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Summary.—(a) *Reasons for Enquiry.*—To add to the available data regarding lift and hinge moment on a control, and to test further the ideas developed in R. & M. 2008[2], with especial reference to the effect of curvature of control surface.

(b) *Range of Investigation.*—Measurement of lift and hinge moment on a two-dimensional aerofoil (section NACA 0015, chord 18 in.) fitted with a 40 per cent control (radius-nose).

(i) Control Section	
NACA 0015 original	two-dimensional and finite aspect ratio ($A = 2{\cdot}67$).
Maximum bulge or depression at $0{\cdot}5\ c_\eta$ from hinge	maximum bulge 3 per cent by 1 per cent steps to maximum depression 2 per cent.
Maximum bulge or depression at $0{\cdot}75\ c_\eta$ from hinge	maximum bulge 3 per cent by 1 per cent steps to maximum depression 1 per cent.
(ii) Range of α	-2 deg to $+6$ deg.
(iii) Range of η	-15 deg to $+15$ deg.

All experiments were carried out with and without turbulence wires.

An investigation was made into the effect of gap between nose of control and main aerofoil, speed effect and effect of reducing trailing-edge thickness by chamfering the last $1\frac{1}{2}$ in. of control surface.

Reynolds number $= 0{\cdot}57 \times 10^6$ ($V = 60$ ft/sec).
$0{\cdot}71 \times 10^6$ ($V = 75$ ft/sec).

Description of angle-measuring apparatus is given in an Appendix.

(c) *Conclusions.*—(i) *Original NACA* 0015 *control section.*—The curve of $b_1/(b_1)_T$ against $a_1/(a_1)_T$ given in Fig. 25 of R. & M. 2008[2] is more fully established by the inclusion of two points taken from data of this report.

The expressions a_2/a_1, b_1/a_1 and (a_2/a_1) $(b_1 - b_2)$ were found to be roughly independent of aspect ratio (Table 5).

(ii) *Convexed and concaved control section.*—The results are given in Figs. 3 to 20.

Convex surface—reduces negative b_1, b_2 and a_1, a_2 (*see* Fig. 21).

Concave surface—increases negative b_1, b_2 and a_1, a_2 (*see* Fig. 21).

Except for extreme degrees of convexity, a linear relation appears to exist between all slopes and a mean trailing-edge angle (Figs. 22, 23). Increasing the boundary-layer thickness by means of wires has a negligible effect on properties of large-chord controls when surface is concave, but a considerable effect when surface is convex (Fig. 21).

Control is extremely sensitive to thickness of trailing edge and to shape of surface just forward of trailing edge (Fig. 24).

The effect of gap between nose of control and main aerofoil ($0{\cdot}28$ per cent c) is measurable but small.

Speed effect (from 60 ft/sec to 75 ft/sec) was found to be negligible.

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Introduction.—The work described herein may be considered a continuation of that given in Part I of R. & M. 2008[1] and follows the suggestions made in Section 20 of Part IV of the same report[2]. It may be divided into two parts: the first part consists of experiments giving hinge moment and lift data on an unmodified control forming part of a NACA 0015 aerofoil, while for the second part similar experiments were undertaken as part of a general research into the effect on the properties of controls of curvature of control surface.

In Part IV of R. & M. 2008[2] it is shown in Fig. 25 that for a two-dimensional aerofoil a curve of $b_1/(b_1)_T$ against $a_1/(a_1)_T$ (where suffix T denotes the theoretical value) may be drawn which will be approximately independent of aerofoil thickness, Reynolds number, position of transition point, etc. The data from which this curve was drawn were mostly obtained from Part I of R. & M. 2008[1] which gave the results of tests on two aerofoils of section NACA 0010 and NACA 0020, both of 30-in. chord. An aerofoil of maximum thickness 15 per cent of the chord—NACA 0015 of 18-in. chord fitted with a 40 per cent radius-nosed control—had been made for experiments in the Compressed Air Tunnel and, as the model was available, it was used for the tests described herein to obtain further data to endeavour to establish more definitely the relation between $b_1/(b_1)_T$ and $a_1/(a_1)_T$. Also, it is hoped later to ascertain from the experimental data of this report whether a similar relation exists between $b_2/(b_2)_T$ and $a_2/(a_2)_T$. Unpublished results of the work done in the Compressed Air Tunnel revealed the value of b_1 to be smaller than expected (approximately zero). As the dimensions of the model—a finite wing of 18-in. chord and 4-ft span—were considered large for the size of the tunnel, it was suspected that the small b_1 may be due to a large tunnel interference, at present not calculable. It was thus decided to include additional tests on the finite wing, not only to check up on the C.A.T. results but also to ascertain whether finite aspect-ratio results could be predicted from the two-dimensional work by using Glauert's aerofoil theory[3].

During the course of the work, further tests were carried out to find the effect on the properties of the control of reducing the gap between the control and the main wing.

The Model and Method of Experiment.—The model consisted of a symmetrical aerofoil of section NACA 0015 fitted with a 40 per cent radius-nosed contol, the gap between control and main aerofoil being 0·05 in. The chord was 18 in. and the span of the working portion 4 ft. For the two-dimensional work, dummy end-pieces fastened to the tunnel walls were provided. They enabled the model to span the tunnel and their attitude, both for main aerofoil and control, was identical with that of the working portion. A general view of the model in the tunnel is given in Fig. 1. The control could freely rotate about two ball-bearing hinges and its hinge moment was measured, as is usual, on a roof balance.

The method of rigging up the model was similar to that given in R. & M. 2008[1, 2]. One end of the aerofoil was rigidly connected by a spindle, which passed through the dummy end-piece, to a piece of apparatus consisting of a cruciform spring which defined the axis about which the aerofoil could roll and which, by being fastened to the wall of the tunnel, acted as a support for one end of the aerofoil. The other end was supported by two wires one behind the other from a roof balance on which were taken readings of rolling moment from which the lift was estimated. The angle of incidence of the aerofoil was set by adjusting the length of one wire relative to the other.

A new method of measuring the angle of incidence and control angle was introduced. This is given in an Appendix to this report and, in effect, consisted of the exact recording of the angular movements of the model on two beams supported from the model below the tunnel. The attitude of the beams to the horizontal and consequently the angle of incidence and control angle to the horizontal could be observed on inclinometers fixed to the beams. A mock-up of this measuring apparatus (*see* Fig. 26a) was used for the work on the unmodified control and the apparatus as described (*see* Fig. 26b) for the subsequent work.

To locate the transition point near the leading edge, thus ensuring that the flow over the control is fully turbulent, experiments, in addition to those on the smooth aerofoil, were carried out with wires of diameter 0·022 in. fixed approximately 4 per cent of the chord from the leading edge.

For the part of the report dealing with the effect on the properties of controls due to curvature of their surfaces, two separate controls with trailing edge as thin as practicable (0·02 in.) were made, one having the maximum bulge or depression at a position 50 per cent of the chord back from the hinge and the other at 75 per cent back. The most highly convexed case was taken first, and each control was progressively modified to give various degrees of convexity or concavity. The various control sections, drawn to scale, are given in Fig. 2: except when straight, the contours of the surfaces form, for the 50 per cent case, a series of circular arcs from hinge line to trailing edge and, for the 75 per cent case, straight lines to a position $3c_\eta/4$ from the hinge line and a series of circular arcs for the last quarter of the control chord.

Nomenclature.—The maximum degree of convexity taken for these tests was when the maximum bulge, indicated as d in Fig. 2, was 3 per cent of the control chord. For ease in presentation, this is represented throughout the report for the 50 per cent case as 50/3 and similarly for the 75 per cent case as 75/3. The first figure thus gives the position of maximum bulge or depression, and the second the degree of convexity or concavity, a negative sign indicating a concave surface.

Scope of Experiments.—(i) *Condition of model (for both lift and hinge moment) :*

(a) Control section ..	original NACA 0015
Smooth wing	two-dimensional ($A = \infty$) finite wing ($A = 2{\cdot}67$)
With turbulence wires (0·022 in. diameter at $x/c = 0{\cdot}04$ from leading edge).	two-dimensional ($A = \infty$) finite wing ($A = 2{\cdot}67$)
(b) Control section ..	various degrees of convexity and concavity (two-dimensional).
Smooth wing	50/3, 50/2, 50/1, 50/0, 50/—1, 50/—2, 75/3, 75/2, 75/1, 75/—1 (*see* Fig. 2).
With turbulence wires..	50/3, 50/2, 50/1, 50/0, 50/—1, 50/—2, 75/3, 75/2, 75/1, 75/—1 (*see* Fig. 2).
(c) Control section (with, and without turbulence wires).	original NACA 0015 with rear $1\frac{1}{2}$ in. chamfered to reduce thickness of trailing edge (two-dimensional) (*see* Fig. 24.)
(d) Control section ..	75/—1 (two-dimensional)
Smooth wing	gap between nose of control and main aerofoil (originally 0·05 in.) reduced to 0·01 in.

(ii) *Angles of incidence and control :*—

Approximate range of α, from —2 deg to +6 deg.

Approximate range of control angle (η), from —15 deg to +15 deg (smooth wing)
from —5 deg to +5 deg (with wires).

(iii) *Wind speed :*

Mostly at 60 ft/sec $R = 0{\cdot}57 \times 10^6$

Some readings at 75 ft/sec $R = 0{\cdot}71 \times 10^6$.

Results.—These are presented in the usual form of coefficient, thus :—

$$C_L = L/qS \quad , \quad a_1 = \frac{dC_L}{d\alpha}, \quad a_2 = \frac{dC_L}{d\eta}$$

$$C_H = H/qS_\eta c_\eta \, , \quad b_1 = \frac{dC_H}{d\alpha}, \quad b_2 = \frac{dC_H}{d\eta}$$

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where L is lift

H hinge moment

S area of aerofoil $= 6$ sq ft

c_η chord of control $= 0 \cdot 6$ ft

S_η area of control $= 2 \cdot 4$ sq ft

q $\frac{1}{2}\rho V^2$.

a_1 and b_1 ($\alpha = 0$ deg, $\eta = 0$ deg) are estimated as the mean slope over a range of α of $\pm$ 2 deg, a_2 and b_2 ($\eta = 0$ deg, $\alpha = 0$ deg) are estimated as the mean slope over a range of η usually of $\pm$ 5 deg: a sudden change in the slope, however, was not included in the estimate.

The results of the experiments on the original unmodified control are given in Tables 1 to 5, while those on the modified control are shown plotted in Figs. 3 to 20.

1. *NACA* 0015 *Aerofoil with* 40 *per cent Control.*—In addition to the values of C_H and C_L (given in Tables 1 to 4), the slopes a_1, a_2, b_1 and b_2 have also been tabulated in Table 5. a_1 and b_1 have been estimated as the mean value over a range of η from 0 deg to ± 4 deg at $\alpha = 0$ deg, and a_2 and b_2 as the mean value over a range of α from -2 deg to 6 deg at $\eta = 0$ deg. No tunnel corrections were applied to the results, but those due to interference arising from constraint due to the finite chord of the wing are given in the table. These corrections, which are taken from report 5388[4], are small, the largest being to b_1 which is of the order of $4\frac{1}{2}$ per cent, those to the other slopes being less than 2 per cent. According to Glauert's aerofoil theory[3], the values of a_2/a_1, b_1/a_1 and $b_1 a_2/a_1 - b_2$ should be independent of aspect ratio. These expressions have been calculated and are also given in Table 5, the agreement in the values for infinite and finite wing being reasonably good considering the latitude one can get on estimating the slopes. $a_1/(a_1)_T$ and $b_1/(b_1)_T$ have been evaluated and the latter has been plotted against the former for the cases of smooth wing and with turbulence wires in Fig. 25 of R. & M. 2008[2]. The points appear to be slightly above the originally drawn curve but the addition of wires near the leading edge shows the same general trend of increasing the positive value of b_1 and of reducing the lift slope. Some of the data given in Table 5 have been used and discussed by Mr. Bryant in his summery[5] of recent researches on control characteristics.

2. *Effect of Curvature of Control Surface.*—(a) *C_H and C_L against* ($\alpha + \eta$).—Both C_H and C_L for all cases of curvature with and without wires have been given in Figs. 3 to 20 in such a way that the slopes a_1, a_2, b_1 and b_2 can be estimated at a glance for all conditions of the model. To do this these coefficients have been plotted against ($\alpha + \eta$) which is tantamount to plotting them as usual against η and at the same time moving the axis by an amount equal to the change in α. The slope of the full-line curves gives a_2 or b_2 for different values of α and that of the broken curves a_1 or b_1 for different values of η. It should be here noted that values meaned from positive and negative angle settings for $\alpha = 0$ deg and 2 deg have been plotted, while for $\alpha = 4$ deg and 6 deg the measured values have been adjusted by an increment equal to that applied to the results for $\alpha = 2$ deg.

A general survey of the results from the figures shows that the C_H or C_L against η curves are straight over a range of η not greater than ± 10 deg for the concaved control, this range being reduced as the control becomes convexed. Except for extreme cases of convexity, b_2 is approximately constant over the range of incidence taken. Also the C_H or C_L against α curves are approximately straight and parallel over a limited range of η, which varies according to the type of control surface and which is generally not much greater than ± 5 deg for the C_H curves. A glance through the figures also shows that b_1 and b_2 become more negative and a_1 and a_2 become more positive as the surface of the control is progressively concaved. This is shown more clearly for b_2 and a_2 in Fig. 21, in which C_H and C_L for extreme cases of curvature (smooth wing only) are plotted against η at $\alpha = 0$ deg for the various degrees of convexity and concavity.

(b) *Effect of Turbulence Wires.*—Fig. 21 also reveals that for convexed surfaces both b_1 and b_2 become less negative or more positive in the presence of a turbulent boundary layer produced by transition wires located near the leading edge of the aerofoil. As the control becomes less convex, the effect of wires becomes progressively less until for the extreme degree of concavity it is negligible. A similar figure (not given in the report) of C_L against η shows that the reduction of negative b_1 and b_2 due to wires is accompanied by a reduction in a_1 and a_2, thus again confirming that if the change in boundary-layer thickness resulting from an alteration in the position of the transition point leads to a reduction in hinge moment, then this reduction arises mainly from the change in circulation marked by a corresponding reduction in lift.

(c) *a_1, a_2, b_1 and b_2 as a Function of the Trailing-Edge Angle.*—The results of the present experiments, as regards the effect on properties of controls of curvature of control surface, have been discussed fully in conjunction with other similar work by Bryant in Ref. 5. In Fig. 9 of that report, b_1 and b_2 have been plotted against percentage bulge or depression, where it is seen that the bulge is more effective at $0 \cdot 25\ c_\eta$ than at $0 \cdot 5\ c_\eta$ from the trailing edge. In the present report a_1 and a_2, in addition to b_1 and b_2, have been plotted against a parameter which would include the change in trailing-edge angle not only due to the position along the chord of the bulge or depression but also due to a change in maximum thickness of the aerofoil section. It was expected that the properties of a control would be affected by the curvature of the control surface for roughly the last quarter of the control chord as well as by the trailing-edge angle defined as the angle between the tangents to the curved surfaces at the trailing edge. Previous work suggests this; for, from data taken from Fig. 13 of Ref. 5, bevelled and curved surfaces over this part of the control having the same trailing-edge angle can give different values of b_2. It was decided to use as parameter a mean trailing-edge angle $(\theta_1 + \theta_2)/2$, where θ_1 is the total angle at the trailing edge and θ_2 the angle between the tangents to the surfaces at a position $c_\eta/4$ back from the trailing edge (*see* Fig. 22, inset). In Fig. 22 (for smooth wing) and Fig. 23 (wires on), a_1, a_2, b_1 and b_2—at $\alpha = 0$ deg, $\eta = 0$ deg—are plotted against this angle. With the exception of the extreme cases of convexity (50/3 and 75/3), the points appear to fall on fairly well defined lines both for the smooth wing and for the wing with wires fitted. Thus, provided that the trailing-edge thickness remains constant and only a reasonable amount of convexity is contemplated, it appears that for a constant c_η/c there is a relationship between the slopes a_1, a_2, b_1, b_2 and a mean trailing-edge angle.

