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Low-Speed Wind-Tunnel Tests of Fowler Flaps, Slats and Nose Flaps on a Model of a Jet Aircraft with a 40 deg Swept-Back Wing

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Summary.—This report presents the results of tests with Fowler flaps on a model of a single-jet aircraft with a 40 deg swept-back 10 per cent thick wing. Slats and nose flaps were also tested as means of delaying the tip stall.

The maximum trimmed lift coefficient without flaps or slats was $1 \cdot 055$ ($R = 2 \cdot 7 \times 10^6$). With half-span Fowler flaps (leaving a gap across the fuselage) and slats over the outer half of the span, this value was increased to $1 \cdot 64$, and there was adequate stability. Tests in which the spanwise extent of the nose flap was varied, indicated that about 50 per cent. wing semi-span per side was the optimum length of slat or nose flap for avoiding instability at the stall.

1. *Introduction*.—In view of the well-known effect of sweepback in reducing the effectiveness of split flaps, a series of wind-tunnel tests has been made to investigate the use of Fowler flaps on a model of a single-engined jet aircraft with a 40 deg swept-back wing, and to compare them with split flaps which had already been tested on the same model.

In the present tests, half and full-span Fowler flaps were tried, neither extending across the fuselage. The model was fitted with slats over the outer half of the span, and, in addition, the effects of various spanwise lengths of nose flaps were measured in order to find the optimum spanwise extent of leading edge devices for preventing tip stall.

2. *Details of Model and Tests*.—2.1. *Model*.—A general arrangement drawing of the model is shown in Fig. 1 and relevant data are given in Table 1. The wing had a maximum thickness-chord ratio of 10 per cent at 40 per cent chord. The quarter-chord line was swept back 40 deg and the aspect ratio was $3 \cdot 65$.

Details of the flaps and slats are also given in Table 1 and drawings of them are shown in Fig. 2. The wing was not cut away to accommodate the Fowler flaps.

The chord of the slats was 10 per cent of the local wing chord. They extended from 50 per cent to 97 per cent of the semi-span. An alternative position, based on the results of R. & M. 2705[1], with the slat dipped into a nose flap position and with zero gap, was also tried (Fig. 7).

The nose flaps were flat plates of constant chord, $13\frac{1}{2}$ per cent of the wing chord at the root and $28\frac{1}{2}$ per cent at the tip. Three spanwise lengths were used, extending from near the tip to 49 per cent $b/2$, 32 per cent $b/2$ and the fuselage side respectively.

* R.A.E. Report Aero. 2302, received 8th February, 1949.

2.2. *Tests Made.*—The tests were made during August and September, 1948, in the No. 2 $11\frac{1}{2} \times 8\frac{1}{2}$ ft Wind Tunnel at the Royal Aircraft Establishment. The wind speed used was 200 ft/sec except for the tests with nose flaps when the speed was reduced to 150 ft/sec because of the strength of the model. The corresponding Reynolds numbers were $2 \cdot 7 \times 10^6$ and $2 \cdot 0 \times 10^6$ based on the wing mean chord. Checks showed (Fig. 3) that scale effect was negligible between Reynolds numbers of $2 \cdot 0 \times 10^6$ and $3 \cdot 4 \times 10^6$.

Measurements of lift, drag and pitching moment without tail unit were made up to and over the stall for the following model conditions, the tests with split flaps having been made earlier in the No. 1 $11\frac{1}{2} \times 8\frac{1}{2}$ ft Wind Tunnel.

Fowler flap span	Slats	Nose flap span
—	—	—
Half	—	—
Full	—	—
—	Open	—
Half	Open	—
Full	Open	—
—	As nose flaps	—
—	—	Full (87 per cent $b/2$)
Half	—	Full
Full	—	Full
Half	—	66 per cent
Half	—	50 per cent

In addition, the effects of half-span nose flaps and half-span Fowler flaps were measured on the complete model with tail unit in order to find the trim changes.

3. *Results and Discussion.*—The results are given in full in Tables 2 to 6 and are plotted in Figs. 3 to 12 at the end of the report. The more important features are discussed in the following sections.

3.1. *Lift and Stability at the Stall* (Tables 2 to 5; Figs. 4 to 9).—Without leading edge devices, the stall starts at the wing tip and gives very flat-topped lift curves (Figs. 4 and 6) and instability near the stall (Fig. 5). The lift and pitching-moment increments caused by the flaps are compared in the following table.

Lift and Pitching Moment Changes caused by Split and Fowler Flaps

Flaps	$\Delta C_{L\,max.}$	ΔC_L at $\alpha = 10$ deg.	ΔC_m at $C_L = 0 \cdot 9$
Half-span splits	0·17	0·47	−0·08
Half-span Fowlers ..	0·39	0·525	−0·20
Full-span Fowlers ..	0·74	0·885	−0·46

The very poor maximum lift coefficient increment for the split flaps is caused by a stall occurring at 5 deg lower incidence than that of the plain wing, whereas with Fowler flaps the stall occurs 3 deg later (*i.e.* 2 deg before the plain wing) giving much better increments of maximum lift.

As mentioned earlier, there is in all these cases an unstable nose-up moment at the stall. This is practically entirely removed by using half-span slats (Figs. 4, 5) except for a small nose-up moment which still remains at the stall with flaps down (Fig. 5) but this is not likely to be noticeable in flight. The slats increase the stalling incidence considerably, especially with flaps so that the stall occurs at practically the same angle with and without flaps. With full-span Fowler flaps, there is an appreciable decrease in the lift curve slope and a forward movement of the aerodynamic centre above an incidence of 15 deg, probably caused by a stall at the inboard end of the slat.

The effect of dipping the slats into a nose flap position (with zero gap) is shown in Fig. 7. This slat setting gives a slightly larger maximum lift, but the stall, starting at the ends of the slats spreads across the slatted portions of the wing, the resulting stability being similar to that without slats. The improvement of lift with this second slat setting is smaller than would be expected from R. & M. 2705[1] and the reduction of stalling angle is unexpected. It seems likely that the end effects are much worse than in the normal slat position.

With 50 per cent span nose flaps (Figs. 8, 9) the results obtained are very similar to those with 50 per cent slats. Tufts showed that the root stalls first and that the stall then spreads from the inner and outer ends of the nose flaps, the part of the wing at about three-quarters of the semi-span from the centre line being the last to stall. As the nose flap span is increased, the maximum lift coefficient is improved at the expense of longitudinal stability at the stall.

The following table summarises the values of maximum lift coefficient obtained, the trimmed values being quoted for a static margin of $0 \cdot 05\bar{c}$.

Condition			$C_{L\,max}$ without tail	$C_{L\,max}$ trimmed about $0 \cdot 35\bar{c}$	Stability at stall
Fowler flap span	Nose flap span	Slats			
—	—	—	1·02	1·055	Unstable
Half	—	—	1·41	1·33	Unstable
Full	—	—	1·76	1·56	Unstable
—	—	Open	1·16	1·18	Stable
Half	—	Open	1·69	1·64	Stable
Full	—	Open	1·995	1·83	Stable
—	Full (87 per cent)	—	1·48	1·54	Unstable
Half	Full	—	1·92	1·89	Unstable
Full	Full	—	2·34	2·20	Unstable
Half	66 per cent	—	1·82	1·77	Unstable
Half	50 per cent	—	1·73	1·68	Stable

3.2. *Trim Changes* (Table 6; Fig. 10).—Pitching moments for the complete model, including the effects of half span nose flaps and half-span Fowler flaps are shown in Fig. 10. The change of trim caused by the nose flaps is negligible; the neutral point moves forward about $0 \cdot 02\bar{c}$. Lowering half-span Fowler flaps gives a nose-down pitching-moment coefficient of 0·06 which is equivalent to 6 deg of elevator.

