NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

REPORT No. 221

MODEL TESTS WITH A SYSTEMATIC SERIES OF 27 WING SECTIONS AT FULL REYNOLDS NUMBER

By MAX M. MUNK and ELTON W. MILLER

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AERONAUTICAL SYMBOLS

1. FUNDAMENTAL AND DERIVED UNITS

	Symbol	Metric		English	
		Unit	Symbol	Unit	Symbol
Length	l	meter	m	foot (or mile)	ft. (or mi.)
Time	t	second	sec	second (or hour)	sec. (or hr.)
Force	F	weight of one kilogram	kg	weight of one pound	lb.
Power	P	kg/m/sec		horsepower	HP.
Speed		m/sec		mi./hr.	M. P. H.

2. GENERAL SYMBOLS, ETC.

Weight, $W=mg$.

Standard acceleration of gravity, $g=9.80665 \text{m/sec}^2=32.1740 \text{ft./sec.}^2$

Mass, $m=\frac{W}{g}$

Density (mass per unit volume), ρ

Standard density of dry air, 0.12497 (kg-m^{-4} sec^2) at 15°C and 760 mm = 0.002378 (lb.-ft.$^{-4}$ sec.^{2})

Specific weight of "standard" air, 1.2255 kg/m^3 = 0.07651 lb./ft.^{3}

Moment of inertia, mk^2 (indicate axis of the radius of gyration, k, by proper subscript)

Area, S; wing area, S_w, etc.

Gap, G.

Span, b; chord length, c.

Aspect ratio = b/c.

Distance from $c.\ g.$ to elevator hinge, f.

Coefficient of viscosity, μ.

3. AERODYNAMICAL SYMBOLS

True airspeed, V.

Dynamic (or impact) pressure, $q=\frac{1}{2}\rho V^2$

Lift, L; absolute coefficient $C_L=\frac{L}{qS}$

Drag, D; absolute coefficient $C_D=\frac{D}{qS}$

Cross-wind force, C; absolute coefficient $C_C=\frac{C}{qS}$

Resultant force, R.

(Note that these coefficients are twice as large as the old coefficients L_c, D_c.)

Angle of setting of wings (relative to thrust line), i_w.

Angle of stabilizer setting with reference to thrust line, i_t.

Dihedral angle, γ.

Reynolds Number = $\rho\frac{Vl}{\mu}$ where l is a linear dimension.

e. g., for a model airfoil 3 in. chord, 100 mi./hr., normal pressure, 0°C: 255,000 and at 15°C, 230,000;

or for a model of 10 cm chord, 40 m/sec, corresponding numbers are 299,000 and 270,000.

Center of pressure coefficient (ratio of distance of $C.\ P.$ from leading edge to chord length), C_p.

Angle of stabilizer setting with reference to lower wing. $(i_t-i_w)=\beta$.

Angle of attack, α.

Angle of downwash, ϵ.

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SUMMARY

A systematic series of 27 wing sections, characterized by a small travel of the center of pressure, have been investigated at 20 atmospheres pressure in the variable density wind tunnel of the National Advisory Committee for Aeronautics.

The results are consistent with each other, and indicate that for such "stable" sections a small effective camber, a small effective S-shape and a thickness of 8 to 12 per cent lead to good aerodynamic properties.

PURPOSE OF THE INVESTIGATION

This report contains the results of the investigation of the first systematic series of wing sections, 27 all together, made in the variable density wind tunnel of the National Advisory Committee for Aeronautics at about 20 atmospheres pressure. It was desired to obtain information about those aerodynamical properties of the wing sections which can not be computed. These are the drag at several angles of attack, and the two values of the lift coefficient when (*a*) the lift coefficient has its maximum and (*b*) when the air forces change irregularly, commonly known as the "burble point." Without additional work, there was also obtained a check on the aerodynamic properties open to computation, namely, the lift and the moment.

PROGRAM OF THE INVESTIGATION

In this first systematic series the measurements were confined to one tank pressure, about 20 atmospheres. This gives approximately a full size Reynolds number, for the model scale is about one-tenth, the velocity about one-half of the actual velocity.

The investigation was confined to such wing sections as have a very small travel of the center of pressure. The rate of the travel of the center of pressure is certainly an aerodynamic property of great practical importance, affecting the usefulness of the section for design purposes; it is not wise to compare the performance of several wing sections without taking the different rates of travel of the center of pressure, if any, into account. Within the useful range of the angle of attack, the wing sections described in this report have their center of pressure at about 25 per cent of the chord. Their rate of travel of the center of pressure is accordingly small, and the comparison of their performance is all that remains to be done. Wing sections with a larger rate of travel of the center of pressure may be taken up in a later research.

ARRANGEMENT OF THE TESTS

The 27 models were made of duralumin and were rectangular and not warped. The span is 30 inches, the aspect ratio is 6. The 27 wing sections form a systematic series. The series begins with three symmetrical sections of different thicknesses, M1, M2, and M3. The curves are affine—i. e., the three sets of ordinates can be obtained from each other by multiplying each ordinate by a constant. Three more sections are then obtained by adding to each of the sets of ordinates M1, M2, M3 the set of ordinates of a certain camberline, say "a," so chosen that theoretically its center of pressure does not travel. The series is further increased by substituting double the ordinates, 2a for a; then another camber line "b," with the same stability characteristics, and then combinations of the two camber lines. The camber lines "a" and "b" will be most easily recognized in wing sections M4 and M10. This process of obtaining the shapes of the wing sections leads to their classification in Table XXVIII. The ordinates of the sections are given in Table XXIX in per cent of the chord. Each figure contains a drawing of the section.

Each airfoil was exposed to the air stream of the variable density wind tunnel of the National Advisory Committee for Aeronautics. It was fastened by thin wires to the balance of this tunnel. Moreover, a skid rigidly fastened to the airfoil was hinged to a vertical bar, forming a part of the balance. This bar extends across the air stream in rear of the model; it is shielded from the air stream and can be moved up and down. When moved thus, the angle of attack of the airfoil is changed. After the airfoil was put in, the tank was closed and the air pressure increased up to about 20 atmospheres. The air forces of the airfoil were then determined over a range of several angles of attack. The drag of the wires and of other attachments were determined in a separate test under the same conditions of flow. The measured drag has been corrected for this drag of the fastening parts in the usual way.

RESULT OF THE TESTS

The results of the tests are given in Tables I to XXVII and are illustrated in the 27 figures. The angle of attack always refers to a line fixed with respect to the section as shown in each diagram. In the tables the air forces are represented by the lift coefficients, the drag coefficients, and the moment coefficients. The lift and drag coefficients are obtained by dividing the lift or drag by the wing area and by the dynamic pressure $V^2\frac{\rho}{2}$, where V denotes the velocity of the air stream and ρ the mass density of the air. The diagrams are so-called polar curves. The lift coefficient is plotted vertically up and against it to the right the drag coefficient and to the left the moment coefficient. This latter refers to the moment of the air forces with respect to a point of the chord, one quarter chord from the leading edge. This point is chosen because it gives the least variation of the moment coefficient. The moment is divided by the wing area, by the dynamic pressure, and by the length of the chord. The Reynolds number is computed with the chord as the characteristic length.

The parabola of the induced drag coefficient for the aspect ratio 6 has been inserted in each diagram. No correction has been made for the influence of the tunnel walls, which may be perceptible, as the wing span is half the tunnel throat diameter. This question is not yet sufficiently cleared up.

In Table XXX a survey of the series and of the results obtained is given. The first column gives the number of the wing section. The next three columns contain the minimum drag coefficient, the lift coefficient at the "burble point," and the maximum lift coefficient, if any. The last column gives the average moment coefficient, which is always small for the wing sections considered in this investigation.

DISCUSSION OF THE RESULTS

The main results of this test lie in the presentation of new information about the properties of the wing sections given in the tables and in the diagrams.

It seems that a small travel of the center of pressure is generally combined with a smaller maximum lift coefficient. Good sections are in the neighborhood of M6.

The test charts show that at full size Reynolds Number the minimum drag is much smaller than we are accustomed to obtain in the ordinary atmospheric wind tunnel. The maximum lift is not necessarily larger at a larger Reynolds Number.

One remark concerning the results seems pertinent. As shown by mathematical reasoning in Technical Report No. 191 of the National Advisory Committee for Aeronautics, the moment curves in the diagrams should theoretically be straight vertical lines. Most of them have approximately this shape, but not all of them. The small discrepancies can often be explained by taking the second approximation of the computations into account. For instance, with actual sections of a finite thickness, the theoretical leading edge is situated halfway between the actual one and the center of curvature of the leading edge, giving a shorter effective chord than the actual one. A very thick section, besides, is slightly more stable than a thin section of the same mean curve. Quite irregular moment curves can only be explained by sudden changes of the character of the flow just as at the burble point.

CONCLUSION

Looking at the results obtained in the variable density tunnel (including Technical Report No. 217) from a broader point of view, it is now established that the results obtained at the full size Reynolds Number do not agree with the results at a diminished Reynolds Number. Furthermore, tests now under way show that the variable density tunnel operated at one atmosphere gives results with a given wing section similar to the results obtained in other wind tunnels.

We conclude from these facts that the results obtained at full size Reynolds Number will give better information to the designer than tests run at largely reduced Reynolds Number. The information from the new tunnel will become more and more useful in the same degree as more results are obtained from it, so that results of new tests can be compared with results of similar older tests made under the same conditions.

TABLE I

Section No. M1.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 40.5° C.
Average Reynolds No. 3,600,000.

Model No. 21
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−3.0	659	−0.208	0.0093	0.008
−1.5	665	−.104	.0075	.006
0.0	665	−.006	.0072	.005
1.5	665	.120	.0077	.012
3.0	665	.231	.0106	.007
4.5	667	.341	.0145	.011
6.0	664	.458	.0199	.008
9.0	666	.667	.0344	.085
12.0	665	.782	.1012	−.017
15.0	661	.805	.1962	−.065
18.0	660	.788	.2574	−.100
21.0	659	.742	.2967	−.094

TABLE II

Section No. M2.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 37.0° C.
Average Reynolds No. 3,620,000.

