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N.P.L. Aerofoil Catalogue and Bibliography

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Summary.

This report catalogues aerofoils which have been designed (or substantially modified) at the N.P.L., and which have been the subject of theoretical investigations, aircraft design studies or wind-tunnel tests. A full Bibliography is included.

This report catalogues aerofoils which have been designed (or substantially modified) at the N.P.L. and which have been the subject of theoretical investigations, aircraft design studies or wind-tunnel tests. Within these limits it is intended to be complete, except that it excludes a number of wing sections designed expressly to the requirements of aircraft firms. A full Bibliography is appended. Detailed numerical data have been collected together elsewhere*. A Numerical Index to the aerofoils is given on the last page.

The report is a revised version of an earlier paper†, brought up to date by the addition of a number of aerofoils designed subsequently to the issue of that paper and by including R. & M. and other references for those papers in the Bibliography which have since been published in some form. For convenience, however, these papers are still identified in the text by their original A.R.C. serial numbers and their original dates, the published references (where available) being readily obtained from the Bibliography. The references in the text are followed by an indication of the nature of the material they contain, particularly whether the paper is concerned with theoretical design or experimental results. The abbreviations are as follows:

CAT	Compressed Air Tunnel
Froude Tank ..	Ship Division, N.P.L.
HST	High Speed Tunnels‡
Theor.	Theoretical results
4 ft	4 ft Wind Tunnel
7 ft	7 ft Wind Tunnel
9 × 7	9 ft × 7 ft Wind Tunnel
13 × 9	13 ft × 9 ft Wind Tunnel

* R. C. Pankhurst: N.P.L. Aerofoil Sections: Tabulated Details. NPL/Aero/211. July, 1951.

† R. C. Pankhurst: N.P.L. Aerofoil Catalogue and Bibliography. C.P. No. 81 (A.R.C. 14,157). July, 1951.

‡ For a general survey of results from aerofoil tests in high-speed tunnels, reference may be made to R. & M. 2560. December, 1946.

The arrangement of the lists of aerofoils follows broadly the successive stages in the development of the design theory:

(1) *'Geometrical' design.*

(*a*) Approximate equations to shapes already derived by conformal transformation (List 1).

(*b*) Approximate equations fitted to existing shapes with a view to calculating their velocity distributions by Goldstein's method (A.R.C. 5804 and 6156, and *J. Ae. Sci.* 1948) (also List 1).

(*c*) Aerofoils originally defined by algebraic formulae specially suited to the calculation of velocity distribution (List 2).

(*d*) Aerofoils defined by algebraic formulae which have been specially contrived to provide for variations in position of maximum thickness, nose radius, nose droop and centre-line camber (19,054) (Lists 11 and 12). Historically, these came much later than (*a*), (*b*) and (*c*).

(2) *'Aerodynamic' design.*

This group comprises all aerofoils designed to have pre-assigned velocity distributions, specified either

(*a*) algebraically (Goldstein: 6225, 8548, *J. Ae. Sci.* 1948, etc.) (Lists 3 and 4a), or

(*b*) numerically (Thwaites: 8659 and 8942; Curtis: 12,154; Woods: 14,708) (Lists 5 and 10), or

(*c*) analytically as a function of the angular co-ordinate on the circle of transformation (Lighthill: 8597 and 8719; Glauert: 10,933. *See* also Williams: 12,999) (List 6).

This group includes aerofoils intended for use with boundary-layer control (Lists 7 to 9), a few of which have been designed for the production of lift independently of incidence (Thwaites: 10,294).

Notation.

Except where otherwise stated, the symbols used follow standard practice: x denotes chordwise distance, y distance normal to the chord, t maximum thickness, and ρ_L leading-edge radius, all in terms of the chord as unit length. Trailing-edge angle is designated τ. The few other symbols used are defined as they occur.

Acknowledgement.

Mr. H. H. Pearcey has collaborated in the preparation of Tables 11 and 12.

LIST 1

Existing Aerofoils to which Equations have been Fitted

These include approximations to P2040 (a 20 per cent thick Piercy aerofoil with its maximum thickness at 40 per cent chord from the leading edge), RAF 6, Clark Y, NACA 16 and a de Havilland high-speed propeller section.

