DESIGN OF TAILLESS AIRCRAFT

by a down load on the tailplane, which, incidentally, appreciably reduces the nett \( C_L \) available. With the tailless types, the flaps are located at the inner parts of the wing and the diving moment is balanced by the moment of up-turned elevators which, in the case of swept-back tailplane types, a high camber of the wing in their vicinity, by introducing reflex curvature, and the lift is thus further reduced. Lengthening the elevator arm about the e.g., by increase of sweep-back, is no cure for the instability, as it tends to reduce the aerodynamic effectiveness of the flaps. Finally, to make matters worse, trailing-edge flaps inordinately reduce the stalling angle of a sweptback wing and the net result of all these effects is a low \( C_{L_{\text{max}}} \) of between 50 and 80 per cent of the trimmed \( C_{L_{\text{max}}} \) of the conventional aircraft. For the same landing speed, therefore, most tailless types must have a much larger wing area, which the Warren-Young design, resulting in additional weight and an increase in profile drag.

Additional defects inherent in this tailless class relate to stability. Swept-back wings are prone to stall premature at high angles of attack. The tailless type will have a tip stall well in advance of the nose-up pitching moment, thus stall ing the aircraft further. This redistribution of lift due to burbling of the parts of the wing introduces an effective dihedral, which, as a result of stability, presents a major problem. The stall may, therefore, be particularly vicious and likely to lead to dangerous instability. An additional form of instability results from the sweep-back, which will introduce an effective dihedral, which, if a degree of sweep required for a tailless design, may be abnormally large at high angles of attack. This effect, coupled with the characteristically low weathercock stability, may give rise to a rolling oscillation combined with tail wag, known as the Dutch Roll, a most undesirable motion which, in most tailless types, is very lightly damped. Finally, longitudinal oscillations are also exposed to the conventional aircraft and it is on record that certain tailless types have proved difficult to handle and have exhibited vicious instability.

It is clear, then, that design of the typical tailless machine presents serious problems and that most of these problems have so far, defied a satisfactory solution. It is therefore worth considering whether there is an entirely different wing-form which will solve these difficulties, and this leads to a consideration of the Warren-Young design.

The Warren-Young wing is illustrated in the perspective and general arrangement drawings of the Skyvan, which is a prototype based on much research. The wing consists of a system of swept-back front planes and swept-forward rear planes, with the front and rear aerofoils merged in semicircular tip surfaces. The rear planes are twisted and wash-out towards the roots, which are well below the roots of the front planes.

Successful Model Research

The Warren-Young wing was originated by the writer, who, with the invaluable assistance of Rex Young, his partner in the venture, carried out a research programme in 1937. After successful research with free-flight models, patents were secured and the design of the prototype was well advanced when the outbreak of war called a halt to these activities. Since then, no opportunity has arisen to build this interesting aircraft, which has none of the major defects inherent in the tailless designs at present favoured. It is significant that a well-known authority on tailless types, Mr. A. R. Weyl, A.F.R.Ae.S., has reported that the design is a sound aerodynamic consideration and has suggested that it is worthy of further development—surely a unique compliment to the design of a 13-year-old project.

The Warren-Young design had the following advantages:

1. An abnormally high flap \( C_{L_{\text{max}}} \), will be developed at a high angle of attack. There is no critical angle and stalling will increase very gradually and without unbalancing effects.
2. Most tailless types develop a very low unflapped \( C_{L_{\text{max}}} \) and the stall is sometimes associated with loss of static stability. The Warren-Young wing will be attack compared with other tailless designs, for which the flapped \( C_{L_{\text{max}}} \) may be as much as 40 per cent subnormal.
3. There is no critical angle of attack; most tailless types have a tendency for lateral instability.
4. It will be more directionally stable than other tailless types, which tend to be very deficient in weathercock stability.
5. Dynamic longitudinal stability will be satisfactory. Other types have a very low dipping in pitch, often no more than 1/10th of that of conventional aircraft.

(a) The specific strength of both wing and fuselage structure will be far higher in comparison to conventional aircraft.

(b) The stalling of both the warren-Young wing and fuselage will occur at a lower angle, at which the aircraft is more controllable and a softer approach to the ground will be possible.

(c) The control of the aircraft will be much lighter and more precise, the power required to operate the controls will be reduced, and the control of the aircraft will be much more positive and predictable. The control of the aircraft will be much more positive and predictable. The aircraft will be much more controllable and a softer approach to the ground will be possible.

(d) The wing design is such that it will be able to operate in a wide range of angles of attack, from a low angle to a high angle, without the risk of stalling or loss of control.

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