Model No. 22.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 19.95 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−3.0	659	−0.236	0.0105	0.010
−1.5	660	−.125	.0086	.003
0.0	660	−.015	.0078	.010
1.5	660	.097	.0087	.010
3.0	657	.207	.0100	.009
4.5	656	.315	.0145	.015
6.0	655	.428	.0185	.007
9.0	654	.652	.0337	.015
12.0	653	.860	.0591	.015
15.0	652	.903	.1181	−.009
18.0	651	.881	.2436	−.026
21.0	650	.835	.3031	−.095

TABLE III

Section No. M3.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 30.0° C.
Average Reynolds No. 3,670,000.

Model No. 23.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.15 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−3.0	660	−0.197	0.0096	0.015
−1.5	662	−.095	.0082	.013
0.0	662	.014	.0089	.014
1.5	662	.128	.0096	.017
3.0	662	.236	.0126	.021
4.5	662	.343	.0162	.026
6.0	661	.471	.0214	.052
9.0	662	.675	.0379	.019
12.0	662	.883	.0591	.019
15.0	661	1.069	.0843	.014
18.0	660	1.059	.1628	−.033
21.0	659	.882	.3495	−.081

TABLE IV

Section No. M4.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 33.0° C.
Average Reynolds No. 3,680,000.

Model No. 24.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.0 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	668	−0.279	0.0286	0.005
−3.0	672	−.180	.0146	.008
−1.5	672	−.087	.0075	.014
0.0	672	.025	.0071	.015
1.5	672	.138	.0067	.016
3.0	668	.248	.0108	.021
4.5	669	.359	.0141	.022
6.0	669	.472	.0199	.023
9.0	668	.700	.0369	.021
12.0	667	.905	.0602	.022
15.0	666	.941	.1340	−.006

TABLE V

Section No. M5.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 41.5° C.
Average Reynolds No. 3,600,000.

Model No. 25.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.1 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−1.5	655	−0.108	0.0076	0.018
0.0	655	.004	.0073	.021
1.5	655	.117	.0082	.020
3.0	656	.231	.0108	.021
4.5	662	.338	.0145	.015
6.0	665	.452	.0190	.025
9.0	662	.681	.0356	.021
12.0	663	.888	.0581	.016
15.0	663	1.076	.0864	.020
18.0	662	1.132	.1625	−.020
21.0	656	1.077	.2526	−.046

TABLE VI

Section No. M6.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 38.0° C.
Average Reynolds No. 3,660,000.

Model No. 26.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.3 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−3.0	662	−0.202	0.0108	0.009
−1.5	663	−.097	.0093	.011
0.0	663	.016	.0080	.012
1.5	663	.126	.0097	.014
3.0	662	.237	.0111	.015
4.5	663	.340	.0147	.026
6.0	665	.456	.0212	.018
9.0	664	.665	.0356	.021
12.0	661	.875	.0565	.025
15.0	663	1.073	.0816	.033
18.0	662	1.222	.1188	.014
21.0	661	1.169	.1891	−.022

TABLE VII

Section No. M7.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 36.0° C.
Average Reynolds No. 3,640,000.

Model No. 27.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.0 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−3.0	657	−0.155	0.0372	0.008
−1.5	657	−.051	.0246	.007
0.0	659	.054	.0088	.018
1.5	653	.167	.0101	.021
3.0	655	.279	.0129	.019
4.5	660	.387	.0161	.019
6.0	659	.505	.0227	.024
9.0	658	.738	.0407	.022
12.0	657	.973	.0654	.018
15.0	656	1.139	.0983	.022
18.0	655	1.123	.1983	−.014
21.0	654	1.011	.2708	−.086

TABLE VIII

Section No. M8.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 44.0° C.
Average Reynolds No. 3,450,000.

Model No. 28.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.0 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−3.0	624	−0.166	0.0100	0.016
0.0	626	.056	.0088	.017
1.5	627	.171	.0101	.016
3.0	627	.283	.0133	.017
6.0	629	.505	.0229	.017
9.0	629	.729	.0393	.029
12.0	628	.949	.0620	.026
15.0	629	1.138	.0921	.015
18.0	625	1.183	.1589	−.037
21.0	624	1.170	.2275	−.085

TABLE IX

Section No. M9.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 37.5° C.
Average Reynolds No. 3,620,000.

Model No. 29.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.1 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−3.0	650	−0.148	0.0113	0.009
0.0	650	.077	.0101	.014
3.0	656	.294	.0148	.018
4.5	655	.404	.0183	.015
6.0	655	.514	.0249	.028
9.0	654	.739	.0428	.025
12.0	654	.947	.0648	.021
15.0	653	1.096	.0920	.015
18.0	651	1.137	.1450	−.004
21.0	645	1.112	.2015	−.022

TABLE X

Section No. M10.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 41.0° C.
Average Reynolds No. 3,630,000.

Model No. 30.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.4 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−6.0	654	−0.345	0.0179	−0.007
−3.0	664	−.132	.0080	−.044
−1.5	617	−.020	.0068	−.034
0.0	667	.089	.0071	−.006
1.5	665	.203	.0094	−.008
3.0	665	.313	.0130	−.010
4.5	611	.451	.0194	−.002
6.0	662	.545	.0241	−.002
9.0	661	.771	.0437	−.021
12.0	660	.965	.0728	−.008
15.0	659	1.004	.1472	.000
18.0	656	.962	.2425	−.012
21.0	650	.907	.3053	−.020

TABLE XI

Section No. M11.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 36.0° C.
Average Reynolds No. 3,860,000.

Model No. 31.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.3 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−3.0	717	−0.120	0.0091	−0.018
−1.5	724	−.018	.0078	−.019
0.0	717	.094	.0089	−.018
1.5	715	.208	.0110	−.017
3.0	720	.313	.0137	−.006
4.5	719	.428	.0186	−.014
6.0	719	.544	.0256	−.012
9.0	721	.762	.0435	−.014
12.0	721	.969	.0682	−.020
15.0	728	1.080	.1135	−.082
18.0	710	1.028	.2159	−.146
21.0	708	.998	.3095	−.184

TABLE XII

Section No. M12.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 34.0° C.
Average Reynolds No. 3,800,000.

Model No. 32.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 19.86 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−3.0	706	−0.118	0.0097	−0.049
−1.5	706	−.017	.0089	−.005
0.0	706	.096	.0091	−.005
1.5	705	.207	.0120	−.005
3.0	705	.318	.0156	−.008
4.5	713	.417	.0191	−.003
6.0	710	.537	.0261	+.003
9.0	706	.760	.0441	−.002
12.0	708	.971	.0662	.000
15.0	707	1.155	.0934	−.006
18.0	706	1.293	.1277	−.025
21.0	706	1.165	.2203	−.072

TABLE XIII

Section No. M13.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 40.0° C.
Average Reynolds No. 3,630,000.

Model No. 33.
Chord 5 in (12.7 cm).
Aspect ratio 6.
Average pressure 20.2 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	658	−0.127	0.0408	−0.043
−3.0	657	−.000	.0236	−.011
−1.5	661	.091	.0116	−.038
0.0	658	.209	.0127	−.036
1.5	661	.324	.0167	−.029
3.0	660	.437	.0214	−.014
4.5	658	.549	.0280	−.019
6.0	657	.670	.0378	−.023
9.0	657	.897	.0602	−.021
12.0	661	1.104	.0903	−.029
15.0	661	1.229	.1324	−.033
18.0	660	1.083	.2500	−.112
21.0	658	1.044	.3210	−.128

TABLE XIV

Section No. M14.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 41° C.
Average Reynolds No. 3,600,000.

Model No. 34.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average temperature 20.3 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	660	−0.118	0.0106	−0.040
−3.0	660	−.004	.0097	−.002
−1.5	661	.101	.0096	−.040
0.0	660	.217	.0119	−.035
1.5	662	.332	.0149	−.048
3.0	661	.444	.0200	−.030
4.5	656	.560	.0263	−.030
6.0	656	.671	.0347	−.027
9.0	656	.897	.0575	−.039
12.0	654	1.100	.0856	−.051
15.0	654	1.224	.1241	−.034
18.0	652	1.244	.1962	−.073
21.0	651	1.150	.2850	−.121

TABLE XV

Section No. M15.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 38° C.
Average Reynolds No. 3,580,000.

Model No. 35.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 19.95 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	640	−0.106	0.0101	−0.032
−3.0	635	.002	.0091	−.032
−1.5	635	.112	.0103	−.029
0.0	641	.227	.0129	−.022
1.5	646	.339	.0166	−.016
3.0	645	.456	.0213	−.035
4.5	644	.566	.0283	−.020
6.0	648	.671	.0367	−.030
9.0	648	.895	.0582	−.022
12.0	645	1.097	.0845	−.019
15.0	645	1.243	.1147	−.034
18.0	651	1.250	.1697	−.081
21.0	639	1.170	.2467	−.141

TABLE XVI

Section No. M16.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 38° C.
Average Reynolds No. 3,640,000.

Model No. 36.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.05 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	648	−0.197	0.0332	−0.011
−3.0	651	−.089	.0145	−.015
−1.5	651	.018	.0080	−.010
0.0	650	.135	.0094	−.008
1.5	652	.247	.0119	−.003
3.0	653	.367	.0159	−.013
4.5	658	.478	.0217	−.010
6.0	662	.597	.0295	−.002
9.0	655	.830	.0610	+.002
12.0	654	1.040	.0767	−.004
15.0	652	1.119	.1310	−.017
18.0	648	1.096	.2172	−.045
21.0	641	1.040	.3116	−.088

TABLE XVII

Section No. M17.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 37° C.
Average Reynolds No. 3,600,000.

