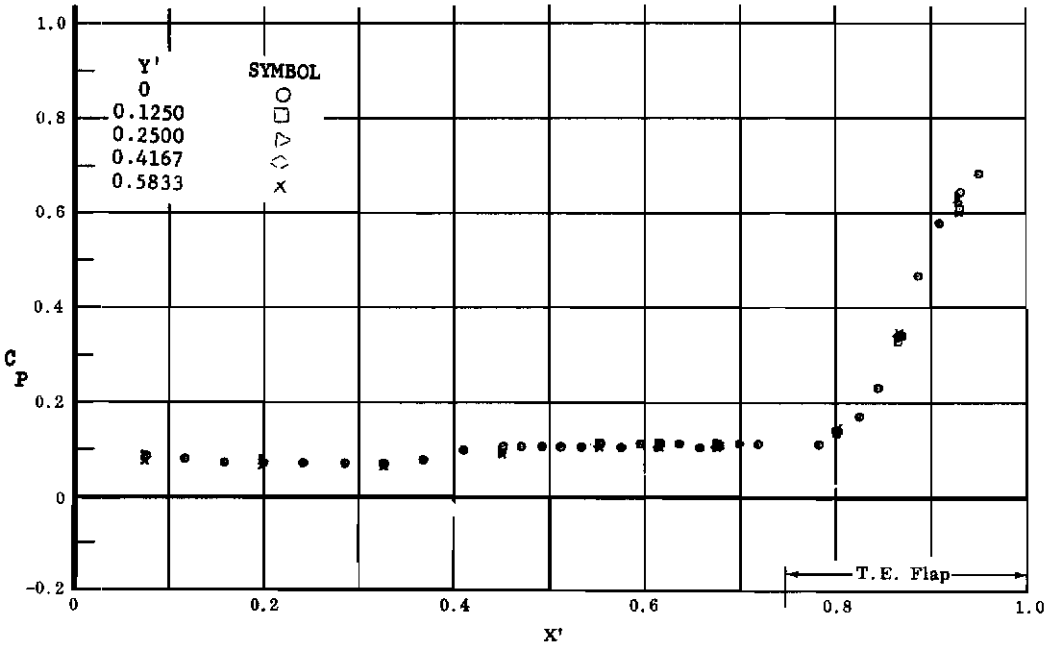


Fig. 110 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = -5°, Re_∞/ft = 3,300,000.



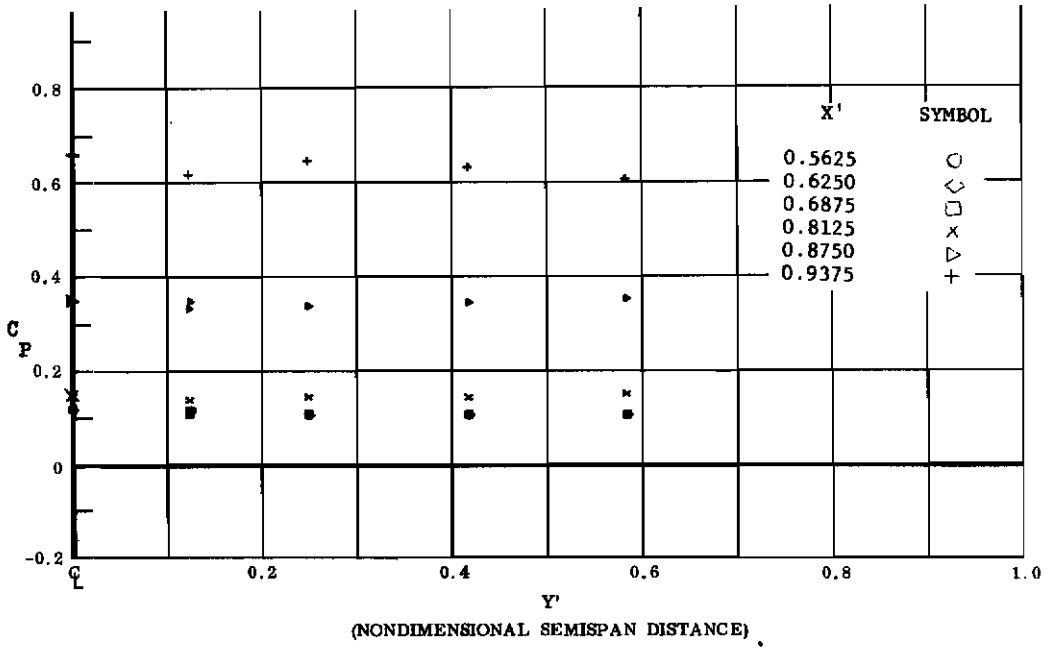
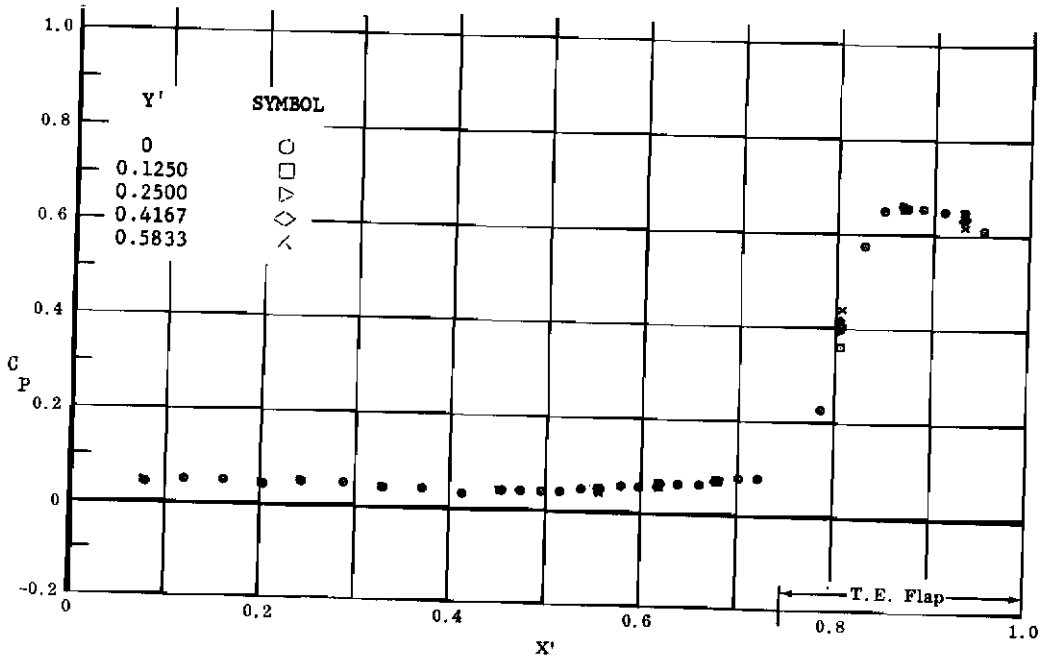


Fig. 111 Streamwise and Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = -5°$, $Re_\infty/ft = 1{,}100{,}000$.



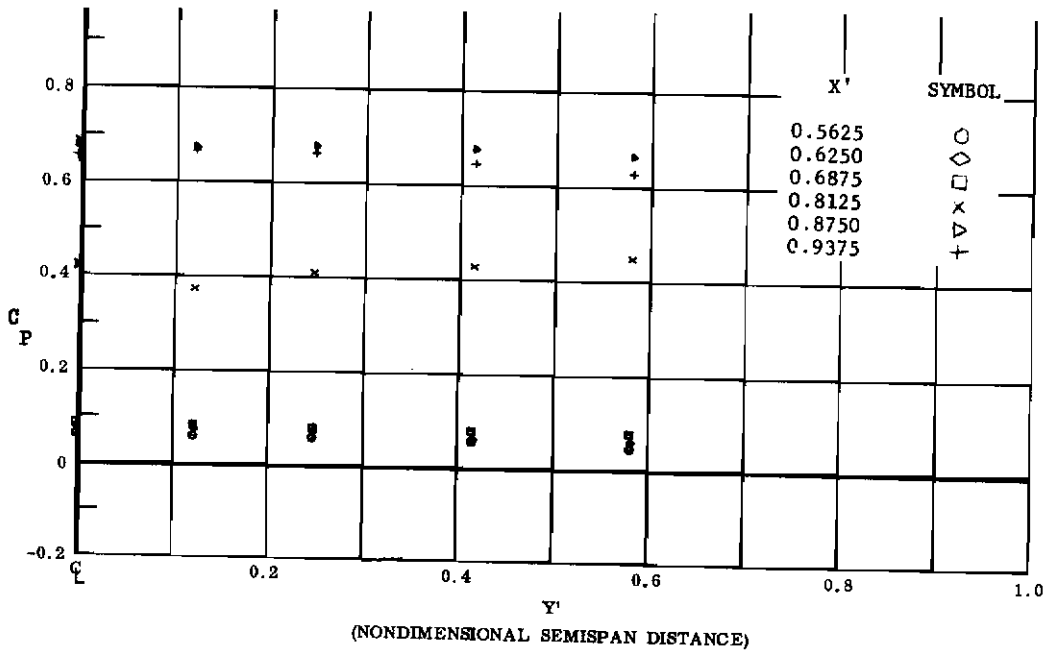


Fig. 112 Streamwise and Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = -5°, Re_∞/ft = 3,300,000.

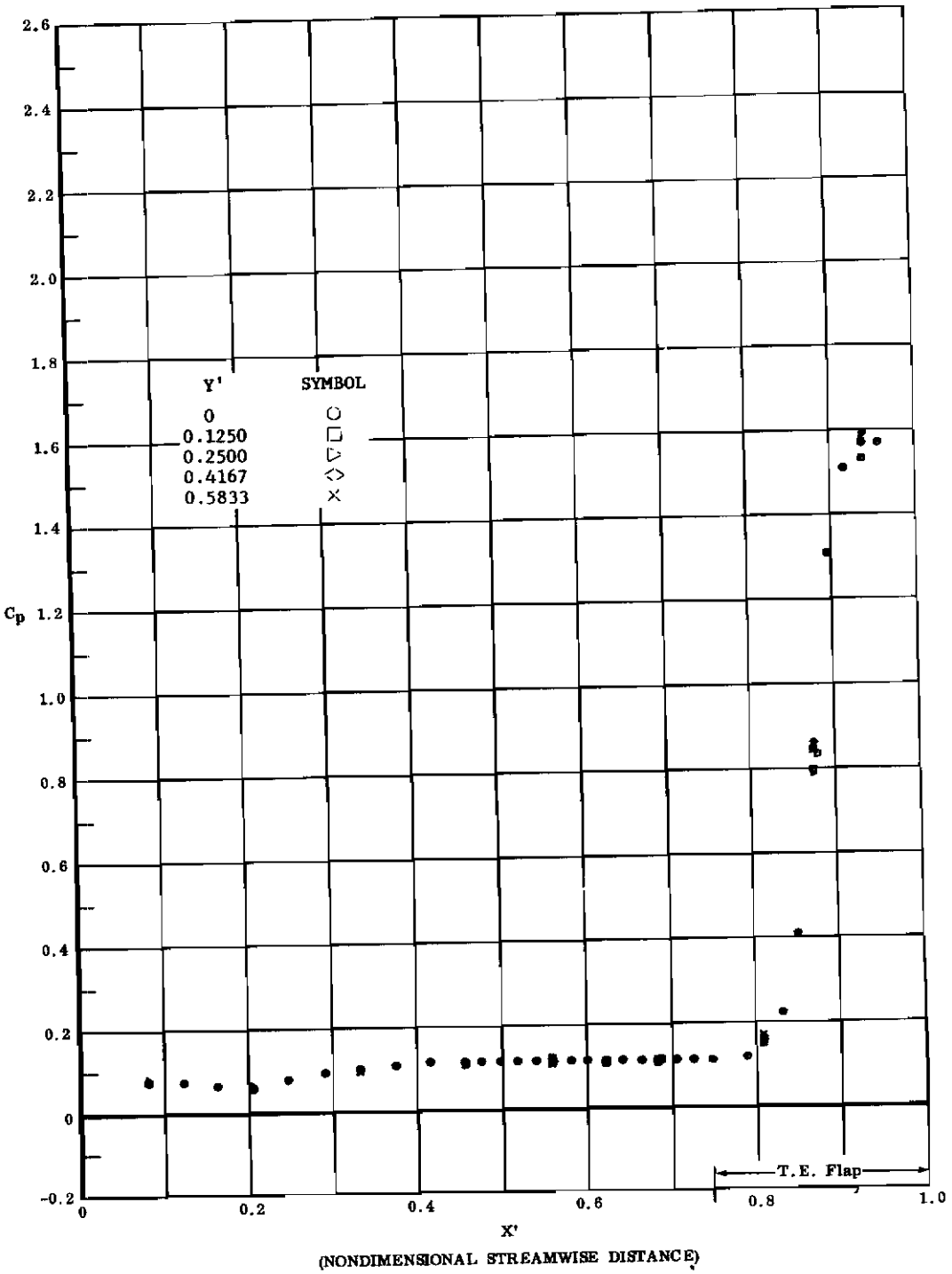


Fig. 113 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -5°$, $Re_\infty/ft = 1{,}100{,}000$.

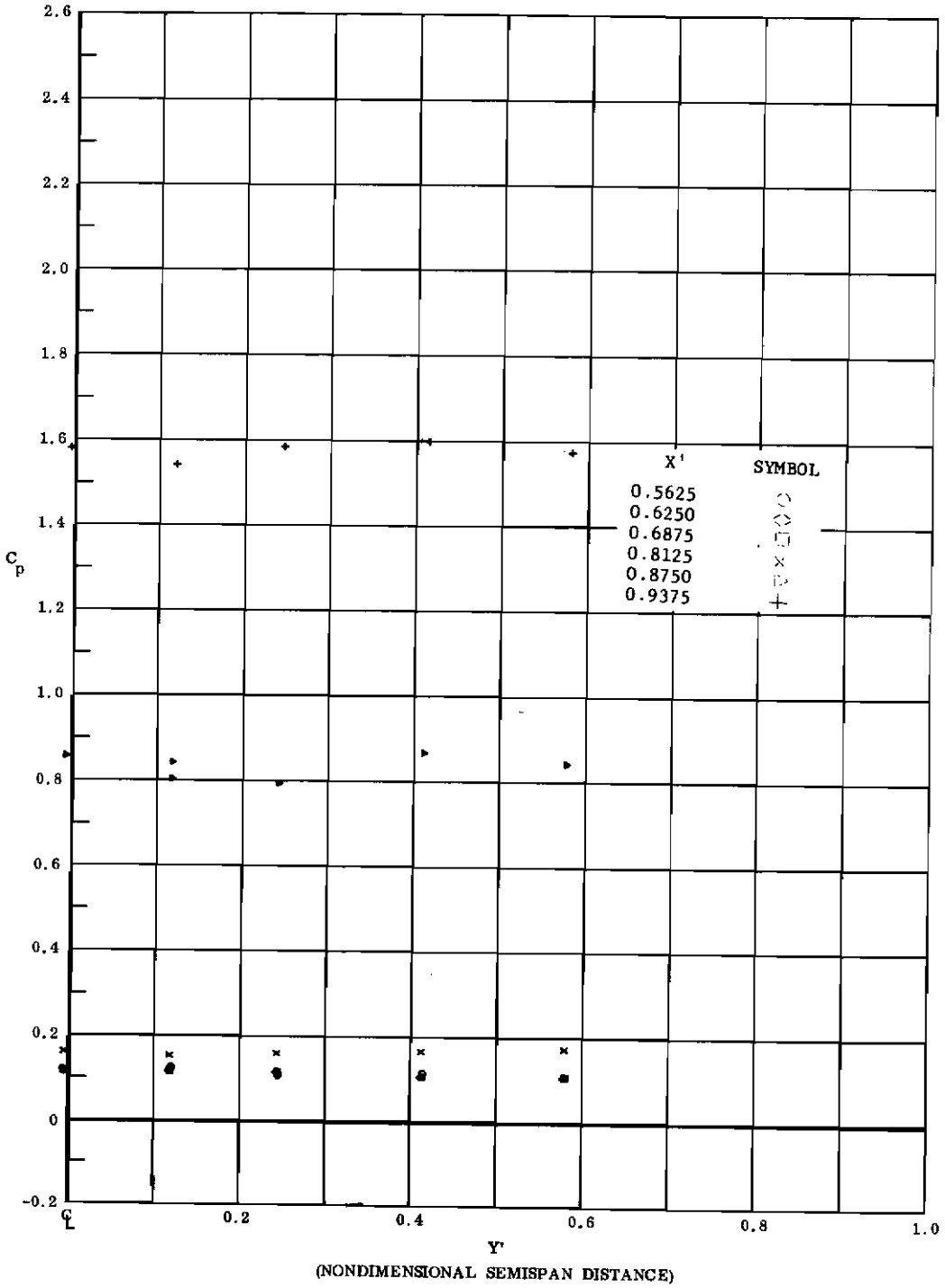


Fig. 113 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = -5°, Re_∞/ft = 1,100,000.

