Wind Tunnel Tests of the characteristics of Wing Flaps and their Wakes

By

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COMMUNICATED BY THE DIRECTOR OF SCIENTIFIC RESEARCH, AIR MINISTRY

Reports and Memoranda No. 1698

31*st August*, 1935*

SUMMARY. Introductory (*Purpose of Investigation*).—To make a comparison of different types of flap on an aerofoil, preliminary to tests on a low wing monoplane.

Range of Investigation.—Plain, slotted and split flaps were tested. Lift, drag and pitching moments have been measured, and the position and intensity of the wake in the region of the tail plane have been observed by measuring total head and observing the behaviour of threads. The tests were made on an 8 × 48 in. rectangular 15 per cent. thick aerofoil of R.A.F. 44 section at a Reynolds Number of $0 \cdot 42 \times 10^6$.

Conclusions.—(1) If a flap of 10 per cent. of the wing chord is used there is little to choose between the plain and split flaps as regards lift and profile drag. But, as the flap size increases the Zap flap gives the higher lift coefficient and the Schrenk and Zap flaps have larger profile drags than the other types.

(2) The Handley Page slotted flap has a low drag which will be useful for take off, and two methods of increasing the drag for landing were tested, (*a*) pulling the flap down beyond the optimum angle for lift, and (*b*) splitting the rear end of the flap, which increases the maximum lift, but involves a second control.

(3) The pitching moment of a Zap flap is larger than that of a corresponding Schrenk type.

(4) The disturbed region near the tail is considerably wider than the wake in which there is loss of total head. The disturbed region with flaps down extends to about the same height as with flaps neutral, since the wake, though wider, is lowered.

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* R.A.E. Report, June 1935.

(5) Rapid variations in downwash were found in traversing the wake behind the large split flaps.

Introductory.—A considerable mass of information is available mainly from America and Germany as to the lift and drag of split flaps, both from model tests on aerofoils with flaps, and from a growing volume of flying experience. It was, however, felt that this information could usefully be supplemented by some systematic tests on flaps of differing type fitted to a typical low wing monoplane. It is proposed in these experiments to measure the effect on trim and tail efficiency of height of tail plane, type of flap and central cutaway ; and it was decided as a preliminary stage to study the effect of full span flaps of various types on a 15 per cent. thick rectangular aerofoil of constant section.

The purpose of this preliminary investigation is to find whether flaps of different types giving the same lift and drag will also produce the same pitching moment, and wakes of equal intensity and position. It seemed possible, for instance, that two flaps with equal drag might differ appreciably in the height of the wake. Such points may be of importance if tail troubles are found when flaps are used.

The preliminary tests consist of measurements of lift, drag and pitching moments on a R.A.F. 44 aerofoil (see Table 1), 15 per cent. thick, size 8 × 48 in. at a Reynolds number of $0 \cdot 4 \times 10^6$ and of a determination of the position and intensity of the wake at a distance of 2·56 chords behind the leading edge of the aerofoil, by measurements of total head. Since the unsteady boundary of the wake causes fluctuations in the band of air on each side of it, a tail plane may be buffetted when in a region wider than the actual wake.[10] Observations were made of the behaviour of threads, to supplement the wake measurements by indicating the width of this unsteady boundary region. The mean direction of the threads was recorded to give a rough indication of the variation of downwash across the wake.

Types of flaps investigated. (Fig. 1).—The types of flap were as follows :—

(*a*) Plain flap (10 per cent. and 20 per cent. chord).

(*b*) 20 per cent. plain flap with leading edge wing slot.

(*c*) Handley Page type slotted flap. 20 per cent. chord (see Table 1).

(*d*) As (*c*) with $7\frac{1}{2}$ per cent. chord split flap attached to the lower surface of the slotted flap as patented by Joseph Ksoll[1].

(*e*) Split flap—Schrenk type 10 per cent. and 20 per cent. chord flaps.

(*f*) Split flap—Zap type 10 per cent., 20 per cent. and 30 per cent. chord flaps.

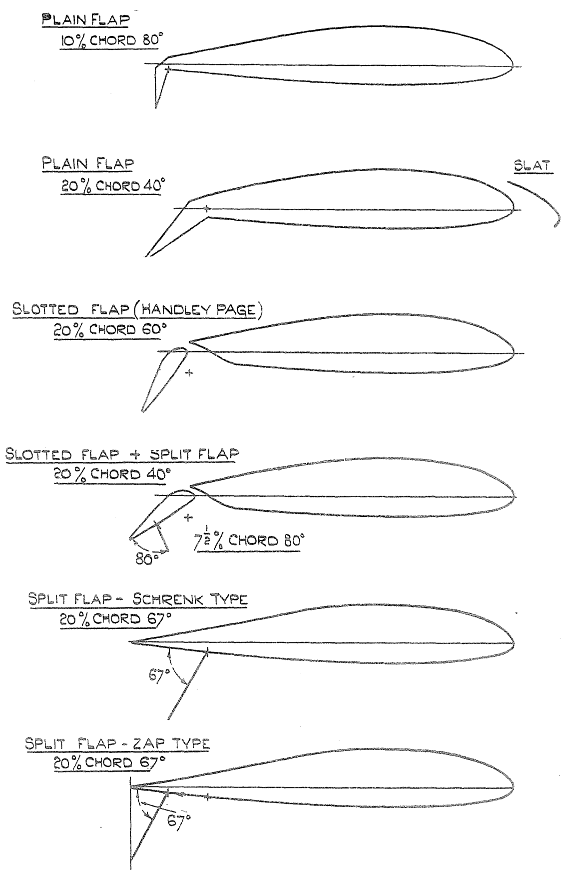


FIG. 1.—Types of Flaps Tested.
Wing Flap Wakes and Characteristics.

Comparative tests were also made on the basic section without a flap, to represent the flaps in the closed or neutral position. In the case of the slotted flap in the neutral position, the effect of the slot was not measured. This has been measured at a few incidences[2], and may be appreciable at top speed unless the discontinuity of surface can be eliminated when the flap is neutral.

For flaps other than the slotted flap, there was no gap between the flap and the remainder of the wing when the flap was down.

Particulars of tests.—Lift, drag and pitching moments have been measured over an incidence range up to the stall.

The wake measurements were in general taken at incidences giving :—(1) 0·695 C_L max., (2) 0·91 C_L max., (corresponding to gliding speeds of 20 per cent. and 5 per cent. above the minimum respectively), (3) C_L max. and (4) beyond the stall.

The wind speed was in general 100 ft. per sec. corresponding to a Reynolds number of $0 \cdot 42 \times 10^6$. Incidences refer to the chord, i.e., the line joining the centres of curvature of the leading and trailing edges. The various coefficients and the quantities relating to the wake are defined in Table 2. The tests were made in the No. 2 7-ft. closed wind tunnel at the R.A.E. during the latter part of 1934. The usual corrections for tunnel constraint have been applied.

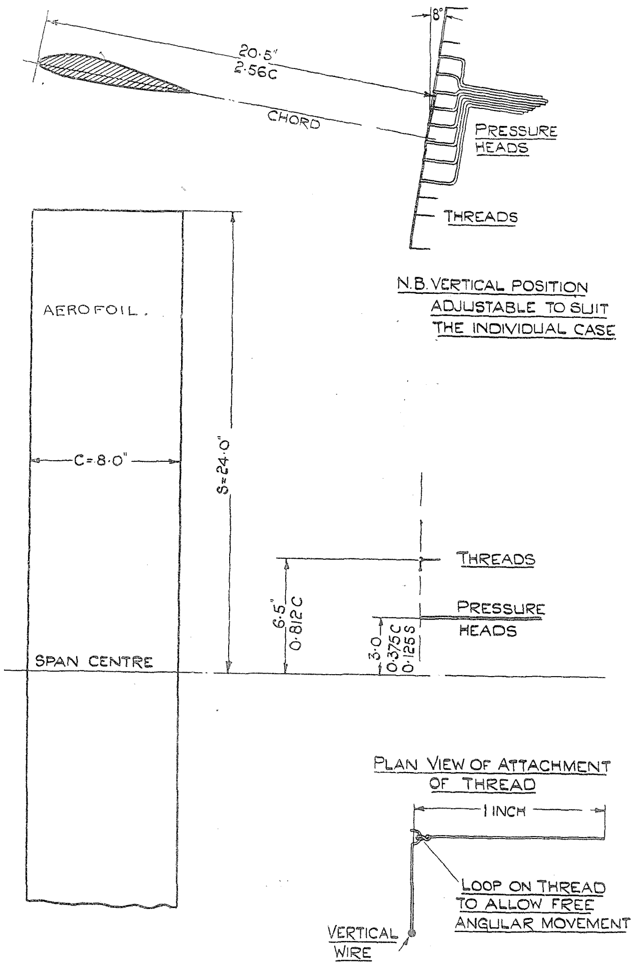


FIG. 2.—Position at which Wakes were measured.