3.3. *Drag and Angle of Glide* (Figs. 11, 12).—Profile drag coefficients are plotted against lift in Fig. 11, and angles of glide ($\tan^{-1} C_D/C_L$) are shown in Fig. 12.

Fowler flaps give only a small reduction in angle of glide compared with split flaps. Without slats or nose flaps (Fig. 12A), the minimum angle of glide occurs at a lift coefficient quite close to the stall. With slats or nose flaps however (Fig. 12B), the angle of glide increases slowly with lift coefficient up to the stall. This may produce undesirable landing characteristics if slow speed approaches are made.

4. *Conclusions*.—The tests have shown that on a 40 deg swept back wing, a Fowler flap gives a much better increment of maximum lift coefficient than does a split flap, largely because it gives a smaller reduction in the stalling angle.

The optimum spanwise extent of nose flap (or slat) for delaying the tip stall, was found to be about 50 per cent semi-span per side. The combination of half-span Fowler flaps (leaving a gap across the fuselage) and half-span slats increases the maximum trimmed lift coefficient from 1·055 to 1·64 and gives satisfactory stability near the stall.

With full-span Fowler flaps, a further increase of maximum lift coefficient to 1·83 is possible, but this gain would probably not offset the extra weight and added complications associated with full span flaps.

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REFERENCE

No.	*Author*	*Title*
1	G. F. Moss	Systematic Wind Tunnel Tests with Slats on a 10 per cent Thick Wing Section (E.Q. 10/40 Profile). R. & M. 2705, October, 1948.

TABLE 1

Relevant Model Data

All dimensions model scale.

Wing		
Gross area S	sq ft	17·07
Wing span b	ft	7·89
Standard mean chord $\bar{c}$	ft	2·16
Aspect ratio		3·65
Section H.S.A.1.		10 per cent thick at 40 per cent Chord
Chord at centre line	ft	3·02
Chord at tip	ft	1·354
Wing body angle		2·4 deg
*Dihedral		3·9 deg
Sweepback of quarter-chord line		40 deg
Washout		0 deg
Fowler Flaps		
Chord (as per cent of local wing chord)		26·4 per cent c
Deflection (measured between wing chord and flap chord)		40 deg
Height from wing T.E. to centre of curvature of flap L.E. (per cent local chord)		2·5 per cent c
Minimum gap between wing and flap		1·9 per cent c
Spanwise distance from centre line to inboard end of flap		14·7 per cent $b/2$
Spanwise distance from centre line to outboard end of flap (half span)		53·4 per cent $b/2$
Spanwise distance from centre line to outboard end of flap (full span)		98·2 per cent $b/2$
Area per flap (half span)	sq ft	1·068
Area per flap (full span)	sq ft	1·940
Nose Flaps		
Chord (constant)	ft	0·384
Nose radius	in	0·125
Deflection (measured between flap chord and wing chord)		130 deg
Spanwise distance from centre line to outer end of flaps		98·2 per cent $b/2$
Spanwise distance from centre line to inner end of flaps		48·8 per cent $b/2$ 32·3 per cent $b/2$ 11·1 per cent $b/2$
Area per flap	sq ft	0·898 1·198 1·582
Slats (a) ***Standard Position***		
Chord (per cent local wing chord)		10·0 per cent c
Forward extension		7·0 per cent c
Dip		2·4 per cent c
Gap		2·0 per cent c

* Dihedral defined as angle to the horizontal of the frontal elevation of the wing quarter-chord line, when wing root incidence is zero.

TABLE 1—*continued*

Slats (a) *Standard Position*—contd	
Position of outer end	96·85 per cent $b/2$
Position of inner end	50·35 per cent $b/2$
(b) *Alternative Position* (*see* Fig. 7)	
Deflection (measured between slat chord and wing chord)	110 deg
Gap	0
Spanwise position as in (a).	
Split Flaps	
Chord at inboard end of flap	0·521 ft
Chord at outboard end of flap	0·783 ft
Distance of inboard end of flap from centre line ..	0·145 $b/2$
Distance of outboard end of flap from centre line ..	0·543 $b/2$
Area per flap	1·024 sq ft
Deflection (about hinge line)	70 deg
Tailplane	
Gross area S_T .. sq ft	3·715
Span b_T .. .. ft	3·14
Mean chord $\bar{c}_T$ .. ft	1·18
Aspect ratio	2·66
Thickness/chord ratio	9 per cent
Setting to wing chord	−1·4 deg
Dihedral	10 deg
Sweepback of quarter-chord line	40 deg
Washout	0
Tail arm l_T .. ft	4·20
(Mean quarter-chord wing to mean quarter-chord tail)	
Tail volume coefficient V_T $\dfrac{S_T l_T}{S\bar{c}}$	0·423

TABLE 2

Lift Drag and Pitching-Moment Coefficients for Model without Tail, and without Slats

$V = 200$ ft/sec

(a) No Fowler Flaps

α (deg)	C_L	C_D	C_m
3·8	0·239	0·0184	0·0140
8·1	0·461	0·0366	0·0436
12·4	0·710	0·0678	0·0707
14·5	0·820	0·0870	0·0812
15·6	0·892	0·1012	0·0860
16·6	0·956	0·1154	0·0891
17·7	0·998	0·1721	0·0915
18·7	1·007	0·2306	0·1119
19·7	1·014	0·2676	0·1218
20·7	1·019	0·2942	0·1204
21·7	1·019	0·3369	0·1222
22·7	1·007	0·3596	0·1223

(b) With Half-span Fowler Flaps

α (deg)	C_L	C_D	C_m
4·4	0·768	0·1411	—0·1265
8·7	1·026	0·1869	—0·1012
13·0	1·281	0·2477	—0·0803
15·2	1·405	0·2840	—0·0722
16·2	1·394	0·5349	—0·0574
17·2	1·381	0·6012	—0·0435
18·4	1·402	0·6423	—0·0398
19·2	1·412	0·6876	—0·0387
20·2	1·396	0·7298	—0·0404
21·4	1·387	0·8836	—0·0338

(c) With Full-span Fowler Flaps

α (deg)	C_L	C_D	C_m
4·9	1·138	0·2406	—0·3528
9·2	1·414	0·3105	—0·3320
13·5	1·662	0·3894	—0·3064
14·6	1·738	0·6158	—0·3028
15·6	1·752	0·6908	—0·2741
16·5	1·713	0·7413	—0·2448
17·5	1·697	0·7870	—0·2300
18·5	1·700	0·9500	—0·2250
19·5	1·709	1·0059	—0·2280
20·5	1·706	1·0444	—0·2298

TABLE 3

Lift, Drag and Pitching-Moment Coefficients—without Tail, with Slats

(a) $V = 200$ ft/sec

α (deg)	C_L	C_D	C_m
−0·5	−0·053	0·0172	−0·0256
1·6	0·066	0·0177	−0·0057
3·8	0·199	0·0210	0·0140
5·9	0·325	0·0278	0·0293
8·1	0·459	0·0380	0·0436
10·2	0·580	0·0503	0·0567
12·4	0·726	0·0716	0·0675
14·5	0·849	0·0935	0·0780
16·6	0·959	0·1208	0·0905
18·8	1·054	0·1675	0·1024
20·8	1·132	0·2468	0·1115
21·9	1·149	0·2881	0·1085
22·9	1·152	0·3237	0·0945
23·9	1·148	0·3544	0·0754
24·8	1·131	0·3815	0·0641
25·8	1·117	0·5969	0·0522

