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WIND-TUNNEL INVESTIGATION OF NACA 66(215)-216, 66,1-212, AND 65_1-212 AIRFOILS WITH 0.20-AIRFOIL-CHORD SPLIT FLAPS

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NACA

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CONFIDENTIAL BULLETIN

WIND-TUNNEL INVESTIGATION OF NACA 66(215)-216, 66,1-212, AND 65_1-212 AIRFOILS WITH 0.20-AIRFOIL-CHORD SPLIT FLAPS

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SUMMARY

An investigation was carried out in the NACA two-dimensional low-turbulence pressure tunnel of the NACA 66(215)-216, 66,1-212, and 65_1-212 airfoil sections equipped with split flaps having chords 20 percent of the airfoil chord. The purpose was to determine the maximum-lift characteristics of these low-drag airfoil sections with split flaps. All the present tests were made at a Reynolds number of approximately 6×10^6 and a Mach number of about 0.15.

The maximum lift coefficients of these airfoils without and with flaps are summarized as follows:

Airfoil section	Maximum section lift coefficient		Flap deflection (deg)
	Without flaps	With flaps	
NACA 66(215)-216	1.56	2.61	70
NACA 66,1-212	1.41	2.17	70
NACA 65_1-212	1.49	2.15	60

INTRODUCTION

Extensive tests of split flaps and other types of high-lift device used in conjunction with the older conventional airfoils have been conducted in wind tunnels and in flight. Because of the data available and because of the simplicity of this device, the split flap may conveniently be used as a basis for comparing the maximum-lift characteristics of various airfoil sections equipped with trailing-edge high-lift devices. The present investigation was carried out in the NACA two-dimensional low-turbulence pressure tunnel to supply information on the maximum-lift and pitching-moment characteristics of three low-drag airfoil sections with split flaps.

The NACA 66(215)-216, the NACA 66,1-212, and the NACA 65_1-212 airfoils were equipped with split flaps having chords 20 percent of the airfoil chords (0.20c). Lift and pitching-moment data were obtained for each airfoil for a range of flap deflection from 40° to 70° at a Reynolds number of approximately 6×10^6. Because the tests were conducted at a Mach number of approximately 0.15, the results are believed to be free from the effects of compressibility.

APPARATUS AND METHODS

The tests were made in the NACA two-dimensional low-turbulence pressure tunnel (designated TDT) by the methods described in reference 1. All data have been corrected for tunnel-wall effect. The ordinates for the airfoils tested are presented in tables I to III.

The 2-foot-chord models were constructed of mahogany with chordwise laminations, and the surfaces were painted and sanded until aerodynamically smooth. The split flaps were simulated by triangular blocks of laminated mahogany attached to the lower surface of the model. One face of the block was cut to the contour of the flap portion of the airfoil lower surface. A typical arrangement is shown in figure 1.

RESULTS AND DISCUSSION

The section lift and pitching-moment characteristics for the NACA 66(215)-216, 66,1-212, and 65_1-212 airfoil sections are presented in figures 2, 3, and 4, respectively. The lift and pitching-moment characteristics of the plain airfoil are included for comparison with the airfoils with flaps deflected. A comparison of the maximum lift coefficients of the three sections tested in the present investigation is given in figure 5, with similar data for the NACA 23012 airfoil from reference 2. Figure 6 shows the variation of the increment of maximum section lift coefficient $\Delta c_{l_{max}}$ with flap deflection for the various airfoils.