The total head in the wake was measured on a bank of pitot tubes (see Fig. 2) connected to a multi-tube sloping manometer, and was compared with that in the air stream with the aerofoil removed. The percentage loss in total head has been plotted in Figs. 10 to 13. The pitot tubes were set at 8° to the horizontal to conform to the mean angle of downwash. In one or two cases where the flow was eddying from all directions the readings show a loss in total head greater than 100 per cent. Here the method of measurement does not hold good, since the pitot is not along the mean wind direction.[4]

The disturbed nature of the flow was observed by means of fine silk threads, arranged as shown in Fig. 2. The threads were 1 in. in length and were made from one third of a strand of No. 18 while silk thread.

In a smooth air stream the threads lie steadily along the wind, whereas in a disturbed flow they vibrate rapidly about their point of attachment, so that the thread appears to an observer as a semi-opaque sector of defined angular limits. This included angle was measured to give a quantitative idea of the degree of disturbance.

The downwash angle is the mean angle of the thread and has been corrected for tunnel constraint.

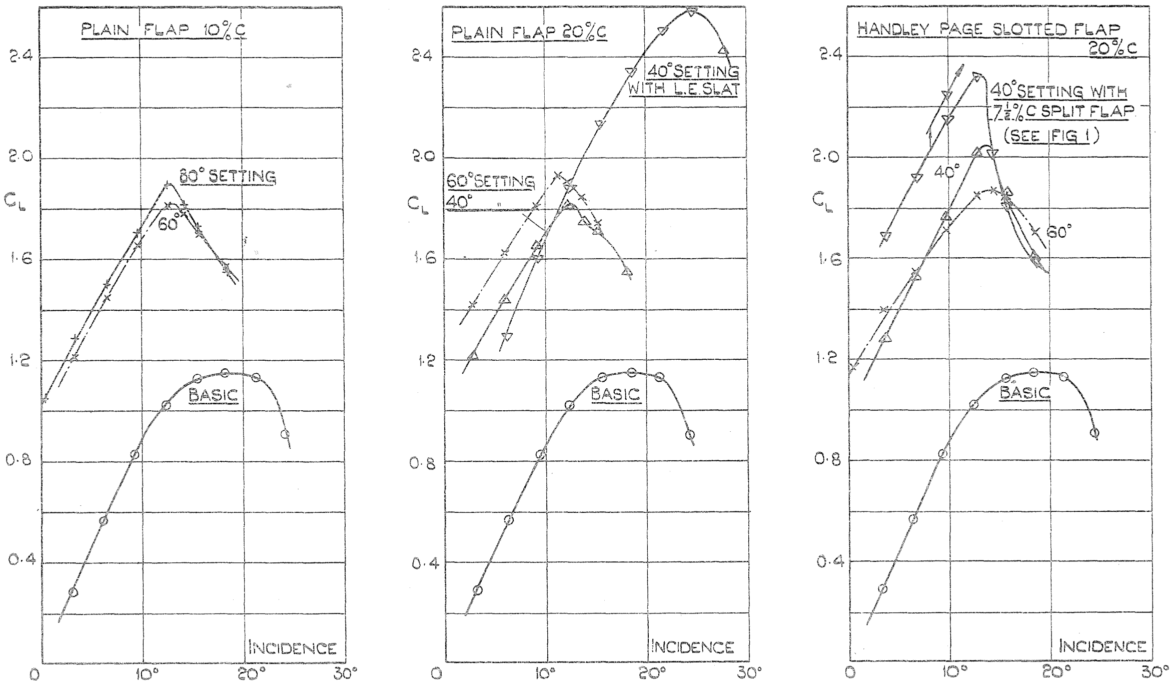


FIG. 3.—Wing Flap Wakes and Characteristics.
Lift Coefficients (C_L).
Plain and Handley Page Slotted Flaps.

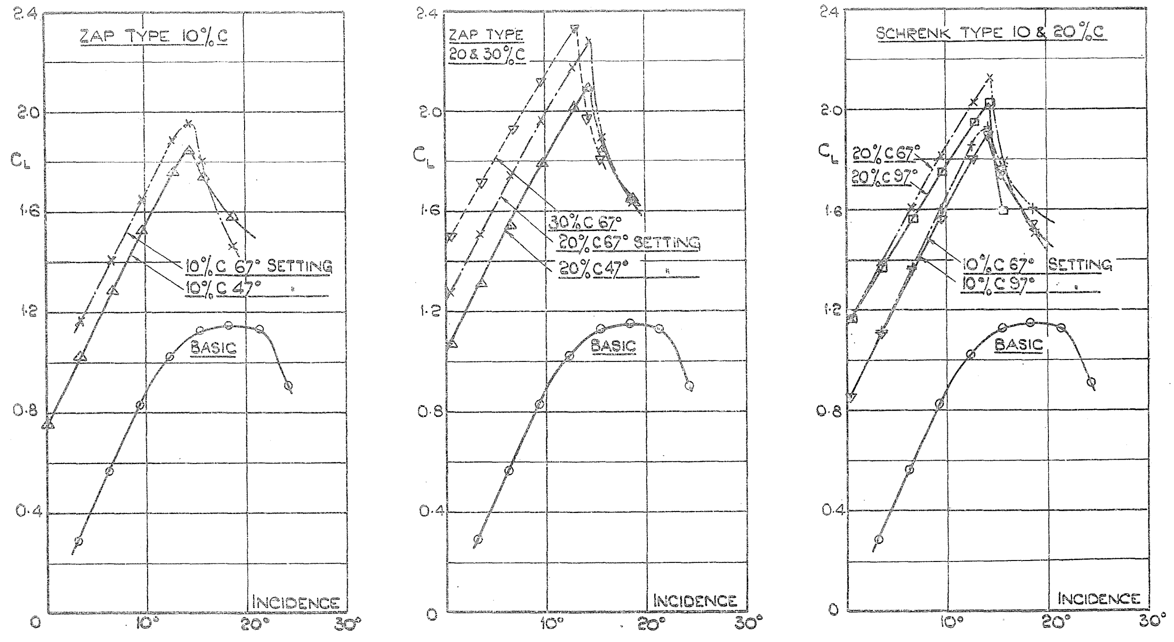


FIG. 4.—Wing Flap Wakes and Characteristics.
Lift Coefficients (C_L).
Split Flaps.

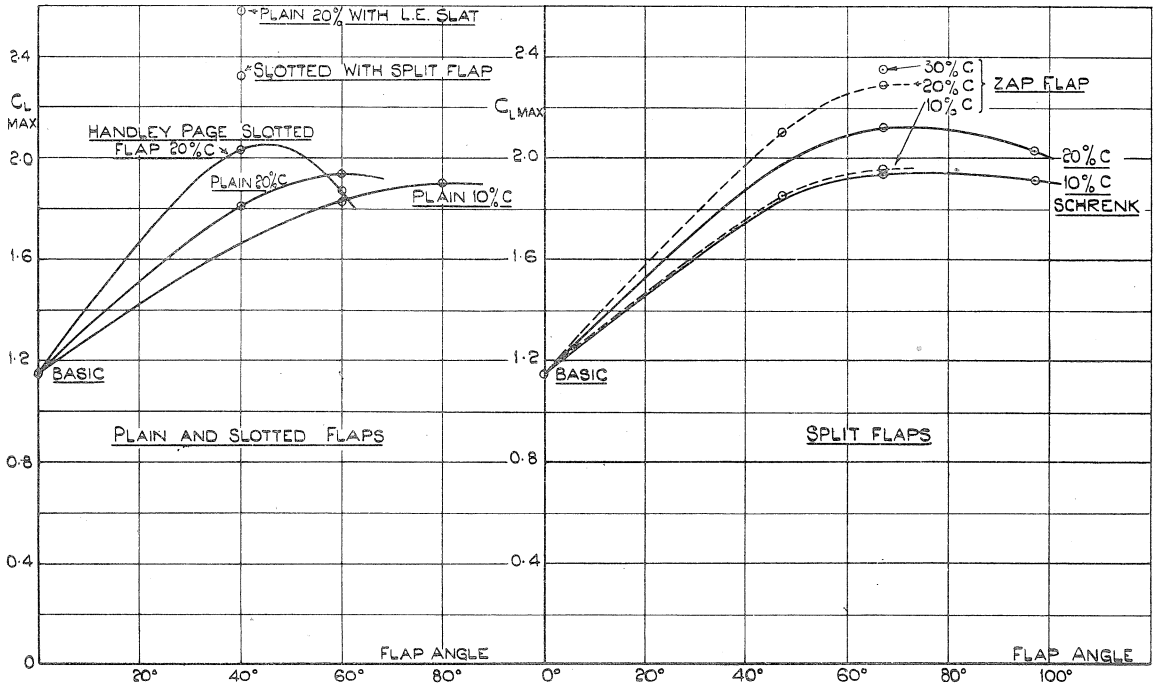


FIG. 5.—Wing Flap Wakes and Characteristics.
Maximum Lift Coefficients (C_L Max.)—Flap Setting.

