Airfoil Sections

FOR THE AEROMODELLER

BY J.W.B. CRUICKSHANKS

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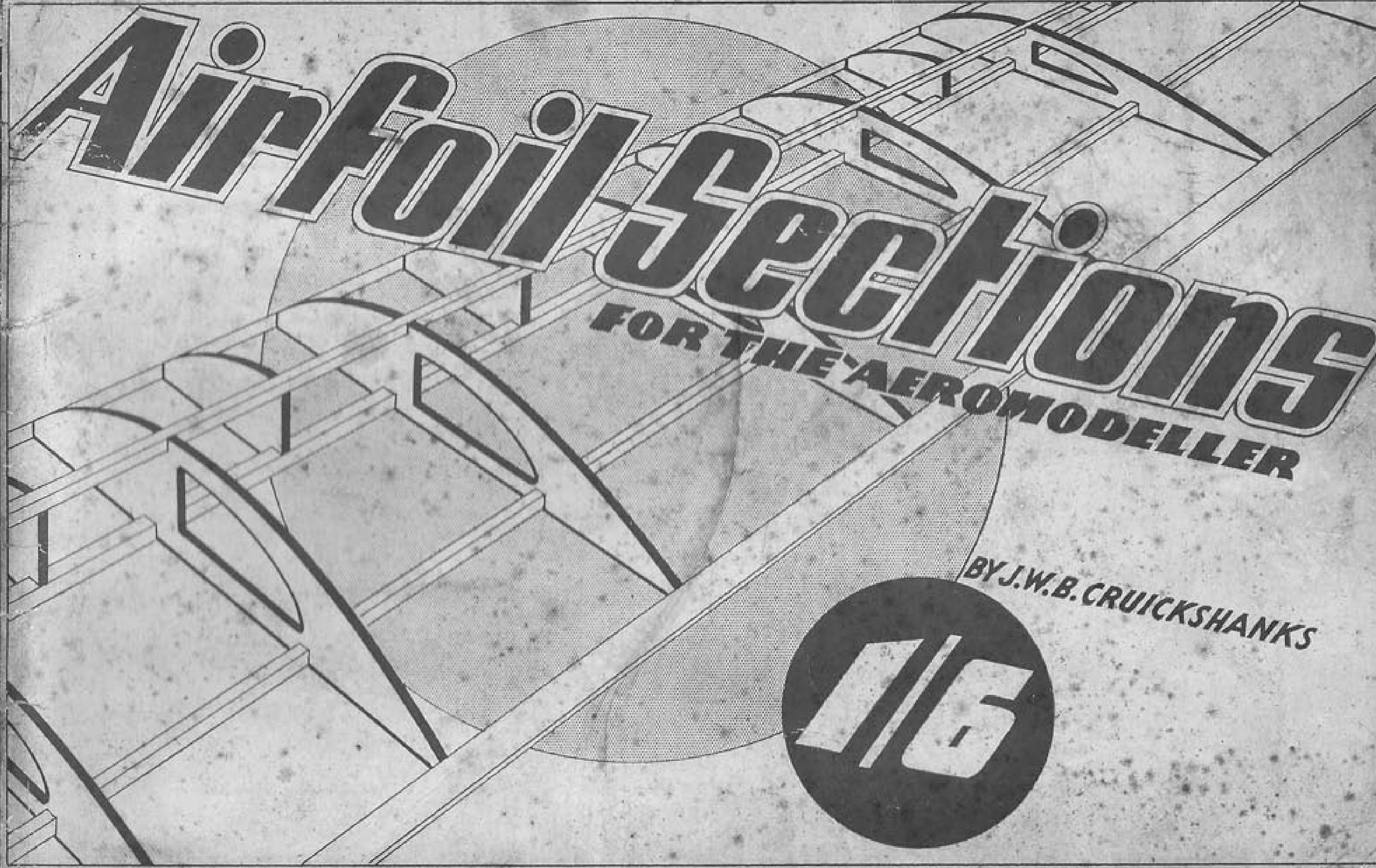

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CHAPTER 1.

IT is the purpose of this little book to give the aeromodeller some idea of the use of various airfoil sections and their suitability for certain purposes. In order to understand the choice of a certain airfoil section for a particular purpose, we will attempt to give the reader some idea of how an airfoil works.

It has been found that a plate placed at an angle to the air-stream exerts an upward or downward force, according to whether the plate is placed at a positive or negative angle to the air-stream. If the angle is positive the force acts upwards, and if negative it acts downwards. By curving the plate the force is found to be increased, and so the modern airfoil or wing is, in fact, a curved plate with a streamline fairing round it. The section of a wing or airfoil section will thus be a symmetrical streamline section whose centre-line has been given a camber. In earlier airfoils this centre line was a circular arc, but in more modern airfoils it has a variety of forms.

From Fig. 1 it will be seen that the force acting on the airfoil has been split up into two components, one parallel with, and one normal to, the air-stream. The force normal to the air-stream is called the lift, and that parallel to the air-stream is called the drag, of the airfoil. The two formulæ from which these forces may be calculated are:

$$L = C_L \frac{p}{2} SV^2 \qquad \ldots \quad \ldots \quad \ldots \quad (1)$$

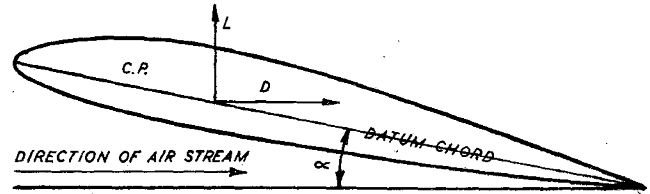


Fig. 1.

$$\text{and } D = C_D \frac{p}{2} SV^2 \qquad \ldots \quad \ldots \quad \ldots \quad (2)$$

where L = lift in lb.
C_L = lift coefficient
p = density of air = ·002378 slugs/cu. ft.
S = wing area in sq. ft.
V = speed in ft./sec.
D = drag in lb.
C_D = drag coefficient

The angle α shown in Fig. 1 is known as the angle of attack, and as this angle is increased so the lift coefficient increases, but the drag coefficient also increases. The lift coefficient increases as the angle of attack is increased up to a critical point, when it starts to decrease again. This angle is known as the stalling angle, and is the point at which the wing is about to stall, and the value of C_L at this point is known as C5 maximum. C_L maximum determines the minimum flying speed of the aircraft.

Thus at this point L = W (the weight of the aircraft), and so for any given aircraft the stalling speed can be found.

$$\text{i.e. } WL = W = C_L \text{ max.} \frac{p}{2} SV^2$$

$$\therefore V^2 = \frac{W}{S \times C_L \text{ max.} \times \frac{p}{2}}$$

$$\therefore V = \sqrt{\frac{W}{S \times C_L \text{ max.} \times \cdot 001189}}$$

where V is in ft. per second

$$\text{and } V = 19{\cdot}77 \sqrt{\frac{W}{S \times C_L \text{ max.}}}$$

where V is in m.p.h.

We have seen that the lift increases with the angle of attack, but the drag also increases, and increases much more rapidly than the lift, and has no critical point within the useful range. The most efficient angle of attack is given by the maximum $\frac{L}{D}$ ratio, that is the angle at which the value of $\frac{C_L}{C_D}$ is greatest and greater lift is obtained in proportion to drag.

The point at which the forces of lift and drag act is known as the centre of pressure, or C.P., and unfortunately this point also varies with angle of attack. At the angle of zero lift, that is, the angle at which $C_L = 0$, the centre of pressure is presumed to be at the trailing edge, and as the angle of attack is increased it moves forward up to the stalling angle, and then proceeds to move backwards very rapidly.

For reasons of stability an airfoil with very little centre of pressure movement is advantageous. Some airfoils have been designed with a fixed centre of pressure or very little centre of pressure movement, e.g. R.A.F. 33.

From the foregoing it will be seen that the following are the main points to be looked for in the selection of airfoil sections. For a slow-flying aircraft, where C_D is not so important, a high C_L maximum is most important. For fast aircraft a low value of the minimum value of C_D is the most important part.

When a high rate of climb is desired, the value of L/D maximum is most important, and when stability is the first consideration C.P. movement is the most important consideration. It is obvious that all these qualities cannot be incorporated in any one airfoil section, and so aeromodellers must select the one which best suits their purpose and which has as many of these good points as possible.

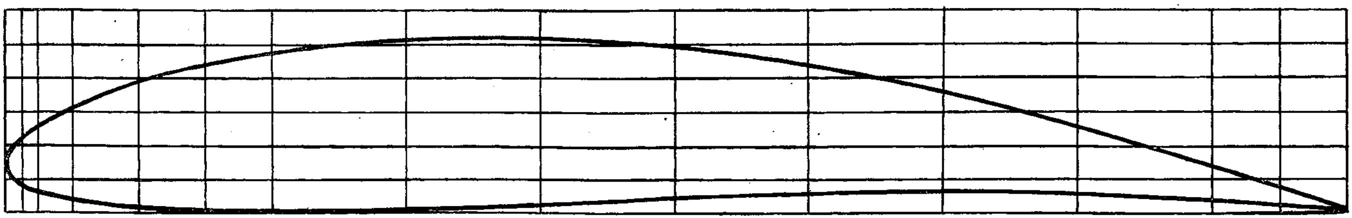
CHAPTER 2.

IN order to assist aero-modellers, we will select one airfoil and enumerate its points and endeavour to show how it may be used in a model. We will deal with R.A.F. 32, which is an airfoil section of great popularity with aero-modellers, as it has been well tried and not found wanting.

R.A.F. 32 is one of a series of airfoils developed from the symmetrical section R.A.F. 30, the others being R.A.F. 31 and R.A.F. 33. The camber of the centre line of R.A.F. 32 is 5 per cent of the chord, as a high value of CL maximum was desired.

The value of CL maximum is 1·308 at 14·7 degrees angle of attack for a wind speed of 60 ft./sec. on a model wing 8 in. × 48 in. R.A.F. 32 has a very good performance, but it has an extremely large centre of pressure movement, which has led to the design of R.A.F. 33,

R.A.F 32



ALL ORDINATES IN PER CENT OF CHORD

STATION	0	1·25	2·5	5·0	10	15	20	30	40	50	60	70	80	90	95	100
UPPER SURFACE	3·42	5·56	6·52	7·84	9·72	11·02	11·92	12·98	13·10	12·46	11·06	9·10	6·56	3·60	1·98	·12
LOWER SURFACE	3·42	1·96	1·50	·88	·30	·08	0·00	·30	·70	1·10	1·46	1·60	1·46	·92	·52	·12

Fig. 2.

which is identical with R.A.F. 32 but has a reflex trailing edge, which limits the C.P. movement. Unfortunately, this modification was found to decrease the CL maximum appreciably.

The centre of pressure movement of R.A.F. 32 is unfortunately large, as at L/D maximum, when CL = ·49, C.P. is at 52 per cent of the chord from the leading edge and at CL maximum at 33 per cent of the chord, that is, a travel of 19 per cent of the chord. However, the fact that CL maximum is fairly high and the minimum drag coefficient occurs at a fairly high value of CL, makes it most suitable for model purposes and overcomes to a large extent the disadvantage of the C.P. movement.

The curves and coefficients given are for a wind speed of 60 ft./sec., about 40 m.p.h., and model wing size 8 in. × 48 in., that is, an aspect ratio of 6. The values may be used, provided the A.R. of the model being designed has an aspect ratio of 6. In order to correct the values for any other aspect ratio we may work out the corrections for an aspect ratio of 10.

$$\text{Aspect ratio} = \frac{\text{span}^2}{\text{wing area}}$$

CL maximum does not change with aspect ratio.

Change in angle of attack for values of CL

$$= \alpha_{10} - \alpha_6 = 18{\cdot}24 \times C_L \left(\frac{1}{10} - \frac{1}{6}\right)$$
$$= (18{\cdot}24 \times -{\cdot}0667)C_L$$
$$= -1{\cdot}218\ C_L$$

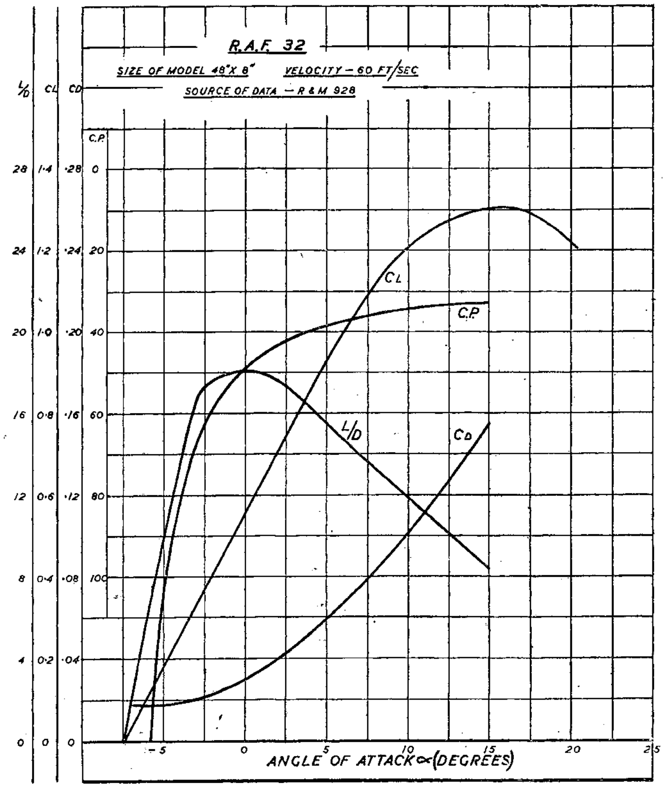


Fig. 3.

$$\text{Change in C.P.} = C_{D_{10}} - C_{D_6} = \frac{C_L{}^2}{\pi}\left(\frac{1}{10} \times \frac{1}{6}\right)$$

$$= \frac{-\cdot 0667}{\pi} \times C_L{}^2$$

$$= -\cdot 0212\ C_L{}^2$$

We will now give the calculations in tabular form, as this has the advantage of showing exactly what is happening and can be more easily followed. We will use the symbols $D\alpha$ for the change in $\alpha = -1{\cdot}218\ C_L$ and DC_D for the change in C = $-\cdot 0212\ C_L{}^2$.

