TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 569

A POSSIBLE METHOD FOR PREVENTING THE AUTOROTATION OF AIRPLANE WINGS

By Oskar Schrenk

From Zeitschrift für Flugtechnik und Motorluftschiffahrt
November 14, 1929

Washington
June, 1930

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM NO. 569.

A POSSIBLE METHOD FOR PREVENTING THE AUTOROTATION OF AIRPLANE WINGS.*

By Oskar Schrenk.

At the suggestion of Professor Betz, the following device was tested with the object of reducing the autorotational speed of airplane wings. The model of a normal wing with the Göttingen profile 420, 1 m (39.37 in.) span and 0.2 m (7.87 in.) chord (Fig. 1), was provided with a pair of symmetrical slots on the suction side, as shown in Figures 2a to 2e, connected with each other inside the wing.**

Autorotation tests with this device were made in the 1.5 m (4.92 ft.) wind tunnel, including the rotational speed of the wing tips u, in terms of the angle of attack α, and of the air speed v. The arrangement of the apparatus is shown in Figure 3.

The effect of the slots can be seen from the experimental curves of Figure 4. The maximum value of u varies between 1/3 and 1/4 the corresponding value for the wing without slots. The best effect of the slots is that produced by the dimensions

*"Eine Möglichkeit zur Unterdrückung der Autorotation von Tragflächen," a Göttingen Laboratory report. From Zeitschrift für Flugtechnik und Motorluftschiffahrt, Nov. 14, 1929, pp. 553-555.
**On the relation between autorotation and spinning. See R. Fuchs and L. Hopf, "Aerodynamik," Berlin, 1922; also the recent articles on this subject in Z.F.M. 1929, and Luftfahrtforschung 1929.

shown in Figure 2a, which, curious to relate, give better results than the slots in Figure 2d. The slots b and c had so little effect that they were left out of the investigation.

The scattering of the test points in certain curves was due to the well-known instability of such a half-separated flow. To the latter must be also attributed certain isolated discrepancies, which appeared when certain alterations in the model led to a previous slot arrangement.* Thus, for example, preliminary tests with the slot arrangement a gave the dash curve in Figure 4. The causes of these discrepancies must be very insignificant and can be determined only by more accurate experiments.

The results exhibit a very intimate dependence on the velocity. Here, as in ordinary model tests, we encounter a region of critical Reynolds Numbers. High-speed measurements in conjunction with rotational velocity were not possible with this apparatus. At first the velocity was thought to depend on the friction of the bearings. Elimination of the bearing friction, by means of roller bearings, suspensions and balancing weights, showed, however, that this assumption was not correct.

The region of the angles of attack investigated extended from 5° to 50°, whereby autorotation occurred only in the cases indicated. Outside of this region, the model could not be induced to rotate, even by vigorous efforts. In most cases the

*The wing model was made out of sheet metal, the slots being cut through the sheet metal and partially modified by soldering.

model was made to rotate only by a sudden impulse. The cases in which it started to rotate of its own accord are indicated by flags.

As one might expect, the slots impaired the normal aerodynamic characteristics of the wing model in the region of high angles of attack, as shown by Figure 5. The values of c_m hardly differ from those of the smooth wing and for this reason they have been left out. Curve f is the polar for the smooth sheet-metal wing.

The cross-sectional area of the flow through the wing was about one-half the cross-sectional area of the profile. A considerably smaller section may be sufficient in practice, presumably one or two times the slot area.

In connection with these results we also investigated a few particular questions. Figure 6 shows the polar variations when the two slots are separated from each other by means of a partition. Some of the profile drag is thus eliminated. Autorotation tests with closed communication channel do not differ from tests of the wing without slots. From this we infer that the flow between the two slots is what causes the decrease in autorotation.

In order to make sure that the result was not due to a generally poor profile (it being well known that aerodynamically poor profiles have some tendency to autorotation), the following experiment was also tried. Wires of 1 millimeter diameter were soldered in front of and parallel to the slots a . The wing thus altered and with a partition has a poorer polar than the one without any partition and without wires. In spite of this, its autorotational speed was much greater than that without the partition and without wires, and hardly any smaller than that of the perfectly smooth wing.

Another experiment dealt with the cause of the impairment of the polar diagram and its remedy. It had to be assumed that, on account of the well-known decrease in lift toward the wing tips, an undesirable equalization of flow takes place in the vicinity of each slot. At the outer end of each slot this flow is directed towards the interior of the wing, while at the inner end, it is directed outward. An undesirably early separation must therefore take place at this end of the slot.