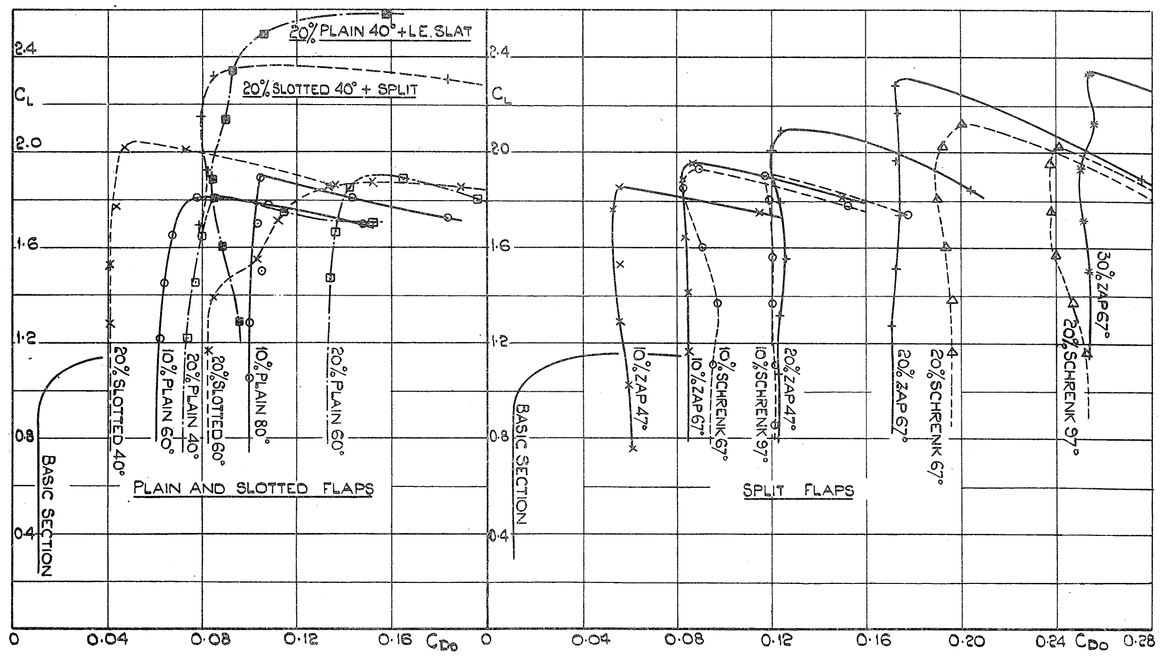


FIG. 6.—Lift Coefficient (C_L)—Profile Drag Coefficient (C_{D_0}).

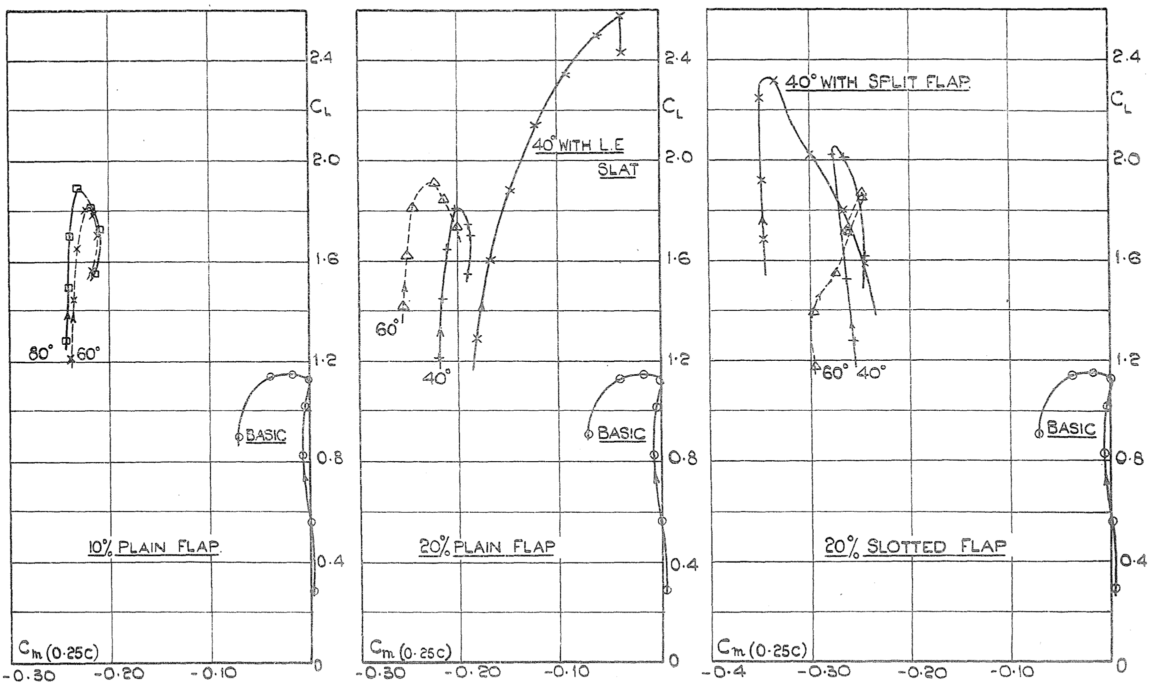


Fig. 7a.—Wing Flap Wakes and Characteristics.
Lift Coefficient—Pitching Moment Coefficient.
→ Indicates Increasing Incidence.

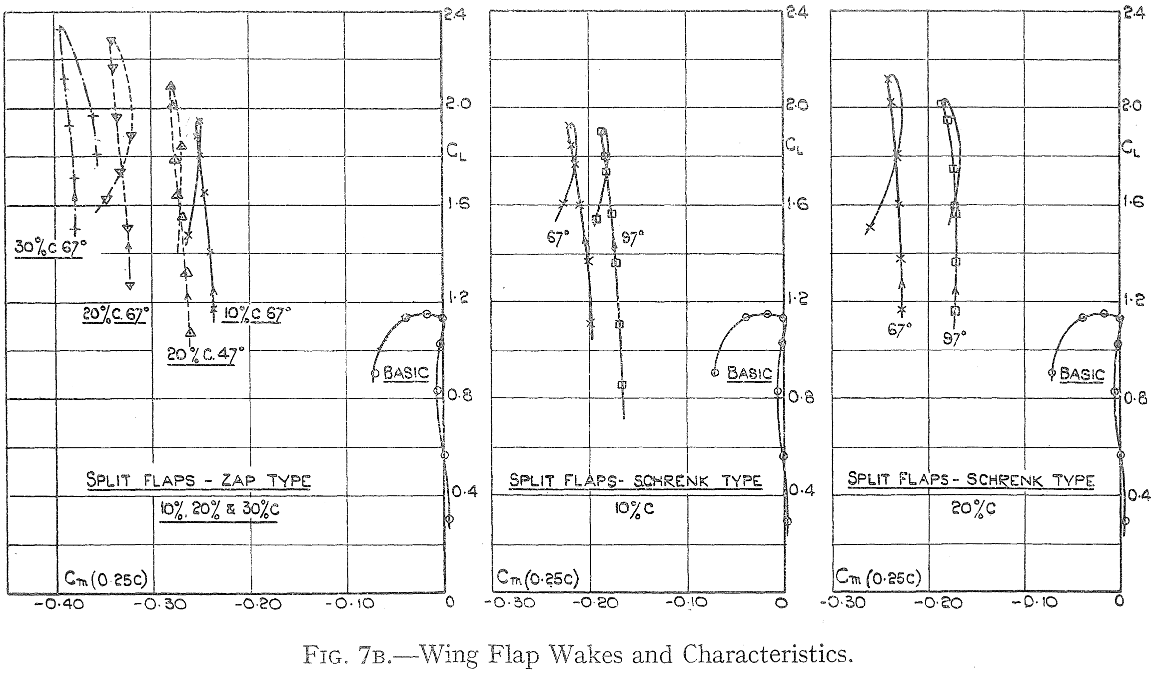


Fig. 7b.—Wing Flap Wakes and Characteristics.
Lift Coefficient—Pitching Moment Coefficient.
→ Indicates Increasing Incidence.