(b) $V = 250$ ft/sec

α (deg)	C_L	C_D	C_m
−0·5	−0·057	0·0241	−0·0267
3·8	0·200	0·0206	0·0145
8·1	0·454	0·0371	0·0430
12·6	0·739	0·0726	0·0686
16·6	0·969	0·1203	0·0900
20·9	1·137	0·2451	0·1030
21·9	1·138	0·4080	0·0874
22·9	1·130	0·4385	0·0771
23·8	1·123	0·4664	0·0652

(c) *Slats in a 'Nose Flap' Position (see Fig. 7)*

$V = 150$ ft/sec

α (deg)	C_L	C_D	C_m
3·7	0·178	0·0286	0·0022
8·0	0·436	0·0403	0·0337
12·3	0·688	0·0689	0·0633
14·5	0·819	0·0904	0·0776
16·6	0·935	0·1151	0·0902
18·8	1·046	0·1447	0·1015
19·8	1·116	0·1780	0·1006
20·9	1·162	0·2193	0·1068
21·9	1·145	0·2550	0·1271
22·8	1·118	0·3051	0·1381
23·8	1·122	0·3443	0·1397

TABLE 3—*continued*

(d) With Slats and Half-span Fowler Flaps

$V = 200$ ft/sec

α (deg)	C_L	C_D	C_m
4·4	0·760	0·1422	−0·1264
8·7	1·025	0·1877	−0·0993
13·0	1·294	0·2513	−0·0777
15·2	1·421	0·2883	−0·0651
17·3	1·503	0·3296	−0·0410
19·4	1·619	0·4189	−0·0295
20·6	1·659	0·6581	−0·0219
21·5	1·693	0·6993	−0·0128
22·5	1·690	0·7576	0·0025
23·5	1·674	0·8670	−0·0104

(e) With Slats and Full-span Fowler Flaps

$V = 200$ ft/sec

α (deg)	C_L	C_D	C_m
0·5	0·875	0·1850	−0·3740
4·9	1·163	0·2438	−0·3544
9·2	1·423	0·3125	−0·3214
13·5	1·664	0·3919	−0·2977
15·6	1·729	—	−0·2736
16·6	1·778	—	−0·2533
17·7	1·841	—	−0·2376
18·7	1·887	—	−0·2192
19·8	1·934	—	−0·2076
20·9	1·996	—	−0·2031
21·8	1·968	—	−0·1836
22·8	1·962	—	−0·1881

TABLE 4

Lift, Drag and Pitching-Moment Coefficients—without Tail, with Full-Span Nose Flaps

(a) No Fowler Flaps
$V = 200$ ft/sec

α (deg)	C_L	C_D	C_m
3·6	0·085	0·0579	—0·0438
8·0	0·402	0·0514	0·0139
12·3	0·697	0·0749	0·0646
14·5	0·842	0·0954	0·0919
15·6	0·905	0·1059	0·1031
16·7	0·984	0·1213	0·1170
17·8	1·053	0·1368	0·1266
18·8	1·115	0·1530	0·1347
19·9	1·184	0·1735	0·1422
21·0	1·259	0·1982	0·1505
22·1	1·314	0·2355	0·1568
23·2	1·389	0·2467	0·1666
24·2	1·441	0·2800	0·1743
24·8	1·474	—	—
25·05	1·478	—	—
25·1	1·412	0·3284	0·1945
26·1	1·329	—	—

(b) No Fowler Flaps
$V = 150$ ft/sec

α (deg)	C_L	C_D	C_m
3·6	0·083	0·0582	—0·0437
8·0	0·401	0·0518	0·0144
12·3	0·692	0·0742	0·0672
14·5	0·832	0·0945	0·0933
16·7	0·966	0·1196	0·1164
18·8	1·111	0·1545	0·1341
21·0	1·263	0·1917	0·1496
22·1	1·320	0·2237	0·1560
23·2	1·401	0·2551	0·1663
24·2	1·459	0·2892	0·1748
24·3	1·460	—	—
24·9	1·477	—	—
25·25	1·484	0·3169	0·1920
25·3	1·438	—	—
26·15	1·392	0·3647	0·2069

(c) With Half-span Fowler Flaps
$V = 150$ ft/sec

α (deg)	C_L	C_D	C_m
4·3	0·627	0·1581	—0·1696
8·7	1·032	0·1976	—0·1167
13·1	1·326	0·2611	—0·0655
15·2	1·437	0·2911	—0·0337
17·4	1·564	0·3303	—0·0068
19·5	1·710	0·3838	0·0117
21·7	1·839	0·4435	0·0296
22·8	1·904	0·4794	0·0409
23·1	1·914	0·4918	—
23·6	1·780	0·5507	0·0520
24·6	1·767	0·5862	0·0585

(d) With Full-span Fowler Flaps
$V = 150$ ft/sec

α (deg)	C_L	C_D	C_m
4·8	1·054	0·2304	—0·3394
9·2	1·385	0·3017	—0·3021
13·5	1·653	0·3861	—0·2590
15·6	1·775	0·4221	—0·2342
17·8	1·903	0·4727	—0·2041
19·9	2·029	0·5304	—0·1737
22·1	2·166	0·6020	—0·1485
23·2	2·236	0·6524	—0·1392
24·2	2·303	0·7009	—0·1287
24·7	2·334	1·0738	—0·1240
25·0	2·159	1·1431	—0·1212
26·1	2·152	1·1873	—0·1180

TABLE 5

Lift, Drag, and Pitching-Moment Coefficients—without Tail, with Half-Span Fowlers and Part-Span Nose Flaps

(a) With 66 per cent Span Nose Flaps
$V = 150$ ft/sec

α (deg)	C_L	C_D	C_m
4·3	0·679	0·1552	—0·1364
8·7	1·011	0·1940	—0·1007
13·1	1·311	0·2581	—0·0638
15·2	1·456	0·2969	—0·0435
17·4	1·593	0·3411	—0·0266
19·6	1·753	0·3936	—0·0044
21·7	1·814	0·4575	0·0129
22·2	1·813	—	—
22·6	1·757	0·5301	0·0296
23·6	1·744	0·5713	0·0366
24·6	1·731	0·6043	0·0467
25·5	1·716	0·6361	0·0553

(b) With 50 per cent Span Nose Flaps
$V = 150$ ft/sec

α (deg)	C_L	C_D	C_m
4·3	0·691	0·1550	—0·1277
8·7	0·990	0·1891	—0·0900
13·1	1·307	0·2565	—0·0667
15·2	1·421	0·2909	—0·0458
19·5	1·663	0·4115	—0·0142
20·5	1·723	0·4597	—0·0109
21·6	1·726	0·5189	—0·0018
22·5	1·695	0·5689	—0·0067
23·5	1·674	0·5982	—0·0256
24·4	1·610	0·6257	—0·0590
25·4	1·602	0·6632	—0·0758