In order to elucidate this question, a second wing model with the same profile was prepared with internal compartments as shown in Figure 7 (slot a). The slot divisions were not uniform because the lift drops more rapidly toward the wing tips. In Figure 8 the polar curve of this profile is compared with that of the smooth wing.* The discrepancy between these two polars is less than that shown in Figure 3. The autorotation of this arrangement is shown in Figure 9.

Lastly, the effect of ailerons was investigated. The sheet-metal wing was equipped with two ailerons of 50 mm (1.97 in.)

*The standard polar of this figure has a somewhat higher maximum lift than those of Figures 5 and 6, presumably because the surface, resulting from a different method of production, was somewhat smoother than that of the sheet-metal wing.

chord and 220 mm (8.66 in.) span. Without slots an aileron deflection of 10° in the retarding direction could not prevent autorotation. When provided with slots, however, the wing came out of the rotation even when it had been made to rotate rapidly. Even the smooth wing stopped rotating at a 20° deflection of the ailerons.

In explanation of these results, which are only preliminary and entirely of a qualitative nature, the following remarks can be made. It is known that, in the case of a rotating wing, the relative angles of attack at both tips are different on account of the rotation. At the upward-moving end it is such that the air flow adheres to the wing, while at the downward-moving end, it is greater with separation of the flow.

Hence the lift of any two symmetrically located wing elements need not be the same, and the pressure ratios are not the same in any case. This pressure difference causes the flow from one slot to the other inside the wing. The result is that the flow is improved by suction at the tip where separation occurs, but considerably impaired by the outward flow at the other wing tip. Consequently, the original state of rotation is no longer free from torsional moments but is, on the contrary, replaced by a new state of smaller rotational speed.

These results can be regarded only as a preliminary survey. In order to obtain a more accurate conception of the results obtainable, it is necessary, in further research, to know more about certain factors capable of affecting the results, such as roughness, Reynolds Number, location, size, shape, distribution and number of slots, internal-flow section, shape of profile and plan form of wing. It can hardly be assumed that the most favorable conditions have been found at the first attempt.

Translation by
National Advisory Committee
for Aeronautics.

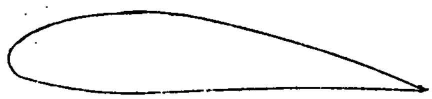

Fig.1

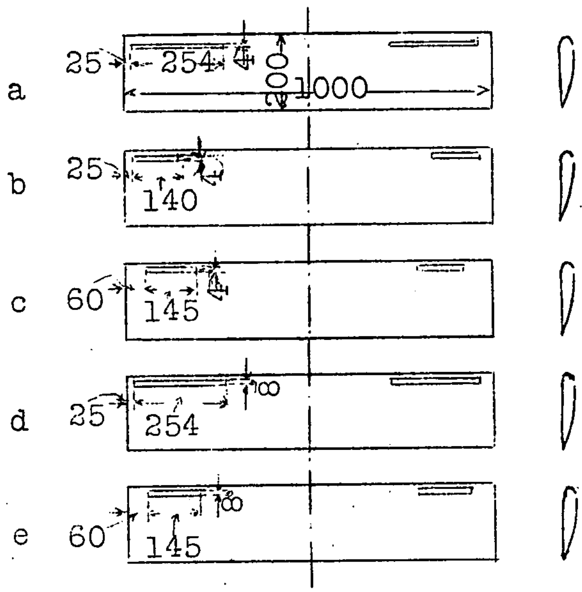

Fig.2

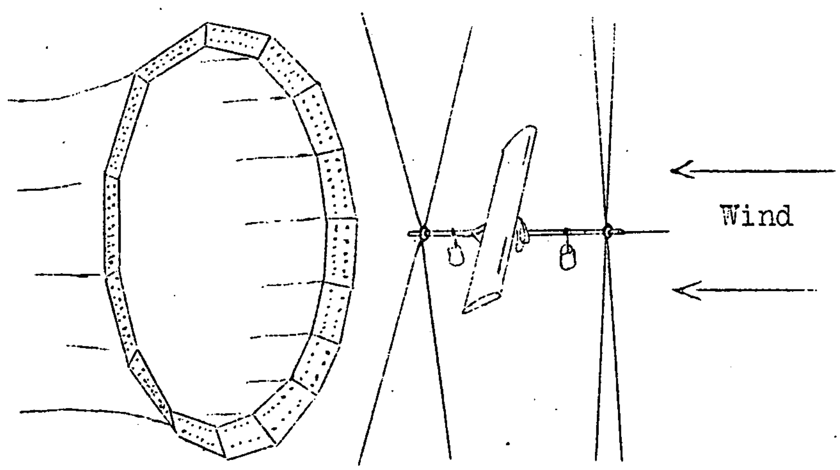

Fig.3 Apparatus mounted in wind tunnel. Exit cone on the left. The weights serve to balance the center of gravity.