An examination of figure 5 shows that higher maximum lifts were obtained with the plain NACA 65_1-212 airfoil than with the plain NACA 66,1-212 airfoil. When the flaps were deflected, however, the maximum lift coefficients for both airfoils were approximately equal. A similar comparison between the two NACA 66-series airfoils shows that considerably higher maximum lift coefficients for all flap deflections were obtained with the 16-percent-thick airfoil. The increments of maximum lift coefficient for this airfoil section were, on the average, 34 percent higher than the increments obtained with the NACA 66,1-212 airfoil section. (See fig. 6.) The increased maximum lift coefficients for the NACA 66(215)-216 airfoil are attributed to the greater thickness and consequent increase in leading-edge radius. Figure 5 also shows that the maximum lift coefficients obtained with the plain NACA 66(215)-216 airfoil at a Reynolds number of 6×10^6 were approximately the same as those obtained from tests of the NACA 23012 airfoil of reference 2 at an effective Reynolds number of 3.5×10^6. For most flap deflections tested, the values of $c_{l_{max}}$ and $\Delta c_{l_{max}}$ (figs. 5 and 6) obtained with the 16-percent-thick low-drag airfoil were higher than those obtained with the 12-percent-thick conventional airfoil.

RESULTS AND DISCUSSION

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SUMMARY OF RESULTS

The maximum lift coefficients of three low-drag airfoils without and with 0.20-airfoil-chord split flaps obtained from tests at a Reynolds number of approximately 6×10^6 are as follows:

Airfoil section	Maximum section lift coefficient		Flap deflection (deg)
	Without flaps	With flaps	
NACA 66(215)-216	1.56	2.61	70
NACA 66,1-212	1.41	2.17	70
NACA 65_1-212	1.49	2.15	60

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REFERENCES

1. Jacobs, Eastman N., Abbott, Ira H., and Davidson, Milton: Preliminary Low-Drag-Airfoil and Flap Data from Tests at Large Reynolds Numbers and Low Turbulence, and Supplement. NACA ACR, March 1942.

2. Wenzinger, Carl J., and Harris, Thomas A.: Wind-Tunnel Investigation of N.A.C.A. 23012, 23021, and 23030 Airfoils with Various Sizes of Split Flap. NACA Rep. No. 668, 1939.

TABLE I.- NACA 66(215)-216 AIRFOIL

[Stations and ordinates are given in percent of airfoil chord]

Upper surface		Lower surface	
Station	Ordinate	Station	Ordinate
0	0	0	0
.401	1.230	.599	-1.130
.640	1.484	.860	-1.344
1.128	1.858	1.372	-1.644
2.362	2.560	2.638	-2.188
4.846	3.604	5.154	-2.972
7.340	4.428	7.660	-3.580
9.838	5.140	10.162	-4.106
14.845	6.276	15.155	-4.930
19.860	7.156	20.140	-5.564
24.879	7.844	25.121	-6.054
29.900	8.366	30.100	-6.422
34.924	8.736	35.076	-6.676
39.949	8.980	40.051	-6.838
44.974	9.092	45.026	-6.902
50.000	9.060	50.000	-6.854
55.025	8.875	54.975	-6.685
60.048	8.496	59.952	-6.354
65.067	7.862	64.933	-5.802
70.081	6.941	69.919	-4.997
75.087	5.860	74.913	-4.070
80.085	4.644	79.915	-3.052
85.075	3.395	84.925	-2.049
90.055	2.103	89.945	-1.069
95.028	.913	94.972	-.281
100.000	0	100.000	0

L.E. radius: 1.575
Slope of radius through L.E.: 0.084

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TABLE II.- NACA 66,1-212 AIRFOIL

[Stations and ordinates are given in percent of airfoil chord]

Upper surface		Lower surface	
Station	Ordinate	Station	Ordinate
0	0	0	0
.424	.947	.576	-.847
.666	1.150	.834	-1.010
1.157	1.447	1.343	-1.233
2.395	1.986	2.605	-1.614
4.884	2.797	5.116	-2.165
7.379	3.441	7.621	-2.593
9.878	3.997	10.122	-2.963
14.884	4.885	15.116	-3.539
19.895	5.574	20.105	-3.982
24.909	6.112	25.091	-4.322
29.925	6.522	30.075	-4.578
34.943	6.816	35.057	-4.756
39.962	7.005	40.038	-4.863
44.981	7.093	45.019	-4.903
50.000	7.075	50.000	-4.869
55.019	6.939	54.981	-4.749
60.036	6.665	59.964	-4.523
65.051	6.195	64.949	-4.135
70.061	5.507	69.939	-3.563
75.066	4.683	74.934	-2.893
80.065	3.759	79.935	-2.167
85.058	2.770	84.942	-1.424
90.043	1.760	89.957	-.726
95.022	.792	94.978	-.160
100.000	0	100.000	0