3. *Effect of Reducing Trailing Edge Thickness by Chamfering Control Surfaces.*—During the course of the experiments, it was noticed that control section 50/1 was roughly similar to that of the original NACA 0015 section except for a thinner trailing edge. At the same time it was discovered that the properties of the control differed considerably for the two cases especially as regards b_1 and b_2, both of which had less negative values for the 50/1 section. As a check on this result, the trailing edge of the original 0015 control section was reduced from $0 \cdot 06$ in. to approximately $0 \cdot 03$ in. by chamfering the surfaces from a position $1\frac{1}{2}$ in. back from the trailing edge (*see* Fig. 24, inset). Further tests showed a numerical reduction in all the slopes by this modification as illustrated by the curves of Fig. 24, in which C_H is plotted against $(\alpha + \eta)$, and by the following table :—

Control Section	Smooth Wing				With Turbulence Wires			
	a_1	a_2	b_1	b_2	a_1	a_2	b_1	b_2
NACA 0015	5·23	3·57	−0·24	−0·52	4·96	3·09	−0·15	−0·39
NACA 0015 chamfered	5·13	3·49	−0·15	−0·45	4·83	2·94	−0·07	−0·27
50/1	5·06	3·34	−0·09	−0·42	4·72	2·82	−0·01	−0·23

This table also shows that all the results for the chamfered control actually come approximately mid-way between those for the other two. Further, it is seen again that, in all cases, a change in a hinge-moment slope tallies with a corresponding change in a lift slope. Thus, this additional experiment illustrates the sensitiveness of the properties of a control due to thickness at, and the type of surface near, the trailing edge, and is qualitatively a confirmation of the results of experiments made recently on a 'Spitfire' half-wing[6].

4. *Effect of Gap between Nose of Control and Main Aerofoil.*—The gap for these experiments was comparatively large, being approximately 0·05 in. or 0·28 per cent of the aerofoil chord, and it was thought that it might have some measurable effect on the results. Therefore, it was decided to reduce it to as small a value as practicable to estimate its effect. The section of the control taken for this test was 75/−1, the gap reduced to 0·01 in. and the results, as curves of C_H or C_L against $(\alpha + \eta)$ for angles of incidence approximately −2 deg and +6 deg, are given in Fig. 25. From the values of a_2 and b_2, given in the table (Fig. 25, inset), the effect of gap, though measurable, is small, reduction of gap increasing a_2 by about $2\frac{1}{2}$ per cent and reducing negative b_2 by about 4 per cent. From this it appears that a nose gap not much greater than 0·1 per cent of the aerofoil chord may be permitted without a_2 and b_2 being much affected.

5. *Speed Effect.*—A few observations, in addition to those at 60 ft/sec, were taken at 75 ft/sec for the following cases :—

(a) C_H on two-dimensional aerofoil, control section 75/0, at $\alpha = 2$ deg, with and without wires.

(b) C_L on finite aerofoil ($A = 2 \cdot 67$), control section original NACA 0015, at $\alpha = -1$ deg to +10 deg (approx.), with and without wires.

Very little speed effect could be detected.

6. *Effect of Wires on Lift of Aerofoil with Concave Control Surfaces (Finite Aspect Ratio).*—This test was carried out over a range of α from 0 deg to 16 deg with a control of section 50/−2 fitted to the aerofoil, the aspect ratio of which was 2·67. The values of C_L against α are given in Table 6. When they are plotted, the resulting straight lines show that the effect of turbulence wires is to reduce slightly the slope of the lift curve, a_1.

7. *Concluding Remarks.*—As already mentioned, some of the data given in this report has been used and discussed in Ref. 5. The results, in general, bear out those obtained previously. They especially emphasise the sensitiveness of the properties of the control to the curvature of the surfaces just forward of the trailing edge and to trailing-edge thickness. They also indicate that, for a large-chord control, any increases in boundary-layer thickness have practically no effect on the properties of the control when the surface is concave but a considerable effect for the convex surface. They also confirm the suggestion that a change in hinge moment is bound up with a change in lift arising mainly from the change in circulation. In Part IV of R. & M. 2008[2] the relationship between $b_1/(b_1)_T$ and $a_1/(a_1)_T$ has been fairly well established for different aerofoil sections under various conditions, and it is hoped later to establish a similar relationship from data from this report for different degrees of convexity and concavity of control surface. Also an investigation, will, it is hoped, be made to find whether a similar relationship exists between $(b_2/b_2)_T$ and $a_2/(a_2)_T$.

Similar experiments have already been carried out with a 20 per cent tabbed control fitted to the same aerofoil (NACA 0015 section) and the report is in preparation. It should be remarked that all work to date on a two-dimensional model has been carried out on an aerofoil which has its maximum ordinate at $0 \cdot 3c$ from the leading edge. It is proposed in a future programme to test, similarly, a low-drag aerofoil ($t/c = 15$ per cent, maximum ordinate at 0·42 from leading edge) with controls of various chords, with and without tabs, in a less turbulent wind-tunnel.

Finally, the authors wish to acknowledge the help given by Messrs. T. W. Brown, W. C. Skelton and Mrs. Hopwood in taking the tunnel observations and in reducing them.

APPENDIX

A Method of Measuring Angles of Incidence and Control Settings

Difficulty has recently been experienced with experiments, in which hinge moment is measured, in determining the angle of incidence and more especially the control angle, to sufficient accuracy. In the research programme suggested in Ref. 7 and inaugurated in R. & M. 2008[1], it was found essential that angles should be obtained to as fine an accuracy as possible or at least to an accuracy as good as that of the force and moment measurements. In the work described in Part I of R. & M. 2008[1] it was found that angle of incidence, the only angle to be measured, could be obtained to an accuracy within ± 2 minutes by using an inclinometer fixed to a straight edge which could rest firmly in a unique position on the aerofoil. In view of this, it was also decided to use an inclinometer for obtaining the control setting, but in this case the measurement would have to be made outside the tunnel, below it in fact, while at the same time incorporating a similar method of obtaining angle of incidence.

Photographs of the apparatus are given in Fig. 26 (Fig. 26a being the original 'mock-up' and Fig. 26b the apparatus about to be described) and the method of using it is shown by a diagrammatic sketch in Fig. 27, in which it is seen that the apparatus consists, in effect, of two arms suspended by wires from the model in such a manner that angular movements of the aerofoil and control are exactly simulated by them and are recorded by readings from two inclinometers, one on each arm. This method of angular measurement has thus an added advantage of recording the angles with the wind on and so obviating the necessity of correcting for deflections due to wind forces or tunnel distortion.

The arms of the apparatus were grooved along their length to enable stirrups, A and B, to slide along them and to be clamped in any position. A pin through a stirrup at O acted as a fulcrum for the arms. As also with the pin at A, it rested on a cylindrical bearing but, in order to reduce friction at the joints to an almost negligible quantity, it was found necessary to shape it as a knife edge. The other pin (at B), in the stirrup operating the arm used for obtaining the angle of the control, could be withdrawn when the angle was not being measured. It was found necessary to balance statically the arm, OB, about the fulcrum, O, to avoid any alteration in the control angle when it was in operation. This was done by incorporating a counterbalance weight, C, having an adjustable leverage from O together with a small sliding weight, R, as a fine adjustment. The apparatus was suspended by three wires (0·010-in. diameter) from three pins, A_1, B_1 and O_1, let into plates securely fastened to the model. A_1 and B_1 are near the leading edge of the aerofoil and the trailing edge of the control respectively; O_1 is at the hinge line of the control but fixed to the main forward portion. The lengths of these wires could be adjusted by means of turnbuckles, T, while the one from the control, BB_1, could be used, in addition, for carrying a weight, W, to keep taut the wire between the control and the hinge-moment balance. To avoid as far as possible any stickiness of the balance due to the hinges of the measuring gear, it was deemed advisable to withdraw the pin at B before any balance readings were taken. The suspension wires were kept taut by the weights, P. In practice, before the apparatus was rigged up, pins, A, O and B, were lined up to lie in a horizontal plane and the inclinometers, D, were each carefully set to read zero. The arms were then suspended from the aerofoil, which with the control had been set horizontal in the tunnel and, after making the lengths, AO and OB, on the arms respectively equal to A_1O_1 and O_1B_1 on the model, the length of the wires was adjusted by means of turnbuckles, T, to give zero readings on the inclinometers. The arms of the apparatus were then respectively parallel to the main aerofoil and control and any angular movement of the model would be recorded exactly on them.

This apparatus for the measurement of angles was found, in practice, to be quite easy to operate and, judging from repeat readings which have been taken from time to time, all observations should be accurate to within ± 2 minutes.

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Summary of Results for NACA 0015 18-*in. Chord.* $V = 60$ *ft/sec.* 40 *per cent Plain Flap* (*Gap* $= \frac{1}{20}$ in.)

TABLE 1

Smooth Wing. Aspect Ratio = 2·667

α = − 2 deg 25 min			α = − 0 deg 24 min			α = 1 deg 42 min			α = 3 deg 39 min			α = 5 deg 37 min		
η	C_H	C_L	η	C_H	C_L	η	C_H	C_L	η	C_H	C_L	η	C_H	C_L
° ′			° ′			° ′			° ′			° ′		
−18 28	0·2040	−0·6630	−23 8	0·2444	−0·6651	−18 34	0·1990	−0·6091	−18 20	0·1989	−0·4829	−18 10	0·1877	−0·3331
−13 31	0·1364	−0·5812	−18 27	0·1955	−0·6022	−13 45	0·1098	−0·4733	−13 39	0·0982	−0·3583	−13 30	0·0887	−0·2328
− 8 33	0·0656	−0·4621	−13 43	0·1184	−0·5465	− 8 46	0·0641	−0·2710	− 8 44	0·0578	−0·1627	− 8 26	0·0477	−0·0281
− 3 46	0·0323	−0·2827	− 8 40	0·0661	−0·3772	− 3 58	0·0252	−0·0693	− 4 1	0·0194	+0·0387	− 3 48	+0·0112	+0·1663
− 3 56	0·0334	−0·2897	− 3 54	0·0290	−0·1819	− 3 54	0·0244	−0·0734	− 2 9	+0·0036	0·1146	− 1 59	−0·0022	0·2403
− 1 58	0·0188	−0·2136	− 2 4	0·0165	−0·1081	− 2 16	+0·0103	+0·0032	− 0 11	−0·0117	0·1969	+ 0 0	−0·0171	0·3274
− 2 10	0·0207	−0·2177	− 0 7	+0·0008	−0·0275	− 0 15	−0·0047	0·0854	+ 0 53	−0·0195	0·2441	1 4	−0·0245	0·3648
− 0 3	+0·0054	−0·1342	+ 1 0	−0·0079	+0·0169	+ 0 46	−0·0130	0·1261	1 51	−0·0270	0·2804	2 4	−0·0330	0·4038
+ 1 0	−0·0023	−0·0917	1 57	−0·0158	0·0587	1 52	−0·0208	0·1665	3 50	−0·0401	0·3586	4 1	−0·0476	0·4817
2 8	−0·0111	−0·0437	3 54	−0·0311	0·1486	3 46	−0·0344	0·2529	5 59	−0·0527	0·4422	6 12	−0·0615	0·5626
1 50	−0·0079	−0·0511	6 2	−0·0474	0·2284	5 54	−0·0495	0·3358	10 55	−0·0944	0·5964	11 12	−0·1149	0·6924
3 54	−0·0265	+0·0301	10 58	−0·0879	0·4355	10 49	−0·0837	0·5179	15 29	−0·1739	0·6974	15 48	−0·1907	0·7930
6 0	−0·0433	0·1182	15 32	−0·1354	0·6130	15 26	−0·1604	0·6210						
11 0	−0·0833	0·3282	20 36	−0·2202	0·6356									
15 38	−0·1274	0·5060	25 12	−0·2653	0·6829									

TABLE 2

Smooth Wing. Aspect Ratio $= \infty$

$\alpha = -2$ deg 3 min			$\alpha = 0$ deg 0 min			$\alpha = 2$ deg 0 min			$\alpha = 4$ deg 1 min			$\alpha = 6$ deg 5 min		
η	C_H	C_L	η	C_H	C_L	η	C_H	C_L	η	C_H	C_L	η	C_H	C_L
° ′			° ′			° ′			° ′			° ′		
−4 57	0·0512	−0·5006	−19 58	0·2247	−0·7877	−4 48	0·0386	−0·1324	−4 51	0·0285	0·0459	−5 13	0·0202	0·2214
−3 6	0·0360	−0·3892	−14 59	0·1837	−0·6659	−3 10	0·0217	−0·0370	−3 16	+0·0123	0·1503	−3 17	+0·0021	0·3467
−1 6	0·0192	−0·2665	−9 46	0·0835	−0·5735	−1 6	+0·0019	+0·0931	−1 15	−0·0062	0·2715	−1 21	−0·0160	0·4582
+0 3	0·0090	−0·2029	−5 0	0·0463	−0·3308	+0 6	−0·0086	0·1634	−0 16	−0·0160	0·3368	−0 15	−0·0253	0·5259
0 59	+0·0004	−0·1427	−3 11	0·0291	−0·2122	1 4	−0·0181	0·2322	+0 51	−0·0254	0·4045	+0 52	−0·0347	0·5892
2 53	−0·0174	−0·0259	−1 14	+0·0110	−0·0905	3 0	−0·0353	0·3556	2 46	−0·0422	0·5223	2 45	−0·0494	0·6932
5 6	−0·0390	+0·1148	+0 6	−0·0004	−0·0139	5 4	−0·0535	0·4684	4 55	−0·0593	0·6402	4 49	−0·0641	0·7914
			0 50	−0·0071	+0·0331									
			2 50	−0·0256	0·1580									
			4 57	−0·0451	0·2916									
			9 55	−0·0858	0·5734									
			14 42	−0·1770	0·7088									

TABLE 4

0·022-*in. Wires* 0·7 *in. from Leading Edge. Aspect Ratio* $= \infty$

$\alpha = -2$ deg 5 min			$\alpha = -0$ deg 2 min			$\alpha = 2$ deg 5 min			$\alpha = 4$ deg 0 min			$\alpha = 6$ deg 4 min		
η	C_H	C_L	η	C_H	C_L	η	C_H	C_L	η	C_H	C_L	η	C_H	C_L
° ′			° ′			° ′			° ′			° ′		
−5 10	0·0397	−0·4508	−19 48	0·2092	−0·7501	−4 37	0·0240	−0·0860	−4 47	0·0202	0·0690	−5 10	0·0179	0·2280
−3 21	0·0277	−0·3698	−15 14	0·1640	−0·6117	−3 35	0·0174	−0·0056	−3 0	+0·0076	0·1714	−3 23	+0·0053	0·3242
−1 7	0·0133	−0·2603	−10 26	0·0926	−0·4627	−1 50	+0·0052	+0·0687	−1 3	−0·0050	0·2719	−1 33	−0·0081	0·4279
−0 12	+0·0062	−0·2035	−5 36	0·0372	−0·3190	+0 12	−0·0078	0·1747	+0 5	−0·0136	0·3351	−0 19	−0·0167	0·4881
+0 52	−0·0009	−0·1479	−3 59	0·0259	−0·2285	1 21	−0·0157	0·2390	0 53	−0·0187	0·3787	−0 44	−0·0242	0·5438
2 45	−0·0138	−0·0455	−1 49	0·0106	−0·1098	3 7	−0·0270	0·3277	2 52	−0·0323	0·4782	+2 40	−0·0380	0·6392
4 54	−0·0284	+0·0736	−0 21	+0·0020	−0·0326	5 12	−0·0417	0·4391	4 58	−0·0473	0·5763	4 44	−0·0532	0·7295
			+1 10	−0·0087	+0·0499									
			3 12	−0·0224	0·1555									
			5 10	−0·0361	0·2672									
			10 19	−0·0814	0·4650									
			14 59	−0·1593	0·6118									