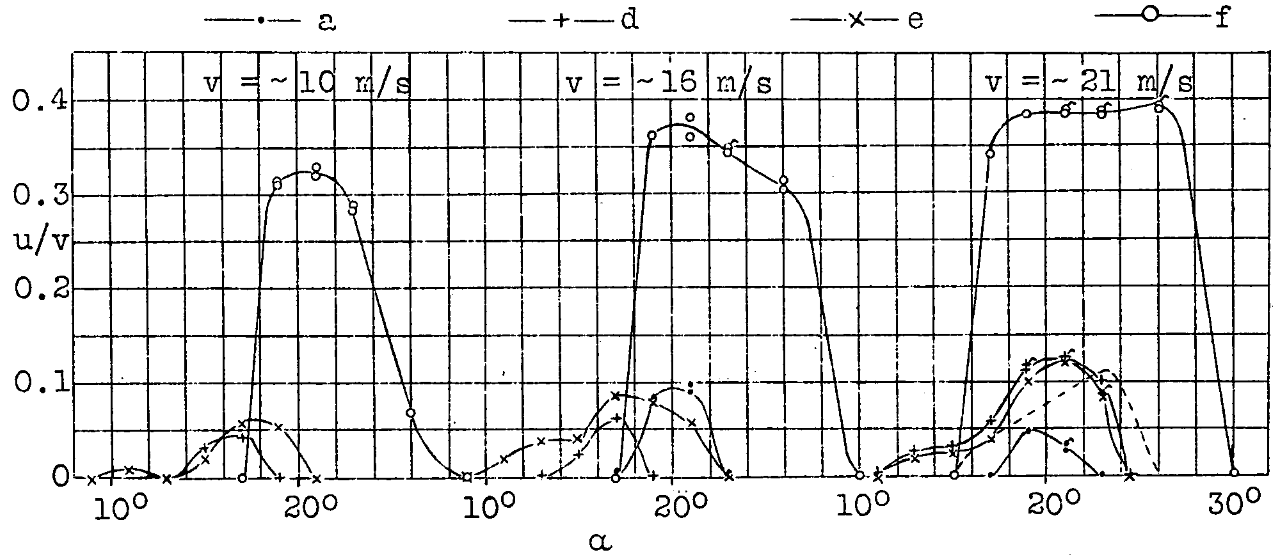

Fig.4 Results of autorotation tests. Curves (a) to (e) correspond to slot arrangements in Figs.2a to 2e. Curve (f) is for the smooth wing. Of the doubly plotted points one corresponds to left rotation and one to right rotation. The flags indicate cases in which the model goes into autorotation.

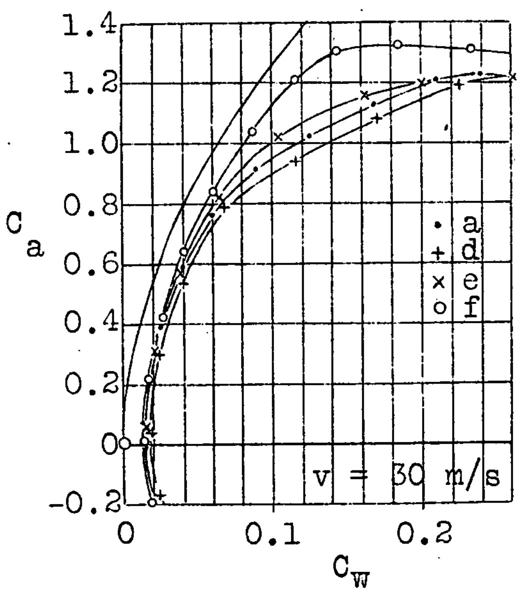

Fig.5 Wing polar with and without slots. Notation same as in Fig.4.

