NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL MEMORANDUM

No. 1117

FORCE AND PRESSURE-DISTRIBUTION MEASUREMENTS ON A RECTANGULAR WING WITH DOUBLE-HINGED NOSE

By H. A. Lemme

Translation

Kraftmessungen und Druckverteilungsmessungen an einem Rechteckflugel mit Doppelknicknase

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FORCE AND PRESSURE-DISTRIBUTION MEASUREMENTS ON A RECTANGULAR WING WITH DOUBLE-HINGED NOSE*

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SUMMARY

The previous measurements on airfoils with hinged nose disclosed a comparatively large low-pressure peak at the bend of the hinged nose; which favored the separation of flow. It was therefore attempted to reduce these low-pressure peaks by reducing the camber of the forward profile and thereby ensure a longer adherence of the flow and a maximum lift increase.

The forces were measured on a rectangular wing with double-hinged nose and end plates, the pressure distributions were measured in the center section of the wing.

The measurements disclosed that the highest lift attained with a single-hinged nose cannot be increased by a double-hinged nose. The sum of the deflection angles of both hinged noses related to the maximum lift is about equal to the corresponding angle of the single-hinge nose ($\approx 30^\circ$ to 40°). The respective angle of attack in both cases amounts to $\approx 21^\circ$. Even the low-pressure peak is about the same in both cases ($p/q \approx -5.5$). Therefore, a milder curvature of the forward portion of the profile affords no definite increase of the maximum lift.

I. INTRODUCTION

Investigations on wings with various types of hinged nose had disclosed a maximum increase in the highest lift of $\Delta c_{a_{max}} = 0.55$ for a hinged-nose deflection of $\approx 30^\circ$ (reference 1), but it was

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accompanied, as is seen from the pressure measurements, by a large low-pressure peak at the bend of the hinged nose which favors the separation of flow.

It was therefore attempted to reduce this low-pressure peak by less camber of the profile; hence, to ensure a longer adherence of the flow and thus attain an increase in the maximum lift.

Accordingly, the forces were measured on a rectangular wing with double-hinged nose (fig. 1) at various hinged-nose deflections. The wing was equipped with end plates. The pressure distribution for the model configuration most favorable for the maximum lift was determined in the center section.

The chord of the hinged-nose was so chosen that the forward hinged-nose bend had a smaller, the rearward hinged-nose bend a greater backward position than on the single-hinged nose (reference 1). The chord of the rearward hinged nose (nose 2) is limited by the fact that the front spar, lying at about 25 percent of the wing chord in full size, must not be weakened by the installation of the hinged nose.

II. MEASUREMENTS AND INTERPRETATION

The measurements were made in tunnel I of the AVA at 2.25-meter jet diameter.

Notation and signs conform to the DIN standards (DINL100 2 Edition, July 1939). Other data necessary are given in figure 1.

1. Force Measurements at $R_e \approx 1.01 \times 10^6$ ($V \approx 31$ m/s)

The maximum lift attained by the deflection of hinged nose 1 or 2 was measured, and the highest lift obtained by simultaneous deflection of both hinged noses determined. The effect on drag and pitching moment was determined at the nose settings most favorable for maximum lift.

2. Pressure Distribution

The pressure distribution in the center section of wing was measured at the deflection of nose 2 most favorable for maximum lift and several deflections of nose 1.

The local pressure p, referred to dynamic pressure q, was plotted against the reference straight line for the angle of attack (profile center line of center section of wing). It should be noted therefore that x is always the distance of the pressure tap from the nose point of the basic profile measured in direction of the profile center line of the center section. (For $\delta_1 > 0$ and $\delta_2 > 0$ the x/l values of the test stations at the hinged nose do not agree with the values of figure 1 which apply to $\delta_1 = \delta_2 = 0$). This method of plotting was chosen so that only one integration is necessary for computing the normal force

$$c_{n_D} = \int^{1} \frac{\Delta p}{q} \, d\left(\frac{x}{l}\right)$$

from the pressure distribution.