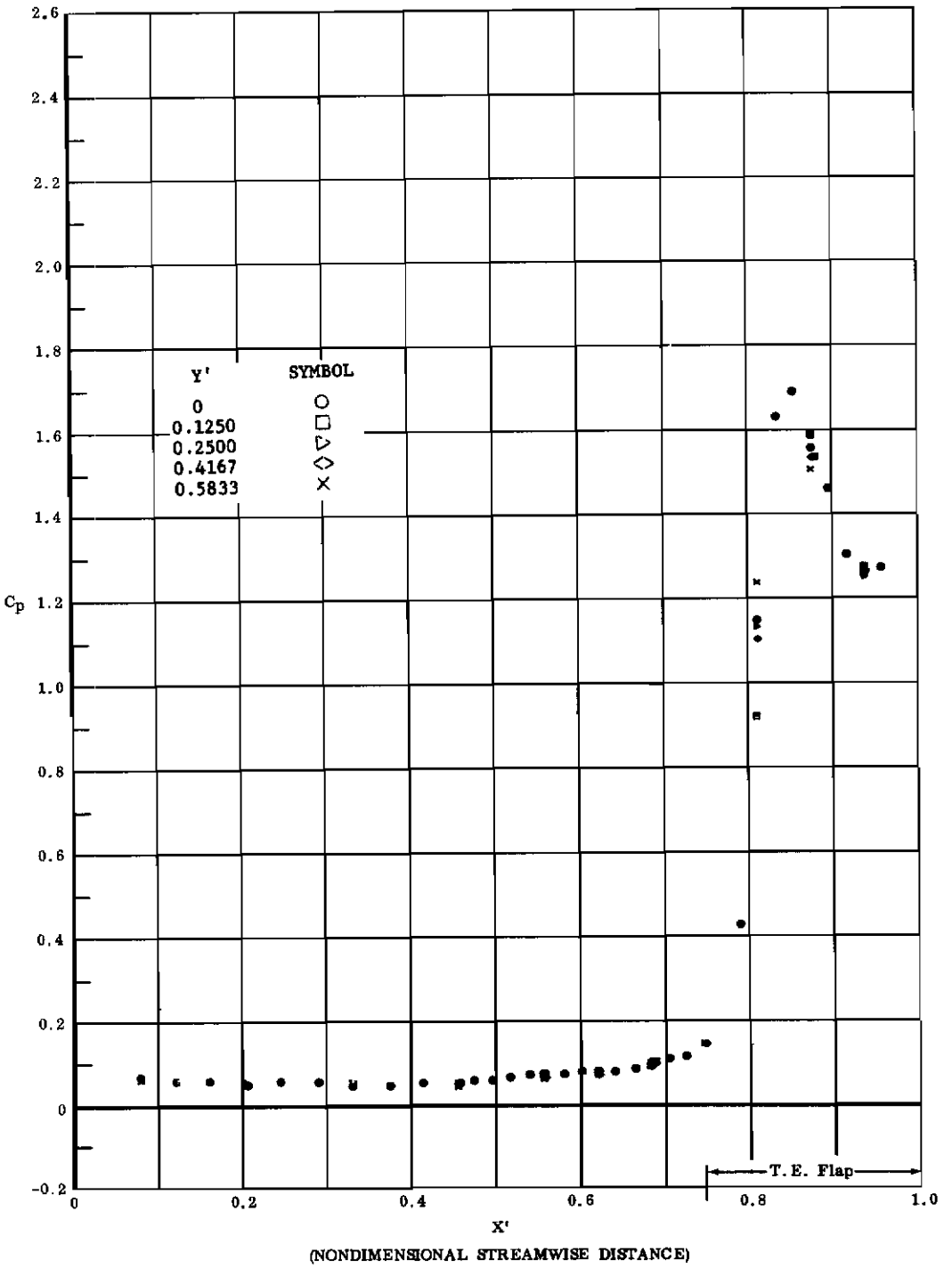


Fig. 114 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -5°$, $Re_\infty/ft = 3,300,000$.

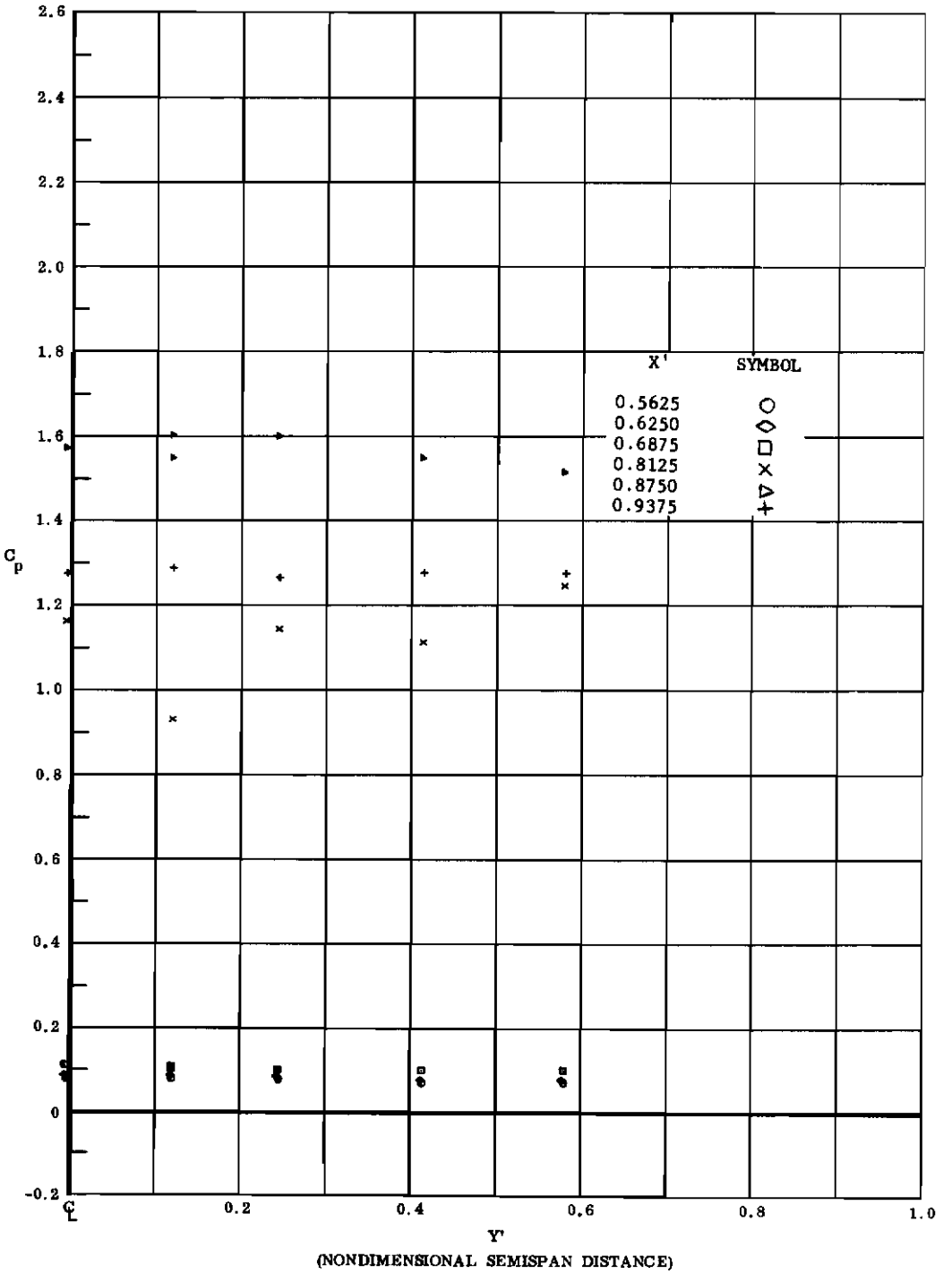
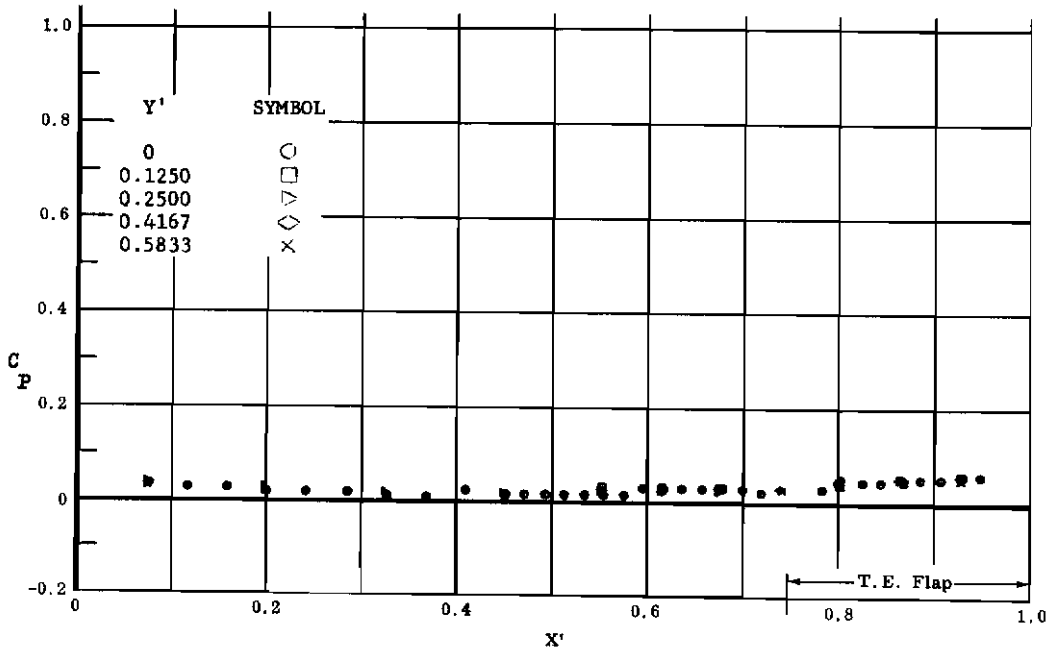


Fig. 114 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = -5°$, $Re_\infty/ft = 3{,}300{,}000$.



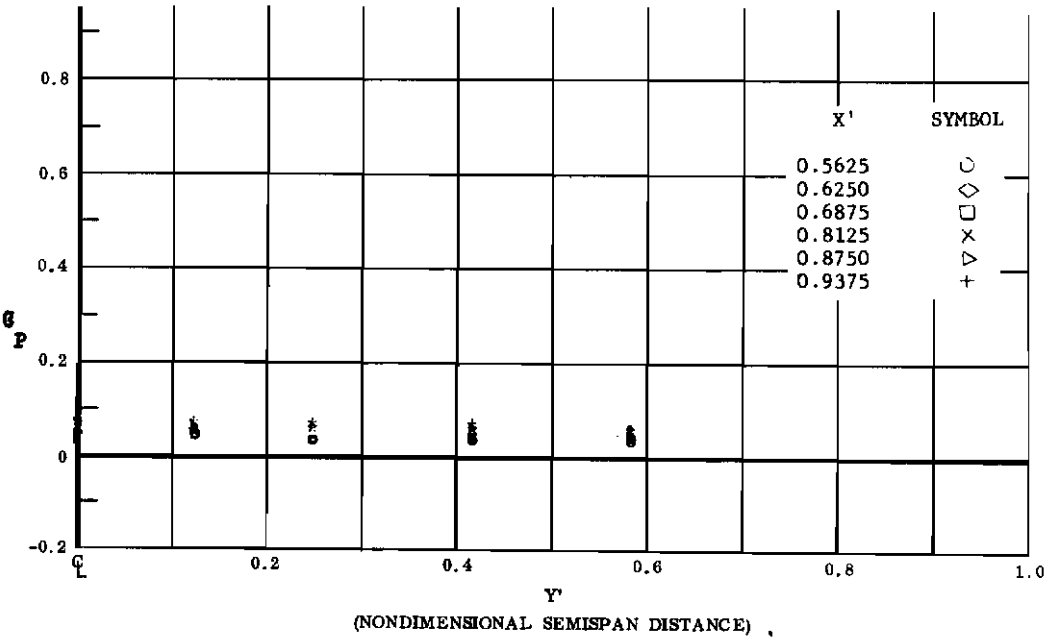
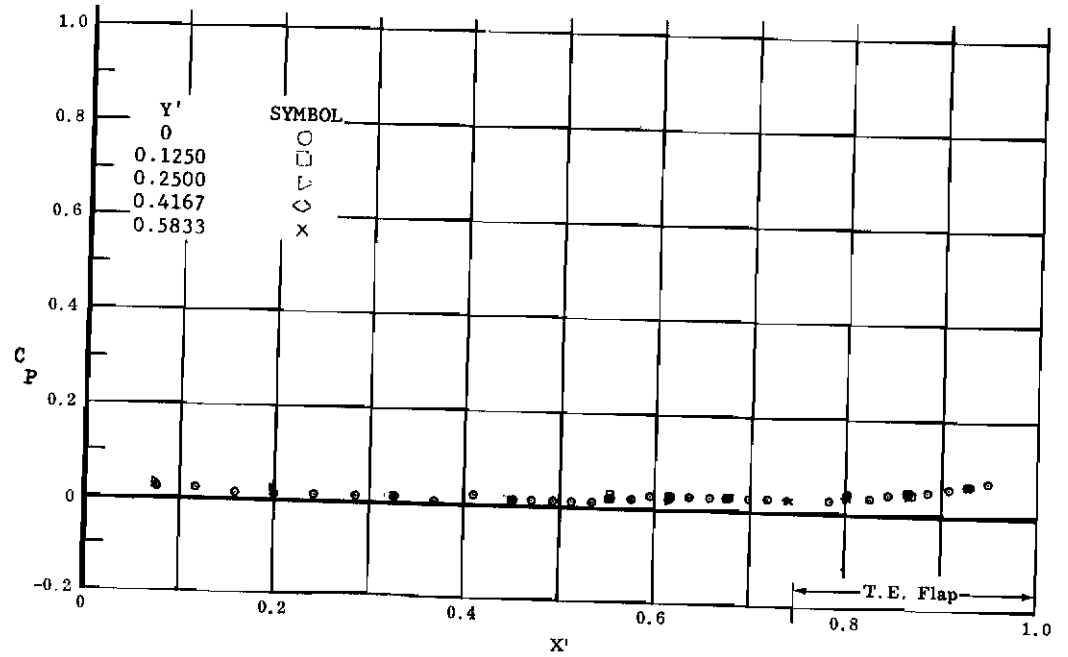


Fig. 115 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = 0°, Re_∞/ft = 3,300,000.



