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MEANS FOR STABILIZATION OF AIRPLANES HAVING HIGHLY SWEPT-BACK WINGS

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Fig. 1

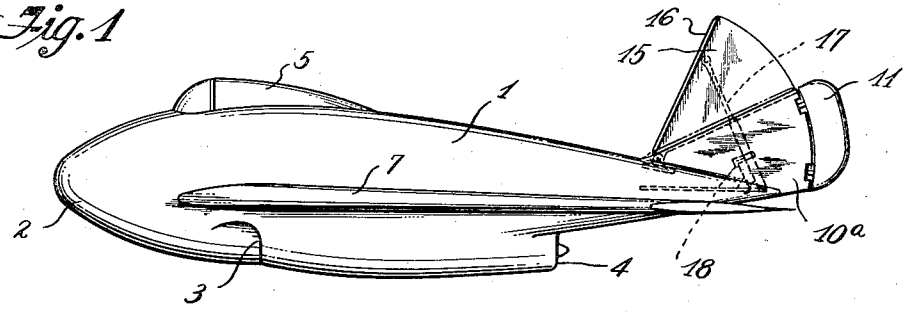


Fig. 2

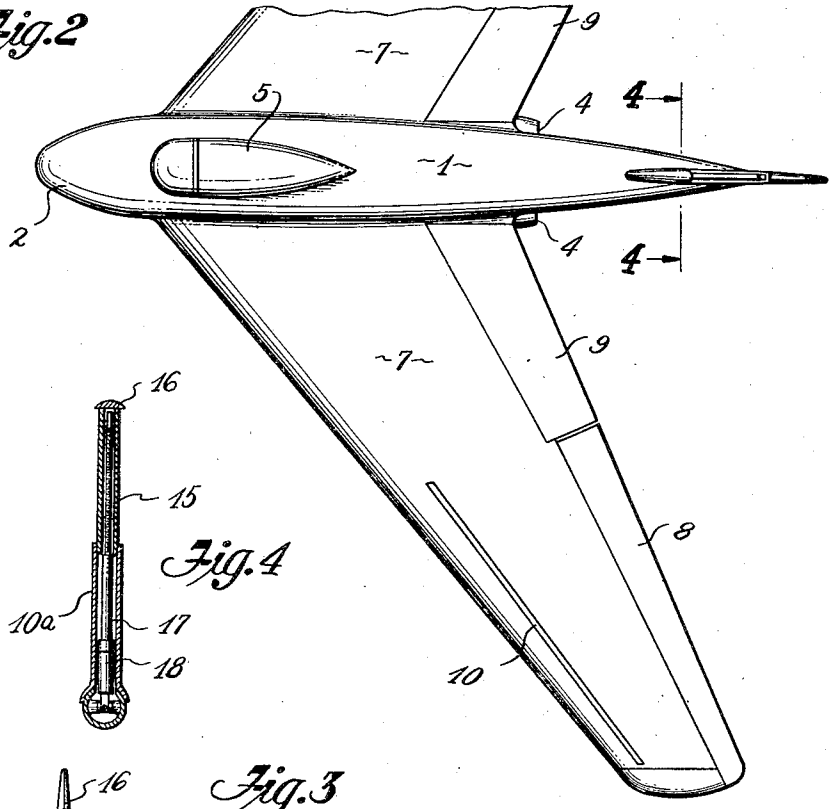
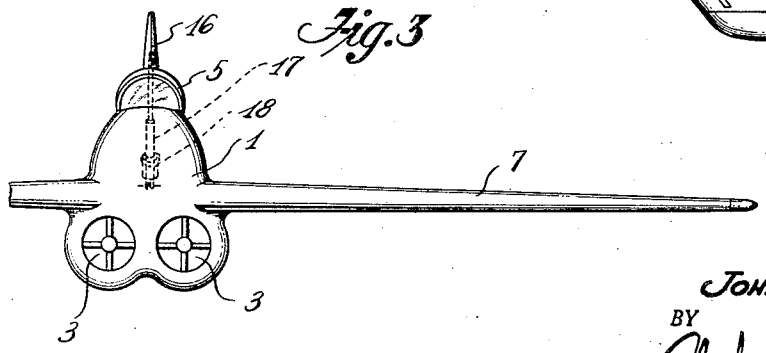


Fig. 4

Fig. 3



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MEANS FOR STABILIZATION OF AIRPLANES HAVING HIGHLY SWEPT-BACK WINGS

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4 Claims. (Cl. 244—91)

1

My invention relates to airplanes, and more particularly to a means and method of stabilizing airplanes having highly swept-back wings.