The angle-of-attack correction for finite jet diameter was applied in the usual manner (reference 3). Since the model configurations chosen for the force measurements were different from those for the pressure-distribution measurements, the lift would have to be measured by a separate force measurement for the angle-of-attack correction. To avoid this measurement the normal force determined from the pressure distribution was used as basis for the pressure-distribution measurements in the correction of the angle of attack in place of the lift.

III. RESULTS OF TESTS

1. Forces

Considering the effect of single-hinged noses of various length (table I), a nose length of $0.11l$ is most favorable for the maximum lift. A length in excess of $0.11l$ affords no increase in the maximum lift.

TABLE I

MAXIMUM LIFT FOR DIFFERENT NOSE LENGTHS

Nose chord in percent of wing chord	Nose angle δ	$C_{a_{max}}$	$\Delta C_{a_{max}}$
0	0	0.72	0
.11	42.5	1.30	.58
.125 (reference 1)	30	1.27	.55
.144	30	1.24	.52

There is probably a smaller increase in maximum lift even for lengths $<0.11l$, but, when bearing in mind that the accuracy of measurement of the highest lift is limited by breakdown phenomena of flow and unavoidable shaking of the balance, the small increase in the maximum lift entailed with $<0.11l$, is of no practical significance.

No increase in maximum lift (fig. 2, table II) is attainable by the simultaneous deflection of two hinged noses.

TABLE II

MAXIMUM LIFT AT SIMULTANEOUS DEFLECTION OF TWO HINGED NOSES

δ_1	δ_2	α	$C_{a_{max}}$	$\Delta C_{a_{max}}$
0	0	12.2	0.72	0
0	30	20.6	1.24	.52
10	25	21.1	1.27	.55
15	20	21.1	1.26	.54
20	15	20.6	1.25	.53
30	10	21.6	1.29	.57
35	5	22.1	1.30	.58
42.5	0	22.1	1.30	.58

The sum of the hinged-nose angles most favorable for the maximum lift is about as great as the corresponding deflection angle of a single-hinged nose (≈30° to 40°). The angle of attack remains about the same as for the single-hinged nose. Less profile camber therefore ensures no longer adherence of flow.

Neither different hinge-nose lengths nor different deflections have any appreciable effect on the lift, drag, and moment (fig. 3).

2. Pressure Distribution

The pressure distributions (fig. 4), which intentionally are restricted to the deflection of hinged nose 2 most favorable for the highest lift, indicate that the deflection of the double-hinged nose is also accompanied by a low-pressure peak at the end of hinged nose 1 $(x/l \approx 0.75)$.

Considering that it is not certain whether the actually occurring low-pressure peaks have been measured (because the test orifices must be a finite distance apart), the greatest low-pressure peak of the double-hinged nose is approximately as great as that of a single-hinged nose $(p/q \approx -5.5)$.

3. Principal Findings of Past Measurements

The test data collected so far on wings with hinged nose have shown that:

By hinging the nose of an NACA 0009-E4 airfoil a maximum lift increase of $\Delta C_{a_{max}} \approx 0.55$ is obtainable; the best nose chord lies at about 11 percent of the wing chord, the angle of deflection at ≈30° to 40°. A greater chord affords no additional increase. A milder curvature of the forward profile by multiple hinging of the nose has also little effect. A slot arranged between the hinged nose and the wing, and released upon deflection of the hinged nose affords no rise in the maximum lift. [An additionally fitted slat produces a further maximum lift increase of $\Delta C_{a_{max}} \approx 0.34$. Con-] cluding, it follows that the maximum lift increase $\Delta C_{a_{max}} \approx 0.55$ attained by curvature of the forward part of the profile in consequence of deflection of a single-hinged nose should be regarded as maximum value: This value cannot be increased by multiple hinging of the forward part of the wing nor by slots which are released at deflection of the hinged nose, in a measure that would justify the additional technical expenditure involved.