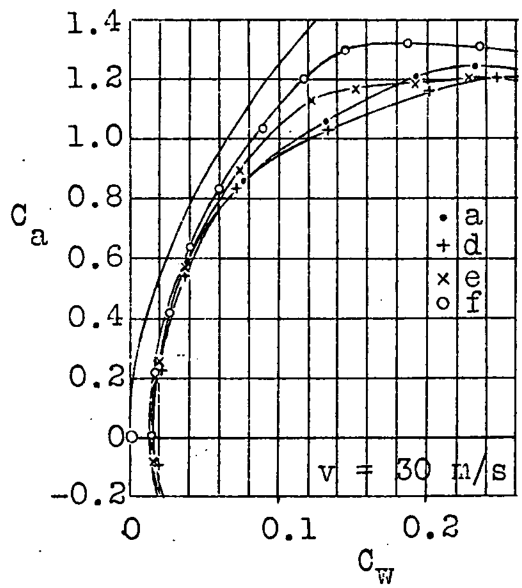

Fig.6 Wing polar as in Fig.5 but with partition between slots inside the wing.

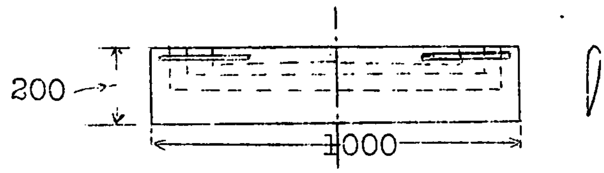

Fig.7 Wing with transverse distribution of slots.

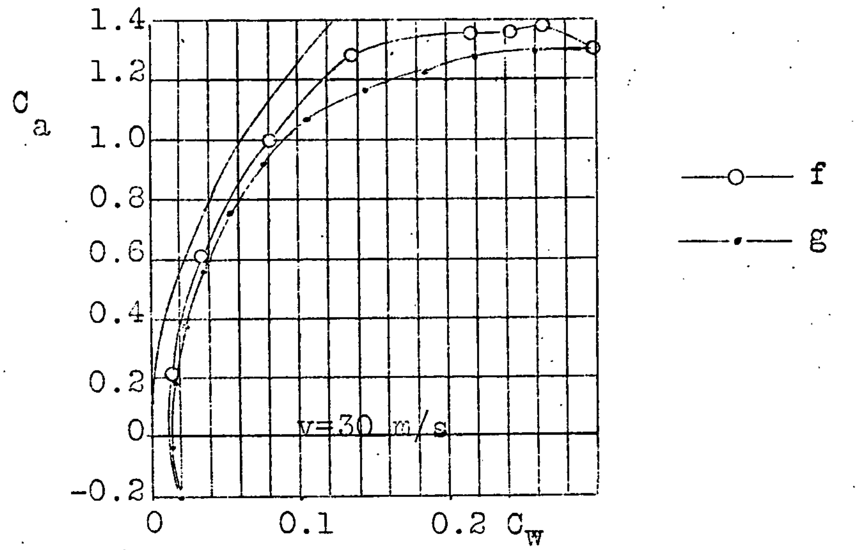

Fig.8 Polar for Fig.7 (g) compared with standard polar (f).

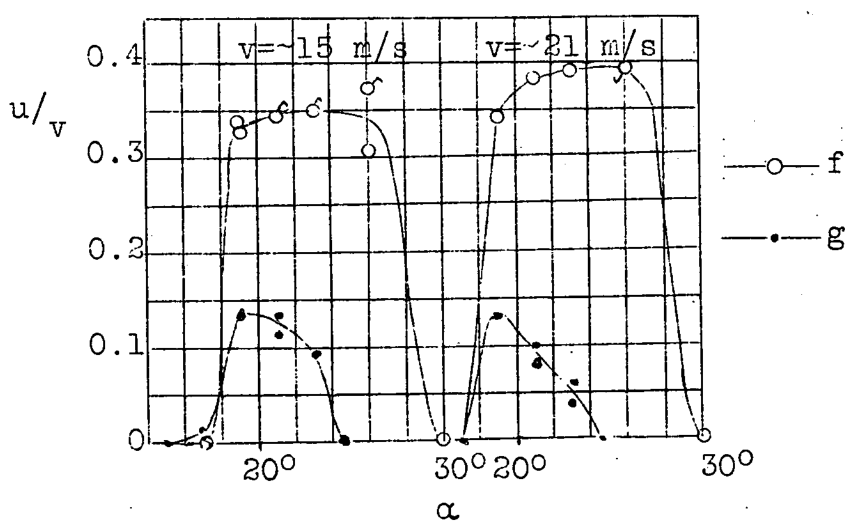

Fig.9 Autorotation curve for Fig.8.