Results. Lift, drag and pitching moments. Tables 3–9. *Figs.* 3–8.—From Figs. 6, 7A and 7B it may be seen that C_{D_0} (the profile drag coefficient) and C_{m_0} (the pitching moment coefficient about the quarter chord point) are reasonably constant for the flapped aerofoils until the stall, so that the simplest manner of comparing the various flaps is to specify C_L max. and the mean values below the stall of C_{D_0} and C_{m_0}.

The results are :—

Type.	Flap size.	Flap angle.	$C_{L\ max}$	C_{D_0}	C_{m_0}
R.A.F. 44	No flap	0	1·14	0·010	0
Plain flap	10 per cent.	60°	1·82	0·064	—0·236
Plain flap	10 ,,	80°	1·90	0·100	—0·240
Plain flap	20 ,,	40°	1·80	0·076	—0·214
Plain flap	20 ,,	60°	1·94	0·136	—0·252
Plain flap and slat	20 ,,	40°	2·58	0·090	Varies
Slotted flap	20 ,,	40°	2·04	0·042	—0·258
Slotted flap	20 ,,	60°	1·88	0·100	—0·296
Slotted and split flap. . . .	20 ,,	40°	2·32	0·082	—0·350
Schrenk flap	10 ,,	67°	1·94	0·092	—0·200
Schrenk flap	10 ,,	97°	1·90	0·120	—0·170
Schrenk flap	20 ,,	67°	2·12	0·194	—0·228
Schrenk flap	20 ,,	97°	2·02	0·242	—0·172
Zap flap	10 ,,	47°	1·84	0·058	—
Zap flap	10 ,,	67°	1·96	0·084	—0·246
Zap flap	20 ,,	47°	2·10	0·124	—0·270
Zap flap	20 ,,	67°	2·28	0·172	—0·330
Zap flap	30 ,,	67°	2·34	0·254	—0·380

In Figs. 3 and 4 it will be seen that the incidence of maximum lift is about the same for all flaps, but the leading edge slat delays the stall by about 13°. In Fig. 5, C_L max. is plotted against flap angle, and if the best flap setting is taken in each case, we get :—

Flap size.	Plain (80°)	Slotted (40°)	Schrenk (67°)	Zap (67°)
10 per cent.	1·90	—	1·94	1·96
20 ,,	1·94	2·04	2·12	2·28
30 ,,	—	—	—	2·34

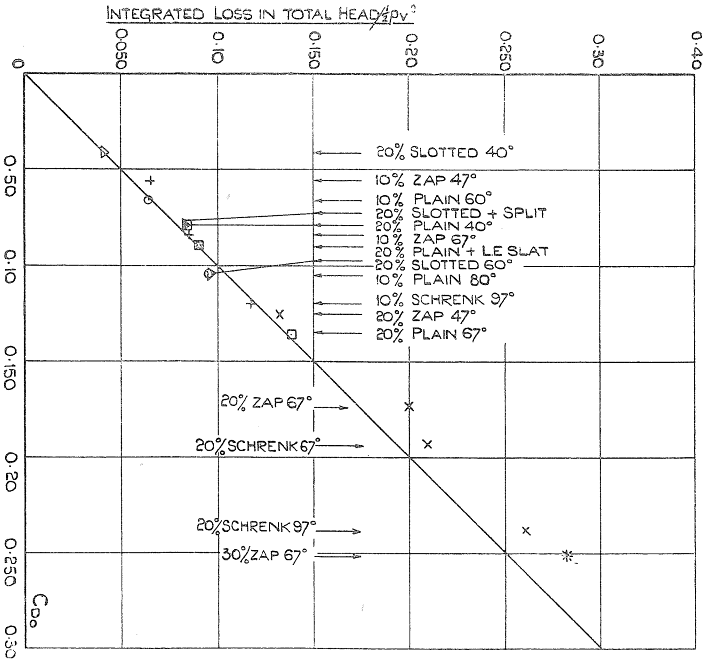
If a 10 per cent. flap is used, there is little to choose between the plain and split types as regards lift or profile drag (see Table on page 8 and Fig. 6), but as the flap size increases, the Zap flap gives the higher lift coefficient, and the Schrenk or Zap flaps have larger profile drags than the other types.

The slotted flap has the smallest profile drag, and this may be an advantage in using the flap for taking off, provided that the drag can be increased for landing. Two methods of increasing the drag are illustrated ; in the one, the flap is pulled down beyond the optimum angle for lift (slotted flap at 60°), and in the other the rear part of the slotted flap is split, involving a second control (case (*d*), and Fig. 1), but giving a considerable increase in maximum lift.

The change in C_{r_0} is larger for a Zap flap than for a Schrenk flap, Fig. 7B (as would be expected, since the Zap flap moves backward). Differences of the order found will correspond to an appreciable difference in trim on aeroplanes fitted with alternative flap arrangements.

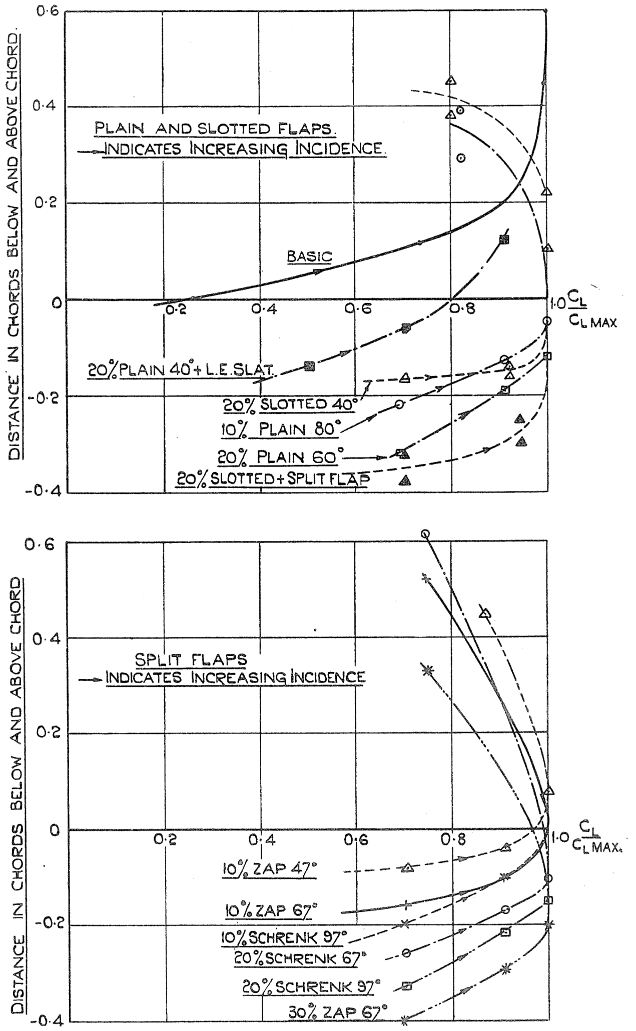
Effect of basic section and Reynolds number on maximum lift.—Maximum lift coefficients of aerofoils of various sections with split flaps from various sources are collected in Table 9. The percentage increase in C_L max. is not consistent for the different sections. When the sections vary in reflex (as R.A.F. 44 and R.A.F. 48), so that the maximum values of the lift differ with flaps neutral, pulling down the flaps tends to equalise the maxima, so that the percentage increase is greater on the wing with initially the lower lift.

The percentage increase in C_L max. due to a Schrenk flap on a wing of given section is unaltered by Reynolds number (N.P.L. compressed air tunnel tests[19]). For the range of Reynolds number available in the R.A.E. 5-ft. tunnel, the percentage increase in C_L max. due to a slotted flap rose with Reynolds number, though this was not the case if the slot was closed.[2] It is therefore possible that the maximum lift with slotted flap may compare more favourably with other types at full scale Reynolds numbers.



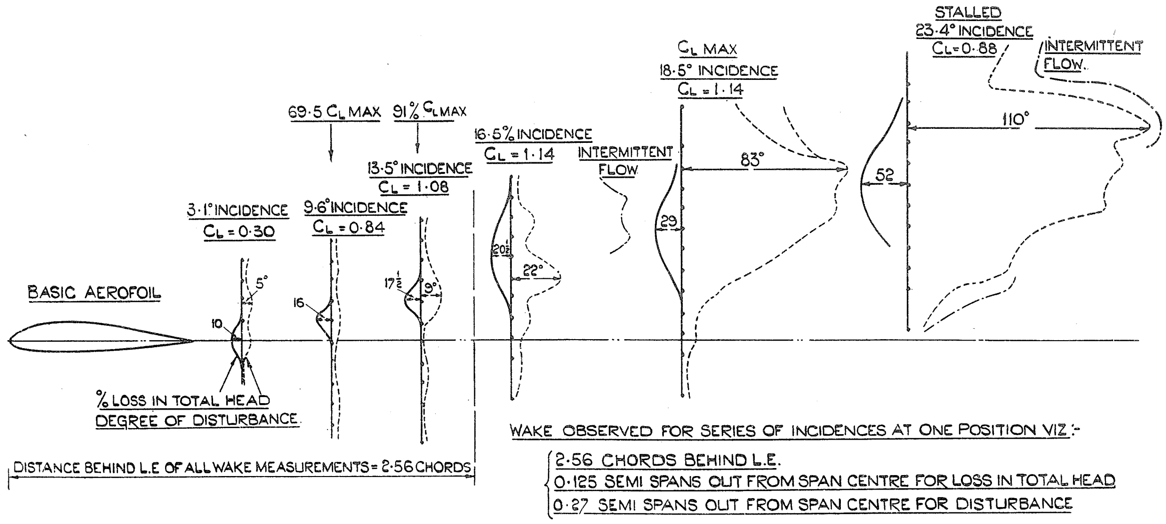
Integrated Loss in Total Head/$\frac{1}{2}\rho v^2$—Profile Drag Coefficient.