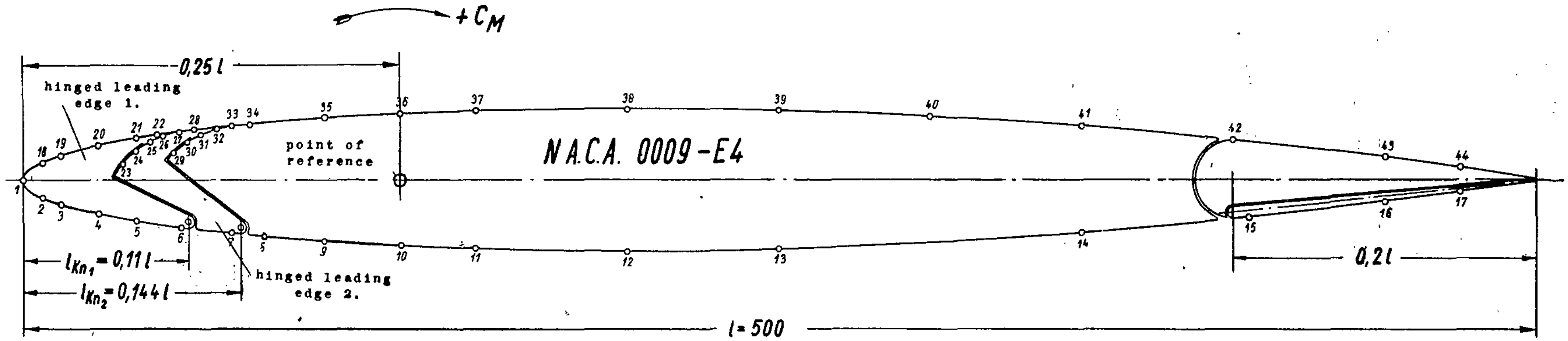
Translated by J. Vanier
National Advisory Committee
for Aeronautics

REFERENCES

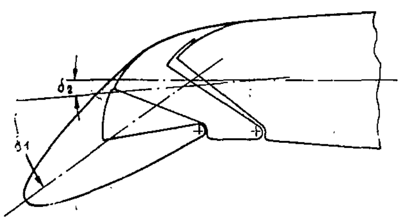
1. Lemme: Force and Pressure-Distribution Measurements on a Wing with Hinged Nose, Slat, Variable Camber and Split Flap.

2. Lemme: Force and Pressure-Distribution Measurements on a Rectangular Wing with Slot-Hinge Nose, Variable Cambor and Split Flap or Fowler Flap.

3. Ergebnisse der Aerodynamischen Versuchsantstalt zu Göttingen. II Issue, Section IV, 1.



width of span b = 1.2m
effective aspect ratio
(taking the height of the end plate into consideration)
$H = 0{,}74\,m)$ $\Lambda \approx 5$



reference length for the longitudinal moment = wing chord: $l = 0.5$m

reference area = wing area: $F = 0.6m^2$

	test points above			18	19	20	21	22	23	24	25	26	27	28	29	30	31
	$\frac{x}{l}$			-0,0132	-0,0246	-0,05	-0,0754	-0,0822	-0,0658	-0,0746	-0,0816	-0,0928	-0,1036	-0,1134	-0,1004	-0,1094	-0,1184
	test points above			32	33	34	35	36	37	38	39	40	41	42	43	44	
	$\frac{x}{l}$			-0,1284	-0,1386	-0,1506	-0,2023	-0,253	-0,303	-0,4027	-0,503	-0,601	-0,701	-0,801	-0,914	-0,951	
test points below	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
$\frac{x}{l}$	0	-0,0128	-0,0248	-0,0498	-0,075	-0,1002	-0,135	-0,161	-0,203	-0,253	-0,304	-0,403	-0,502	-0,702	-0,812	-0,903	-0,95

Figure 1.