NPL No.	Aerofoil	Thickness	Design C_L	References (A.R.C. Report numbers)
41	P2040	0·20	Symmetrical	*Aircraft Engineering*, Vol. 11, p. 151. 1939 (Theor.); 4800, 8718, 10,730, 11,084 and R. & M. 2058 (HST)
51	RAF 6 approx.	0·10	—	7780 (Theor.)
52		0·15	—	7780 (Theor.)
53	Clark Y approx.	0·06	—	6028 (Theor.); 9756 and R. & M. 2058 (HST)
54		0·07	—	6028 and 6897 (Theor.); 7308, 9756 and 11,191 (HST)
55		0·10	—	6028 (Theor.)
56		0·12	—	5804, 6028 and 6156 (Theor.)
57		0·15	—	6028 (Theor.); 11,191 (HST)
58		0·25	—	6028 (Theor.)
59, 60	de Havilland approx.	0·07	—	6132 and 6897 (Theor.)
61, 62		0·10		6132 (Theor.)
63	NACA 16 approx.	0·12	0	5804 (Theor.) } *See* 8863 (Theor.) for range of thickness and camber
64		0·07	0·3	6897 (Theor.)
65		0·07	0·5	6897 (Theor.)
66		0·07	0·6	6897 (Theor.)
67	NACA 16 (approx.) propeller sections*	0·04	0·35	7308 and 9756 (HST)
68		0·05	0·30	14,525 (HST)
69		0·06	0·22	9756 and 11,191 (HST)
70		0·06	0·55	10,551 (HST): no results available
71		0·06	0·88	10,551 (HST): no results available
72		0·065	0·30	14,525 (HST)
73		0·07	0·55	9756 and 11,191 (HST)
74		0·10	0·22	9756 and 11,084 (HST)
75		0·10	0·30	11,114, 13,238 and 14,525 (HST)
76		0·10	0·55	9756 and 11,084 (HST)
77		0·10	0·88	9756 and 11,084 (HST)
78		0·15	0·22	11,084 (HST)
79		0·15	0·55	11,084 (HST)
80		0·15	0·88	11,191 (HST)

* These 'NACA 16 propeller sections' comprise an approximation to the NACA 16 fairing, superposed on a logarithmic camber-line. In the notation used in the reports on these sections the third digit signifies the camber, and the fourth the thickness, according to the following arbitrary scheme:

Code	1	2	3	4	5	6
Design C_L	0·22	0·55	0·88	0·35	—	—
Thickness (per cent) ..	7	10	14	4	6	15

For instance, NACA 16/15 is cambered to a design C_L of 0·22 and is 6 per cent thick.

Note.—R. & M. 2058 = A.R.C. 6062 + 6528 + 7216 (HST; some CAT results are also included).

LIST 2

EC, EQ, ECH and EQH Aerofoils

The shapes of these aerofoils were actually defined by algebraic formulae*. In each case the fairing (half-thickness) comprises an elliptic forward portion and a cubic or quartic rear portion which, in the case of ECH and EQH, is replaced by a hyperbolic curve very near the trailing edge. The numbers following the letters indicate the maximum thickness and its chordwise position, followed by the value and position of the maximum camber (if any). For instance, the aerofoil EC 1250/0640 comprises a fairing with an elliptic nose and cubic rear portion, with maximum thickness 12 per cent of the chord occurring at 50 per cent chord from the leading edge; this fairing is superposed on a camber-line with maximum camber 0·6 per cent, occurring at 40 per cent chord.

NPL No.	Aerofoil	References
101	EC 1240	4726, 5272, 5862, 6532, 7026, 7615, 8041, 8682, 11,084 and R. & M. 2058 (HST)
102	EC 1240/0640	4708 and 4713 (HST)†; 5035 and 5255 (CAT); 5862, 8682, 11,084 and R. & M. 2058 (HST)†
103	EC 1240/0658	8682, 11,084 and R. & M. 2058 (HST)
104	EC 1250	4978 (CAT); 5622, 6130, 6146, 6378, 6662, 6999, 7067, 7176, 7278, 7308, 7448, 7800, 8395, 8682, 8866, 10,729, 11,084 and R. & M. 2058 (HST); 13,906 (Flight)
105	EC 1250 with concave control ..	11,933 and 12,284 (HST)
106	EC 1250 with wedge tail ..	10,551 (HST): no results available. Trailing-edge angle 10·8°
107	EC 1250/0640	10,551 (HST): no results available
108	EC 1250/1050	10,551 (HST): no results available
109	EC 1550	4978 (CAT); R. & M. 2058 (HST); 8725 (Derivative measurements)
116	EQ 1550, hollow ground ..	8725 (Derivative measurements)
117	EQ 1550/1050	4978 (CAT)
121	E76CH 0747	7669 (Theor.)
122	E81CH 0748	7669 (Theor.)