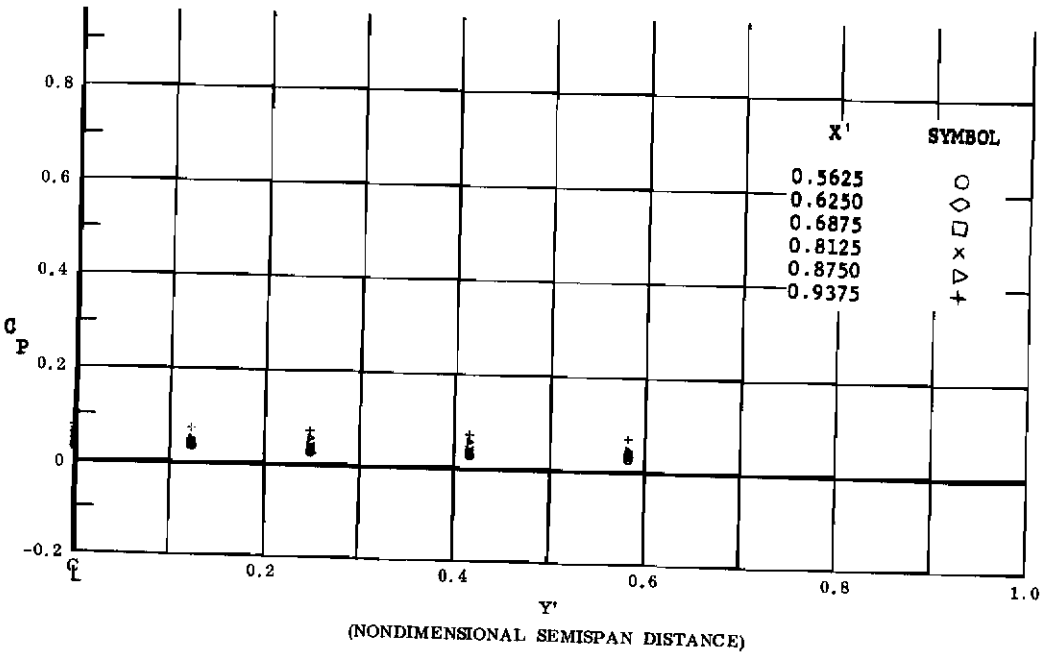
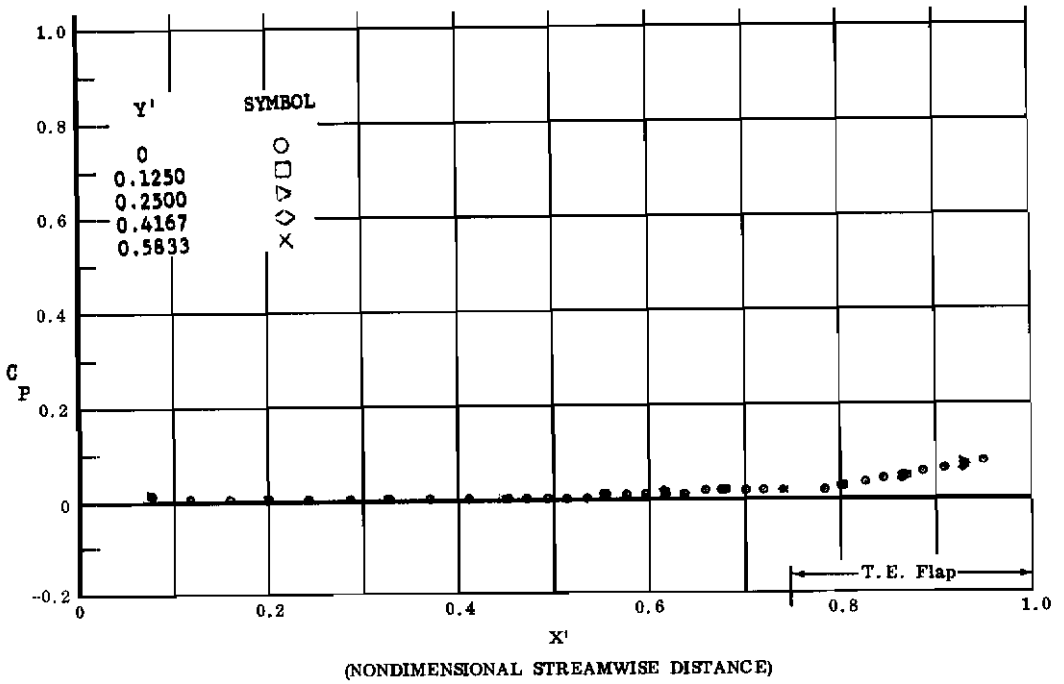


Fig. 116 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, $\alpha = 0°$, $Re_\infty/ft = 2,200,000$.



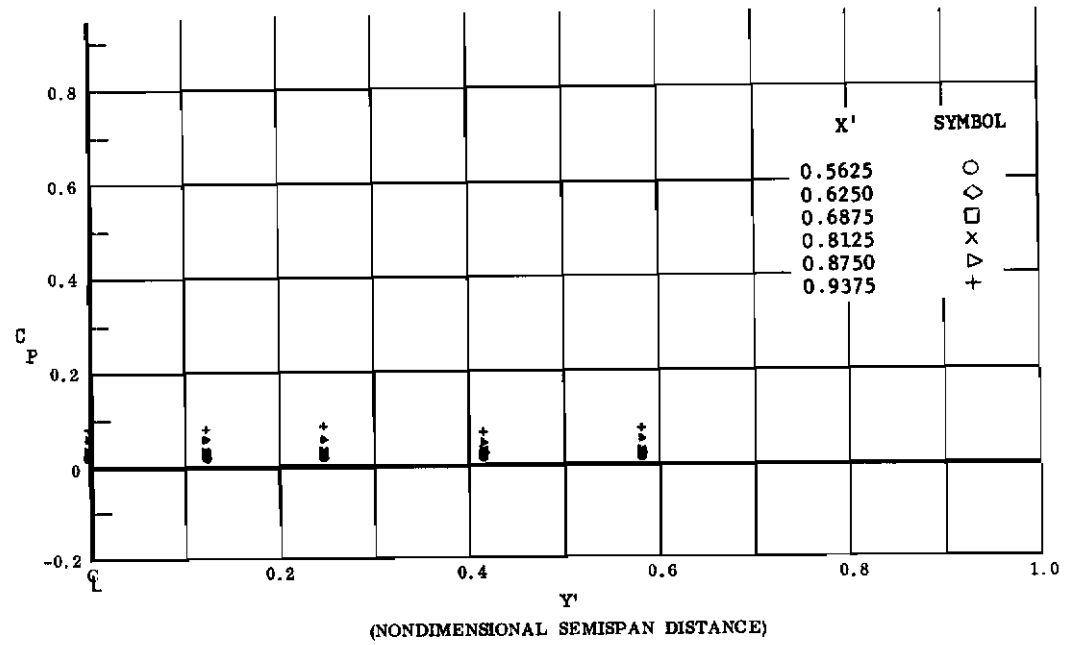
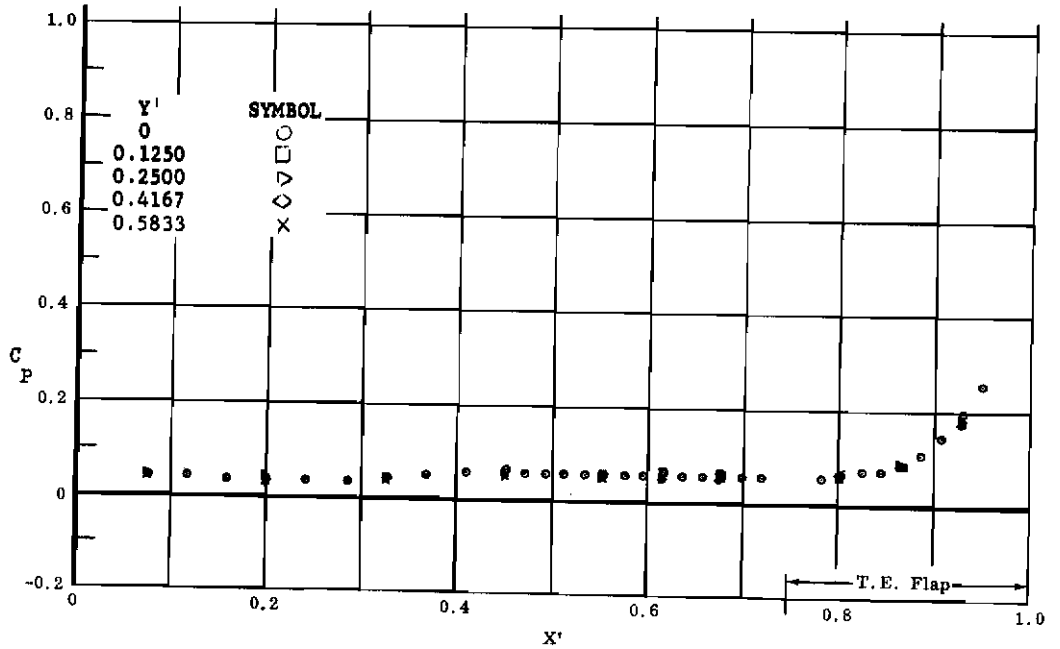


Fig. 117 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = 0°, Re_∞/ft = 3,300,000.



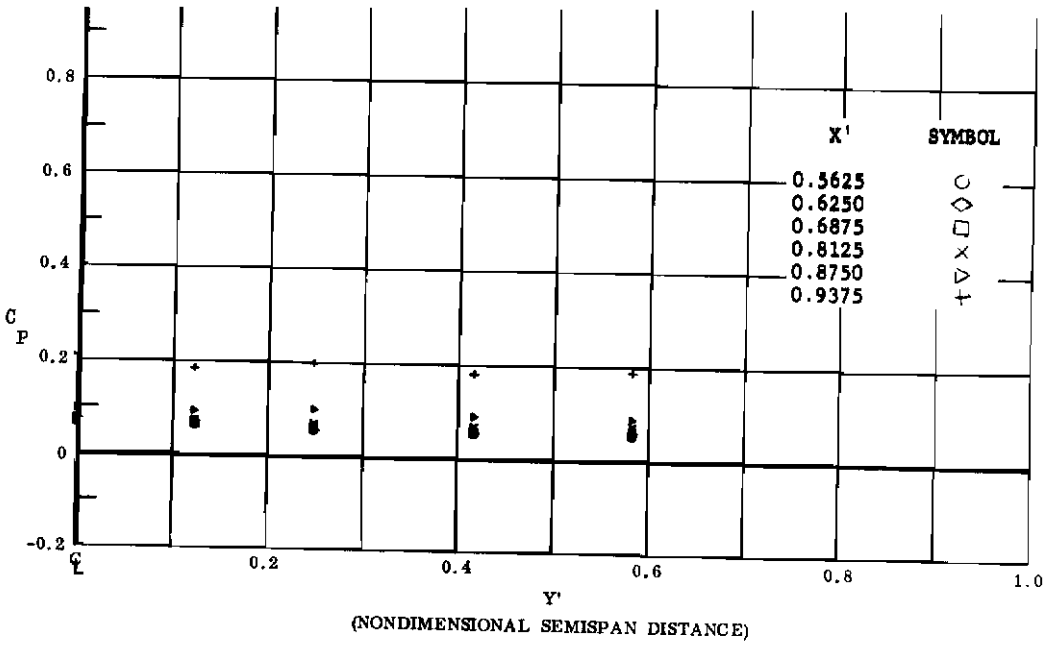
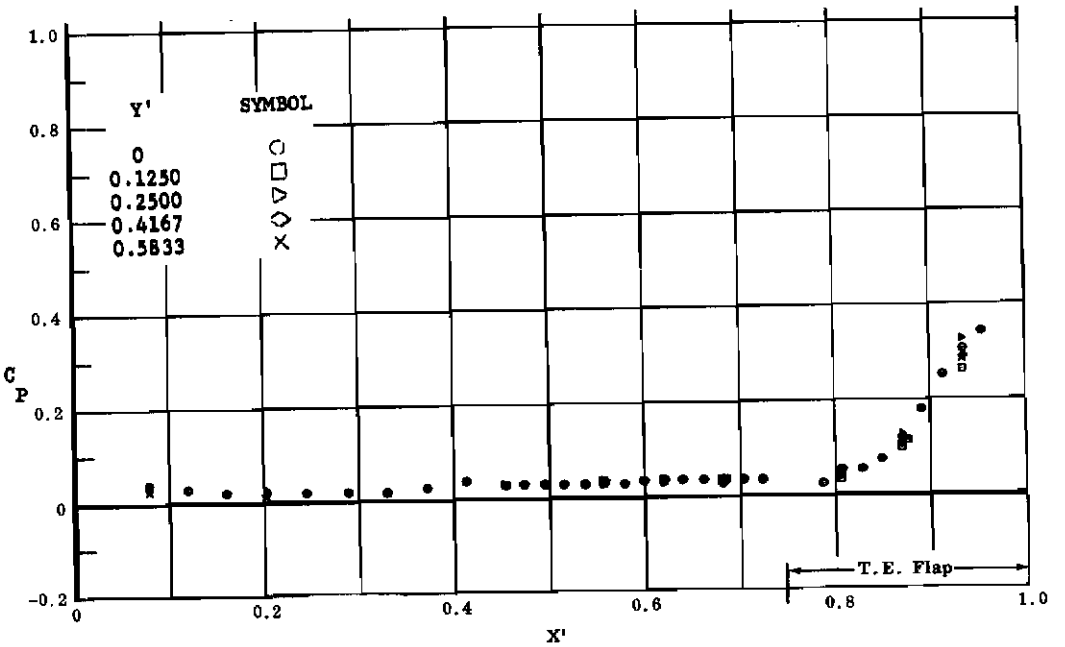


Fig. 118 Streamwise and Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = 0°, Re_∞/ft = 1,100,000.