FIG. 8.—Wing Flap Wakes and Characteristics.



Position of Peak Loss in Total Head relative to Chord

FIG. 9.—Wing Flap Wakes and Characteristics.



Loss in Total Head expressed as percentage of that of Free Stream.

Degree of Disturbance expressed as the Divergent Angles taken up by the Threads.

FIG. 10.—The Wake Behind the Basic Aerofoil.

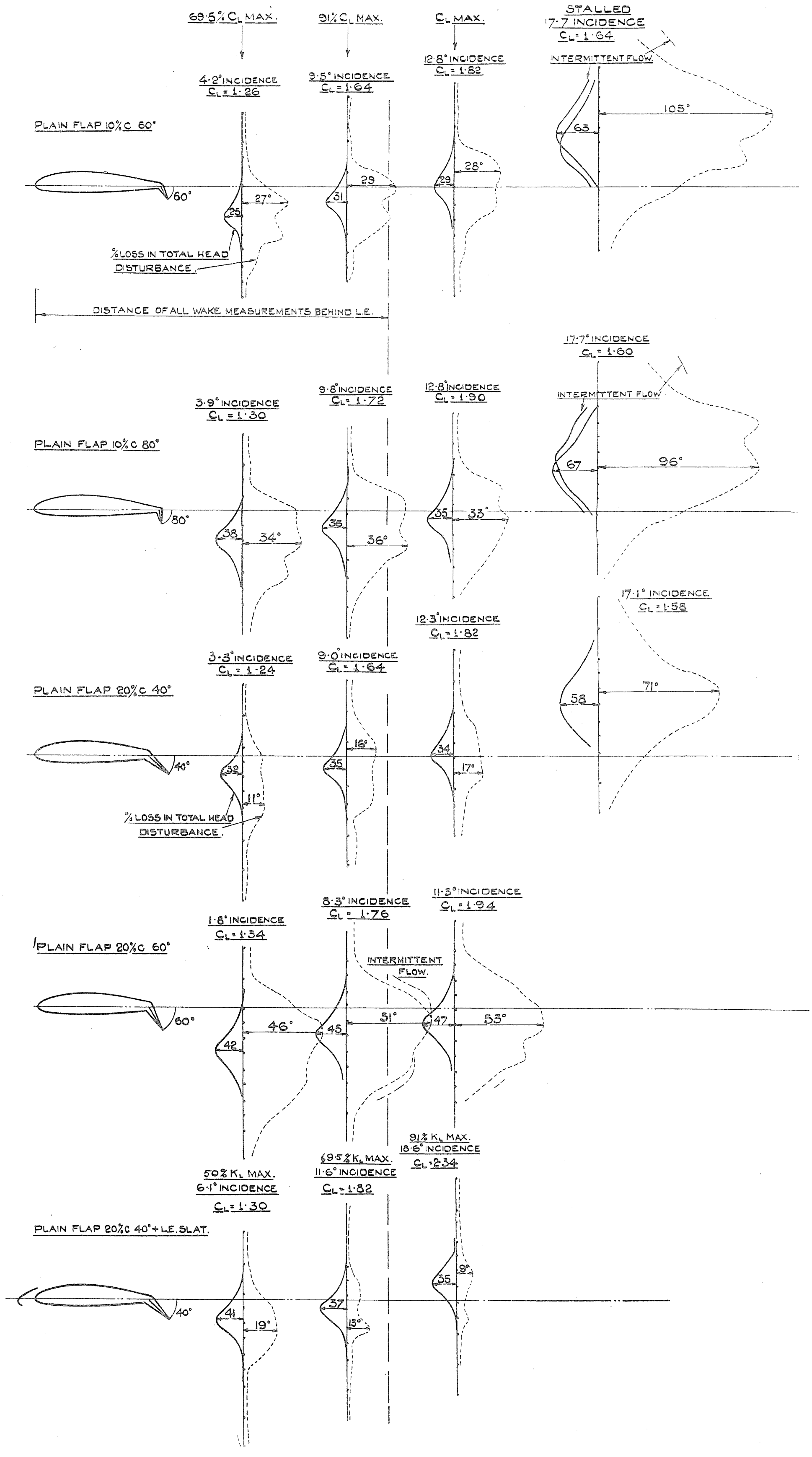


FIG. 11.—The Wake behind Plain Flaps.

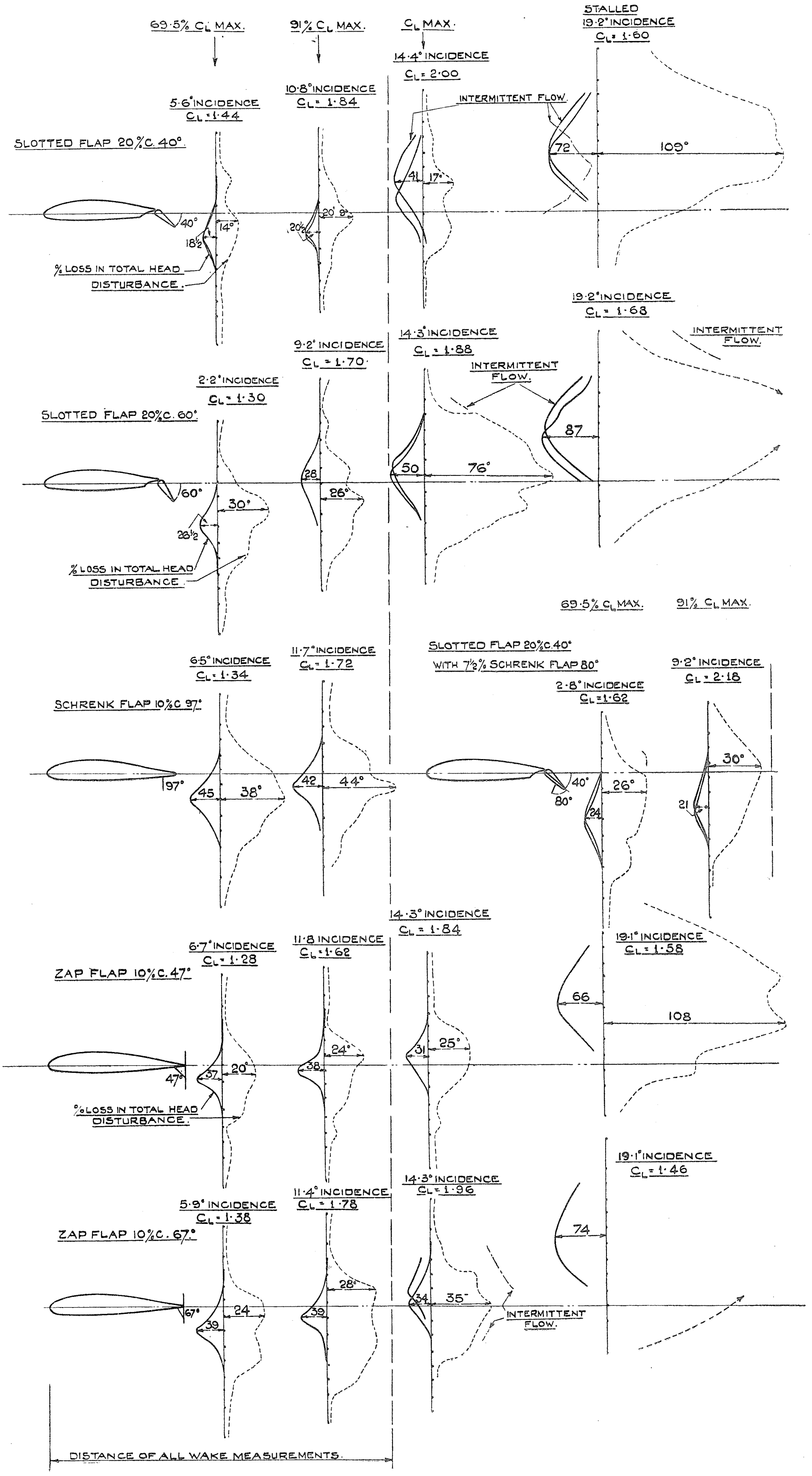


FIG. 12.—The Wake behind Slotted and Split Flaps.

