An Unorthodox Aeroplane

by

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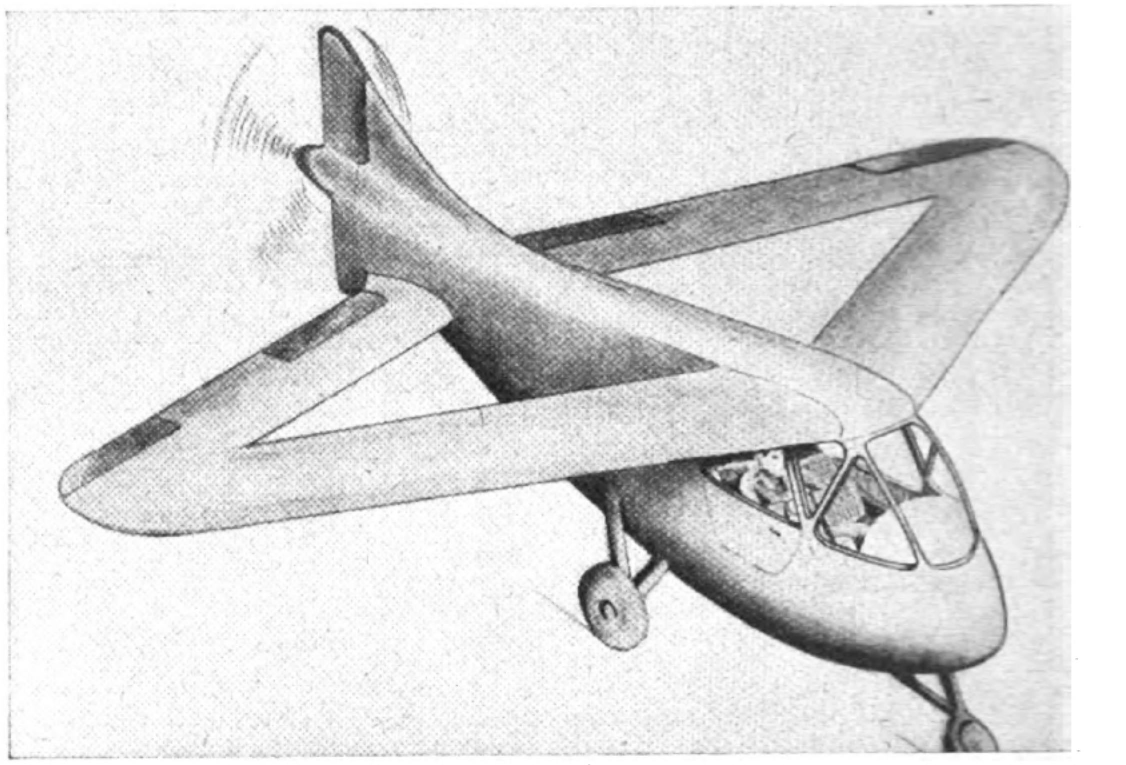
In view of the recent series of articles by Mr. A. R. Weyl on the subject of annular and disc-wing aircraft, these details of a novel pre-War project, the Warren-Young Skycar are interesting. This aeroplane was designed in collaboration with Rex Young, and together they did much research with free-flight models; they prepared patents which were accepted in 1939.



THE Warren-Young wing consists of an integral system of swept-back front planes and swept-forward rear planes; the union of the front and rear components is merged in large semi-circular tip surfaces. This configuration exploits the advantageous aerodynamic properties of both swept and tandem aerofoils, and eliminates the inherent limitations and defects of the conventional type aeroplane. In addition, the faults of the swept-back tailless design, normal tandem arrangement and low aspect ratio tailless type are eradicated, and moreover additional advantages are gained.

The wing differs both aerodynamically and structurally from other unorthodox aerofoil systems and is not closely related to the annular type, which it may appear to resemble. The annular aeroplane is, in effect, a combined tandem and low aspect ratio aerofoil, compared with the tandem and swept surfaces of the Skycar. Also structurally the annular wing is more complicated and less efficient than the W-Y system, with its simple triangulated geometry.