Columns (1), (3) and (7) are read off the curves.

Column (5) obtained by squaring the values in Column (1).

,, (2) obtained by multiplying the values in Column (1) by − 1·218.

,, (4) obtained by adding Columns (2) and (3).

,, (6) obtained by multiplying the values in Column (5) by − ·0212.

,, (8) obtained by adding values in Columns (6) and (7).

Thus Columns (1), (4) and (8) are the values to be used for an aspect ratio of 10.

The values given in Columns (1), (4) and (8) are the values which should be used in the calculations for the wing of aspect ratio 10. The corrections should be gone through for whatever value of aspect ratio is used.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C_L	$D\alpha$	$\alpha 6$	$\alpha 10$	$C_L{}^2$	DC_D	CD_6	CD_{10}
·028	− ·034	−7	−7·034	·000783	−·000016	·0174	·01738
·184	− ·224	−4·8	−5·024	·034	−·0006	·0190	·0184
·340	− ·414	−2·9	−3·314	·1155	−·00245	·0202	·01775
·49	− ·597	−0·8	−1·397	·24	−·0051	·0272	·0221
·646	− ·787	+1·2	+ ·413	·4175	−·00885	·036	·02715
·788	− ·96	3·1	2·14	·62	−·01315	·0466	·03345
·93	−1·132	5·1	3·968	·865	−·01835	·0604	·04205
1·066	−1·299	7·0	5·701	1·132	−·024	·0766	·0526
1·172	−1·428	9·0	7·572	1·375	−·02915	·0926	·06345
1·234	−1·502	10·8	9·298	1·52	−·0322	·1098	·0776
1·272	−1·55	12·8	11·25	1·62	−·0343	·129	·0947
1·308	−1·592	14·7	13·108	1·708	−·0362	·1518	·1156

The value of C_L maximum and the angle of zero lift are unaffected by change of aspect ratio, and so it will be seen that only the C_D and the angle of attack need be considered.

It is to be hoped that the data given on this section, R.A.F. 32, will be of value to the aero-modeller, as no more reliable section can be found for use in models, and it can always be relied upon to give a good performance.

CHAPTER 3.

THE modern airfoil is generally derived from a streamline shape, the centre line of which has been given a camber. This can be seen in R.A.F.32, which is derived from R.A.F.30. We can see, then, that the airfoil has two surfaces, an upper and a lower. The upper surface is convex and the lower surface either flat, concave or convex.

In order to obtain the outline of these surfaces, a table of ordinates is given. These ordinates are expressed as percentages of the chord. Where the surface is above the datum chord the ordinate is positive, and where it is below it is negative.

The chord is defined as the projection of the line joining the leading and trailing edges of the airfoil.

In order to illustrate how the profile of an airfoil is drawn, we will take as an example the Clark Y airfoil. We will assume that a chord of ten inches is required, and so a line 10 inches long is drawn. This is the datum line illustrated in Fig. 4. This line should be divided into tenths. This gives divisions one inch long, and each inch division is ten per cent of the chord. Some of these divisions may be further sub-divided, as shown in the figure. Thus we have "stations" along the chord, expressed as percentages of the chord from the leading edge. Perpendiculars to the datum line should be erected at each of these stations.

Referring to the ordinates given on page 15, we see that at station 0 for the Clark Y airfoil the ordinate is 3·5 per cent of the chord; that is, the leading edge is 3·5 per cent of the chord above the datum line. Therefore, mark off $\frac{3{\cdot}5 \times 10}{100} = {\cdot}35$ inches above the datum line.

At station 1·25 per cent the upper surface is 5·45 per cent above the datum, and so we mark off ·545 inches above the datum at station 1·25 per cent. Similarly at 30 per cent of the chord the upper surface is 11·7 per cent above the datum, therefore we mark off 1·17 inches above the datum at station 30 per cent. By following this procedure for the upper surface, a number of points are obtained through which a smooth curve can be drawn. Thus the profile of the upper surface is obtained. In a similar manner we can find the profile of the lower surface.

At station 1·25 per cent the ordinate is 1·93; therefore we mark off ·193 inches above the datum at station 1·25 per cent. The other points along the lower surface are found in a similar way. It will be noticed that from 30 per cent to 100 per cent the ordinate is 0, and so the profile of the lower surface coincides with the datum line at these portions of the profile. A curve is drawn through the points from the leading edge to station 30 per cent of the chord, and continued by a straight line to the trailing edge. Thus the profile of the lower surface is obtained and we have now completed the drawing of the aerofoil profile.

All the airfoils in this book have been drawn with chords of seven inches, and so if we wish to draw the airfoil section profile to a chord of five inches we would draw a line five inches long and divide it up as before, and erect perpendiculars at the stations. We can then measure the ordinates from the drawing at the end of the book and multiply it by 5/7, which will give the ordinate at the corresponding station on the 5-inch chord airfoil section.

This procedure may be followed graphically, as shown in Fig. 5 and, if a pair of dividers is used, will probably be more accurate than scaling off the drawing.

Mark off AB equal to the chord in the book, and AC equal to the chord required. Join BC. Mark off AB′ equal to one of the dimensions in the book. Draw B′C′ parallel to BC. Then AC′ is the corresponding ordinate on the airfoil section, whose chord is equal to AC.

However, it would be more accurate to use the tables of ordinates given. In some cases, as in the early editions of "The Handbook of Aeronautics" and other publications, the stations are not given in regular percentages of the chord but are irregular divisions of the chord. This, of course, is more difficult, but once the stations are found the rest follows similarly to the methods shown.

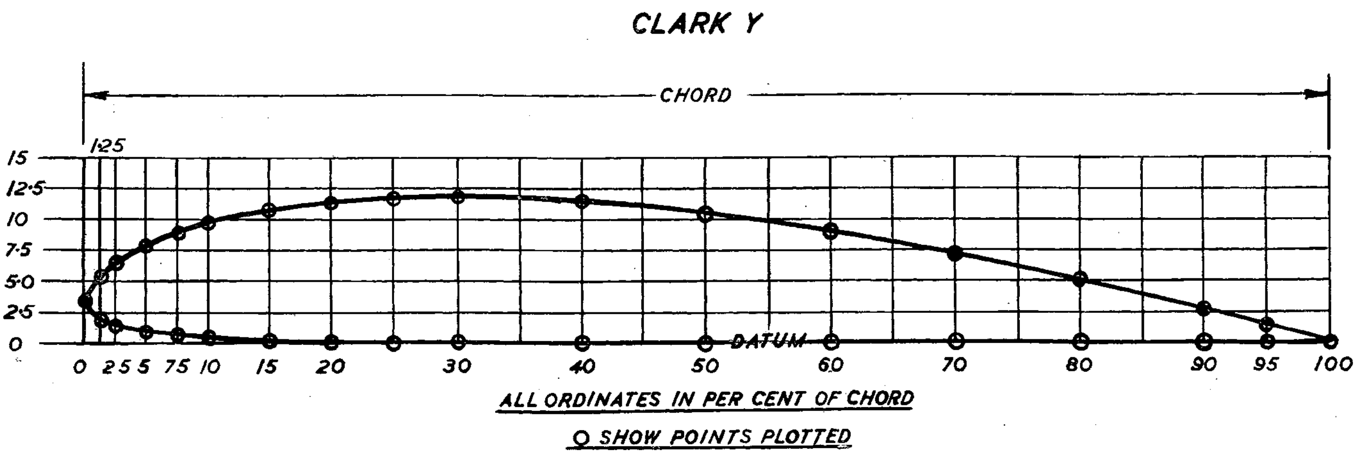


Fig. 4.

There are also different positions for the datum chord. In some it is a straight line drawn from the trailing edge tangential to the lower surface, and sometimes just tangential to the lower surface, as shown with R.A.F.33.

Most modern sections, however, as, for instance, the later N.A.C.A. and R.A.F. sections, have as the datum chord the line joining the leading and trailing edges of the airfoil. It is in this latter case that negative values of the ordinates of the lower surface are met with.

The leading edge is generally semi-circular in shape; that is, it is blunt, and the trailing edge should be carried on to form a knife edge, if possible. Readers will notice that in the tables of ordinates given there is some difference between the ordinates at the trailing edge. This is due to the fact that, in full-size construction, it is impossible, for structural reasons, to arrive at a knife edge, and so the trailing edge is finished off by a radius of small dimension.

In conclusion, it cannot be emphasised too strongly that accuracy in following the profile, especially at the fore part, is of great importance, as small deviations may cause quite an appreciable change in the aerodynamic characteristics of the airfoil section.

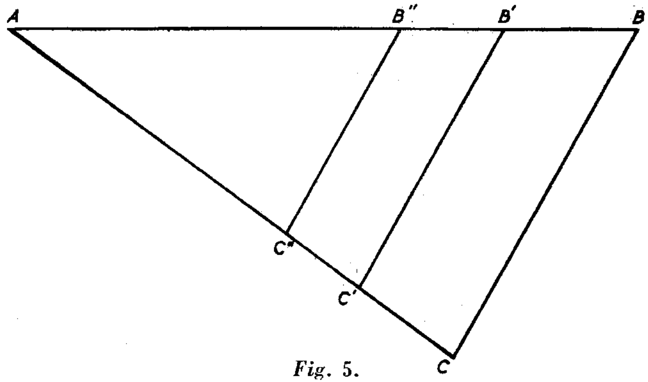
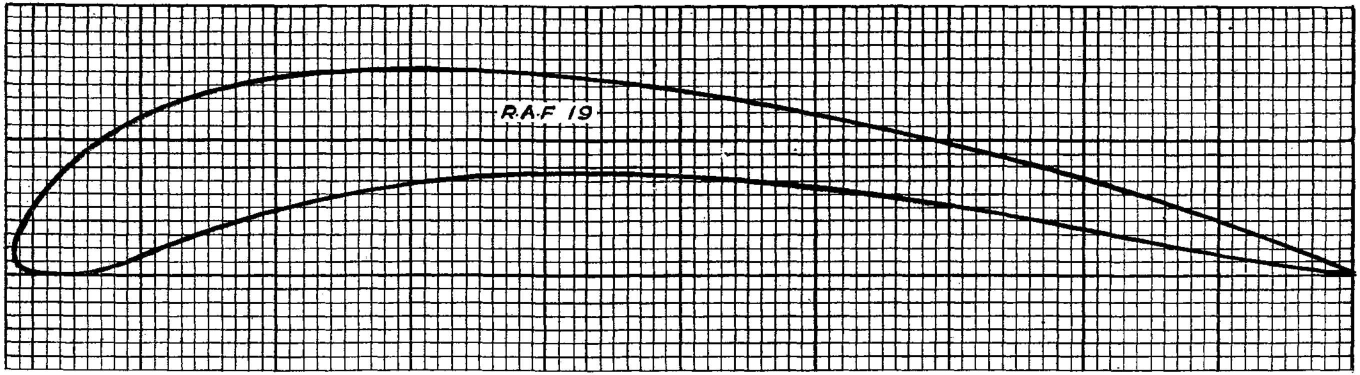


Fig. 5.

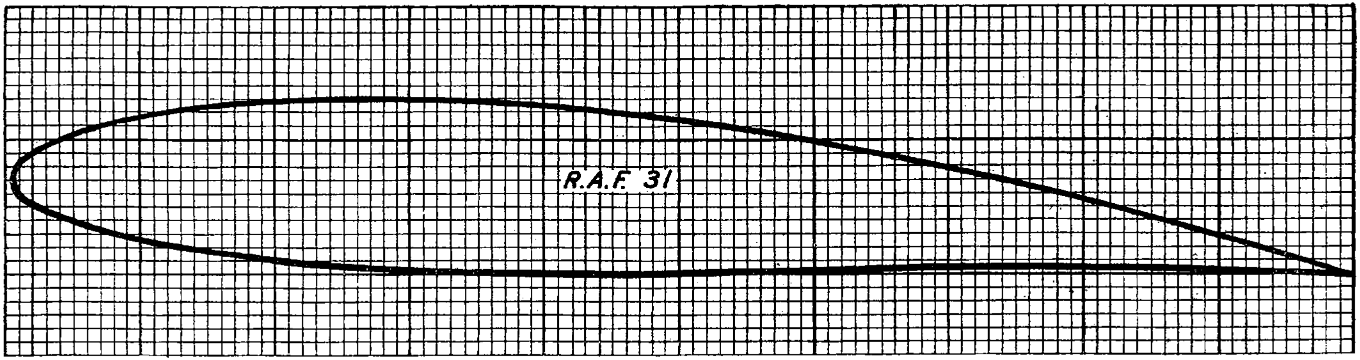


R.A.F. 19

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	1·20	3·90	5·80	8·5	10·40	11·80	13·70	14·70	15·20	14·70	13·40	11·70	9·50	7·10	4·30	2·60	·60
Lower surface	1·20	·39	·000	·10	·60	1·40	3·20	4·90	6·90	7·50	7·20	6·20	5·00	3·40	1·70	·80	·60

This airfoil appears to be one designed purely for a large C_L maximum, and as such should be most useful to designers for duration models. C_L maximum is 1·528 and occurs at about 15·8 degrees angle of attack. The slope of the C_D curve is very steep and should keep modellers from using this section for faster flying models. L/D maximum is 16·6 and occurs at an angle of attack of about $-1·0$ degree when $C_L = ·57$. A large tail surface should be used for this airfoil, as the centre of pressure movement is very large, being at 39 per cent of the chord at C_L maximum and 72 per cent at one-quarter C_L maximum.