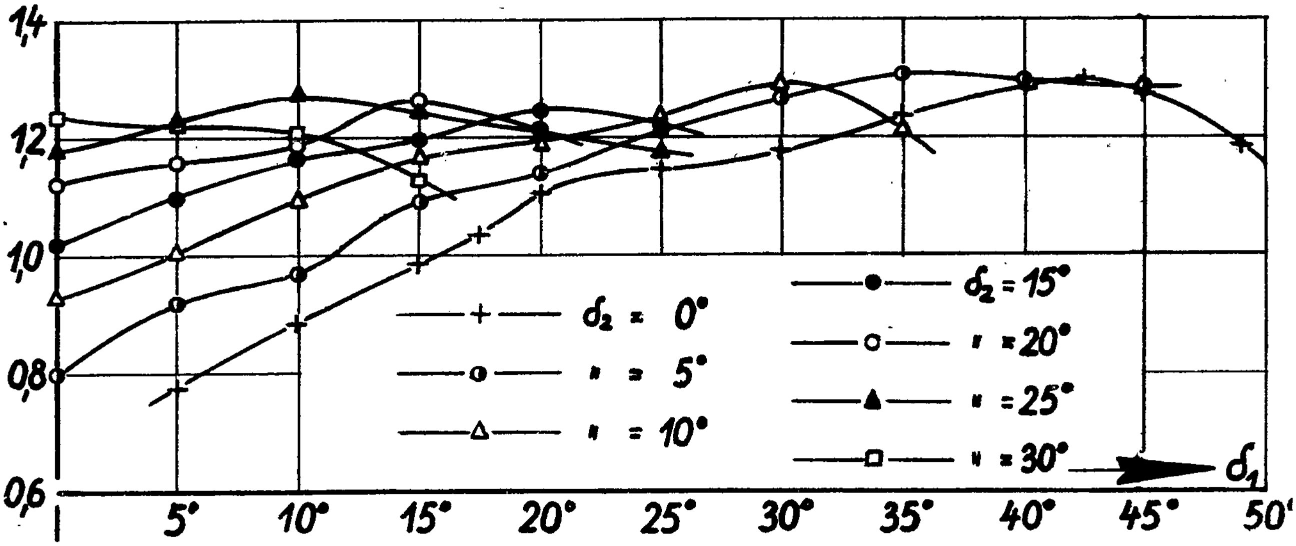


Figure 2. Maximum lift at simultaneous deflection of two hinged noses.

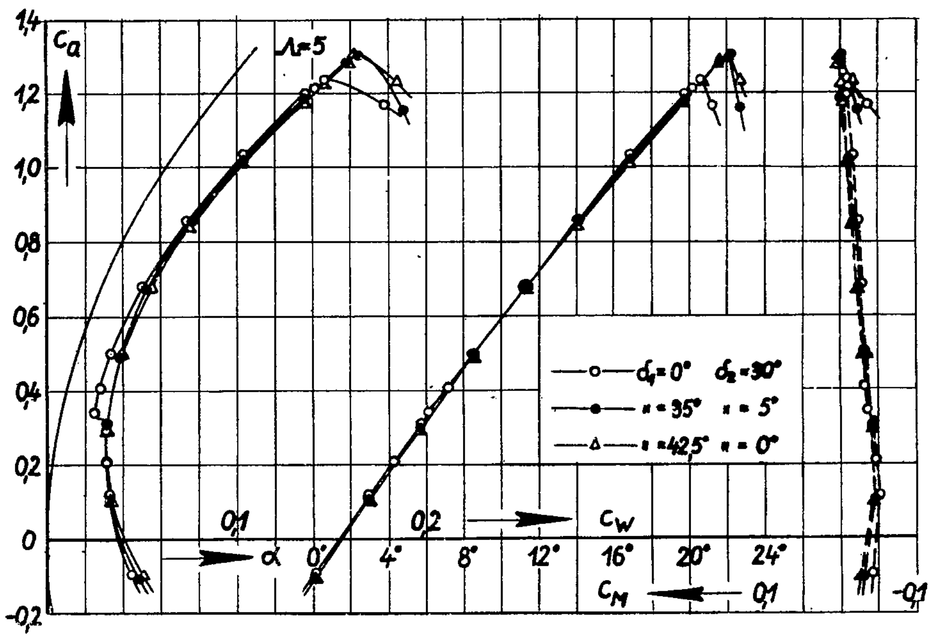


Figure 3. Lift plotted against drag, angle of attack and pitching moment for different hinged nose angles.

