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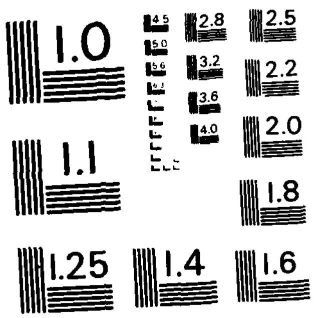
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DEPARTMENT OF DEFENCE SUPPORT

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AERONAUTICAL RESEARCH LABORATORIES

MELBOURNE, VICTORIA

Aerodynamics Technical Memorandum 346

STATIC PRESSURE AND AXIAL VELOCITY DISTRIBUTIONS NEAR THE CENTRE OF THE WORKING SECTION OF THE ARL 2.7 M X 2.1 M WIND TUNNEL

N. MATHESON

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AR-002-936

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STATIC PRESSURE AND AXIAL VELOCITY DISTRIBUTIONS NEAR THE CENTRE OF THE WORKING SECTION OF THE ARL 2.7 M X 2.1 M WIND TUNNEL

by

N. MATHESON

SUMMARY

The static pressure and axial velocity distributions of the flow in working section number two of the 2.7 m X 2.1 m low speed wind tunnel have been determined for four unit Reynolds numbers along five streamlines near the centre of the section.

Current results generally agree with previous results although the static pressure gradient is 28% larger than obtained previously, and deviations from the mean velocity are not quite as large.

The results obtained, and given in this report, are satisfactory for their intended purpose of correcting for flow variations in the working section when testing reflex ship models up to 3 m in length.

POSTAL ADDRESS: Director, Aeronautical Research Laboratories,
P.O. Box 4331, Melbourne, Victoria, 3001, Australia.

CONTENTS

NOTATION

a	=	Constant
b	=	Constant
c	=	Constant
C_{PS}	=	$P_{SDIF}/((P_{TR} - P_{SR})\ (25.4\ SG\ \sin\theta))$ = Local static pressure coefficient
C_{PSI}	=	$(P_S - P_{SR})/(P_{TR} - P_{SR})$ = Local static pressure coefficient from inclined manometer measurements
d	=	Constant
H_R	=	Reference dynamic pressure
H_L	=	Local dynamic pressure
L	=	Length of parallel working section
P_a	=	Atmospheric pressure (inches of Hg)
P_S	=	Local static pressure (inches of water inclined)
P_{SR}	=	Reference static pressure (inches of water inclined)
P_T	=	Local total pressure (inches of water inclined)
P_{TR}	=	Reference total pressure (inches of water inclined)
P_{SDIF}	=	Difference between local and reference static pressures (mm of water vertical)
SG	=	Specific gravity of inclined manometer fluid
T	=	Temperature of air in the working section (°C)
V	=	Local velocity
V_m	=	Mean velocity across working section
V_R	=	Reference velocity
v	=	Velocity deviation from mean value
x	=	Distance downstream from the beginning of the parallel working section
θ	=	Angle of inclination to the horizontal of the inclined manometer

1. INTRODUCTION

To predict full scale performance accurately from model tests in a wind tunnel it is necessary to know details of the flow in which the model is tested. This is particularly imporatant for long streamline bodies at zero or low angles of incidence.

Ideally, the longitudinal static pressure gradient should be zero and the axial velocity of the flow should remain constant at every point in the working section. However, practical limitations result in some variation in the static pressure and axial velocity along the length of the working section. In addition, at any transverse plane, there is usually a small variation in axial velocity and pressure gradient across the section, although near the wall viscous effects dominate and larger variations occur.

In this report details of the static pressure and axial velocity of the flow near the centre of working section number 2 of the low speed wind tunnel are given. These measurements were made just before testing a 3 m long reflex model of the below waterline portion of a ship's hull. Although the results of similar calibration experiments were available [1,2,3,4] various small changes had been made to the working section, and it was considered wise to check their effects before testing such a long model.

2. EXPERIMENTS AND RESULTS

The static and total pressures of the flow in the working section were measured at four dynamic heads of approximately 560, 1260, 2240, and 3500 pascal, corresponding to unit Reynolds numbers per metre of 2.0, 3.0, 4.0, and 5.0 x 10^6. The measurements were taken at eleven longitudinal positions denoted by 1,2,3,....11, along five different streamlines, C(centre), T(top), P(port (or outside)), and S(Starboard (or inside)) as shown in figure 1. Time did not permit more extensive tests or tests at other locations.

The static and total pressures were determined using an NPL substandard pitot-static probe. No corrections for blockage were applied as the probe and its strut support occupied a negligible portion of the tunnel sectional area. The reference total and static pressures and hence the nominal airspeed in the working section were obtained from piezometric rings at either end of the contraction.

The total and static pressures from both the piezometric rings and the pitot tube were measured using an inclined multitube manometer filled with water. The level of the manometer fluid could be resolved to within ±0.25 mm (±0.01") at any angle of inclination. The reference dynamic pressure (pascal) indicated on the control console was also recorded.

A multitube manometer was used in preference to the existing scanivalve and pressure transducer set up because it was more accurate as shown in table 1. However, the inclined manometer was not sufficiently accurate for determining static pressure coefficients and consequently a Betz manometer was used to measure the difference between the local and reference static pressures to within ±0.1 mm of water.

All the results are tabulated in the units in which they were measured in appendix 1.

TABLE 1 - Accuracy of Pressure Measurement

Data: 1. Pressure transducer : Statham type PM 131TC; ±2.5 psid; hysteresis and linearity ±0.75% full scale; thermal shift, sensitivity 0.01%/°F, zero ±0.01% full scale /°F, compensated temperature range -65°F to 250°F. Computer application with a given calibration allows accuracy of ±0.1% full scale.

2. Inclined manometer : filled with water at 42° 8' to the horizontal. Accuracy of pressure measurement, Δh = ±1.0 mm (±0.04"), (consisting of ±0.25 mm (±0.01") for each total and static tube at ambient pressure, and ±0.25 mm (±0.01") for each total and static tube under pressure), inclination ±0° 1'.

R_N/metre	Nominal Velocity (m/s)	Pressure		% Error in pressure	
		Pascal	p.s.i.	Statham transducer	Inclined manometer
2.0	30.5	560	0.081	±3.02	±1.19
3.0	45.7	1260	0.183	±1.36	±0.55
4.0	61.0	2240	0.325	±0.75	±0.31
5.0	76.2	3500	0.508	±0.49	±0.21

3. STATIC PRESSURE DISTRIBUTION

The static pressure coefficients (C_{PS}) using the measured pressure differences from the Betz manometer are tabulated in appendix 1 and plotted in figure 2 along the length of the working section for each streamline and reference unit Reynolds number. The value of C_{PS} for an error of 0.1 mm of H_2O in the static pressure difference is also shown.

From figure 2 it is apparent that the pressure distribution is non-linear particularly forward of x/L = 0.20. However, the use of a linear approximation from x/L = 0.20 to x/L = 0.80 should be sufficiently accurate for most purposes, and a straight line

$$C_{PS} = a(x/L) + b \qquad (1)$$

was fitted to these results using a least squares method, and the coefficients a and b are given in table 2.

TABLE 2 - Coefficients a and b for least squares analysis of static pressure distributions for $0.204 \leq (x/L) \leq 0.796$ determined from pressure differences measured on the Betz manometer

Stream-line	$C_{PS} = a(x/L) + b$							
	$R_N/m = 2.0 \times 10^6$		$R_N/m = 3.0 \times 10^6$		$R_N/m = 4.0 \times 10^6$		$R_N/m = 5.0 \times 10^6$	
	$-a \times 10^2$	$b \times 10^2$	$-a \times 10^2$	$b \times 10^2$	$-a \times 10^2$	$b \times 10^2$	$-a \times 10^2$	$b \times 10^2$
C	3.66	1.11	3.52	1.19	3.57	1.27	3.59	1.28
P	3.54	0.97	3.51	1.06	3.61	1.14	3.71	1.22
S	4.84	0.54	4.22	1.39	4.11	1.43	4.17	1.49
T	4.65	2.23	4.43	2.20	4.38	2.09	4.64	1.98
B	3.53	1.61	3.25	1.63	3.16	1.66	3.23	1.71

As expected, the pressure gradient is effectively independent of Reynolds number as shown in figure 3, but there is significant variation between the streamlines. For instance, the gradients along the centre and port streamlines were the same with an average value of $d(C_{PS})/d(x/L) = -0.0359$, but along the starboard and top streamlines the average value was -0.0443, and along the bottom streamline the gradient was -0.0329. Over all five streamlines the maximum and minimum values were -0.0484 and -0.0316, and the average gradient was -0.0387.

The results above are given for guidance only, and the actual gradient applied in a given situation will depend on the model and type of tests being made. All of the results are tabulated in appendix 1 so that corrections for other locations can be determined as required.

4. AXIAL VELOCITY DISTRIBUTIONS

The reference velocity determined from the piezometric rings across the contraction can be adjusted to indicate the velocity at any given point in the working section. For the present tests the reference velocity was arbitrarily set to correspond to the velocity near the entrance to the working section. The velocity at other points in the working section can then be found by calibration.

The axial velocity distribution along each streamline for each reference unit Reynolds number is shown in figure 4. These velocity ratios were determined from measurements on the inclined manometer and they are less accurate than the static pressure curves in figure 2. The maximum variation in V/V_R corresponding to an error in both H_L and H_R of 0.04" of water inclined is also shown in figure 4.

Like the static pressure results, the axial velocity distributions are approximately linear downstream of $x/L = 0.2$, and a straight line

$$V/V_R = c(x/L) + d \qquad (2)$$

was fitted to them using a least squares analysis. The coefficients c and d for the straight line are given in table 3.

TABLE 3 - Coefficients c and d for least squares analysis of the axial velocity ratio distributions for $0.204 \leqslant (x/L) \leqslant 0.7696$

Stream - line	$V/V_R = c(x/L) + d$							
	$R_N/m = 2.0 \times 10^6$		$R_N/m = 3.0 \times 10^6$		$R_N/m = 4.0 \times 10^6$		$R_N/m = 5.0 \times 10^6$	
	c	d	c	d	c	d	c	d
C	0.0166	1.024	0.0169	1.023	0.0168	1.022	0.0205	1.020
P	0.0199	1.030	0.0140	1.034	0.0199	1.030	0.0176	1.030
S	0.0191	1.025	0.0212	1.025	0.0234	1.022	0.0313	1.018
T	0.0346	1.014	0.0228	1.018	0.0249	1.016	0.0238	1.017
B	0.0159	1.027	0.0126	1.029	0.0143	1.027	0.0158	1.026

The gradient of the velocity ratios is effectively independent of Reynolds number, but there is a significant variation between the streamlines as shown in figure 5. The gradients are, naturally, of opposite sign to the pressure gradient. Over all five streamlines the average axial velocity gradient is $d(V/V_R)/d(x/L) = 0.0201$.

The axial velocity ratios at the transverse plane of the centreline of the mechanical balance, $x/L = 0.43$, are shown in figure 6. The variation with Reynolds number is less than ±0.2% and it can easily be taken into account in a test programme, but the variation of approximately ±0.5% between the five positions is more difficult to allow for.

All of the results are tabulated in appendix 1 so that corrections can be made appropriate to the model being tested at the time.

5. COMPARISON WITH PREVIOUS RESULTS

Some details of the static pressure gradients and axial velocity distributions of flows measured in the original working section are given in references 1,2,3 and 4.

From the leading edge of the working section to a position $x/L = 0.90$ the pressure gradient along the centre of the working section is given as $d(C_{PS})/d(x/L) = -0.026$ (quoted as $dP/dx = -0.0019.\frac{1}{2}\,\rho\,V^2$ lb.ft.$^{-3}$ in reference 1) for $R_N/m = 4.2 \times 10^6$. This gradient is 28% smaller than the value of -0.036 for $0.20 \leqslant (x/L) \leqslant 0.80$ found from the present tests. The significance of this difference depends on the model and type of tests being made, but in many cases it will not have a marked effect.

