TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 855

MODEL EXPERIMENTS ON THE FORCES AND MOMENTS ACTING ON AN END PLATE FITTED TO A WING

By O. Schrenk

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SUMMARY

This paper reports on 4-component balance measurements with and without angle of sideslip made on an airfoil with end plate at one tip. In addition, pressure-distribution measurements on the end plate served as basis for the determination of the forces on the end plate and for the bending moments.

I. INTRODUCTION

The increasing use of end plates for various purposes has raised the question of forces and moments on the end plate itself and on the wing due to the presence of the end plate.

A particular case occasioned an investigation, the results of which are briefly described in the following.

II. DESCRIPTION OF MODEL

The model shown in figures 1 and 2, a wing section with approximately constant center of pressure, had a thickness of 17 percent of the chord (Göttingen No. 683 thinned) and carried an end plate (Göttingen No. 459) only at the left wing tip (as seen from the pilot's seat). The end plate carried 31 pressure tubes, the pressure being transmitted through the wing toward the other wing tip and then to a multiple manometer.

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*"Modellversuche über die Kräfte und Momente einer am Flügelende angesetzten Endscheibe." Luftfahrtforschung, vol. 14, no. 11, November 20, 1937, pp. 570-572.

III. EXPERIMENTAL QUANTITIES

(See fig. 1)

γ is the angle of sideslip.

c_{a_F}, c_{w_F}, c_{m_F}, wing coefficients from force-test measurements; wing drag measured in horizontal longitudinal direction of the airplane.

c_{s_F}, side force coefficient of wing = S/qF including end plate; (force measurements, wing area as reference area); side force measured in the direction of the lateral axis of the airplane.

c_{a_E}, lift, i.e., cross-wind force coefficient of the wing end plate at the individual test section, referred to that chord (pressure-distribution measurements).

c_{m_E}, moment of the end plate about the axis 0 - 0, determined from pressure-distribution measurements. (For designation, see fig. 9.)

t_E, chord of end plate at test section.

IV. TESTS AND RESULTS

The results of a normal 4-component measurement (lift, drag, pitching moment, and side force) are shown for the model in figures 3 and 4. Figure 3 discloses that, for equal α, the values of c_{a_F} increase somewhat with increasing γ; this characteristic is associated with the increased suction effect in the zone immediately adjacent to the end plate, when the air strikes it from the outer side. Inversely, lift-reducing pressure increases arise when the air strikes the end plate on the inner side. A conclusion from the side force of the whole arrangement as to the force applied to the end plate is not further possible because the quantity c_{s_F} includes the effect of the opposite wing tip without end plate.

The pressure distributions on the end plate at the test sections 2 - 2 and 3 - 3 are shown in figures 5 to 7. The appended c_{a_E} values were obtained from such

pressure-distribution measurements by integration, the chord of the particular test sections serving as reference chord; c_{a_E} values at other parallel sections on the end plate may be obtained by interpolation. This distribution of the cross-wind force of the end plate itself is directly proportional to the distribution of the values $c_{a_E} t_E$ as shown in figure 8.

The distribution of these cross-wind forces over the height of the end plate ultimately afforded the bending moment of the end plate about the axis 0 - 0 (fig. 9). The total pressure force on the end plate can be established in similar manner, although that is less important in practice.

Translation by J. Vanier,
National Advisory Committee
for Aeronautics.

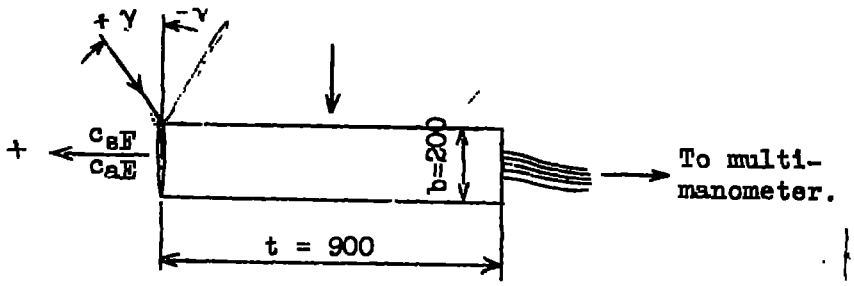
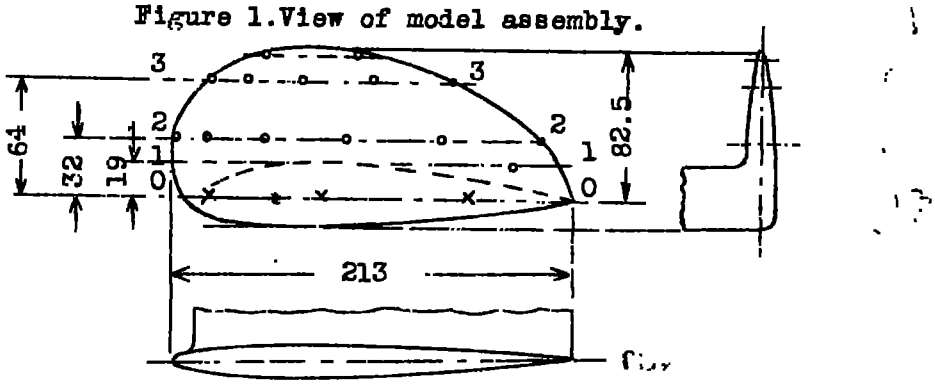
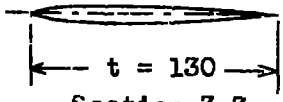