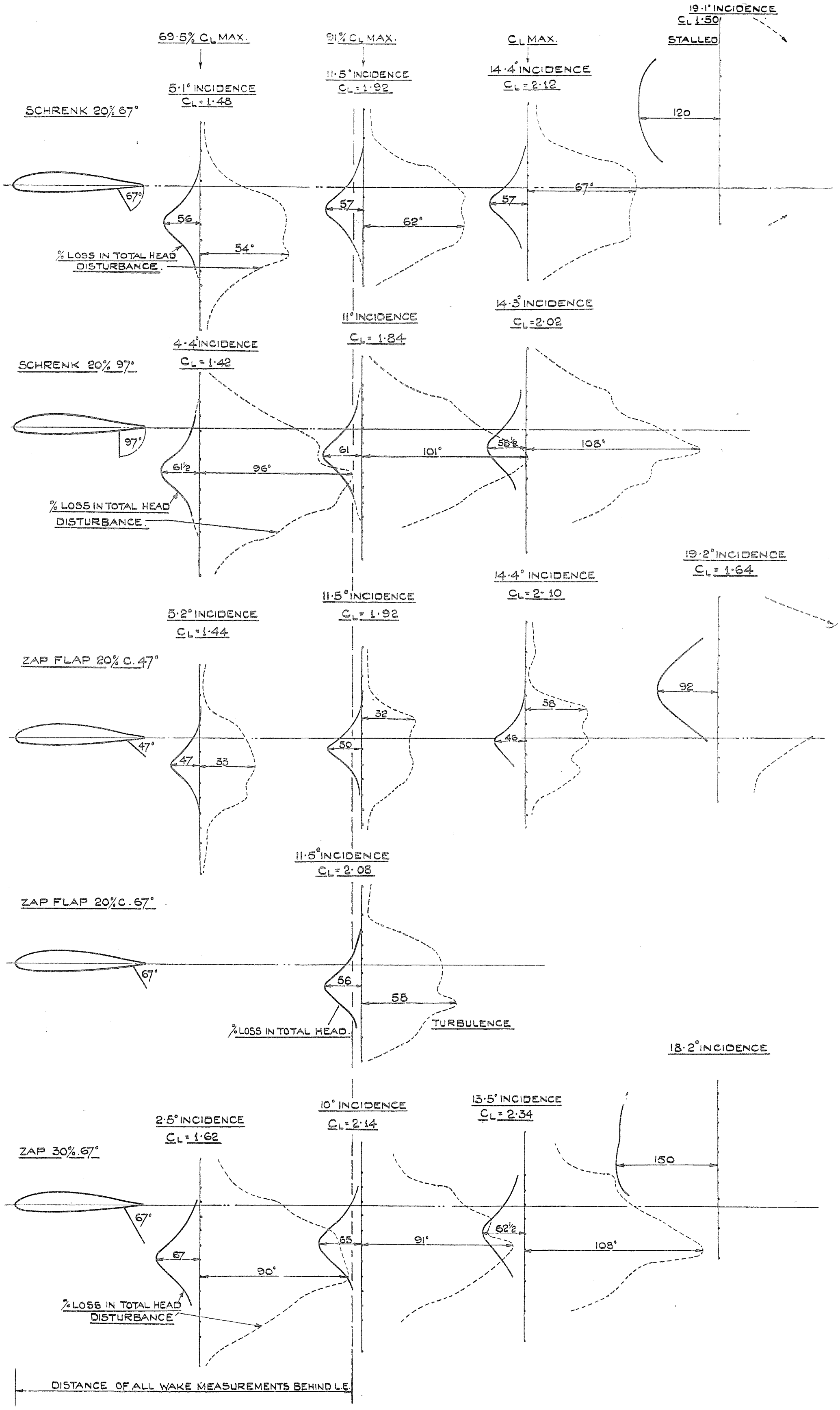


FIG. 13.—The Wake behind Split Flaps.

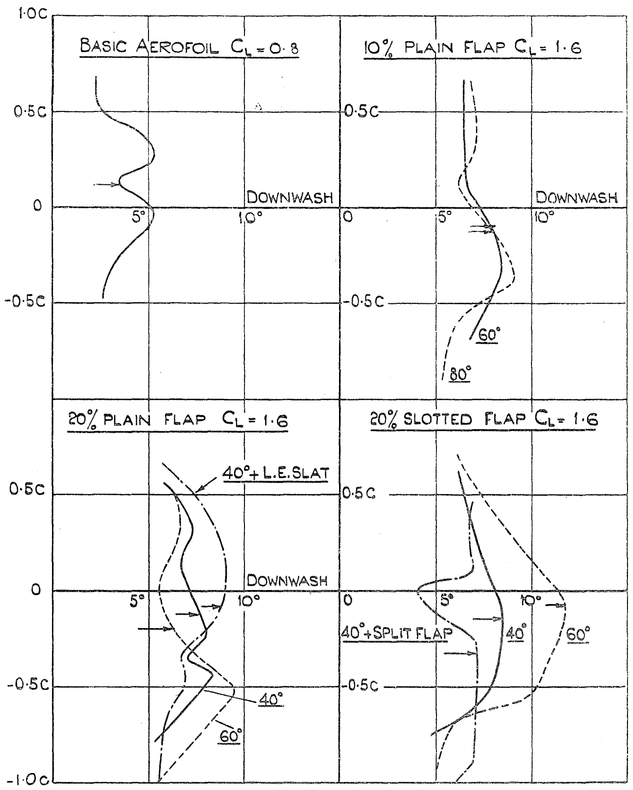


FIG. 14.—Wing Flap Wakes and Characteristics.

Downwash Distribution Across Wake.

Position Rel. to Wing Chord. Downwash Angles Rel. to Flight Path.

⟶ Indicates Position of Max. Loss in Total Head.

Measurements of wake. Figs. 8–15.—The integrated loss in total head measured along a vertical traverse near the plane of symmetry, some distance behind the wing should be approximately equal to the profile drag and independent of the lift coefficient ; therefore different types of flap of the same profile drag will have the same loss in total head in the wake. The experimental verification of this is plotted in Fig. 8.

An analysis of the results follows :—

(1) Distribution of intensity in the wake is very similar for all types of flap with a given C_{D_0}, and does not vary noticeably with lift coefficient.

(2) For different values of C_{D_0}, the "peak" loss of total head and the width of the wake in which there is a reduction of total head of over (*a*) 10 per cent. and (*b*) 20 per cent. are tabulated for typical cases :

	$C_{D_0} = 0\cdot01$	$0\cdot10$	$0\cdot20$
Maximum loss in total head	15 per cent.	39 per cent.	58 per cent.
Width of wake (*a*) 20 per cent. loss . .	—	0·20c	0·43c
(*b*) 10 per cent. loss . .	0·08c	0·35c	0·62c

(3) The effect of pulling down the flaps is to lower the wake (Fig. 9), so that it will in general be possible to keep the tail plane of a low wing monoplane above the wake until the stall.

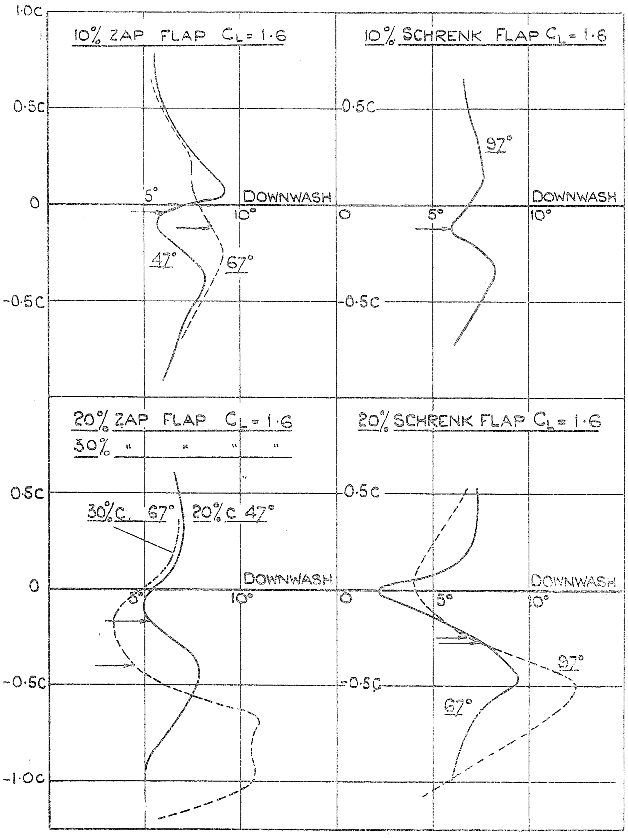


FIG. 15.—Wing Flap Wake and Characteristics.