* So also were the much later families of aerofoils of Lists 11 and 12.

† More precisely, EC 1240/05$_8$40.

Note.—R. & M. 2058 = A.R.C. 6062 + 6528 + 7216 (HST; some CAT results are also included).

NPL No.	Aerofoil	References
126	EQH 1240	5804 (Theor.)
127	EQH 0950/1050	5547‖ (CAT)
128	EQH 1250	5804 (Theor.)
129	EQH 1250/0640	11,084 and R. & M. 2058 (HST)
130	EQH 1250/1050	5517† (CAT); 11,084 and R. & M. 2058 (HST)
131	EQH 1250/1550‡	6676, 6785 and 6998 (13 × 9)
132	EQH 1250/4050	6156 (Theor.)
133	EQH 1260	5804 (Theor.); 5592 (Froude tank, 13 × 9 and 9 × 7)
134	EQH 1550	8682, 11,084 and R. & M. 2058 (HST)
135	EQH 1550/1058	4978§ (CAT); 11,084 and R. & M. 2058 (HST)
136	EQH 2450	*J. Ae. Sci.* 1948 (Theor.)

‖ There mis-named EQ 0950/1050.

† There mis-named EQ 1250/1050.

‡ More precisely, EQH 12*50/1550 (i.e., $t = 0 \cdot 118$).

§ There mis-named EQ 1550/1058.

Note.—R. & M. 2058 = A.R.C. 6062 + 6528 + 7216 (HST; some CAT results are also included).

LIST 3

'Roof-top' Aerofoils and Simple Camber-lines designed Aerodynamically

These include the first aerofoils designed, by Goldstein's approximate method, to have prescribed velocity distributions.

(*a*) *Symmetrical 'Roof-top' Aerofoils.*

Ref. 6225 (Theor.)

Aerofoil	A	B	C	D	E	F	G	H
NPL No.	141	142	143	144	145	146	147	148

Ref.	J. Williams (Theor.)	8877 (Theor.) 9748 (13 × 9)	7814 (Theor.)	7814 (Theor.)	13,446 (13 × 9)	J. Williams (Theor.)††
Aerofoil	8%	15%	18%	24%	33%‡‡	8%
NPL No.	149	150	151	152	153	154

See also NPL 282 (List 4)

†† October, 1953.

‡‡ Tested with distributed suction over the region of adverse gradient.

(*b*) *Camber-lines* with g_i constant when $0 \leqslant x \leqslant X'$ and decreasing linearly thence to zero at the trailing edge*.

Report 8548 (Theor.) gives the relevant data for $X' = 0 \cdot 25, 0 \cdot 30, 0 \cdot 35, \ldots, 0 \cdot 95, 1$. These camber-lines, regarded as aerofoils of zero thickness, are referred to as follows:

X' . .	0·25	0·3	0·35	0·4	0·45	0·5	0·55	0·6	0·65	0·7	0·75	0·8	0·85	0·9	0·95	1
NPL .	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176

The camber-lines of the following two 'roof-top' aerofoils are of this type:

Aerofoil NPL 177: 'Roof-top' 1442/1547† of Reports 8682, 9585, 11,190 and 13,531 (HST).

Aerofoil NPL 178: R537–1515 of Report 10,620 (Theor.).

(*c*) *Camber-lines* for which g_i is constant (k) when $0 \leqslant x \leqslant X'_1$, then varies linearly to sk at X'_2 and then linearly again to zero at the trailing edge.