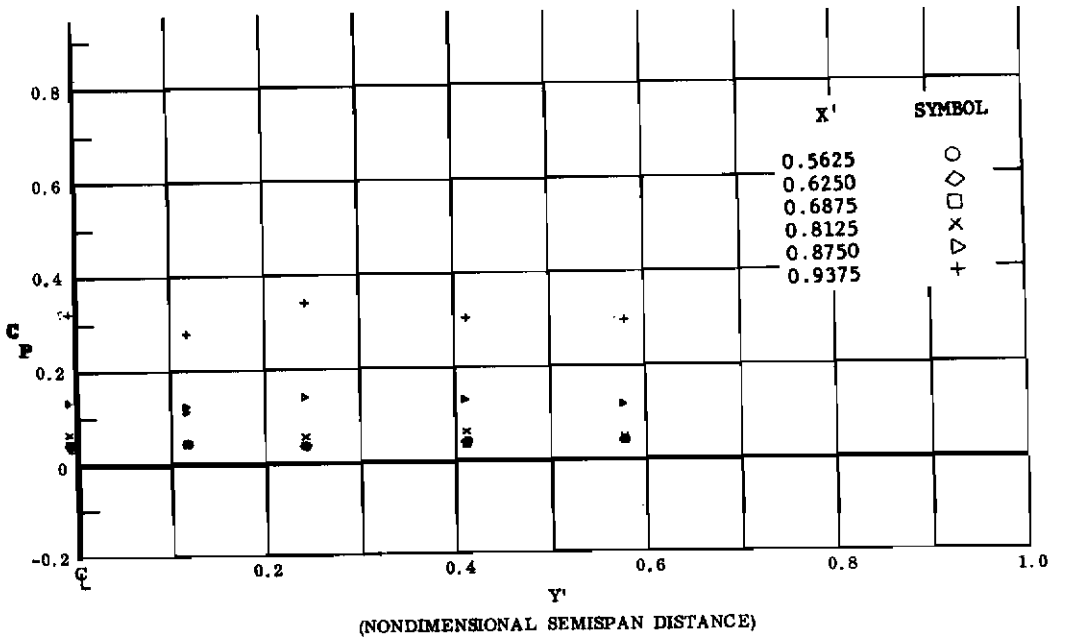
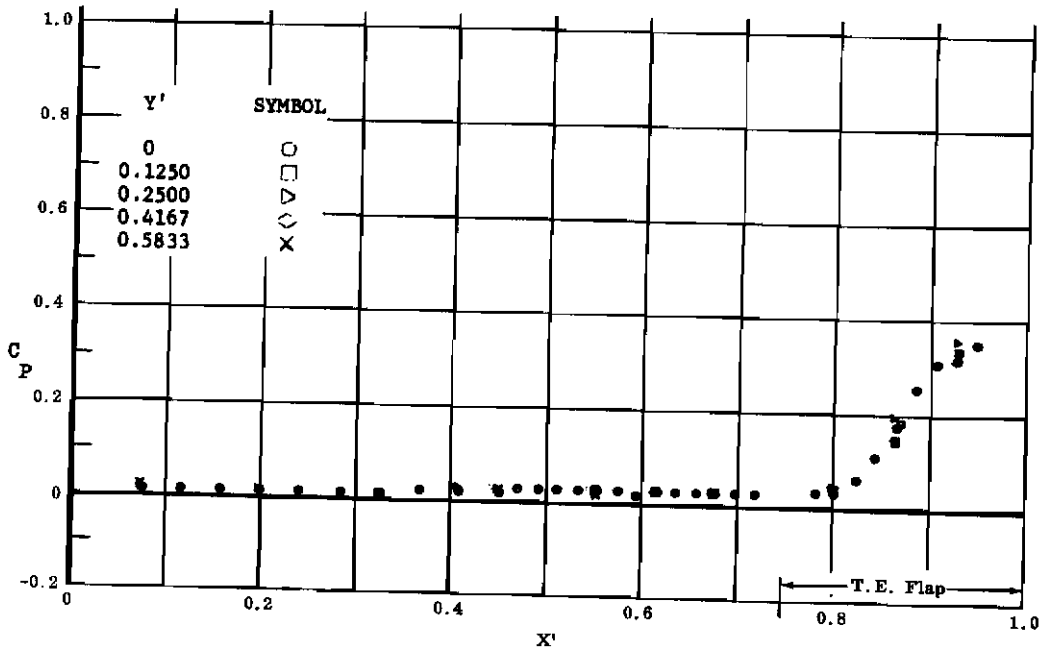


Fig. 119 Streamwise and Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = 0°, Re_∞/ft = 2,200,000.



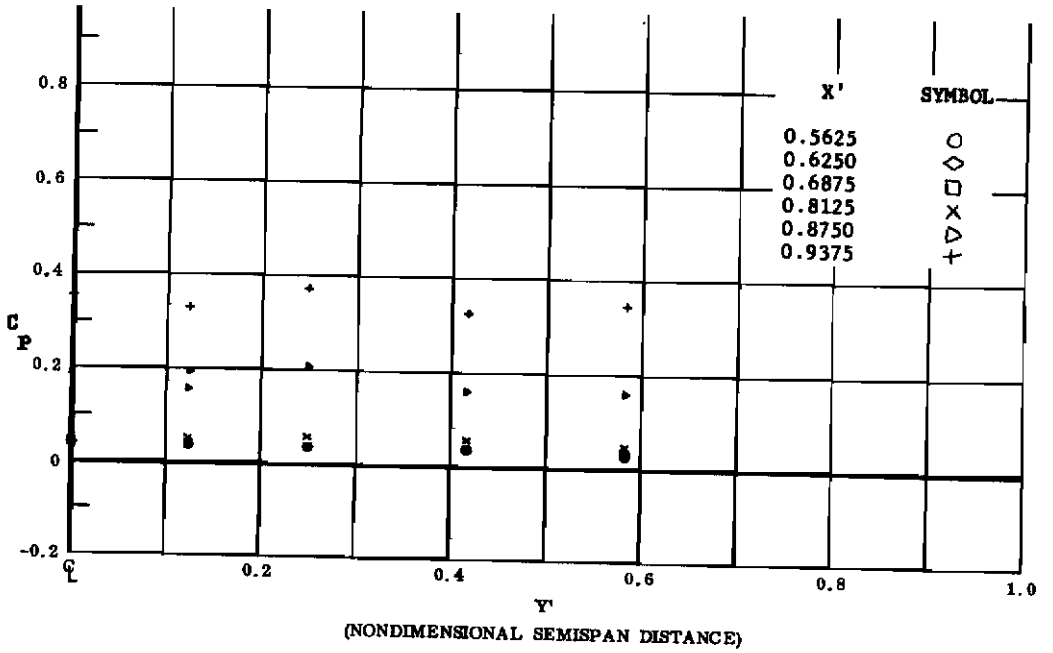


Fig. 120 Streamwise and Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = 0°, Re_∞/ft = 3,300,000.

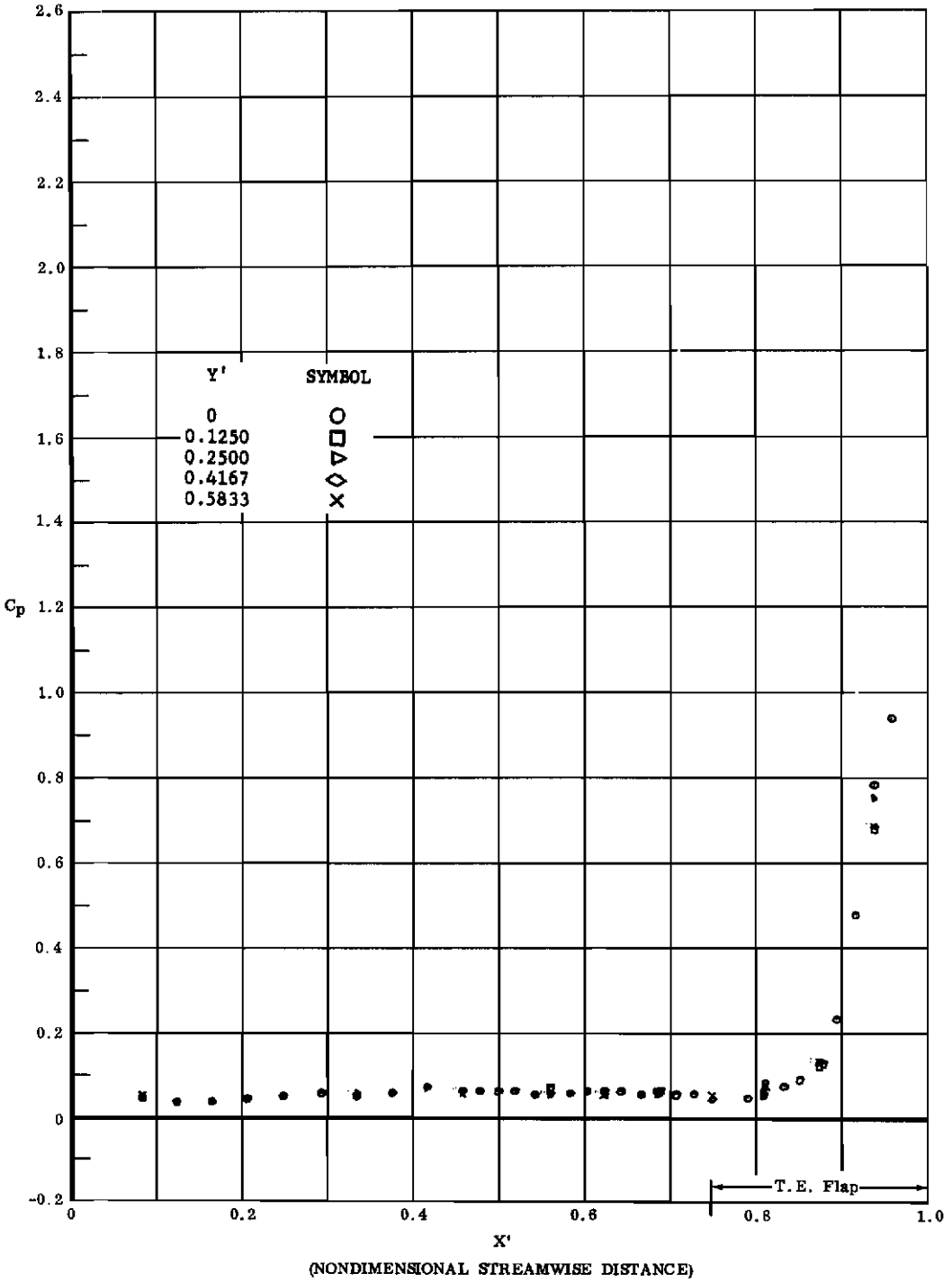


Fig. 121 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = 0°$, $Re_\infty/ft = 1{,}100{,}000$.

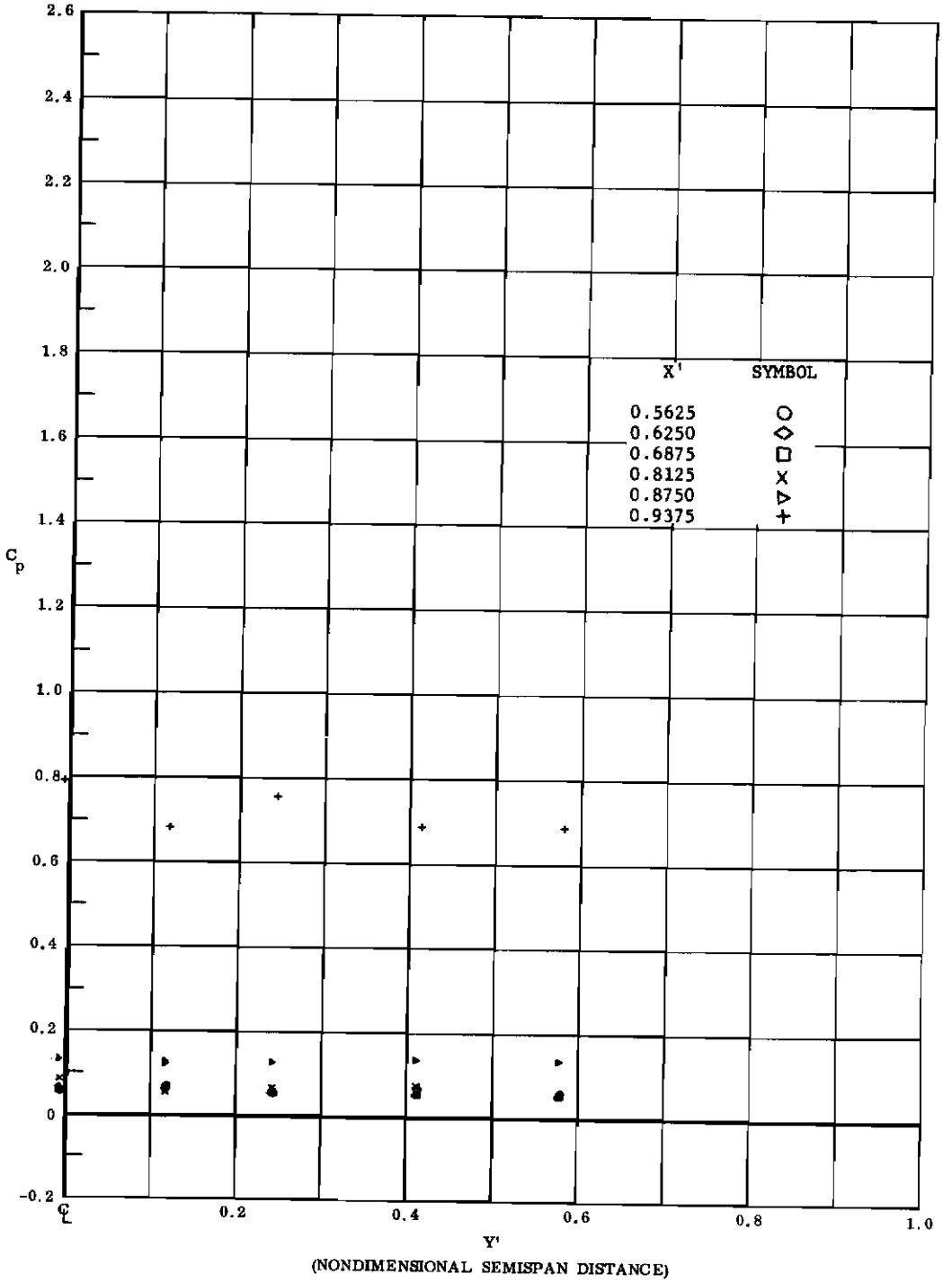


Fig. 121 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = 0°$, $Re_\infty/ft = 1{,}100{,}000$.

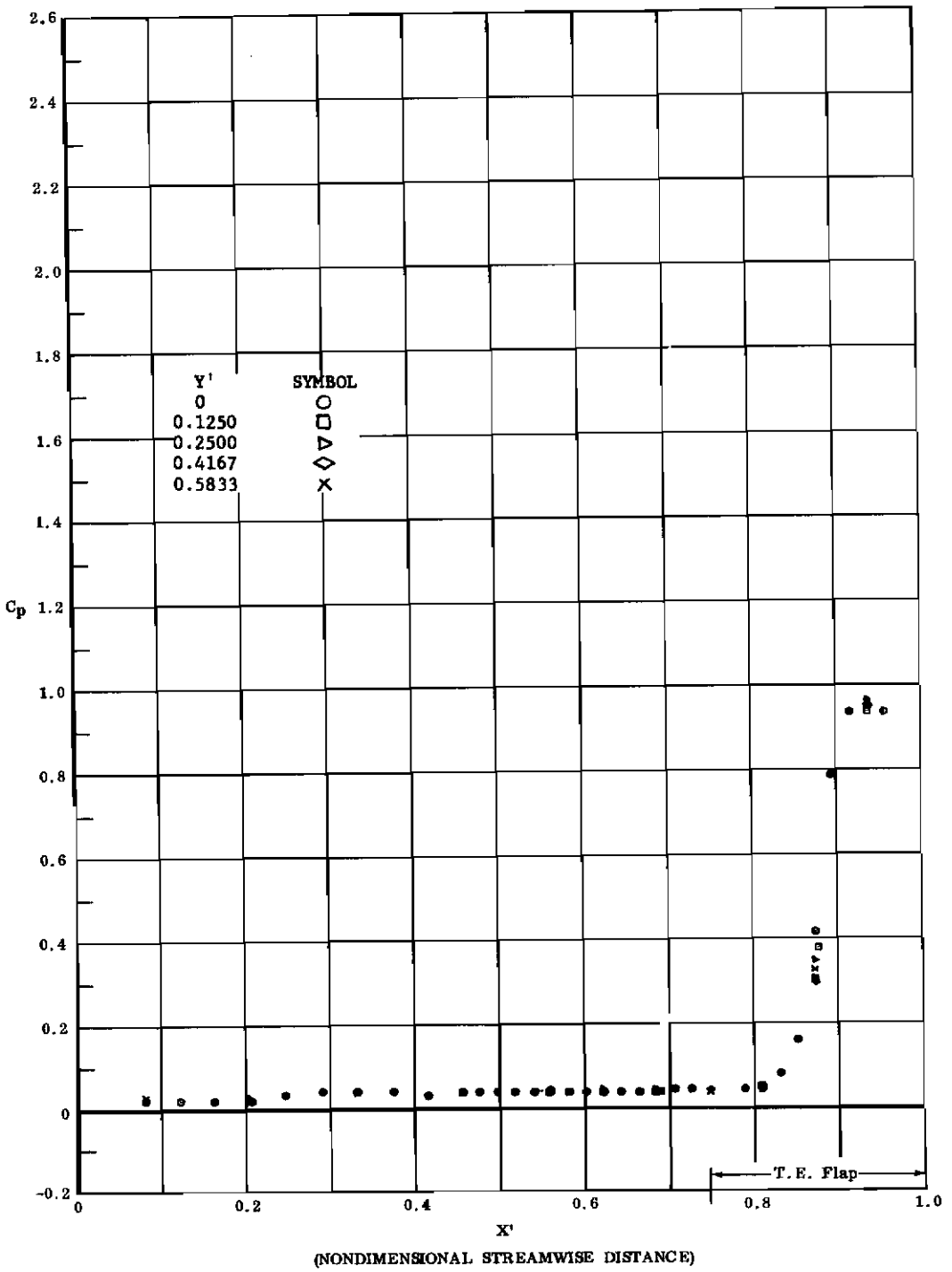


Fig. 122 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = 0°$, $Re_\infty/ft = 2{,}200{,}000$.