Downwash Distribution Across Wake.

Position Rel. to Wing Chord. Downwash Angles Rel. to Flight Path.

→ Indicates Position of Max. Loss in Total Head.

In Fig. 9 the height of the centre of the wake above the chord line is plotted. There is a band of disturbed air above and below this position whose thickness is not entirely defined by the width of the wake, since the flow at the boundary of the wake may be highly disturbed even though the loss in total head is negligible. The observations of the angles through which the threads vibrate are plotted (dotted lines) in Figs. 10–13. The results suggest that the tail plane, if it is to lie in undisturbed air, should be kept clear of a band twice the width of the wake ; where this width is defined as that in which the loss of total head is greater than 10 per cent. Using this rough rule, the top of the disturbed region with flap down (when compared at the same values of C_L/C_L max.) may lie at the same height as, or slightly lower than, the top of the smaller disturbed region due to the wing without flaps.

The downwash angle is deduced from the mean angle of the threads and the accuracy is low (not better than $\pm 1°$). These angles are plotted in Figs. 14 and 15, and suggest that with the larger split flaps there is a rapid variation in downwash across the wake, which might be of importance if the tail plane ever enters the wake. The calculated value for the downwash is $\varepsilon = 5C_L$ (degrees) on the longitudinal axis at the position of the threads behind the wing (Ref. 5, p. 169).

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Slotted flaps

See Refs. 2 and 15.

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TABLE 1

Ordinates of R.A.F. 44 aerofoil, and of slotted flap

R.A.F. 44 section is derived from R.A.F. 34 by multiplying the ordinates relative to the chord by $\frac{15}{12{\cdot}64}$

Ordinates given in terms of the chord.

Distance from L.E.	Basic Section.		20 per cent. chord slotted flap.			
			Slot Ordinate.		Flap Ordinate.	
	Above chord.	Below chord.	Below chord.	Above chord.	Upper surface.	Lower surface.
0·0125	0·0235	0·0192				
0·025	0·0335	0·0254				
0·05	0·0488	0·0334				
0·10	0·0691	0·0419				
0·15	0·0828	0·0464				
0·20	0·0916	0·0494				
0·25	0·0965	0·0505				
0·30	0·0987	0·0513				
0·35	0·0981	0·0514				
0·40	0·0959	0·0513				
0·45	0·0918	0·0505				
0·50	0·0855	0·0488				
0·55	0·0783	0·0466				
0·60	0·0696	0·0438				
0·65	0·0609	0·0406				
0·70	0·0511	0·0366				
0·738	—	0·0337	0·0338	—		
0·75	0·0414	0·0321	0·0282	—		
0·775	—	—	0·0133	—		
0·797	—	—	0	0		
0·80	0·0320	0·0273		—	—0·0187	—
0·805	—	—		—	—0·0037	—0·0245
0·812	—	—		—	+0·0050	—0·025
0·820	—	—		0·0132	0·0102	—0·025
0·830	—	—		0·0187	0·0157	
0·850	0·0231	0·0220		0·0225	0·0202	
0·867	—	—		—	0·0202	
0·900	0·0150	0·0159		—	—	
0·95	0·0076	0·0090				
1·0	0	0				
	L.E. radius 0·0152 T.E. radius 0·0015		L.E. of flap radius 0·0066 at 0·0157 below chord. Flap hinge. Ahead of T.E. 0·1525 Below chord 0·0510			

TABLE 1—*contd.*

Ordinates of Slat in terms of Aerofoil Chord

Plaster Type

Tangent chord = 0·1725

Slat closed

Distance behind L.E. of upper edge = 0·150
Distance behind L.E. of lower edge = 0·020

Slat open

Forward extension of lower edge = 0·105
Downward extension of lower edge = 0·050
Rear gap = 0·0375

TABLE 2

Description of coefficients

Lift (and drag coefficients).

$$C_L \text{ (and } C_D) = \frac{L \text{ (and D)}}{\frac{1}{2}\,\varrho\, S\, V^2}$$

Pitching moment coefficents (about a point on the chord at 0·25 × chord aft of leading edge).

$$C_m\,(0\cdot25c) = \frac{M}{\frac{1}{2}\,\varrho\, c\, S\, V^2}$$

where ϱ = air density
S = aerofoil area
V = wind speed
c = aerofoil chord

Profile drag coefficient

$$C_{D_0} = C_D - C_{D_i}$$

where C_{D_i} = induced drag coefficient

$$= \frac{1}{\pi A}\,(1 + \delta)\, C_L{}^2$$

A = aspect ratio 6
$\delta = 0\cdot04$

Angle of glide γ.

$$\tan\gamma = \frac{C_D}{C_L}$$

Wake measurement quantities

Loss in total head.—Expressed as a percentage of the total head in the same air-stream with the model absent, measured over a range of height relative to the extension of the aerofoil chord.

Degree of disturbance.—Expressed as the angle of divergence of fine silk threads about their points of attachment.

Downwash.—The mean angle of the threads to the undisturbed wind direction when corrected for tunnel constraint.

TABLE 3

Lift, drag and pitching moment coefficients

Basic aerofoil

Angle of incidence.	C_L	C_D	C_m (0·25c)
Reynolds number = 0·42 × 10^6 V = 100 ft./sec.			
3·1°	0·292	0·0152	0·0036
6·2	0·562	0·0280	−0·0004
9·4	0·826	0·0484	−0·0068
12·1	1·022	0·0718	−0·0032
15·5	1·128	0·1030	−0·0008
18·4	1·146	0·151	−0·0162
21·3	1·136	0·212	−0·0396
24·1	0·91	0·331	−0·071
Reynolds number = 0·34 × 10^6 V = 80 ft./sec.			
12·4°	1·022	0·0740	
15·5	1·132	0·1026	
18·4	1·152	0·151	
21·3	1·13	0·209	
Reynolds number = 0·50 × 10^6 V = 120 ft./sec.			
15·5°	1·130	0·1012	
18·4	1·146	0·148	

TABLE 4

Lift, drag and pitching moment coefficients

Plain flap 10 per cent. c. Reynolds No. of test = 0·42 × 10^6.

Angle of incidence.	Flap setting 60°			Flap setting 80°		
	C_L	C_D	C_m (0·25c)	C_L	C_D	C_m (0·25c)
0·5°	—	—	—	1·052	0·1616	—
3·5	1·212	0·1436	−0·236	1·284	0·1924	−0·242
6·6	1·448	0·1804	−0·235	1·500	0·229	−0·240
9·7	1·658	0·219	−0·233	1·704	0·263	−0·238
12·8	1·806	0·258	−0·224	1·894	0·304	−0·231
14·3	1·78	0·284	−0·216	1·82	0·325	−0·218
15·7	1·70	0·308	−0·212	1·72	0·348	−0·208
18·7	1·56	0·379	−0·218	1·55	0·404	−0·215

TABLE 5

Lift, drag, and pitching moment coefficients

Plain flap 20 per cent. c.

Angle of incidence.	Flap setting 40°			Flap setting 60°		
	C_L	C_D	C_m (0·25c)	C_L	C_D	C_m (0·25c)
	Reynolds Number = 0·42 × 10^6			V = 100 ft./sec.		
2·9°	1·216	0·1556	—0·218	1·420	0·248	—0·255
6·0	1·450	0·1922	—0·215	1·622	0·282	—0·251
9·1	1·648	0·230	—0·211	1·808	0·321	—0·246
11·3	—	—	—	1·930	0·351	—
12·2	1·810	0·267	—0·202	1·910	0·356	—0·224
13·7	1·752	0·284	—0·189	1·844	0·368	—0·213
15·1	1·71	0·314	—0·186	1·74	0·385	—0·202
18·1	1·55	0·372	—0·189	—	—	—
	Reynolds No. = 0·34 × 10^6.			V = 80 ft./sec.		
9·1°	1·648	0·233				
12·2	1·806	0·270				
13·7	1·790	0·291				

Plain flap 20 per cent. c set at 40°, with leading edge slat

Angle of incidence.	C_L	C_D	C_m (0·25c)
	Reynolds No. = 0·42 × 10^6		
6·1°	1·296	0·1884	—0·1822
9·2	1·602	0·231	—0·1684
12·3	1·882	0·281	—0·1478
15·5	2·140	0·342	—0·1222
18·6	2·340	0·395	—0·0904
21·8	2·500	0·450	—0·061
24·8	2·580	0·524	—0·037
27·7	2·43	0·602	—0·036
	Reynolds No. = 0·34 × 10^6		
18·6°	2·350	0·396	
21·8	2·520	0·456	
24·8	2·580	0·526	
27·7	2·35	0·606	

TABLE 6

Lift, drag, and pitching moment coefficients

Handley Page slotted flap 20 per cent. c.