Model No. 37.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 19.93 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	640	−0.191	0.0307	−0.010
−3.0	641	−.092	.0095	−.014
−1.5	639	.017	.0092	−.011
0.0	640	.133	.0103	−.008
1.5	648	.244	.0126	−.006
3.0	645	.360	.0163	−.001
4.5	644	.476	.0236	−.003
6.0	644	.588	.0300	+.010
9.0	643	.823	.0495	+.003
12.0	641	1.029	.0745	−.019
15.0	640	1.221	.1064	−.001
18.0	640	1.233	.1783	−.046
21.0	638	1.230	.2513	−.040

TABLE XVIII

Section No. M18.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 45° C.
Average Reynolds No. 3,530,000.

Model No. 38.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.08 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	630	−0.175	0.0111	−0.002
−3.0	635	−.055	.0093	−.015
−1.5	633	.052	.0096	−.012
0.0	633	.164	.0117	−.009
1.5	639	.282	.0149	−.007
3.0	636	.393	.0188	.000
4.5	635	.520	.0250	−.084
6.0	645	.614	.0322	+.003
9.0	640	.823	.0542	.000
12.0	639	1.018	.0769	−.005
15.0	638	1.123	.1220	−.007
18.0	635	1.188	.1717	−.035
21.0	635	1.194	.2315	−.051

TABLE XIX

Section No. M19.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 43° C.
Average Reynolds No. 3,500,000.

Model No. 39.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.2 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	639	−0.115	0.0570	−0.031
−3.0	636	.030	.0441	+.015
−1.5	642	.123	.0341	−.032
0.0	642	.249	.0257	−.031
1.5	649	.384	.0189	−.023
3.0	637	.496	.0240	−.015
4.5	642	.598	.0297	−.021
6.0	639	.719	.0389	−.023
9.0	641	.946	.0633	−.011
12.0	641	1.153	.0940	−.031
15.0	641	1.258	.1392	−.052
18.0	636	1.171	.1984	−.079
21.0	634	1.137	.2999	−.168

TABLE XX

Section No. M20.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 51° C.
Average Reynolds No. 3,350,000.

Model No. 40.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.0 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	613	−0.078	0.0531	−0.037
−3.0	614	+.029	.0404	−.038
−1.5	622	.136	.0287	−.038
0.0	616	.252	.0173	−.035
1.5	622	.369	.0175	−.002
3.0	622	.487	.0233	−.034
4.5	624	.592	.0310	−.023
6.0	624	.713	.0408	−.030
9.0	616	.946	.0652	−.036
12.0	617	1.156	.0945	−.036
15.0	626	1.311	.1310	−.068
18.0	625	1.300	.1884	−.088
21.0	620	1.256	.2488	−.133

TABLE XXI

Section No. M21.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 40° C.
Average Reynolds No. 3,530,000.

Model No. 41.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.09 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	632	−0.088	0.0132	−0.029
−3.0	632	.019	.0115	−.030
−1.5	631	.131	.0119	−.029
0.0	633	.250	.0147	−.029
1.5	635	.365	.0180	−.021
3.0	635	.472	.0233	−.020
4.5	635	.589	.0305	−.019
6.0	634	.697	.0393	−.021
9.0	633	.913	.0609	−.024
12.0	633	1.097	.0882	−.025
15.0	629	1.176	.1365	−.049
18.0	624	1.212	.1927	−.072
21.0	628	1.217	.2376	−.073

TABLE XXII

Section M22.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 38° C.
Average Reynolds No. 3,510,000.

Model No. 42.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 19.6 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	633	−0.184	0.0616	+0.006
−3.0	637	−.058	.0483	−.013
−1.5	633	.056	.0370	−.013
0.0	637	.179	.0273	−.013
1.5	630	.298	.0165	−.006
3.0	635	.417	.0187	−.001
4.5	634	.529	.0250	−.005
6.0	633	.649	.0340	−.003
9.0	632	.882	.0582	−.002
12.0	631	1.080	.0908	−.028
15.0	631	1.206	.1368	−.031
18.0	630	1.221	.1901	−.065
21.0	625	1.183	.2751	−.103

TABLE XXIII

Section No. M23.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 48° C.
Average Reynolds No. 3,370,000.
Model No. 43.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 19.94 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	611	−0.148	0.0614	−0.001
−3.0	613	−.033	.0467	−.007
−1.5	617	.073	.0361	−.009
0.0	617	.192	.0206	+.004
1.5	620	.308	.0160	.000
3.0	620	.425	.0201	+.004
4.5	620	.531	.0278	+.017
6.0	611	.665	.0355	+.004
9.0	612	.880	.0573	−.008
12.0	607	1.100	.0859	−.004
15.0	610	1.232	.1264	−.018
18.0	606	1.236	.1850	−.070
21.0	606	1.234	.2392	−.080

TABLE XXV

Section No. M25.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 35° C.
Average Reynolds No. 3,640,000.
Model No. 45.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.0 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	657	−0.114	0.0662	+0.005
−3.0	653	−0.008	.0543	−.014
−1.5	652	.111	.0470	−.025
0.0	652	.251	.0424	−.030
1.5	653	.381	.0381	−.028
3.0	653	.502	.0364	−.023
4.5	647	.630	.0388	−.017
6.0	650	.745	.0460	−.032
9.0	650	.920	.0790	−.045
12.0	645	1.111	.1114	−.049
15.0	648	1.234	.1496	−.064
18.0	645	1.232	.2029	−.078
21.0	646	1.220	.2455	−.080

TABLE XXIV

Section No. M24.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 40° C.
Average Reynolds No. 3,500,000.
Model No. 44.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.0 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	641	−0.133	0.0150	−0.027
−3.0	640	−.019	.0126	−.021
−1.5	635	.087	.0123	−.001
0.0	635	.204	.0143	−.014
1.5	635	.320	.0181	−.013
3.0	638	.431	.0221	+.002
4.5	638	.533	.0282	+.035
6.0	637	.653	.0367	+.025
9.0	637	.875	.0583	−.014
12.0	636	1.055	.0866	−.011
15.0	640	1.126	.1294	−.036
18.0	632	1.133	.1868	−.067
21.0	631	1.155	.2293	−.064

TABLE XXVI

Section No. M26.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 41° C.
Average Reynolds No. 3,510,000.
Model No. 46.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.0 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	636	−0.082	0.0684	−0.011
−3.0	633	.039	.0571	−.023
−1.5	633	.159	.0484	−.033
0.0	632	.283	.0410	−.032
1.5	632	.402	.0293	−.023
3.0	629	.532	.0294	−.021
4.5	632	.634	.0359	−.026
6.0	630	.753	.0459	−.026
9.0	630	.976	.0702	−.029
12.0	630	1.133	.1114	−.051
15.0	626	1.186	.1654	−.066
18.0	628	1.197	.2012	−.114
21.0	627	1.185	.2486	−.119

TABLE XXVII

Section No. M27.
Span 30 in. (76.2 cm).
Area 0.0968 m².
Average temperature 35° C.
Average Reynolds No. 3,630,000.
Model No. 47.
Chord 5 in. (12.7 cm).
Aspect ratio 6.
Average pressure 20.2 atmos.

Angle of attack degrees	Dynamic pressure q kg/m²	Lift coefficient C_L	Drag coefficient C_D	Moment coefficient C_M
−4.5	640	−0.011	0.0497	−0.030
−3.0	640	.081	.0300	−.036
−1.5	641	.182	.0203	−.034
0.0	640	.295	.0189	−.029
1.5	645	.411	.0232	−.023
3.0	644	.519	.0285	−.026
4.5	643	.624	.0358	−.020
6.0	642	.737	.0457	−.019
9.0	642	.929	.0707	−.027
12.0	641	1.007	.1100	−.042
15.0	640	1.048	.1508	−.044
18.0	637	1.081	.1913	−.079
21.0	631	1.086	.2380	−.072

TABLE XXVIII

CLASSIFICATION OF THE SECTIONS

Section	Camber line	Thickness	Section	Camber line	Thickness	Section	Camber line	Thickness
M1	Straight	I	M10	b	I	M19	(2b)	I
M2	Straight	II	M11	b	II	M20	(2b)	II
M3	Straight	III	M12	b	III	M21	(2b)	III
M4	a	I	M13	a+b	I	M22	(a+2b)	I
M5	a	II	M14	a+b	II	M23	(2+2b)	II
M6	a	III	M15	a+b	III	M24	(a+2b)	III
M7	2a	I	M16	(2a+b)	I	M25	2(a+b)	I
M8	2a	II	M17	(2a+b)	II	M26	2(a+b)	II
M9	2a	III	M18	(2a+b)	III	M27	2(a+b)	III

TABLE XXIX

ORDINATES FOR N. A. C. A. AIRFOILS M1 TO M27

[U=Upper camber. L=Lower camber]