In comparing the results it should be noted that the gradient given in reference 1 was obtained before the installation of a new more efficient fan[4] and when the working section was much cleaner, for example, when all screws and permanent fittings were flush with the surfaces and before the protruding protective grills were fitted over the lights. The previous results were also taken when the working section was fixed to the main shell before alternative sections were introduced and when the pressure equalising slot was 0.55 m downstream of its present position. Differences in the results may also be related to changes in roughness of the working section caused by continuous use over the years.

In figures 2 and 3 of reference 4, the velocity deviation, v, from the mean velocity across the working section at $x/L = 0.52$ is given at $R_N/m = 2.1 \times 10^6$ and 5.3×10^6 respectively. Results from current tests have been linearly interpolated and extrapolated to these conditions and plotted in figure 8 with the results from reference 4. The velocity deviation for the current tests was determined as the difference between the velocity at the selected position and the mean velocity over all five positions.

As can be seen from figure 7, the deviation from the mean velocity at $R_N/m = 5.3 \times 10^6$ is not as great as found previously, but at $R_N/m = 2.1 \times 10^6$ the deviation is greater. The reason for these differences is not clear, although at $R_N/m = 2.1 \times 10^6$ it is possibly due to the relatively low accuracy of the results. The difference may also be related to the changes in the working section configuration mentioned above. However, care must be used in interpreting the velocity results because they are subject to comparatively large errors as they were determined from measurements on an inclined multitube manometer. For example, at $R_N/m = 5.0 \times 10^6$, the velocity ratio could be in error by up to ± 0.2%.

6. CONCLUDING REMARKS

The static pressure and axial velocity distributions of the flow in the second working section of the 2.7 m x 2.1 m low speed wind tunnel have been determined for four unit Reynolds numbers along five streamlines near the centre of the section.

Current results generally agree with previous results for the original fixed working section although the static pressure gradient is 28% larger than obtained previously and the deviations from the mean velocity are not as large.

The results obtained and given in this report are adequate for their intended purpose of correcting for flow variations in the working section when testing ship models up to 3 m in length.

All results are given in the report so that appropriate analysis can be made for different models under test. However, more comprehensive results may be needed to ensure adequate corrections can be made for tests of more geometrically complex models.

REFERENCES

1. "The 9 ft x 9 ft wind tunnel at C.S.I.R. Division of Aeronautics, Fishermen's Bend, Melbourne". Council for Scientific and Industrial Research, Division of Aeronautics, Report No. A.6., August 1943.

2. "Supplementary Notes to Report No. A6 on the 9 ft x 7 ft tunnel". Council for Scientific and Industrial Research, Division of Aeronautics, Report No. A6, Part 2.

3. "The 9 ft x 7 ft wind tunnel at C.S.I.R. Division of Aeronautics, Fishermen's Bend, Melbourne. General Information". Council for Scientific and Industrial Research, Division of Aeronautics, Report No. A6, Part 3.

4. "The 9 ft x 7 ft wind tunnel at C.S.I.R. Division of Aeronautics, Fishermen's Bend, Melbourne. Appendix II. Recalibration of 9 x 7 tunnel after installation of new fan". Council for Scientific and Industrial Research, Division of Aeronautics, Report No. A.6., Appendix II, March 1945.

APPENDIX 1

Pressures, pressure coefficients, and velocity ratios along the working section of the wind tunnel

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Reference manometers fluid level - no flow in working section.									
0		19.78	19.75	19.77	19.77	0			
Position C-1, x/L = 0.056 (P_a = 30.32" Hg, θ = 42° 8', SG = 1.042)									
555	23	20.06	16.84	19.92	16.59	2.1	4.075	3.708	1.0217
1252	24	20.42	13.20	20.14	12.81	4.5	3.755	3.525	1.0090
2234	24	20.97	8.11	20.49	7.40	7.8	3.663	3.424	1.0101
3485	27	21.73	1.68	20.96	0.60	12.6	3.796	3.545	1.0085
Position C-2, x/L = 0.130									
559	25	20.04	16.80	19.97	16.62	0.8	1.869	1.404	1.0216
1259	25	20.38	13.12	20.24	12.72	2.1	1.936	1.636	1.0199
2237	26	20.88	8.00	20.63	7.30	4.0	1.868	1.753	1.0199
3491	27	21.58	1.50	21.18	0.40	6.5	1.945	1.826	1.0180
Position C-3, x/L = 0.204									
561	25	20.05	16.80	20.02	16.62	0.2	0.621	0.350	1.0276
1262	25	20.39	13.11	20.33	12.70	0.7	0.690	0.544	1.0259
2241	26	20.89	7.99	20.79	7.26	1.3	0.699	0.569	1.0253
3496	27	21.57	1.46	21.42	0.35	2.1	0.697	0.589	1.0244
Reference manometer fluid level - no flow in working section.									
0		20.34	20.31	20.33	20.33	0			

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position C-4, x/L = 0.278 (P_a = 30.40, θ = 42° 6', SG = 1.0420)									
566	18	20.60	17.32	20.58	17.14	0.1	0.308	0.173	1.0288
1255	19	20.94	13.70	20.91	13.30	0.3	0.277	0.234	1.0274
2241	20	21.50	8.60	21.45	7.90	0.7	0.311	0.306	1.0261
3500	21	22.28	2.15	22.21	1.05	1.1	0.299	0.308	1.0260
Position C-5, x/L = 0.352									
552	20	20.60	17.40	20.60	17.24	-0.1	-0.315	-0.178	1.0295
1258	20	20.95	13.69	20.95	13.30	-0.1	-0.138	-0.078	1.0286
2240	20	21.50	8.60	21.49	7.90	0.0	0.000	0.000	1.0276
3495	21	22.30	2.20	22.29	1.10	0.0	0.000	0.000	1.0275
Position C-6, x/L = 0.426									
560	21	20.61	17.37	20.62	17.21	-0.3	-0.623	-0.526	1.0307
1257	22	20.95	13.70	20.97	13.32	-0.4	-0.416	-0.312	1.0293
2243	23	21.49	8.58	21.52	7.88	-0.7	-0.311	-0.306	1.0291
3496	24	22.25	2.14	22.31	1.10	-1.0	-0.349	-0.280	1.0278
Position C-7, x/L = 0.500									
561	23	20.63	17.38	20.65	17.22	-0.4	-0.932	-0.700	1.0321
1260	23	20.96	13.69	21.01	13.29	-0.9	-0.829	-0.700	1.0326
2239	23	21.49	8.60	21.56	7.90	-1.2	-0.622	-0.526	1.0306
3500	24	22.23	2.10	22.33	1.04	-2.0	-0.547	-0.560	1.0292
Position C-8, x/L = 0.574									
557	23	20.62	17.39	20.65	17.23	-0.6	-1.250	-1.056	1.0338
1262	23	20.98	13.70	21.04	13.30	-1.1	-0.966	-0.855	1.0332
2241	24	21.50	8.60	21.60	7.90	-1.9	-0.855	-0.832	1.0317
3498	25	22.22	2.10	22.39	0.97	-2.9	-0.896	-0.813	1.0326

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position C-9, x/L = 0.648									
557	24	20.63	17.40	20.67	17.22	-0.7	-1.563	-1.232	1.0383
1261	24	20.97	13.70	21.04	13.30	-1.4	-1.105	-1.089	1.0340
2239	25	21.50	8.61	21.63	7.91	-2.4	-1.089	-1.051	1.0329
3502	26	22.24	2.10	22.44	1.00	-3.7	-1.044	-1.036	1.0325
Position C-10, x/L = 0.722									
564	25	20.64	17.37	20.69	17.21	-0.9	-1.852	-1.565	1.0364
1262	25	20.98	13.70	21.07	13.30	-1.7	-1.379	-1.321	1.0352
2247	26	21.50	8.56	21.65	7.87	-3.0	-1.239	-1.309	1.0331
3493	27	22.19	2.10	22.47	1.00	-4.6	-1.446	-1.292	1.0345
Position C-11, x/L = 0.796									
559	24	20.64	17.40	20.68	17.34	-1.0	-1.558	-1.755	1.0352
1262	25	20.98	13.70	21.08	13.31	-2.0	-1.517	-1.554	1.0352
2246	26	21.50	8.57	21.70	7.87	-3.5	-1.628	-1.528	1.0354
3543	27	22.26	1.88	22.59	0.70	-5.6	-1.671	-1.550	1.0371
Position P-1, x/L = 0.056									
569	31	20.67	17.37	20.59	17.16	1.2	2.141	2.067	1.0242
1264	31	21.00	13.71	20.81	13.19	3.1	2.479	2.405	1.0245
2246	32	21.53	8.60	21.18	7.66	5.7	2.636	2.489	1.0237
3505	33	22.26	2.10	21.73	0.70	9.1	2.583	2.546	1.0221
Position P-2, x/L = 0.130									
564	29	20.66	17.39	20.61	17.16	0.5	1.235	0.869	1.0319
1271	29	21.00	13.67	20.90	13.14	1.4	1.233	1.080	1.0310
2256	30	21.51	8.52	21.34	7.61	2.7	1.235	1.173	1.0293
3510	32	22.23	2.04	21.96	0.53	4.4	1.290	1.229	1.0310

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position P-3, x/L = 0.204									
561	29	20.66	17.41	20.63	17.20	0.2	0.621	0.350	1.0321
1262	29	20.98	13.70	20.93	13.17	0.6	0.552	0.466	1.0346
2250	30	21.49	8.54	21.39	7.60	1,2	0.697	0.523	1.0331
3489	32	22.17	2.10	22.02	0.60	2.2	0.699	0.618	1.0339
Position P-4, x/L = 0.278									
572	28	20.66	17.34	20.65	17.12	0.0	0.000	0.000	1.0358
1264	28	20.97	13.68	20.96	13.13	0.1	0.000	0.078	1.0385
2248	29	21.46	8.52	21.44	7.60	0.3	0.078	0.131	1.0354
3487	30	22.16	2.10	22.11	0.60	0.6	0.200	0.169	1.0363
Position P-5, x/L = 0.352									
548	27	20.65	17.47	20.65	17.27	-0.2	-0.317	-0.358	1.0359
1264	27	20.97	13.68	20.98	13.14	-0.3	-0.275	-0.233	1.0392
2253	28	21.49	8,52	21.50	7.60	-0.4	-0.155	-0.174	1.0364
3508	29	22.18	2.00	22.20	0.50	-0.5	-0.149	-0.140	1.0377
Position P-6, x/L = 0.426									
569	27	20.66	17.36	20.66	17.14	-0.3	-0.306	-0.517	1.0375
1259	27	20.97	13.71	21.00	13.19	-0.7	-0.553	-0.545	1.0393
2236	28	21.48	8.61	21.53	7.67	-1.1	-0.467	-0.483	1.0390
3510	29	22.19	2.00	22.26	0.60	-1.6	-0.397	-0.447	1.0365
Position P-7, x/L = 0.500									
545	26	20.64	17.48	20.66	17.26	-0.5	-0.958	-0.900	1.0422
1260	26	20.97	13.70	21.02	13.17	-1.0	-0.829	-0.778	1.0413
2256	27	21.49	8.50	21.58	7.60	-1.7	-0.772	-0.739	1.0386
3510	28	22.19	2.00	22.33	0.60	-2.5	-0.744	-0.698	1.0382