L.E. radius: 0.893
Slope of radius through L.E.: 0.084

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TABLE III.- NACA 65_1-212 AIRFOIL

[Stations and ordinates are given in percent of airfoil chord]

Upper surface		Lower surface	
Station	Ordinate	Station	Ordinate
0	0	0	0
.423	.970	.577	-.870
.664	1.176	.836	-1.036
1.154	1.491	1.346	-1.277
2.391	2.058	2.609	-1.686
4.878	2.919	5.122	-2.287
7.373	3.593	7.627	-2.745
9.873	4.162	10.127	-3.128
14.879	5.073	15.121	-3.727
19.890	5.770	20.110	-4.178
24.906	6.300	25.094	-4.510
29.923	6.687	30.077	-4.743
34.942	6.942	35.058	-4.882
39.961	7.068	40.039	-4.926
44.981	7.044	45.019	-4.854
50.000	6.860	50.000	-4.654
55.017	6.507	54.983	-4.317
60.032	6.014	59.968	-3.872
65.043	5.411	64.957	-3.351
70.050	4.715	69.950	-2.771
75.053	3.954	74.947	-2.164
80.052	3.140	79.948	-1.548
85.045	2.302	84.955	-.956
90.033	1.463	89.967	-.429
95.017	.672	94.983	-.040
100.000	0	100.000	0

L.E. radius: 0.932
Slope of radius through L.E.: 0.084

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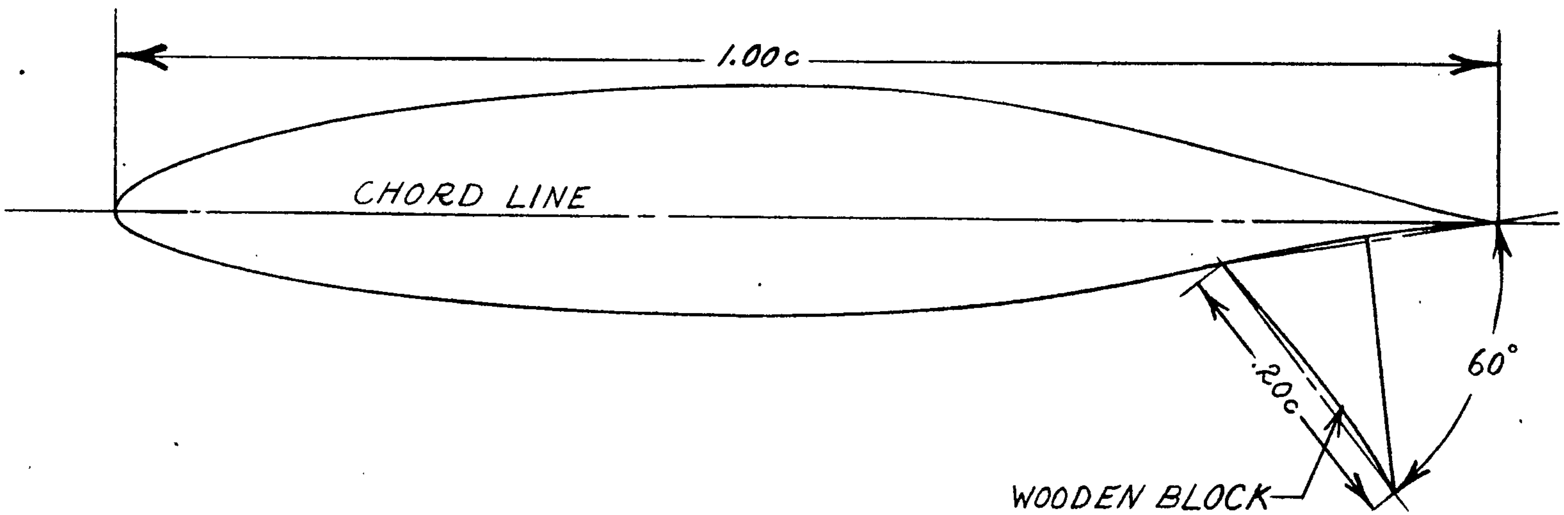

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Figure 1.- View showing the NACA 66(215)-216 airfoil with 0.20c split flap deflected 60°.