TABLE 6

Lift, Drag and Pitching Moment Coefficients of Model with Tailplane and Fin

$V = 150$ ft/sec

(a) No Slats or Flaps

α (deg)	C_L	C_D	C_m
3·8	0·198	0·0198	0·0221
8·1	0·477	0·0401	0·0186
12·4	0·738	0·0656	0·0191
14·5	0·865	0·0990	0·0161
15·6	0·948	0·1175	0·0108
16·6	1·013	0·1331	0·0053
17·7	1·073	0·1876	−0·0038
18·7	1·053	0·2687	0·0125
19·7	1·044	0·3108	0·0209
20·7	1·052	0·3322	0·0316
21·7	1·064	0·3621	0·0245
22·7	1·068	0·3972	0·0291
23·7	1·084	0·4272	0·0139
24·7	1·090	0·4527	−0·0041
25·7	1·074	0·5013	−0·0656

(b) With 50 per cent Span Nose Flaps

α (deg)	C_L	C_D	C_m
3·7	0·111	0·0485	0·0067
8·0	0·430	0·0513	0·0109
12·4	0·743	0·0821	0·0155
14·6	0·894	0·1068	0·0148
16·7	1·008	0·1353	0·0197
18·9	1·149	0·1964	0·0269
19·9	1·191	0·2427	0·0182
21·0	1·237	0·2910	0·0030
22·0	1·248	0·3273	−0·0169
23·0	1·254	0·3631	−0·0509
24·0	1·248	0·3922	−0·1027

(c) With 50 per cent Span Nose Flaps and Half-span Fowler Flaps

α (deg)	C_L	C_D	C_m
4·3	0·641	0·1514	−0·0461
8·7	0·952	0·1841	−0·0420
13·0	1·283	0·2521	−0·0480
15·2	1·407	0·2885	−0·0397
17·3	1·539	0·4045	−0·0357
19·5	1·662	0·4173	−0·0238
20·5	1·719	0·4613	—
21·0	1·723	0·4914	−0·0179
21·5	1·719	0·5222	−0·0031
22·5	1·699	0·5661	0·0020
23·4	1·635	0·5908	−0·0173
24·4	1·592	0·6231	−0·0720
25·4	1·602	0·6630	−0·0948

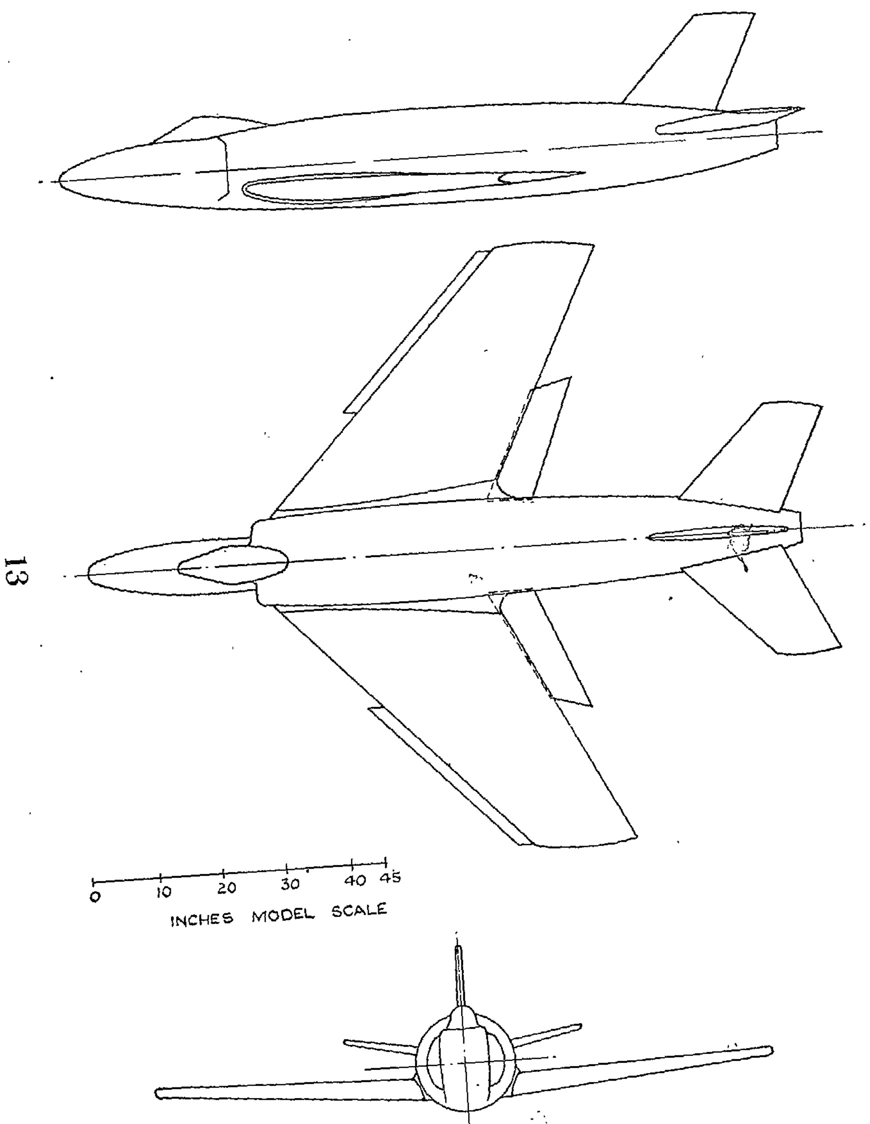

FIG. 1. General arrangement of model showing half-span Fowler flap and half-span nose flap.