No.		Per cent of chord																	
		0	1.25	2.50	5.0	7.5	10	15	20	25	30	40	50	60	70	80	90	95	100
M1	U	0.00	1.03	1.36	1.80	2.10	2.34	2.67	2.88	3.01	3.08	3.05	2.85	2.53	2.08	1.54	0.91	0.57	0.20
	L	.00	−1.03	−1.36	−1.80	−2.10	−2.34	−2.67	−2.88	−3.01	−3.08	−3.05	−2.85	−2.53	−2.08	−1.54	−.91	−.57	−.20
M2	U	.00	1.30	1.74	2.33	2.74	3.05	3.49	3.78	3.95	4.03	4.00	3.74	3.30	2.71	1.99	1.15	.69	.20
	L	.00	−1.30	−1.74	−2.33	−2.74	−3.05	−3.49	−3.78	−3.95	−4.03	−4.00	−3.74	−3.30	−2.71	−1.99	−1.15	−.69	−.20
M3	U	.00	1.86	2.51	3.39	4.00	4.47	5.14	5.57	5.83	5.95	5.89	5.50	4.85	3.96	2.88	1.62	.93	.20
	L	.00	−1.86	−2.51	−3.39	−4.00	−4.47	−5.14	−5.57	−5.83	−5.95	−5.89	−5.50	−4.85	−3.96	−2.88	−1.62	−.93	−.20
M4	U	1.10	2.32	2.86	3.67	4.31	4.83	5.61	6.16	6.51	6.67	6.56	6.0[illegible]	5.24	4.30	3.39	2.59	2.29	2.09
	L	1.10	.19	.07	.01	.02	.07	.20	.33	.38	.39	.33	.18	.05	.01	.21	.71	1.09	1.60
M5	U	1.89	3.28	3.93	4.87	5.63	6.23	7.14	7.77	8.15	8.34	8.26	7.69	6.80	5.77	4.73	3.78	3.38	3.13
	L	1.89	.59	.34	.09	.02	.00	.04	.07	.11	.13	.07	.02	.02	.17	.59	1.33	1.89	2.50
M6	U	.00	1.97	2.81	4.03	4.94	5.71	6.82	7.55	8.01	8.22	8.05	7.26	6.03	4.58	3.06	1.55	.88	.26
	L	.00	−1.76	−2.20	−2.73	−3.03	−3.24	−3.47	−3.62	−3.71	−3.79	−3.90	−3.94	−3.82	−3.48	−2.83	−1.77	−1.08	−.26
M7	U	.76	2.05	2.77	3.92	4.87	5.68	6.89	7.74	8.26	8.49	8.25	7.32	5.99	4.51	3.13	2.13	1.87	1.79
	L	.76	.00	.04	.32	.65	.99	1.58	1.98	2.23	2.31	2.06	1.53	.85	.27	.00	.30	.71	1.32
M8	U	.95	2.66	3.52	4.82	5.86	6.73	8.08	9.00	9.57	9.82	9.60	8.80	7.22	5.63	4.12	2.94	2.56	2.31
	L	.95	.06	.01	.13	.37	.64	1.09	1.43	1.63	1.72	1.55	1.05	.51	.10	.04	.59	1.12	1.91
M9	U	1.81	4.08	5.14	6.76	8.03	9.08	10.69	11.74	12.38	12.73	12.51	11.43	9.83	7.98	6.11	4.52	3.94	3.53
	L	1.81	.44	.15	.00	.05	.16	.42	.63	.75	.80	.66	.40	.09	.01	.32	1.25	2.03	3.06
M10	U	1.34	2.49	2.97	3.68	4.24	4.71	5.40	5.87	6.16	6.31	6.25	5.82	5.13	4.28	3.35	2.40	1.92	1.42
	L	1.34	.41	.19	.04	.01	.01	.04	.08	.11	.12	.09	.03	.01	.09	.27	.58	.79	1.03
M11	U	2.13	3.59	4.24	5.12	5.78	6.31	7.11	7.66	7.99	8.16	8.10	7.61	6.83	5.83	4.73	3.57	2.97	2.39
	L	2.13	.93	.67	.39	.23	.15	.08	.04	.02	.01	.02	.07	.21	.46	.87	1.43	1.76	2.15
M12	U	.00	2.03	2.86	4.01	4.89	5.59	6.61	7.30	7.74	7.95	7.86	7.25	6.27	4.98	3.50	1.89	1.07	.20
	L	.00	−1.65	−2.14	−2.72	−3.07	−3.31	−3.60	−3.80	−3.92	−3.98	−3.96	−3.82	−3.50	−3.00	−3.31	−1.37	−.81	−.20
M13	U	.84	2.11	2.76	3.77	4.58	5.24	6.28	6.98	7.43	7.65	7.51	6.86	5.81	4.55	3.22	1.87	1.23	.60
	L	.84	.02	.01	.15	.35	.55	.93	1.21	1.38	1.44	1.34	1.05	.66	.30	.07	.00	.05	.16
M14	U	1.28	2.80	3.56	4.70	5.63	6.37	7.51	8.31	8.78	9.01	8.89	8.15	6.99	5.56	4.02	2.42	1.62	.80
	L	1.28	.16	.05	.04	.13	.25	.51	.74	.87	.93	.83	.58	.30	.06	.01	.05	.18	.38
M15	U	2.41	4.47	5.44	6.89	8.04	8.97	10.33	11.28	11.87	12.17	12.03	11.20	9.86	8.16	6.29	4.33	3.35	2.39
	L	2.41	.78	.42	.13	.02	.00	.03	.09	.14	.17	.11	.03	.00	.14	.41	1.02	1.44	1.94
N16	U	.83	2.04	2.71	3.81	4.69	5.42	6.56	7.34	7.82	8.03	7.85	7.06	5.83	4.48	3.14	1.96	1.49	1.16
	L	.83	.01	.04	.25	.51	.78	1.24	1.59	1.80	1.88	1.71	1.30	.72	.26	.01	.13	.35	.68
M17	U	1.16	2.72	3.51	4.75	5.74	6.54	7.70	8.52	9.14	9.37	9.23	8.37	7.05	5.55	4.01	2.64	2.06	1.57
	L	1.16	.08	.01	.07	.23	.43	.78	1.06	1.26	1.30	1.15	.80	.38	.07	.02	.33	.68	1.16
M18	U	2.20	4.25	5.25	6.78	7.99	8.94	10.47	11.48	12.12	12.42	12.26	11.33	9.82	8.09	6.23	4.45	3.66	2.95
	L	2.20	.56	.25	.03	.00	.03	.17	.31	.41	.46	.41	.19	.03	.05	.40	1.17	1.75	2.51
M19	U	.75	2.04	2.88	4.30	5.39	6.39	7.81	8.88	9.50	9.80	9.54	8.50	6.94	5.16	3.37	1.87	1.24	.71
	L	.75	.03	.20	.68	1.21	1.71	2.54	3.12	3.48	3.63	3.43	2.74	1.84	.96	.30	.02	.10	.33
M20	U	.98	2.64	3.57	5.13	6.32	7.41	8.95	10.04	10.77	11.07	10.81	9.70	8.04	6.10	4.16	2.40	1.66	1.05
	L	.98	.00	.03	.39	.82	1.25	1.95	2.46	2.78	2.92	2.72	2.11	1.32	.58	.11	.06	.24	.58
M21	U	1.68	3.89	5.04	6.86	8.30	9.50	11.33	12.58	13.34	13.70	13.46	12.23	10.36	8.17	5.89	3.70	2.73	1.92
	L	1.68	.17	.02	.83	.30	.55	1.03	1.42	1.66	1.75	1.57	1.11	.54	.12	.03	.41	.81	1.44
M22	U	.72	2.11	2.98	4.45	5.60	6.66	8.22	9.31	9.96	10.25	9.94	8.75	7.06	5.14	3.36	1.97	1.53	1.32
	L	.72	.02	.22	.79	1.38	1.92	2.84	3.48	3.87	4.00	3.73	2.88	1.85	.84	.16	.06	.33	.79
M23	U	.87	2.60	3.63	5.23	6.51	7.60	9.28	10.44	11.15	11.48	11.19	9.95	8.14	6.08	4.09	2.53	1.98	1.66
	L	.87	.01	.12	.54	1.01	1.49	2.30	2.86	3.21	3.34	3.06	2.30	1.40	.53	.04	.17	.54	1.12

TABLE XXIX—Continued

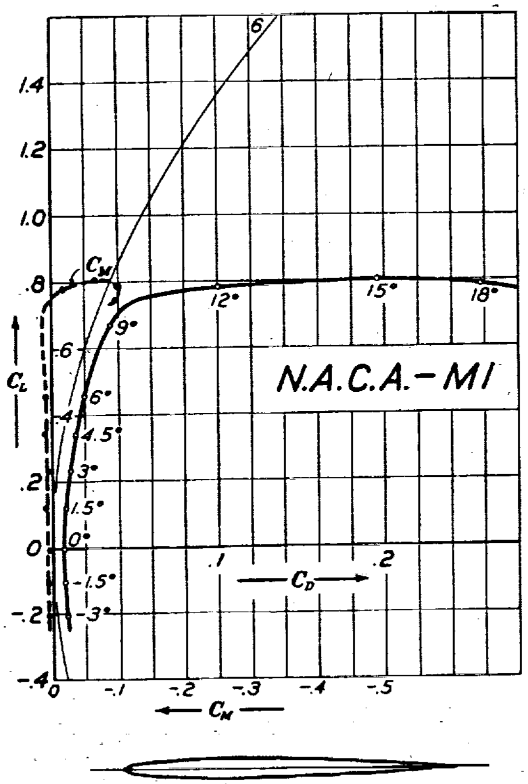
No.		Per cent of chord																
		0	1.25	2.50	5.0	7.5	10	15	20	25	30	40	50	60	70	80	90	95	100
M24	U	1.50	3.80	5.00	6.92	8.38	9.66	11.59	12.93	13.72	14.08	13.76	12.40	10.39	8.11	5.82	3.85	3.09	2.48
	L	1.50	.12	.01	.13	.40	.72	1.31	1.77	2.04	2.13	1.92	1.33	.64	.13	.04	.63	1.26	2.13
M25	U	.67	2.28	3.24	5.04	6.39	7.60	9.52	10.89	11.69	12.05	11.68	10.22	8.16	5.86	3.66	1.90	1.31	.93
	L	.67	.09	.45	1.28	2.15	2.91	4.14	5.04	5.54	5.78	5.44	4.36	2.96	1.54	.47	.00	.11	.48
M26	U	.82	2.60	3.71	5.66	7.11	8.41	10.47	11.96	12.80	13.19	12.82	11.32	9.11	6.68	4.32	2.35	1.66	1.20
	L	.82	.02	.25	.94	1.68	2.39	3.54	4.35	4.84	5.04	4.72	3.73	2.44	1.19	.29	.02	.26	.72
M27	U	1.22	3.67	5.06	7.23	9.00	10.47	12.72	14.28	15.24	15.69	15.33	13.72	11.36	8.65	5.93	3.56	2.64	1.91
	L	1.22	.04	.05	.44	1.00	1.55	2.47	3.17	3.57	3.74	3.45	2.59	1.53	.59	.04	.23	.68	1.39