In conventional airplanes having no wing sweepback, or only a moderate sweepback, the method of obtaining dynamic and directional stability is well known. An airplane is directionally stable when an increased angle of yaw results in an increased yawing moment in a direction to decrease the angle of yaw. In other words, directional stability simply requires that when an airplane skids or yaws so as to create a lateral component of airflow, the center of pressure of the resultant applied lateral force shall be behind the center of gravity of the airplane. This requirement is usually satisfied by the use of a vertical stabilizer or fin positioned at the rear of the airplane. Directional control is usually obtained by attaching a vertical rudder to the vertical fin. Broadly speaking, the vertical tail area of conventional airplanes may be 5 to 10 per cent of the wing area, with the rudder comprising about 40 to 60 per cent of the tail area.

The vertical tail, in addition to providing "static" directional stability, as described above, is even more important, in combination with wing dihedral, in determining the rolling-yawing motions of the airplane following a disturbance from equilibrium. It is generally conceded that divergent or lightly damped motions are allowable, provided that the rate of divergence or the frequency oscillation is so low that a pilot with ordinary responses can make the corrections required to restore the airplane to its original attitude. The lateral-directional behavior of an airplane can be separated into two distinct types of motion, the so-called "spiral" and "Dutch roll" modes of oscillation. Because of its normally slow rate of divergence, the former type of motion is generally considered of secondary importance and present-day airplanes are designed to provide high damping in the "Dutch roll" mode.

The character of the Dutch roll is chiefly determined by the relationship between vertical tail size and wing dihedral, so that for a combination of large vertical tail and low wing dihedral the oscillation becomes highly damped. The size of the vertical fin required to produce sufficient damping in Dutch roll is in fact almost proportional to the effective dihedral of the airplane, but while the damping increases with vertical tail size, the period of the oscillation decreases so that a large fin can, for high speed aircraft, result in a high-frequency oscillation which will, in spite of its damping, be objectionable.

2

For airplanes without sweepback, the effective dihedral is nearly constant, for a given geometry, over the angle of attack range, and an appropriate fin area can be chosen to give proper damping for that dihedral. With sweepback, however, the effective dihedral increases as the angle of attack is increased, independently of what the built-in wing dihedral may be. This requires that, in order to avoid poor damping for the low-speed high angle of attack condition, the fin area be made appropriate to the large effective dihedral for this attitude. The fin thereby required will obviously be larger than is necessary for high-speed low angle of attack flight, and in addition to increasing the drag of the airplane can become objectionable by increasing the frequency of oscillation beyond the comfortable limit.

To further complicate the problem, high speed aircraft with sweptback wings may be designed to avoid the use of horizontal tail surfaces and controls because the sweepback in general places the wing tips well back of the center of gravity of the airplane and in consequence pitch controls can be placed at or near the wing tips. As a result, the fuselage can be made relatively short. This may eventuate in the vertical fin being placed at the rear of, but relatively close to, the center of gravity of the airplane. As a result, the fin must be increased in area still further due to the short effective lever arm.

Under these circumstances, for example, operative airplanes having 45° sweepback have been provided with a vertical fin having an area close to 20 per cent of the wing area in order to achieve dynamic directional and lateral stability. The disadvantages to the use of such large vertical fins are concerned with the increased drag and frequency of oscillation for the high-speed condition, as already discussed. As the maximum vertical fin area is needed only at high angles of attack, I have found that an important reduction in drag and a decrease in the critical Dutch roll frequency can be obtained by utilizing a vertical fin having a fixed area sufficiently large to provide dynamic lateral and directional stability at small angles of attack, and which can be enlarged in area at high angles of attack to provide the proper stability at such angles of attack.

It is, therefore, an object of my invention to provide a means and method of adequately stabilizing airplanes having sweptback wings at high angles of attack, without introducing unnecessarily high drag forces or objectionably rapid oscillations at lower angles of attack.

It is another object of my invention to correlate, in flight, the vertical fin area with effective dihedral as the effective dihedral changes with the attack angle of airplanes having highly sweptback wings.

Other objects and advantages of my invention can be more fully understood by references to the appended drawings in which:

Fig. 1 is a side view of an airplane embodying my invention.

Fig. 2 is a partial top view of the airplane shown in Fig. 1.

Fig. 3 is a front view of the airplane shown in Fig. 1.

Fig. 4 is a sectional view taken as indicated by line 4—4 in Fig. 2.

The present invention will be described as applied to a turbo-jet driven fighter airplane designed to operate in the 500 to 600 miles per hour range. As shown in Figures 1, 2, and 3, such an airplane comprises a fuselage 1 of streamlined form, with the front rounded end 2 faired into air intakes 3 for two turbo-jet engines (not shown) positioned in the lower half of the fuselage, and exhausting through jet outlets 4. The pilot is positioned in the upper half of the fuselage and is provided with vision by means of transparent bubble canopy 5.