TABLE 3

0·022-in. Wires 0·7 in. from Leading Edge. Aspect Ratio $= 2 \cdot 667$

$\alpha = -2$ deg 26 min			$\alpha = -0$ deg 38 min			$\alpha = 1$ deg 39 min			$\alpha = 3$ deg 40 min			$\alpha = 5$ deg 34 min		
η	C_H	C_L	η	C_H	C_L	η	C_H	C_L	η	C_H	C_L	η	C_H	C_L
° ′			° ′			° ′			° ′			° ′		
− 3 52	0·0261	−0·2680	−18 29	0·1832	−0·5186	− 3 54	0·0181	−0·0441	− 4 7	0·0154	0·0537	− 3 46	+0·0082	0·1730
− 2 3	0·0148	−0·2030	−13 32	0·1184	−0·4160	− 2 3	+0·0063	+0·0229	− 2 19	+0·0044	0·1204	− 2 0	−0·0018	0·2372
− 0 4	+0·0042	−0·1339	− 8 30	0·0473	−0·3038	− 0 5	−0·0051	0·0922	− 0 20	−0·0074	0·1941	+ 0 2	−0·0143	0·3110
+ 1 1	−0·0020	−0·0937	− 3 50	0·0219	−0·1560	+ 1 0	−0·0114	0·1367	+ 0 46	−0·0132	0·2336	1 5	−0·0206	0·3524
2 5	−0·0091	−0·0538	− 2 3	+0·0098	−0·0896	2 6	−0·0172	0·1744	1 49	−0·0191	0·2707	2 8	−0·0267	0·3860
4 1	−0·0209	+0·0180	− 0 2	−0·0012	−0·0155	3 57	−0·0277	0·2387	3 40	−0·0295	0·3386	4 7	−0·0370	0·4527
6 4	−0·0323	0·0921	+ 1 2	−0·0083	+0·0231	6 6	−0·0401	0·3125	5 46	−0·0425	0·4096	6 12	−0·0518	0·5174
			2 9	−0·0150	0·0634									
			4 2	−0·0267	0·1304									
			6 5	−0·0364	0·2072									
			11 1	−0·0689	0·3457									
			15 33	−0·1432	0·4545									

Repeat Run to obtain b_1 more accurately

$\eta = 0$ deg

α	C_H	C_L
° ′		
− 2 47	0·0062	−0·1592
− 1 47	+0·0039	−0·1041
+ 0 20	−0·0008	+0·0087
2 8	−0·0043	0·1029
4 0	−0·0081	0·2027
6 39	−0·0131	0·3465

TABLE 5

Tunnel Results (Uncorrected)

Tests on NACA 0015, 18-in. Chord, in 7 ft Tunnel, 40 per cent Plain Flap (Gap = 1/20 in.)

$V = 60$ *ft/sec*

		a_1	a_2	b_1	b_2
Smooth wing	$A = \infty$	5·17	3·50	−0·227	−0·504
	$A = 2{\cdot}67$	3·22	2·34	−0·150	−0·428
With wires at $x/c = 0{\cdot}04$	$A = \infty$	4·91	3·04	−0·158	−0·394
	$A = 2{\cdot}67$	3·04	2·06	−0·116	−0·334

a_1 and b_1 ($\alpha = 0$ deg; mean of $\eta = \pm 4$ deg)
a_2 and b_2 ($\eta = 0$ deg; mean of $\alpha = -2$ deg. to $+6$ deg)

$\frac{a_2}{a_1}$, $\frac{b_1}{a_1}$, $\frac{b_1 a_2 - b_2 a_1}{a_1}$ independent of aspect ratio (Glauert, R. & M. 1095).

	Aspect Ratio	$\frac{a_2}{a_1}$	$\frac{b_1}{a_1}$	$b_1 \frac{a_2}{a_1} - b_2$
Smooth wing	∞	0·677	−0·0439	0·350
	2·67	0·727	−0·0466	0·319
With wires at $x/c = 0{\cdot}04$	∞	0·619	−0·0322	0·296
	2·67	0·678	−0·0382	0·255

N.B.—(a) No tunnel corrections for the case of finite aspect ratio ($A = 2{\cdot}67$) have been applied.

(b) No tunnel corrections have been applied for the case of infinite aspect ratio (end fillets in position) for interference arising from constraint due to finite chord of wing. These corrections are small and are given below from Ref. 4.

$$\frac{a_1}{(a_1)_0} = 1{\cdot}019, \quad \frac{a_2}{(a_2)_0} = 1{\cdot}017, \quad \frac{b_1}{(b_1)_0} = 1{\cdot}044, \quad \frac{b_2}{(b_2)_0} = 1{\cdot}018.$$

The subscript ($_0$) refers to ∞ stream.

TABLE 6

Concave Aileron, 50/−2. Finite Aspect Ratio (Aspect Ratio = 2·67)

$V = 60$ *ft/sec*, $\eta = 0$ deg

Lift Coefficient

Smooth Wing			Wires On	
α	C_L		α	C_L
0	0		0	0
° ′			° ′	
4 0	0·251		1 59	0·130
5 59	0·377		2 54	0·179
8 5	0·509		3 54	0·248
12 7	0·757		6 0	0·367
16 6	0·984		7 54	0·491
			10 1	0·623
			14 4	0·852
			16 6	0·975

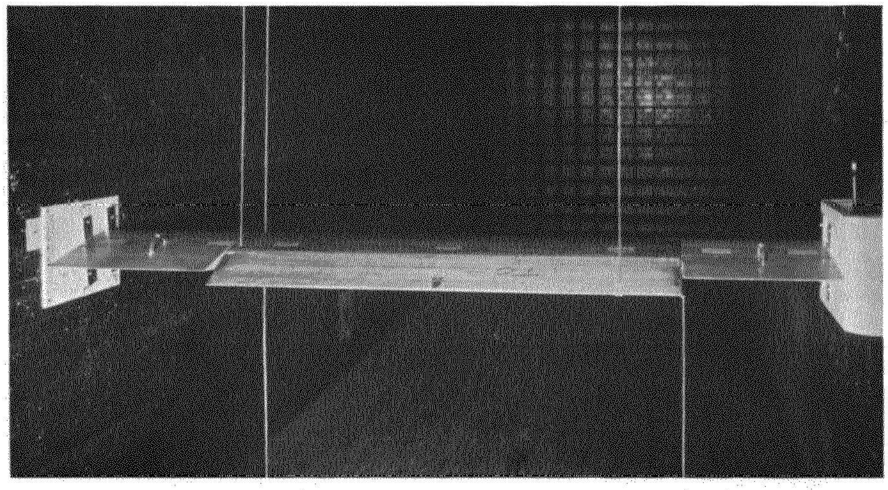


FIG. 1. General View of Model in Tunnel.

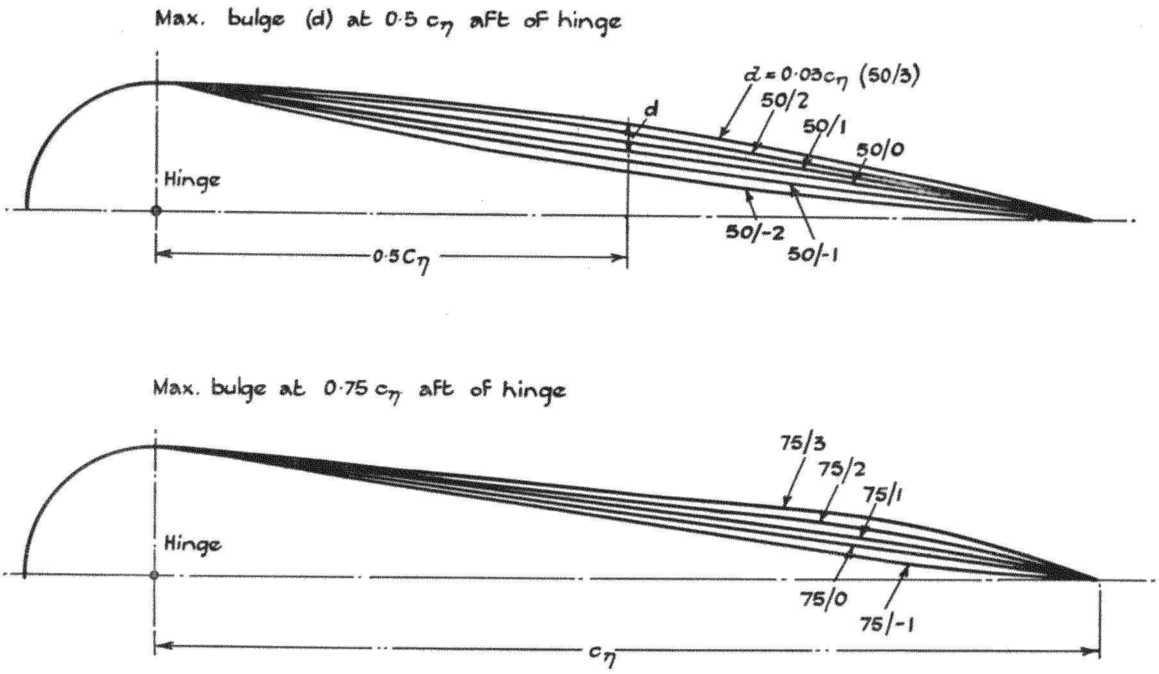


FIG. 2. NACA 0015 Aerofoil. Various Sections of Control (0·4 c).

(96757)

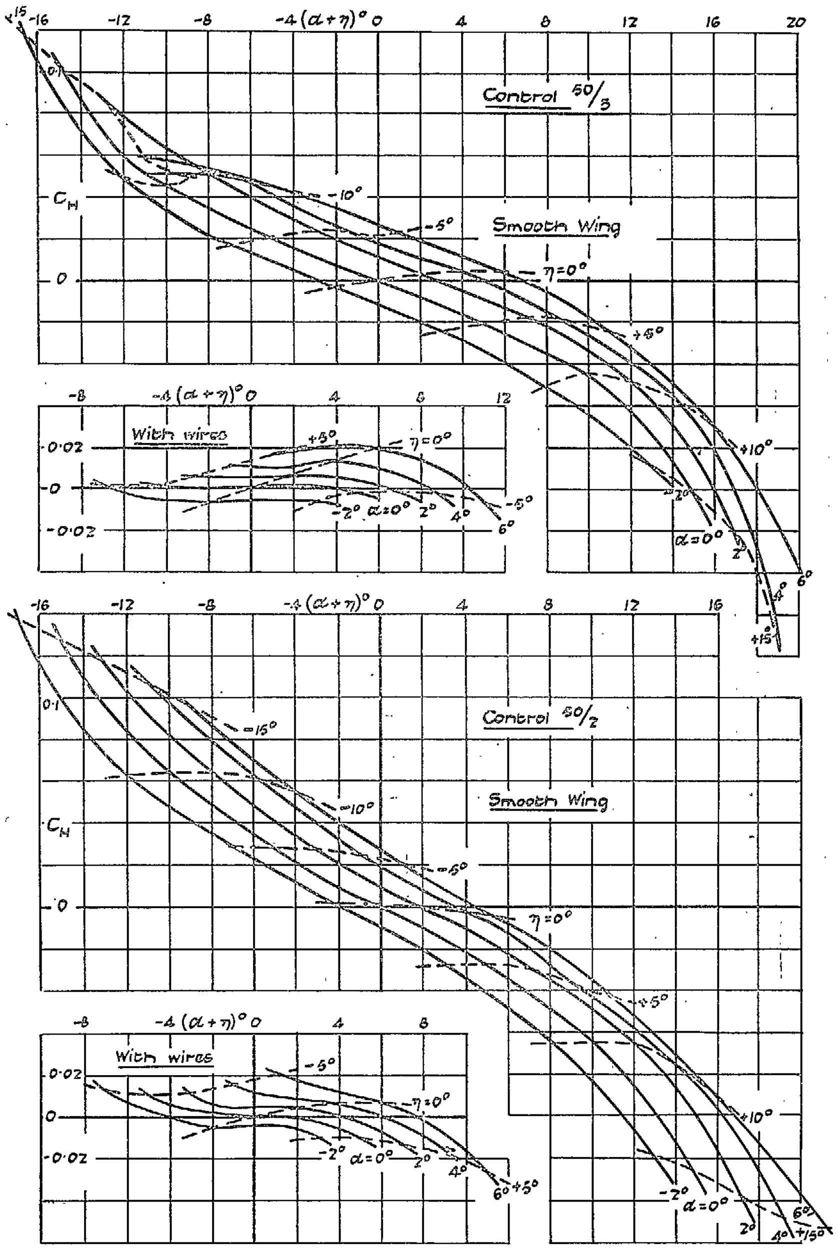


FIG. 3.

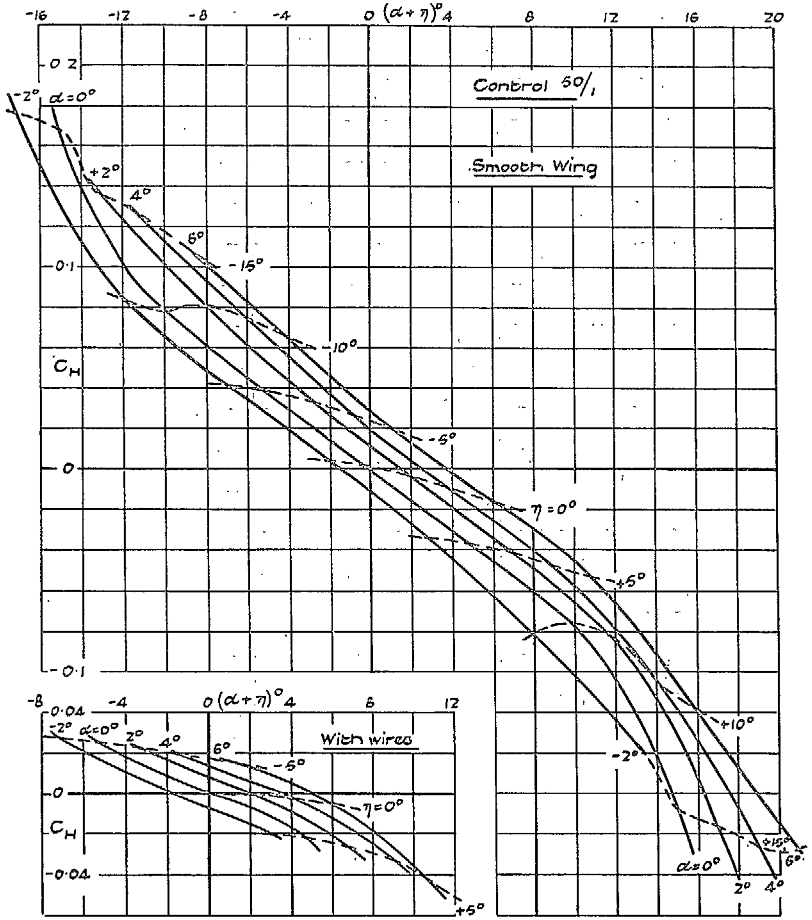


FIG. 4.