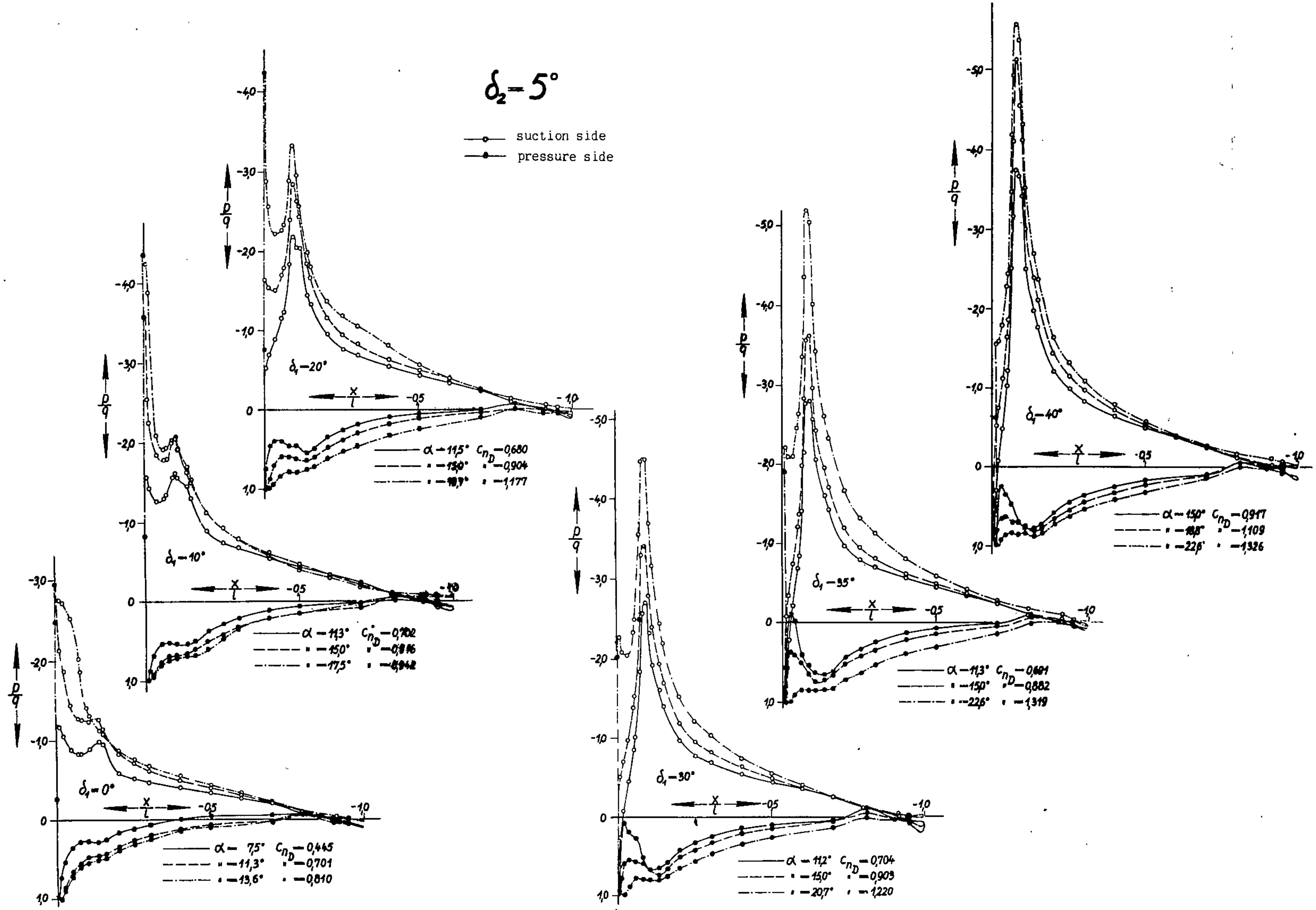


Figure 4. Pressure-distribution measurement.