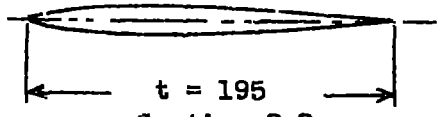
Figure 1.View of model assembly.



o Orifices inside and outside.
× " outside only.
• " at trailing edge.



Section 3-3



Section 2-2

Figure 2.- End plate showing the test orifices.

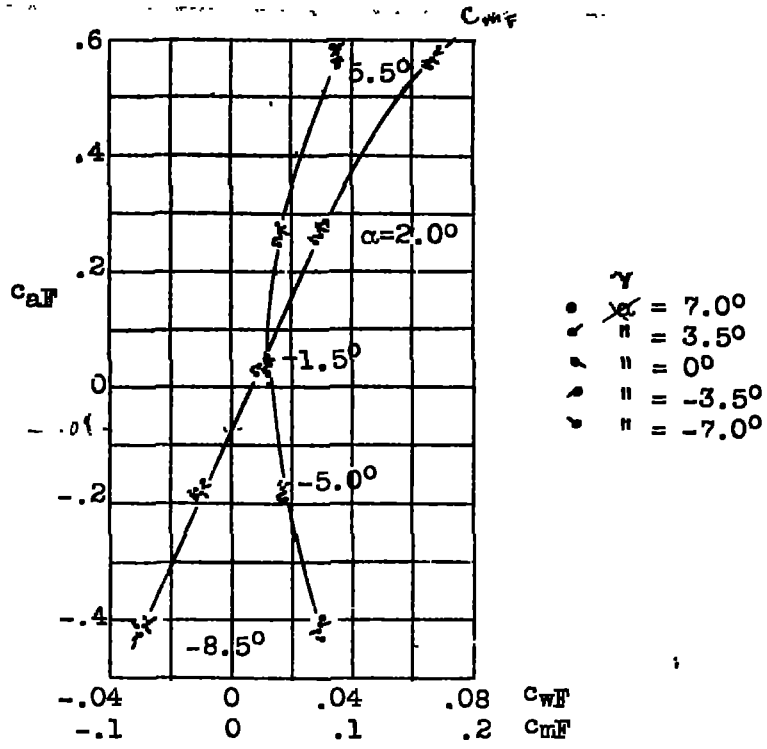


Figure 3.- Polar and moment curve of the wing.

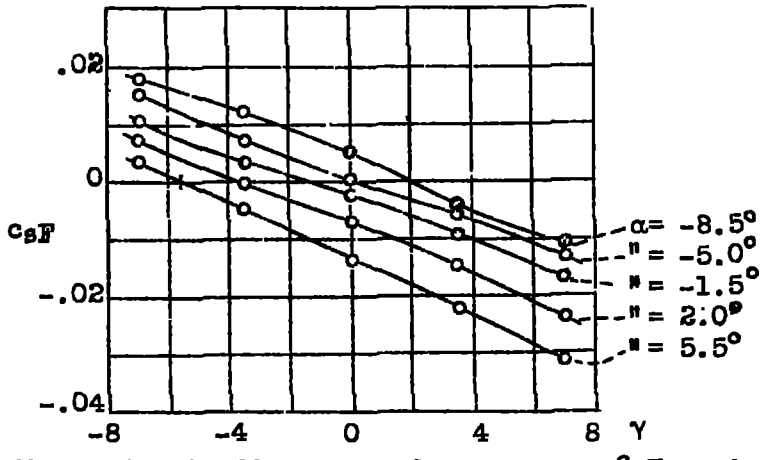
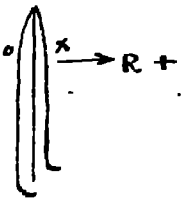