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position P-8, x/L = 0.574									
564	26	20.66	17.39	20.68	17.17	-0.6	-0.926	-1.043	1.0408
1257	26	20.99	13.74	21.05	13.20	-1.2	-0.970	-0.936	1.0427
2242	26	21.50	8.59	21.61	7.65	-2.1	-0.932	-0.918	1.0411
3494	27	22.20	2.10	22.39	0.60	-3.3	-0.997	-0.926	1.0420
Position P-9, x/L = 0.648									
562	24	20.65	17.39	20.69	17.16	-0.8	-1.548	-1.395	1.0454
1260	24	20.99	13.72	21.07	13.19	-1.5	-1.243	-1.167	1.0433
2248	25	21.50	8.56	21.66	7.61	-2.7	-1.317	-1.178	1.0432
3477	26	22.20	2.20	22.44	0.80	-4.1	-1.252	-1.156	1.0410
Position P-10, x/L = 0.722									
562	24	20.64	17.40	20.68	17.18	-0.9	-1.558	-1.579	1.0442
1260	24	20.97	13.71	21.07	13.20	-1.9	-1.521	-1.480	1.0433
2241	24	21.50	8.60	21.69	7.63	-3.3	-1.554	-1.444	1.0452
3498	25	22.23	2.11	22.52	0.67	-5.1	-1.493	-1.430	1.0429
Position P-11, x/L = 0.796									
562	25	20.65	17.39	20.69	17.18	-1.0	-1.548	-1.744	1.0424
1266	25	21.00	13.70	21.11	13.19	-2.2	-1.651	-1.704	1.0437
2248	26	21.54	8.60	21.75	7.68	-3.9	-1.704	-1.701	1.0440
3499	27	22.23	2.10	22.57	0.60	-6.0	-1.741	-1.681	1.0455
Position S-1, x/L = 0.056									
557	30	20.67	17.44	20.56	17.28	1.4	3.125	2.464	1.0124
1290	31	21.06	13.62	20.83	13.19	3.5	2.969	2.660	1.0154
2247	31	21.51	8.57	21.11	7.84	6.5	3.021	2.836	1.0138
3501	31	22.28	2.14	21.68	1.05	10.4	2.934	2.913	1.0128

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position S-2, x/L = 0.130									
561	29	20.64	17.39	20.59	17.22	0.8	1.242	1.399	1.0230
1259	29	20.96	13.70	20.85	13.30	1.9	1.383	1.480	1.0219
2244	30	21.44	8.52	21.22	7.80	3.6	1.629	1.573	1.0204
3496	31	22.22	2.11	21.88	0.90	5.8	1.643	1.627	1.0222
Position S-3, x/L = 0.204									
566	29	20.66	17.38	20.62	17.21	0.4	0.923	0.693	1.0243
1264	29	20.99	13.70	20.94	13.27	1.0	0.026	0.776	1.0270
2251	30	21.50	8.54	21.38	7.80	1.9	0.851	0.828	1.0248
3505	31	22.20	2.04	22.00	0.80	3.2	0.944	0.895	1.0262
Position S-4, x/L = 0.278									
564	30	20.65	17.38	20.64	17.20	0.1	0.000	0.174	1.0304
1257	30	20.94	13.69	20.92	13.24	0.3	0.139	0.234	1.0314
2251	30	21.36	8.40	21.31	7.68	0.7	0.309	0.305	1.0267
3489	31	21.97	1.90	21.90	0.70	1.3	0.299	0.365	1.0285
Position S-5, x/L = 0.352 (P_a = 30.44" Hg, = 42° 8', SG = 1.0420)									
563	19	20.63	17.35	20.63	17.17	-0.1	-0.308	-0.173	1.0318
1257	19	20.96	13.73	20.96	13.30	-0.2	-0.139	-0.156	1.0314
2247	20	21.55	8.60	21.55	7.81	-0.2	-0.077	-0.087	1.0312
3458	21	22.33	2.36	22.34	1.20	-0.3	-0.100	-0.085	1.0297
Position S-6, x/L = 0.426									
553	20	20.62	17.42	20.63	17.24	-0.3	-0.631	-0.533	1.0341
1258	20	20.99	13.76	21.02	13.29	-0.7	-0.556	-0.548	1.0362
2245	21	21.59	8.66	21.63	7.86	-1.0	-0.388	-0.437	1.0332
3383	22	22.31	2.74	22.40	1.60	-1.5	-0.512	-0.432	1.0317

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR}	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
		(inches of water - inclined)							
Position S-7, x/L = 0.500									
561	21	20.65	17.40	20.67	17.21	-0.5	-0.932	-0.875	1.0366
1267	21	21.00	13.70	21.05	13.35	-1.1	-0.837	-0.864	1.0363
2251	22	21.57	8.60	21.65	7.80	-1.8	-0.696	-0.784	1.0346
3451	23	22.36	2.38	22.50	1.22	-2.7	-0.752	-0.763	1.0328
Position S-8, x/L = 0.574									
562	22	20.65	17.40	20.69	17.21	-0.8	-1.553	-1.399	1.0396
1270	22	21.00	13.70	21.08	13.24	-1.5	-1.238	-1.162	1.0385
2236	23	21.56	8.64	21.68	7.86	-2.4	-1.010	-1.050	1.0363
3486	25	22.36	2.30	22.56	1.00	-3.6	-1.048	-1.012	1.0375
Position S-9, x/L = 0.648									
560	24	20.65	17.40	20.70	17.23	-1.0	-1.863	-1.749	1.0381
1263	24	21.00	13.73	21.10	13.29	-1.8	-1.519	-1.400	1.0386
2239	25	21.55	8.64	21.70	7.86	-2.9	-1.242	-1.268	1.0366
3491	26	22.31	2.21	22.55	0.90	-4.4	-1.246	-1.235	1.0386
Position S-10, x/L = 0.722									
555	25	20.65	17.42	20.69	17.24	-1.1	-1.563	-1.936	1.0383
1270	26	21.00	13.70	21.10	13.24	-2.0	-1.513	-1.549	1.0398
2238	27	21.52	8.64	21.70	7.84	-3.3	-1.479	-1.446	1.0386
3510	28	22.29	2.09	22.55	0.75	-5.0	-1.339	-1.396	1.0396
Position S-11, x/L = 0.796									
556	25	20.65	17.40	20.69	17.24	-1.2	-1.553	-2.099	1.0351
1259	25	21.00	13.75	21.11	13.30	-2.3	-1.662	-1.794	1.0401
2245	26	21.54	8.60	21.74	7.82	-3.9	-1.627	-1.701	1.0384
3518	27	22.30	2.04	22.63	0.80	-6.1	-1.681	-1.698	1.0388

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position T-1, x/L = 0.056									
554	28	20.66	17.45	20.52	17.28	2.2	4.088	3.897	1.0094
1280	28	21.03	13.69	19.71	13.23	5.2	4.241	4.007	1.0116
2240	29	21.56	8.63	21.01	7.92	9.0	4.186	3.929	1.0147
3503	30	22.30	2.14	21.52	1.05	13.3	3.825	3.721	1.0084
Position T-2, x/L = 0.130									
568	28	20.67	17.37	20.58	17.20	1.3	2.446	2.239	1.0167
1267	28	21.00	13.71	20.82	13.30	3.0	2.342	2.327	1.0177
2240	29	21.51	8.60	21.20	7.90	5.1	2.329	2.230	1.0162
3522	30	22.24	1.97	21.81	0.77	6.8	2.075	1.892	1.0196
Position T-3, x/L = 0.204									
551	28	20.65	17.45	20.59	17.30	0.7	1.577	1.244	1.0188
1279	28	20.99	13.62	20.89	13.21	1.6	1.226	1.228	1.0229
2256	29	21.49	8.49	21.32	7.79	2.5	1.234	1.086	1.0214
3512	30	22.18	1.85	21.99	0.78	3.6	0.887	0.999	1.0222
Position T-4, x/L = 0.278									
552	27	20.65	17.44	20.60	17.27	0.5	1.258	0.886	1.0233
1276	27	21.00	13.65	20.90	13.21	1.2	1.230	0.923	1.0250
2243	27	21.49	8.54	21.36	7.86	2.0	0.929	0.872	1.0222
3488	28	22.16	2.10	22.02	1.00	2.3	0.649	0.647	1.0244
Position T-5, x/L = 0.352									
563	26	20.66	17.40	20.63	17.21	0.3	0.619	0.523	1.0290
1270	27	21.00	13.68	20.93	13.26	0.8	0.823	0.618	1.0257
2249	27	21.49	8.53	21.40	7.80	1.2	0.619	0.523	1.0256
3488	28	22.18	2.11	22.10	1.01	0.9	0.349	0.253	1.0259

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position T-6, x/L = 0.426									
560	26	20.65	17.40	20.63	17.25	0.2	0.311	0.350	1.0245
1258	26	21.00	13.72	20.96	13.34	0.5	0.414	0.388	1.0252
2249	27	21.51	8.58	21.47	7.84	0.7	0.233	0.306	1.0279
3487	28	22.25	2.20	22.23	1.10	0.1	0.050	0.028	1.0273
Position T-7, x/L = 0.500									
557	25	20.66	17.42	20.65	17.23	0.0	0.000	0.000	1.0322
1257	25	21.01	13.76	20.99	13.35	0.1	0.139	0.078	1.0280
2241	26	21.54	8.62	21.53	7.90	0.0	0.000	0.000	1.0283
3480	27	22.30	2.25	22.35	1.15	-0.6	-0.300	-0.169	1.0290
Position T-8, x/L = 0.574									
558	23	20.67	17.41	20.65	17.16	-0.2	-0.310	-0.349	1.0424
1261	24	21.02	13.76	21.02	13.35	-0.3	-0.138	-0.234	1.0300
2250	25	21.56	8.63	21.59	7.90	-0.8	-0.310	-0.349	1.0302
3497	26	22.35	2.20	22.47	1.10	-2.2	-0.646	-0.616	1.0306
Position T-9, x/L = 0.648									
557	22	20.66	17.41	20.67	17.16	-0.4	-0.621	-0.700	1.0441
1258	23	20.01	13.76	20.05	13.36	-0.8	-0.693	-0.624	1.0320
2240	24	21.58	8.70	21.66	7.96	-1.5	-0.700	-0.657	1.0325
3505	25	22.37	2.20	22.57	1.00	-3.5	-1.043	-0.979	1.0349
Position T-10, x/L = 0.722									
560	25	20.66	17.40	20.69	17.24	-0.7	-1.238	-1.221	1.0335
1260	25	21.01	13.75	21.09	13.34	-1.4	-1.245	-1.091	1.0353
2251	25	21.55	8.60	21.69	7.86	-2.7	-1.161	-1.177	1.0346
3507	26	22.30	2.11	22.58	1.00	-5.4	-1.438	-1.509	1.0346

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position T-11, x/L = 0.796									
567	25	20.65	17.36	20.69	17.18	-0.9	-1.534	-1.555	1.0376
1257	25	21.00	13.75	21.10	13.35	-1.8	-1.524	-1.404	1.0361
2244	26	21.56	8.64	21.74	7.91	-3.4	-1.474	-1.486	1.0358
3497	26	22.34	2.21	22.67	1.11	-6.3	-1.692	-1.765	1.0357
Position B-1, x/L = 0.056									
560	18	20.66	17.41	20.56	17.21	1.7	2.795	2.974	1.0200
1261	18	21.02	13.81	20.80	13.31	3.9	2.925	3.059	1.0214
2245	19	21.75	8.83	21.34	7.94	7.0	3.103	3.059	1.0196
3485	21	22.66	2.62	22.00	1.21	11.0	3.248	3.096	1.0193
Position B-2, x/L = 0.130									
563	19	20.66	17.40	20.60	17.19	0.8	1.548	1.395	1.0275
1259	19	21.06	13.80	20.94	13.30	2.0	1.521	1.558	1.0280
2244	20	21.68	8.79	21.46	7.90	3.6	1.633	1.577	1.0269
3522	21	22.59	2.20	22.24	0.84	5.8	1.670	1.604	1.0252
Position B-3, x/L = 0.204									
561	21	20.66	17.41	20.61	17.20	0.5	1.242	0.875	1.0291
1242	21	21.03	13.89	20.95	13.38	1.2	0.985	0.951	1.0318
2240	22	21.64	8.71	21.49	7.84	2.3	1.085	1.004	1.0287
3480	23	22.46	2.41	22.24	1.10	3.7	1.049	1.041	1.0276
Position B-4, x/L = 0.278									
561	22	20.66	17.40	20.64	17.20	0.4	0.310	0.697	1.0320
1265	22	21.04	13.76	20.97	13.24	1.0	0.828	0.777	1.0325
2243	23	21.63	8.70	21.50	7.81	1.9	0.930	0.830	1.0302
3516	24	22.46	2.26	22.26	0.80	3.2	0.942	0.894	1.0315