Ref. 8277 (Theor.). The following table numbers these camber-lines, regarded as aerofoils of zero thickness.

		s								
X'_1	X'_2	0·4	0·3	0·2	0·1	0	−0·1	−0·2	−0·3	−0·4
0·4	0·8	180	181	182	183	184	185	186	187	188
	0·9	189	190	191	192	193	194	195	196	197
	1·0	198	199	200	201	202	203	204	205	206
0·5	0·8	207	208	209	210	211	212	213	214	215
	0·9	216	217	218	219	220	221	222	223	224
	1·0	225	226	227	228	229	230	231	232	233
0·6	0·8	234	235	236	237	238	239	240	241	242
	0·9	243	244	245	246	247	248	249	250	251
	1·0	252	253	254	255	256	257	258	259	260

The camber-line of the following 'roof-top' aerofoil is of this type:

Aerofoil NPL 261: Goldstein Reflex GR 1540/2037 of Reports 7209 and 11,084 (HST).

* g_i denotes the first approximation to the super-velocity when $C_L = C_{L\,\text{opt}}$, excluding the contribution due to the finite thickness of the aerofoil ($C_{L\,\text{opt}}$ being the lift coefficient at which the velocity over the camber-line alone is finite at the leading edge).

† Designated 'H.S.4' at R.A.E. (Not to be confused with the HSA series of List 5.)

LIST 4

Modified 'Roof-top' Aerofoils

(*a*) *MR series.*

In the 'MR' series, the figures following indicate (*a*) X_q, the designed chordwise position of peak velocity at zero lift, (*b*) the upper limit of the C_L-range of favourable gradients on both surfaces, (*c*) the value of $C_{L\,opt}$ (defining the camber), and (*d*) the aerofoil thickness. For example, MR 640–018 has the following properties: $X_q = 0 \cdot 6$; upper limit of C_L-range $= 0 \cdot 40$; $C_{L,opt} = 0$ (zero camber); 18 per cent thick.

NPL No.	Aerofoil	Reference
269	14·7% Goldstein	8140 (13×9)
270	MR 413–010	8532 (Theor.)
271	MR 424–015	8532 (Theor.)
272	MR 450–020	8532 (Theor.)
273	MR 513–010	8532 (Theor.)
274	MR 523–015	8532 (Theor.)
275	MR 525–015	8532 (Theor.)
276	MR 546–020	8532 (Theor.)
277	MR 613–010	8532 (Theor.)
278	MR 622–015	8532 (Theor.)
279	MR 645–021	8532 (Theor.)
280	14·7% Watson	8941 (Theor.)
(*b*) *Geometrical modifications of basic 'roof-top' aerofoils.*		
281	1541a	13,039 (7 ft No. 2)
282	1541*	13,039 (7 ft No. 2) and 15,292 (9×7)
283	1541b	13,039 (7 ft No. 2)
284	1541c	13,039 (7 ft No. 2)
285	1541d	13,039 (7 ft No. 2)
290	RAE 102†, cusped	17,386
291	Cambered RAE 102† ..	15,456

* This was the basic ('Roof-top') section.

† For details of the RAE 102 aerofoil *see* 13,254.

LIST 5

Aerofoils designed by Approximate Method using Numerical Conjugation

'AN' signifies an aerofoil designed by approximate methods using numerical conjugation; 'NAN' indicates that the aerofoil also employs a new stock camber-line. The numbers following these letters have the same significance as for the 'MR' series. For instance, AN 420–109 has the following properties: $X_q = 0 \cdot 4$; upper limit of C_L-range $= 0 \cdot 20$; $C_{L\,\mathrm{opt}} = 0 \cdot 1$; 9 per cent thick. Similarly, NAN 532–1415 has $X_q = 0 \cdot 5$; upper limit of C_L-range $= 0 \cdot 32$; $C_{L\,\mathrm{opt}} = 0 \cdot 14$; 15 per cent thick. 'HSA' signifies 'high-speed aerofoil'.

NPL No.	Aerofoil	Reference
301	AN 414–011	8659 (Theor.)
302	AN 528–015	8659 (Theor.)
303	AN 420–109	8942 (Theor.)
304	HSA I	9076 (Theor.)
305	HSA II	9076 (Theor.)
306	HSA III	9076 (Theor.)
308	HSA V*	9809 (Theor.); 11,496 (4 ft No. 2); 11,560; 11,758
309	HSA VI*	9809 (Theor.)
310	HSA VII	B. Thwaites (Theor.) (1946; unpublished)
311	NAN 530–117	10,620 (Theor.)
312	NAN 524–0412	10,620 (Theor.)
313	NAN 532–1415	10,620 (Theor.)
314	NAN 530–1413	10,620 (Theor.)
315	NAN 540–1513	10,620 (Theor.)
316	NAN 522–112	10,620 (Theor.)
317	NAN 525–110	10,620 (Theor.)
318	NAN 521–0411	10,620 (Theor.)
319	NAN 545–1515	10,620 (Theor.)
320	NPL 320	12,154 (Theor.)
321	NPL 321	15,184 (13 × 9)
322	NPL 322	Sleeve for '*Vampire*' wing (Handley Page flight tests with strip suction†)
323	NPL 323	J. Williams (Theor.) (Unpublished)
324	NPL 324	J. Williams (Theor.) (Unpublished)

* Designed for use with distributed suction over the nose.