Figure 4.- Coefficients of side force C_{sF} against angle of sideslip γ (for designation of γ and C_{sF} see fig. 1)



$$\text{Area} = c_{a_E} = \frac{c \int_0^1 p \, d\left(\frac{x}{c}\right)}{S} \qquad S = c \times 1$$

$\alpha = -8.5$

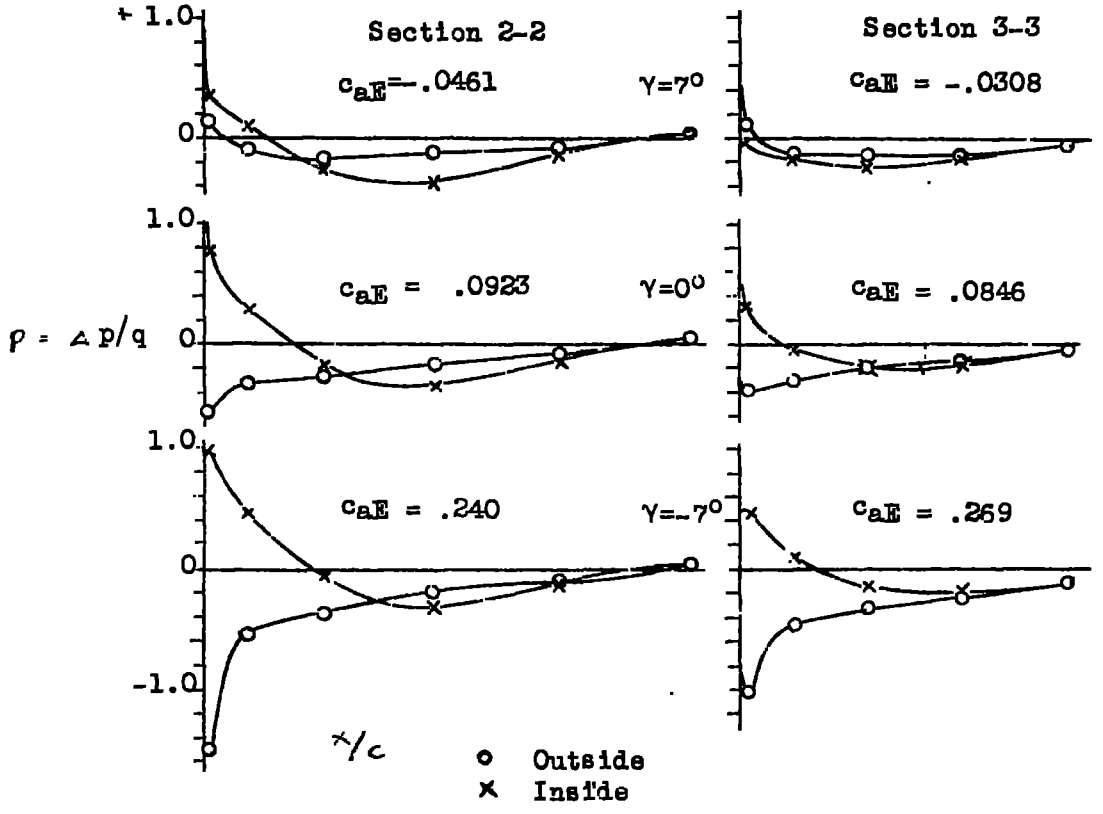


Figure 5.- Pressure distributions for α = -8.5 deg.