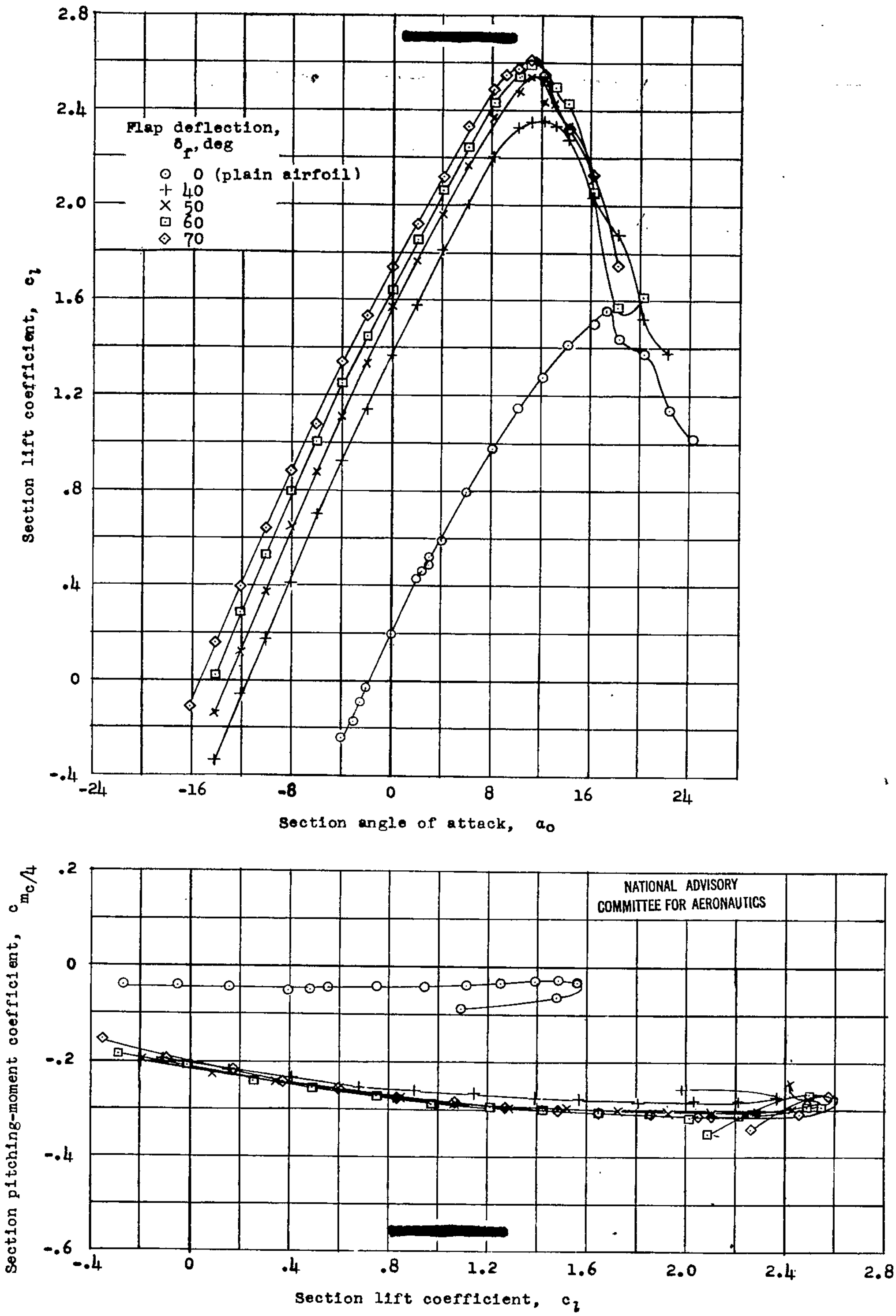

Figure 2.- Section lift and pitching-moment characteristics for an NACA 66(215)-216 airfoil with a 0.20c split flap; Reynolds number, R, 6×10^6. Tests, TDT 247, 568, 571.

