AERODYNAMICAL COEFFICIENTS ON CAMBERED SURFACES

SIR,—There seems to be a considerable difficulty in devising a suitable rule to express lift and resistance for aerocurves. In Mr. Page's paper to the Society (February 14th, 1911) he adopts the rules followed by Rateau and Soreau:

$$L \propto (\theta + d)$$
$$R \propto (a\theta^2 + b\theta + c)$$

θ is chord angle of incidence; d is a "deviation" angle.

Mr. Berriman, in his criticism of the said paper and his later contributions to the British Association and Royal Society of Arts, adopts Lanchester's form :—

$$L \propto (\alpha + \beta)$$

where α is the entry angle, β the trail angle, $\alpha + \beta$ the "deflection angle." In my paper on Propellers (AËRONAUTICAL JOURNAL, July, 1911, p. 112) a similar line is followed.

The objection to the first method lies in :—

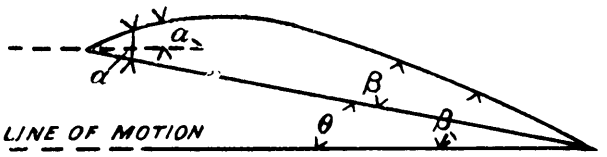
(1) The uncertainty as to d;

(2) The anomalous increase in the "sweep factor";

(3) Irregularities or even negative values of b.

The second method is open to the very palpable difficulty that the total reaction is apparently invariable, the variations in lift being simply due to the change in the direction of the resultant pressure.

May I mention that the following method seems to agree fairly well with the results.



(1) *For perfectly continuous stream line motion—*

$$L \propto (\alpha + \beta) \text{ or } (\alpha_1 + \beta_1)$$

There is only one position in which this can occur and for this position the lift-to-drift ratio is a maximum.

(2) For smaller values of θ there is a *discontinuity* behind the dipping edge. (Incidentally this causes the c.p. to recede.)

(3) For larger values of θ there is a *discontinuity* at the *upper rear surface.* (This again causes the c.p. to recede so that the c.p. is most advanced in the position of perfect flow.)

Numerous experiments have shown that when θ is between 3° and 8° (mean, say, 5° or 6°), L/R is a maximum, so that for the position of maximum L/R :—

$$\alpha_1 = \alpha - 5°$$
$$\beta_1 = \beta + 5°$$

Experiment also indicates when $\theta = -5°$ or thereabouts, L/R = o.

On this basis a formula,

$$L \propto [\alpha_1 + \beta + \theta]$$

would seem to give satisfactory results, θ being the only variable, α_1 being the *entry angle in the position of stream line flow* (maximum efficiency) and β the trail-to-chord angle.

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The resistance is a more difficult item to express. The resultant is inclined forward of the normal to the trail tangent plane and for the best value of θ, is apparently almost exactly perpendicular to the chord, so that

$$R = P \sin \theta$$

or approximately L sin θ.

As θ decreases R does so slightly, being a minimum when $\theta = o$, and is then almost wholly skin friction.

In the paper of mine referred to above, L/R is computed somewhat on these lines.

As to the effect of aspect ratio, I am inclined to regard this as purely due to the relative elimination of end-contractions of stream which must occur as the aspect ratio increases. Employing Lanchester's rule,

$$L \propto Cc,$$

I find that for greater aspect ratio than 2, the rule

$$c = \frac{3n - 2}{n} \quad \text{(n being aspect ratio)}$$

is fairly accurate.

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February 19th, 1912.

WIND TUNNEL RESEARCH

SIR,—It has been suggested that a short note on the difficulties to be met with in Wind Channel work might find a fitting place among the correspondence on Mr. Handley Page's paper.

Let it be said at once that it is too soon—probably years too soon—to expect the various Laboratories to arrive at agreement between themselves to a high degree of accuracy, on account of the considerable possibility of error which attaches to Wind Channel work on models. Error may arise from :—

(1) Errors in model making ;
(2) The use of a law of similarity which is incorrect ;
(3) Ordinary errors of observation ; and
(4) Various systematic errors.

Of these, (1) is not usually serious, at least if care is taken, in the case of wooden models, that they have not warped since being made.

As for (2), this, most fortunately, does not make any enormous difference in the case of aeroplane work, but in the case of large work, such as dirigible balloon envelopes, in predicting full scale results from model tests, differences of as much as 30 per cent. may occur between the results obtained by the use of the theory employed by, for instance, Captain Crocco, and that employed by the N.P.L. In view of such discrepancies as these it is to be hoped that some better agreement between the various authorities may soon be arrived at.

Errors of the third class are all those that can be summed up in the phrase " failure to repeat readings exactly." They occur in all classes of experimental work, they are amenable to treatment by the Theory of Probable Errors as given in the text-books, and hence they can always be reduced as far as may be nccessary by a sufficient number of repetitions of the readings. These errors are apt to be rather large in Wind Channel work, owing to the irregularity of the artificial wind, although, be it understood, a natural