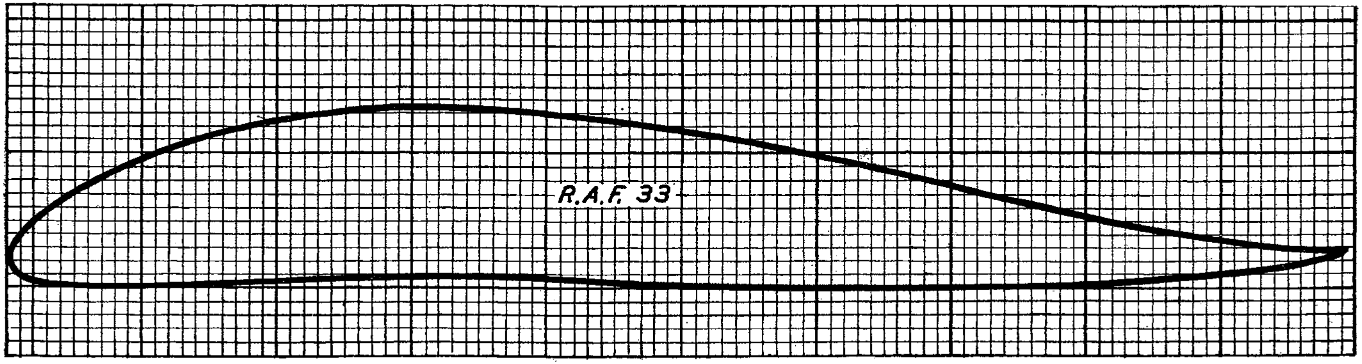
C_D minimum is ·0285. This airfoil may prove to be a bit of a gamble, as the stability question may be doubtful.



R.A.F. 31

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	7·18	8·88	9·7	10·7	—	11·84	12·52	13·00	13·14	12·48	11·42	9·8	7·74	5·40	2·92	1·61	·12
Lower surface ..	7·8	5·36	4·72	3·74	—	2·58	1·72	1·14	·44	·12	·02	·10	·22	·32	·24	·14	·12

This airfoil is of the same family as R.A.F. 32, but the maximum camber is only 2 per cent, as against the 5 per cent of R.A.F. 32. The C_L maximum is not so high as for R.A.F. 32, but C_D minimum is lower, and the C.P. movement is not so large. C_L maximum is 1·052 at 9·5 degrees angle of attack. The minimum value of C_D is ·0132, and occurs at −4·4 degrees at a C_L of ·132. L/D maximum is 19·1 at C_L of ·428, and an angle of attack of −·4 degree. The centre of pressure moves from 36·3 per cent at L/D maximum to 28·6 per cent at C_L maximum. The data of this airfoil is published in R. and M., 928, but this is unfortunately out of print.



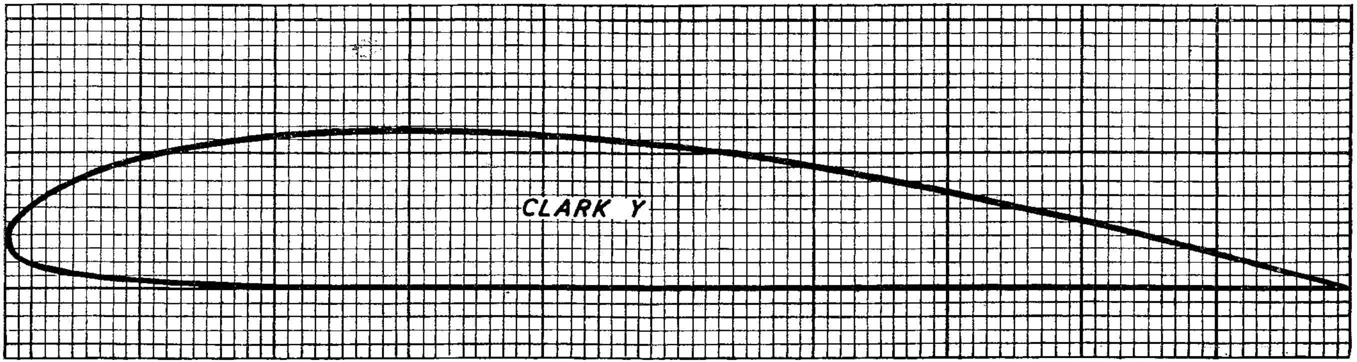
R.A.F. 33

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	2·14	4·42	5·54	7·8	—	9·62	11·28	12·30	13·22	12·94	11·66	9·70	7·5	5·30	3·50	2·86	2·38
Lower surface	2·14	·64	·28	·08	—	·08	·20	·34	·58	·50	·26	·08	·04	·24	·96	1·48	2·38

This airfoil has the same maximum camber as R.A.F. 32, but has a reflexed trailing edge to control the centre of pressure movement of R.A.F. 32. Unfortunately, the C_L maximum has been reduced without much change in C_D minimum. C_L maximum is 1·234, and occurs at 16·3 degrees angle of attack. C_D minimum is ·0176, and occurs −1·1 degrees angle of attack, at which value C_L is ·098. L/D maximum is 17·5, and occurs at 4·8 degrees angle of attack at a C_L of ·588.

There is practically no C.P. movement, which is one of the main advantages of this airfoil section.

The data on this airfoil section is also published in R. and M. 928.



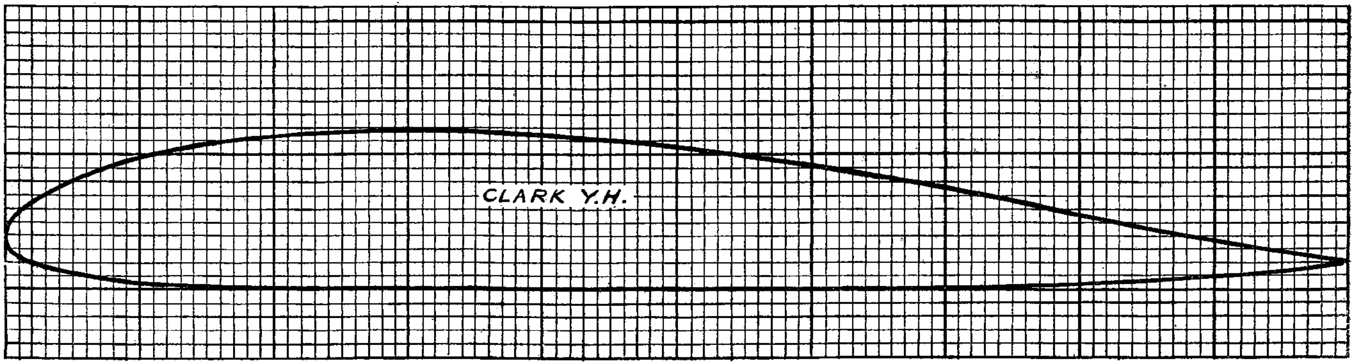
CLARK Y

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	3·5	5·45	6·50	7·90	8·85	9·60	10·68	11·36	11·70	11·40	10·52	9·15	7·35	5·22	2·80	1·49	·12
Lower surface ...	3·50	1·93	1·47	·93	·63	·42	·15	·03	0	0	0	0	0	0	0	0	0

This is one of the most popular sections among modellers all over the world, and is also used as an airscrew section. It has the advantage of making a wing easy to construct, and the performance has all-round merit.

C_L maximum is 1·68 for full scale work, and 1·24 for model work. C_D minimum for an aspect ratio of 6 is ·0085. L/D maximum is 21·2. The angle of zero lift is −5·0 degrees. C_L maximum occurs at about 19 degrees angle of attack, and C_D minimum at 4·5 degrees, and L/D maximum at about 4·5 degrees when C_L is ·4. C.P. movement is from 40 per cent at L/D maximum to 30 per cent at C_L maximum. The all-round performance of this airfoil can be used to the advantage of the modeller.

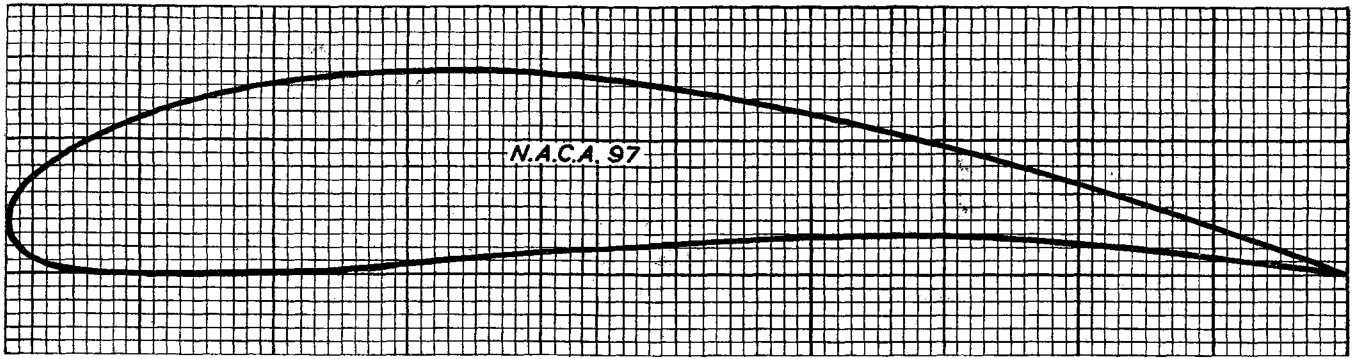
Data on this airfoil is given in so many places that only a few references can be given. They are N.A.C.A. 628, 586, 352, 541, and 502.



CLARK Y.H.

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	4·1	—	6·8	8·1	9·0	9·8	10·8	11·3	11·9	11·45	10·5	9·1	7·55	5·6	3·7	1·85	2·1
Lower surface ..	4·1	—	1·85	1·2	—	·45	0·00	—	—	—	—	—	—	·4	1·0	1·37	2·0

This airfoil, which is one developed by Col. V. E. Clark (as was the Clark Y), should be of the greatest value to those aeromodellers who desire an airfoil with very little centre of pressure movement. The reflex trailing edge, like that of R.A.F. 33, has been introduced especially for that purpose. Results for a very low Reynolds's Number given in R. and M. 1706. C_L maximum is given as 1·116, and occurs between an angle of 14·9 and 16 degrees angle of attack. The angle of zero lift is given as −2·9 degrees. This is taken from N.A.C.A. report 628. Centre of pressure is practically nil, due to the reflexed trailing edge. C_D minimum is ·0132 at an angle of attack of −1·6 degrees angle of attack, at which value C_L=·094. C_D at C_L maximum is ·1242. L/D maximum is equal to 19·07 and occurs at a C_L of ·328 at +1·5 degrees angle of attack. On the whole this should prove a very useful airfoil for aeromodellers.



N.A.C.A 97

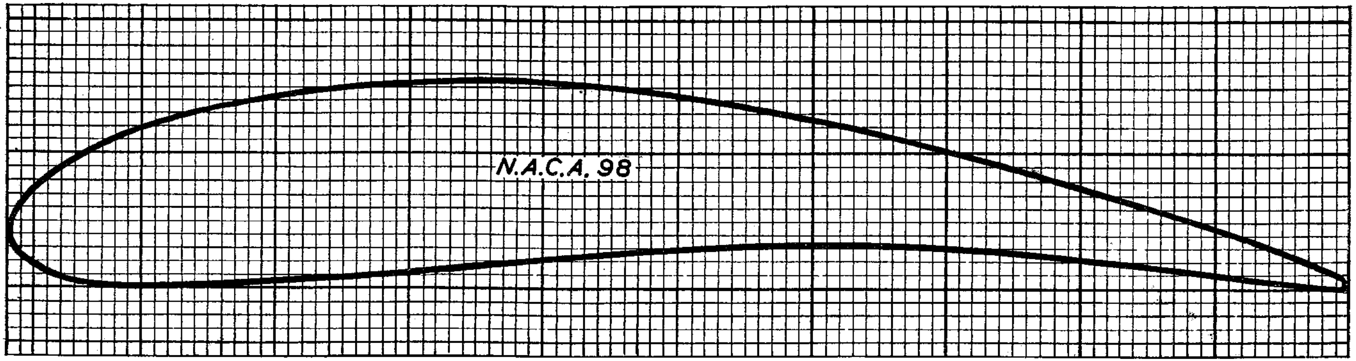
Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	4·17	—	7·93	9·5	10·8	11·8	13·3	14·28	15·15	15·00	13·94	12·20	9·77	6·87	3·60	1·87	·13
Lower surface ..	4·17	—	·73	·33	·10	·03	0·00	·17	·83	1·73	2·50	2·86	2·80	2·30	1·33	·67	0·00

This is one of the earlier N.A.C.A. sections and should prove useful to modellers.

C_L maximum is 1·335, and C_D minimum is ·0133, for an aspect ratio of 6. L/D maximum is 18·2, and the centre of pressure is at 33 per cent of the chord at C_L maximum, and 59 per cent at ·25 C_L maximum. C_L maximum occurs at an angle of attack of 15 degrees. L/D maximum is at −2 degrees at a C_L of ·49. The angle of zero lift is about −9·3 degrees.

The thickness to chord ratio of this airfoil is 14·32 per cent.

Data is abstracted from N.A.C.A. report 352.

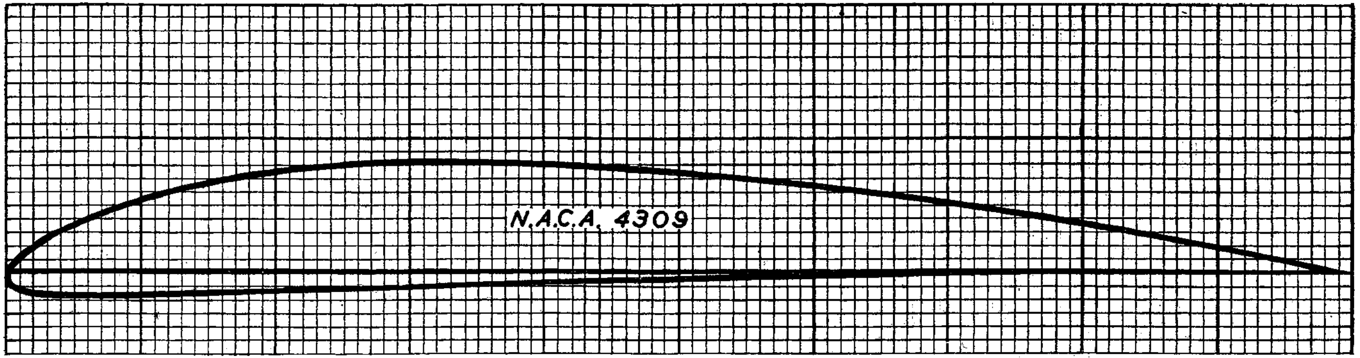


N.A.C.A. 98

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	4·00	—	8·00	9·60	10·85	11·93	13·4	14·38	15·37	15·30	14·28	12·60	10·30	7·70	4·87	3·27	·90
Lower surface ..	4·00	—	·13	·30	·10	0·00	0·00	·23	1·07	2·06	2·87	3·23	3·13	2·47	1·33	·56	·90

This airfoil is very similar to N.A.C.A. 97, but a different centre line is used. C_L maximum is slightly higher, being 1·363, and occurs at an angle of attack of 17 degrees. C_D minimum for an aspect ratio of 6 is ·0138, which is fairly large. The angle of zero lift is −8·0 degrees. L/D maximum is 17·4, and occurs at an angle of attack of −1·5 degrees and a C_L of ·43. The centre of pressure moves from 33 per cent at C_L maximum to 68 per cent at ·25 C_L maximum, which is slightly more than for N.A.C.A. 98.