The early Rhombic aeroplanes are more closely related, but due to the contemporary limitations of aeronautical knowledge and faulty conceptions of the requirements, these flying machines could not have been successful. Moreover, the Warren-Young type differs in essential details. The stall, for example, is indefinitely delayed due to the non-burbling properties of back-swept and forward-swept aerofoils in combination with the delayed maximum lift coefficient of the rear aerofoil of the tandem system. The calculated wing C_L relationship reveals a smooth flat-topped curve attaining maximum lift at an angle of attack of 40 degrees. The rear aerofoil of the W-Y wing is in the downwash, but not the turbulence, caused by the circulation of the flow around the leading aerofoil, with the result that lift is delayed with respect to the front surface and is developed at higher angles of attack. The slope of the lift coefficient curve also increases with angle, a factor favourable for longitudinal stability, and the value of $C_{L\,max.}$ at 40 degrees is higher than for the swept-back aerofoil.

A high $C_{L\,max.}$ is developed compared with that normal for other all-wing types. This high value, approximately 90 per cent. of conventional, results from the continuance of large C_L values from the unstalled leading aerofoil at the high angle for which the rear aerofoil maximum coefficient is developed.

The aerofoil system is balanced by the equilibrium of lift forces compared with the very large anti-lift forces required for other all-wing types, or the parasitic loads associated with the conventional tailplane layout. The balance conditions imposed by the stability requirements for a conventional aeroplane, and indeed for all non-tandem tailless types, in which the tailplane is replaced by a reflexed trailing edge, by flaps or by tip washout, is illustrated in Fig. 3A. In Fig. 3B is illustrated the equilibrium of a tandem aerofoil system and in which both surfaces are lifting. This advantage is common to all tandem systems, but with the usual arrangement a high maximum lift coefficient is not developed, since a partial stall occurs when the leading aerofoil reaches the critical angle.

Stability in pitch is maintained throughout the operating range by the tandem aerofoil effect and the continuity of the

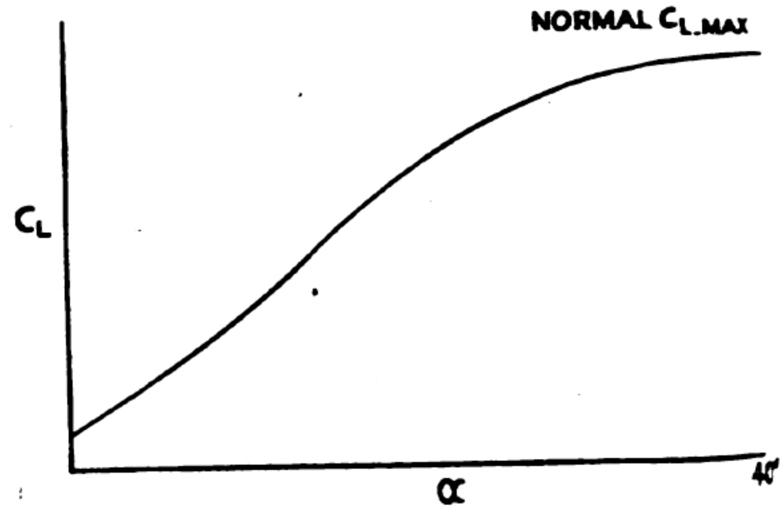


Fig. 2.—The smooth flat-topped lift curve for the Warren-Young wing shows a high maximum lift angle.

pressure distribution. Other all-wing types tend to both static and dynamic instability. The longitudinal stability of the Warren-Young wing depends upon the relative slopes of the lift curves of the front and rear aerofoils, and derives from the relation in which the ratio of the front plane lift coefficient to that of the rear is decreasing with angle of attack and the consequent stable travel of the centre of pressure.

Autorotation is not possible with such a wing, since there is no reversed slope for the curve of wing C_L. Furthermore, the span is reduced compared with the conventional monoplane with similar loading due to division of the air load between front and rear planes.

Flexural and torsional rigidity of the wing structure is exceptional due to the short span of the component planes, the triangulated geometry, and the bracing effect of the rear planes arising from the large dihedral angle. The dihedral is, however, dictated primarily by aerodynamic interference considerations and thereby the rear planes are placed below the turbulent wake which streams away from the trailing edge of the leading aerofoils.