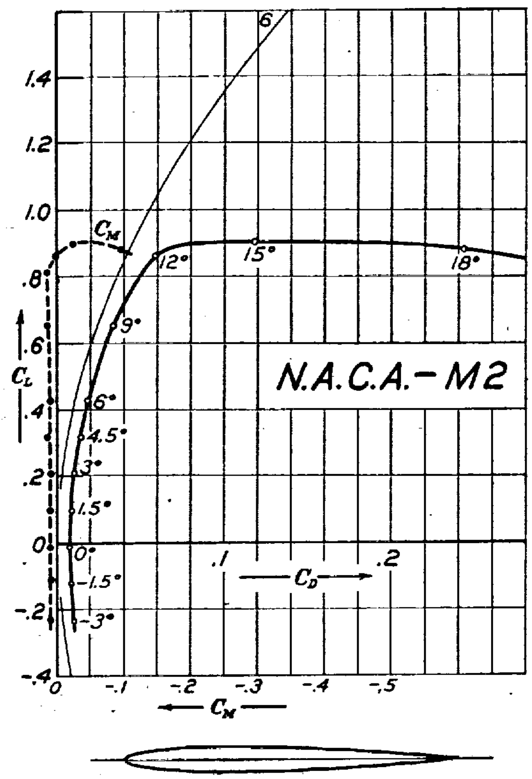
TABLE XXX

AERODYNAMIC PROPERTIES OF THE SECTIONS[1]

Section No.	Minimum drag coefficient	Maximum lift coefficient	Burble lift coefficient	Average moment[2] coefficient
1	0.0072	0.805	0.75	0.008
2	.0078	.903	.85	.010
3	.0082	1.069	1.05	.018
4	.0067	....	.95	.020
5	.0073	1.132	1.15	.020
6	.0080	1.222	1.20	.025
7	.0088	1.139	....	.022
8	.0089	1.183	1.15	.020
9	.0101	1.137	1.10	.020
10	.0068	1.004	1.00	−.010
11	.0078	1.080	1.05	−.015
12	.0089	1.293	1.30	.000
13	.0116	1.299	....	−.025
14	.0096	1.244	1.20	−.035
15	.0091	1.250	1.20	−.025
16	.0080	1.119	1.10	−.005
17	.0092	....	1.20	−.002
18	.0093	....	1.00	−.005
19	.0189	1.258	1.20	−.025
20	.0173	1.311	1.30	−.035
21	.0115	....	1.10	−.025
22	.0165	1.221	....	−.010
23	.0160	1.236	1.20	−.002
24	.0123	....	1.10	.000
25	.0364	1.234	....	−.030
26	.0293	1.197	....	−.030
27	.0189	....	.90	−.030

[1] Moments taken about a point at 25 per cent of the chord.
[2] The last column gives the average moment coefficient, which is always small for the wing sections considered in this investigation.