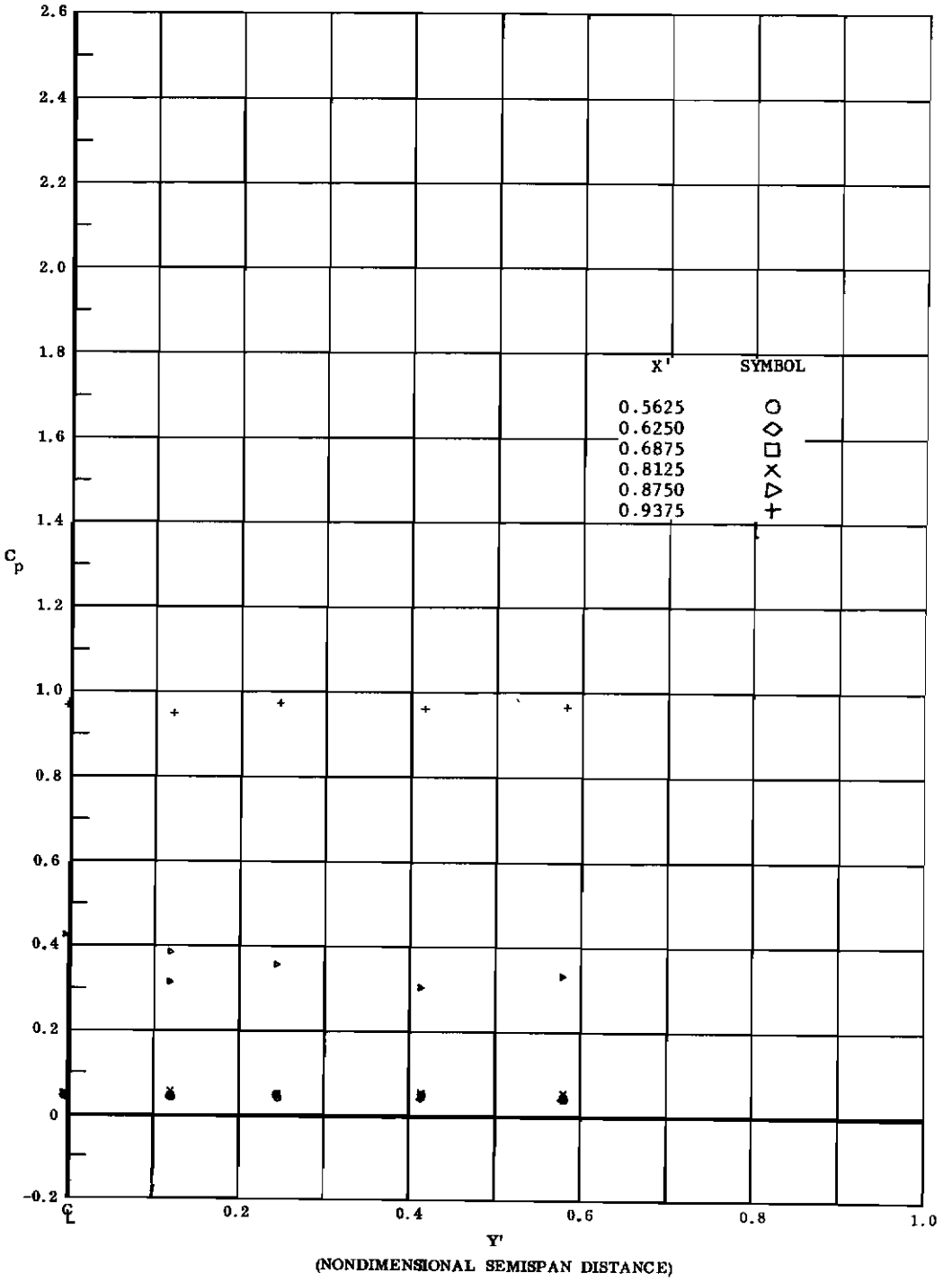


Fig. 122 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = 0°$, $Re_\infty/ft = 2{,}200{,}000$.

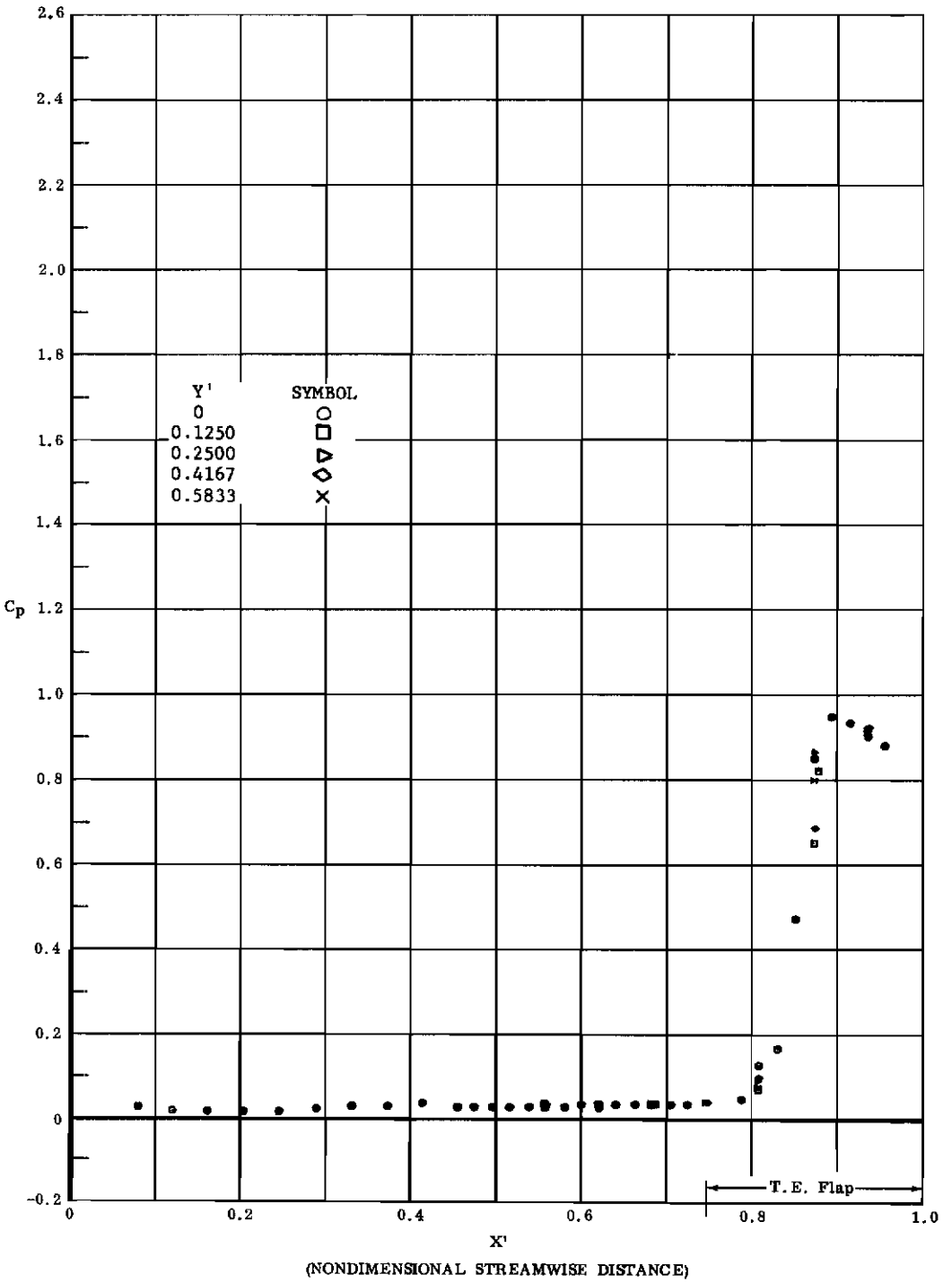


Fig. 123 Streamwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = 0°$, $Re_\infty/ft = 3,300,000$.

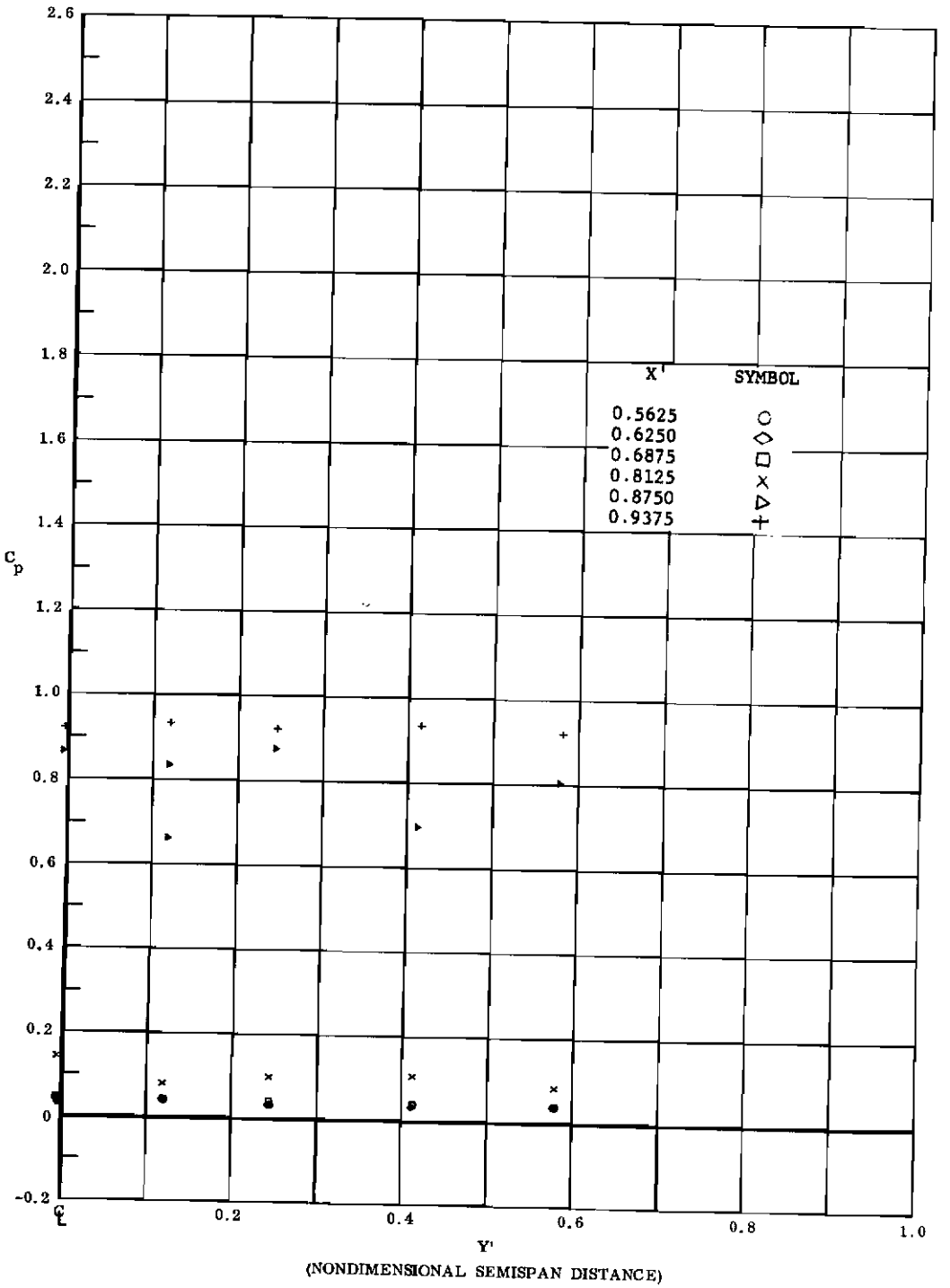
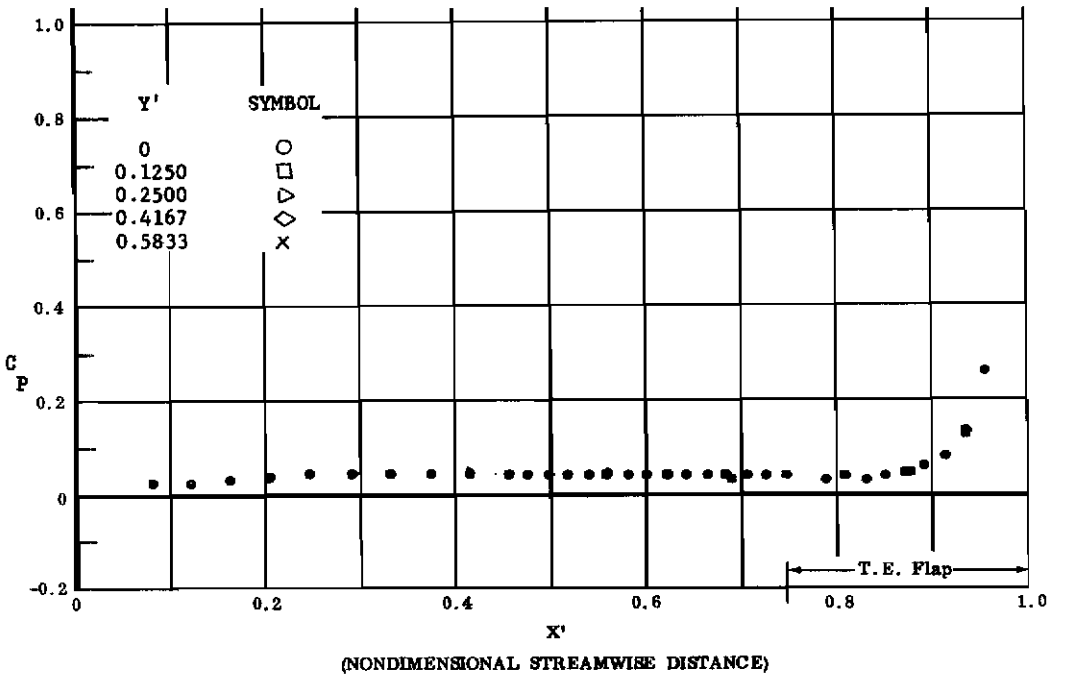


Fig. 123 Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = 0°$, $Re_\infty/ft = 3{,}300{,}000$.



