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# ROYAL AIRCRAFT ESTABLISHMENT

Farnborough, Hants.

## EFFECT OF A CHORDWISE GAP ON THE TIP STALL OF A SWEEP BACK WING

by

D. J. KETTLE

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Report No. Aero.2165  
October, 1946.

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

The effect of a chordwise gap on the tip stall  
of a swept back wing.

by

D. J. Kettle

R.A.E. Ref. Aero 1483/L/169  
M.O.S. Ref. S.B.50138/R.D.T.1(c)

SUMMARY

During previous tests on a 12 ft. span model of a tailless glider with  $36.4^\circ$  of sweepback, a preliminary run made over the higher range of  $C_L$  indicated that chordwise gaps  $\frac{1}{4}$ " wide between the variable incidence wing tips and the main wing had a considerable stabilizing effect (flaps and elevons  $0^\circ$ ).

These tests were made to investigate this effect, more fully.

The gap removes most of the reduction in stability which is due to the tip stall, while having little other effect.

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1 Introduction

During previous tests<sup>1</sup> on a 12ft span model of a tailless glider with 36.4° of sweepback a preliminary run made over the higher range of  $C_L$  indicated that chordwise gaps  $\frac{1}{2}$ " wide between the variable incidence tips and the main wing had a considerable stabilizing effect: (Flaps, elevons and variable incidence tips set at 0°). It was decided to investigate the effect of the gaps over the lower range of  $C_L$ , and in addition over the whole range of  $C_L$  with flaps 60° and elevons -10°.

The tests were made in the R.A.E. 24 ft. Wind Tunnel during July and September, 1946.

2 Description of test rig

Details of the model (which is the same as that used for the tests described in ref.1.) are given in Appendix I and in fig.1.

3 Range of investigations

Lift, drag and pitching moment measurements were made with the chordwise gaps sealed and unsealed (flaps and elevons 0°, and flaps 60°, elevons -10°). The variable incidence wing tips were set at 0° throughout. The tests were made at a constant windspeed of 120 ft./sec. giving a Reynold's Number of  $1.55 \times 10^6$  based on mean wing chord.

4 Results

4.1 Presentation of results

Definitions of the conventions used are given in Appendix II.

4.2 Discussion of results

Lift and pitching moment curves are given in figs. 2,3, and 4,5 for the two cases of flaps and elevons 0°, and flaps 60° and elevons -10° respectively. The stabilizing effect of the chordwise gaps found in the case of the plain wing<sup>1</sup> is shown in fig.3 to be present only above a  $C_L$  of 0.75, below which value the gaps have little effect. With flaps 60° and elevons -10° the gaps have little effect up to the stall, but cause a reduction in  $C_{L,max}$  of 0.04.

Values of  $C_D$  are plotted against  $C_L$  in Figs. 6 and 7.  $C_{D,min}$  remains unaffected by the presence of the gaps in the two cases tested.

5 Conclusions

The general conclusions drawn from these tests may be summarized as follows:-

(i) There is a pronounced instability of the wing above a  $C_L$  of 0.75, which is much improved by opening chordwise gaps between the main wing and the variable incidence tips: (flaps and elevons -10°).

(ii) With flaps 60° and elevons -10° the gaps have little effect on the stability below the stall, but cause a reduction in  $C_{L,max}$  of 0.04.

LIST OF REFERENCES

<u>No.</u>	<u>Author</u>	<u>Title etc.</u>
1	D.J. Kettle	24ft. Wind Tunnel Tests on the G.A. V wing tailed glider. Part 1: Lift, drag and pitching moment measurements. A.R.C. 9704 R.A.E. Report No. Aero.2124. March, 1946.

Attached : 19604S - 19608  
Appendices I and II  
Tables I and II

Circulation

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Appendix I

Model data (Scale 1/3.78)

Wing:

gross area	S = 24.60 ft. <sup>2</sup>
span	b = 12.0 ft.
mean chord	$\bar{c}$ = 2.05 ft.
aspect ratio	A = 5.85
root chord	C <sub>R</sub> = 3.00 ft.
tip chord	C <sub>T</sub> = 0.965 ft.
root section	18% R.A.F. 34
tip section	15% R.A.F. 34
dihedral angle	Y = 2.9°
geometric washout	5°
mean 1/4 chord point position	
behind L.S. root chord	2.408 ft.
above " " "	0.1049 ft.