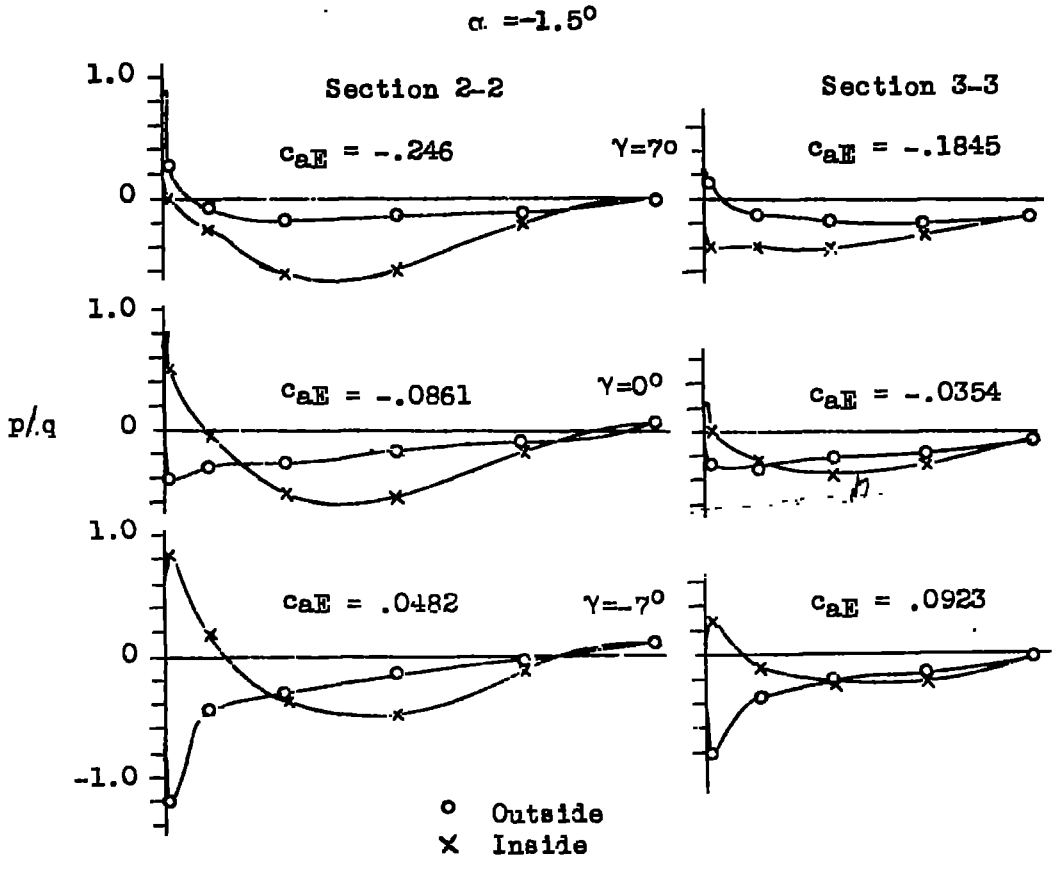


Figure 6.- Pressure distributions for α = -1.5 deg.

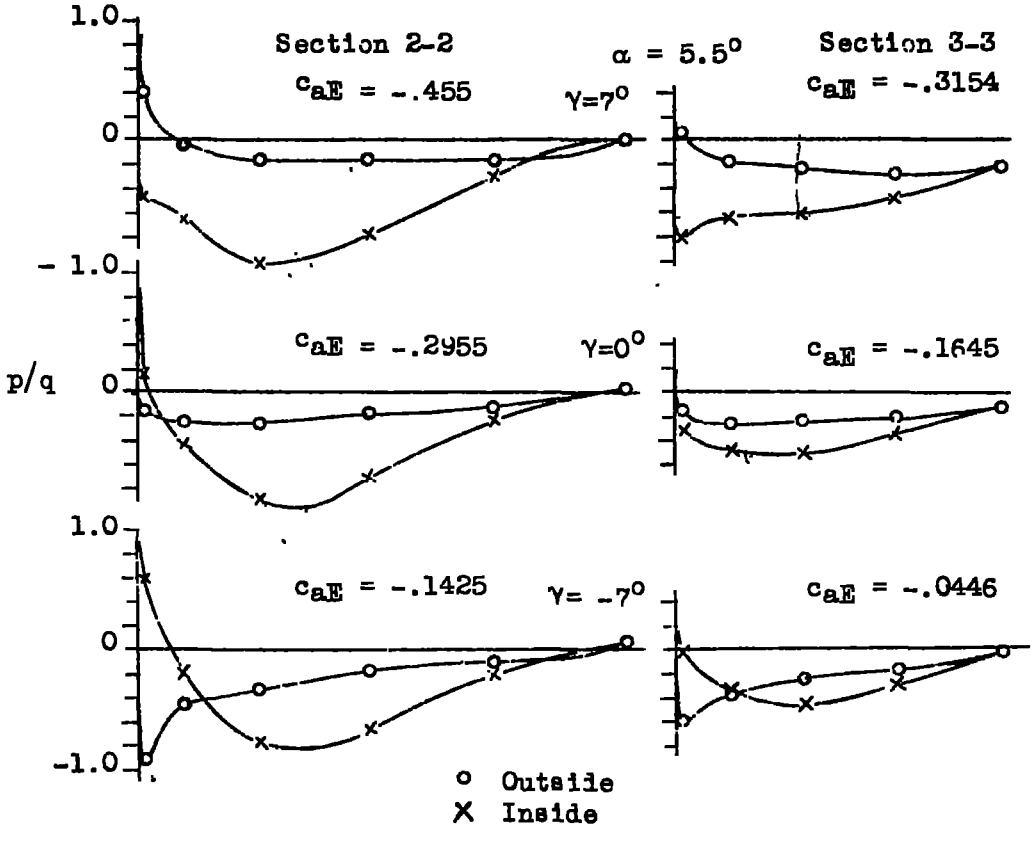


Figure 7.- Pressure distributions for α = 5.5 deg.