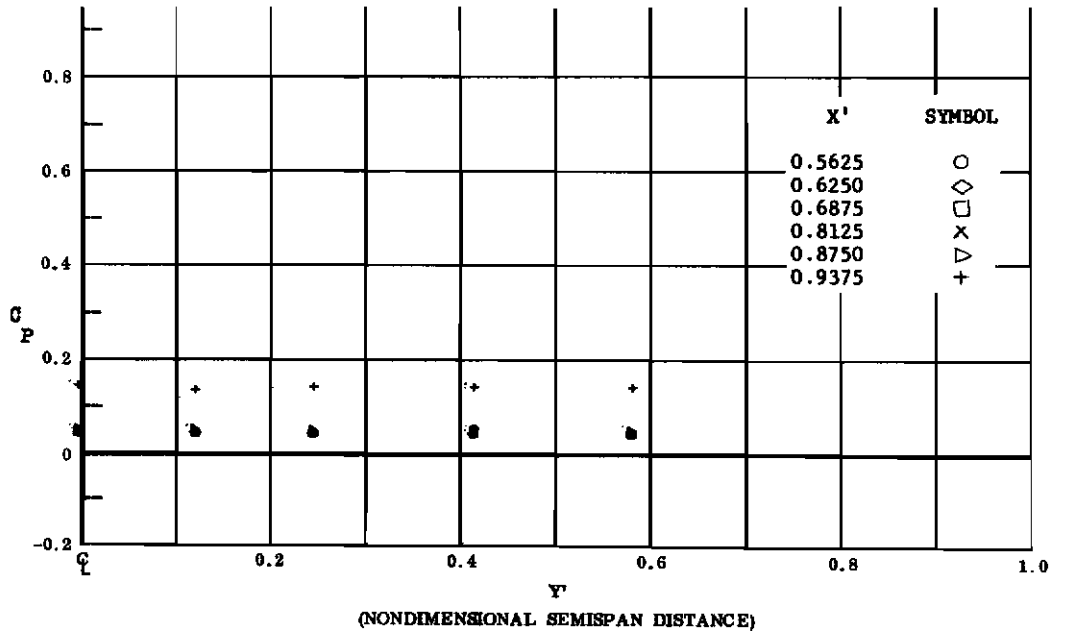
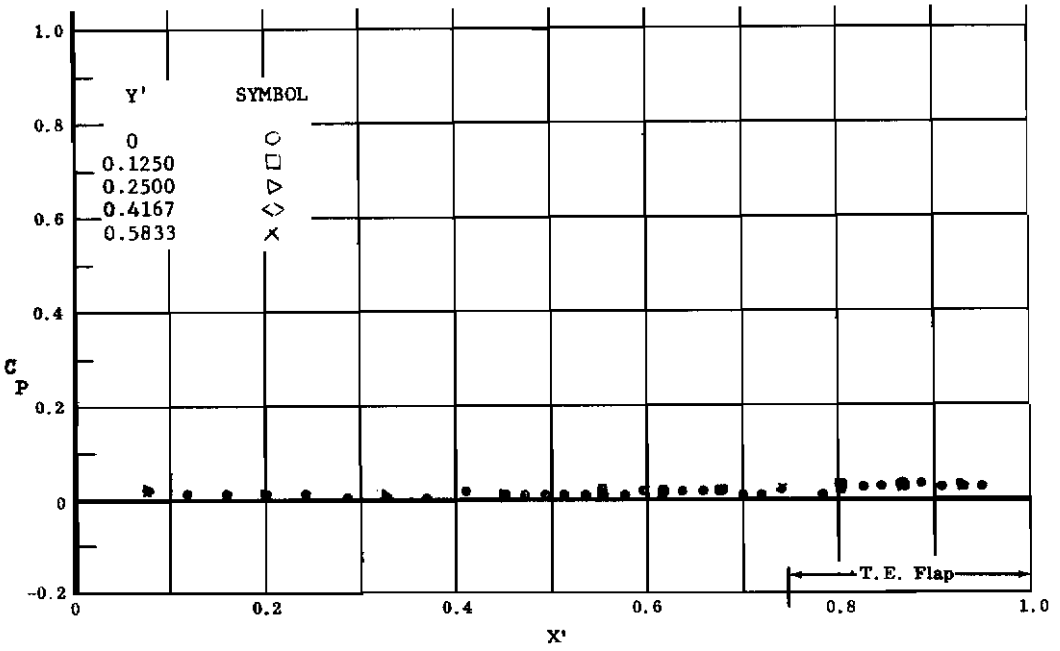


Fig. 124 Streamwise and Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = 2 1/2°, Re_∞/ft = 1,100,000.



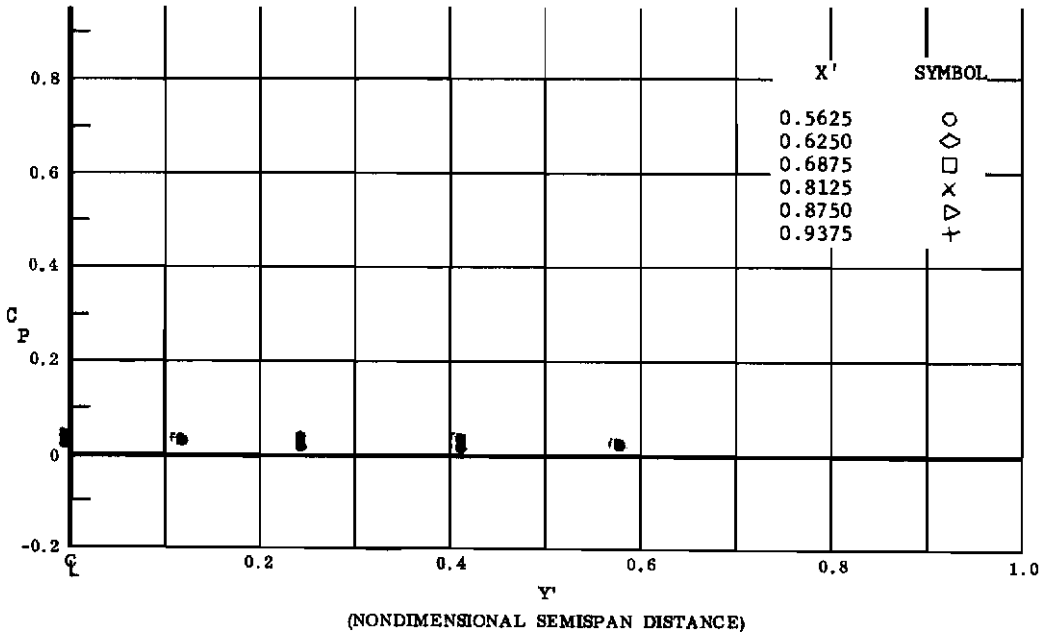
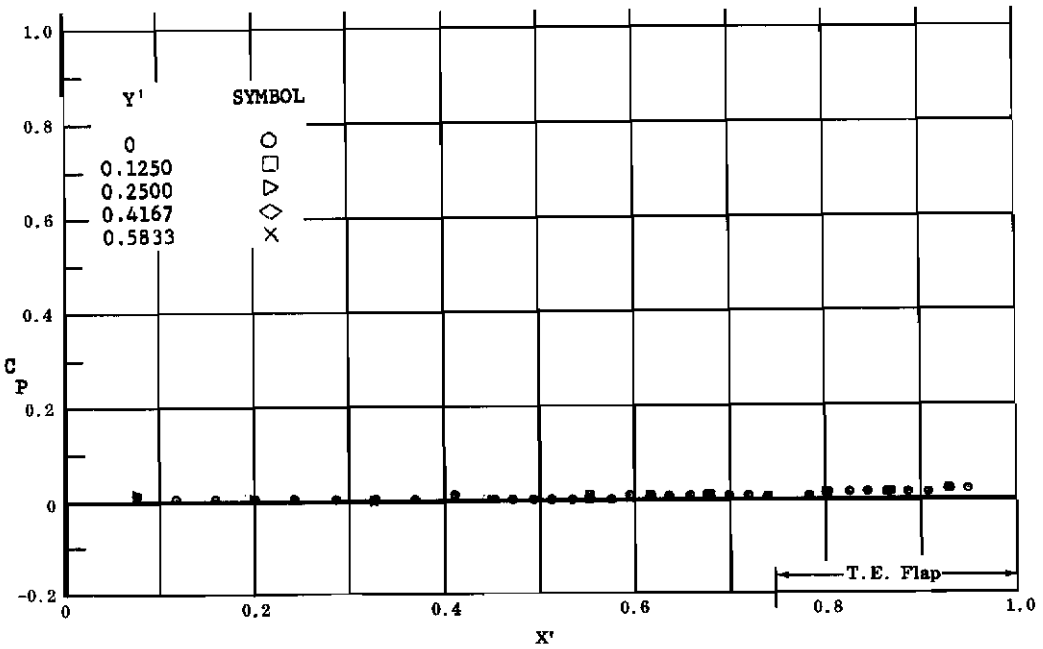


Fig. 125 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = +3°, Re_∞/ft = 1,100,000.



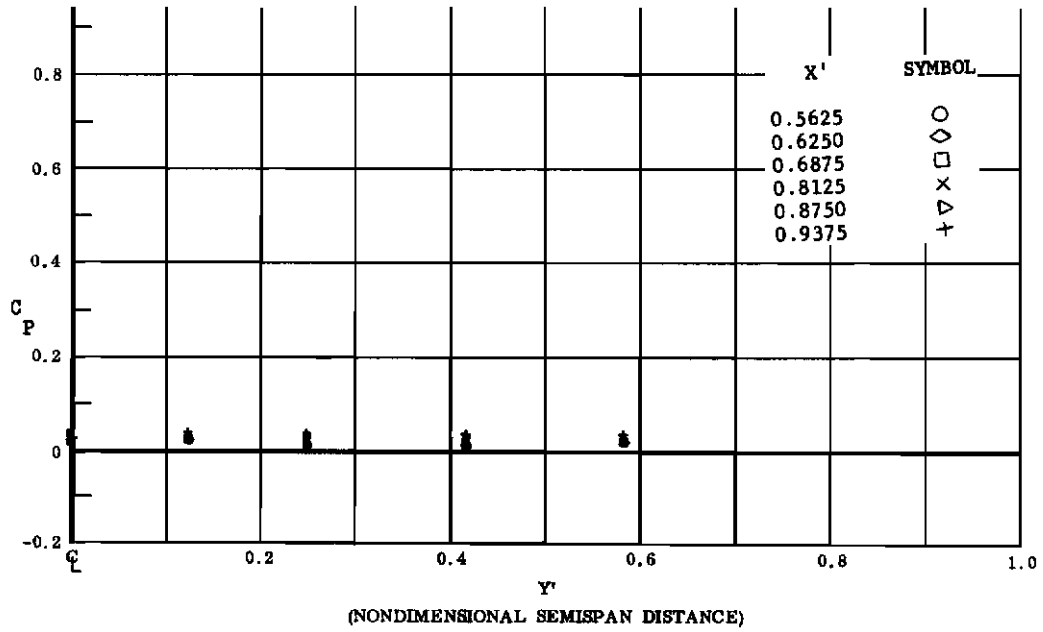
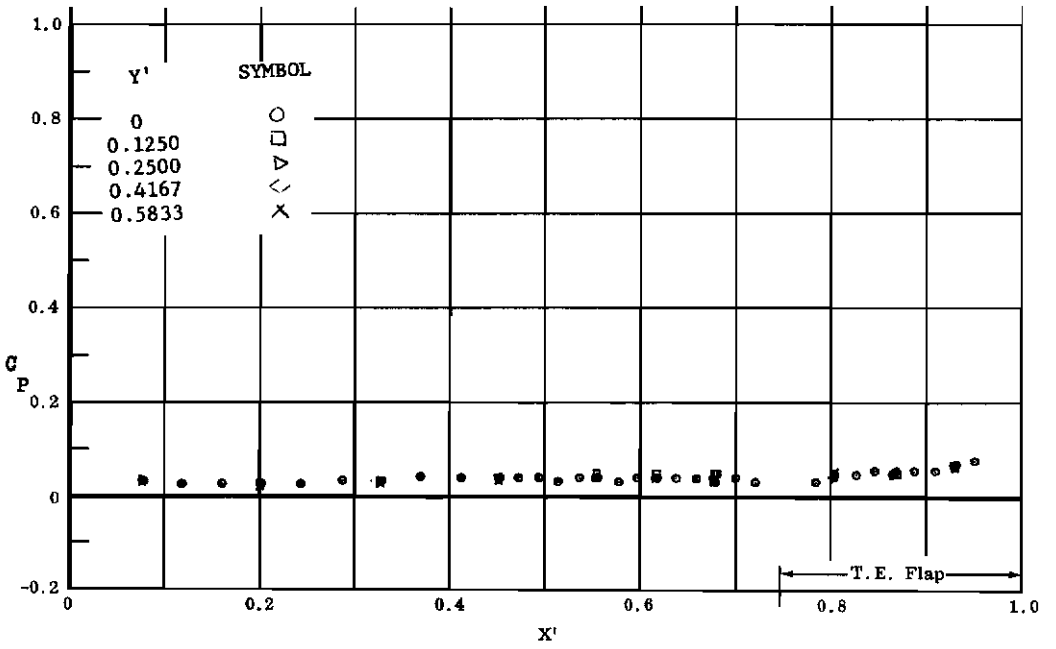


Fig. 126 Streamwise and Spanwise Pressure Distributions; 10° Ramp, Coolant Flow Off, α = +3°, Re_∞/ft = 3,300,000.