Elecons:

span (each)	3.34 ft.
area aft of hinge	1.51 ft. <sup>2</sup>
chord aft of hinge	30% local chord

Flaps

type	split
angle when open	60°
span from C/L of aircraft	2.7 ft.
area	1.42 ft. <sup>2</sup>
chord 20% local chord i.e. root	7.20 ins.
tip	4.31 ins.

Variable incidence tips:

span (each)	30% semispan
hinge line	on 25% chord.

Appendix II

Sweepback angle: measured from C/L of aircraft

The angle between the y axis and the projection of line AC (see fig.1) on the xy plane.

Dihedral angle : measured on the sweepback portion only

The angle between the y axis and the projection of the line BC (see fig.1) on the yz plane.

A, B and C are sectional 1/4 chord points. (The xyz axes are defined as in all R & M'S; for these models the x axis is taken to be parallel to the root chord).

Mean quarter chord point:

The position of the mean quarter chord point is defined as  $\bar{x}$ ,  $\bar{z}$ , where

$$\bar{x} = \int_{-b/2}^{+b/2} ox dy + S \qquad \bar{z} = \int_{-b/2}^{+b/2} cz dy + S$$

where  $S = \int_{-b/2}^{+b/2} ody = \text{gross wing area.}$

Elevon angle

$\eta$ ; positive when elevon is deflected downwards; measured as the angle between the elevon chord normal to the hinge line and the xy plane.

Variable incidence wing tip angle

The angle of the variable incidence wing tip is defined as positive when the trailing edge of the tip moves downwards.

The values of  $\alpha$  have been corrected for tunnel constraint.

TABLE I

Lift, drag and pitching moment coefficients

Effect of sealing gaps between main wing and tips. Variable incidence tips set at 0°.

Flaps 0° Elevons 0°

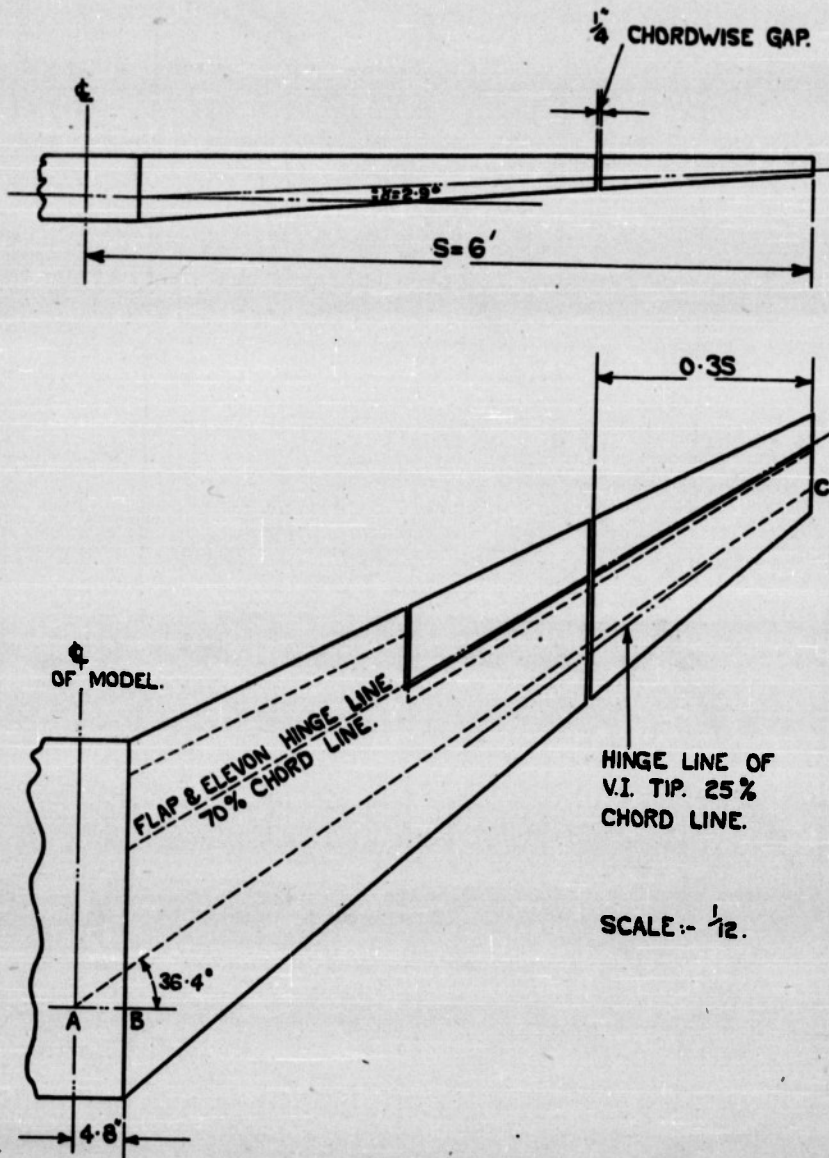
Gap unsealed				Gap sealed			
$\alpha^\circ$	$C_L$	$C_D$	$C_{m-\frac{c}{4}}$	$\alpha^\circ$	$C_L$	$C_D$	$C_{m-\frac{c}{4}}$
- 0.43	-0.063	0.033	+0.025	+ 0.53	+0.007	0.031	+0.018
+ 1.60	+0.078	0.030	+0.015	+ 3.64	+0.239	0.035	+0.003
+ 4.23	+0.261	0.033	+0.001	+ 6.27	+0.418	0.038	-0.009
+ 6.46	+0.446	0.041	-0.010	+ 8.41	+0.567	0.047	-0.019
+ 9.00	+0.596	0.051	-0.017	+11.24	+0.745	0.064	-0.027
+11.45	+0.743	0.065	-0.027	+13.19	+0.865	0.080	-0.021
+13.88	+0.898	0.091	-0.030	+14.00	+0.947	0.087	-0.016
+15.65	+0.980	0.110	-0.032	+15.60	+1.030	0.112	+0.001
+16.10	+1.062	0.124	-0.024	+17.60	+1.110	0.140	+0.025
+18.30	+1.169	0.159	-0.021	+19.80	+1.194	0.185	+0.040
+20.50	+1.267	0.202	-0.020	+21.80	+1.267	0.230	+0.052
+22.70	+1.317	0.247	-0.013	+23.90	+1.305	0.281	+0.075
+23.70	+1.320	0.258	-0.010	+26.10	+1.315	0.335	+0.081
+25.20	+1.336	0.299	+0.001	+28.30	+1.306	0.389	+0.085
+27.10	+1.371	0.353	-0.007	+30.00	+1.318	0.439	+0.091
+29.60	+1.339	0.421	-0.019				