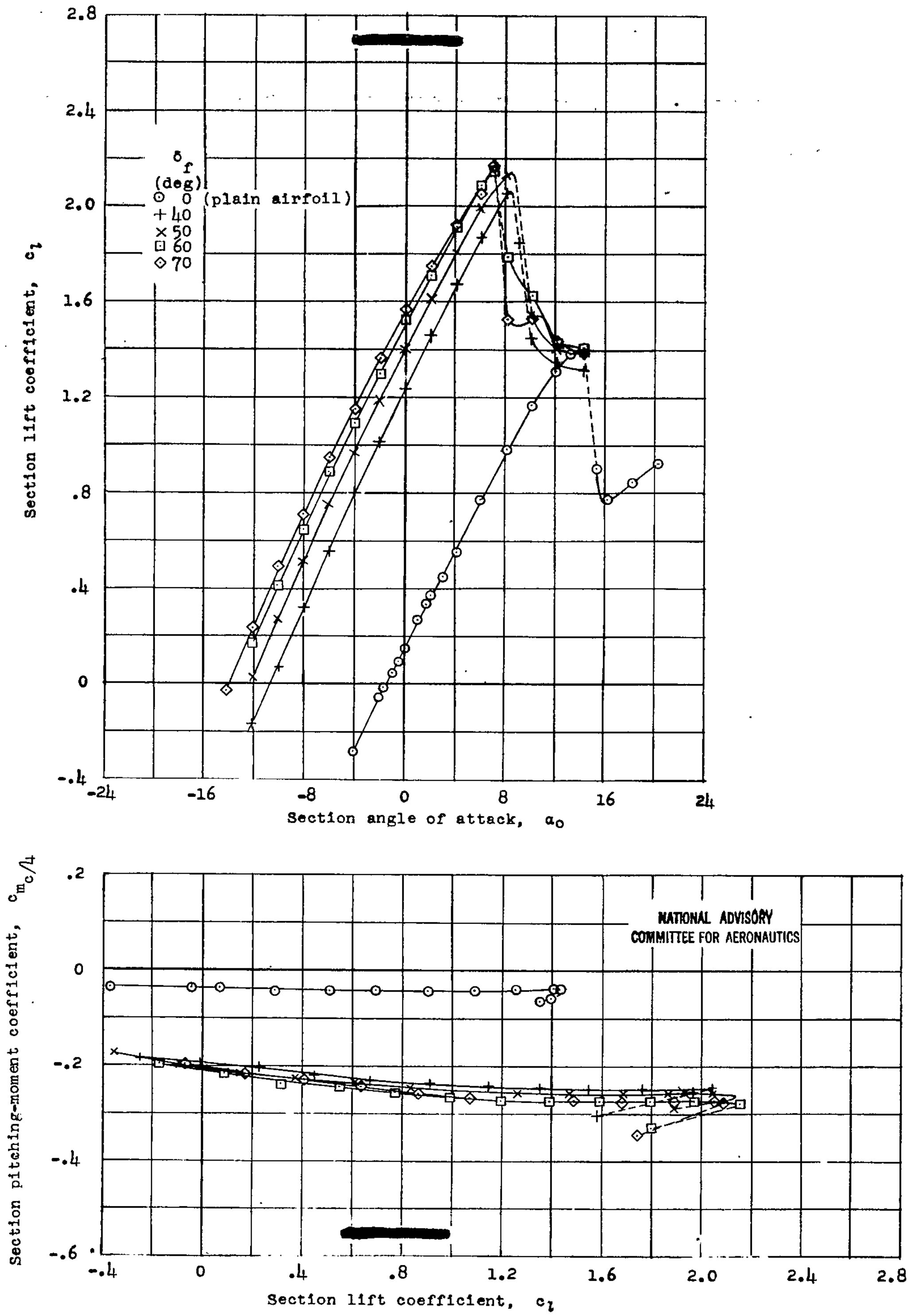

Figure 3.- Section lift and pitching-moment characteristics for an NACA 66,1-212 airfoil with a 0.20c split flap; R, 6×10^6. Tests, TDT 424, 570, 576, 602.