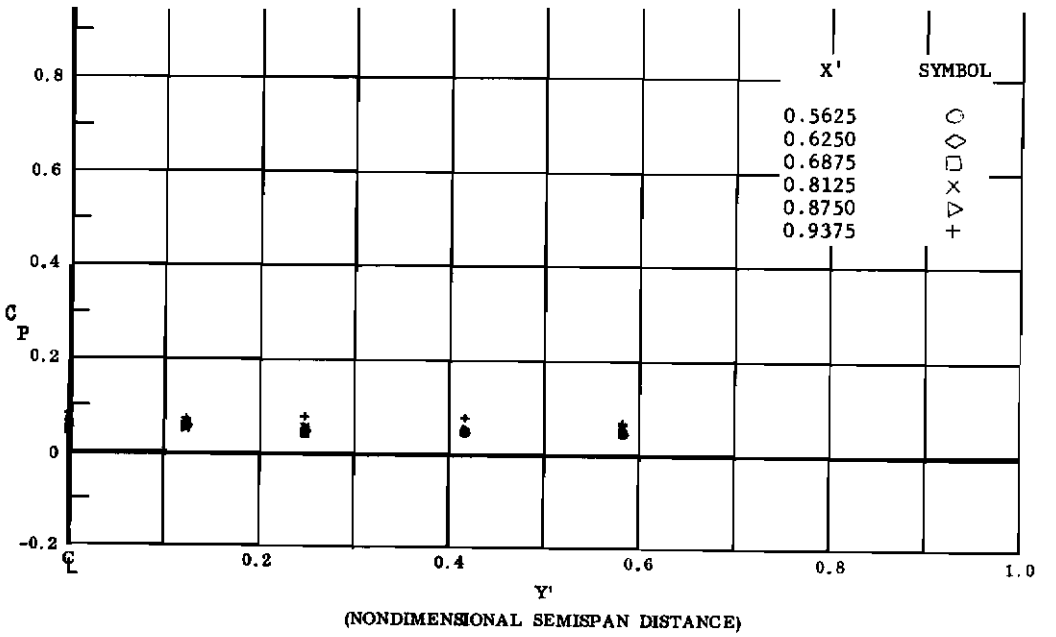
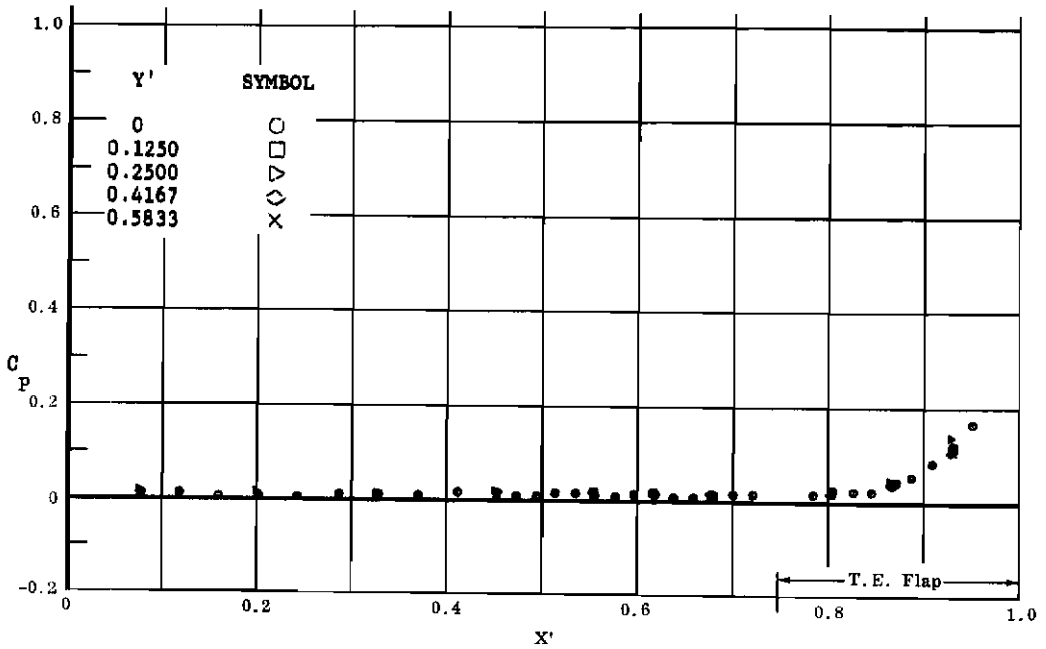


Fig. 127 Streamwise and Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, $\alpha = +3°$, $Re_\infty/ft = 1{,}100{,}000$.



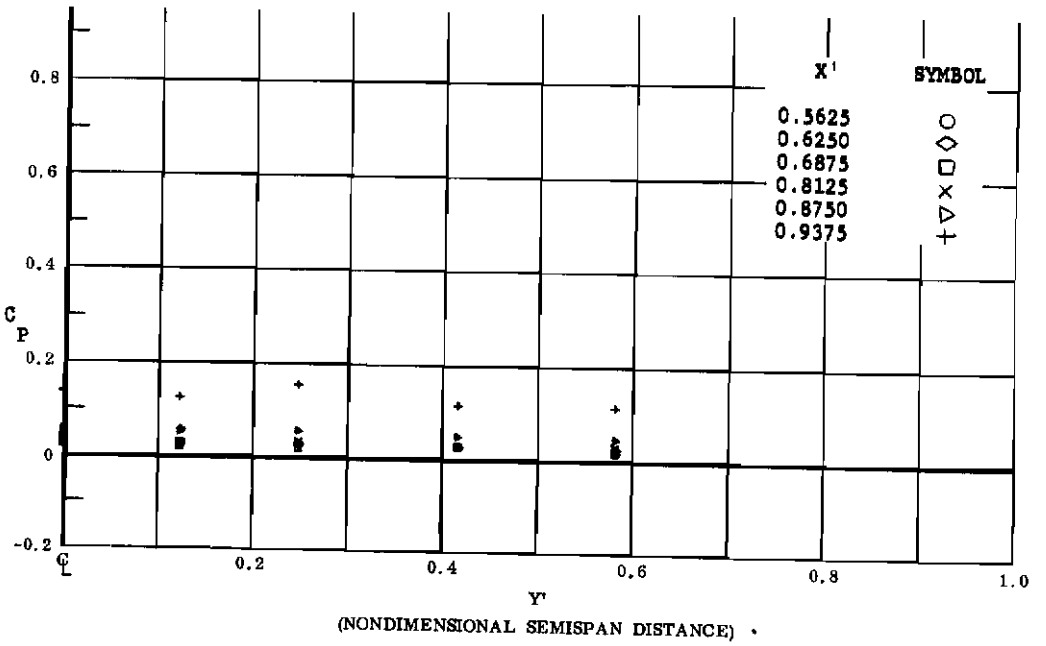
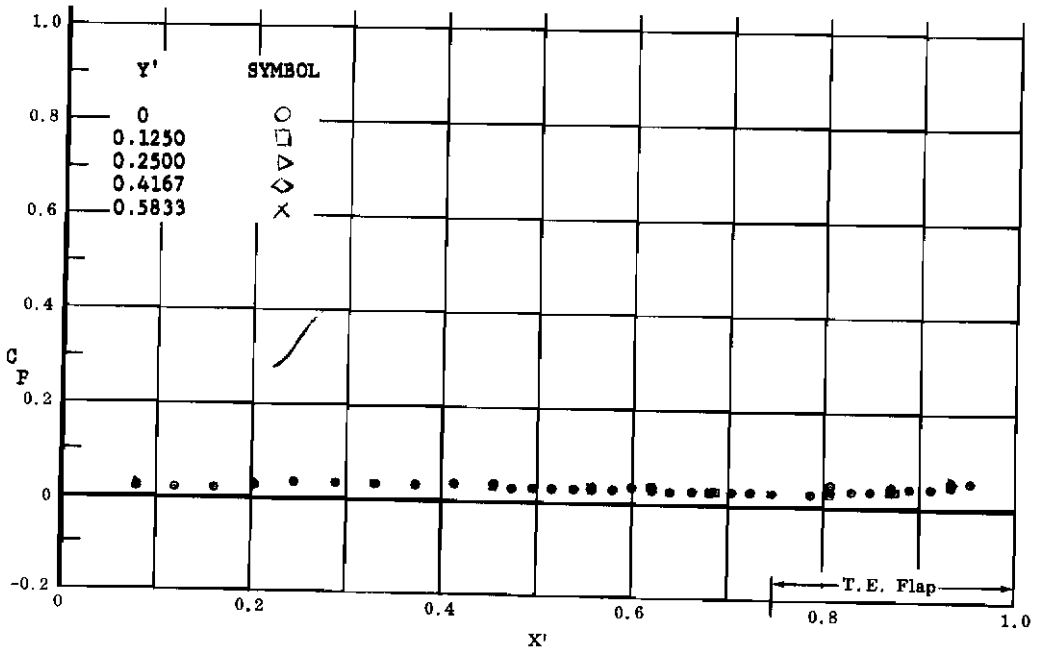
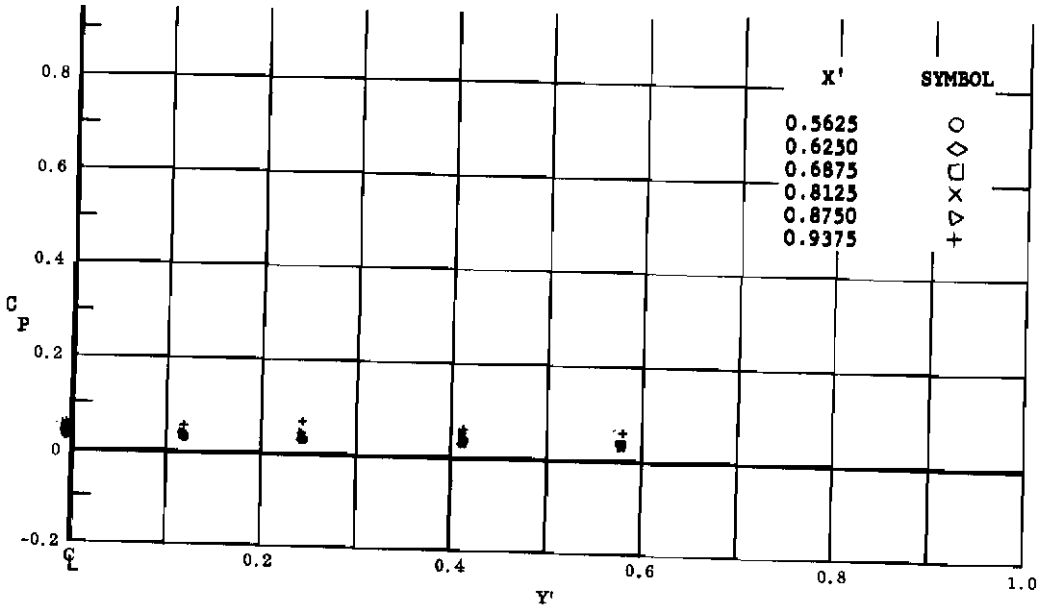


Fig. 128 Streamwise and Spanwise Pressure Distributions; 20° Ramp, Coolant Flow Off, α = +3°, Re_∞/ft = 3,300,000.

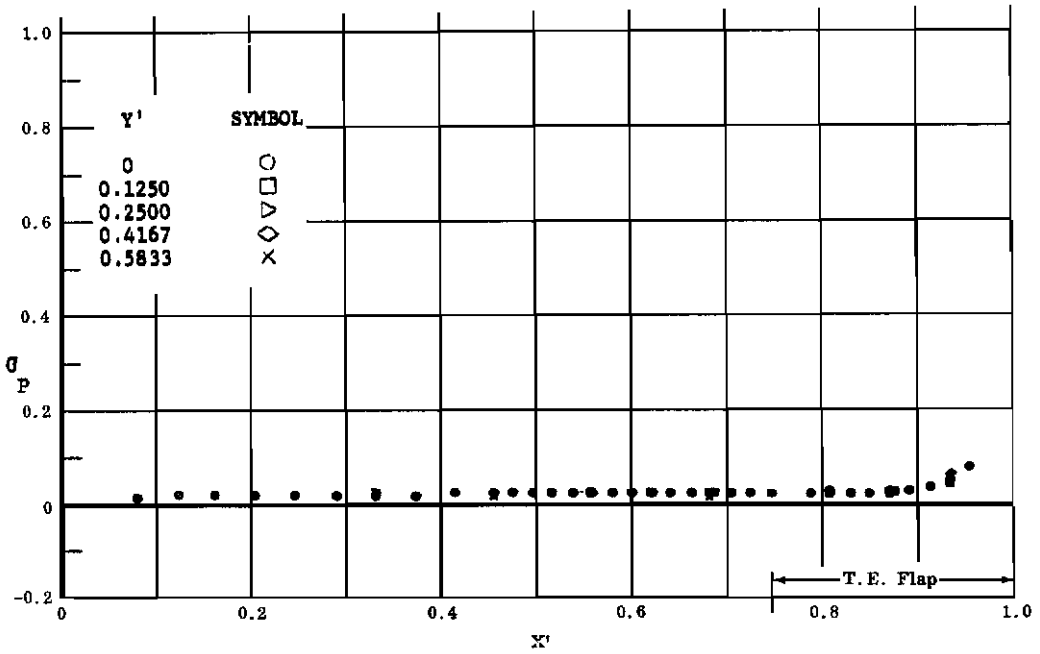


(NONDIMENSIONAL STREAMWISE DISTANCE)



(NONDIMENSIONAL SEMISPAN DISTANCE)

Fig. 129 Streamwise and Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = +5°$, $Re_\infty/ft = 1{,}100{,}000$.



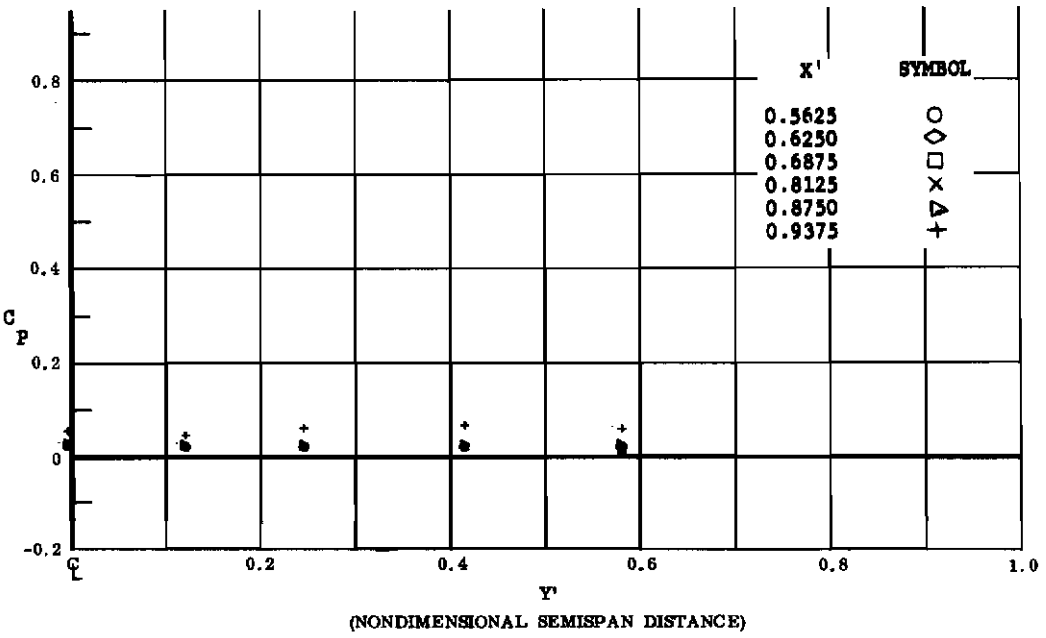
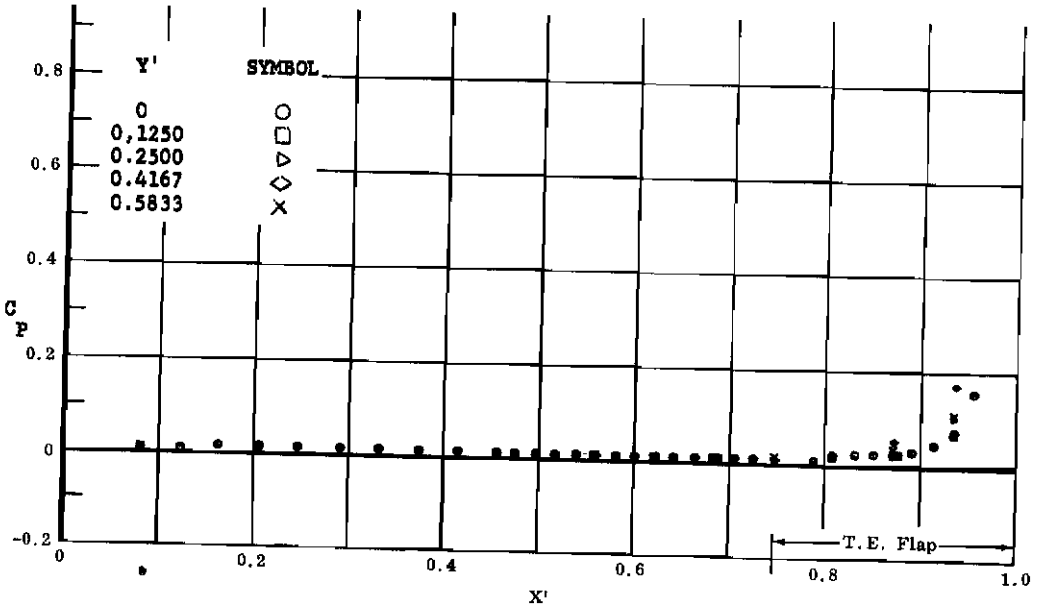


Fig. 130 Streamwise and Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = +5°$, $Re_\infty/ft = 2{,}200{,}000$.