TABLE IILift, drag and pitching moment coefficients

Effect of sealing gaps between main wing and tips. Variable incidence tips set at 0°.

Flaps 60°, Elevons -10°

Gap Unsealed				Gap sealed			
$\alpha^\circ$	$C_L$	$C_D$	$C_{m\frac{c}{4}}$	$\alpha^\circ$	$C_L$	$C_D$	$C_{m\frac{c}{4}}$
- 1.46	0.252	0.144	0.114	- 0.49	0.313	0.146	0.117
+ 0.77	0.412	0.145	0.102	+ 2.43	0.507	0.148	0.095
+ 3.40	0.588	0.149	0.037	+ 5.35	0.705	0.152	0.078
+ 5.85	0.728	0.157	0.074	+ 8.28	0.904	0.161	0.056
+ 8.57	0.917	0.170	0.053	+11.21	1.081	0.175	0.034
+10.93	1.035	0.188	0.041	+14.14	1.246	0.198	0.019
+13.18	1.160	0.213	0.025	+17.10	1.366	0.235	0.027
+14.16	1.213	0.228		+19.18	1.444	0.308	0.091
+16.52	1.311	0.260	0.019	+21.19	1.436	0.336	0.104
+18.68	1.445	0.302	0.052	+23.18	1.448	0.378	0.107
+20.38	1.151	0.331	0.054				
+22.17	1.157	0.358	0.054				



G.A. TAILLESS WING.  
 $36.4^\circ$  SWEEPBACK.

(9)

FIG. 2 & 3.