Thin section wing panels 7 are attached to the fuselage 1 and are swept back at an angle of 47° at the leading edge, but with substantially zero built-in dihedral. Elevons 8 are provided on the outward trailing edges of the wing panels 7 and are moved together for pitch control and differentially for roll control. High lift flaps 9 are provided along the inner trailing edges of the wing panels 7. Slot 10 defines the position of an anti-stall device.

The fuselage 1 terminates approximately in line with the rear of the wing panel tips and a fixed vertical fin 10*a* is positioned on the end of the fuselage, to which a rudder 11 is attached. The elevons, rudder, high lift flaps, and wing slots are operated in the normal manner by the pilot for control of the airplane.

The area of the fixed vertical fin 10*a* is made sufficiently large to provide dynamic lateral and directional stability at low angles of attack, and in the case of the airplane shown, the area of the fixed vertical fin and the attached rudder can be somewhat less than 10 per cent of the wing area and still provide adequate directional and lateral control at low angles of attack.

Even though the wings have little or no actual dihedral, as the angle of attack of the airplane decreases, an effective dihedral due to sweepback becomes apparent and this effective dihedral increases with angle of attack until at certain landing attitudes, for example, the area of the vertical fin and tail is not sufficient to stabilize against the Dutch roll type of instability. For this reason, means have been provided to increase the vertical fin area and, in the example shown, this increase in vertical fin area is obtained by the use of a movable vertical fin 15 (shown extended), normally nesting inside the fixed vertical fin, the opening in the fixed vertical fin 10 being closed by fairing 16 on the leading edge of the movable vertical fin as shown in Figure 4. In this figure, skin thicknesses are exaggerated for clarity. Actually, those skilled in the art will have no difficulty in designing a retractable unit that will be well faired in all positions. The best form is required when the movable fin is retracted, at which time smooth contours are readily obtained.

The movable vertical fin is preferably sectoral in shape and is pivoted at its apex to move in and out of the fixed vertical fin under the control of a mechanism such as an electric screw jack 17, similar to screw jacks utilized to extend high lift landing flaps, for example, and bear the forces exerted thereon. The screw jack 17 can be operated by a reversible motor 18 under the control of the pilot, and the movable vertical fin position can be made known to the pilot by the use of a position transmitter operating a position indicator (not shown) located in view of the pilot, as is well known in the art.

There are, of course, many ways in which the vertical movable fin can be made to operate at high angles of attack. It can be operated directly under the control of the pilot, as described, so that at high angles of attack the pilot can enlarge the vertical fin area to obtain the desired stability. Often, however, the anti-stall slots as shown herein near the outer portion of the leading edge of the wing panels are both manually and automatically operated to open at high angles of attack by means of differential pressures between undisturbed air, top wing surface pressure, and lower wing surface pressure. In case of an airplane equipped with such automatic slot control, the extension of the movable vertical fin can take place simultaneously with the operation of the anti-stall slots. Because of such various modes of operation of the movable vertical fin, no particular circuit or means other than direct pilot operation have been described herein.

In the example illustrated and described, the movable vertical fin is arranged to substantially double the area of the vertical fin at high angles of attack, thereby providing a vertical fin area of somewhat less than 20 per cent of the wing area in airplanes having 40° to 50° sweepback; i. e., on the order of 60°, arrangements can be made to increase the vertical fin area still more if required.

It will thus be noted that the vertical fin area required for satisfactory stability is attained at high angles of attack, and yet at lower angles of attack, with the movable vertical fin retracted within the fixed vertical fin, a drag corresponding to roughly 10 per cent of the wing area drag is eliminated and the frequency of oscillation is reduced, thereby permitting the airplane to fly at high speeds at angles of attack which do not require the maximum vertical fin area.

What is claimed is:

1. In an airplane, sweptback wing panels on said airplane, a fixed vertical fin located aft of the center of gravity of said airplane, and having sufficient area to maintain dynamic directional and lateral stability at low angles of attack, and a movable vertical fin positioned inside said fixed vertical fin and extensible therefrom to increase total fin area at high angles of attack.

2. In an airplane, sweptback wing panels on said airplane, a fixed vertical fin located aft of the center of gravity of said airplane, and having only sufficient area to maintain dynamic directional and lateral stability at low angles of attack, a movable vertical fin positioned inside said fixed vertical fin and extensible upwardly therefrom to increase total fin area, and a rudder attached to said fixed vertical fin.

3. Apparatus in accordance with claim 2 wherein the area of said fixed vertical fin is on the order of 10 per cent of the area of said wing panels,

4. Apparatus in accordance with claim 2 wherein the area of said fixed vertical fin is on the order of 10 per cent of the area of said wing panels and wherein said movable fin is capable of increasing said area to a total area on the order of 20 per cent of the wing area with sweepback angles of between 20° and 60°.

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