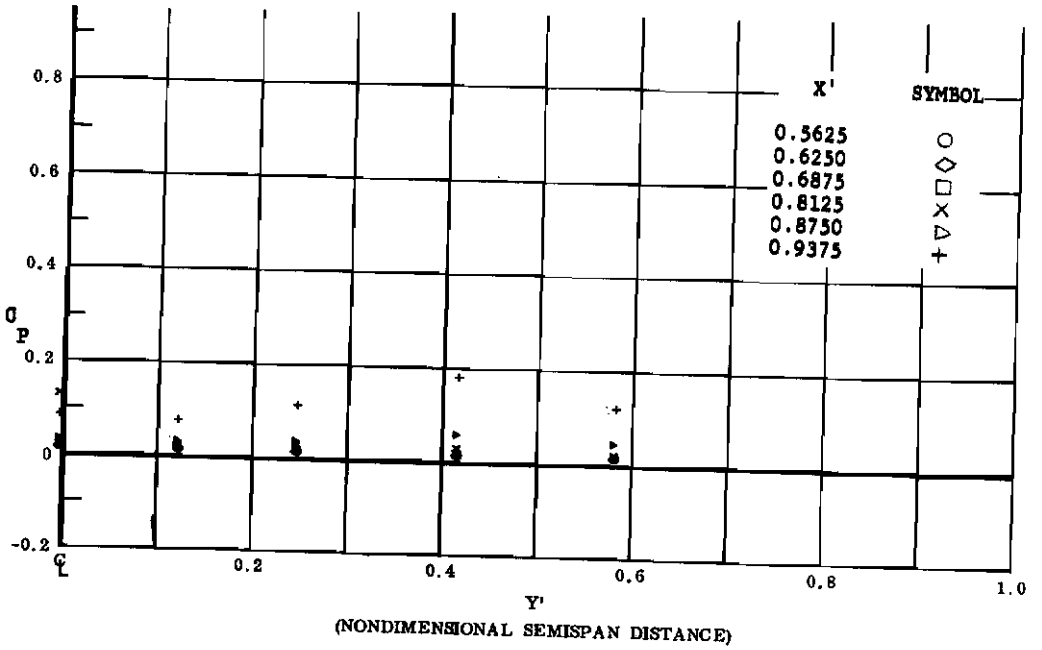
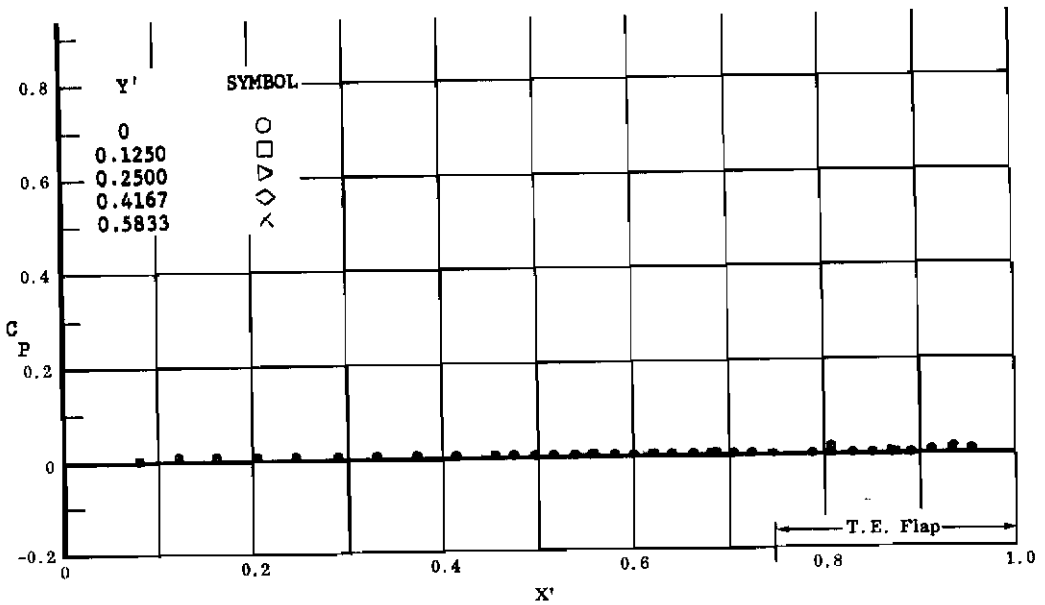


Fig. 131 Streamwise and Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = +5°$, $Re_\infty/ft \approx 3{,}300{,}000$.



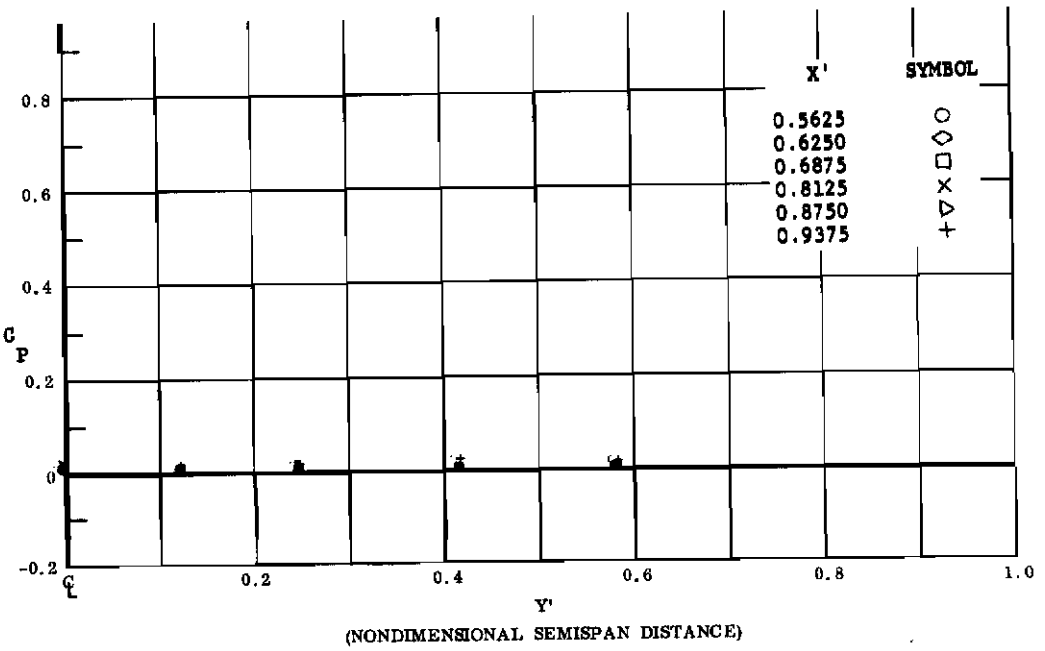
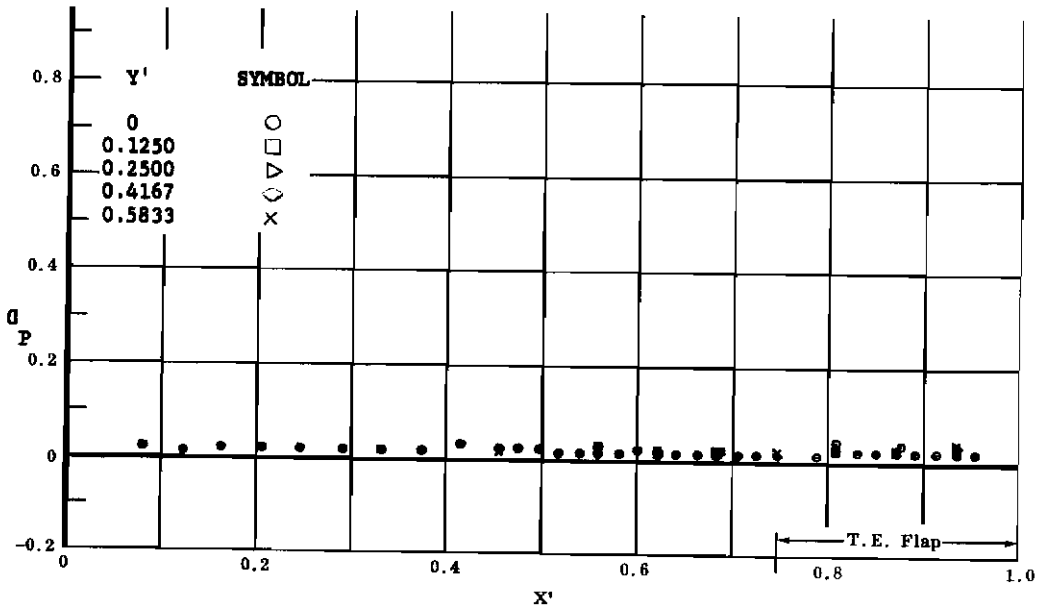


Fig. 132 Streamwise and Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, α = +8°, Re_∞/ft = 3,300,000.



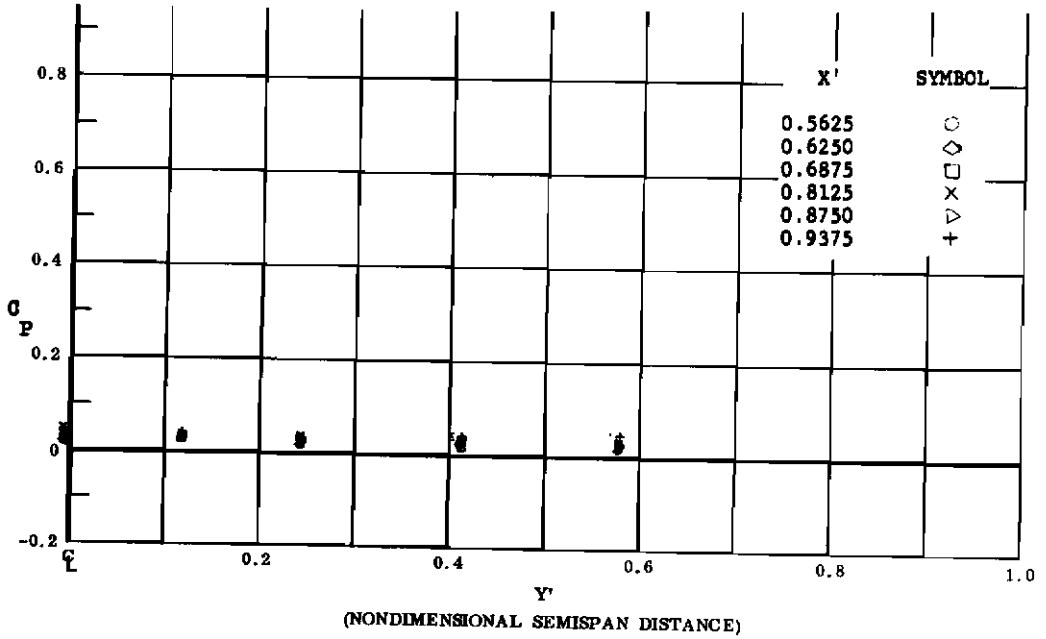
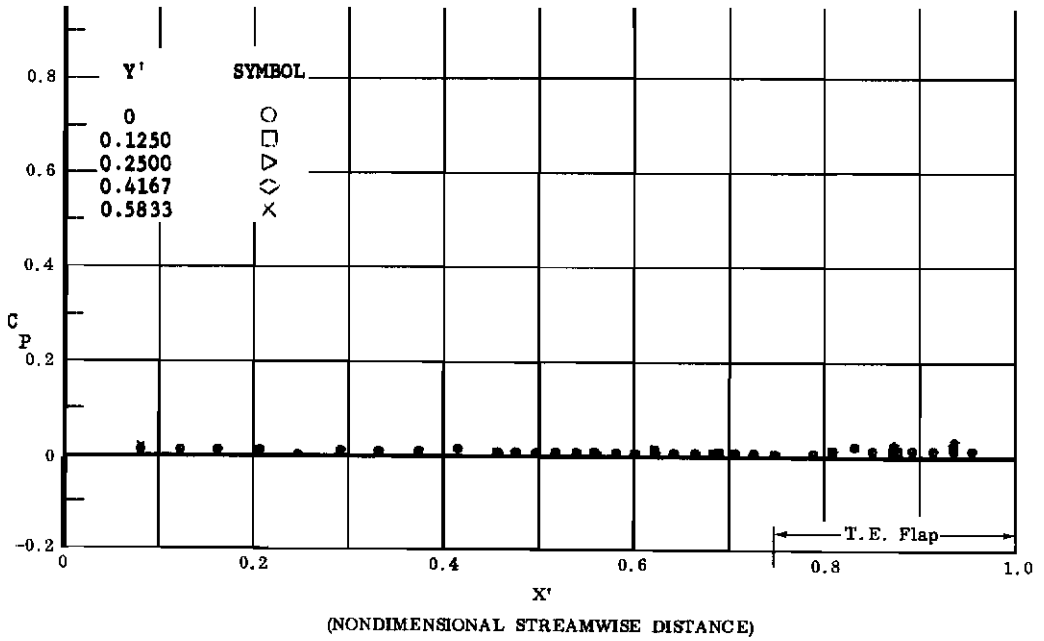


Fig. 133 Streamwise and Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = +10°$, $Re_\infty/ft = 1{,}100{,}000$.



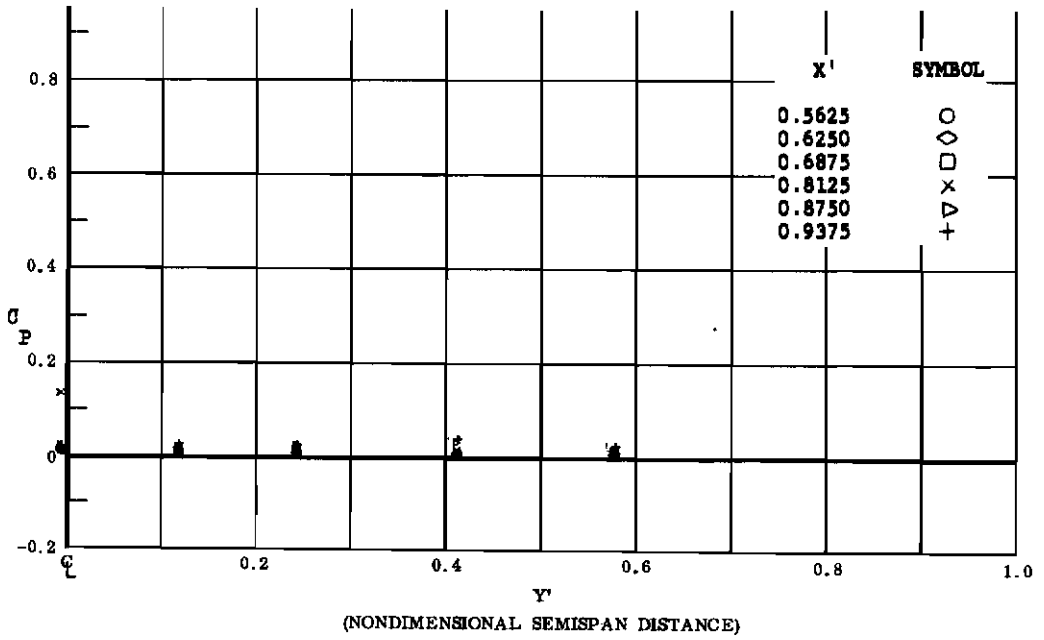


Fig. 134 Streamwise and Spanwise Pressure Distributions; 30° Ramp, Coolant Flow Off, $\alpha = +10°$, $Re_\infty/ft = 3,300,000$.