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position B-5, x/L = 0.352									
559	23	20.66	17.43	20.64	17.21	0.2	0.313	0.352	1.0352
1265	23	21.04	13.76	21.00	13.25	0.6	0.414	0.466	1.0339
2243	24	21.62	8.70	21.53	7.82	1.3	0.621	0.568	1.0313
3488	25	22.41	2.34	22.29	0.92	2.1	0.549	0.590	1.0327
Position B-6, x/L = 0.426									
560	24	20.66	17.41	20.65	17.21	0.0	0.000	0.000	1.0336
1269	24	21.05	13.74	21.02	13.23	0.3	0.275	0.232	1.0344
2254	25	21.61	8.63	21.57	7.75	0.7	0.232	0.304	1.0330
3495	26	22.40	2.30	22.33	0.85	1.2	0.299	0.337	1.0345
Position B-7, x/L = 0.500									
562	24	20.66	17.40	20.66	17.20	-0.1	-0.310	-0.174	1.0350
1259	24	21.04	13.77	21.04	13.27	0.0	-0.138	0.000	1.0360
2257	25	21.61	8.64	21.60	7.74	0.1	0.000	0.044	1.0349
3501	27	22.44	2.30	22.43	1.00	0.2	0.000	0.056	1.0323
Position B-8, x/L = 0.574									
561	25	20.67	17.42	20.67	17.21	-0.2	-0.311	-0.350	1.0366
1265	25	21.04	13.74	21.04	13.26	-0.3	-0.138	-0.232	1.0345
2241	26	21.60	8.70	21.62	7.81	-0.5	-0.233	-0.219	1.0359
3504	27	22.40	2.25	22.45	0.80	-0.9	-0.298	-0.252	1.0373
Position B-9, x/L = 0.648									
563	25	20.68	17.41	20.69	17.21	-0.3	-0.617	-0.522	1.0364
1270	25	21.05	13.74	21.07	13.21	-0.7	-0.412	-0.542	1.0391
2251	26	21.61	8.65	21.65	7.76	-1.0	-0.387	-0.436	1.0365
3500	27	22.40	2.24	22.49	0.78	-1.5	-0.497	-0.420	1.0385

APPENDIX 1 (CONT.)

H_R (pascal)	T (°C)	P_{SR} (inches of water - inclined)	P_{TR}	P_S	P_T	P_{SDIF} (mm of water)	C_{PSI} x 10^2	C_{PS} x 10^2	$\frac{V}{V_R}$
Position B-10, x/L = 0.722									
565	26	20.69	17.40	20.70	17.20	-0.6	-0.613	-1.037	1.0362
1263	26	21.05	13.76	21.09	13.27	-0.9	-0.689	-0.698	1.0379
2240	27	21.60	8.71	21.66	7.83	-1.4	-0.544	-0.613	1.0370
3510	28	22.40	2.20	22.50	0.85	-2.1	-0.545	-0.586	1.0360
Position B-11, x/L = 0.796									
564	27	20.67	17.40	20.69	17.17	-0.7	-0.926	-1.217	1.0423
1272	27	21.01	13.70	21.06	13.20	-1.2	-0.824	-0.928	1.0391
2237	28	21.55	8.64	21.63	7.80	-1.8	-0.699	-0.787	1.0362
3515	29	22.31	2.10	22.45	0.70	-2.8	-0.690	-0.782	1.0382

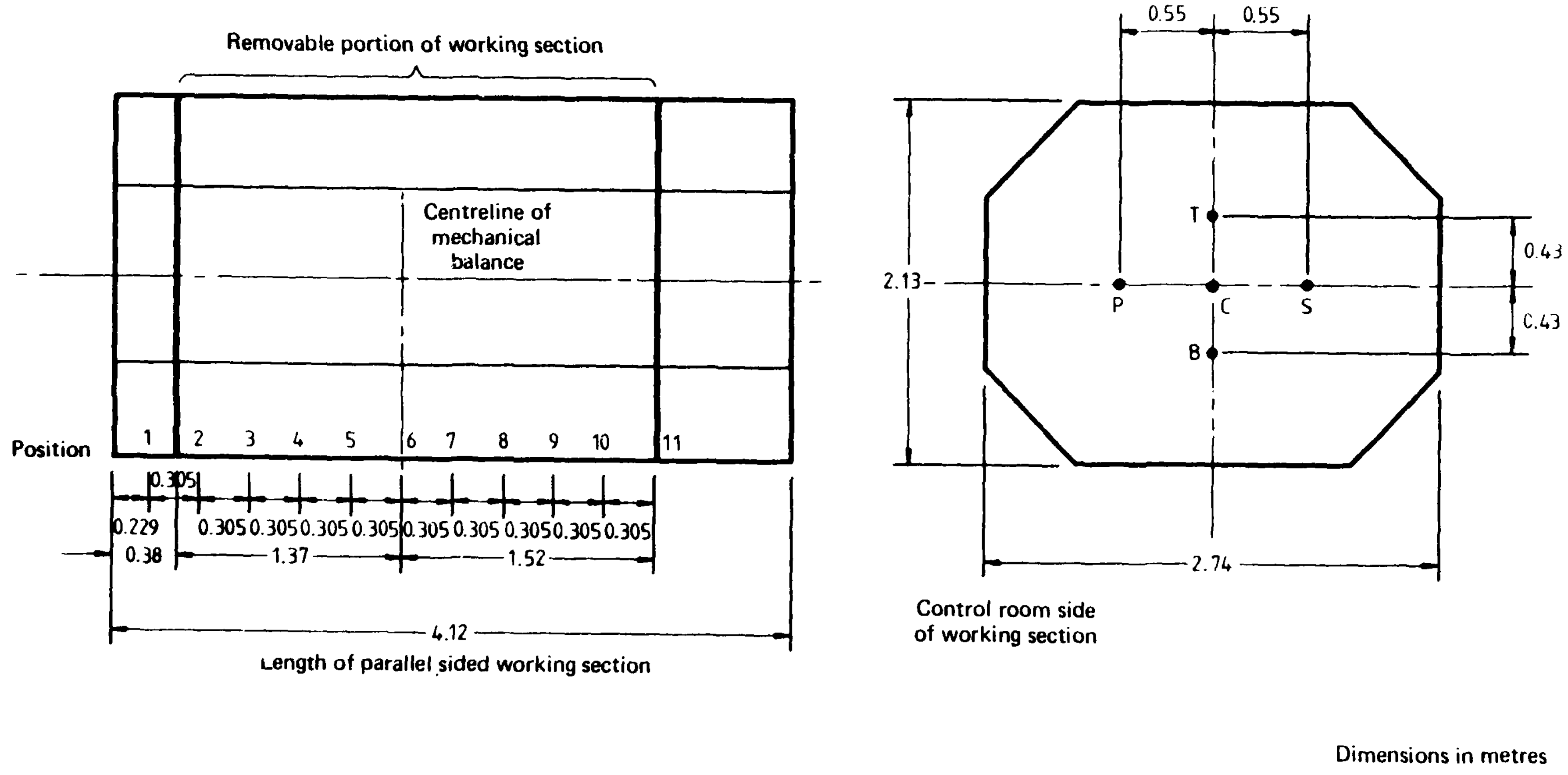

FIG. 1. POSITIONS AT WHICH PRESSURE MEASUREMENTS WERE TAKEN IN THE WORKING SECTION.