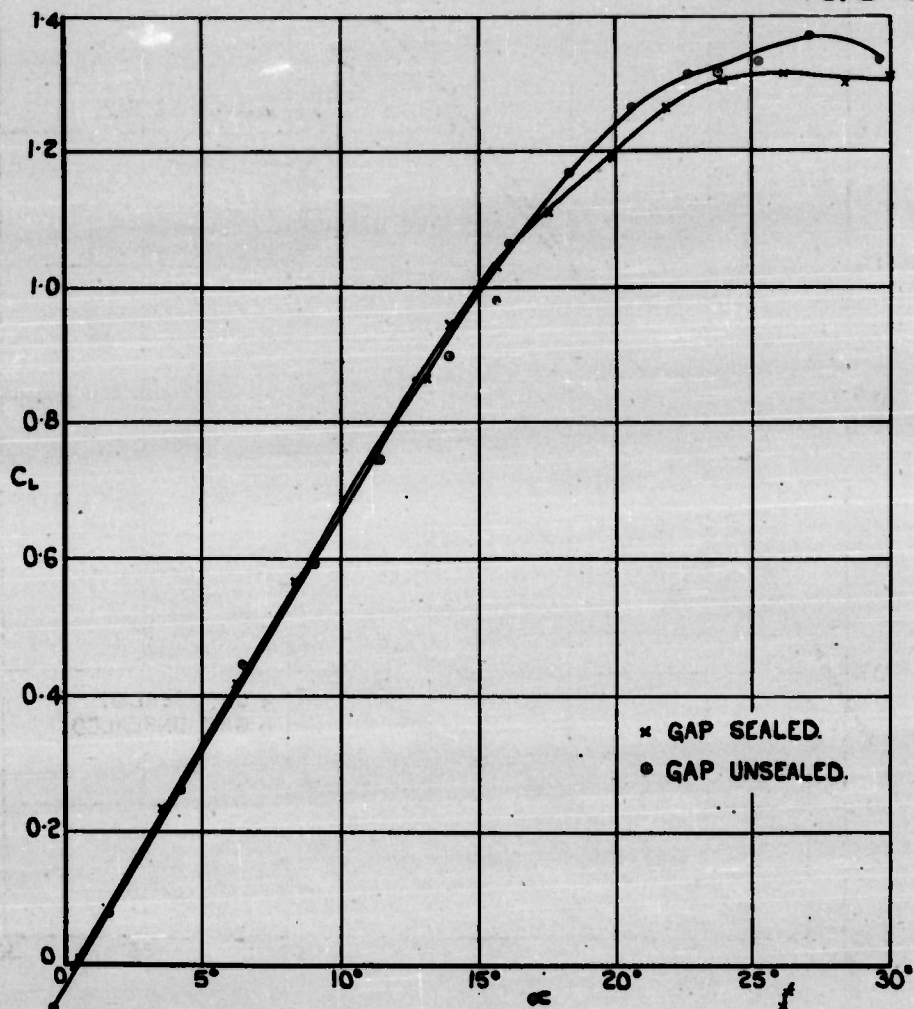


FIG. 2  $C_L$  vs  $\alpha$

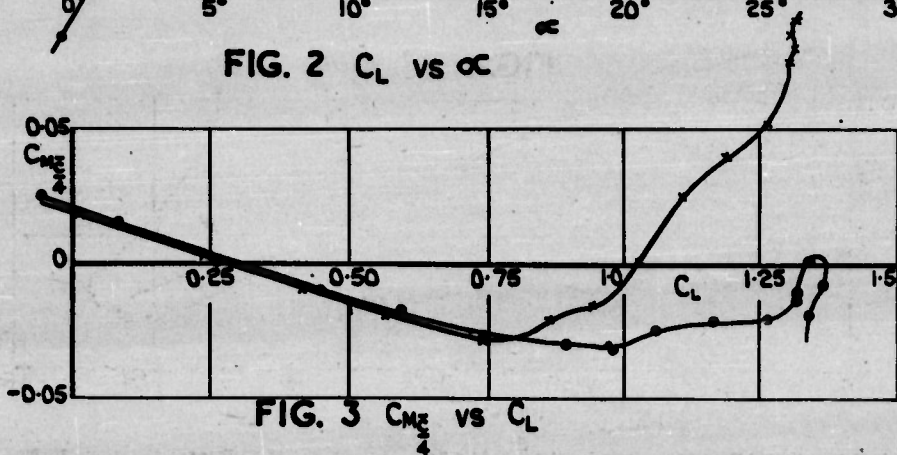


FIG. 3  $C_{ME}/4$  vs  $C_L$

THE EFFECT OF SEALING THE GAPS BETWEEN THE MAIN WING AND VARIABLE INCIDENCE TIPS. FLAPS AND ELEVONS 0°

FIG. 4 & 5.