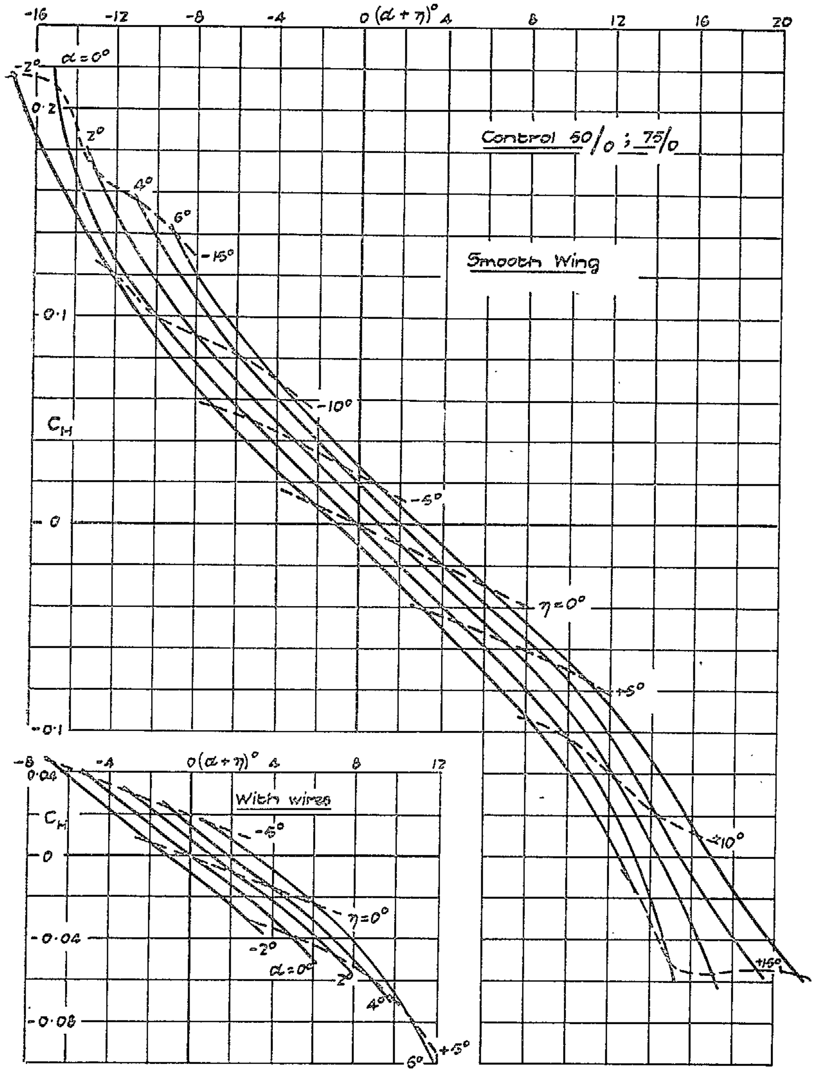

o (α + η)°
Control 50/0 ; 75/0
Smooth Wing
C_H
α = 0°
η = 0°
With wires

FIG. 5.

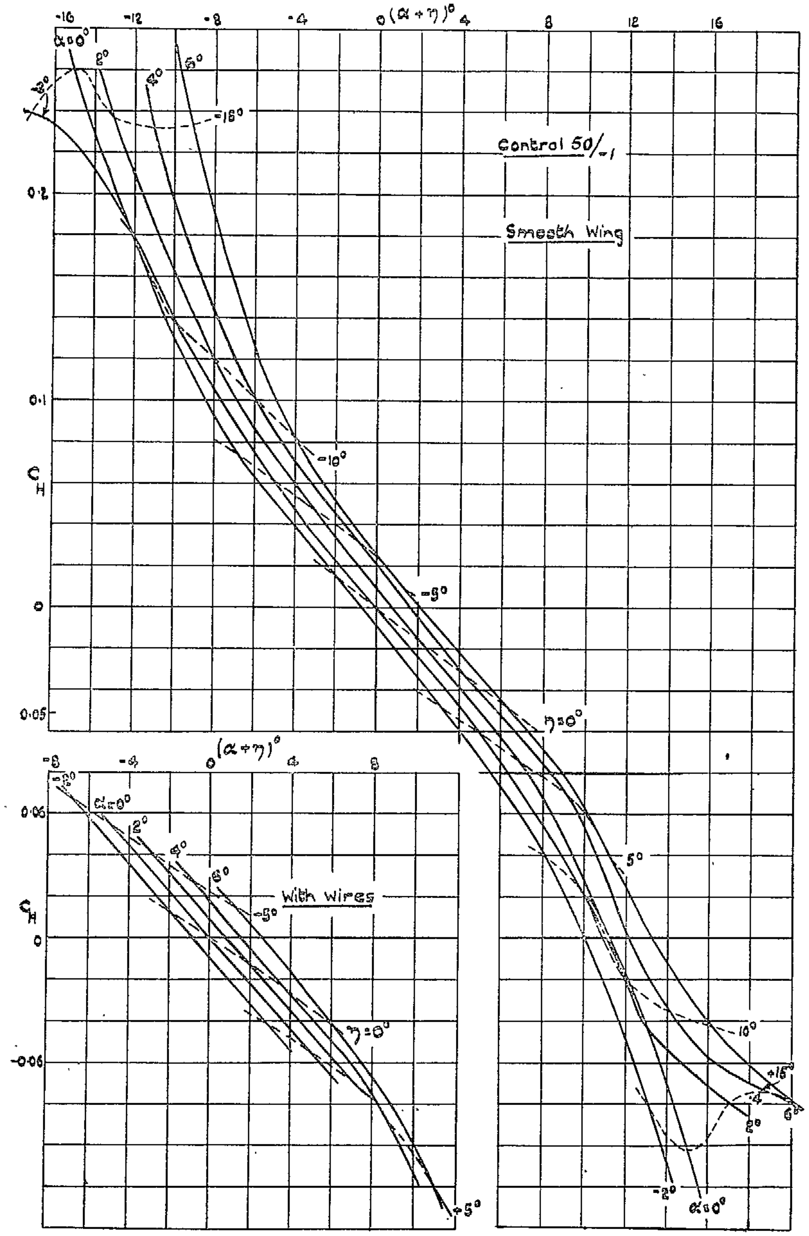

o (α + η)°
Control 50/-1
Smooth Wing
C_H
α = 0°
η = 0°
With wires

FIG. 6.

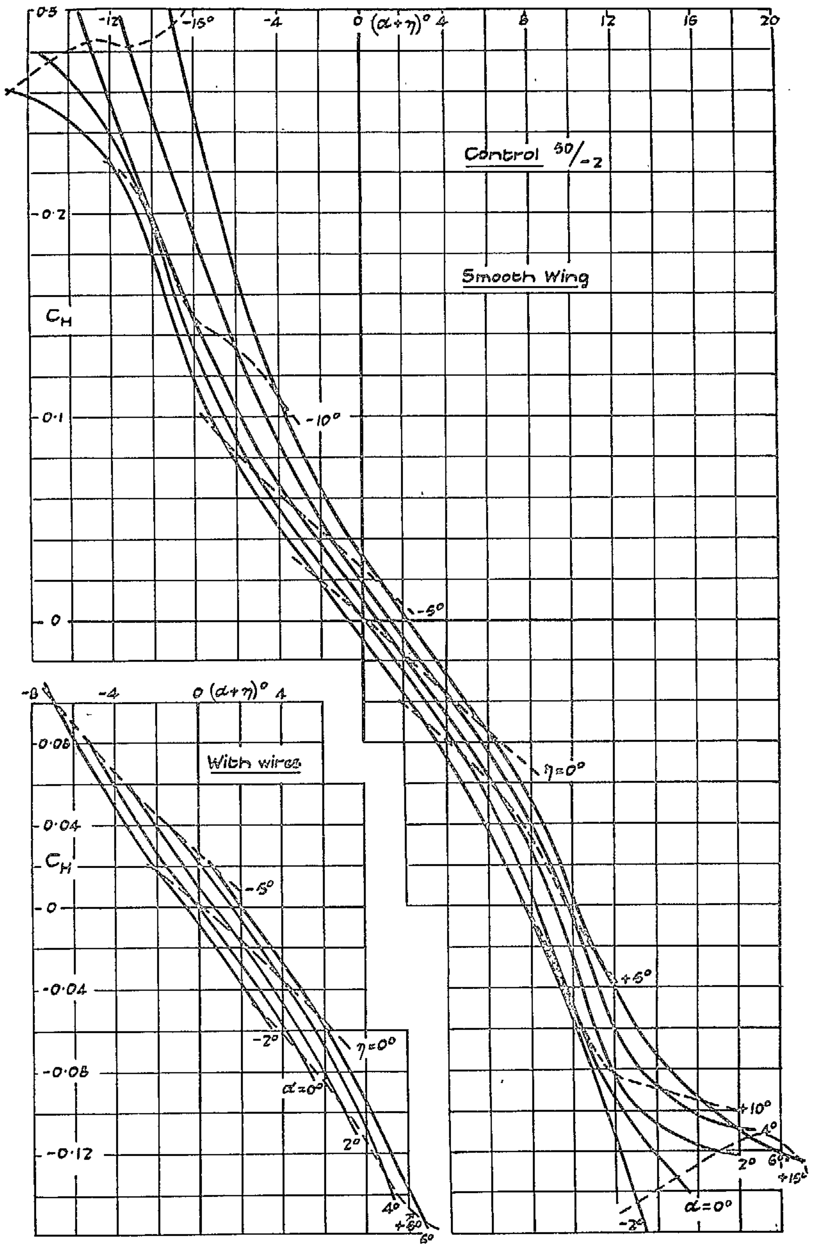

Control 50/-2
Smooth Wing
With wires
C_H
$(\alpha+\eta)°$
$\eta=0°$
$\alpha=0°$

FIG. 7.

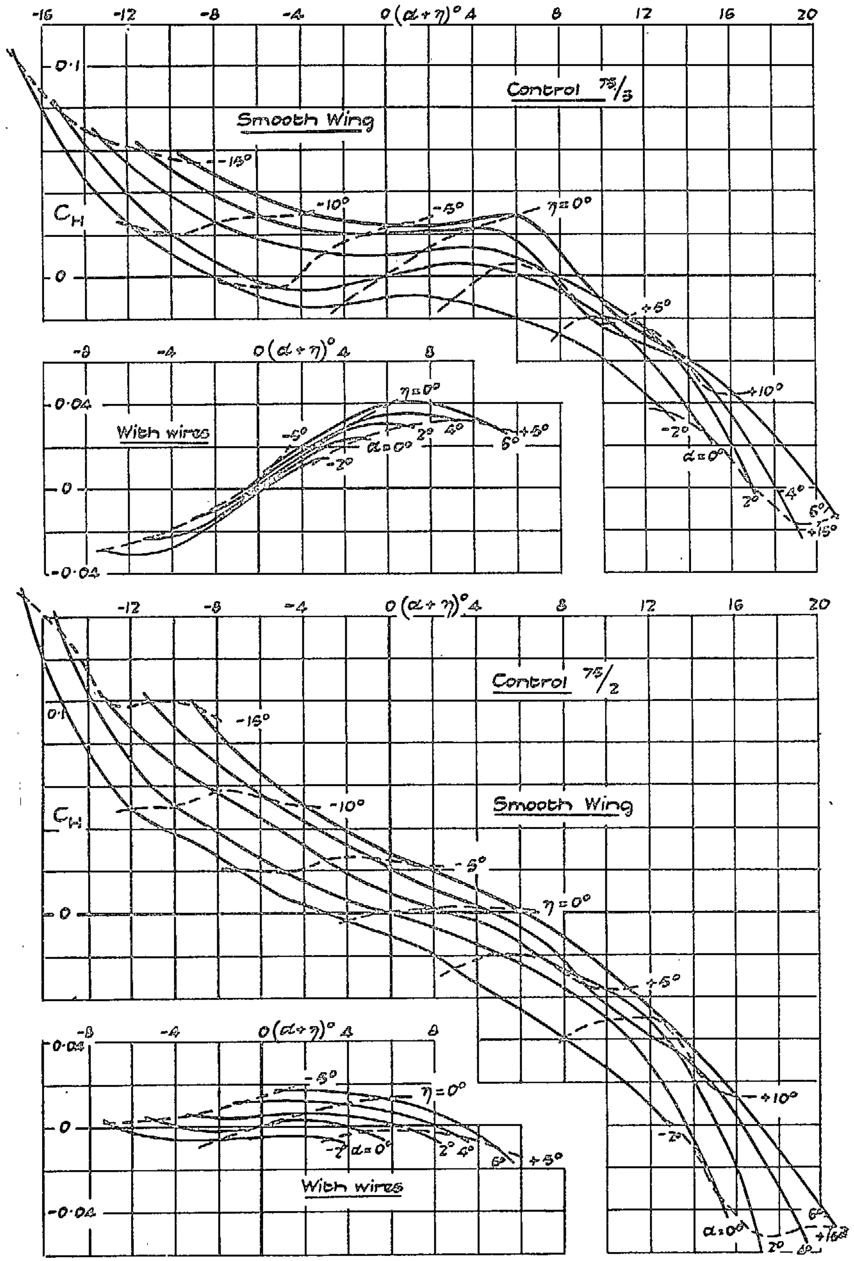

Control 75/3
Smooth Wing
With wires
Control 75/2
Smooth Wing
With wires
C_H
$(\alpha+\eta)°$
$\eta=0°$
$\alpha=0°$

FIG. 8.

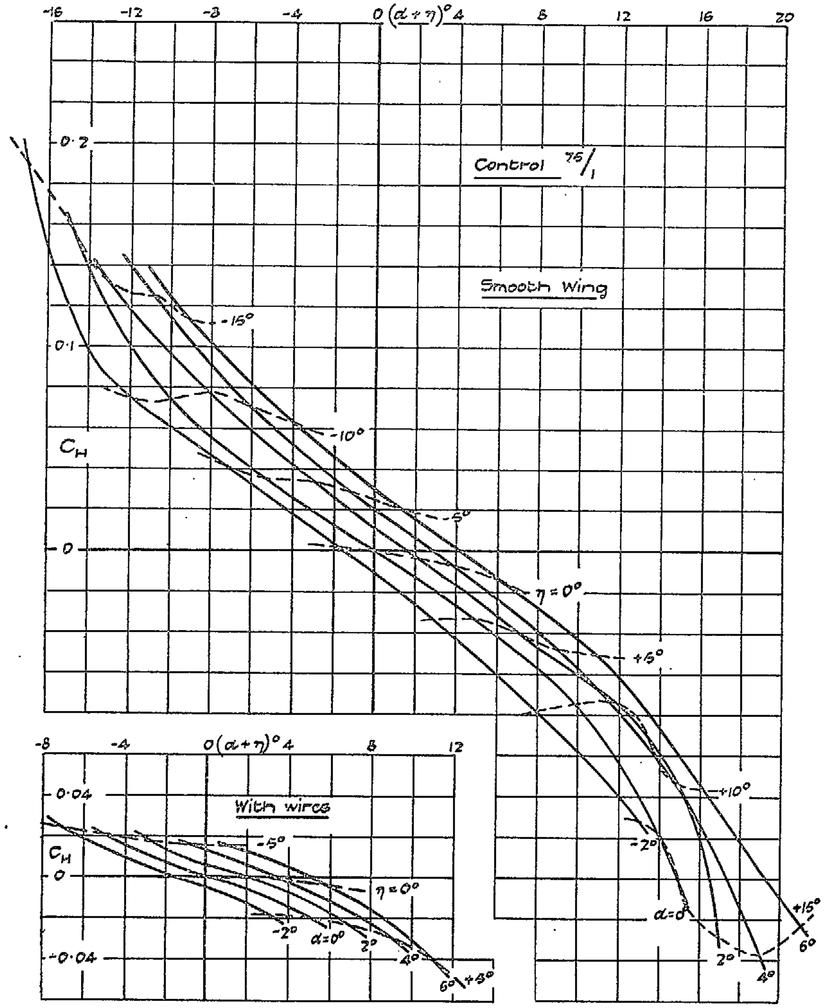

Control 75/1
Smooth Wing
With wires
C_H
$(\alpha+\eta)°$
$\eta = 0°$

FIG. 9.