The comparison of N.A.C.A. 97 and 98 should be studied by readers, as the increase in C_L maximum is accompanied by other disadvantages.



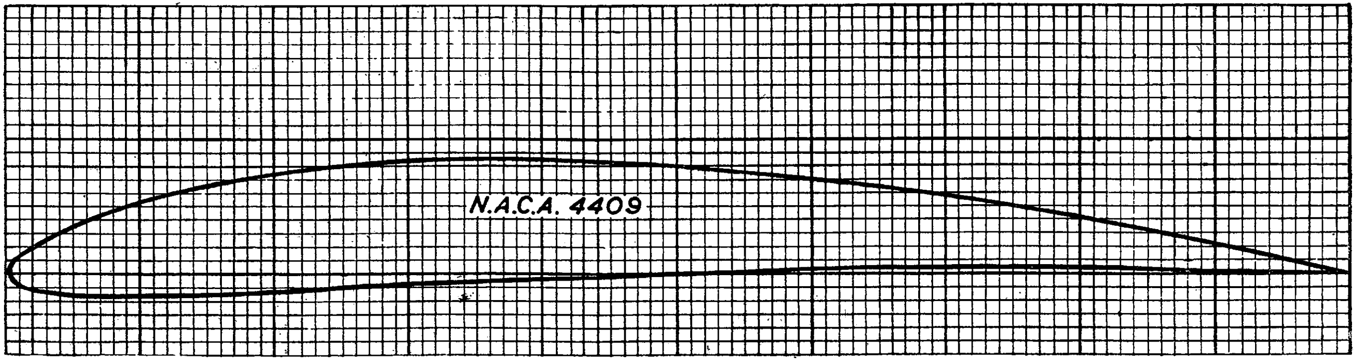
N.A.C.A. 4309

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	0	1·98	2·8	4·09	5·05	5·86	7·08	7·88	8·5	8·29	7·65	6·71	5·46	3·95	2·16	—	0
Lower surface ..	0	– ·94	–1·21	–1·37	–1·36	–1·26	–1·01	– ·76	– ·5	– ·43	– ·29	– ·15	– ·05	0	+ ·05	—	0

This airfoil is one of the first series of related airfoils of the N.A.C.A. It has a centre line camber of 4 per cent, which occurs at 30 per cent of the chord from the leading edge, and the thickness to chord ratio is 9 per cent of the chord.

C_L maximum, taken from the wind tunnel values, is 1·71, which is very high. When this value is corrected for use in model work C_L maximum is 1·22. The angle of zero lift is –3·6 degrees, and the minimum value of C_D, for an aspect ratio of 6, is ·0080. L/D maximum is 22·3, and occurs at about +1·8 degrees angle of attack, when C_L is ·39. The centre of pressure movement is not large, and this should prove quite a useful section for faster models.

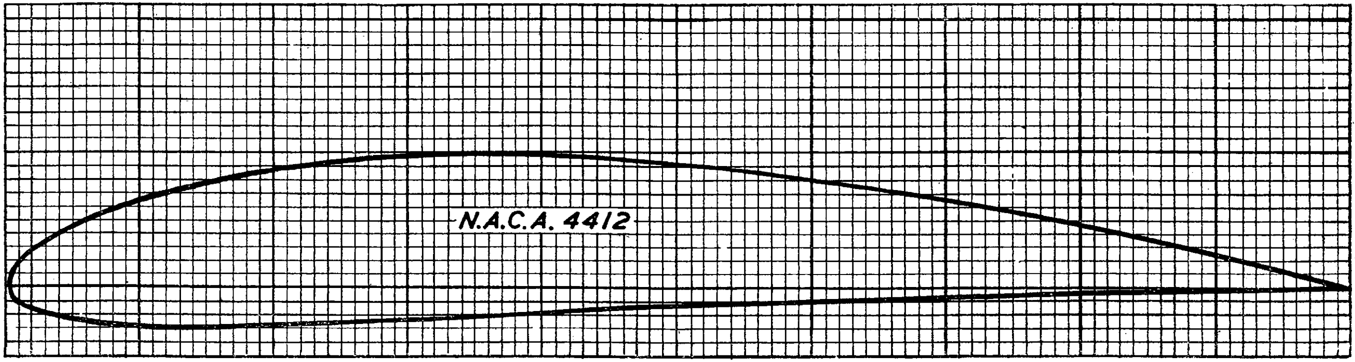
A full report on this section is given in N.A.C.A. report 460.



N.A.C.A. 4409

Station ..	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	0	1·81	2·61	3·74	4·64	5·37	6·52	7·33	8·25	8·35	7·87	7·00	5·76	4·21	2·33	1·26	0
Lower surface ..	0	–1·05	–1·37	–1·65	–1·74	–1·73	–1·55	–1·30	– ·76	– ·35	– ·07	·14	·26	·26	·14	·03	0

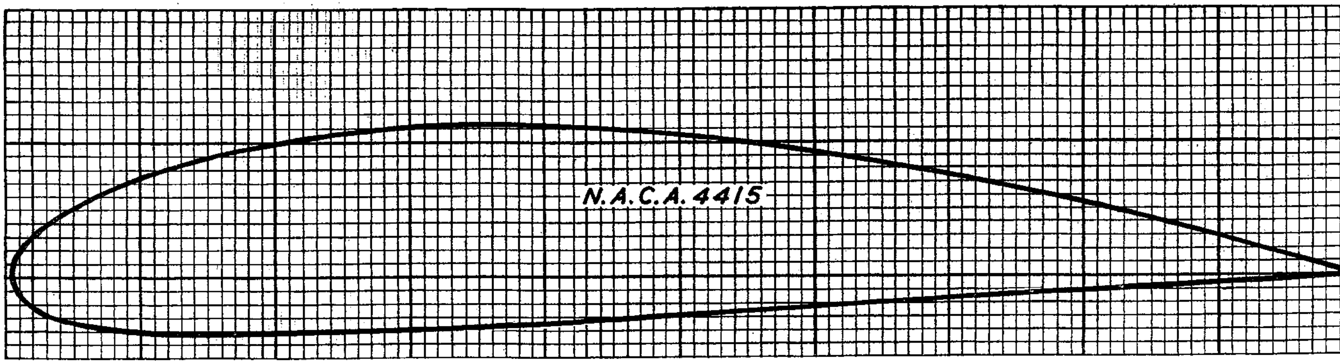
This airfoil, together with N.A.C.A. 4415, is developed round the same centre line as N.A.C.A. 4412. The thickness to chord ratio is 9 per cent. The angle of zero lift is –3·9 degrees. C_L maximum is 1·77 for full scale work, and 1·26 for model work. C_D minimum for an aspect ratio of 6 is 0077, which is very low, and gives an inkling that this airfoil is more suitably for fast-flying models. The centre of pressure movement is not large, and should help models which are lacking in inherent stability. This airfoil section is reported in N.A.C.A. report 460.



N.A.C.A. 4412

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	0	2·44	3·39	4·73	5·76	6·59	7·89	8·80	9·76	9·80	9·19	8·14	6·69	4·89	2·71	1·47	0
Lower surface ..	0	– 1·43	– 1·95	– 2·49	– 2·74	– 2·86	– 2·88	– 2·74	– 2·26	– 1·80	– 1·40	– 1·00	– ·65	– ·39	– ·22	– ·16	0

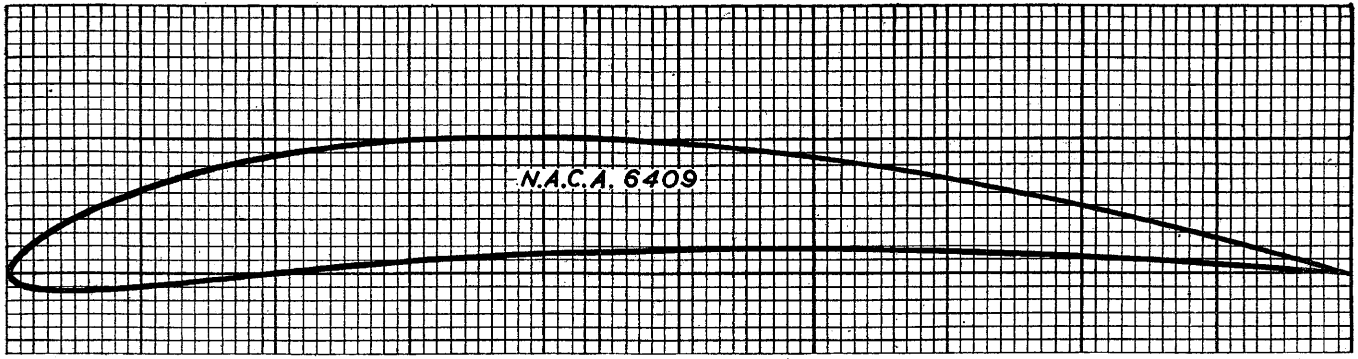
This section is one more suitable for faster flying models, although it has a good all round performance. The thickness chord ratio is 12 per cent, and the maximum camber of the centre line is 4 per cent, which occurs at 40 per cent of the chord. C_L maximum is given in N.A.C.A. report 460 as 1·74, and this gives a figure of 1·30 for model work. The angle of zero lift is −4·0 degrees, and a minimum value of C_D of ·0084. The centre of pressure is at 31 per cent of the chord at C_L maximum, and there is quite a small movement compared with some of the other airfoils described. This airfoil is described fully in N.A.C.A. report 460, and further tests have been made and reported in N.A.C.A. report 586.



N.A.C.A. 4415

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	0	3·07	4·17	5·74	6·91	7·84	9·27	10·25	11·25	11·25	10·53	9·30	7·63	5·55	3·08	1·67	0
Lower surface ..	0	– 1·79	– 2·48	– 3·27	– 3·71	– 3·98	– 4·18	– 4·15	– 3·75	– 3·25	– 2·72	– 2·14	– 1·55	– 1·03	– ·57	– ·36	0

This airfoil is also given in N.A.C.A. report 460, and has an angle of zero lift of –4·0 degrees. CL maximum is 1·72 in full scale work, and 1·35 in model work. CD minimum for an aspect ratio of 6 is ·0092. It would be most advantageous if we used the three airfoil sections N.A.C.A. 4409, 4412, and 4415 in a tapered wing, having 4415 at the root and 4409 at the tip. It would be near enough if we took the mean values of the characteristics. This would give a CL maximum of 1·30, and a minimum value of CD, for an aspect ratio of 6, of ·0084. The laying out of such a wing may cause trouble to some readers, but I shall be only too glad to assist if asked.

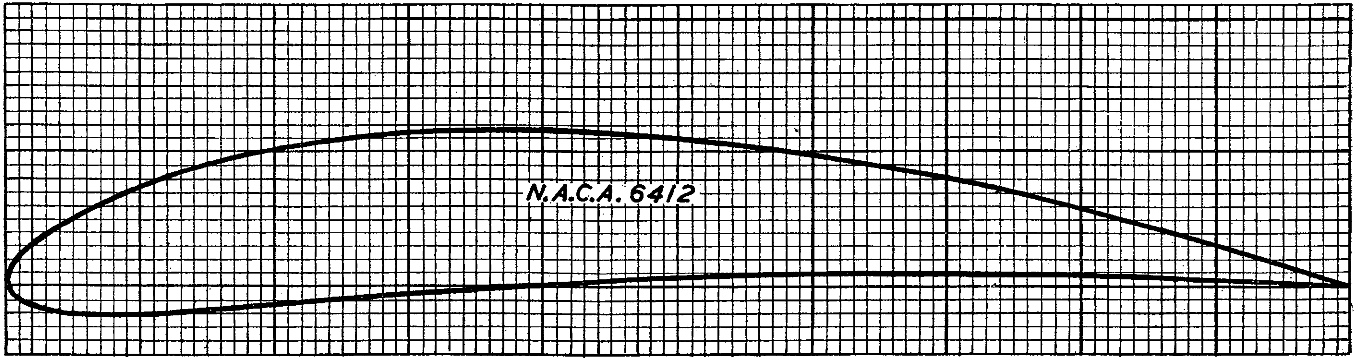


N.A.C.A. 6409

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	0	2·06	2·96	4·30	5·42	6·31	7·78	8·88	10·13	10·35	9·81	8·78	7·28	5·34	2·95	—	0
Lower surface ..	0	− ·88	− 1·11	− 1·18	− 1·08	− ·88	− ·36	+ ·17	1·12	1·65	1·86	1·92	1·76	1·36	·74	—	0

This is another of the series of 78 related airfoils of the N.A.C.A. It has a maximum camber of 6 per cent of the chord at 40 per cent of the chord from the leading edge, and the thickness to chord ratio is 9 per cent. This camber of the centre line is rather larger than is generally met with in practice, but should prove quite useful for model work, although high cambers generally have the effect of causing large centre of pressure movement. From the N.A.C.A. report 460 C_L maximum is given as 1·80, which value, when corrected for model work, gives a value of 1·33. The angle of zero lift is −5·9 degrees, and the minimum value of C_D for aspect ratio of 6 is ·0100. L/D maximum is 21·6, and occurs at C_L ·42.

This airfoil is fully reported on in N.A.C.A. report 460.

