AERODYNAMICS OF THE DELTA . . .

considerations of aerodynamic performance, line up with practical design requirements and, in particular, the overriding necessity for keeping weight and drag low in order to obtain maximum performance? A preliminary question is whether a tailplane is necessary.

From the earliest days of flying, the question has been raised as to whether aircraft can be flown satisfactorily without a tailplane. Confining attention only to the case of the high-speed jet aircraft, each of the functions of a tailplane will be examined in turn in relation to the delta wing aircraft. The functions are :—

(*a*) *To trim out changes of centre of gravity position according to the load carried and the consumption of fuel.*—Investigation shows that a control surface at the trailing edge of the wing, provided that the latter has a large root chord (as has the delta), can cater for all but extreme c.g. movements.

(*b*) *To deal with trim changes due to landing flaps, etc.*—With the low wing-loading associated with the delta wing, take-off and landing speeds are moderate without the use of flaps, and this question does not, therefore, arise.

(*c*) *To provide damping of pitching oscillations.*—The reduction of damping of the pitching oscillation has led to difficulty on some tailless aircraft, but it does not arise on the delta, since the large chord near the root gives adequate damping.

(*d*) *To deal with loss of stability or control power consequent on distortion of the wing structure at high speed.* ("*Aeroelastic distortion*").—At very high speeds, all aircraft structures distort to a greater or less extent under the high loads imposed, and this distortion alters the aerodynamic form. In extreme cases this leads to loss of stability or control power, making the aircraft dangerous or impossible to fly at high speeds. An aircraft with a high aspect-ratio, swept-back wing would need a tailplane to deal with this, but the shape of the delta wing makes it extremely stiff, both in bending and in torsion, and a tailplane does not appear to be necessary.

(*e*) *To provide for spin-recovery.*—Although this point has not been proved, it is expected that the controls on a tailless delta wing would not be powerful enough to ensure recovery from a fully developed spin. A tailplane appears to be the only way of dealing with the problem. This restriction is of small significance for transport or bomber-type aircraft.

It can, therefore, be concluded that for a delta-wing aircraft of the transport type a tailplane is unnecessary. Its deletion leads immediately to a considerable saving of weight and drag, and to a major gain in performance.

We have now shown that, compared with a conventional aircraft, the delta-wing aircraft will be simpler by the omission of the following items: the tailplane; the rear fuselage necessary to carry the tailplane, and wing flaps and other high-lift devices such as the drooped wing leading edge. There is a saving of weight, of design and manufacturing effort, and of maintenance when the aircraft is in service. These economies will have a considerable bearing on the initial cost and the man-power necessary to produce and maintain a number of aircraft.

Because of its shape, and the large root chord, the delta wing provides a large internal volume in relation to its surface area, even when using the thin sections which, as noted above, are essential for high-speed aircraft. Simple calculations show that for the same wing area, the delta wing has 33 per cent more internal volume than an untapered wing, while, if the inboard half of the wing only is considered (as this represents a more practical case from the point of view of the aircraft designer) the internal volume of the delta wing is more than twice that of the corresponding untapered wing.

It is found that without exceeding a wing thickness of as little as 8 to 10 per cent, it is possible on a moderate-sized delta-wing aircraft to bury completely the engines, the undercarriage, and sufficient fuel tanks for long range. The fuselage also has a tendency to disappear into the wing at the root.

The result is the attainment of an aircraft consisting only of a wing, a fin and a rudimentary fuselage, representing a degree of aerodynamic cleanliness which has never before been reached. In fairness, it must be pointed out that this is achieved at the expense of a rather larger wing area than usual, but investigation shows that the drag of this area is less than that due to a conglomeration of items such as engine nacelles, tailplane, etc.

From the design point of view, the shape of the delta wing leads to an extremely stiff structure without the use of thick wing skins, and strength becomes the determining feature rather than structural stiffness. This avoids the inefficiency of conventional swept-back wings where the wing has to be made stronger than necessary in order that it shall be stiff enough.

Summing-up, it can be said that in order to meet the requirements of large loads for a long range, at high speed, the high performance transport or military aircraft of the future will cruise at a considerable altitude, at a speed not much below that of sound. The delta wing provides the only satisfactory solution to these requirements, for the following reasons :—

(1) It meets the four features necessary for avoiding the drag rise near the speed of sound, i.e., it is highly swept back, it can be made very thin, the wing loading is low, and the aspect ratio is low.

(2) Extensive wind-tunnel and flight tests have shown that the low-aspect-ratio delta wing gives minimum changes in stability and control characteristics at speeds near the speed of sound.

(3) In spite of the wing being thin, its internal volume is large, so that the engines, undercarriage, fuel, and all the necessary equipment can be contained within the wing and a rudimentary fuselage.

(4) Adequate control can be obtained by control surfaces on the wing, thus eliminating the need for a conventional tailplane. Together with item 3, this leads to a considerable reduction in the drag of the aircraft, and, therefore, to high performance.

(5) Auxiliary devices such as flaps, nose flaps, or slots, and the all-moving tailplane, are unnecessary, thereby saving weight and design effort, and simplifying manufacture and maintenance.

(6) The delta wing is very stiff and free from distortion troubles.

"NO HIGHWAY" ON THE SCREEN

ALTHOUGH Nevil Shute's novel *No Highway* was concerned with aviation and the plot hinged on the uncertainty of metal fatigue, it was quite unnecessary for readers of the book to have even an elementary knowledge either of the industry or of science in order to enjoy an exciting and satisfactory story. In making a film of the book, however, considerable liberties have been taken by Twentieth Century-Fox with the central character—Theodore Honey, the absent-minded, eccentric research worker at the Royal Aircraft Establishment, who has been turned into a Rhodes scholar, in order, we presume, to explain away the "folksy" accent of Mr. James Stewart in the part. No effort is made to explain the change in Mr. Honey's physical appearance which, if our memory serves correctly, Mr. Shute summed up as "little" and "frog-like." Even if Mr. Stewart has any enemies, the worst of them would not describe him thus; yet Miss Marlene Dietrich (as Monica Teasdale) is obliged to call him "a funny little man."

The technical matter included in the film script can hardly be regarded as entirely satisfactory. Since interest has to be focused on the possible failure of the new Reindeer aircraft's tail structure it was, perhaps, necessary that the design of this unit should be arresting. Yet that would not seem reason enough for "designing" a hideous fantasy which, structurally, does not appear as though it would stand up to the vigorous stampings of a ten-year-old child, and aerodynamically is enough to bring one out in a cold sweat. The faked take-off and landing of the Reindeer was a decidedly dicey affair, which Messrs. Waygood-Otis might well envy.

The wrecking of the Reindeer by Mr. Honey was convincing, an epithet that can less truthfully be applied to the interior scenes in the aircraft, which has a cockpit rather like the console of a cinema organ (veneered hardwood with nooks and crannies), nor of some of the technical dialogue, during which flying-boats, airscrews and piston engines are airily dismissed as obsolete.