† cf. '*Boundary Layer and Flow Control*' (Ed. G. V. Lachmann), pp. 112 to 113. Pergamon Press, 1961.

LIST 6

Low-drag Aerofoils designed by Lighthill's Exact Method

NPL No.	Aerofoil	Reference
331	19·6% Symmetrical	8597, Appendix I (Theor.)
332	13% Symmetrical	8597, Appendix VI (Theor.). See also 8658
333	19·2% Symmetrical	8597, Appendix VII (Theor.)
334	14·1% Symmetrical	8597, Appendix X (Theor.)
335	13% Symmetrical	13,003 (13 × 9)
336	15% Symmetrical	A. R. Curtis (Theor.) (Unpublished); 14,337 (Theor.)
337	15% Symmetrical	A. R. Curtis (Theor.) (Unpublished); 14,337 (Theor.)

LIST 7

Low-drag Slot-suction Aerofoils

(*a*) *Designed by Goldstein's approximate method.*

NPL No.	Section	References
351	16%, cambered	8877 (Theor.)
352	A preliminary design	6784 (Shape only)
353	16% symmetrical Griffith ..	6784, 7178 and 7463 (4 ft tunnel); 7561, 7464, 8054, 8055 and 9320 (13 × 9)
354	21% symmetrical Griffith ..	A. R. Curtis (Theor.) (Unpublished modification of NPL 355)
355	22% symmetrical Griffith ..	10,096 (HST)
356	30% symmetrical Griffith ..	8864, 9810, 10,097, 10,630 and 11,599 (13 × 9); 11,610 (Theor.)
357	30% symmetrical, multi-slot ..	11,796, Aerofoil XIII (Theor.)
358	30%, cambered	J. Williams (Theor.) (Unpublished)
359	33% symmetrical, multi-slot ..	11,796, Aerofoil IX (Theor.)

(*b*) *Designed by Lighthill's exact method.*

NPL No.	Section	References
361	70% symmetrical .. .. .. (Modified Joukowski)	8597, Appendix II (Theor.)
362	34% symmetrical	8597, Appendix IV (Theor.)
363	40% symmetrical	8719, Fig. 1 (Theor.)
364	48% symmetrical	8597, Appendix V (Theor.)
365	31% symmetrical (GLAT III)* ..	10,933 (Theor.)
366	GLAT III with spread velocity drop	12,999 (Theor.)
367	Stagnation-streamline modification of GLAT III	12,999 (Theor.)

* 'GLAS' indicates an Aerofoil designed by Glauert using Lighthill's method, usually for use with suction at a Single slot; a 'GLAT' aerofoil employs Two slots. GLAS III is an exception to this rule, as it has a slot on both upper and lower surfaces.

NPL No.	Section	References
371	Bulrush I	A. R. Curtis (Theor.) (Unpublished)
372	Bulrush II	
373	Bulrush III	
374	Bulrush IV	
375	Bulrush V	
376	Bulrush VI	
377	25% 'Lobster-pot'	M. B. Glauert (Theor.); 15,790 (Expt.)
379	30%, cambered	8597, Appendix XI (Theor.)
380	41%, cambered	8597, Appendix XIII (Theor.)
381	GLAS I*	9180 (Theor.)
382	GLAS II	9180, 10,933 and 11,610 (Theor.); 10,854 and 11,797 (13×9); 11,269 (CAT)
383	GLAS III	9180 (Theor.)
384	GLAS IV	9180 (Theor.)
385	38%, cambered	12,999 (Theor.)
386	Sink-slot modification of GLAS II	12,999 (Theor.); Australian A.R.L. Notes 100 and 101 (Expt.)
387	Sink-slot modification of NPL 385	12,999 (Theor.)