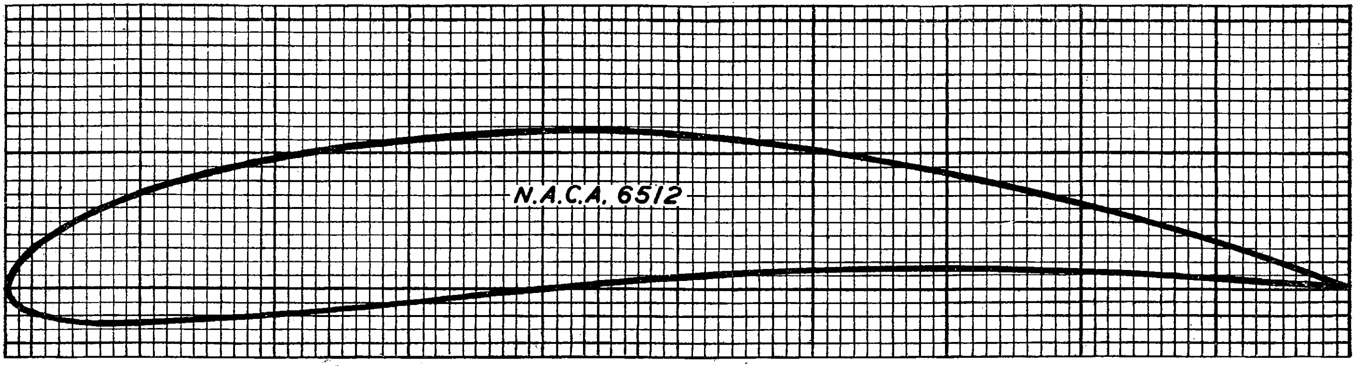


N.A.C.A. 6412

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	0	2·73	3·8	5·36	6·57	7·58	9·18	10·34	11·65	11·80	11·16	9·95	8·23	6·03	3·33	1·79	0
Lower surface	0	– 1·23	– 1·64	– 1·99	– 2·05	– 1·99	– 1·67	– 1·25	– ·38	+ ·20	·55	·78	·85	·73	·39	·16	0

N.A.C.A. 6412 is basically the same airfoil as N.A.C.A. 6409, only the thickness to chord ratio is slightly greater, being 12 per cent as against 9 per cent. The angle of zero lift is –5·9 degrees, and C_L maximum is 1·82 from the report, which gives a corrected figure of 1·52. This is a very high figure, and shows that this is more suitable for slow flying models than N.A.C.A. 6409. These two airfoils could be used in a tapered wing using say 6412 at the root, and 6409 at the tip, and taking the average of the two values for C_L maximum. For an aspect ratio of 6, the minimum value of C_D is ·0103.

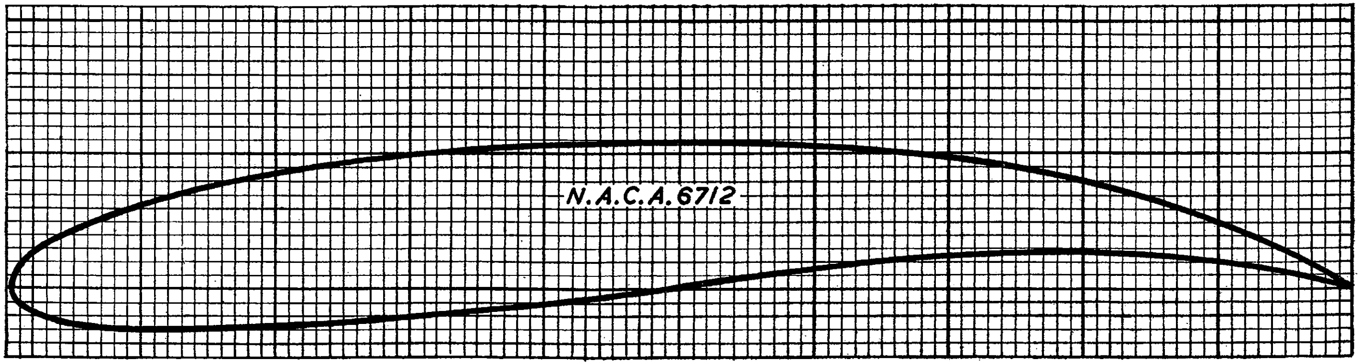
This airfoil is reported in N.A.C.A. report 460.



N.A.C.A. 6512

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	0	2·57	3·56	5·02	6·13	7·06	8·57	9·69	11·07	11·56	11·29	10·35	8·76	6·54	3·68	—	0
Lower surface ..	0	– 1·34	– 1·82	– 2·26	– 2·43	– 2·45	– 2·27	– 1·91	– ·98	– ·06	+ ·71	1·21	1·39	1·24	·72	—	0

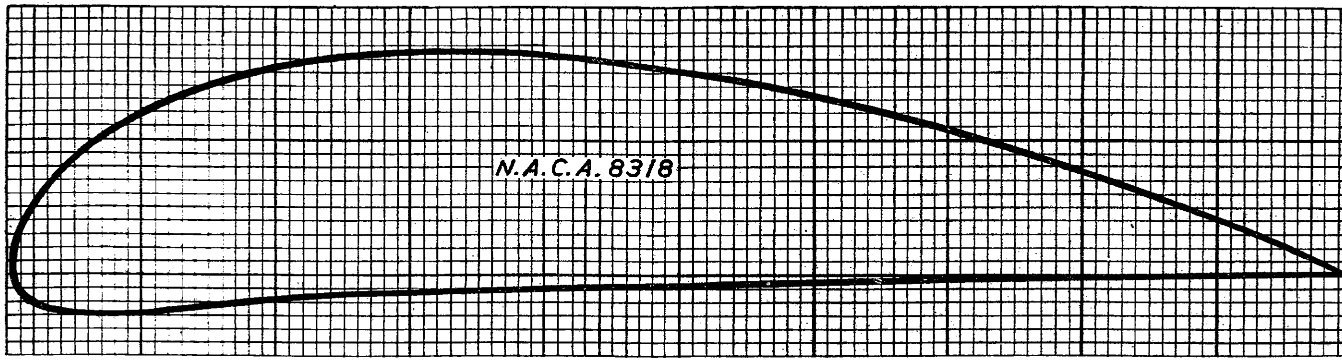
This section is rather similar to R.A.F. 32, as the centre line has a camber of 6 per cent of the chord, which occurs at 50 per cent of the chord, and a thickness to chord ratio of 12 per cent. CL maximum from the results given is 1·87, and corrected for model work 1·50. This value is very good, and should prove very useful. The angle of zero lift is –6·2 degrees, and the minimum value of CD occurs at this value for an aspect ratio of 6, and is ·0119. L/D maximum is 20·6, and occurs at an angle of attack of =·4 degree at a CL of ·42. This airfoil, as can be seen, is more suitable for models in which stalling speed is of primary importance, and for further details N.A.C.A. report 460 should be consulted.



N.A.C.A. 6712

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface . .	0	2·36	3·28	4·60	5·61	6·44	7·75	8·75	10·07	10·70	10·80	10·44	9·67	8·02	4·88	2·71	0
Lower surface . .	0	−1·50	−2·03	−2·59	−2·89	−3·02	−3·01	−2·80	−1·99	− ·92	+ ·19	1·31	2·34	2·73	1·88	1·02	0

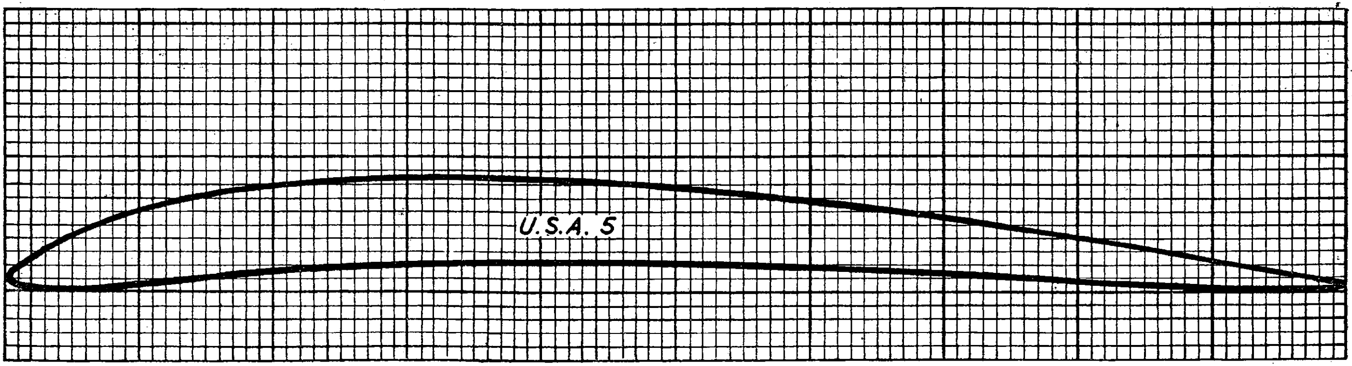
This is another of the freakish type of airfoil sections, as the centre line has a camber of ·6 per cent of the chord, and is situated at 70 per cent of the chord. The thickness to chord ratio is 12 per cent. This airfoil section has the characteristics of an ordinary section, with flaps depressed and, as such, may cause stability trouble in models. A model with this section should have a slightly larger tail-plane area than normal, but if this is done the performance should be quite good. C_L maximum is corrected from 2·05 to 1·45, and C_D minimum for an aspect ratio of 6 is ·0119. The angle of zero lift is −7·3 degrees.



N.A.C.A. 8318

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	0	5·50	6·97	9·23	10·97	12·40	14·53	15·94	17·00	16·57	15·34	13·49	11·04	8·02	4·41	2·39	0
Lower surface ..	0	- 1·33	- 1·86	- 2·35	- 2·42	- 2·34	- 1·94	- 1·49	- 1·00	- ·86	- ·55	- ·25	- ·04	+ ·03	- ·01	- ·08	0

This airfoil is rather a freak, and as such is rather a gamble; although it may prove very successful it may also be exactly the opposite. The mean camber line has a camber of 8 per cent at 30 per cent of the chord, and the thickness to chord ratio is 18 per cent. CL maximum given in the N.A.C.A. report is 1·59, which gives a figure of 1·74 when corrected for model work. However, I think that it might be advisable to use a figure of 1·60, as readings on this airfoil may be regarded with suspicion. The angle of zero lift is −7·2 degrees, and the value of CD at this angle is about ·013. This airfoil is reported in N.A.C.A. report 586.

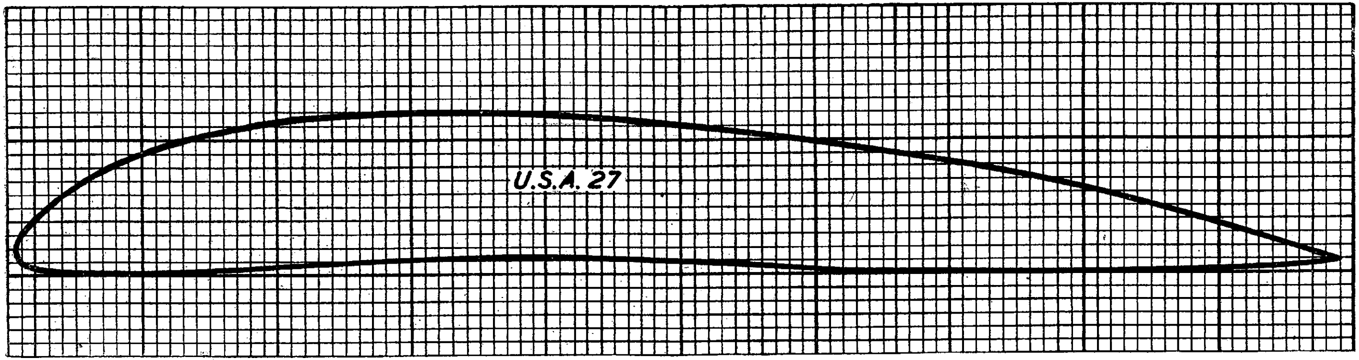


U.S.A. 5

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	·73	2·10	3·04	4·42	5·41	6·22	7·20	7·94	8·38	8·17	7·66	6·76	5·62	4·20	2·48	1·50	·50
Lower surface	·33	·17	·03	·03	·25	·60	1·15	1·59	2·00	2·16	1·94	1·62	1·16	·77	·40	·20	·00

This airfoil is one of the older designs of airfoils, and may not have sufficient thickness for efficient use. C_L maximum is 1·21, which occurs at about 14 degrees angle of attack. L/D maximum is 22·6, and C_D minimum is ·0117. C.P. is at 32 per cent at C_L maximum, and at 56 per cent at ·25 C_L maximum. C_L at L/D maximum is ·39, and the angle of attack at L/D maximum is + ·8 degree.

Data has been abstracted from N.A.C.A. report 352.



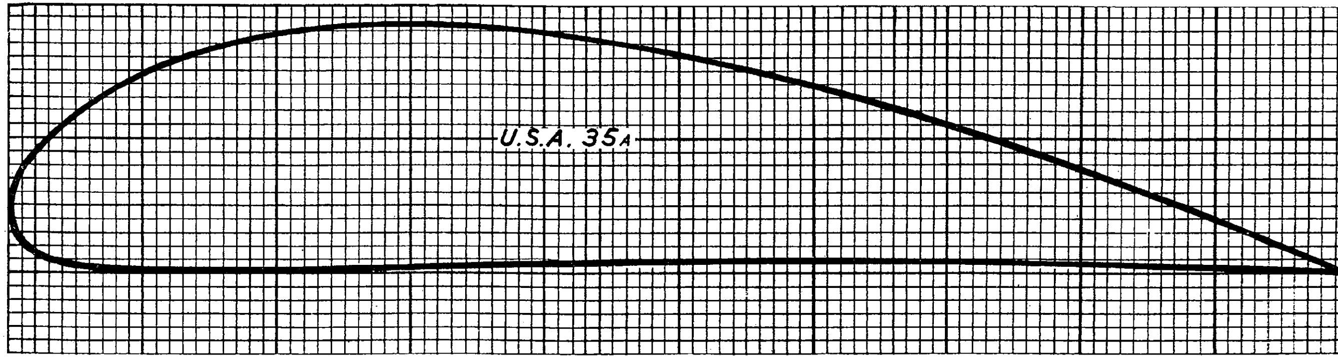
U.S.A. 27

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	1·77	3·80	5·07	6·94	8·22	9·19	10·50	11·37	11·97	11·68	10·86	9·54	8·08	6·10	3·69	2·26	·67
Lower surface ..	1·77	·50	·36	·19	·10	·02	·10	·36	·93	1·14	·75	·28	·06	·01	·12	·33	·65

This airfoil, which is of fairly early design, has quite a good performance when corrected for model use. C_L maximum for full scale work is 1·71, and 1·41 for model work. C_L maximum occurs at an angle of attack of **20** degrees. L/D maximum is 21 at + 1 degree angle of attack, and C_L of ·4. C.P. movement is not large, being from **40** per cent of the chord at L/D maximum to **30** per cent at C_L maximum. The minimum value of C_D for an aspect ratio of **6** is ·0098.