N.A.C.A.-M1
C_L
C_D
C_M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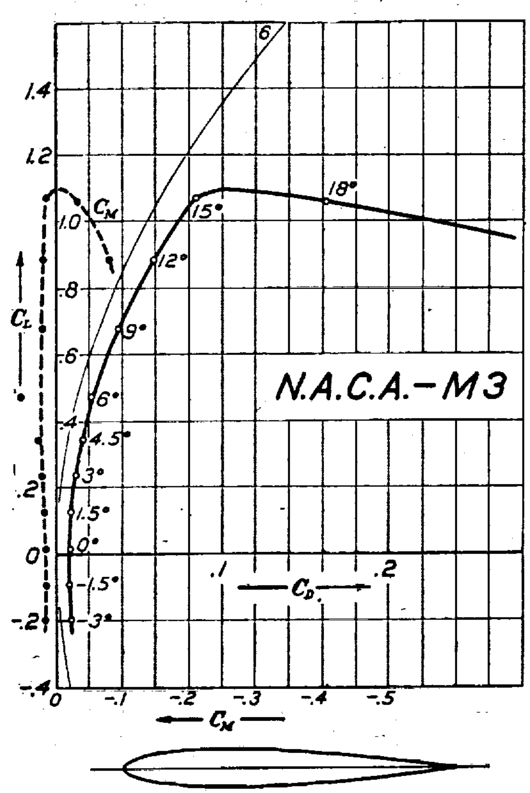
C_M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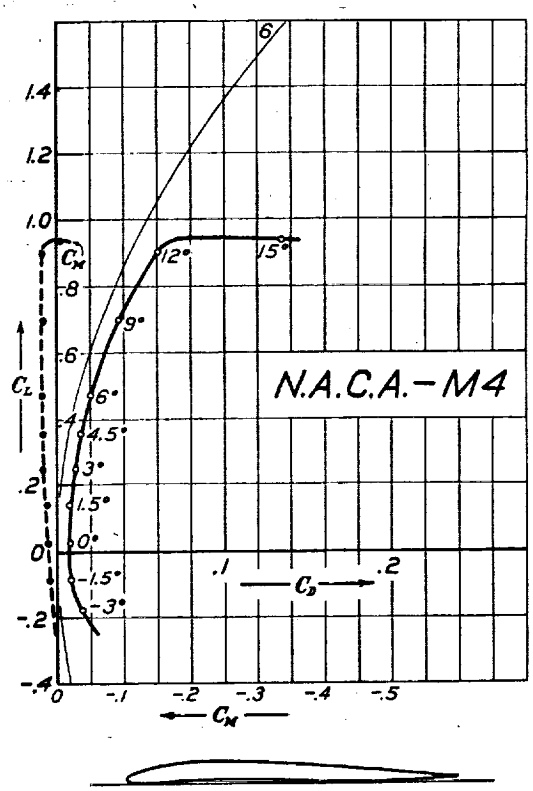
C_D
C_M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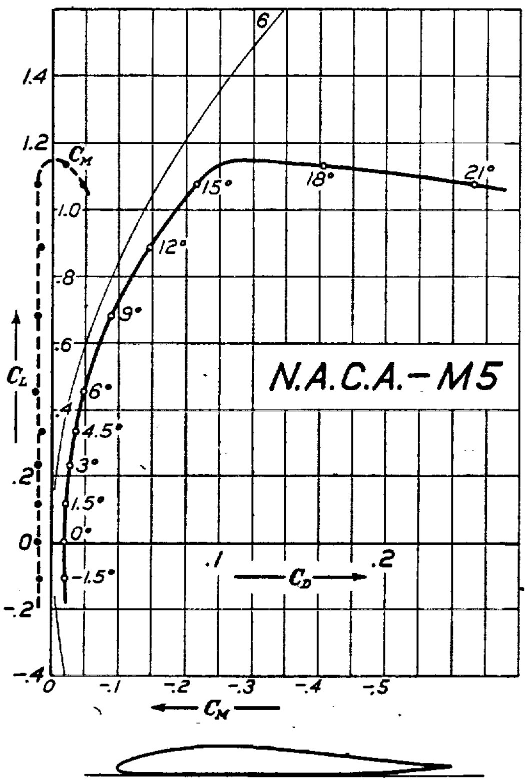
C_M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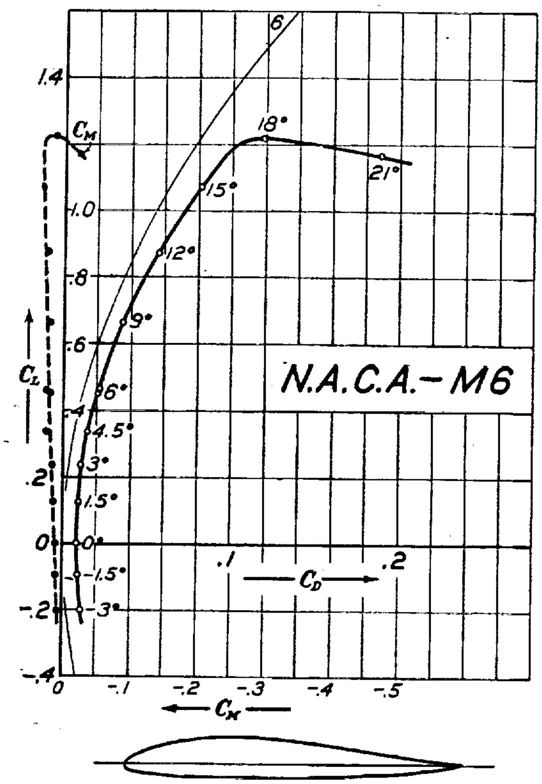
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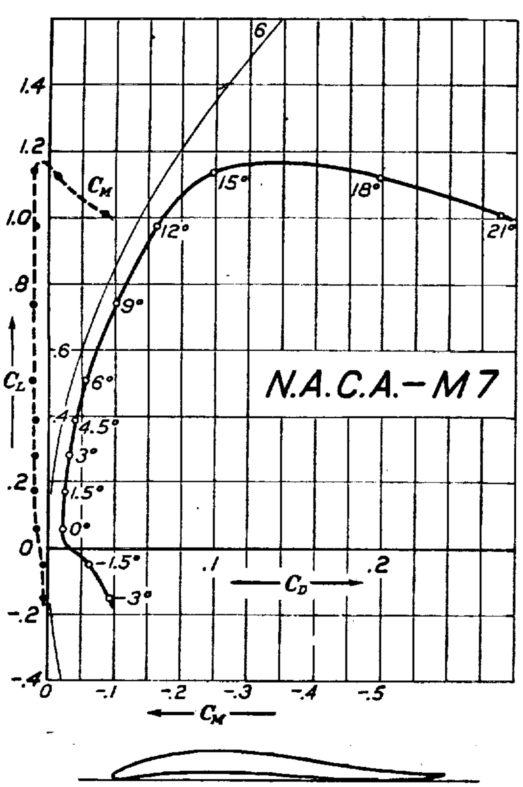
C_L
C_D
C_M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C_L
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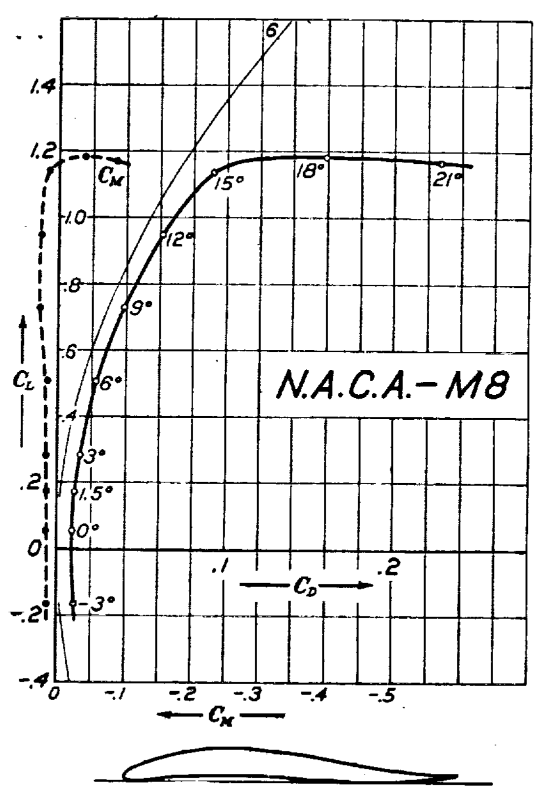
C_M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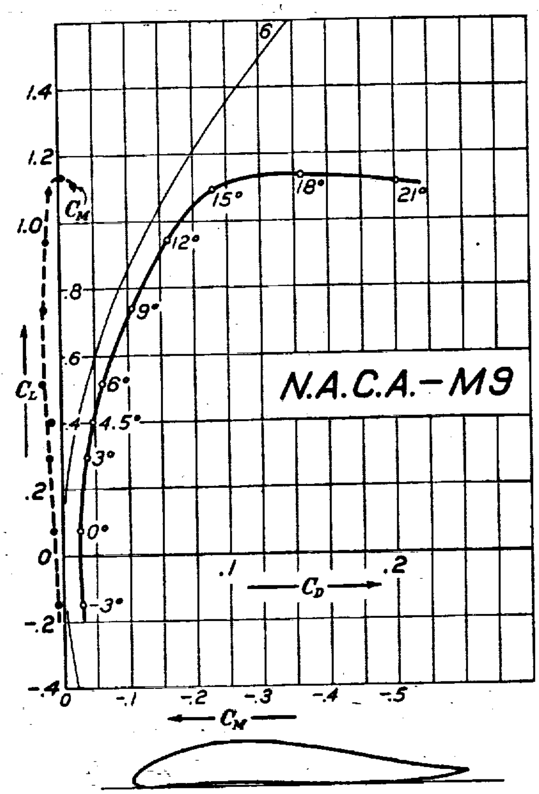
C_L
C_D
C_M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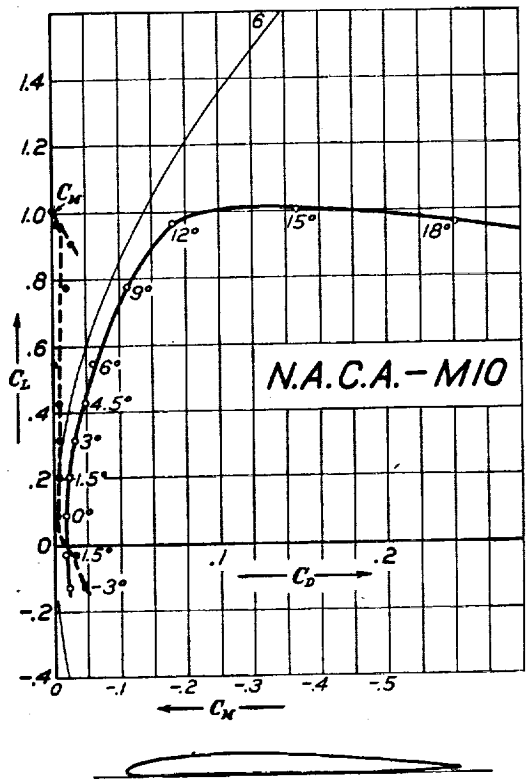
C_L
C_M
C_D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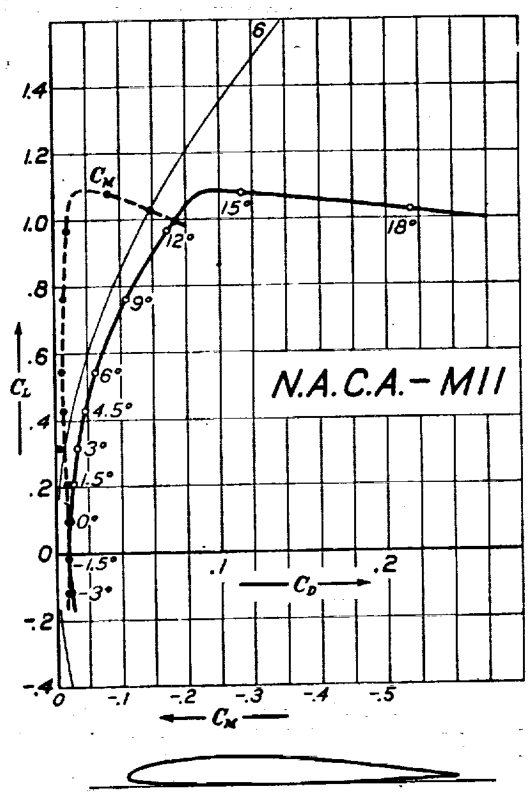
C_D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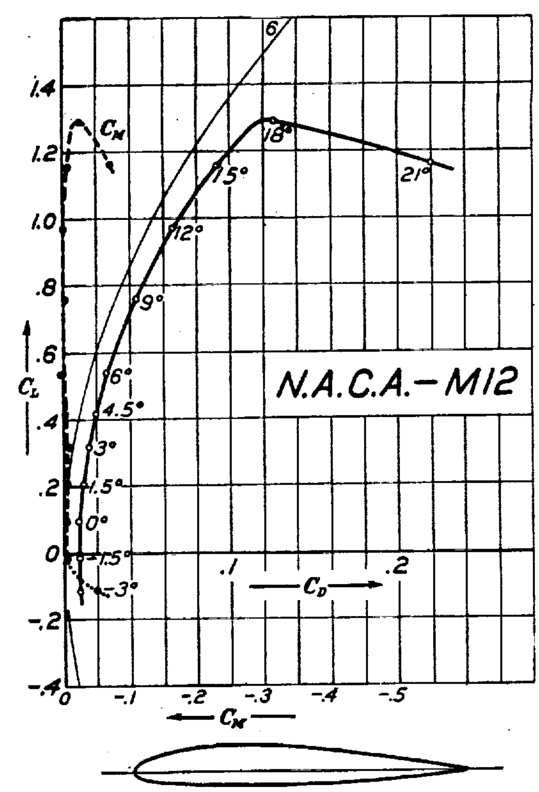
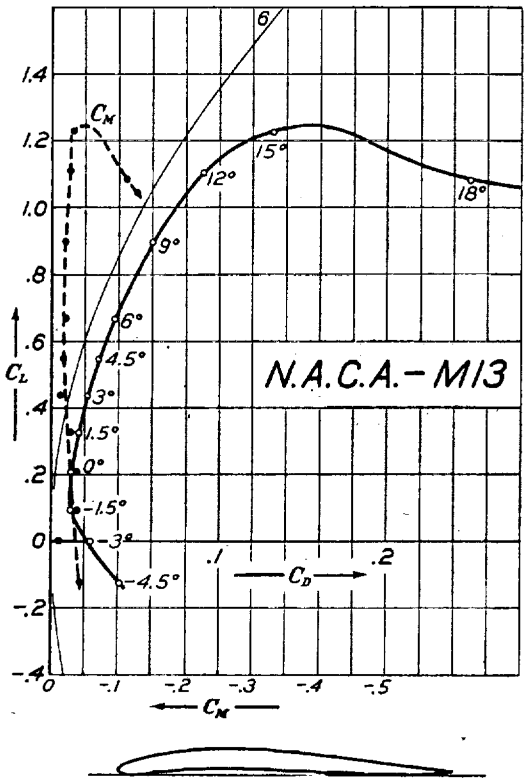
C_D