Angle of incidence.	Flap setting 40°.			Flap setting 60°.		
	C_L	C_D	C_m (0·25c)	C_L	C_D	C_m (0·25c)
	Reynolds No. = 0·42 × 10^6 V = 100 ft./sec.					
0·5°	—	—	—	1·178	0·1592	—0·296
3·6	1·280	0·1308	—0·257	1·398	0·1936	—0·295
6·7	1·524	0·1692	—0·262	1·548	0·233	—0·273
9·8	1·764	0·215	—0·269	1·118	0·274	—0·261
12·9	2·020	0·271	—0·276	1·850	0·322	—0·247
14·3	2·008	0·295	—0·265	1·872	0·246	—0·246
15·8	1·86	0·326	—0·251	1·850	0·380	—0·245
18·7	1·62	0·386	—0·245	1·71	0·454	—0·263
	Reynolds No. = 0·34 × 10^6 V = 80 ft./sec.					
9·8°	1·760	0·215				
12·9	2·020	0·272				
14·3	1·916	0·295				
	Reynolds No. = 0·25 × 10^6 V = 60 ft./sec.					
9·8°	1·744	0·217				
12·9	1·986	0·271				
14·3	1·924	0·293				

Handley Page slotted flap 20 per cent. c set at 40° with 7½ per cent. Schrenk type split flap set at 80° to flap chord

Angle of incidence.	C_L	C_D	C_m (0·25c)
	Reynolds No. = 0·42 × 10^6		
3·7°	1·696	0·237	—0·346
6·8	1·920	0·285	—0·348
9·9	2·154 2·244	0·336 0·312	—0·350
13·0	2·32	0·381	—0·336
14·4	2·03	0·410	—0·300
15·8	1·80	0·432	—0·267
18·7	1·59	0·478	—0·245

TABLE 7

Lift, drag and pitching moment coefficient

Split flaps—Schrenk type

Angle of incidence.	C_L	C_D	C_m (0·25c)	C_L	C_D	C_m (0·25c)
	20 per cent. c flap set at 67°			20 per cent. c flap set at 97°		
	Reynolds No. = 0·42 × 10^6			Reynolds No. = 0·34 × 10^6		
0·5°	1·168	0·273	—0·226	1·164	0·328	—0·1718
3·6	1·380	0·301	—0·229	1·368	0·350	—0·1706
6·7	1·602	0·335	—0·228	1·562	0·374	—0·1704
9·8	1·810	0·371	—0·231	1·750	0·406	—0·1728
12·9	2·024	0·418	—0·237	1·950	0·446	—0·1786
14·4	2·120	0·448	—0·241	2·022	0·466	—0·1848
15·8	1·79	0·460	—0·231	1·596	0·476	—0·1724
18·7	1·51	0·576	—0·261	—	—	—
	10 per cent. c flap set at 67°			10 per cent. c flap set at 97°		
	Reynolds No. = 0·42 × 10^6			Reynolds No. = 0·42 × 10^6 V = 100 ft./sec.		
0·4°	—	—	—	0·858	0·161	—0·167
3·5	1·110	0·164	—0·197	1·110	0·189	—0·171
6·6	1·362	0·200	—0·202	1·362	0·221	—0·173
9·7	1·600	0·231	—0·209	1·560	0·254	—0·177
12·8	1·852	0·272	—0·216	1·804	0·298	—0·184
14·3	1·932	0·296	—0·220	1·902	0·316	—0·189
15·7	1·78	0·328	—0·214	1·740	0·344	—0·183
18·7	1·60	0·395	—0·226	1·540	0·404	—0·193
				10 per cent. c flap set at 97°—*cont.*		
				Reynolds No. = 0·25 × 10^6 V = 60 ft./sec.		C_L 0·50 × 10^6 V = 120 ft./sec.
6·6°				1·302	0·213	1·332
9·7				1·558	0·251	1·576
12·8				1·786	0·295	1·808
14·3				1·880	0·313	1·930
15·7				1·71	0·334	1·75
18·7				1·48	0·488	—

TABLE 8

Lift, drag, and pitching moment coefficients

Split flaps—Zap type

Angle of incidence.	C_L	C_D	C_m (0·25c)	C_L	C_D	C_m (0·25c)
	10 per cent. c. flap set at 47°.			10 per cent. c. flap set at 67°		
	Reynolds No. = 0·42 × 10^6.			V = 100 ft./sec.		
0·3°	0·758	0·0922		—	—	—
3·5	1·024	0·1168		1·162	0·1596	—0·237
6·6	1·284	0·1480		1·410	0·1938	—0·242
9·7	1·524	0·1834		1·650	0·233	—0·247
12·8	1·760	0·225		1·884	0·278	—0·254
14·3	1·844	0·247		1·950	0·296	—0·252
15·8	1·744	0·283		1·81	0·331	—0·250
18·7	1·59	0·351		1·47	0·397	—0·264
	20 per cent. c flap set at 47°			20 per cent. c flap set at 67°		
0·5°	1·070	0·187	—0·262	1·272	0·262	—0·324
3·6	1·318	0·219	—0·267	1·506	0·294	—0·326
6·7	1·550	0·258	—0·271	1·740	0·341	—0·334
9·8	1·792	0·300	—0·277	1·962	0·385	—0·336
12·9	2·012	0·342	—0·280	2·170	0·432	—0·340
14·4	2·096	0·365	—0·282	2·280	0·458	—0·341
15·8	1·84	0·391	—0·270	1·89	0·472	—0·322
18·7	1·64	0·454	—0·276	1·63	0·590	—0·346
				30 per cent. flap set at 67°		
0·6°				1·500	0·378	—0·380
3·7				1·718	0·414	—0·381
6·8				1·930	0·454	—0·385
9·9				2·120	0·504	—0·390
13·0				2·33	0·554	—0·394
				Ditto R.N. = 0·34 × 10^6		
13·0°				2·340	0·554	—0·393
14·3				1·970	0·546	—0·360
15·8				1·81	0·582	—0·356

TABLE 9

Variation of maximum lift coefficient with wing section
Wind tunnel tests of Schrenk type split flap on aerofoil

Aerofoil.	Report Ref.	Particulars of Test.	C_L max. basic section.	C_L max. flap down.	Increase in C_L max.	Per cent. increase in C_L max.
		10 per cent. Schrenk 90°				
R.A.F. 44 (15 per cent. thick)	Present tests	R.N. = $0 \cdot 4 \times 10^6$ ..	1·15	1·92	0·77	66
		N.P.L. C.A.T. :—				
R.A.F. 48 (15 per cent. thick)	19	R.N. = 3×10^6 ..	1·34	2·10	0·76	57
		R.N. = $0 \cdot 3 \times 10^6$ ..	1·16	1·90	0·65	56
Clark YH (12 per cent. thick)	19	R.N. = $3 \cdot 5 \times 10^6$ ..	1·35	2·10	0·75	56
		R.N. = $0 \cdot 3 \times 10^6$ ..	1·11	1·75	0·64	57
Clark YH (12 per cent. thick)	22	R.N. = $3 \cdot 9 \times 10^6$ ..	1·31	2·11	0·80	61
	21	R.N. about $0 \cdot 3 \times 10^6$	1·25	2·06	0·81	65
		10 per cent. Schrenk 60°				
20 per cent. thick.	21	R.N. about $0 \cdot 3 \times 10^6$	1·25	2·00	0·75	60
R.A.F. 44 ..	Present	R.N. = $0 \cdot 4 \times 10^6$ ..	1·15	1·92	0·78	59
		20 per cent. Schrenk 90°				
R.A.F. 44 ..	Present	R.N. = $0 \cdot 4 \times 10^6$ ..	1·15	2·06	0·91	80
R.A.F. 48 ..	19	R.N. = 3×10^6 ..	1·34	2·18	0·84	63
		R.N. = $0 \cdot 3 \times 10^6$ ..	1·16	1·88	0·72	62
20 per cent.	21	R.N. about $0 \cdot 3 \times 10^6$	1·25	2·18	0·93	74
		20 per cent. Schrenk 60°				
R.A.F. 44 ..	Present	R.N. = $0 \cdot 4 \times 10^6$ ..	1·15	2·12	0·97	85
20 per cent. thick.	21	R.N. about $0 \cdot 3 \times 10^6$	1·25	2·15	0·90	72
Clark Y (12 per cent. thick).	17	R.N. = $0 \cdot 6 \times 10^6$ ..	1·27	2·12	0·85	67