The angle of zero lift is at −4·7 degrees angle of attack.

Data on this airfoil may be obtained from N.A.C.A. reports 628 and 352.

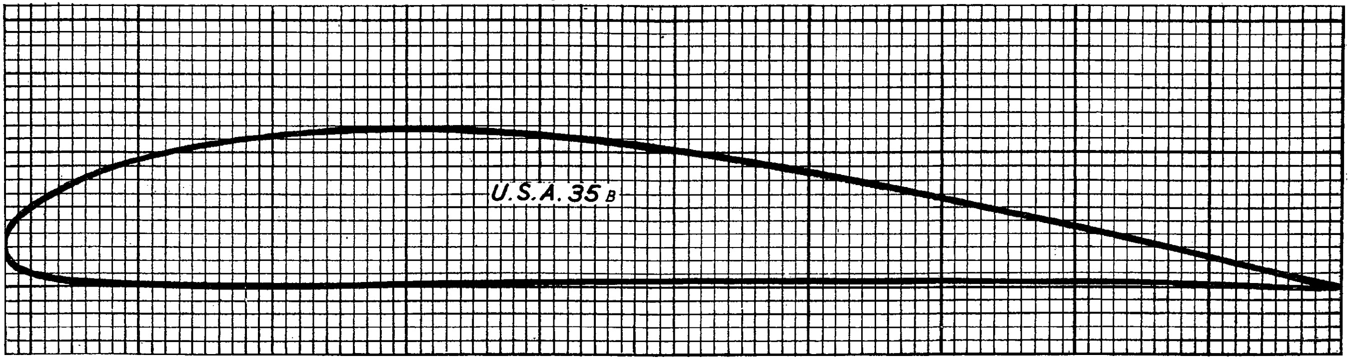


U.S.A. 35a

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	4·33	8·09	9·54	11·81	13·58	14·85	16·60	17·73	18·46	17·89	16·21	13·83	11·11	7·88	4·31	2·39	·43
Lower surface ..	4·33	1·62	1·00	·46	·22	·10	·00	·08	·24	·40	·58	·66	·60	·50	·32	·19	0

This airfoil has a very large thickness to chord ratio, namely 18·22 per cent, and should prove very useful in thick wings. C_L maximum is 1·51. This occurs at about 19 degrees, but the peak of the C_L curve is very flat, and between 16 degrees and 20 degrees. There is very little change in the value of C_L, which should prove very useful to designers of duration models. C_D minimum for an aspect ratio of ·6 is ·0121. L/D maximum is about 18, and occurs at about -2 degrees angle of attack, and a C_L of ·43. The angle of zero lift is $-8·0$ degrees. The centre of pressure moves from 50 per cent at L/D maximum to 34 per cent of C_L maximum.

Data is abstracted from N.A.C.A. report 628.



U.S.A. 35b

Station..	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	2·76	5·15	6·11	7·52	8·65	9·45	10·56	11·28	11·76	11·42	10·33	8·81	7·08	5·02	2·72	1·50	·25
Lower surface ..	2·76	1·03	·63	·28	·14	·07	·00	·05	·15	·28	·39	·45	·42	·35	·20	·12	0

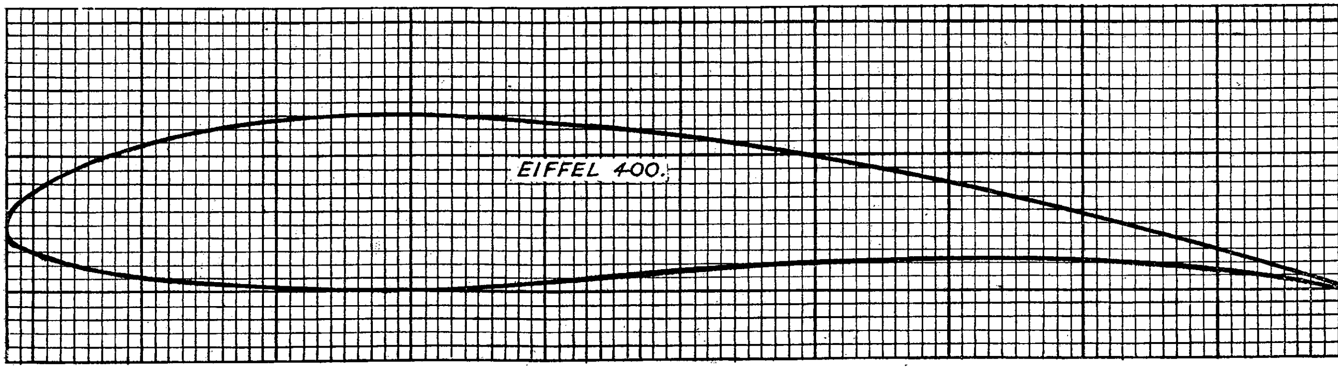
This is a very similar airfoil to 35A, but the thickness to chord ratio is less, namely 11·61.

It could be used with U.S.A. 35A in a tapered wing with advantage.

C_L maximum for full-scale work is 1·81, and for model work 1·44; it occurs at an angle of attack of 20 degrees. C_D maximum for an aspect ratio of 6 is ·0087. L/D maximum is 21·7, and occurs at about 0 degree at a C_L of ·4.

The angle of zero lift is −5·2 degrees. The centre of pressure moves from 45 per cent of the chord at L/D maximum to 30 per cent at C_L maximum.

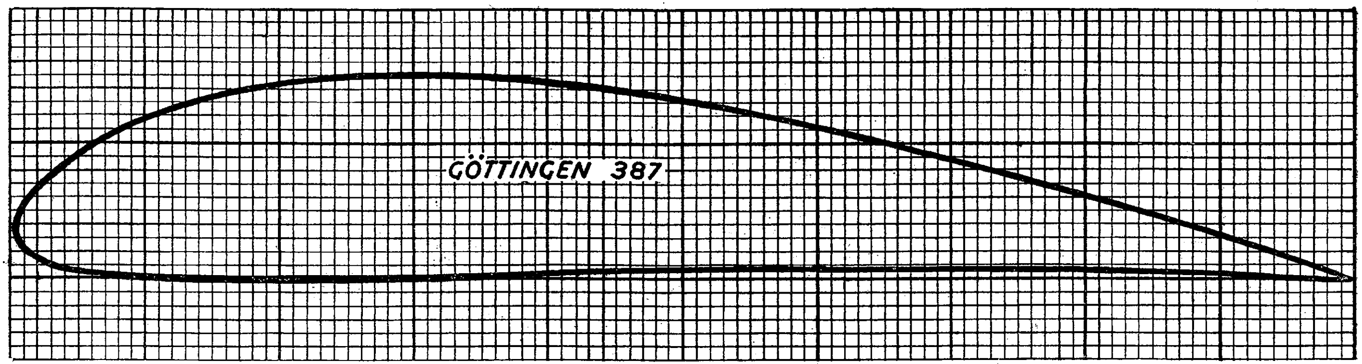
The data is taken from N.A.C.A. report 628.



EIFFEL 400

Station ..	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	4·80	6·63	7·48	8·77	9·79	10·5	11·85	12·50	13·10	12·60	11·60	9·90	8·0	5·80	3·1	1·69	0·00
Lower surface	4·80	3·39	2·85	2·03	1·41	1·00	·43	·10	·10	0·80	1·30	2·00	2·40	2·20	1·30	·71	0·000

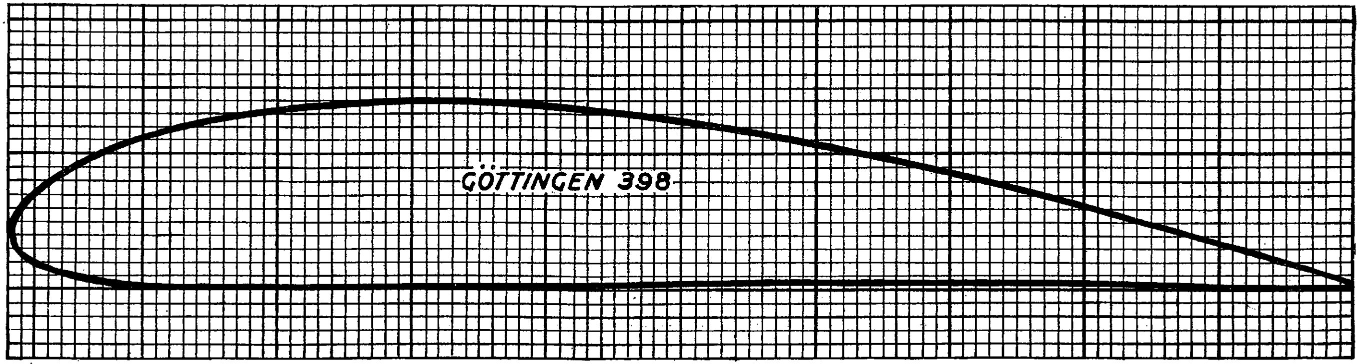
This airfoil should be most useful to aero-modellers. The section has been widely used in Germany for use in gliders. It should prove most useful to designers of duration models, having a C_L maximum of about 1·14 and a L/D maximum of about 22. C_L maximum occurs at about 12 degrees angle of attack, and L/D maximum at about $-$·5 degree at a C_L of ·5. C_D minimum is about ·013 and appears to occur at about $-4·0$ degrees angle of attack when $C_L = ·21$. The angle of zero lift is about $-7·0$ degrees angle of attack. Centre of pressure movement is unfortunately large, as is common with this type of airfoil, but can be compensated for by a large tail surface.



GOTTINGEN 387

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	3·20	6·25	7·65	9·50	10·85	11·95	13·40	14·40	15·05	14·60	13·35	11·35	8·90	6·15	3·25	1·75	·15
Lower surface ..	3·20	1·30	1·05	·55	·25	·10	·00	·00	·20	·40	·45	·50	·45	·30	·15	·05	0

This, as with several other Gottingen sections, is quite a favourite with modellers, and has a C_L maximum of 1·70, corrected to 1·45. C_D minimum for an aspect ratio of 6 is ·0097. The angle of zero lift is −6·6 degrees. C_L maximum occurs at about 18·5 degrees angle of attack, and L/D maximum is 20·5 at about −1 degree at a C_L of ·4. Centre of pressure movement is fair, as at L/D maximum the C.P. is at 46 per cent of the chord, and at C_L maximum it is at 32 per cent of the chord. The thickness ratio of this airfoil is 14·85 per cent of the chord, and so no trouble about spar depth need be experienced. Data on this airfoil has been published in several places; the figures given are from N.A.C.A. report 628. Further data may be obtained from R. and M. 1706, N.A.C.A. reports 352 and 628.

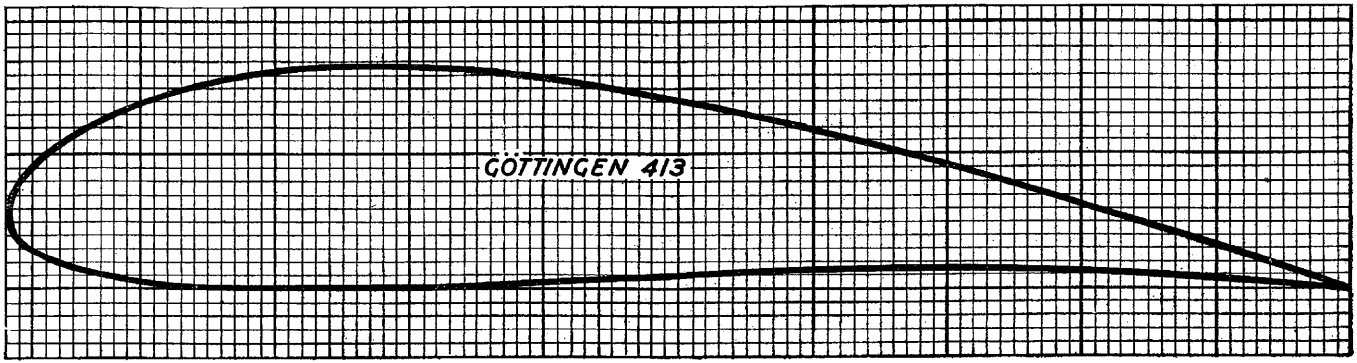


GOTTINGEN 398

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	3·74	6·20	7·40	9·17	10·37	11·25	12·53	13·34	13·80	13·34	12·27	10·63	8·53	6·12	3·40	1·92	·40
Lower surface ..	3·74	1·89	1·28	·69	·35	·18	·03	·00	·05	·17	·27	·33	·35	·27	·13	·06	0

Another Gottingen airfoil similar to 387, but with a thickness to chord ratio of 13·75 per cent. CL maximum full scale is 1·68, and for model work 1·38, which is slightly lower than 387. CL maximum occurs at 18·5 degrees angle of attack. L/D maximum occurs at approximately 0 degrees angle of attack, and has a value of 20 at a CL of about ·41. The angle of zero lift is −6·0 degrees, and CD minimum is ·0094 for an aspect ratio of 6. This value is slightly lower than 387, and shows a suitability for a faster flying model. C.P. moves from 43 per cent at L/D maximum to 30 per cent at CL maximum.

Data has been extracted from N.A.C.A. report 628.