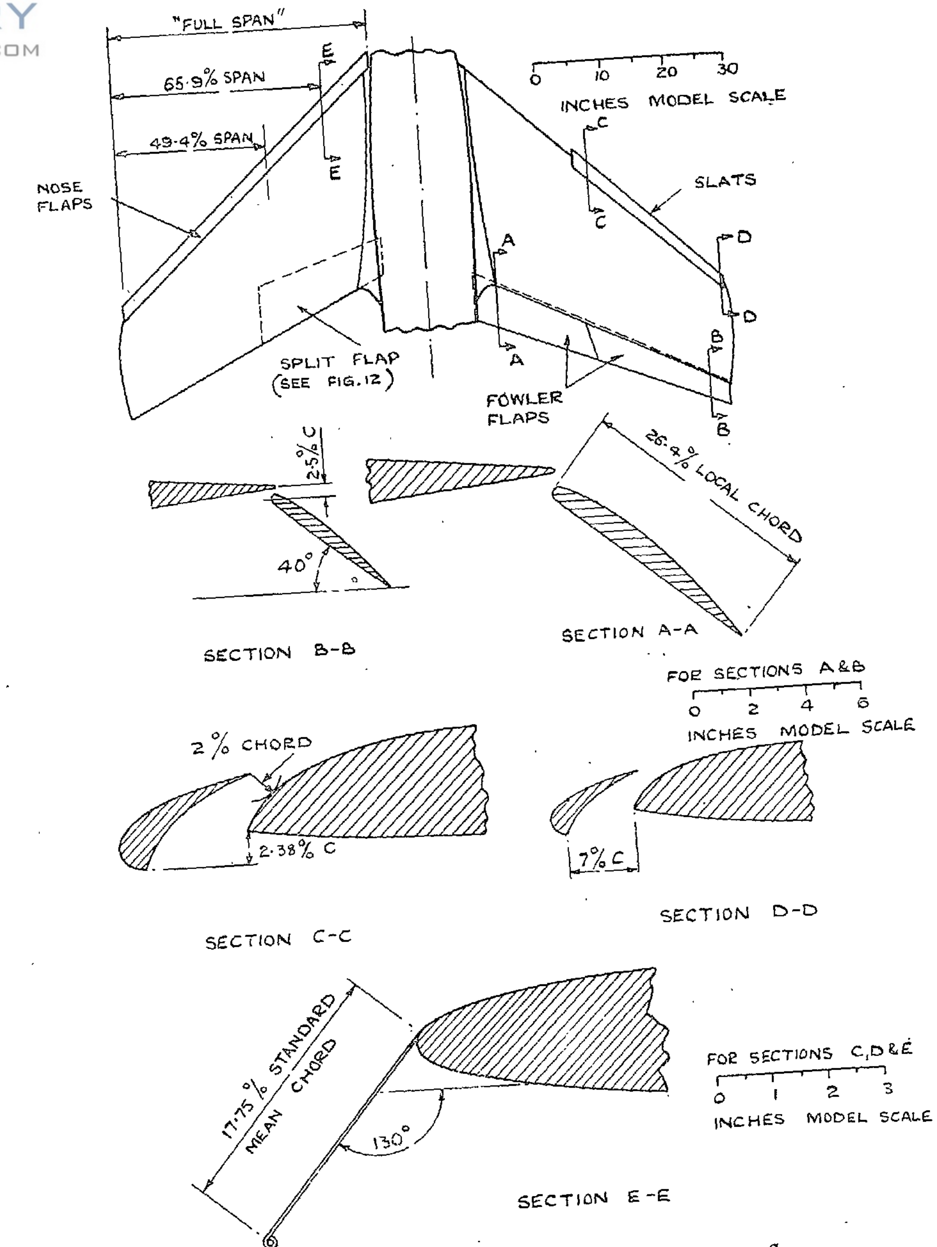

FIG. 2. Details of Fowler flaps, slats and nose flaps.

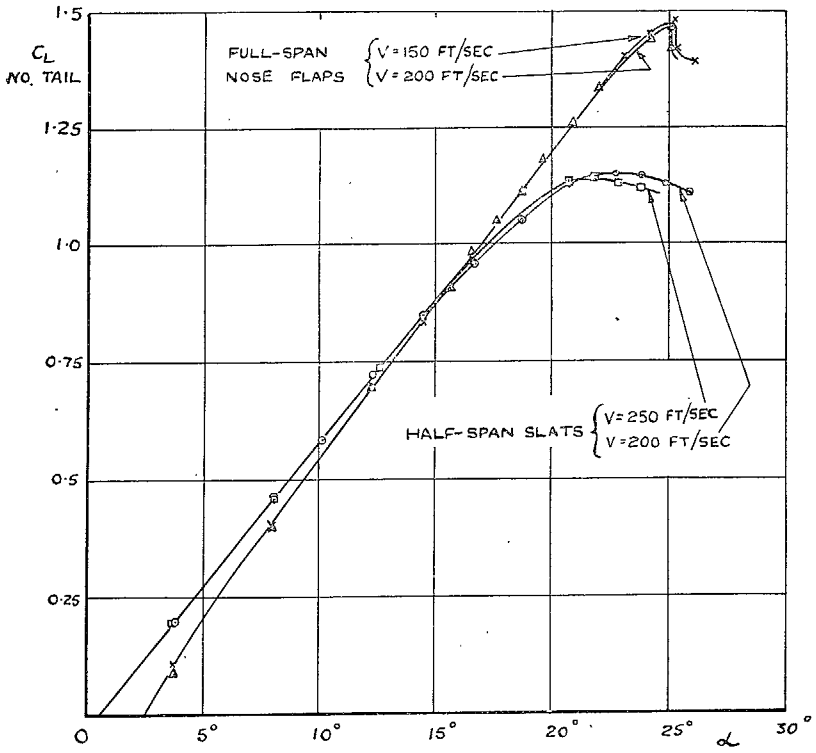

FIG. 3. Scale effect on lift.

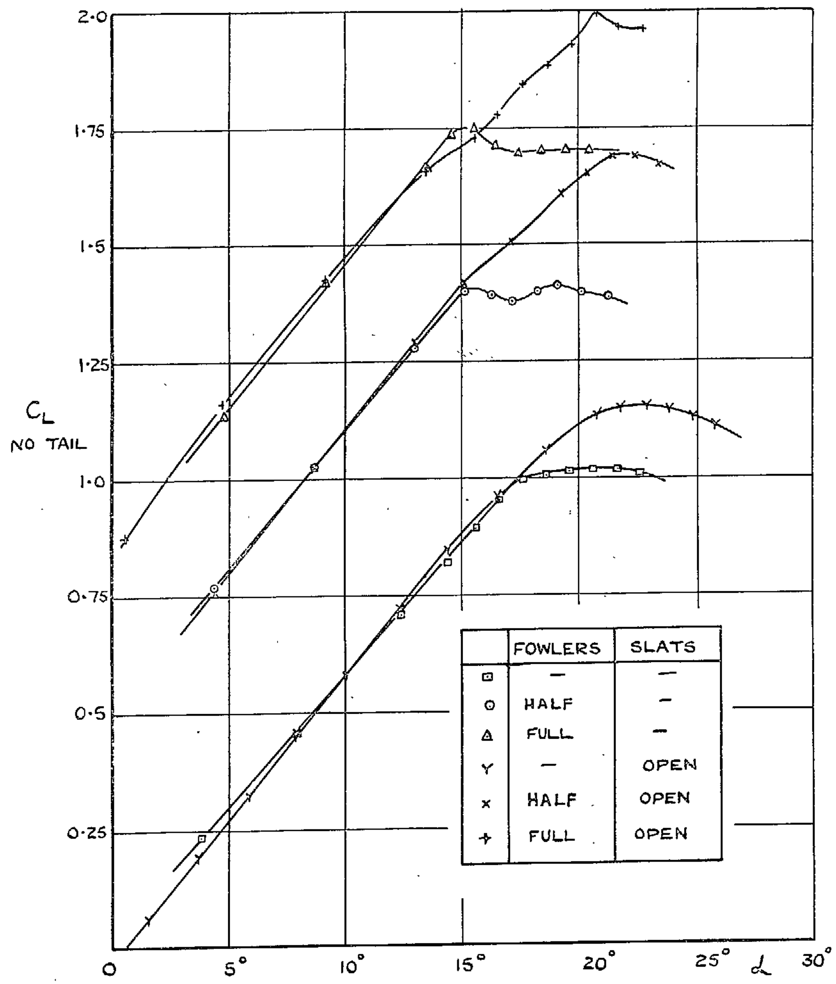

FIG. 4. Effects of slats and Fowler flaps on lift.