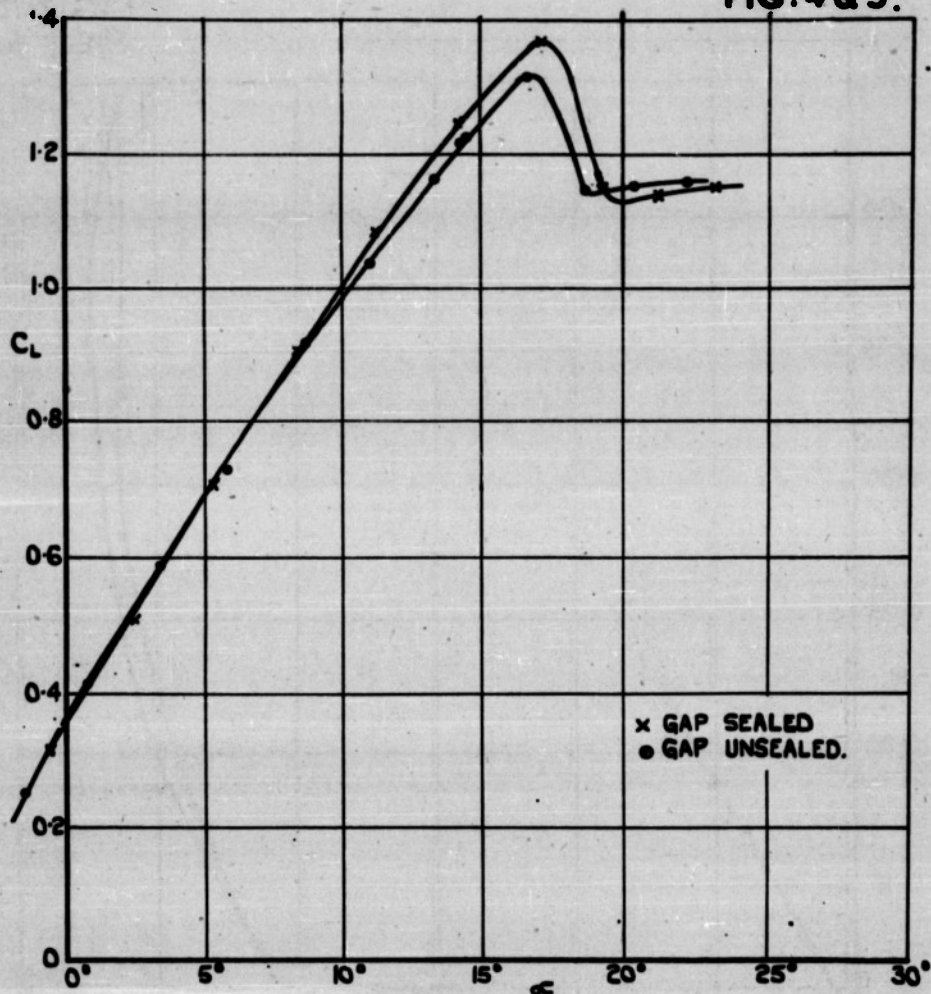


FIG. 4.  $C_L$  vs  $\alpha$