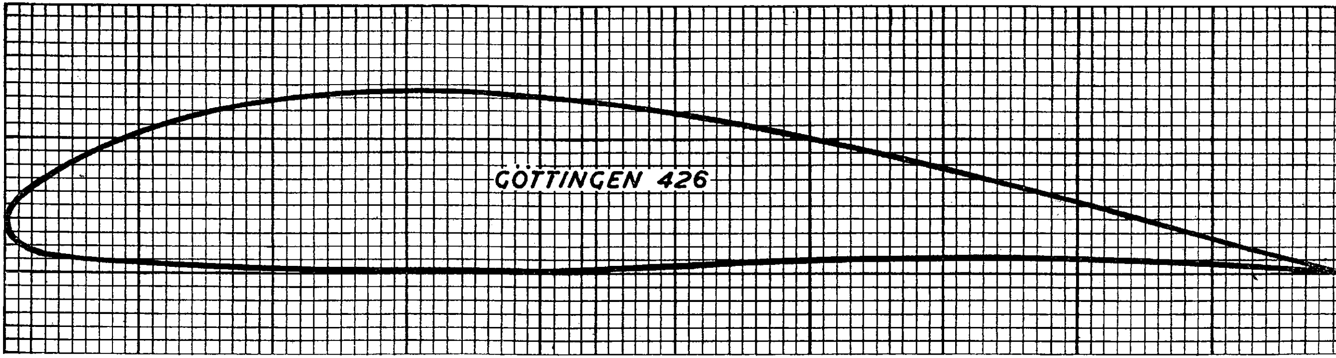


GOTTINGEN 413

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	5·93	8·89	10·24	11·75	12·94	13·91	15·31	16·12	16·93	15·85	14·15	11·85	9·22	6·11	3·05	1·56	·16
Lower surface ..	5·93	3·23	2·32	1·56	·95	·49	·09	·00	·18	·59	·97	1·35	1·40	1·34	·94	·59	0

This is rather a thicker section than 387 and 398, having a thickness to chord ratio of 16·45. The disadvantage of this airfoil is that there is a great decrease in thickness towards the trailing edge, which does not allow of great spar depth.

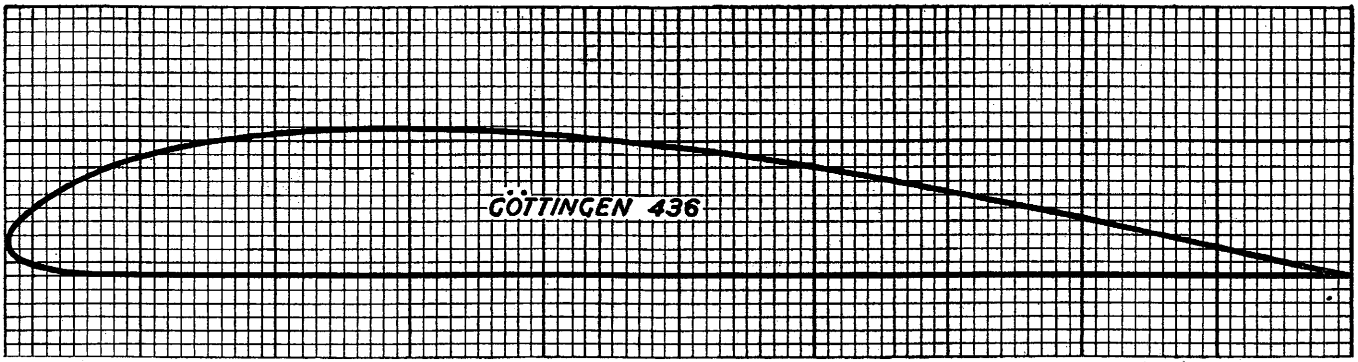
C_L maximum is 1·61 for full-scale work, and 1·31 for models. C_D minimum for an aspect ratio of 6 is ·0104, and L/D maximum is 20 at C_L of ·42, and an angle of attack of −2 degrees. C_L maximum occurs at about 20 degrees angle of attack. Angle of zero lift is −7·7 degrees. Data has been extracted from N.A.C.A. report 628.



GOTTINGEN 426

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	3·5	5·6	6·65	8·2	9·4	10·35	11·85	12·85	13·6	13·15	11·75	9·9	7·65	5·25	2·60	1·25	0
Lower surface ..	3·5	1·6	1·35	1·05	·75	·6	·35	·15	0	·15	·35	·65	·85	·90	·60	·35	0

This is a very suitable airfoil, which should give a very good performance, and I propose to give a rather fuller account of its characteristics. All characteristics may be used directly after aspect ratio corrections, as all values relate to an aspect ratio of 6. At −6 degrees C_L = ·072 and C_D = ·0212. At −3·3 degrees, C_L = ·272, and C_D = ·018. L/D maximum occurs at −·5 degree, and is 19·6 when C_L = ·487 and C_D = ·0248. At +3·7 degrees, C_L = ·80 and C_D = ·0464. At 7·9 degrees C_L = 1·09, and C_D = ·0796. C_L maximum = 1·28, and occurs at 13·7 degrees when C_D = ·1612.



GOTTINGEN 436

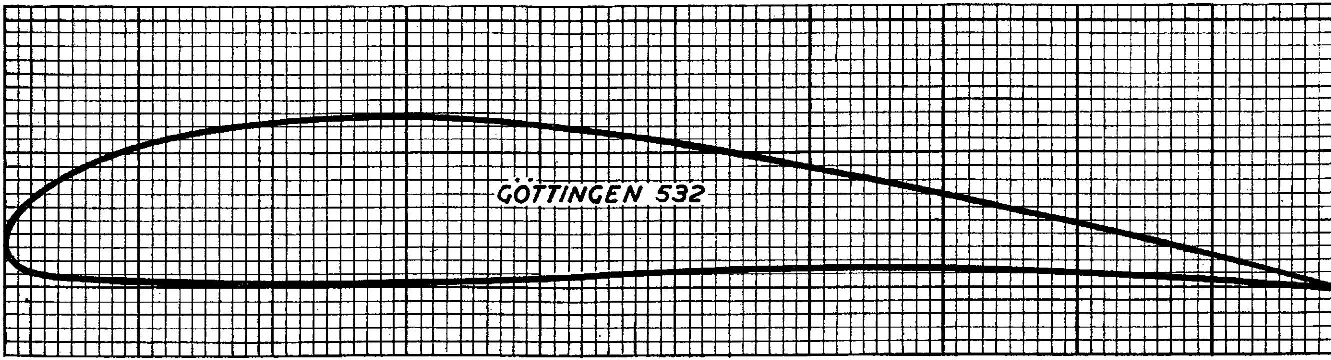
Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	2·66	4·53	5·54	7·00	8·11	8·98	10·16	10·82	11·08	10·55	9·60	8·28	6·60	4·70	2·64	1·54	·43
Lower surface	2·66	1·21	·79	·37	·15	·05	0	0	0	0	0	0	0	0	0	0	0

This airfoil has, like the Clark Y, a flat under surface for a portion of its profile, which makes construction of a model wing easy.

CL maximum, full scale, is 1·68, and, for models, 1·24. CL maximum occurs at about 18·5 degrees angle of attack, and CD minimum, which is ·0085, at about – 4 degrees. The angle of zero lift is –4·4 degrees, and L/D maximum is 21·8, and occurs at ·8 degree angle of attack at CL of ·38.

This airfoil seems to have the characteristics suitable for a faster type of model, and owing to the profile should be useful to beginners.

The data is abstracted from N.A.C.A. report 628.



GOTTINGEN 532

Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	2·45	5·85	7·05	8·55	9·65	10·55	11·60	12·25	22·75	12·05	10·70	9·00	7·10	4·90	2·60	1·40	·20
Lower surface ..	2·45	1·15	·80	·50	·30	·15	·00	·00	·25	·65	1·05	1·35	1·50	1·35	·80	·45	0

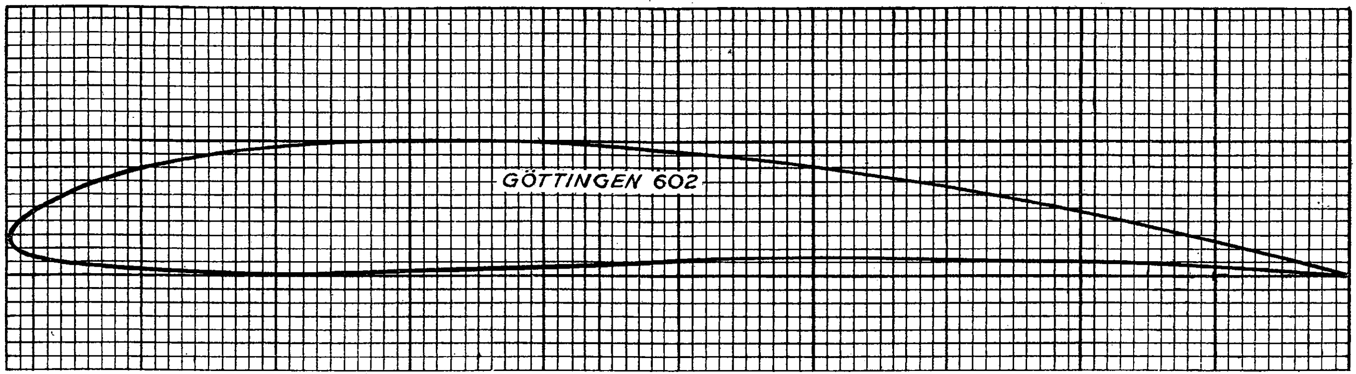
The performance of this airfoil is extremely good, but modellers may be troubled with constructional difficulties, as the section narrows down considerably towards the trailing edge, but, if modellers can overcome this they should be well repaid.

CL maximum has a full scale value of 1·91, and a model value of 1·61. CL maximum occurs at about 20 degrees angle of attack. L/D maximum is 22, and occurs at $-$·5 degree when CL=42.

The angle of zero lift is $-$6·1 degree, and CD minimum for an aspect ratio of 6 is ·0088.

So far the characteristics seem to be ideal, but C.P. movement is fairly large. At L/D maximum C.P. is at 48 per cent of the chord, and at CL maximum 31 per cent of the chord. This will necessitate a larger tail-plane.

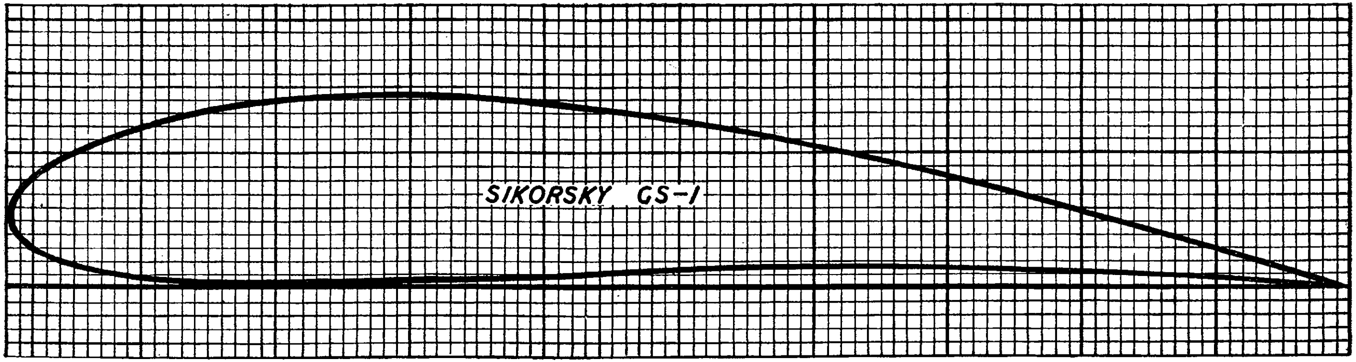
Data is taken from N.A.C.A. report 628.



GOTTINGEN 602

Station ..	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	2·50	4·00	4·85	6·20	7·05	7·75	8·80	9·45	10·00	9·80	9·10	8·00	6·55	4·75	2·55	1·35	0
Lower surface	2·50	1·48	1·15	·75	·50	·40	·20	0	·40	·65	1·00	1·25	1·15	1·00	·60	·30	0

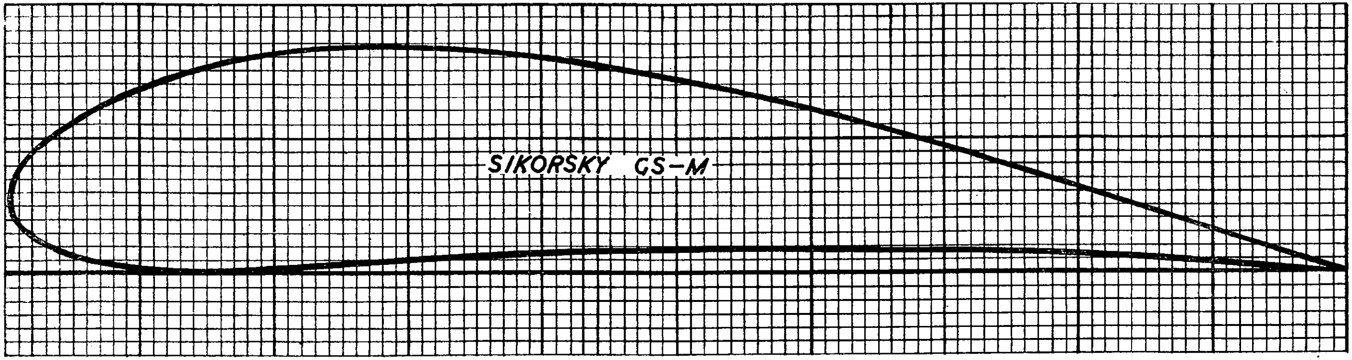
The profile of this airfoil, which is one of the Gottingen sections, so useful to aero-modellers, has been modified slightly by giving the under surface a slightly greater camber than is usual. It is claimed that this increase in camber will improve the performance of slow-flying models. This can be easily understood, as, in fact, the increase in the camber of the under surface increases the camber of the centre line, which generally increases CL maximum. Usually this procedure has the disadvantage of increasing centre of pressure movement, but this can be rectified by giving the model a slightly greater tail area. The profile shown is that for the modified airfoil.