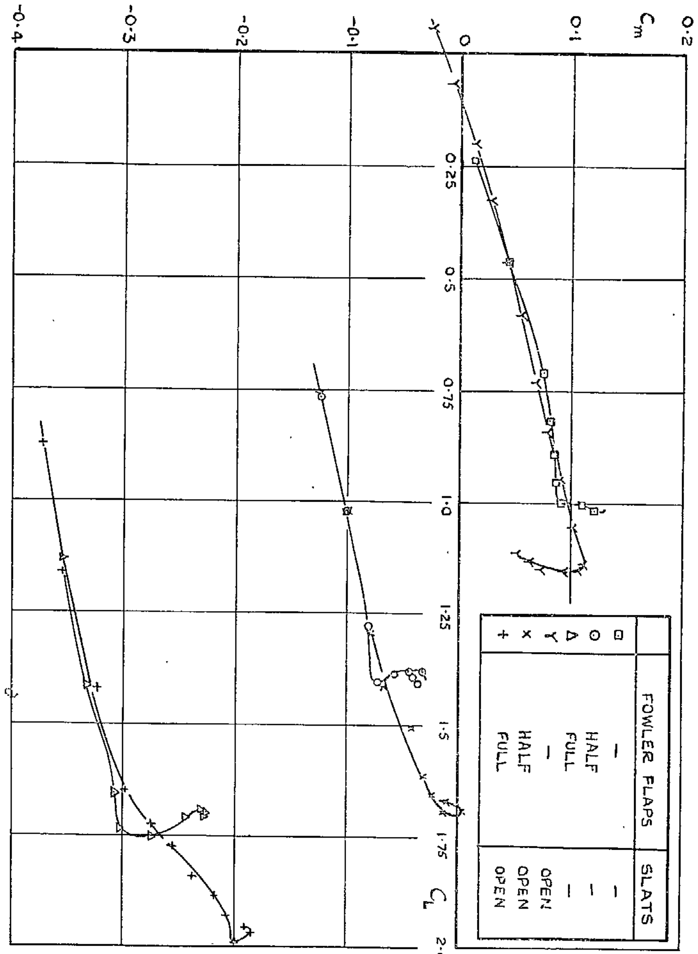

FIG. 5. Effects of slats and Fowler flaps on pitching moments.

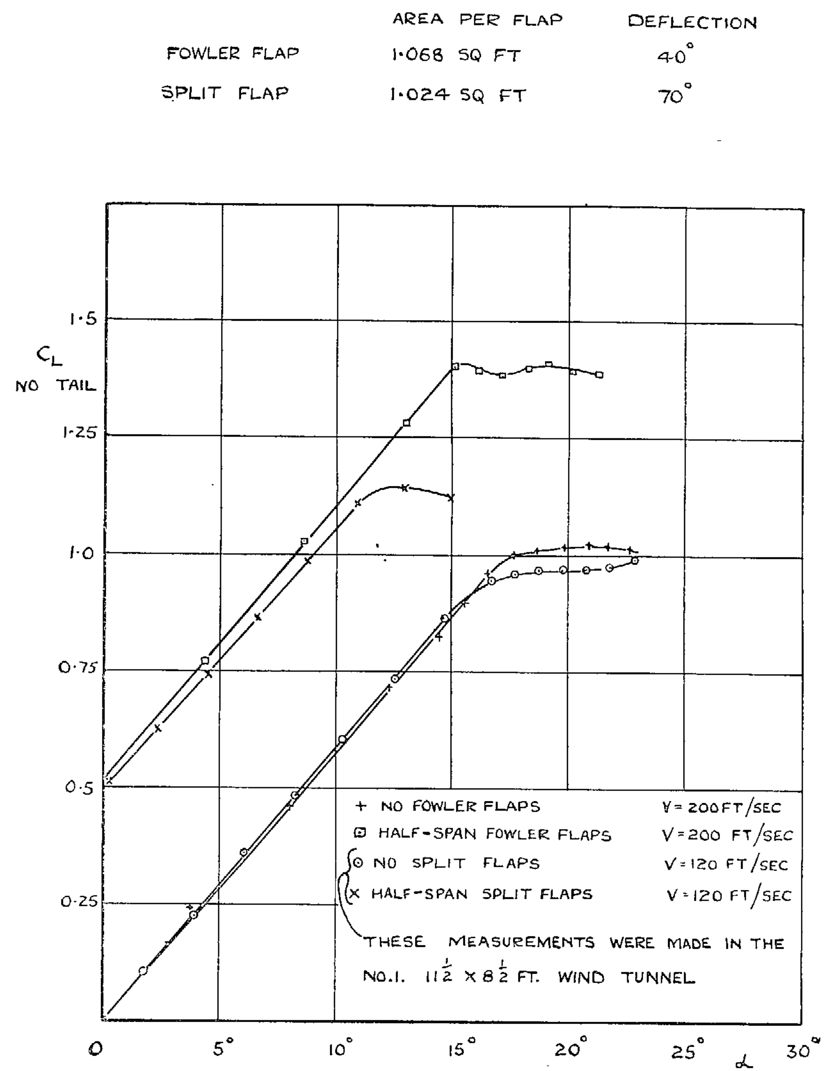

FIG. 6. Lift curves showing effects of Fowler and split flaps.

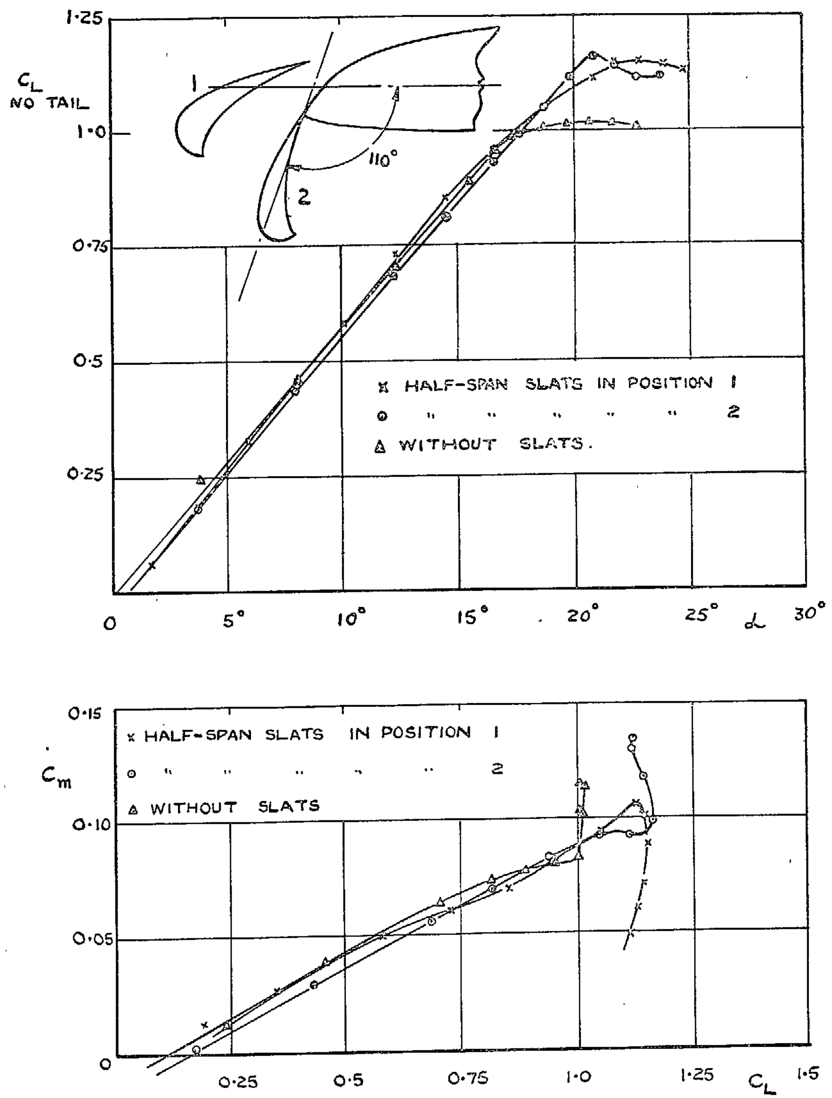

FIG. 7. Effects of slats in nose flap position (i.e. zero gap).