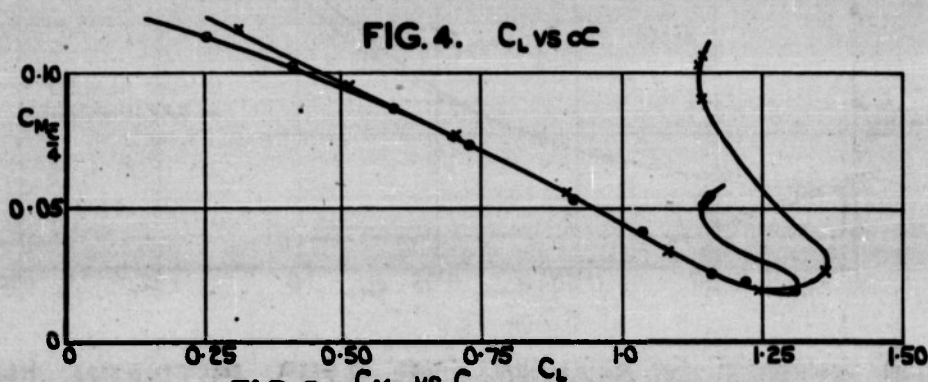
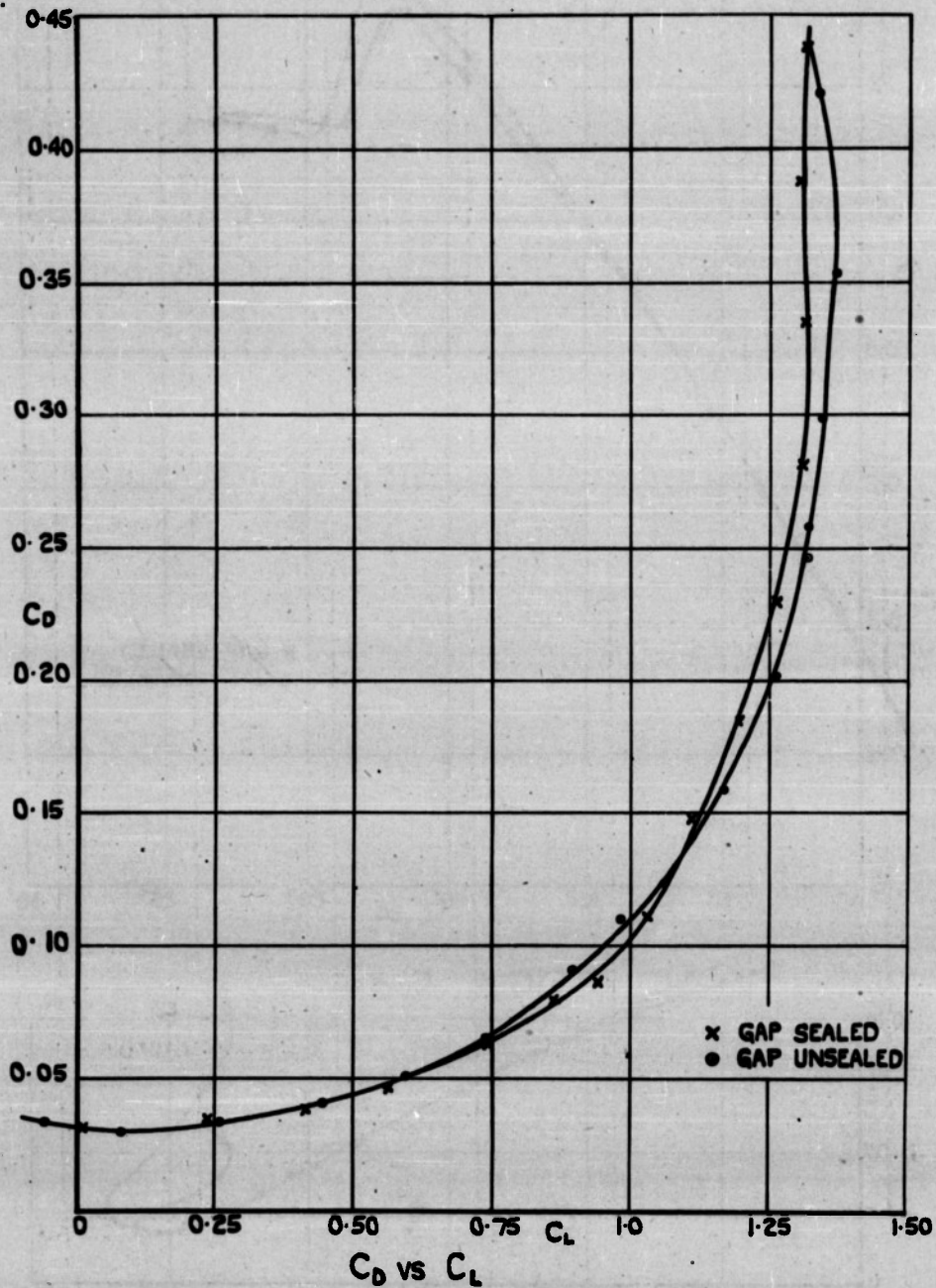