N.A.C.A.-M12
C_L
C_M
C_D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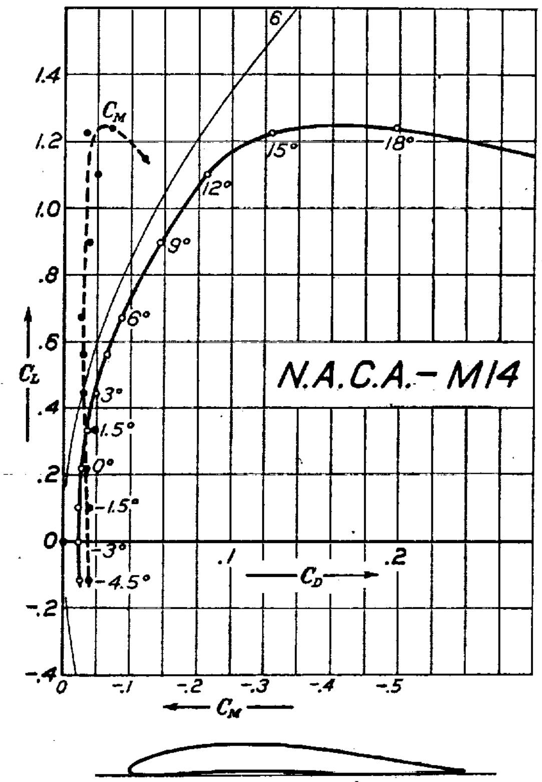
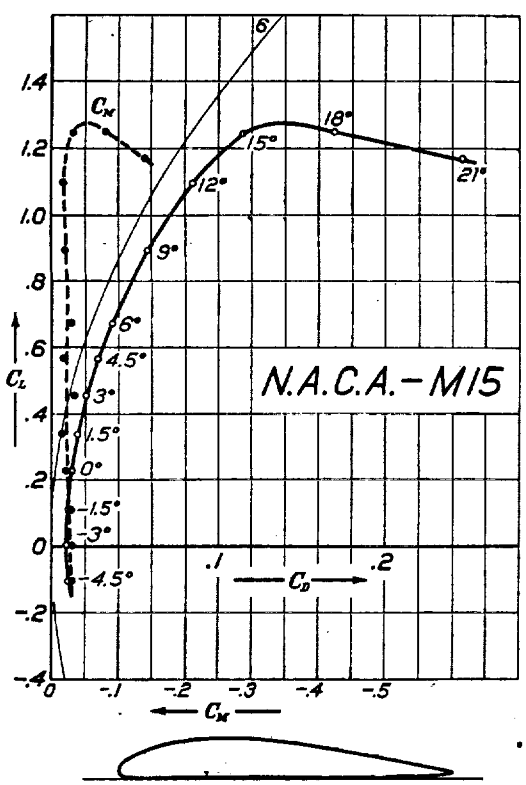
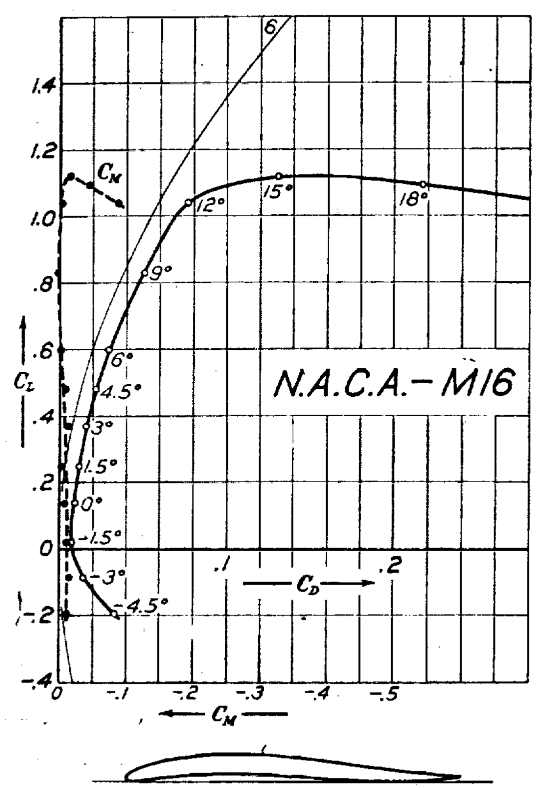
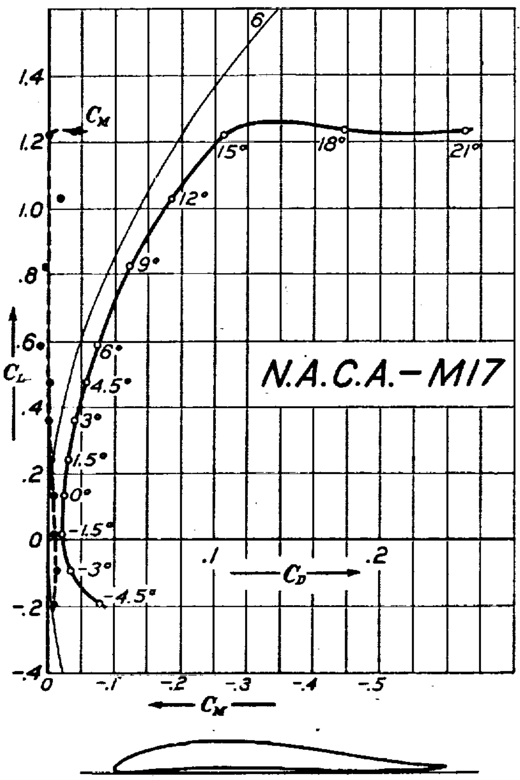
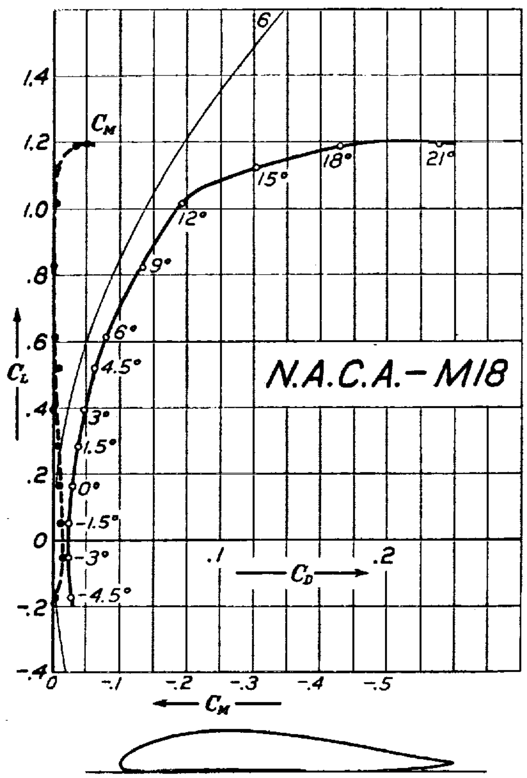
C_M
C_L
C_D
C_M


N.A.C.A.-M14
C_M
C_L
C_D
C_M


N.A.C.A.-M15
C_M
C_L
C_D
C_M


N.A.C.A.-M16
C_M
C_L
C_D
C_M


N.A.C.A.-M17
C_M
C_L
C_D
C_M
15°
18°
21°
12°
9°
6°
4.5°
3°
1.5°
0°
-1.5°
-3°
-4.5°


N.A.C.A.-M18
C_M
C_L
C_D
C_M
15°
18°
21°
12°
9°
6°
4.5°
3°
1.5°
0°
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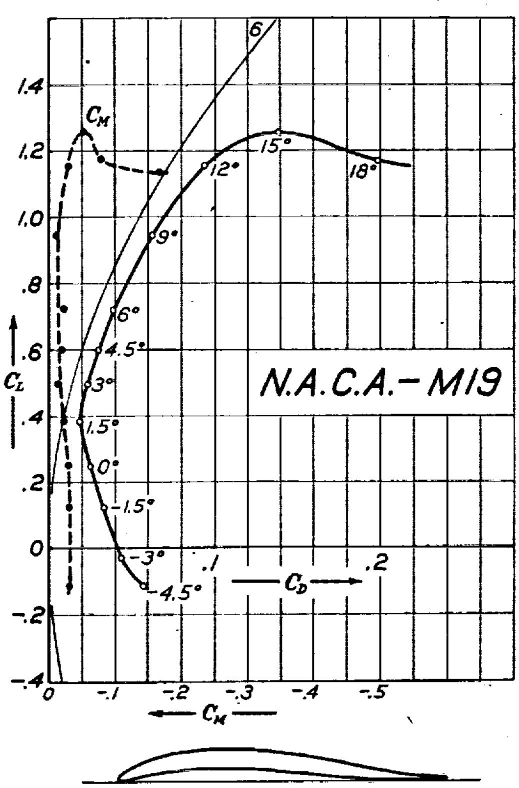
-4.5°


N.A.C.A.-M19
C_M
C_L
C_D
C_M
15°
18°
12°
9°
6°
4.5°
3°
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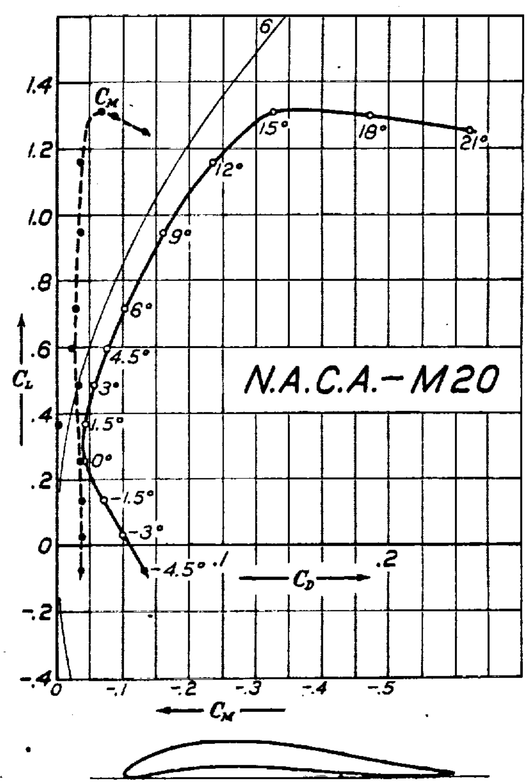
0°
-1.5°
-3°
-4.5°