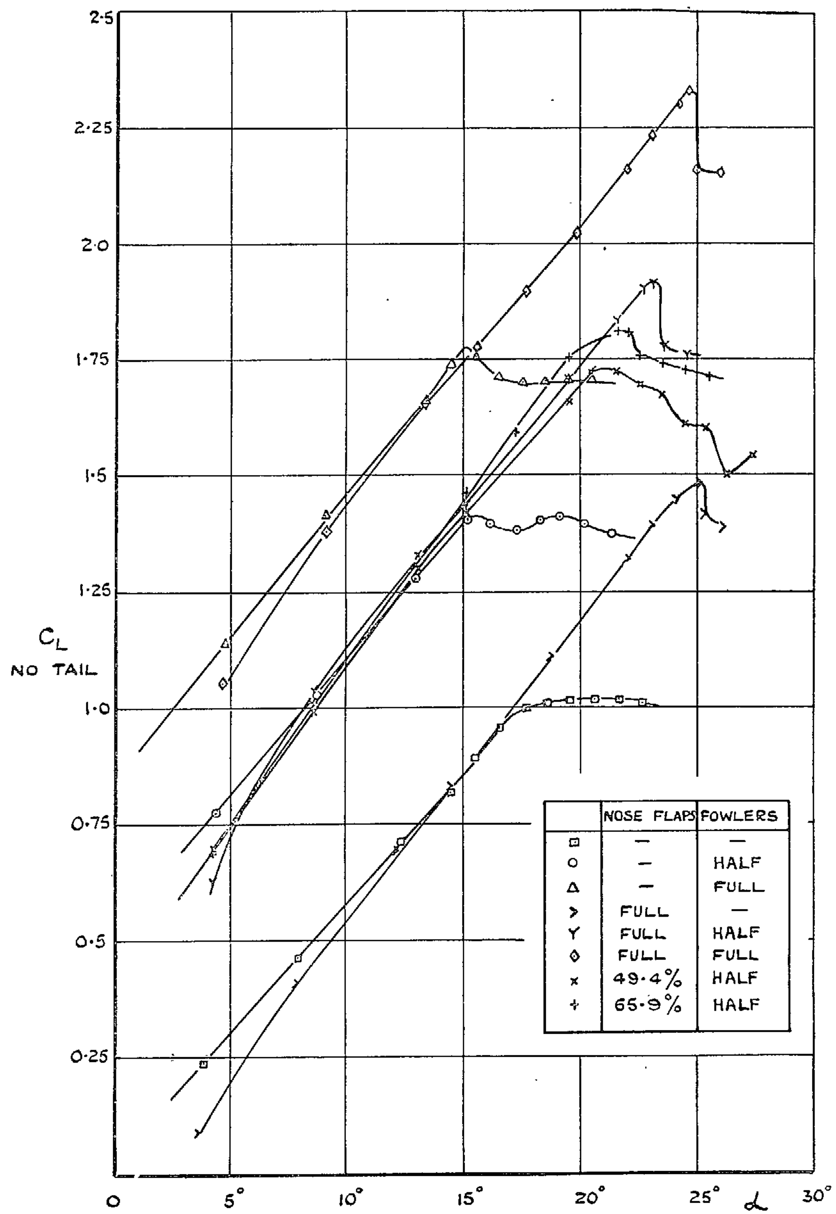

FIG. 8. Lift coefficients with nose flaps and Fowler flaps.

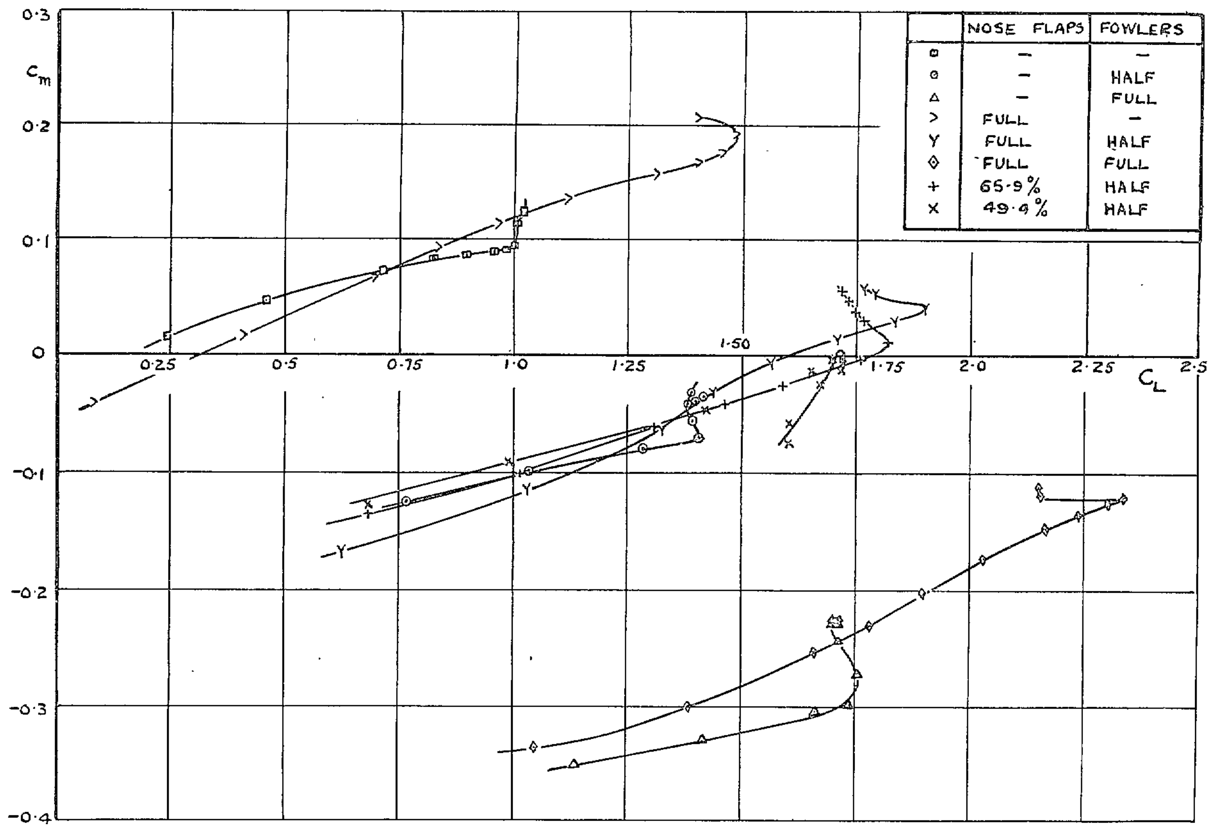

FIG. 9. Pitching moments with nose flaps and Fowler flaps.