FIG. 5.  $C_{Mz}$  vs  $C_L$

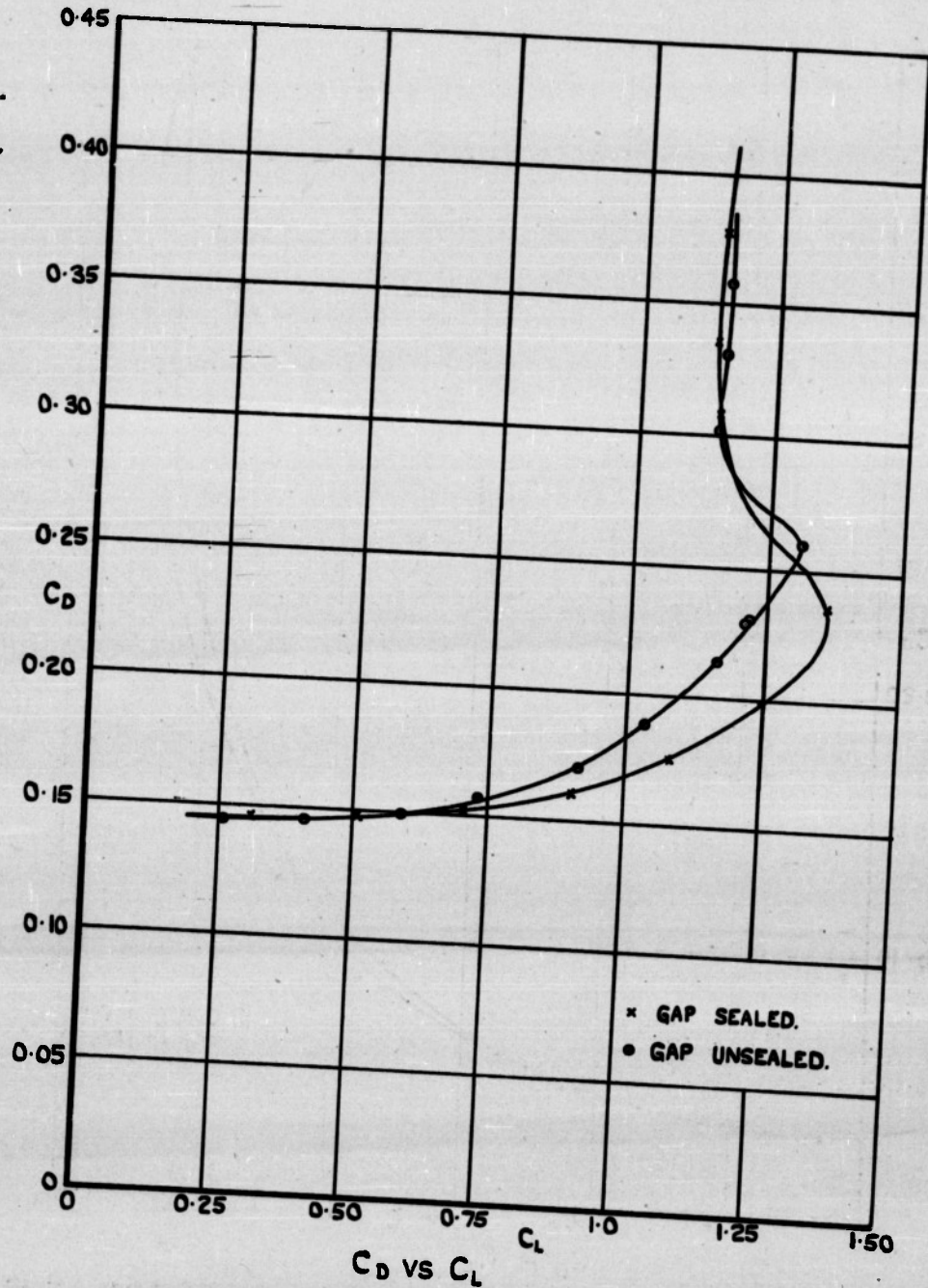
THE EFFECT OF SEALING GAPS BETWEEN THE MAIN WING AND VARIABLE INCIDENCE TIPS. FLAPS 60° ELEVONS -10°

FIG. 6.



THE EFFECT OF SEALING THE GAPS BETWEEN THE  
 MAIN WING AND V.I. TIPS.  
 FLAPS AND ELEVONS 0°

FIG. 7.



$C_D$  VS  $C_L$   
 THE EFFECT OF SEALING THE GAPS  
 BETWEEN THE MAIN WING AND V.I. TIPS  
 FLAPS 60°, ELEVONS -10°.

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TITLE: Effect of a Chordwise Gap on the Tip Stall of a Swept Back Wing

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## ABSTRACT:

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