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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

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[illegible] MEMORANDUM 146

THE WING WITH A POINTED TIP.

By Stephan v. Prondzynski.

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# THE WING WITH A POINTED TIP.

By Stephan v. Prondzynski.

In airplane construction generally one finds an almost exclusive use of wing tips that are practically square and but occasionally those with large rounded tips. For use as a canti..ev wing, however, a wing with pointed tips may contain valuable a.. dynamic advantages.

The tests conducted by Eiffel indicate that in rectangular plates, the lighting effect diminishes toward the lateral ends, or tips. The explanation of this decrease is generally known, but may be briefly reviewed here.

The wind flowing around the wing profile generates on the upper surface of the wing a suction force and on the lower a compression. This pressure difference results in a discharge of the air masses, from under the wing, around the wing tips to the upper surface, (Figs. 1 and 2). This current of air, from the lower surface, was proven experimentally by Gustav Lilienthal about 1913. Furthermore, this current although vertical in relation to the direction of the wind, does not exert a lighting force and as a result the energy generated, is needlessly des... ed or lost in eddy production. The stronger the rarefication or suction on the upper surface the greater this waste becomes and in thick airfoils used in cantilever construction, where the upper side is strongly arched, it may amount to a great deal.

A test by Dipl. Eng. Betz, at the Göttingen testing station, about 1915, revealed the extraordinarily favorable lift and resistance experienced in a Joukowski airfoil in which the lateral tip losses were prevented. A comparison with another good thick profile of rectangular shape in which the tip losses were not prevented is shown in the following table:

| Name of profile | Lift and resistance in $kg/m^2$ Wind velocity 10 m/sec. | | | Resistance and L/D under load of 8.75 $kg/m^2$. Wind velocity 10 m/sec. | |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| | L/D | L | D | D | L/D |
| Joukowski | 24.0 | 7.15 kg. | 0.298 kg. | 0.437 kg. | 20.0 |
| Airfoil 301 | 15.5 | 4.50 " | 0.290 " | 0.920 " | 9.5 |

An approximate shape of these airfoils is shown in Figs. 3 and 4. As already mentioned, the extraordinarily favorable result in the Joukowski airfoil may be due, for the most part, to the fact that the tip losses were prevented by the use of a special attachment, (Lateral Abschottung). A similar device cannot be employed on airplanes as it would create a great area and an excessive moment at the wing tips.

Lateral tip losses, however, can be prevented in another way, that is, by tapering the wing, in plan form, in which case the wind from the lower surface will pass around the leading and trailing edges, as it should, with practically none around the tips.

A test, conducted at the Göttingen testing station in three single flights with square and pointed tips, revealed a decided advantage in favor of the latter, showing an essentially better L/D ratio. In a later criticism of these results, by Dr. Munk, it was claimed that there was no advantage in having the wings tapered to a point in plan form. The writer feels that this may prove correct in regard to war airplanes.

Assuming the same span for both types, the pointed wing, in order to generate the same dynamic pressure or lift, would require the same area as the square tipped wing, (Figs. 5 and 6); or with less area, a greater angle of attack, both conditions impairing the aerodynamic properties of the wing.

A small span will be necessary perhaps for war airplanes in which is required a limited moment of inertia around the vertical or normal axis in order to secure the best maneuverability, but in commercial airplanes of to-day, where economy is very essential, maneuverability may be given less consideration, thereby permitting a greater span and moment.

In further reference to this feature, Fig. 7 has been prepared. This shape has the same area as Fig. 5, and may also be considered as well proportioned. The same profile is used throughout, the ratio of ordinate to chord remaining the same, and since the chord at the center of the span is 1.33, a larger ordinate and a thicker section than that of Fig. 5 exists at the center. This wing will furthermore permit the use of a span of constantly decreasing cross-section and weight, toward the wing tips, the bending moment and wind pressure being less as the impact area decreases.

A disadvantage in this design is, that the span may become excessive or too great for the hangar. To meet this obstacle the structure can be such as to permit the removal of a portion of the tips or to provide detachable ailerons, as shown in Fig. 8.

Another and doubtless the best proof that the pointed tip wings contain aerodynamic properties superior to those of the square tipped wings is observed in nature, in the wings of birds where the pointed shape is found extensively.

In conclusion attention is called to the fact that Eiffel and Lilienthal both discovered, through test and theory, the disadvantages in the square tipped wings, especially in the case of thick wings.

Up to the present time no wings have been constructed with pointed tips in the plan form, owing to the use of thin wings made possible in the biplane truss and semi-cantilever construction. Furthermore, as mentioned in a preceding paragraph, the pointed wing necessitates a greater span with a resulting greater moment of inertia and impaired maneuverability, making them very unsuitable for war airplanes.

Translated by National Advisory Committee for Aeronautics.


Fig. 1.

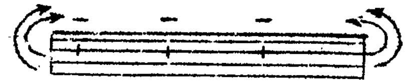


Fig. 2.

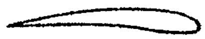

Fig. 3
Joukowski

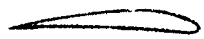

Fig. 4
Aerofoil 301

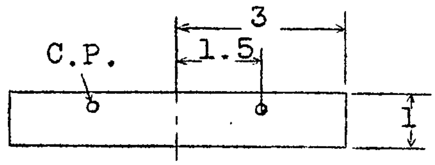


Fig. 5.

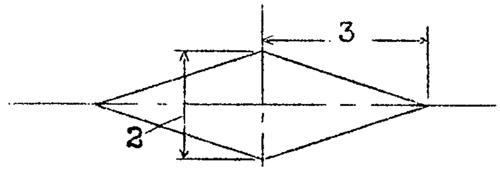


Fig. 6.

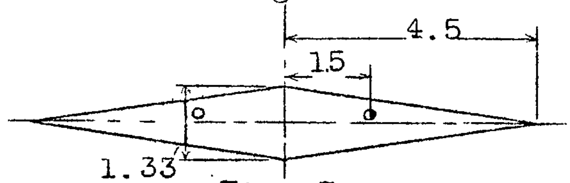


Fig. 7.

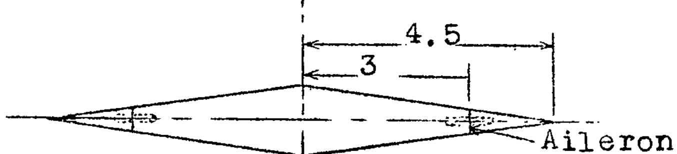


Fig. 8