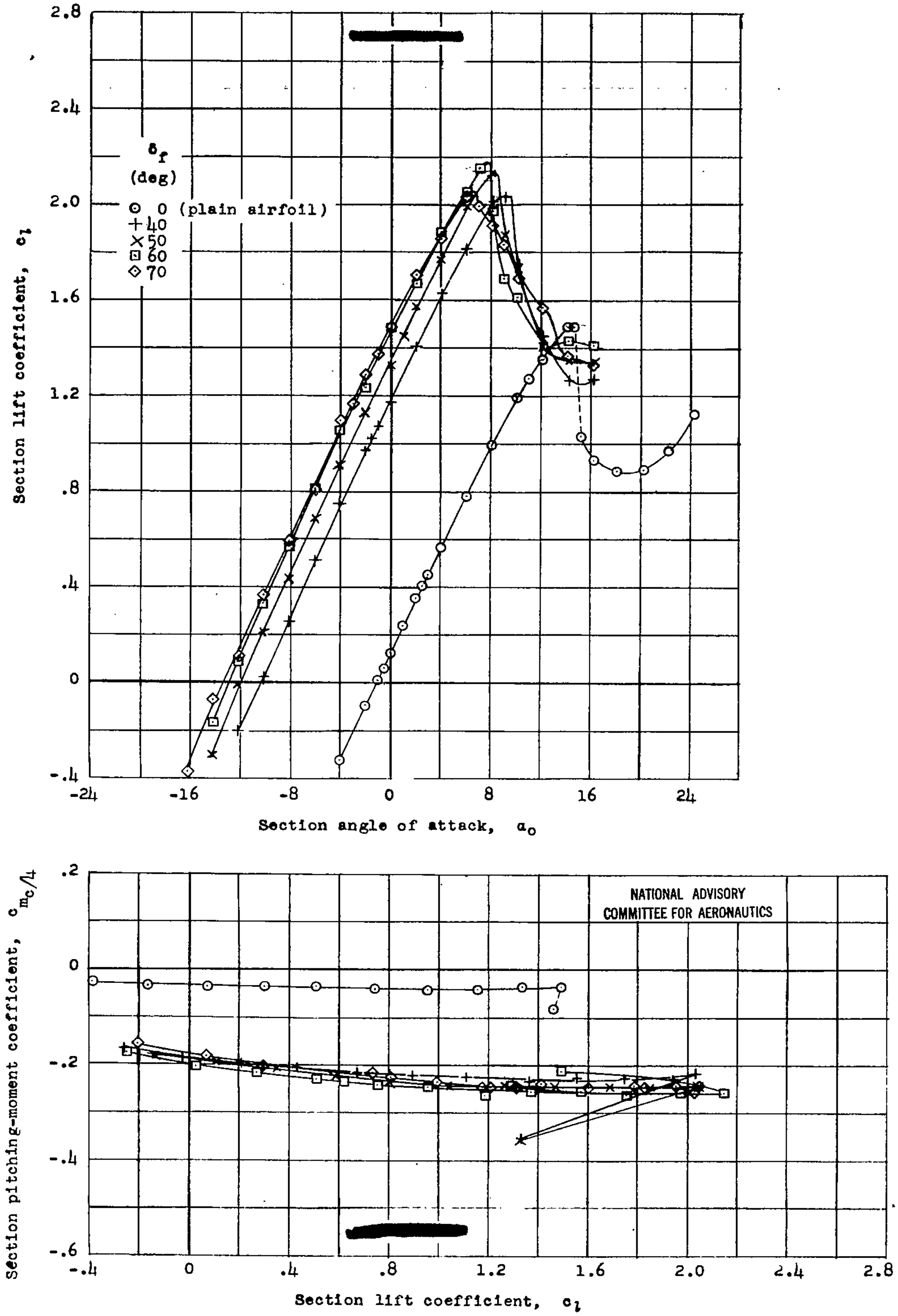

Figure 4 .- Section lift and pitching-moment characteristics for an NACA 65_1-212 airfoil with a 0.20c split flap; R, 6×10^6. Tests, TDT 356, 569, 599.