N.A.C.A.-M20
C_M
C_L
C_D
C_M
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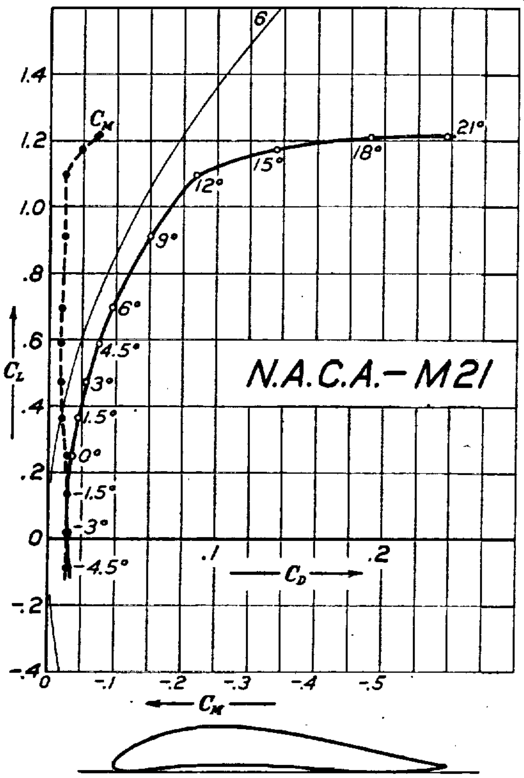
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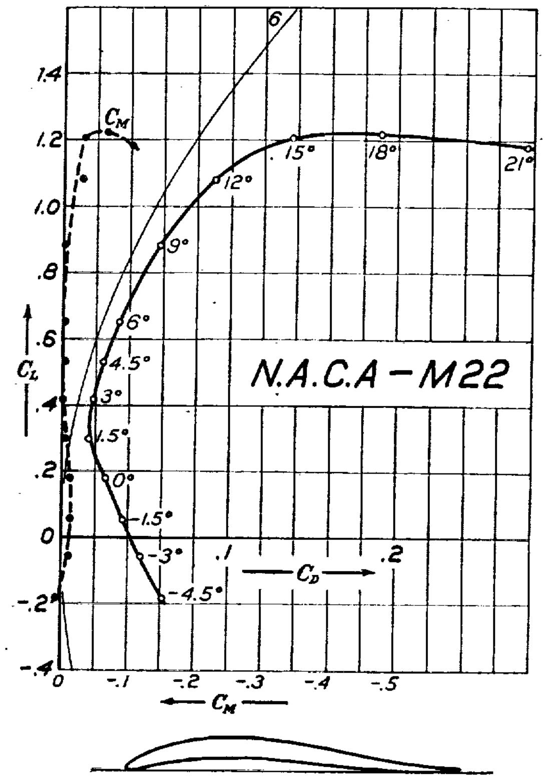
C_L
C_M
C_D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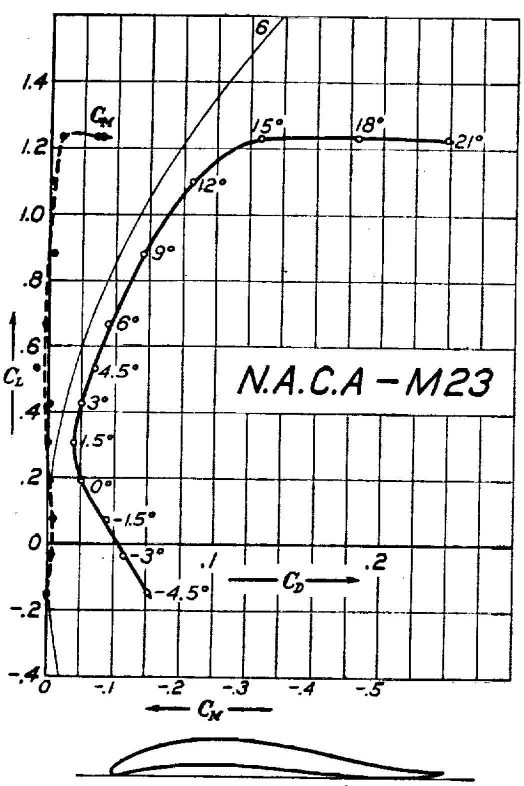
C_L
C_M
C_D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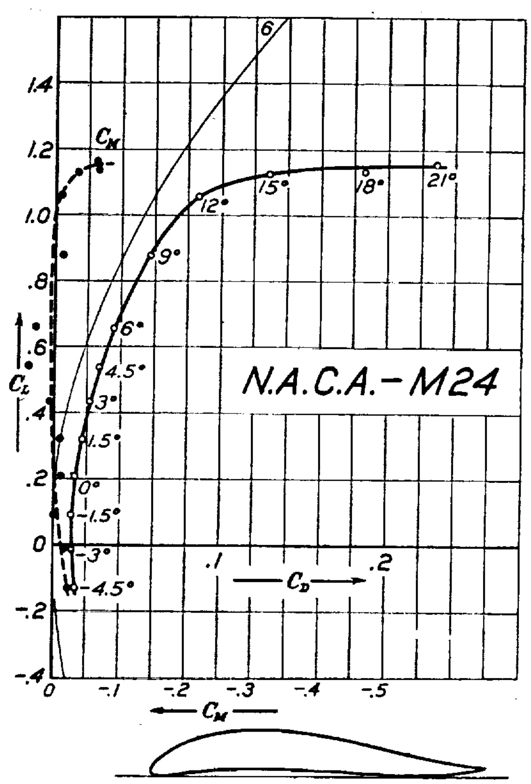
C_L
C_M
C_D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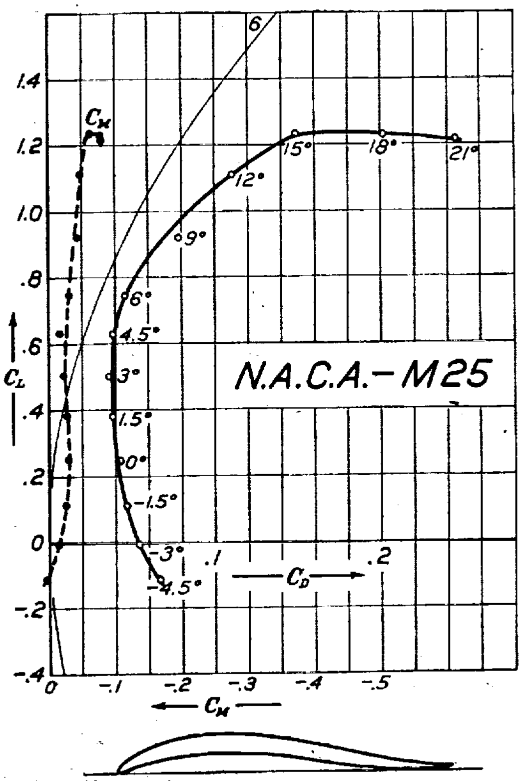
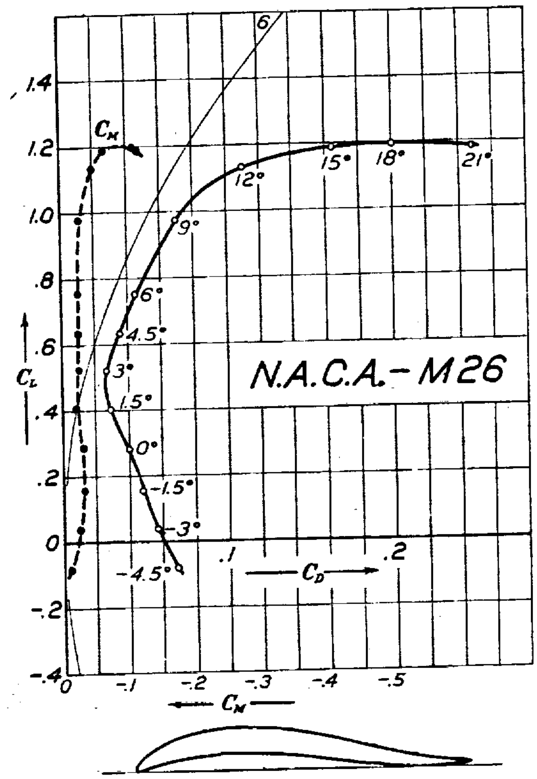
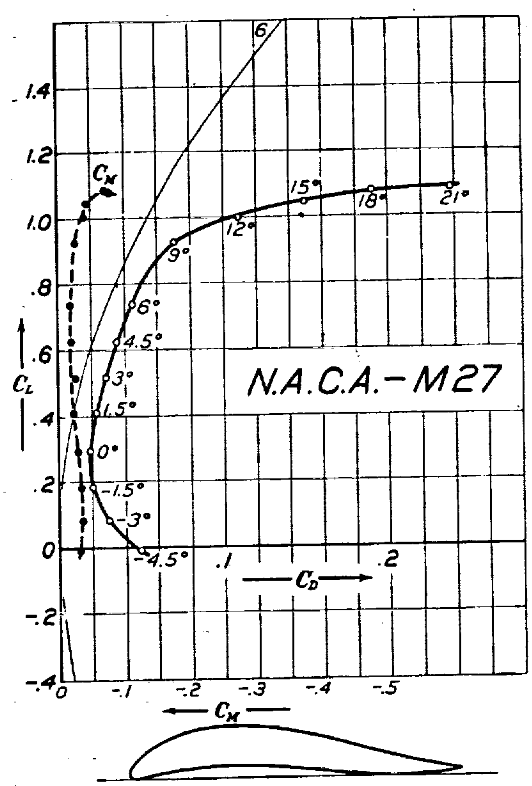
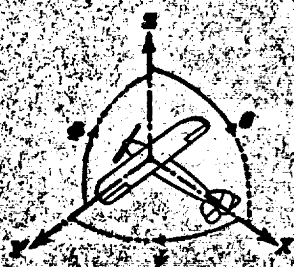
C_M
C_D


N.A.C.A.-M25
C_L
C_D
C_M
C_M


N.A.C.A.-M26
C_L
C_D
C_M
C_M


N.A.C.A.-M27
C_L
C_D
C_M
C_M



Positive directions of axes and angles (forces and moments) are shown by arrows

Axis		Force (parallel to axis) symbol	Moment about axis			Angle		Velocities	
Designation	Symbol		Designation	Symbol	Positive direction	Designation	Symbol	Linear (component along axis)	Angular
Longitudinal	X	X	rolling	L	$Y \longrightarrow Z$	roll	Φ	u	p
Lateral	Y	Y	pitching	M	$Z \longrightarrow X$	pitch	Θ	v	q
Normal	Z	Z	yawing	N	$X \longrightarrow Y$	yaw	Ψ	w	r

Absolute coefficients of moment

$$C_l = \frac{L}{qbS} \quad C_m = \frac{M}{qcS} \quad C_n = \frac{N}{qfS}$$

Angle of set of control surface (relative to neutral position), δ. (Indicate surface by proper subscript.)

4. PROPELLER SYMBOLS

Diameter, D

Pitch (a) Aerodynamic pitch, p_a

(b) Effective pitch, p_e

(c) Mean geometric pitch, p_g

(d) Virtual pitch, p_v

(e) Standard pitch, p_s

Pitch ratio, p/D

Inflow velocity, V'

Slipstream velocity, V_s

Thrust, T

Torque, Q

Power, P

(If "coefficients" are introduced all units used must be consistent.)

Efficiency $\eta = T\,V/P$.

Revolutions per sec., n; per min., N.

Effective helix angle $\Phi = \tan^{-1}\left(\frac{V}{2\pi rn}\right)$

5. NUMERICAL RELATIONS

1 HP. = 76.04 kg/m/sec = 550 lb./ft./sec.

1 kg/m/sec = 0.01315 HP.

1 mi./hr. = 0.44704 m/sec

1 m/sec = 2.23693 mi./hr.

1 lb. = 0.4535924277 kg

1 kg = 2.2046224 lb.

1 mi. = 1609.35 m = 5280 ft.

1 m = 3.2808333 ft.