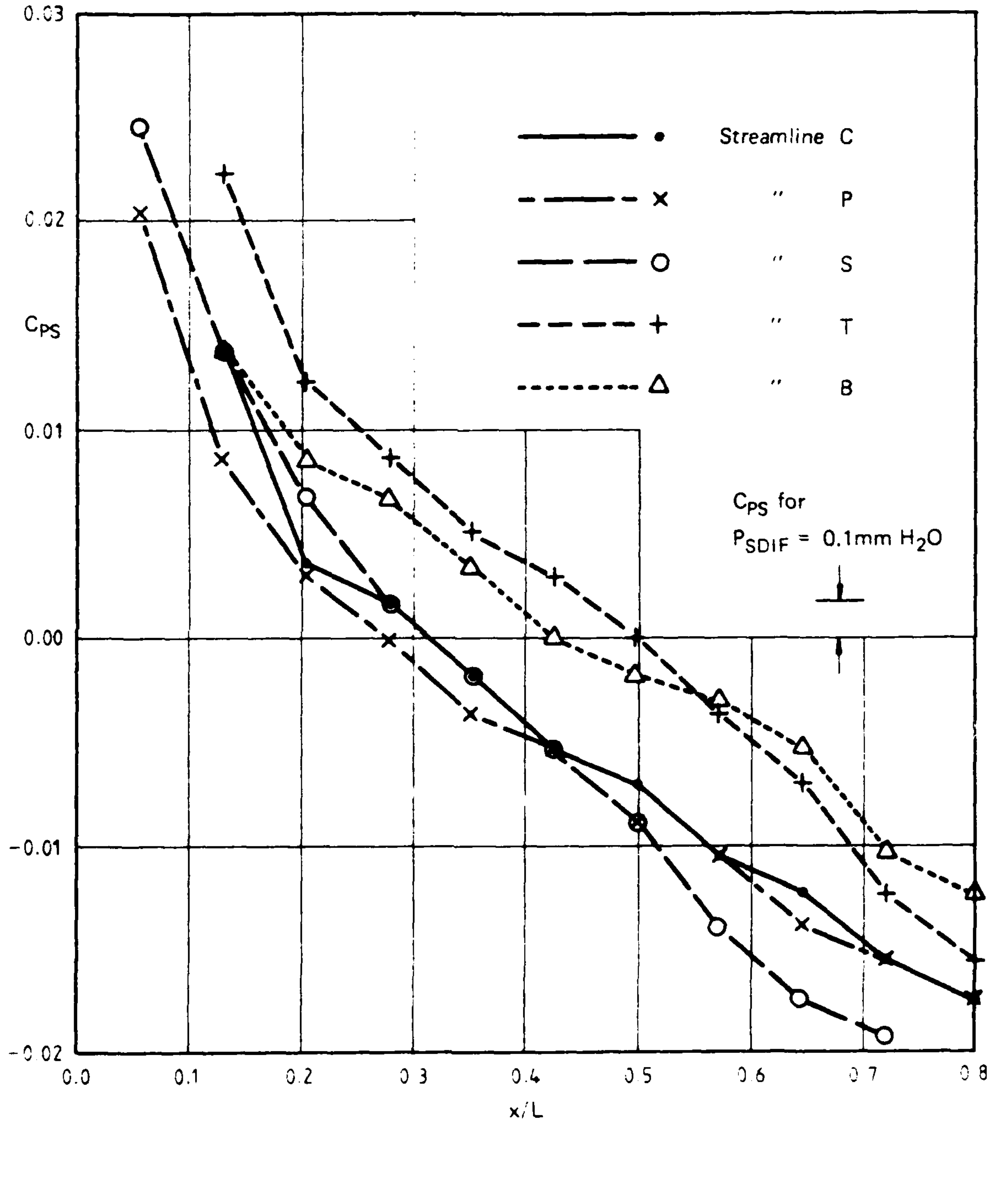

FIG. 2. STATIC PRESSURE COEFFICIENTS ALONG THE WORKING SECTION
(a) $R_N/m = 2.0 \times 10^6$

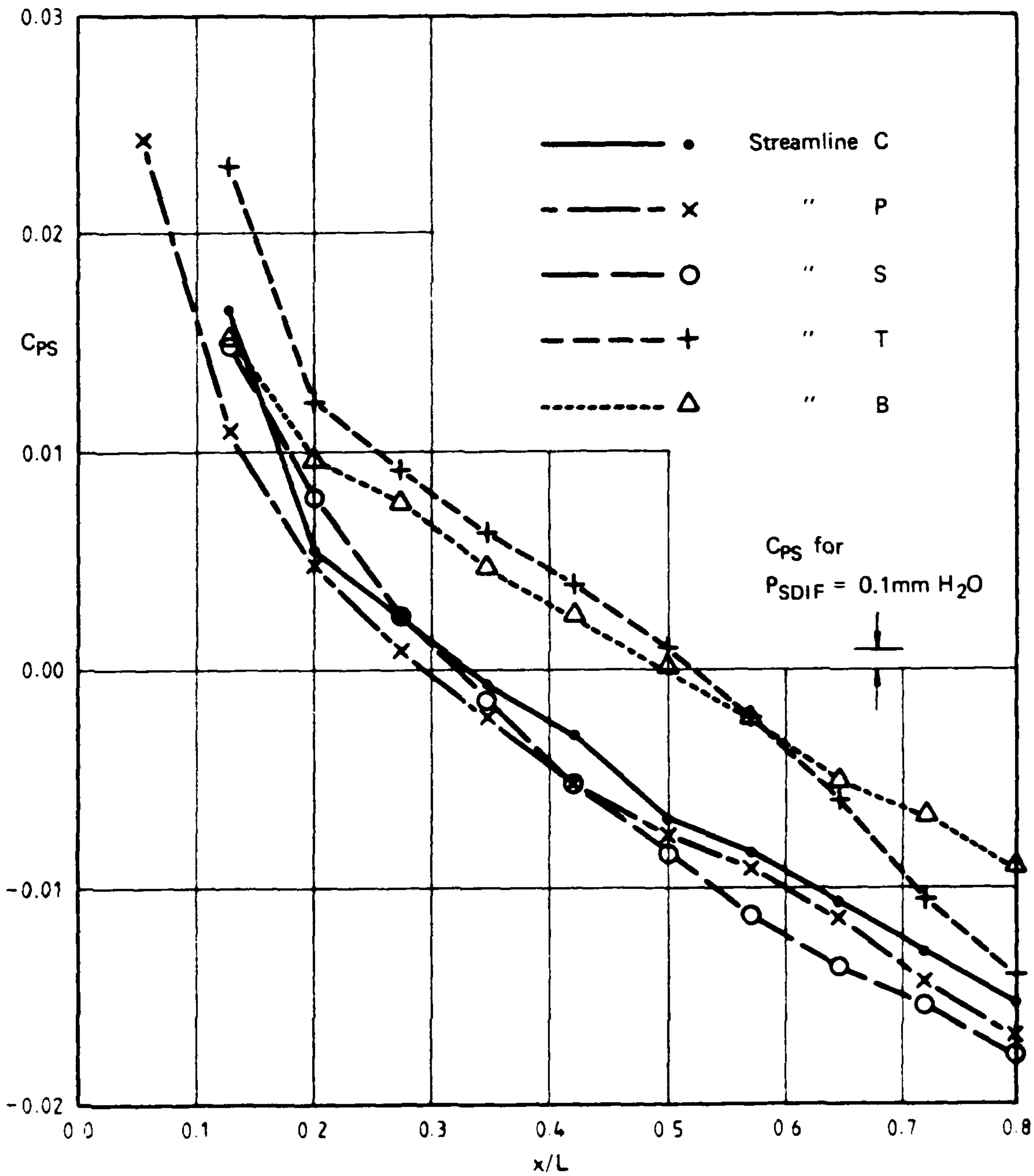

FIG. 2. (CONT.) (b) $R_N/m = 3.0 \times 10^6$

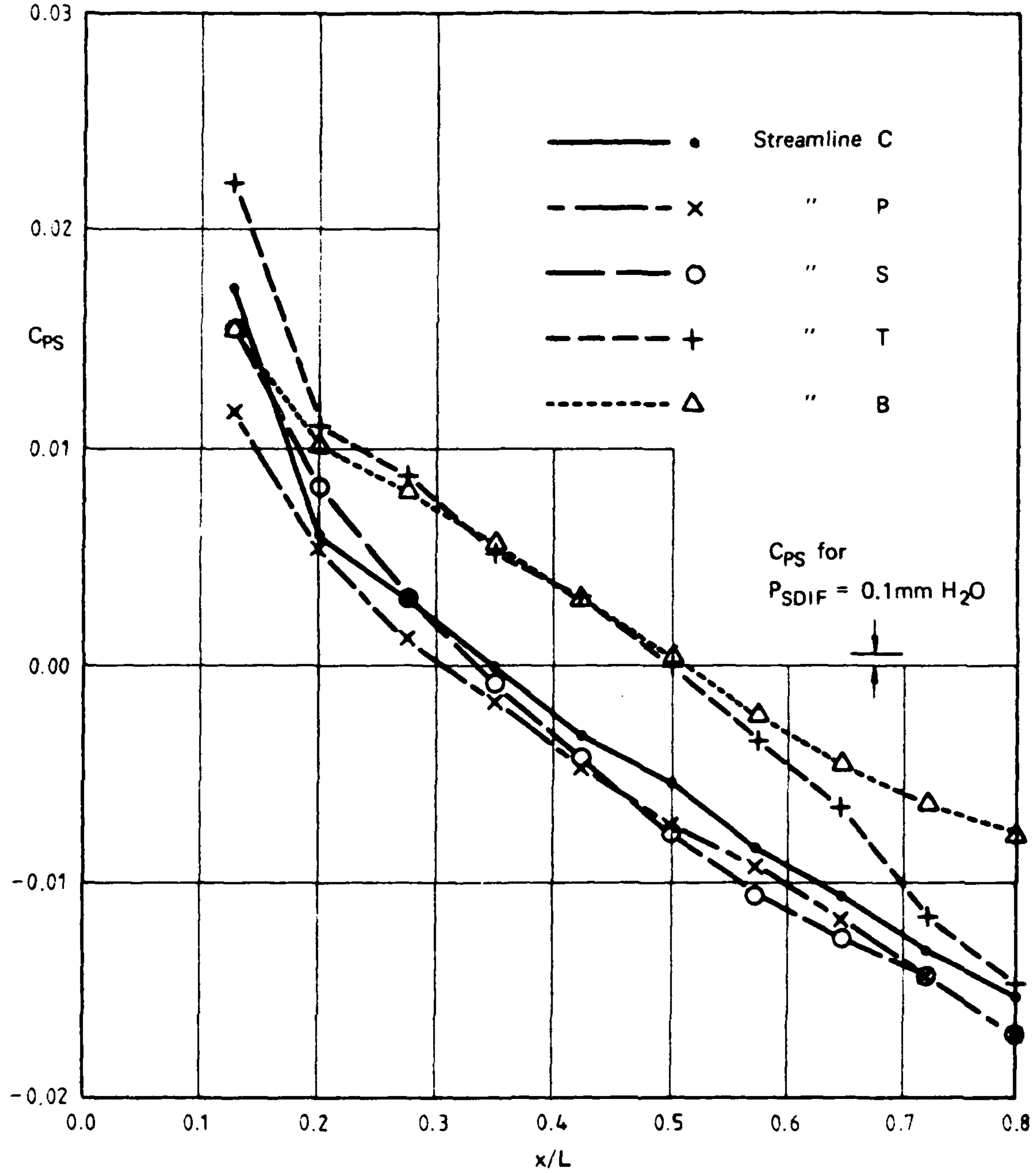

FIG. 2. (CONT.) (c) $R_N/m = 4.0 \times 10^6$

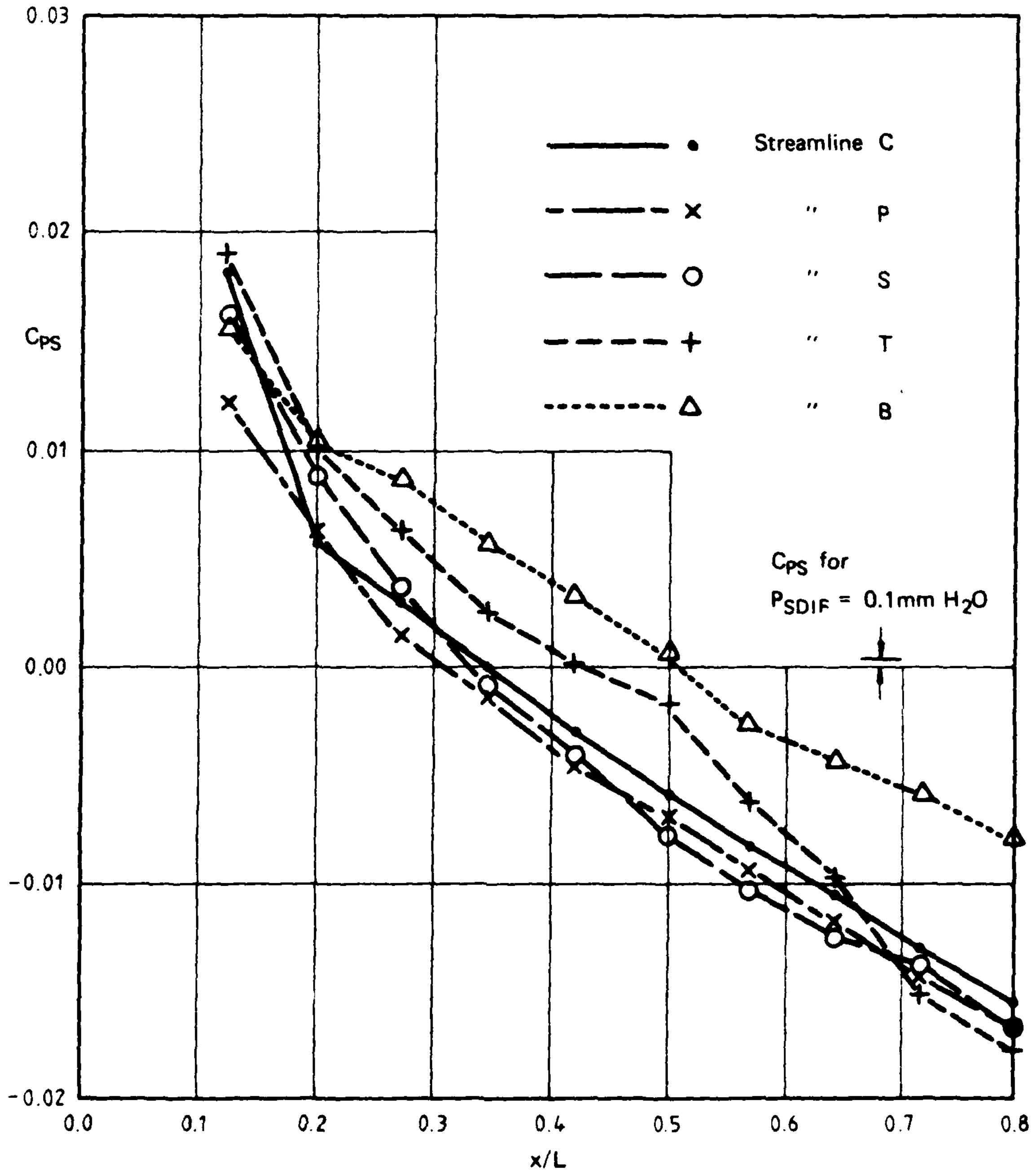

FIG. 2. (CONT.) (d) $R_N/m = 5.0 \times 10^6$

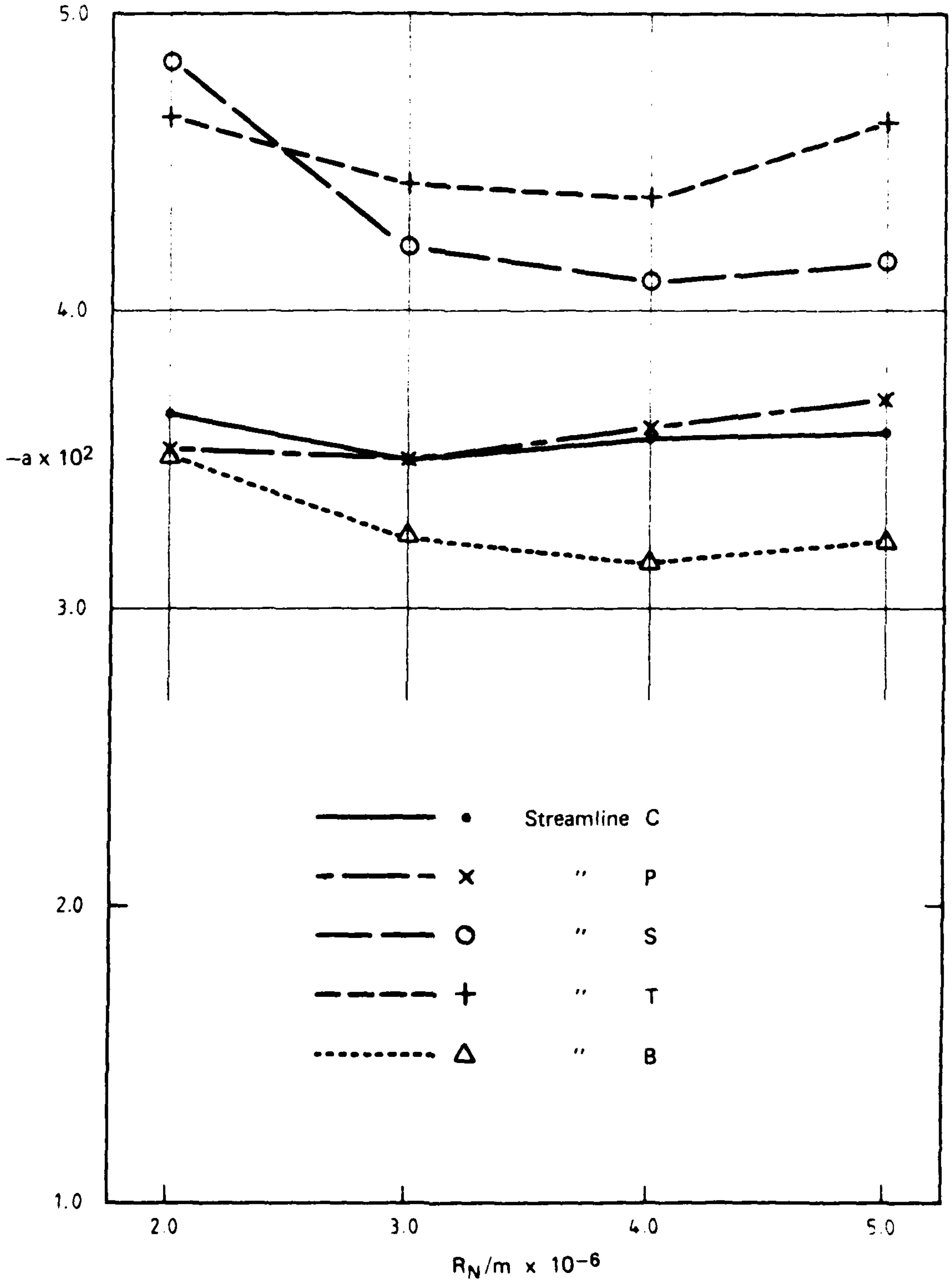

FIG. 3. PRESSURE GRADIENT AS A FUNCTION OF UNIT REYNOLDS NUMBER

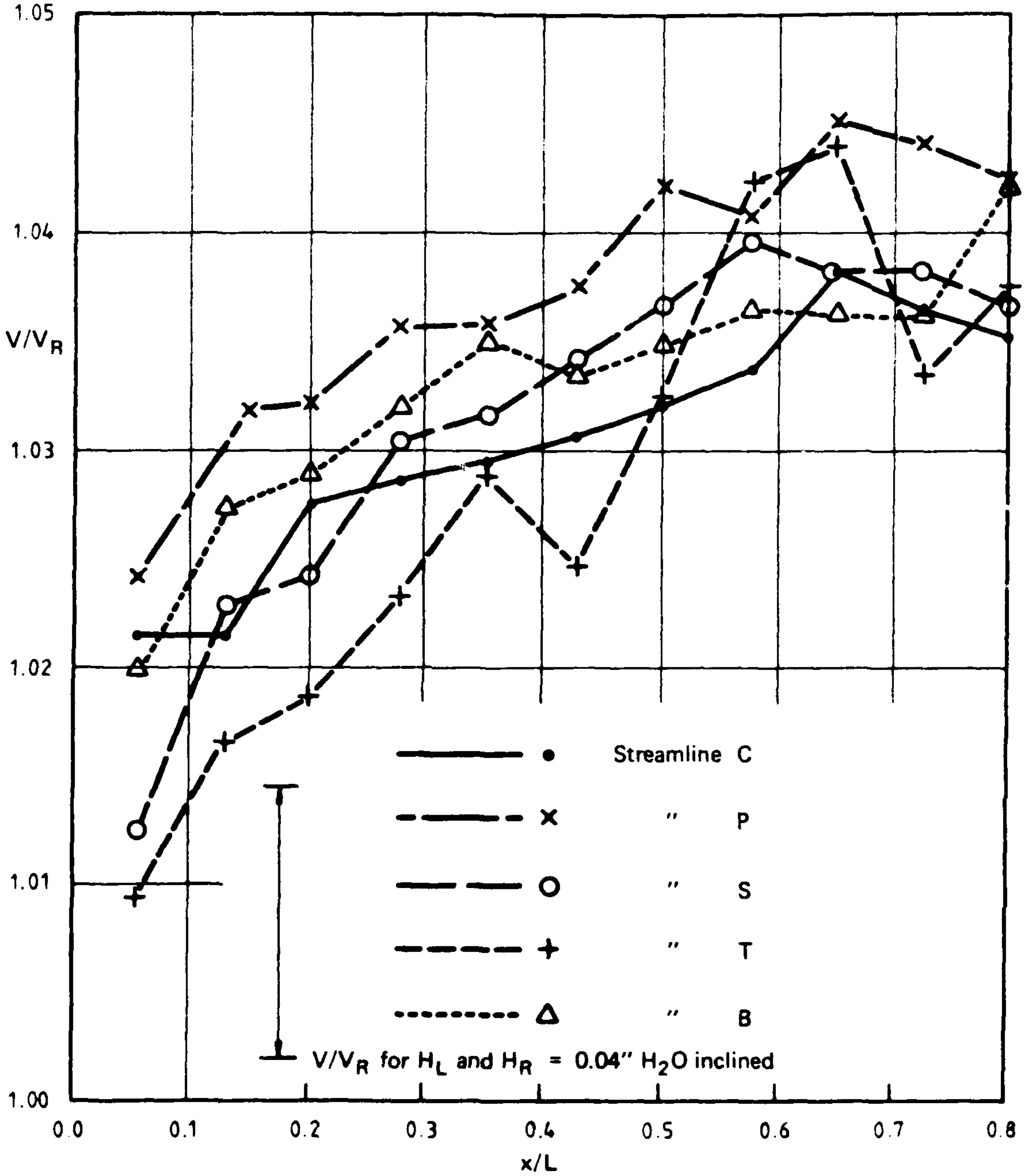

FIG. 4. AXIAL VELOCITY DISTRIBUTION ALONG THE WORKING SECTION
(a) $R_N/m = 2.0 \times 10^6$

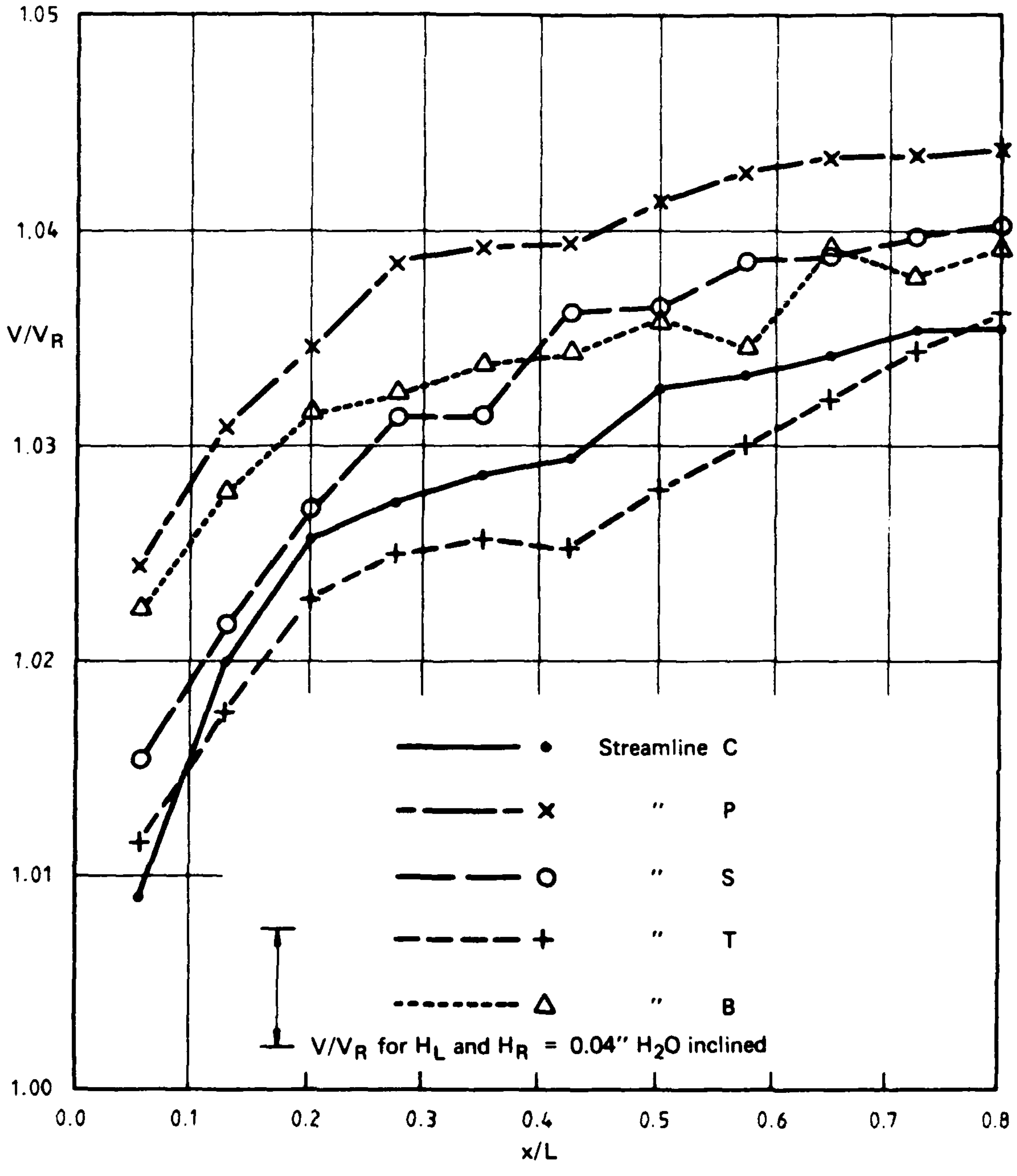

FIG. 4. (CONT.) (b) $R_N/m = 3.0 \times 10^6$