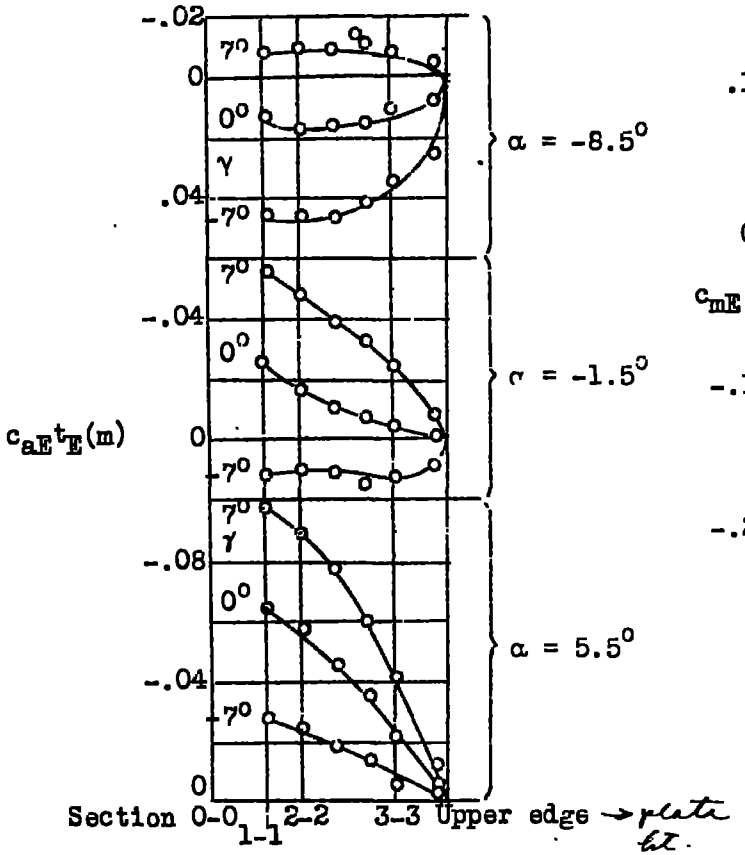


Figure 8.- Lift, i.e. cross-wind force distribution over the end plate versus plate height.

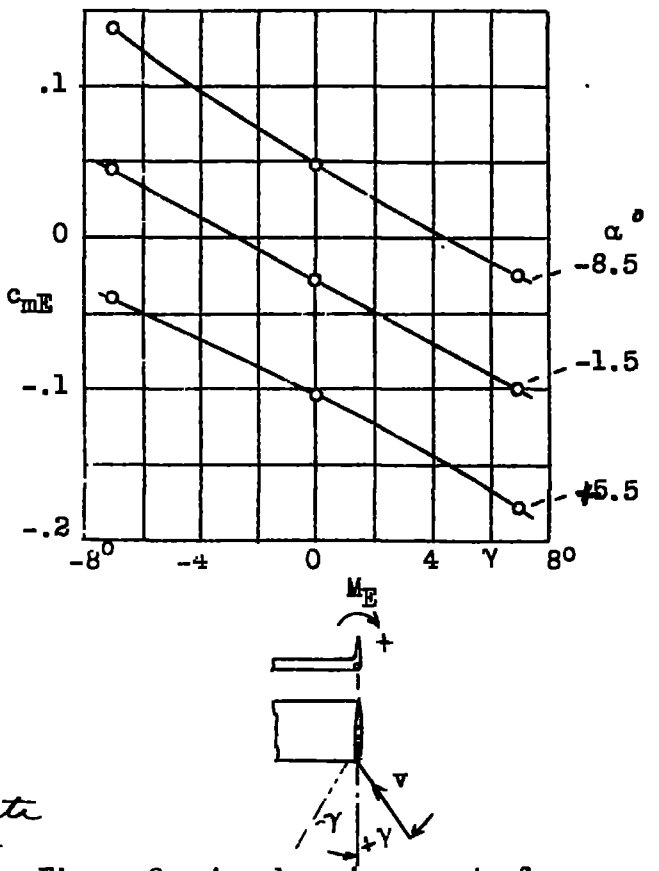


Figure 9.- Aerodynamic moment of the end plate.