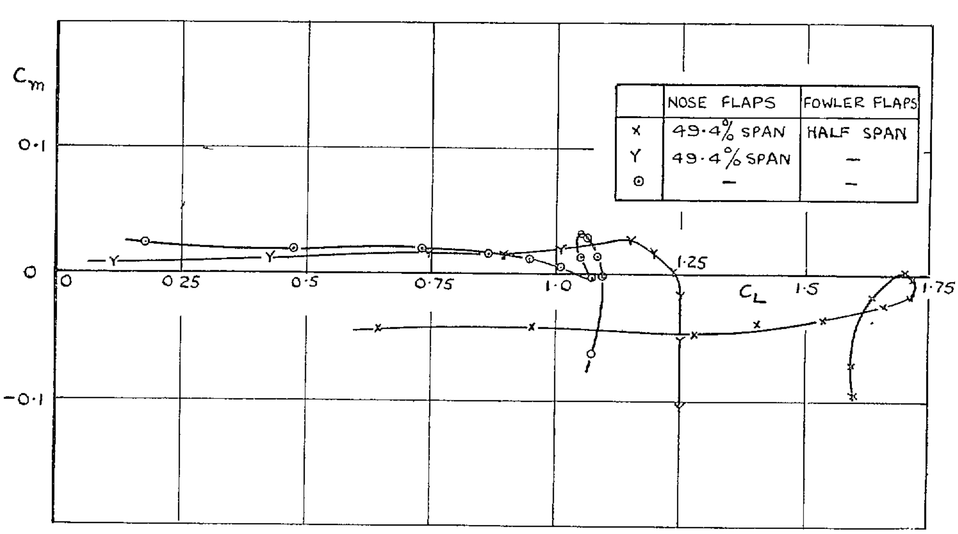

FIG. 10. Effects of nose flaps and Fowler flaps on pitching moments with tail.

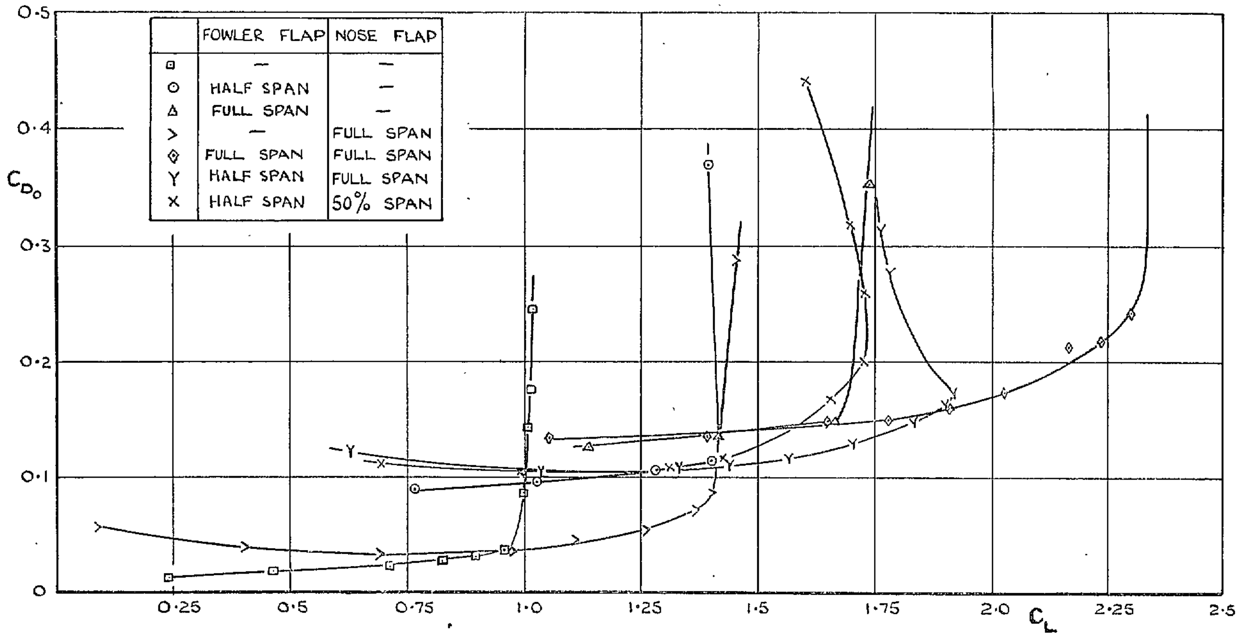

Fig. 11. Profile drag coefficients.

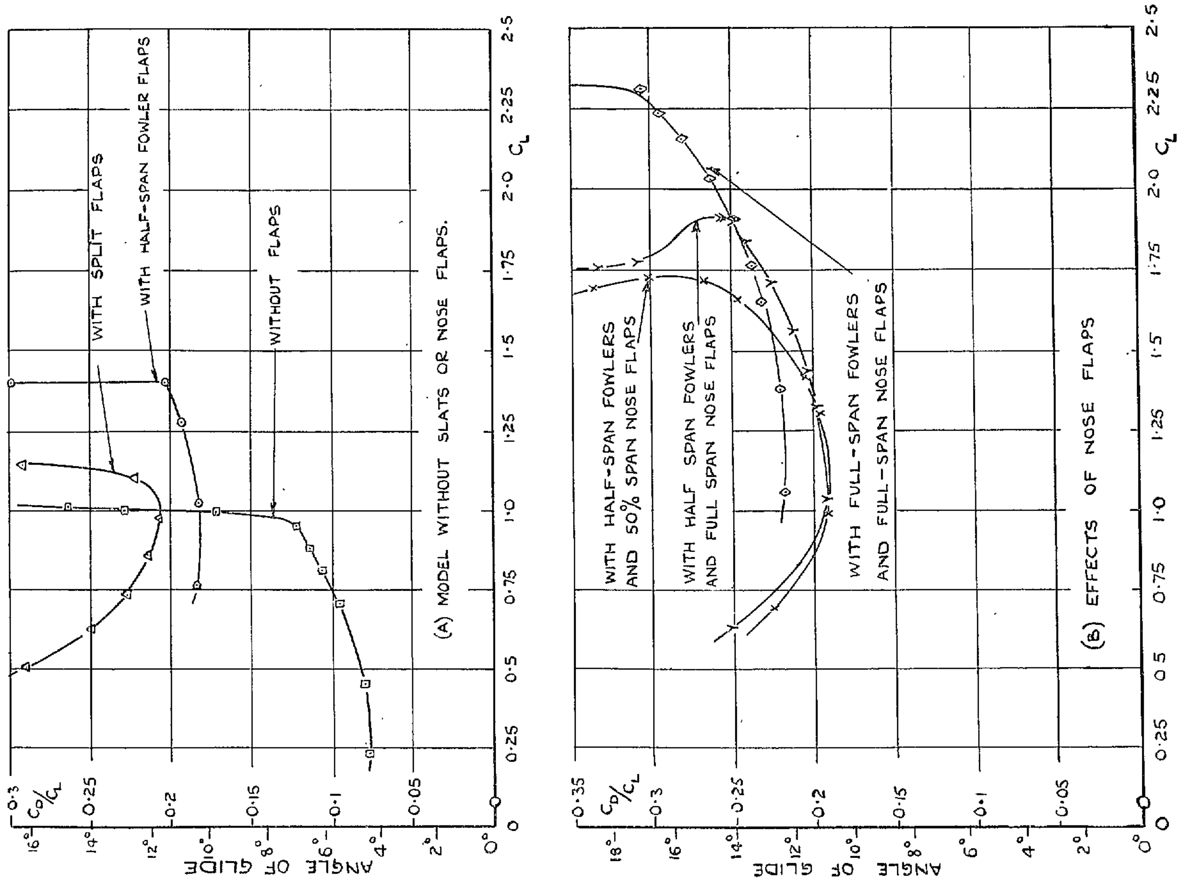

Fig. 12. Angles of glide.

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