The permissible range of C.G. location is not critical; the principal reaction to displacement of the centre of gravity is to change the angle of attack to trim. On the other hand, all tailless designs and also conventional types are very sensitive to changes in the static margin. A wide tolerance is useful in small aircraft, enabling the seating to be placed apart from

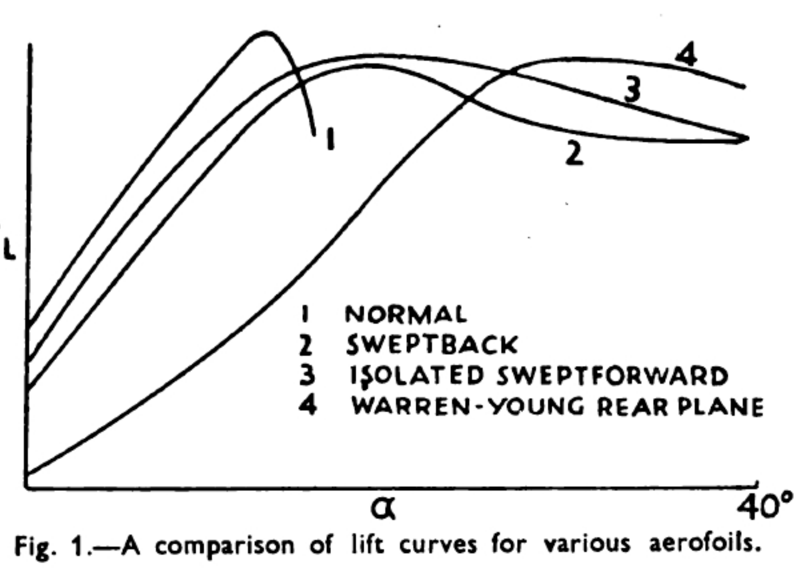


Fig. 1.—A comparison of lift curves for various aerofoils.

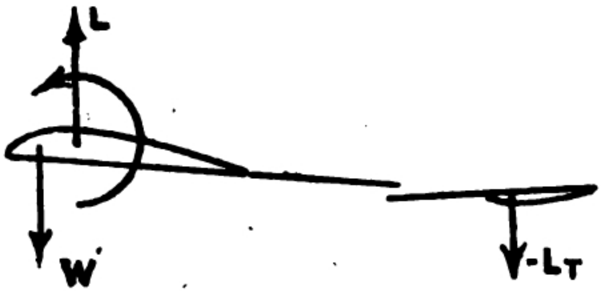


Fig 3A.

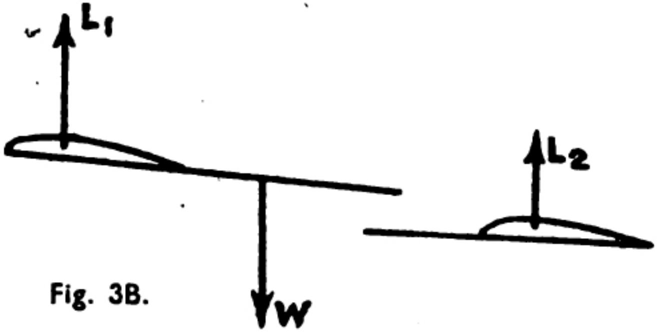


Fig. 3B.

C.G., and in a position where the best field of view obtains. And with large aircraft it is an advantage if the useful load can be disposed at will, without concern for disturbance of the stability characteristics.

Fuselage loads are reduced by the disposition of the lift forces at two widely separated locations, thus minimizing the fuselage bending moments. The conventional layout, particularly the very large aeroplane with the useful load distributed from nose to tail, suffers maximum bending moments and in consequence exceptionally high structure weight, with ciated repercussions upon performance.

The foregoing aerodynamic predictions, based upo meal investigation, need to be confirmed by wind-tu but that the general conclusions are accurate has been by tests with models in free flight, which conclusivel strated the non-stalling and stable characteristics. A tive and more realistic approach to the problem is to wing as a whole and to calculate the aerodynamic reference to the circulation phenomena. The theory ever, complex and too difficult for discussion in an e dissertation.

In the absence of precise information, certain as must be made and in particular the pressure distri the tip surface is not readily predictable by the n component analysis. Characteristics can, however, be and controlled by appropriate adjustment of the sect meters and relative incidence relationship and the properties thereby induced.

The Warren-Young Skycar is to have the qualitie in the W-Y wing but is also an advanced design respects. The propeller is at the extreme rear of th and is driven by a shaft connecting to the engine a of the cabin. This arrangement, which was embo Warren-Young project as early as 1937 (British Patent tion 508022) and which is now becoming fashi particularly suitable for single-engined aircraft and following advantages: The elimination of slipstream reduction of noise and elimination of fumes; important, an unobstructed view for pilot and passe

The Skycar should have a top speed comparab similarly powered conventional monoplane and a level air speed similar to the minimum flying spe comparable orthodox type. The estimated minimum speed for this two-seater light aircraft is 35 m.p.h Skycar should fly much slower than this, in a para descent with maintenance of positive control about a