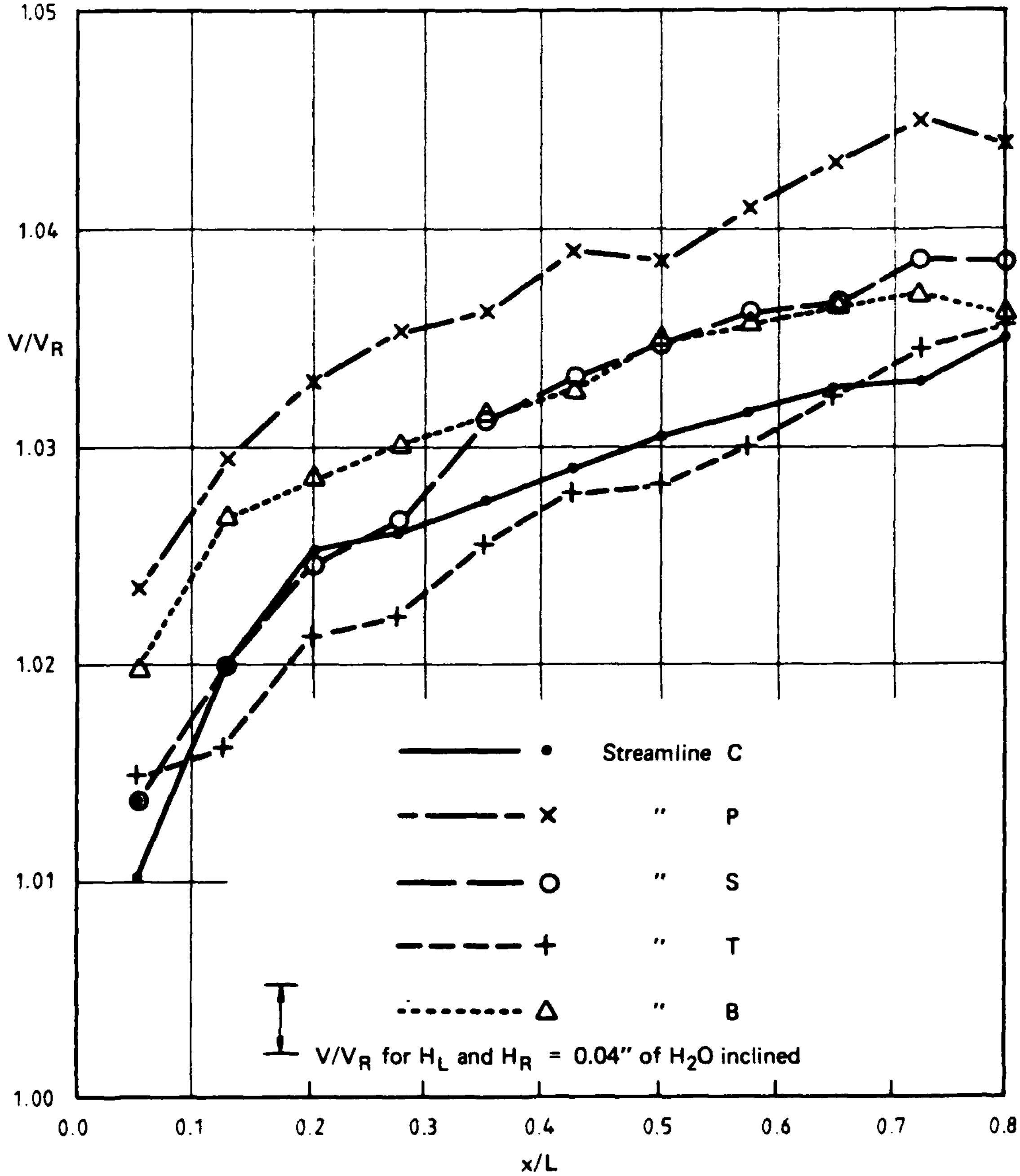

FIG. 4. (CONT.) (c) $R_N/m = 4.0 \times 10^6$

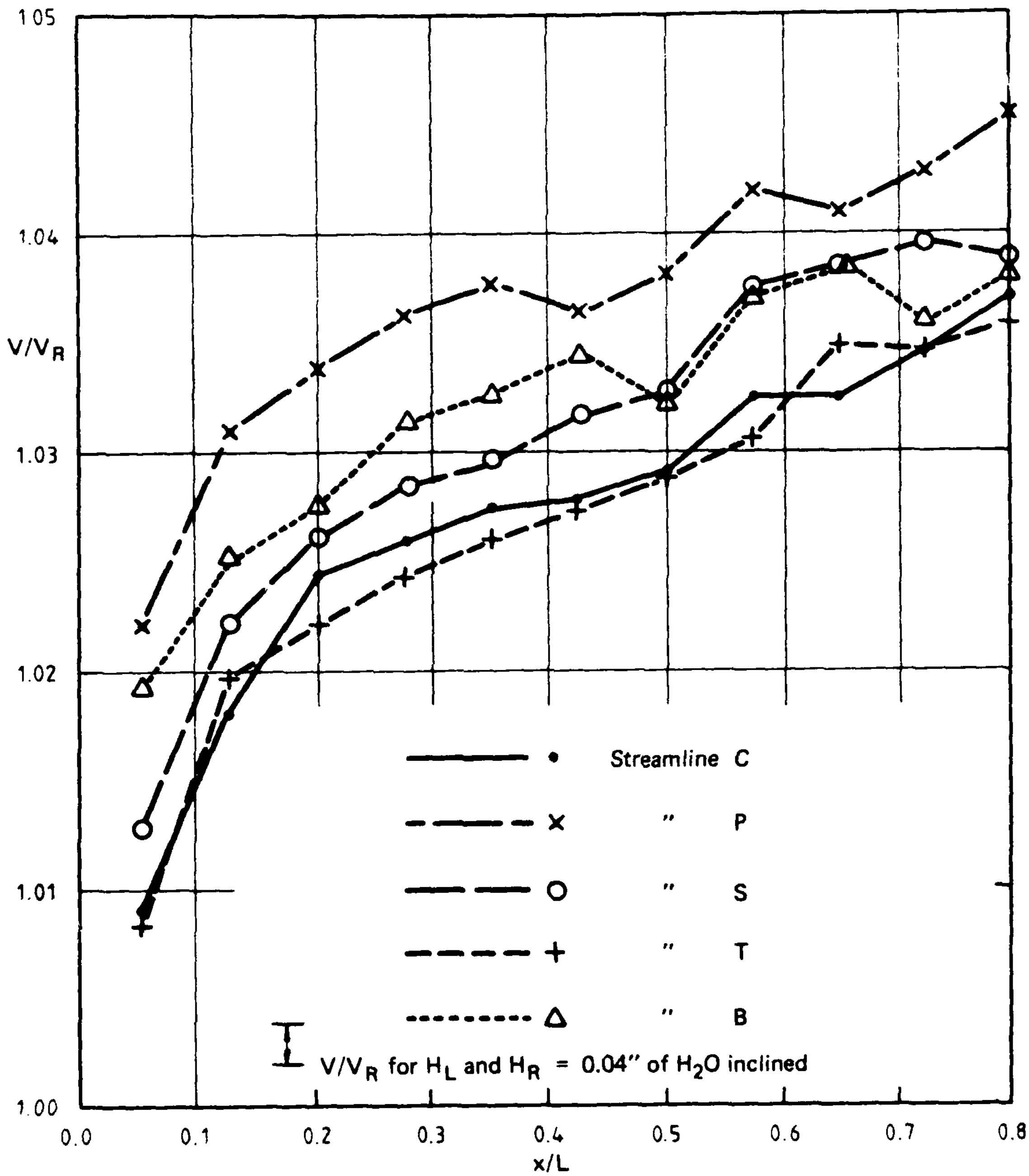

FIG. 4. (CONT.) (d) $R_N/m = 5.0 \times 10^6$

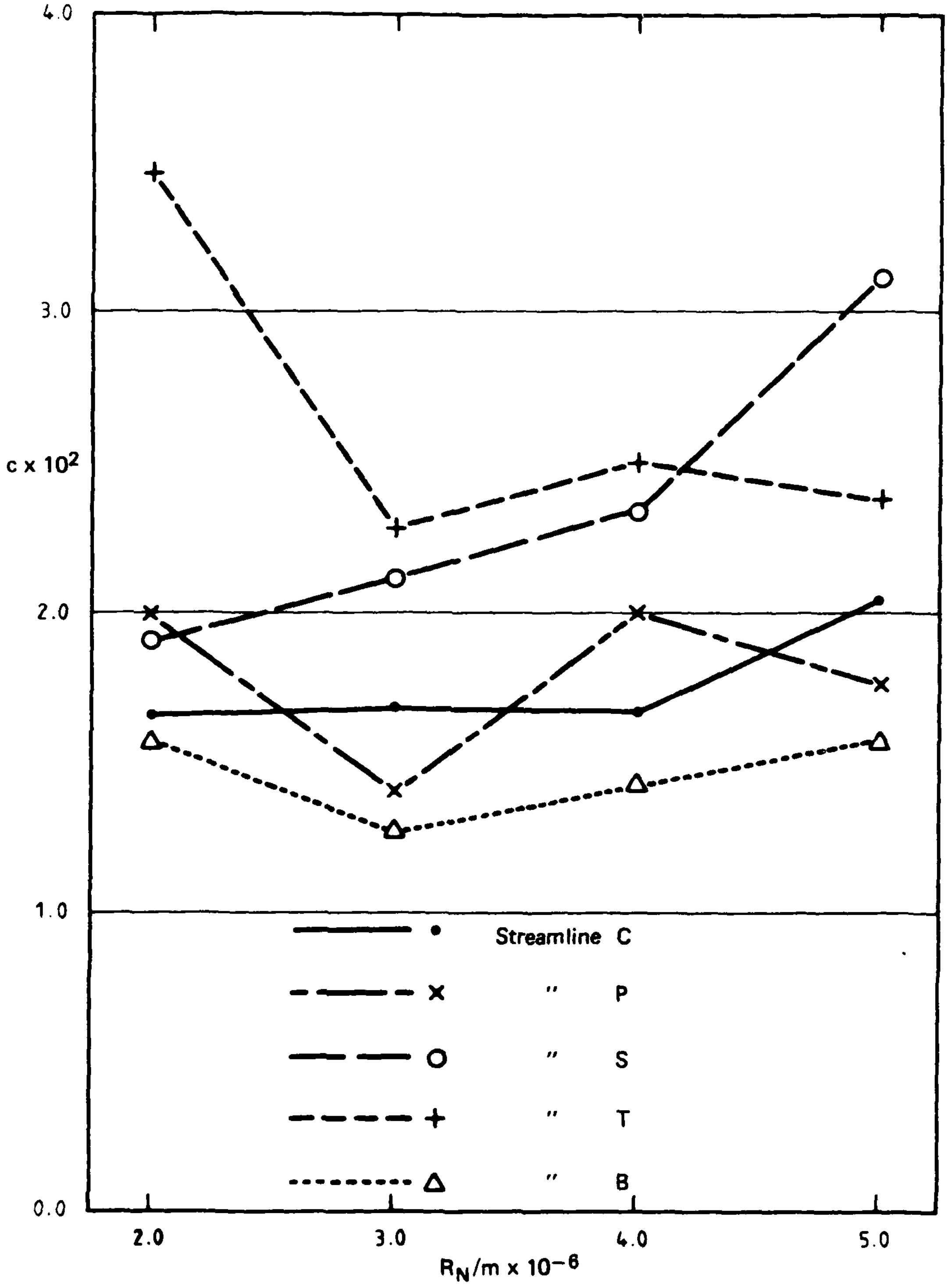

FIG. 5. VELOCITY RATIO GRADIENT AS A FUNCTION OF UNIT REYNOLDS NUMBER

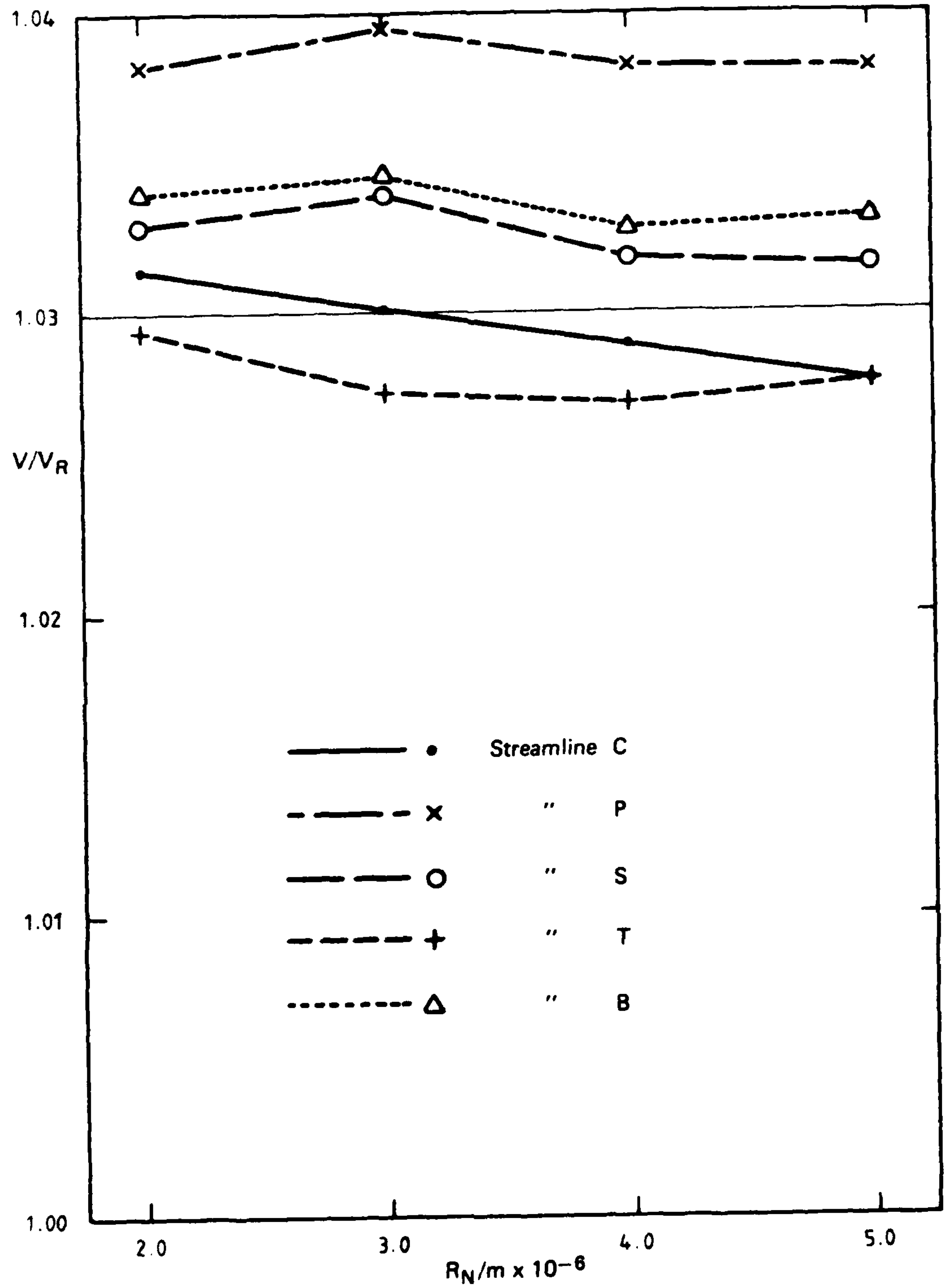

FIG. 6. VELOCITY RATIO AT THE POSITION OF THE MECHANICAL BALANCE AS A FUNCTION OF UNIT REYNOLDS NUMBER

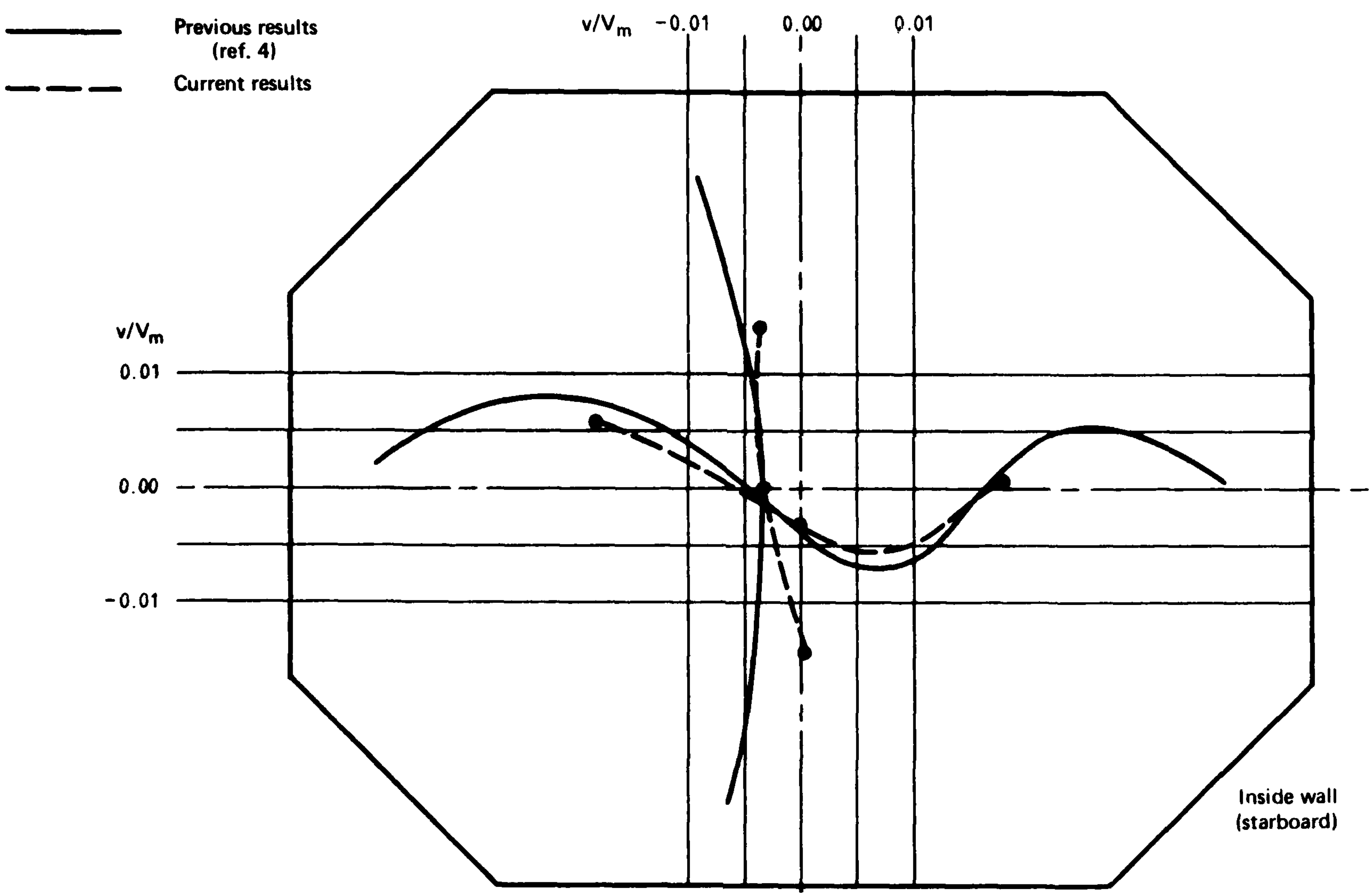

FIG. 7. VELOCITY DISTRIBUTIONS ALONG THE CENTRELINES OF THE WORKING SECTION AT $x/L = 0.52$

(a) $R_N/m = 5.3 \times 10^6$

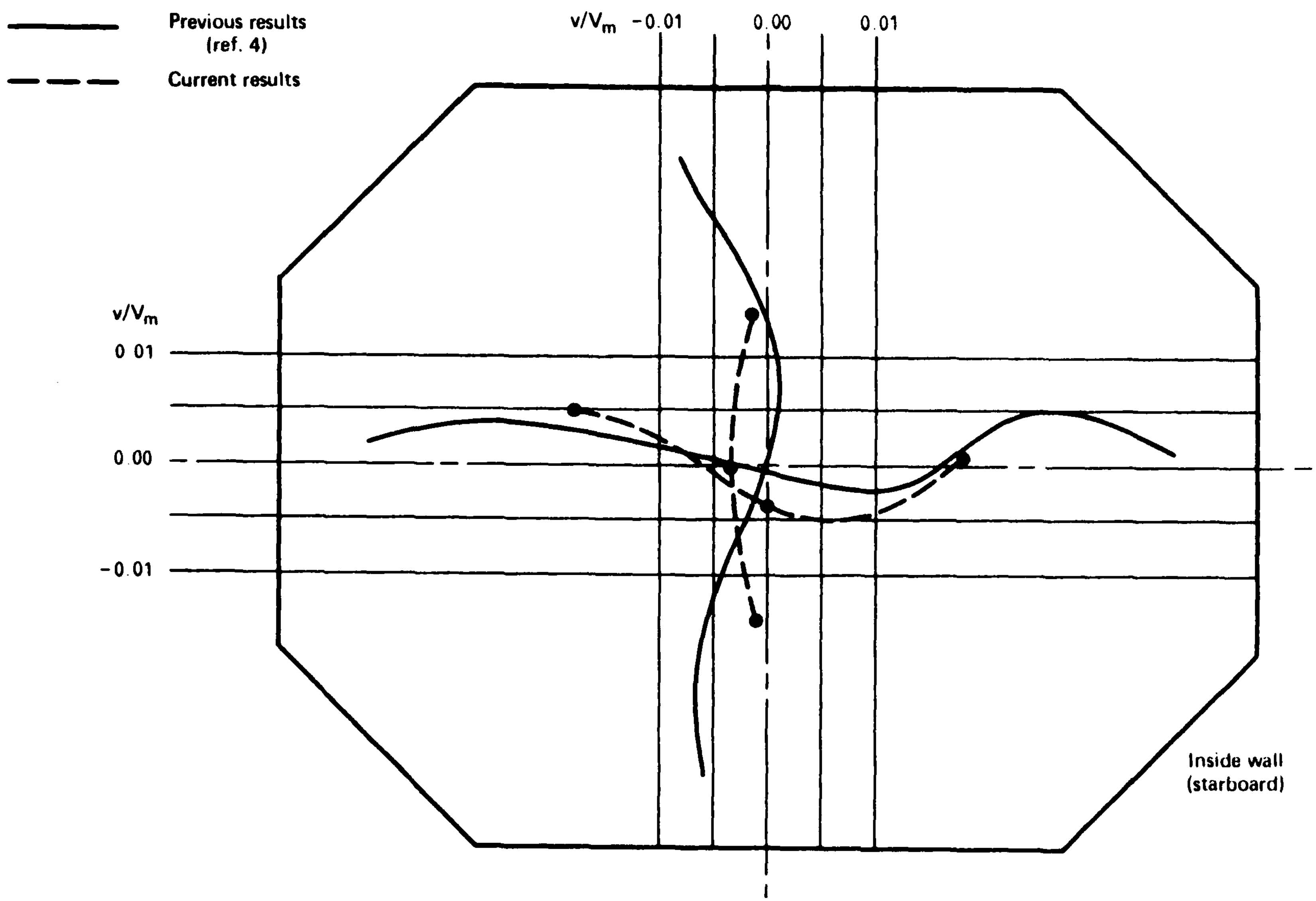

FIG. 7. (CONT.) (b) $R_N/m = 2.1 \times 10^6$

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4. Title
STATIC PRESSURE AND AXIAL VELOCITY DISTRIBUTIONS NEAR THE CENTRE OF THE WORKING SECTION OF THE ARL 2.7 m X 2.1 m WIND TUNNEL

5. Security
a. document: UNCLASSIFIED
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Subsonic wind tunnel
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0101
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16. Abstract

The static pressure and axial velocity distributions of the flow in working section number two of the 2.7 m X 2.1 m low speed wind tunnel have been determined for four unit Reynolds numbers along five streamlines near the centre of the section.

Current results generally agree with previous results although the static pressure gradient is 28% larger than obtained previously, and deviations from the mean velocity are not quite as large.

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16. Abstract *(Contd)*

The results obtained, and given in this report, are satisfactory for their intended purpose of correcting for flow variations in the working section when testing reflex ship models up to 3 m in length.

17. Imprint

Aeronautical Research Laboratories, Melbourne.

18. Document Series and Number	19. Cost Code	20. Type of Report and Period Covered
Aerodynamics Technical Memorandum 346	53 6090	—

21. Computer Programs Used

—

22. Establishment File Ref(s)

—

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