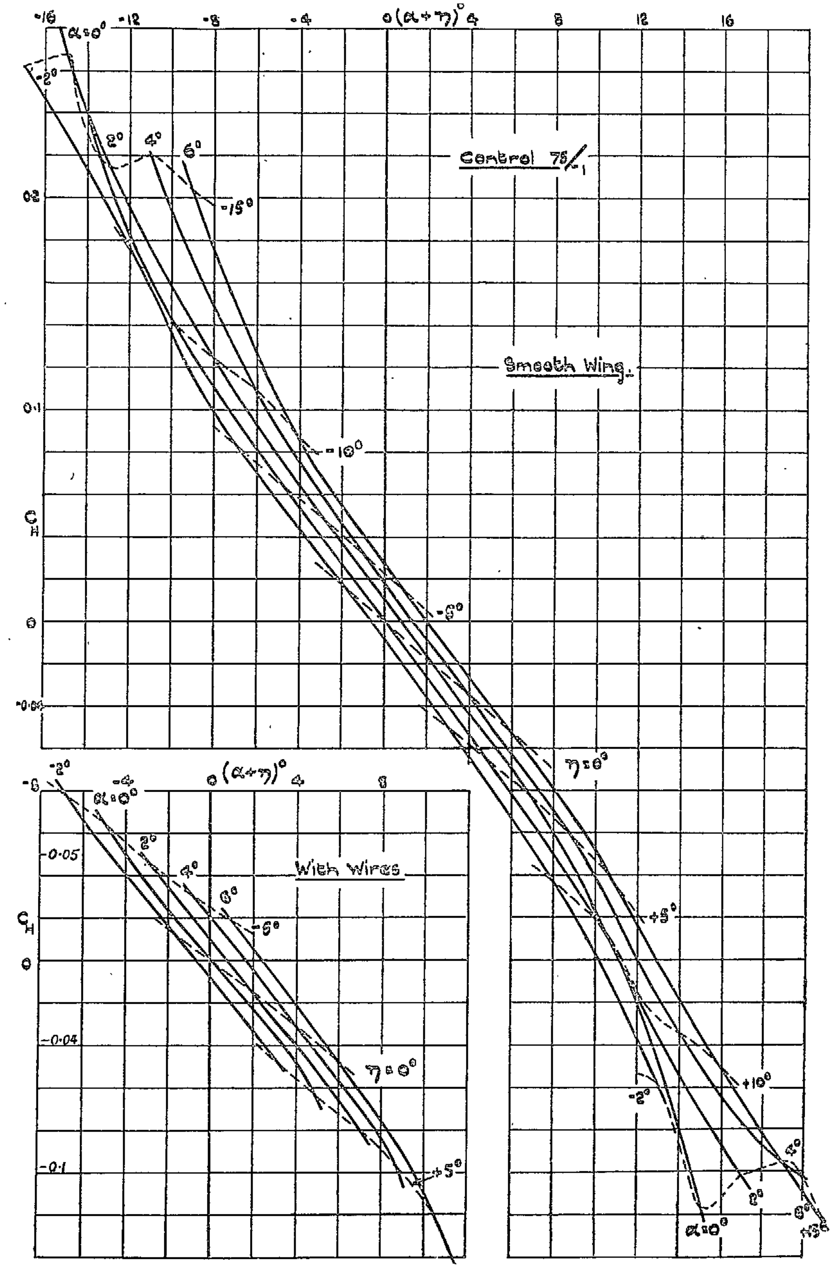

Control 75/1
Smooth Wing.
With Wires
C_H
$(\alpha+\eta)°$
$\eta = 0°$

FIG. 10.

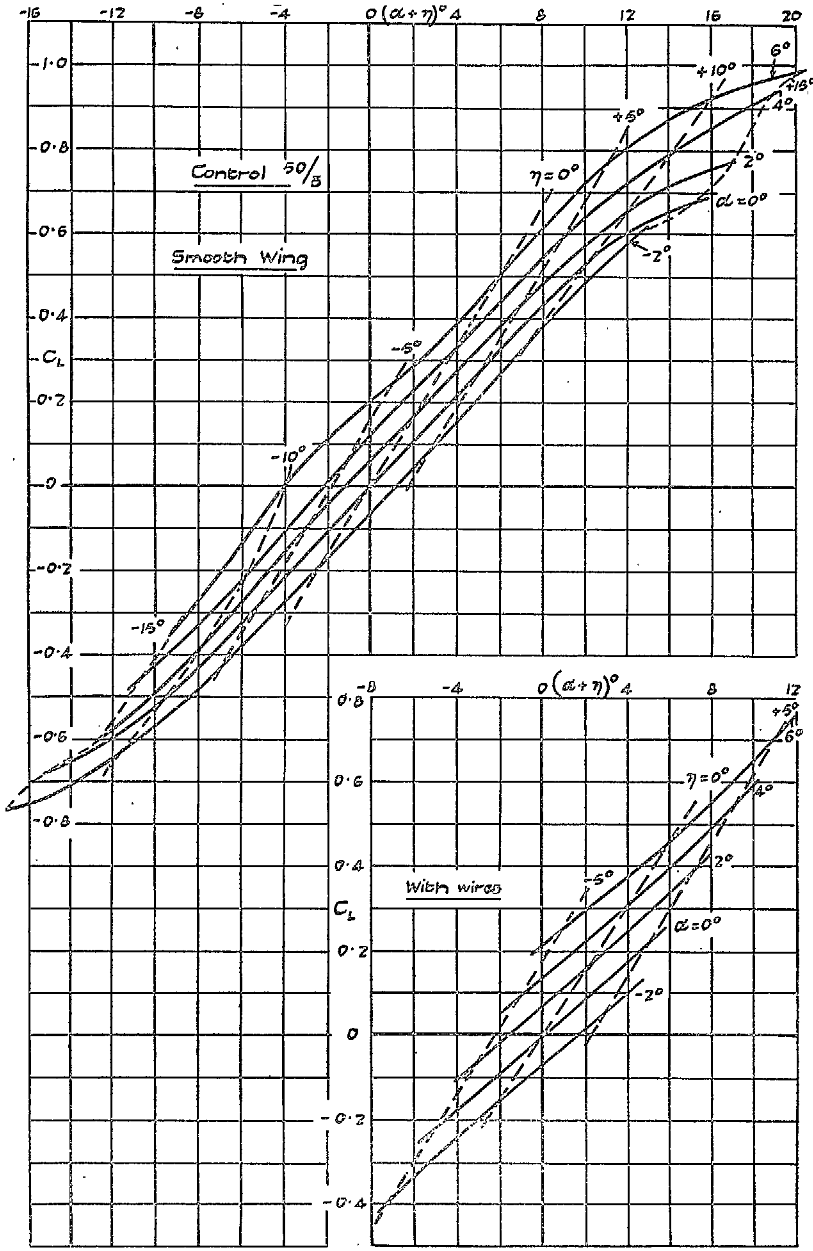

Control 50/3
Smooth Wing
With wires
C_L
$(\alpha+\eta)^\circ$
$\eta = 0^\circ$
$\alpha = 0^\circ$

FIG. 11.

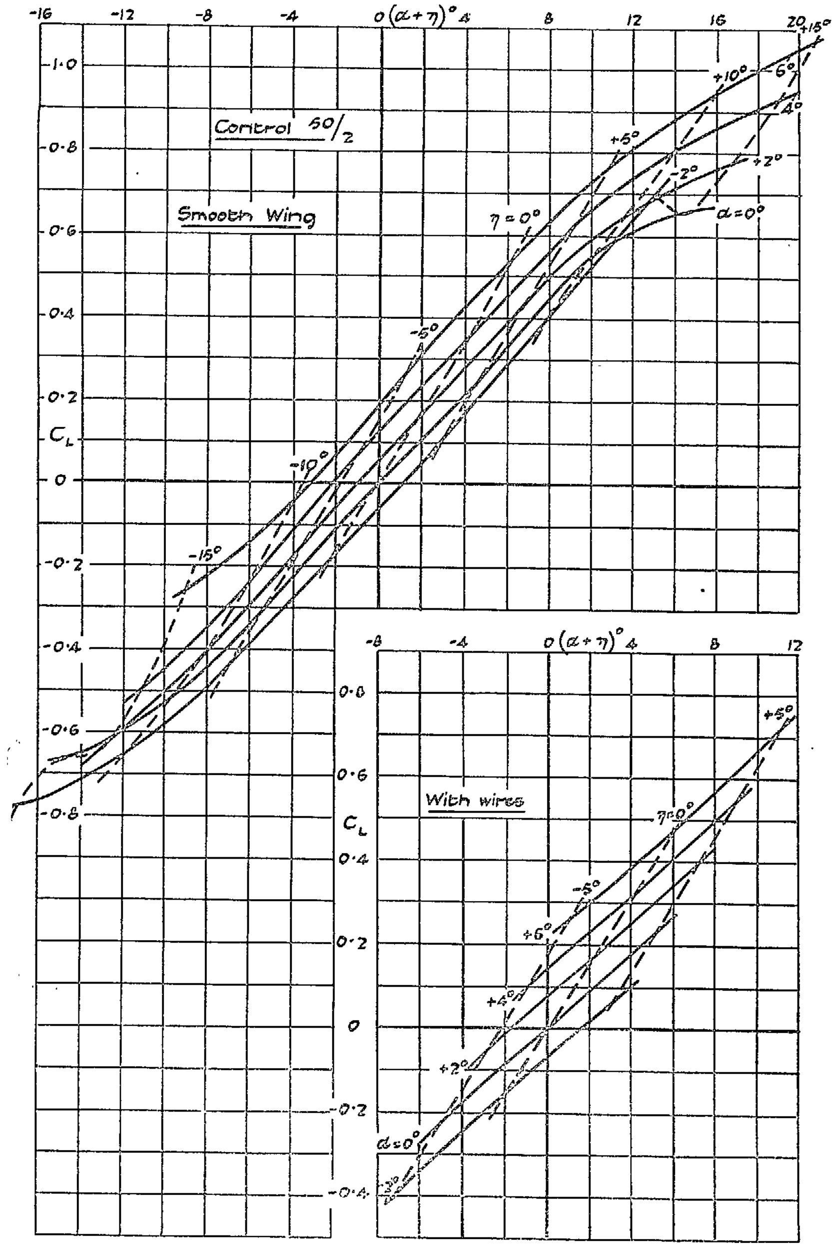

Control 50/2
Smooth Wing
With wires
C_L
$(\alpha+\eta)^\circ$
$\eta = 0^\circ$
$\alpha = 0^\circ$

FIG. 12.

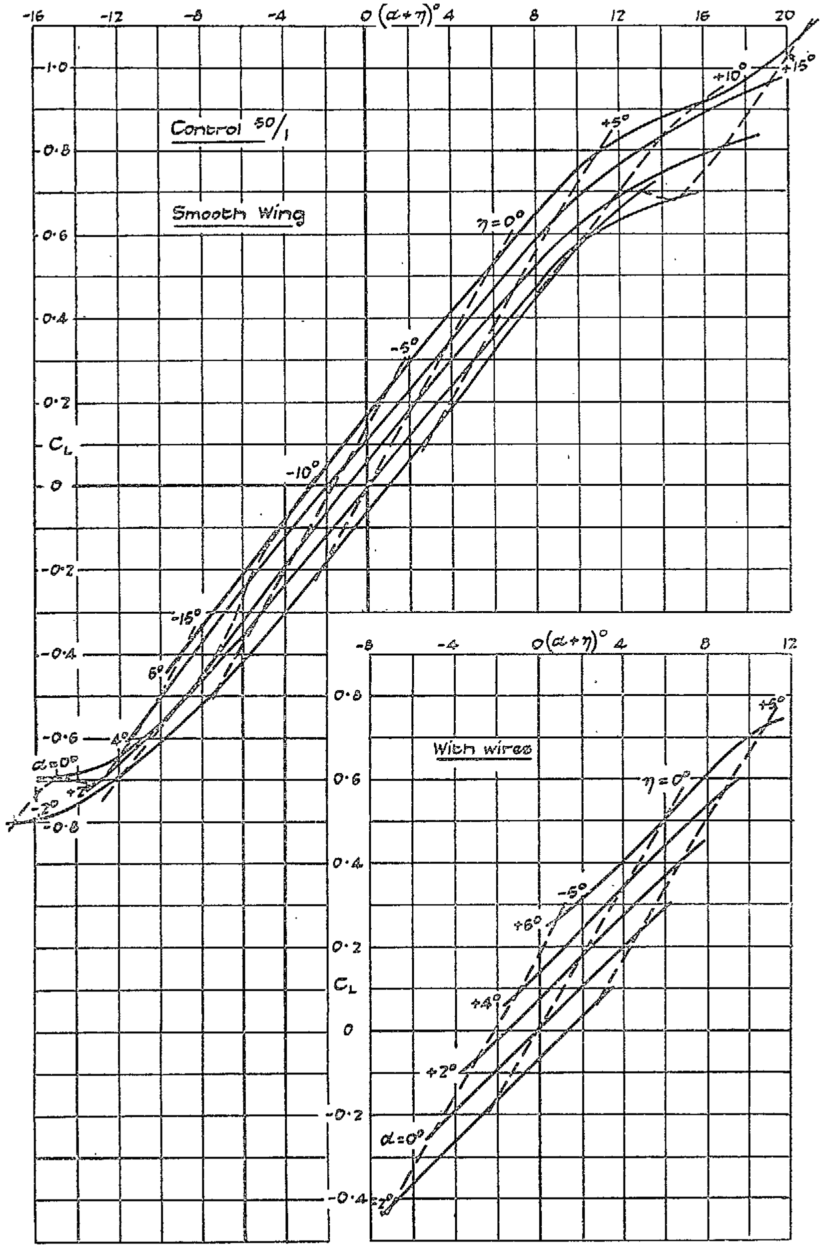

(α+η)°
Control 50/1
Smooth Wing
η = 0°
+5°
+10°
+15°
-5°
-10°
-15°
α=0°
C_L
With wires

Fig. 13.