LIST 8

Nose-slot Suction Aerofoils

These are thin aerofoils designed for high maximum lift.

NPL No.	Section	References
401	11% symmetrical	8597, Appendix VIII (Theor.)
402	5·4%, bi-convex	8658 (Theor.)
403	8·6%, sharp-nosed	8658 (Theor.); 10,506 (4 ft No. 2); 11,560
404	8·6%, round-nosed	10,507 (4 ft. No. 2); 11,560
405	13%, cambered	8658 (Theor.)
406	14·2%, cambered	8658 (Theor.)
	8% symmetrical sections:	
407	A1	12,144 (Theor.)
408	A2	
409	A3	
410	A4	
411	A5	
412	A6	
413	B1	
414	C1	
415	D1	
416	D2	
417	E1	

* 'GLAS' indicates an Aerofoil designed by Glauert using Lighthill's method, usually for use with suction at a Single slot; a 'GLAT' aerofoil employs Two slots. GLAS III is an exception to this rule, as it has a slot on both upper and lower surfaces.

NPL No.	Section	References
	8% sections, cambered:	
418	A2	12,144 (Theor.)
419	A5	
420	D2	
421	E1	
431	D2/1	13,090 (Theor.)
432	D2/2	
433	D2/3	
434	D2/4	13,090 (Theor.); 14,713 (4 ft No. 2)

LIST 9

Aerofoils designed for obtaining Lift Independently of Incidence

Ref.: 10,294 (Theor.)

NPL No.	Section
451	34·23% (TFA III)*
452	20% TFA
453	14·65% (TFA V)
454	CVA I†
455	CVA II

LIST 10

Aerofoils designed to have Prescribed Velocity Distributions in Subsonic Compressible Flow (Woods)

Ref.: 14,708 (Theor.)

NPL No.	Section
461	Aerofoil I of 14,708
462	Aerofoil II of 14,708
463	Aerofoil III of 14,708
464	Aerofoil IV of 14,708
465	Aerofoil V of 14,708
467	Wedge-tail modification of NPL 462

* 'TFA' denotes 'Thwaites Flap Aerofoil'.

† 'CVA' denotes 'Constant-velocity Aerofoil'.

LIST 11

Geometric Families of Aerofoils with Varying Position of Maximum Thickness, Nose Radius, Nose Droop and Centre-line Camber (Tanner)

(*a*) *Tunnel floor bumps*: section shapes used, as half-aerofoils on the floor of a wind tunnel, for research on boundary-layer control at high subsonic speeds.

Ref.: 19,865 (HST)

$$y = (1-x)\{1 - (1-x)^n\}\tan\frac{\tau}{2}$$

where x is measured from the leading edge, and τ is the trailing-edge angle of the equivalent aerofoil (bump plus its image).

NPL No.	n	$\tan\frac{\tau}{2}$	t
469	3	0·127	0·12
470	3	0·169	0·16

(t denotes the thickness for the equivalent aerofoil).

Note.—The aerofoil used in 17,564 (HST) was the same as NPL 469 from the leading edge up to $x = 2/3$.

(*b*) 10% *thick basic shapes*, defined by

$$y = \pm\, \alpha x\,(1-x^n).$$

Ref.: 19,054 (Theor.)

NPL No.	471	472	473	474	475	476	477	478	479
n . .	$-\frac{3}{4}$	$-\frac{1}{2}$	$-\frac{1}{4}$	0*	$\frac{1}{2}$	2	3	6	20

Note.—α is the surface slope at $x = 0$.

(*c*) *Rounded-nose aerofoils, including section shapes used for* 50° *sweptback wing.*

Ref.: 19,546 (HST) and 21,987 (HST)

$$y = \pm\left(\tan\frac{\tau}{2}\right)(1-x)\,[1-(1-x)^3]\tanh\sqrt{\left\{2\left(\frac{x^2}{a^2}-1\right)\right\}}$$

where x and a are measured from the leading edge of the basic sharp-nosed section (NPL 481), and the unit of length is the chord of this same basic section. The chord of each of the derived aerofoils is $(1-a)$ times that of the basic section.

* $n \to 0$, $\alpha \to \infty$.