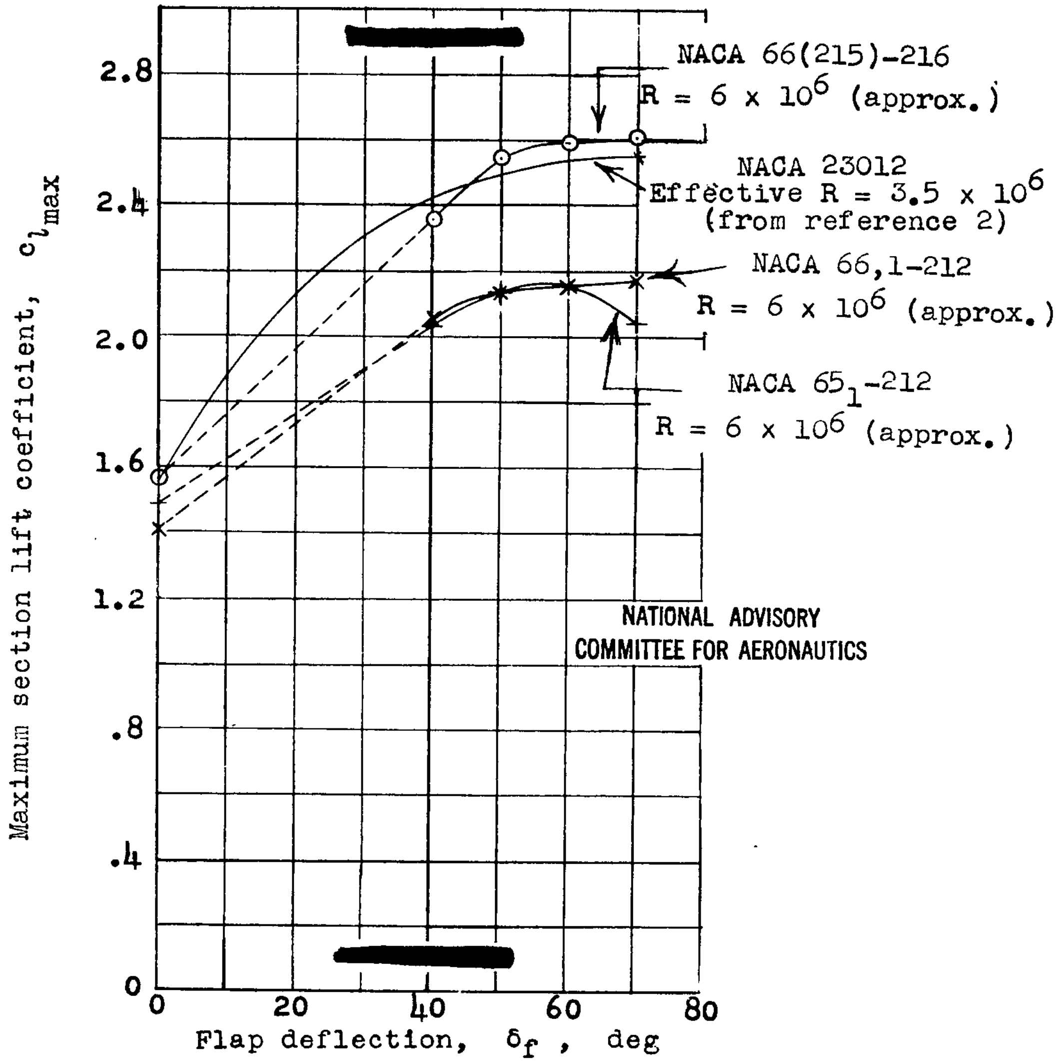

Figure 5.- Effect of flap deflection on maximum section lift coefficient for the various airfoil sections.