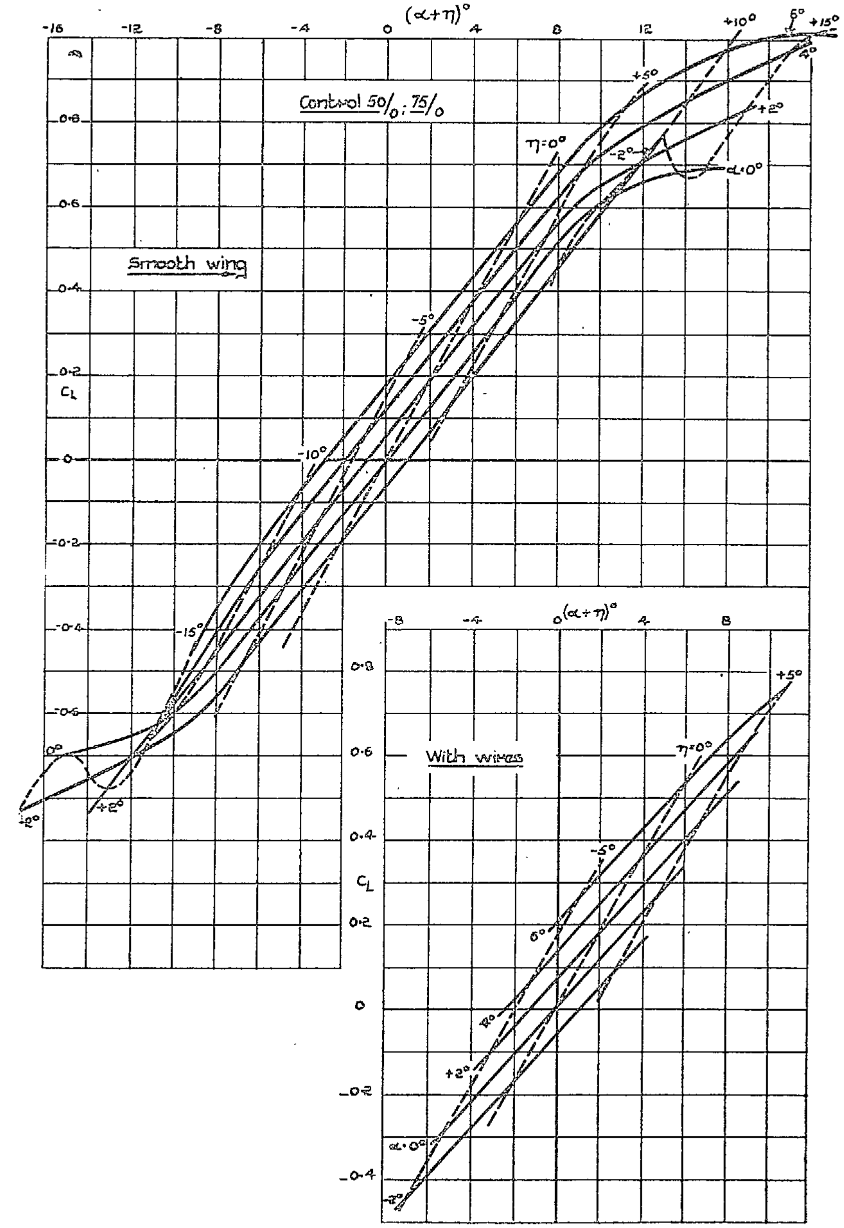

(α+η)°
Control 50/0 : 75/0
Smooth wing
η=0°
+5°
+10°
+15°
-5°
-10°
-15°
α=0°
C_L
With wires

Fig. 14.

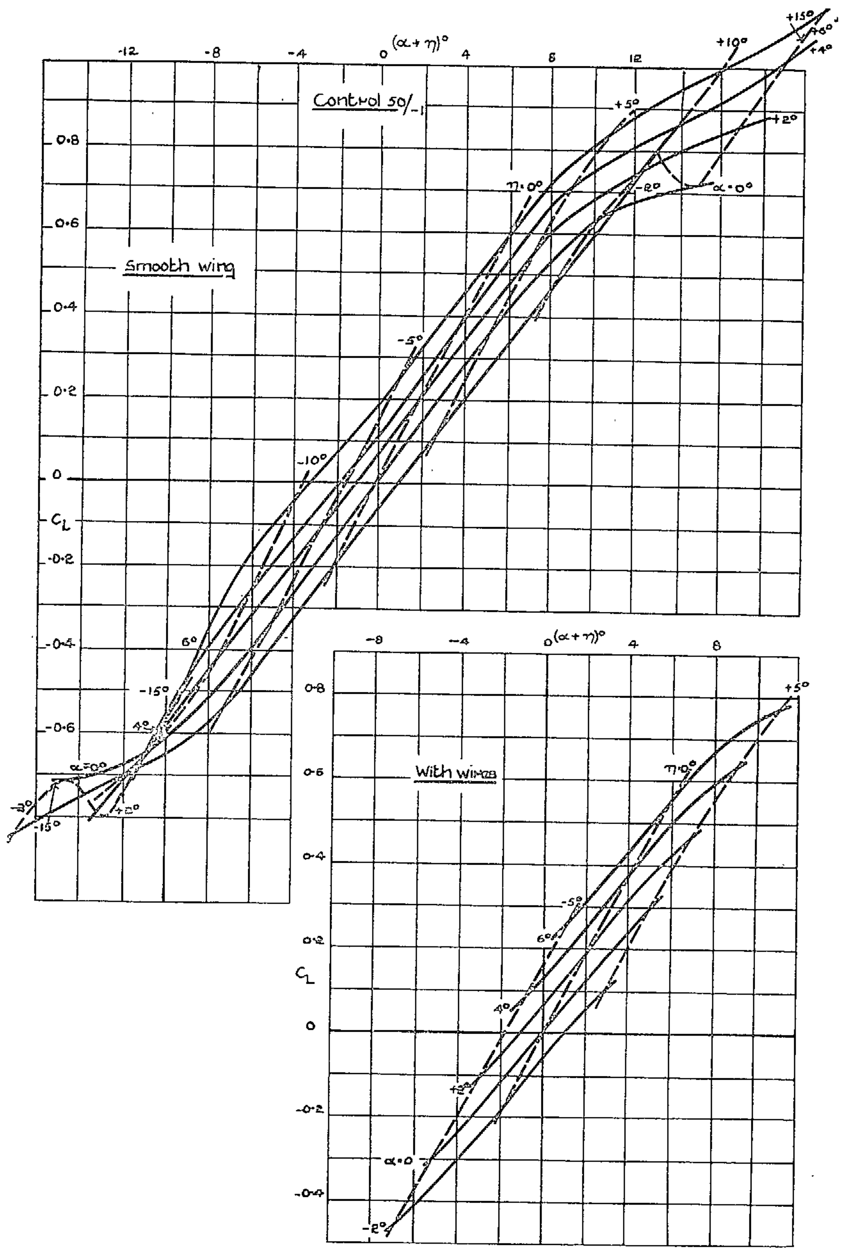

Control 50/-1
Smooth wing
With wires
$(\alpha+\eta)^\circ$
C_L
$\eta = 0^\circ$
$\alpha = 0^\circ$

Fig. 15.

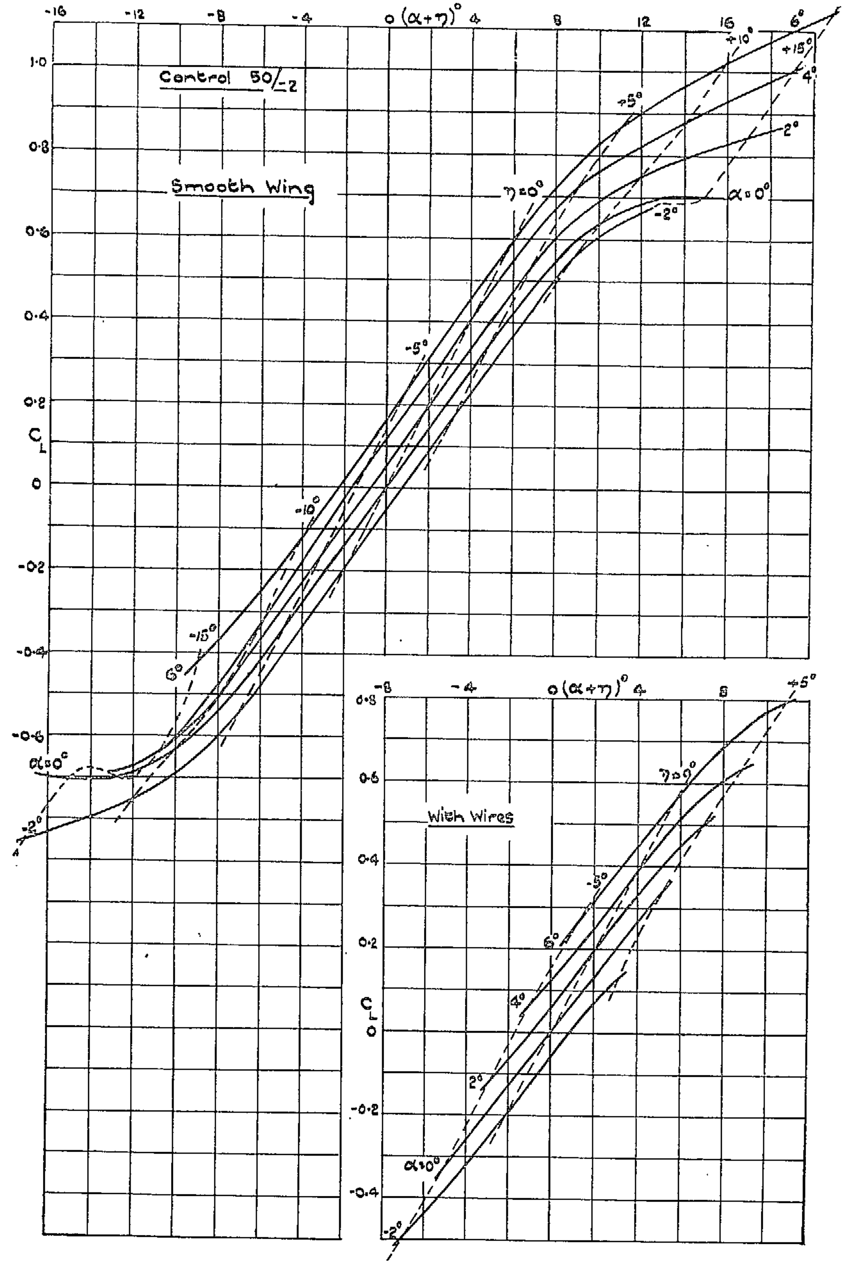

Control 50/-2
Smooth Wing
With Wires
$(\alpha+\eta)^\circ$
C_L
$\eta = 0^\circ$
$\alpha = 0^\circ$

Fig. 16.

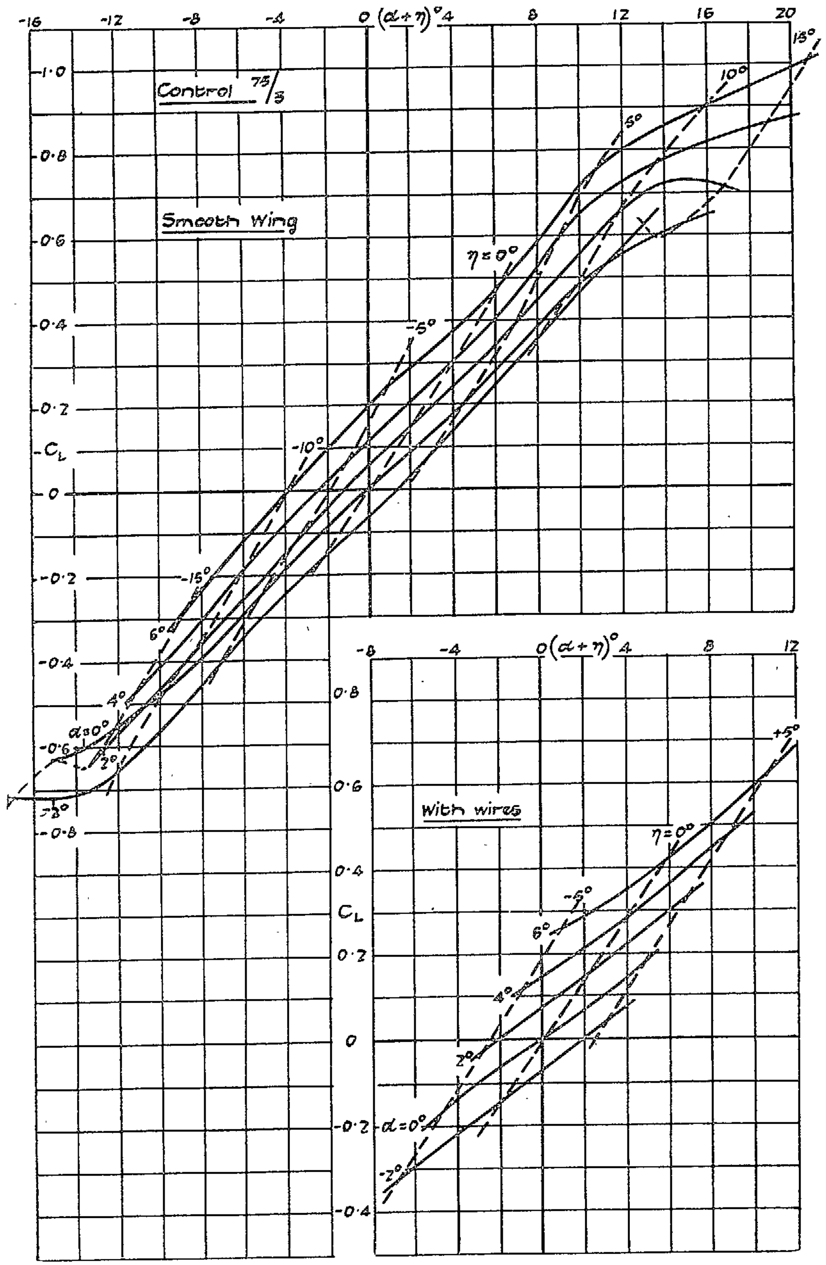

Control 75/3
Smooth Wing
With wires
$(\alpha+\eta)^\circ$
C_L
$\eta = 0°$
$\alpha = 0°$

FIG. 17.

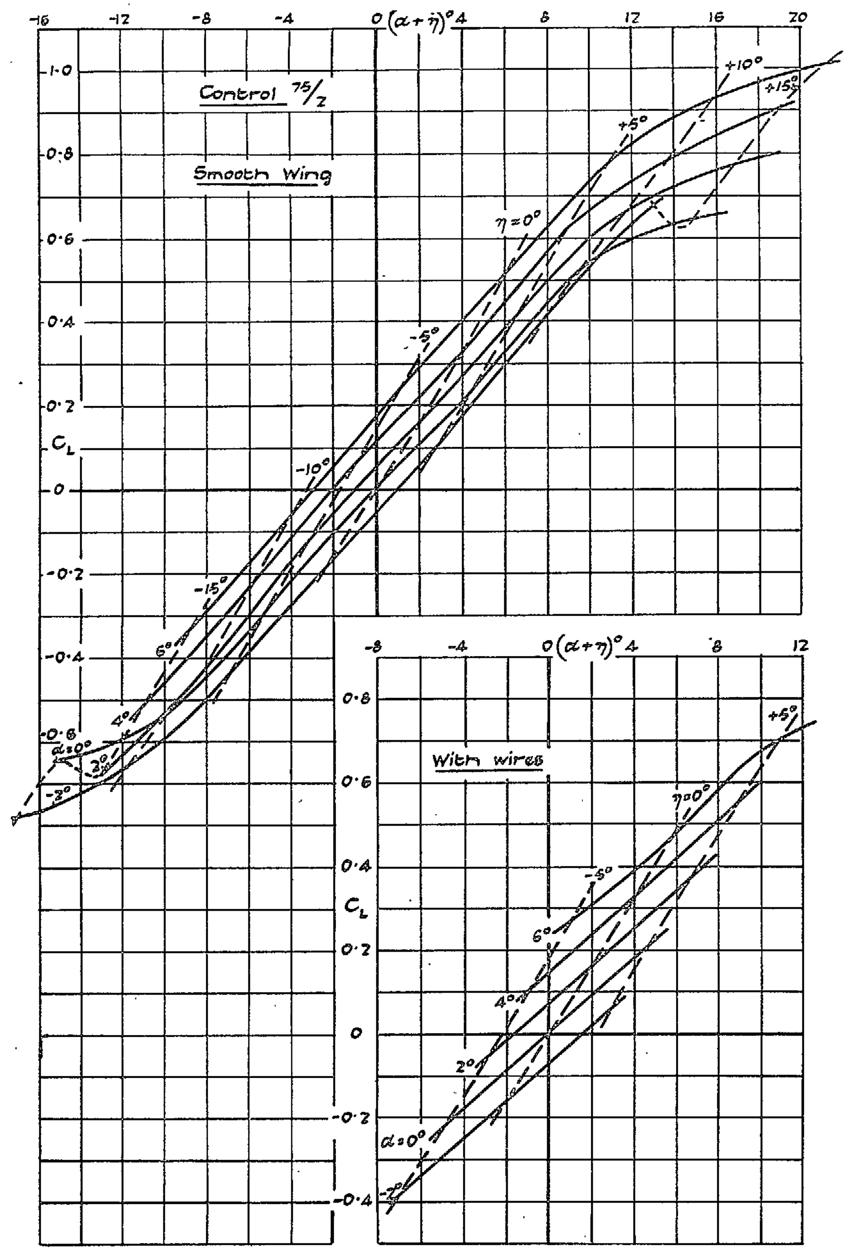

Control 75/2
Smooth Wing
With wires
$(\alpha+\eta)^\circ$
C_L
$\eta = 0°$
$\alpha = 0°$

FIG. 18.