SIKORSKY GS—1

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	5·00	7·46	8·45	9·79	10·81	11·66	12·92	13·68	14·15	13·59	12·30	10·47	8·29	5·76	2·98	1·49	0
Lower surface	5·00	2·83	2·06	1·20	·69	·38	·08	·00	·25	·66	·97	1·11	1·05	·83	·99	·26	0

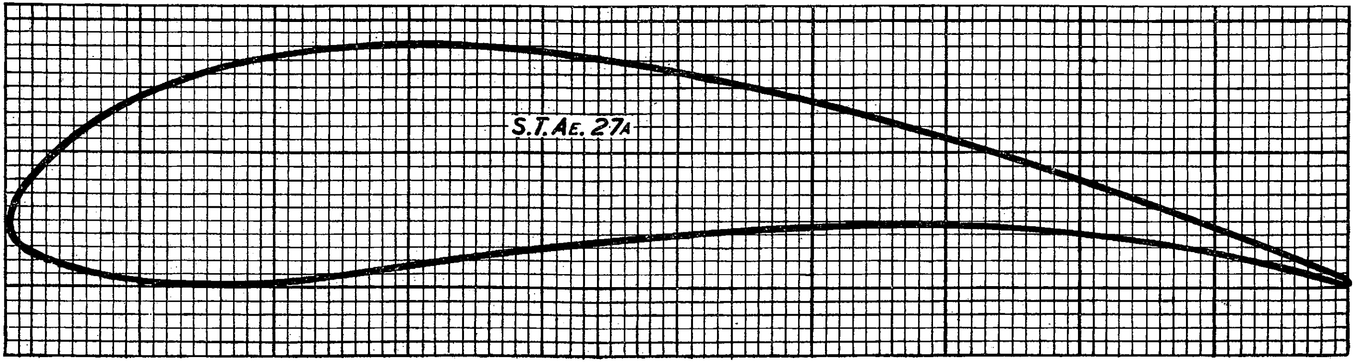
This is a very similar airfoil to the Sikorsky GS-M, but is thinner, having a thickness to chord ratio of 13·9. C_L maximum is given in the N.A.C.A. report as 1·78. Correcting this value for model work gives a value of 1·41. For an aspect ratio of 6 the minimum value of C_D is ·0086. The angle of zero lift is −6·8 degrees, and L/D maximum 21·2, at an angle of attack of about −1·5 degrees, at which angle C_L is equal to ·40. The centre of pressure movement of this airfoil is very similar to that of Sikorsky GS-M; at C_L maximum the C.P. is at 31·5 per cent of the chord, and at L/D maximum it is at 48 per cent of the chord. One of the main features of the Sikorsky airfoils is the blunt leading edge, which is rather like some of the Gottingen sections. The data on this section has been abstracted from N.A.C.A. report 628.



SIKORSKY GS—M

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	5·58	8·61	9·73	11·30	12·60	13·62	15·29	16·25	16·72	16·10	14·51	12·18	9·42	6·44	3·37	1·77	·09
Lower surface ..	5·58	3·18	2·19	1·15	·50	·18	·00	·26	·89	1·43	1·75	1·80	1·64	1·23	·65	·31	·09

This airfoil section is a useful section, and should prove especially suited to thick wings, having a maximum thickness to chord ratio of 16·05 per cent. C_L maximum is 1·69, taken from the N.A.C.A. report, and when this value has been corrected for model work a value of 1·47 is obtained. Angle of zero lift is −7·9 degrees. The minimum value of C_D for an aspect ratio of 6 is ·0101, and the maximum L/D ratio is 20, and occurs at about −2 degrees angle of attack when C_L=·46. Unfortunately, the movement of the centre of pressure is fairly great, as at C_L maximum C.P. is at 32 per cent of the chord, and at L/D maximum at 47 per cent of the chord from the leading edge. Data on this airfoil has been obtained from N.A.C.A. report 628.



S.T.Ae 27a

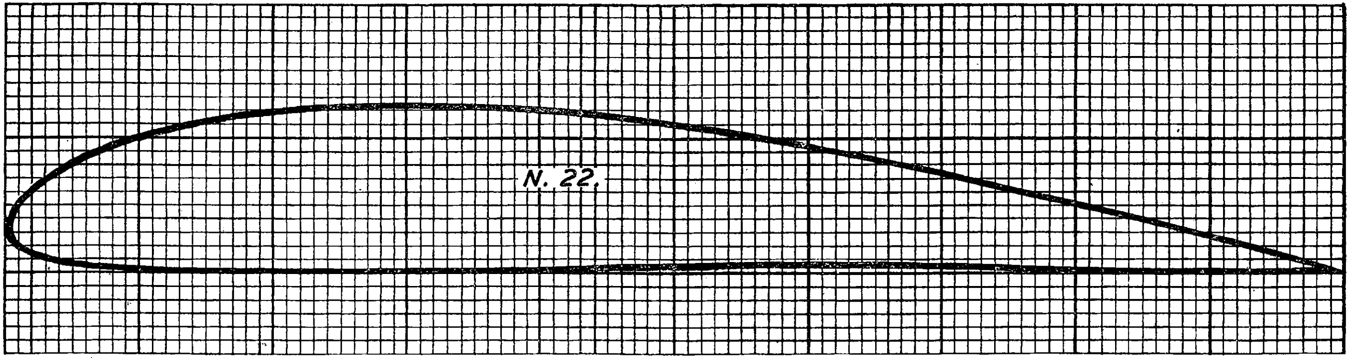
Station	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	5·00	7·57	9·10	11·20	12·73	14·00	15·96	17·34	18·00	17·34	16·00	14·00	11·20	8·00	4·44	2·30	·12
Lower surface ..	5·00	2·70	2·03	1·20	·65	·30	·00	·30	1·80	3·00	3·80	4·40	4·50	3·80	2·30	1·15	0

This airfoil seems, from theoretical considerations, to be certainly one of the most suitable for slow flying models which has been produced, as, when the value of C_L maximum has been corrected for use in model work, a value of 1·87 is obtained, and this is extraordinarily high. The minimum value of C_D is ·0137 for an aspect ratio of 6. This value is very high, but is compensated for by the high value of C_L maximum. L/D maximum is about 17·8, and occurs at a value of C_L of about ·5, at an angle of attack of −3 degrees. C_L maximum occurs at about 14·5 degrees.

Centre of pressure movement is fairly large, as at C_L maximum it is at 37 per cent of the chord, and at 60 per cent at L/D maximum.

The maximum thickness to chord ratio is 19·8 per cent, and the maximum camber is 8 per cent of the chord. The angle of zero lift is −10·2 degrees.

This airfoil is reported in N.A.C.A. report 628.



N.22

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	3·37	5·58	6·66	8·25	9·33	10·13	11·28	12·01	12·42	12·01	11·04	9·57	7·68	5·51	3·06	1·73	·40
Lower surface ..	3·37	1·70	1·15	·62	·32	·16	·03	·00	·05	·15	·24	·30	·32	·24	·12	·05	0

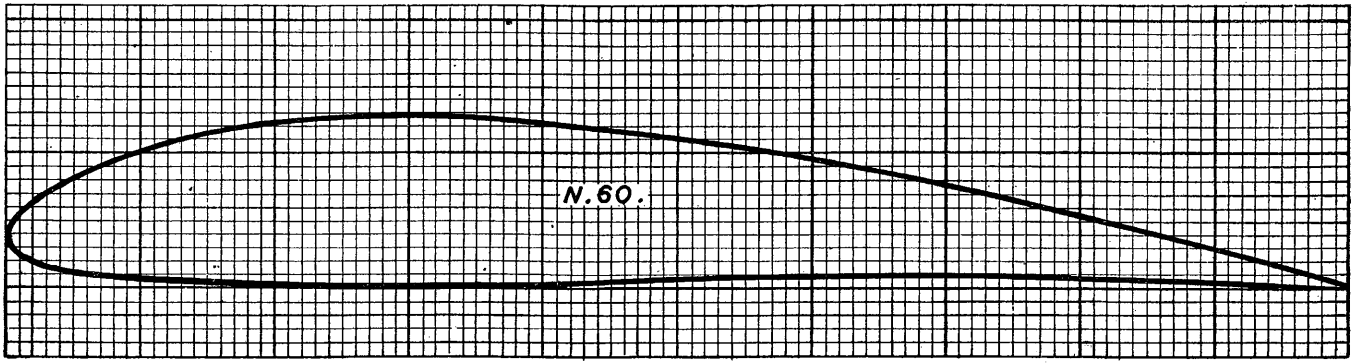
This is an airfoil which is similar in characteristics to C·72.

C_L maximum is 1·72 for full scale work and 1·28 for model work, and occurs at an angle of attack of about 18·5 degrees. The stall is very sudden on this airfoil. L/D maximum is 21, and occurs at 0 degree angle of attack at a C_L of ·4. C_D minimum is ·0089 for an aspect ratio of 6.

The centre of pressure moves from 43 per cent of the chord at L/D maximum to 30 per cent at C_L maximum.

The angle of zero lift is −5·4 degrees.

Data is abstracted from N.A.C.A. report 628.



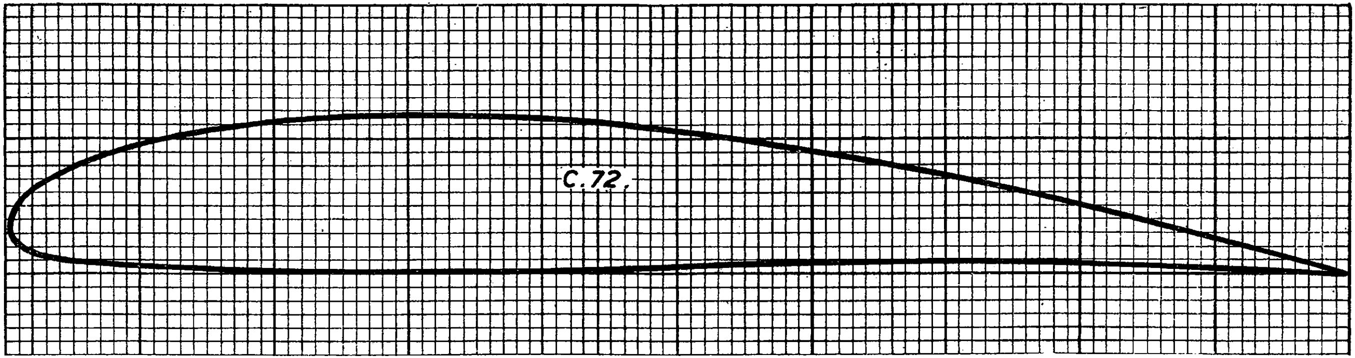
N.60

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	3·40	5·60	6·76	8·24	9·33	10·14	11·32	11·98	12·41	12·03	11·06	9·55	7·66	5·50	3·04	1·72	·40
Lower surface	3·40	1·91	1·46	·96	·62	·40	·15	·04	·04	·22	·48	·71	·78	·64	·37	·19	0

This airfoil is similar to N.22, but has a slightly higher C_L maximum. C_L maximum for full scale work is 1·73, and this value, when corrected for model work, gives a value of 1·29. The minimum value of C_D for an aspect ratio of 6 is ·0090.

The angle of zero lift is −5·5 degrees. L/D maximum is 21·2, and occurs at 0 degree angle of attack, and a C_L of ·4. The centre of pressure moves from 44 per cent of the chord at L/D maximum to 31 per cent at C_L maximum.

The data has been abstracted from N.A.C.A. report 628.

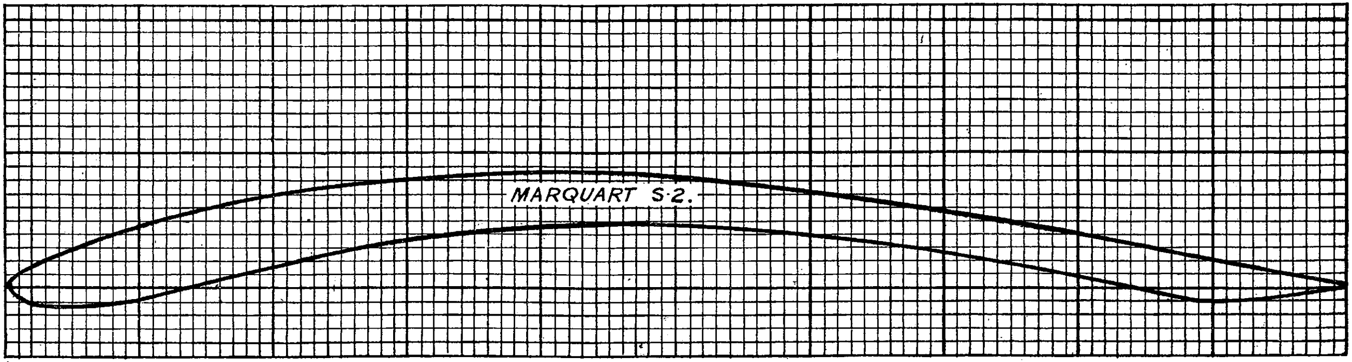


C.72

Station	0	1·25	2·5	5·0	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface ..	3·49	5·55	6·51	7·89	8·85	9·60	10·69	11·36	11·73	11·41	10·53	9·15	7·36	5·23	2·80	1·52	·10
Lower surface ..	3·49	1·92	1·47	·93	·64	·43	·16	·03	·00	·21	·59	·85	·91	·72	·40	·21	0

This airfoil has a very high C_L maximum for full scale work, but does not seem quite so suitable for model work. However, it should be used in faster flying models. C_L maximum for full scale work is 1·74, and, when this value has been corrected for model work, 1·30. C_L maximum occurs at an angle of attack of 18·5 degrees. C_D minimum for an aspect ratio of 6 is ·0087. L/D maximum is 21·2, and occurs at 0 degree angle of attack, and a C_L of ·4. The angle of zero lift is $-5·6$ degrees. The centre of pressure moves from 45 per cent of the chord at L/D maximum to 30 per cent at C_L maximum. This airfoil stalls very suddenly, so care must be taken with the stability of the model.

Data is abstracted from N.A.C.A. report 628.



MARQUARDT S—2

Station ..	0	1·25	2·5	5	7·5	10	15	20	30	40	50	60	70	80	90	95	100
Upper surface	0·00	—	—	2·35	—	4·40	—	6·70	7·80	8·30	7·90	6·90	5·60	3·90	2·00	—	0·00
Lower surface	0·00	—	—	−1·50	—	−1·00	—	+1·50	3·50	4·50	4·50	3·90	2·60	·90	−1·00	—	0·00

This airfoil seems very well adapted to model use, and seems to resemble some of the earlier R.A.F. sections. Unfortunately I have been unable to obtain information regarding the coefficients, but should imagine that owing to the profile the performance of slow-flying models equipped with this airfoil should be of the highest.

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