NPL No.	481	482	483	484	485	486
Other names*	T1 D	T2 E	T3	T4	T5 F	T6 G
a	0	0·0080	0·0146	0·0274	0·0543	0·1400
$t \times 10^2$	8·00	8·07	8·12	8·23	8·46	9·30
$x_t \times 10^2$	37·0	36·5	36·0	35·1	33·3	30·2
$\rho_L \times 10^2$	0	0·100	0·181	0·325	0·590	1·166
τ (deg.)	9·670	9·670	9·670	9·670	9·670	9·670

Note.—t, x_t and ρ_L have been expressed in terms of the actual aerofoil chord (c), not the chord of the basic sharp-nosed section.

NPL 481 is the 8% thick version of NPL 477, but with $x = 1$ and $x = 0$ treated as leading edge and trailing edge respectively. If the leading edge is used as origin in the usual way, the equation to the section becomes

$$y = \pm (1-x)\{1 - (1-x)^n\} \tan \frac{\tau}{2}.$$

NPL 481–486 form a series with increasing leading-edge radius.

NPL No.	481	482	485	486	487	488	489
Other names*	T1 D	T2 E	T5 F	T6 G	C	B	A
$t \times 10^2$	8·00	8·07	8·46	9·30	7·55	6·90	6·78
$(\rho_L/c) \times 10^2$	0	0·10	0·59	1·17			
$(\rho_L/c_D) \times 10^2$	0	0·10	0·56	1·00	0·38	0·38	0·20
$-m/c_D$	0	—	—	—	0·06	0·16	0·18
$-n/c_D$	0	—	—	—	0·024	0·061	0·067

Note.—NPL 481, 487, 488 and 489 form a series with increasing extent of nose droop. NPL 481–486 are without droop. c_D denotes chord of basic sharp-nosed section (NPL 481); $(-m, -n)$ is the position of the leading edge when drooped; and ρ_L here denotes nose radius before being made non-dimensional.

(*d*) *Approximately* 4% *thick round-nosed section with small trailing-edge angle.*

Ref.: 19,451

NPL 490 (*see* List 12). This is the basic shape from which were derived NPL 491 and 492, and to which NPL 500–504 also are related (List 12). The equation to NPL 490, in terms of actual co-ordinates (X, Y) (*not* referred to the chord (C) as unit length) was given in 19,451† in the form

$$Y = \pm (C-X)[1 - \{(C+s)^{-1}(C-X)\}^n] \tanh \sqrt{\left[2\left\{\left(\frac{X+s}{s}\right)^2 - 1\right\}\right]} \tan \frac{\tau}{2}.$$

* T denotes Tanner aerofoil; A to G follow the nomenclature of 21,987.

† Misprints in the equation as given in that paper have been corrected above.

LIST 12

Aerofoils with Small Trailing-edge Angles, Thick Trailing Edges etc., to alleviate Wave Drag and Shock-induced Separation

NPL No.	Section	T.E. thickness	Reference
490*	3·83%; symmetrical	Zero	19,451, Equation (1) (Theor.)
491	4%; symmetrical	0·0022c	19,451 (HST)
492	5·6%; symmetrical	0·0250c	†(HST)
495	2·67%; symmetrical	Zero	Scaled-down version of NPL 490. †(Theor.)
497	3·83%; symmetrical	0·0175c	Scaled-down version of NPL 492. †(Theor.)
500	2·7%; symmetrical	Zero	Effectively the basis of NPL 502–504
502	4%; symmetrical	0·0250c	†(Theor.)
503	3½% (approx.) with drooped leading-edge extension		Droop (and T.E. thickness) to be intermediate between that of NPL 502 (zero) and that of NPL 504 (below)
504	3·2%, with drooped leading-edge extension	0·0198c	†(HST)

* Defined in List 11(d).

† Holder, Pearcey and Nash: R. Ae. Soc. paper, February, 1962.

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Numerical Index to NPL Aerofoils

NPL No.	List
41; 51–80	1
101–109; 116, 117; 121–122; 126–136 ..	2
141–154	3(a)
161–178	3(b)
180–261	3(c)
269–285; 290, 291	4
301–306; 308–324	5
331–337	6
351–359	7(a)
361–367; 371–377; 379–387	7(b)
401–421; 431–434	8
451–455	9
461–465; 467	10
469, 470	11(a)
471–479	11(b)
481–489	11(c)
490	11(d)
490–492; 495, 497; 500, 502–504	12

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