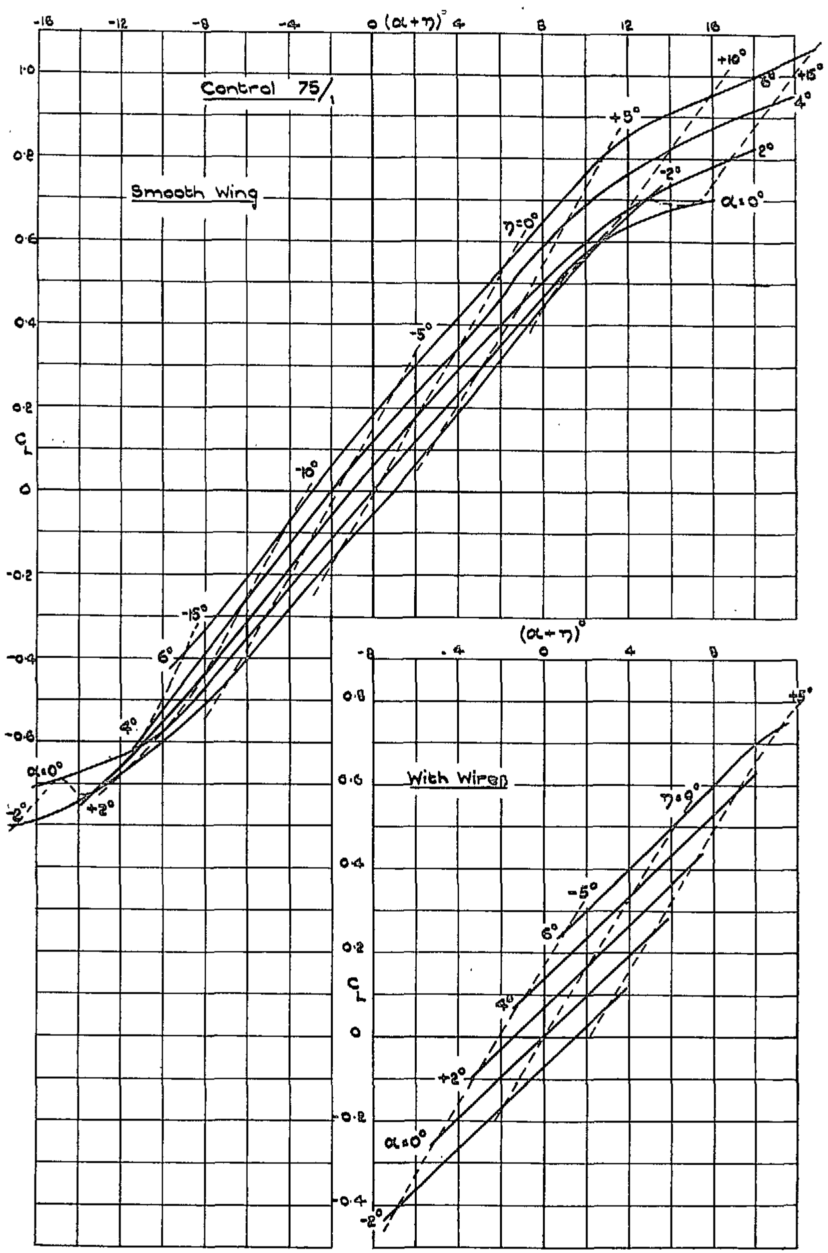

Control 75/1
Smooth Wing
With Wires
C_L
$(\alpha+\eta)^\circ$
$\alpha=0°$
$\eta=0°$

FIG. 19.

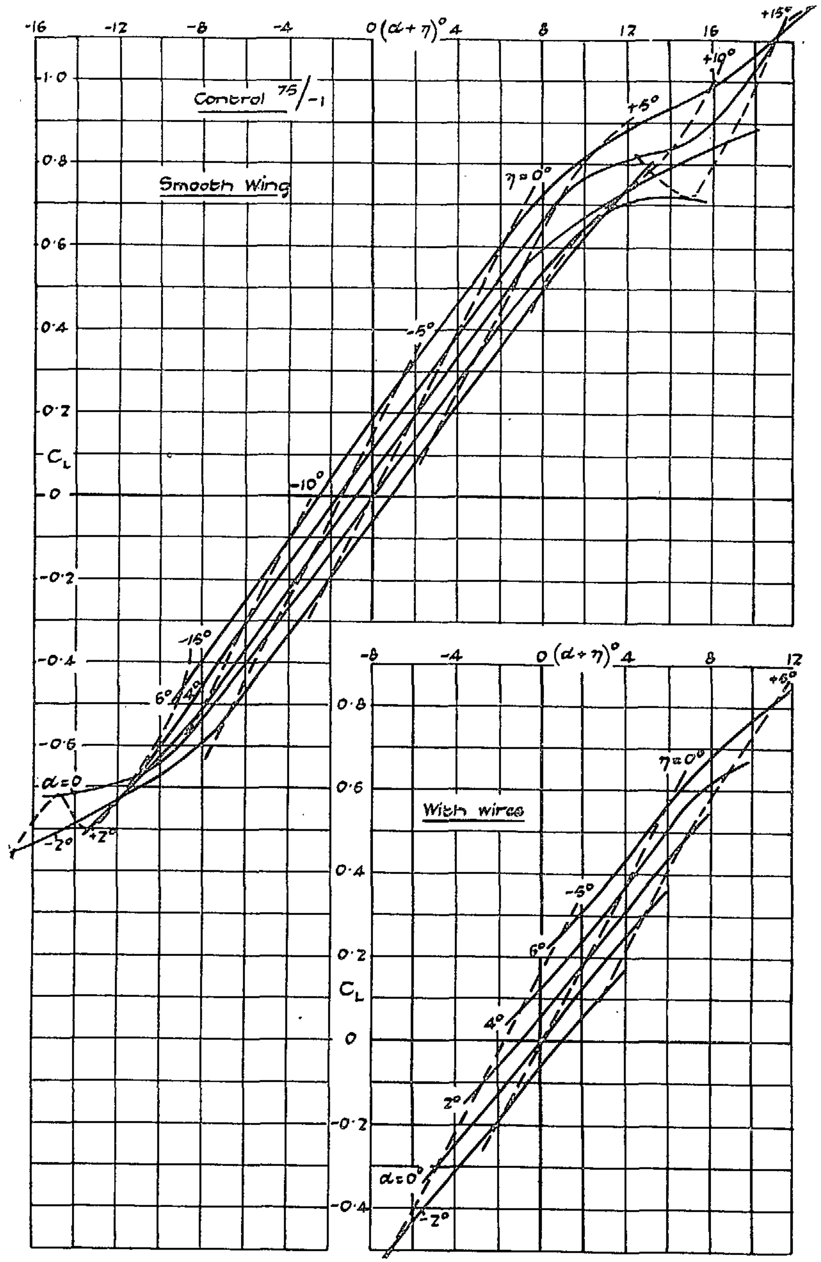

Control 75/-1
Smooth Wing
With wires
C_L
$(\alpha+\eta)^\circ$
$\alpha=0$
$\eta=0°$

FIG. 20.

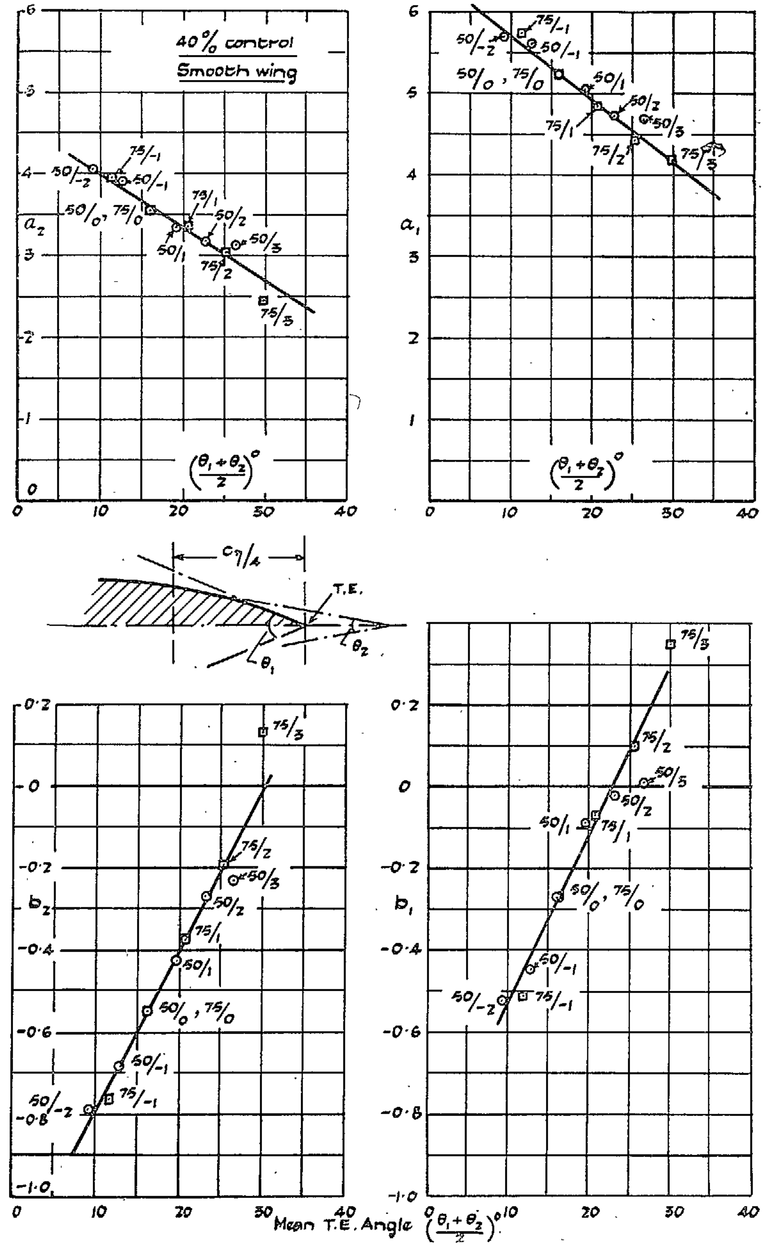


FIG. 22. Plotting of a_1, a_2, b_1, b_2 ($\alpha = 0$ deg, $\eta = 0$ deg) against a Mean Trailing-Edge Angle.

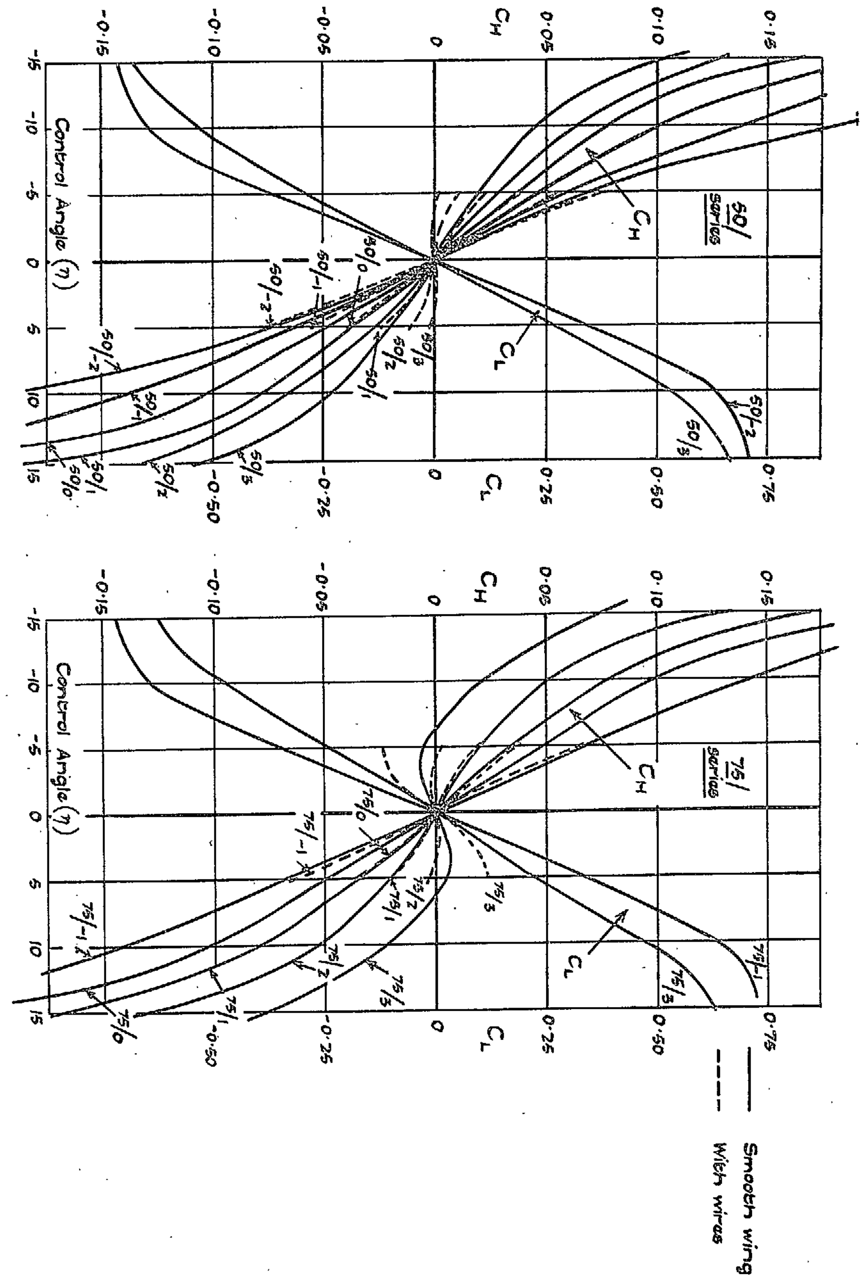


FIG. 21. Effect of Curvature of Control Surface on C_H and C_L against Control Angle. Incidence 0 deg.