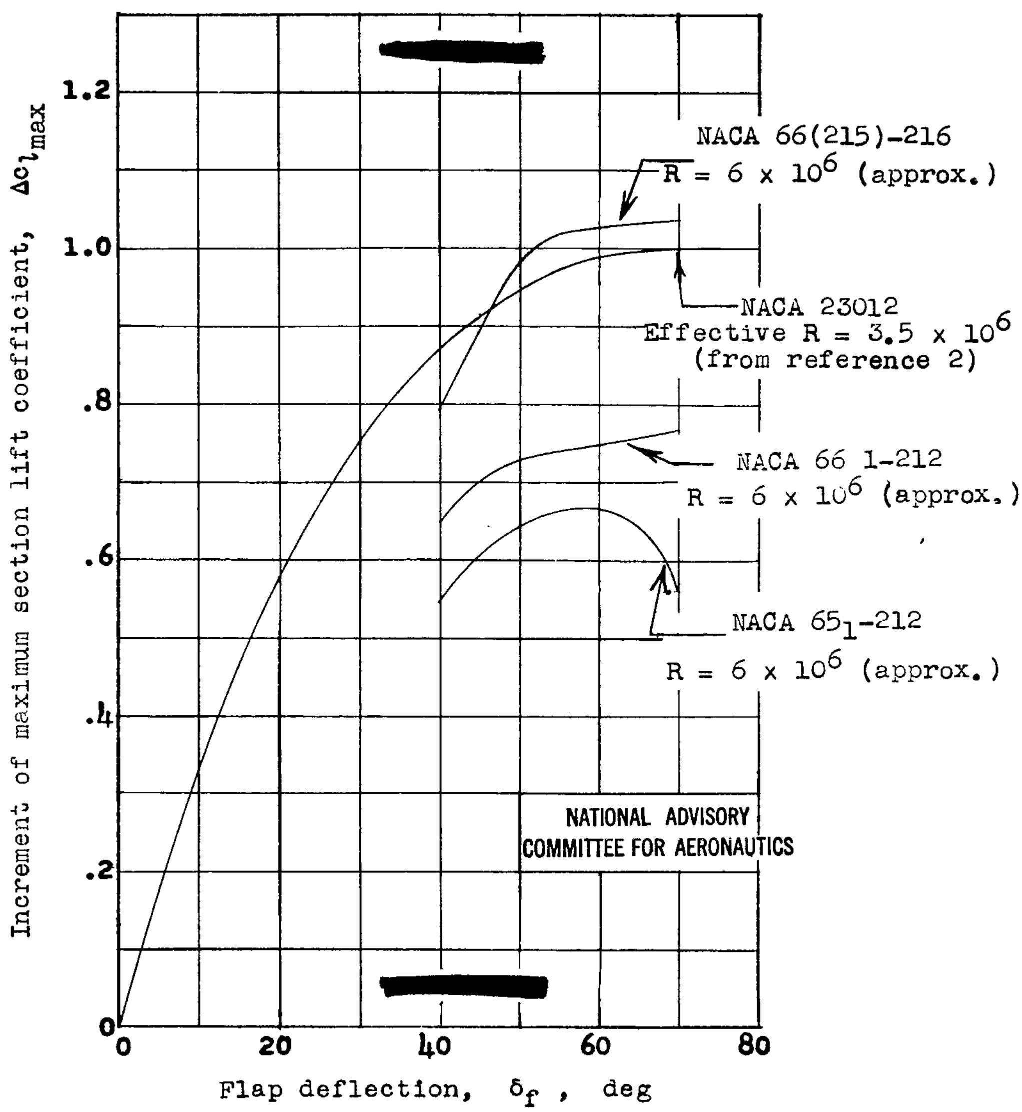

Figure 6.- Effect of flap deflection on the increment of maximum section lift coefficient for the various airfoil-flap arrangements.