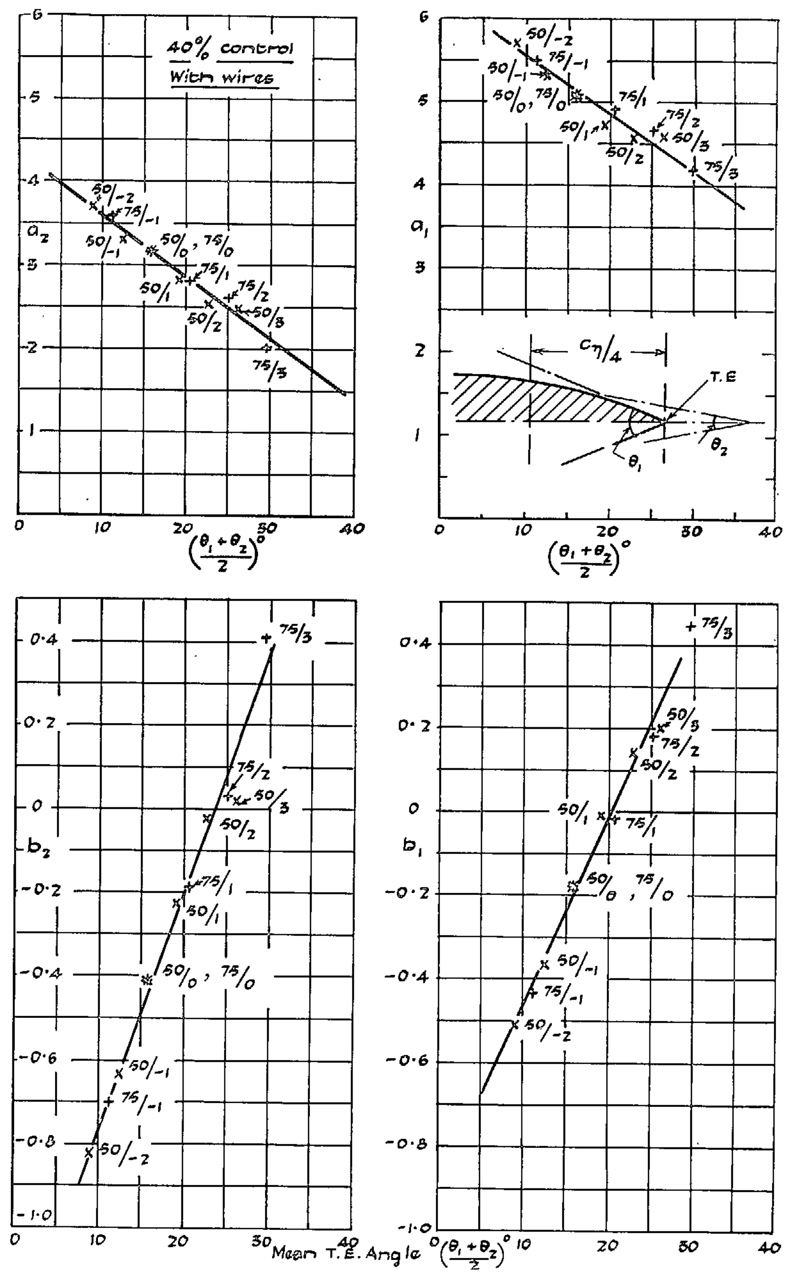
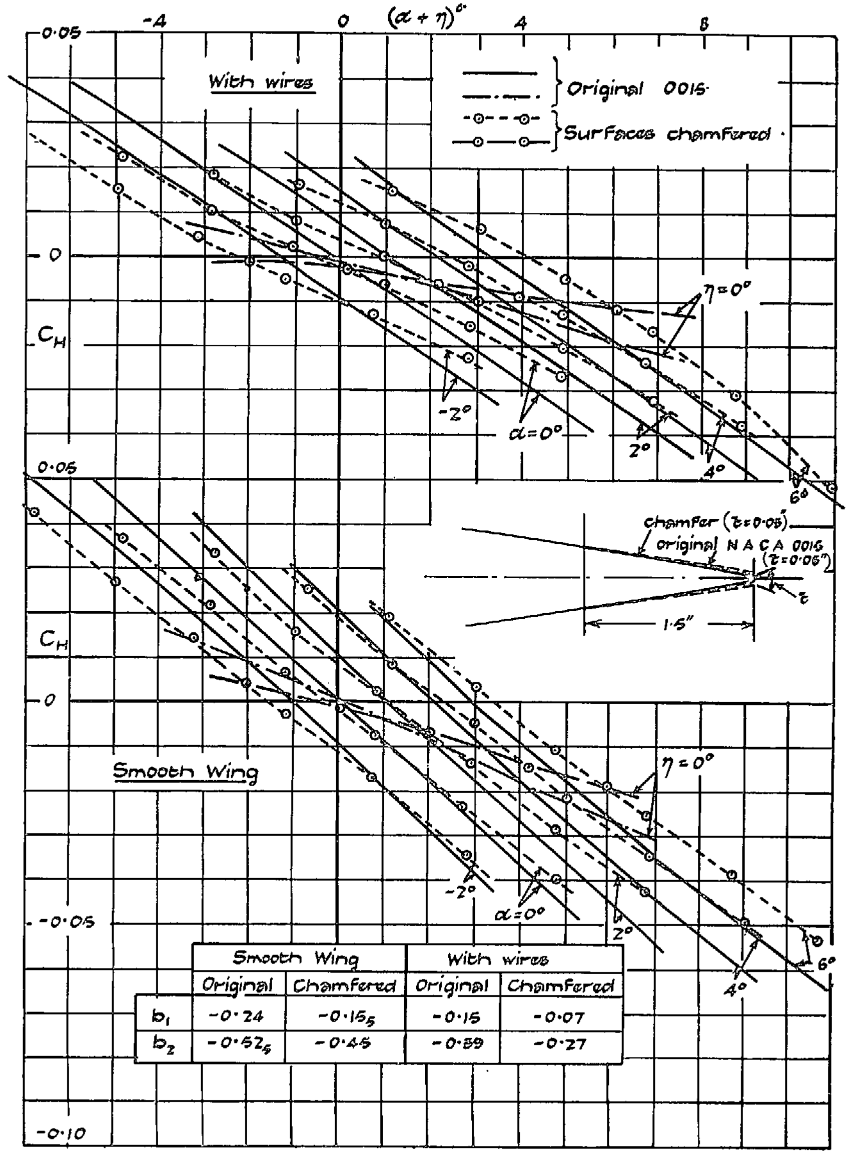
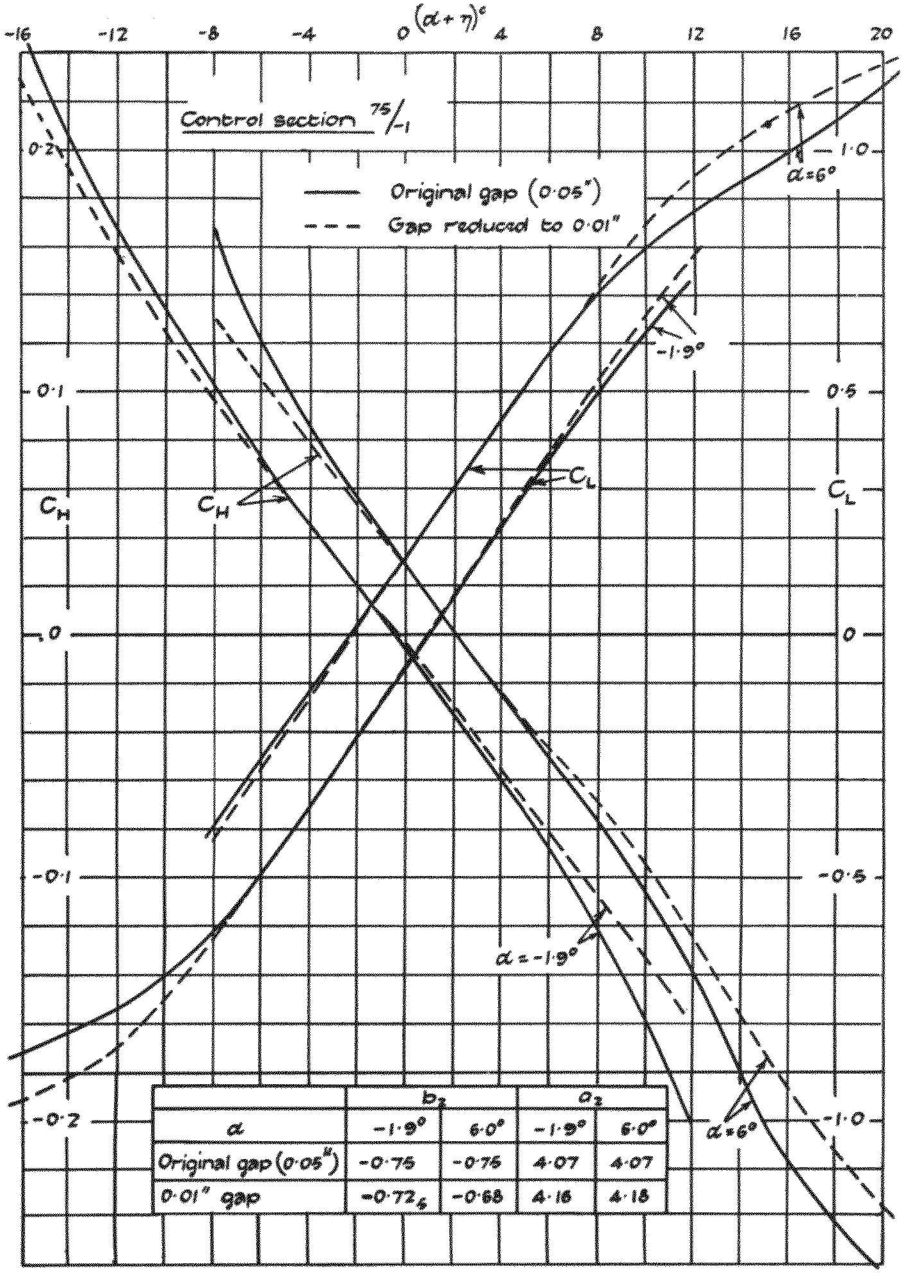


FIG. 23. Plotting of a_1, a_2, b_1, b_2 ($\alpha = 0$ deg, $\eta = 0$ deg) against a Mean Trailing-Edge Angle.



	Smooth Wing		With wires	
	Original	Chamfered	Original	Chamfered
b_1	-0·24	-0·16$_5$	-0·15	-0·07
b_2	-0·52$_5$	-0·45	-0·39	-0·27

FIG. 24. Effect on Hinge Moment of Chamfering the Surface near the Trailing Edge of NACA 0015 Section



	b_2		a_2	
α	−1·9°	6·0°	−1·9°	6·0°
Original gap (0·05")	−0·75	−0·75	4·07	4·07
0·01" gap	$-0{\cdot}72_5$	−0·68	4·16	4·18

FIG. 25. Effect of Reducing Gap between Nose of Control and Main Aerofoil.

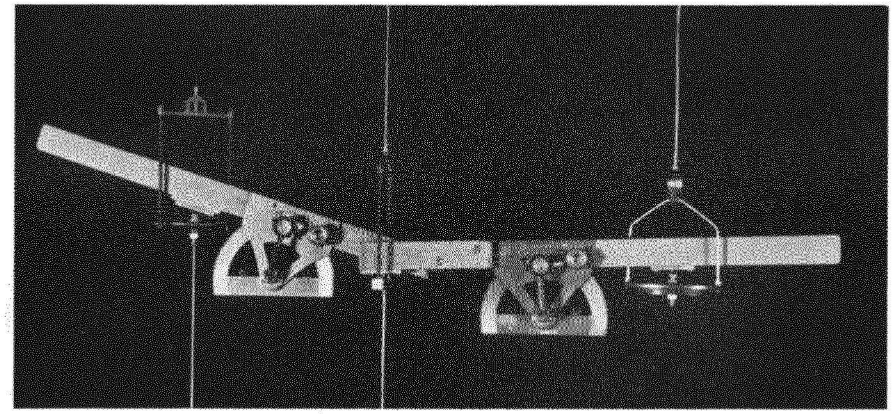


FIG. 26a. Original " Mock-up " of Apparatus.

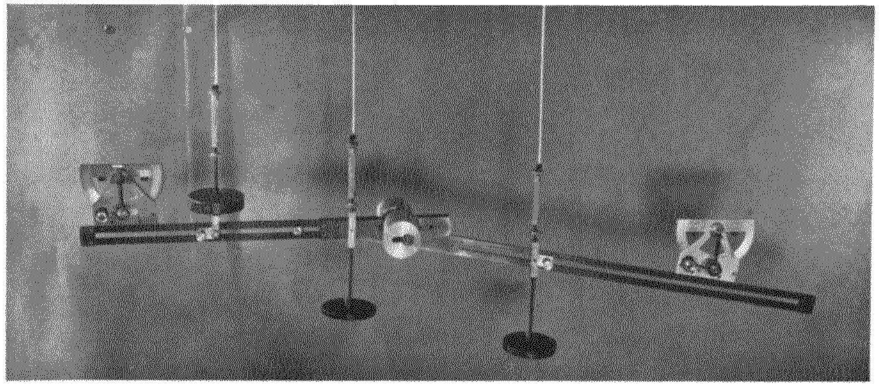


FIG. 26b. Apparatus as described in Text.

Angle-Measuring Apparatus.

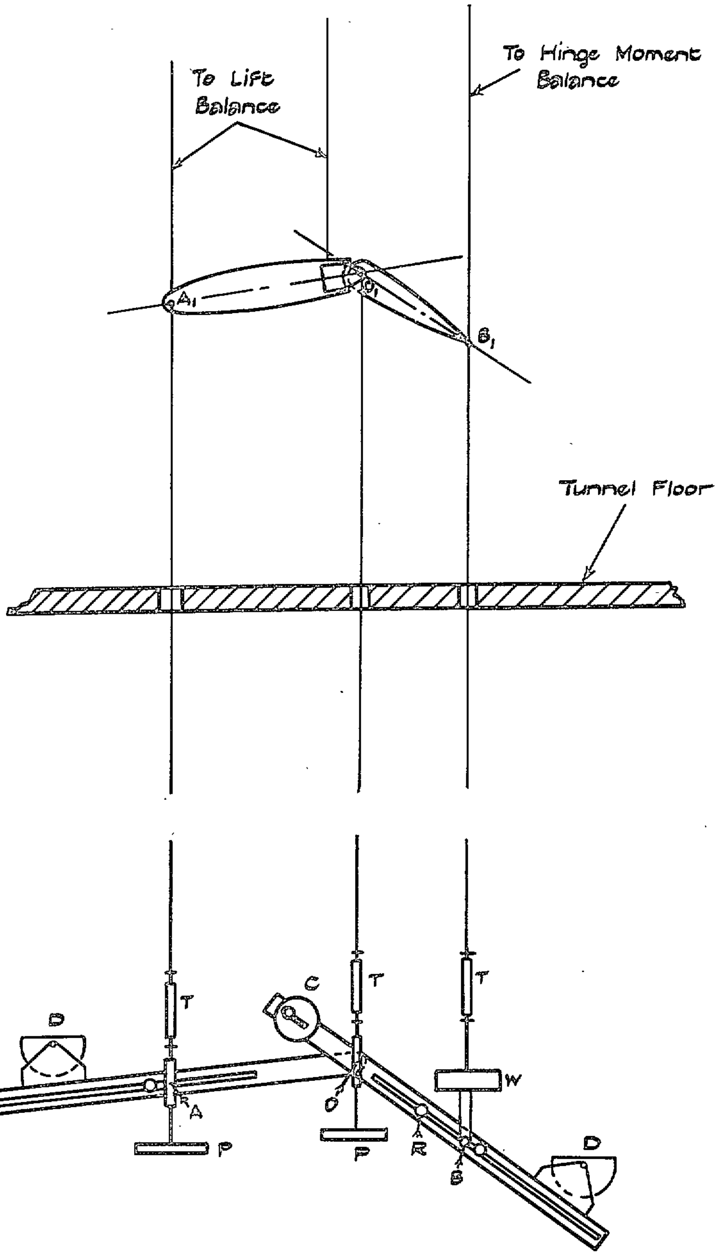


FIG. 27.

(96757) Wt. 14/655 K.5 10/52 Hw.

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