Oct. 20, 1953 | B. O. HOWARD | 2,656,132

STABILIZING TAB

Filed March 26, 1951 | 2 Sheets-Sheet 1

Fig. 1.

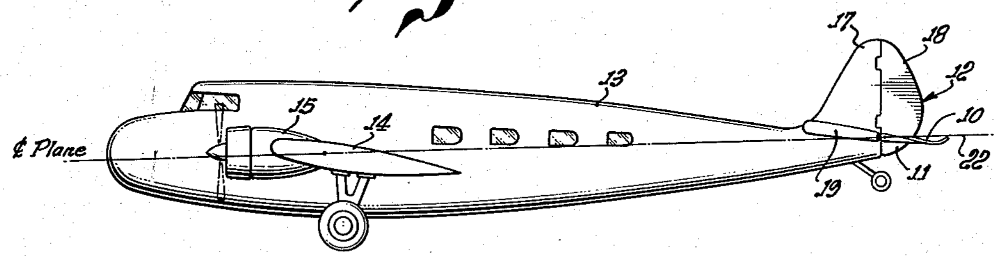

Fig. 2.

Fig. 3.

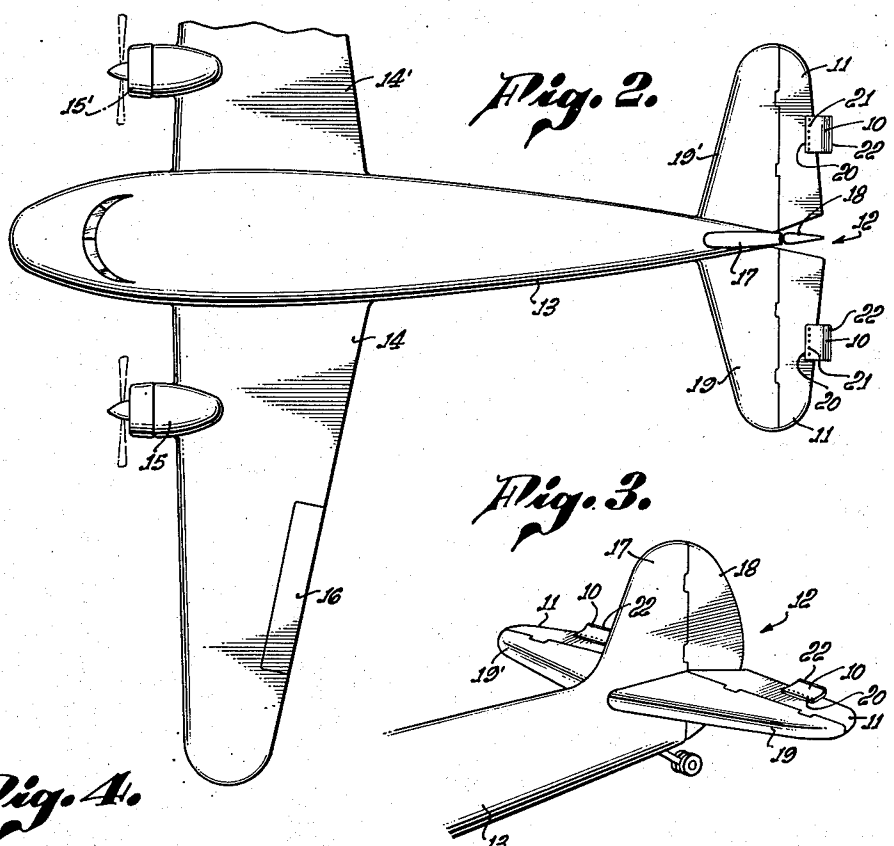

Fig. 4.

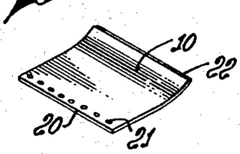

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Fig. 5.

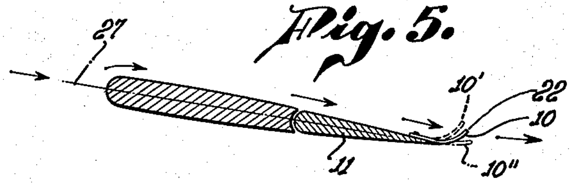


Fig. 6.

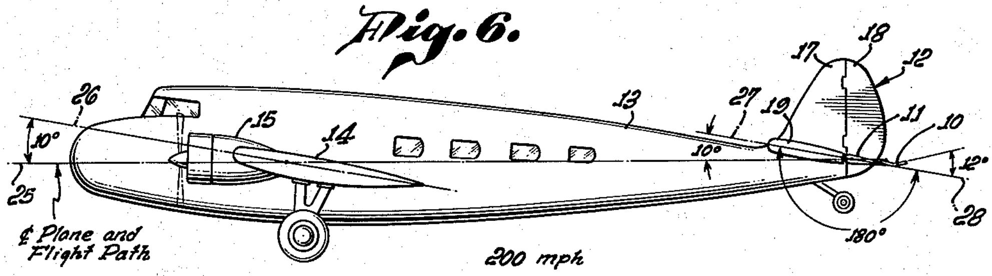


Fig. 7.

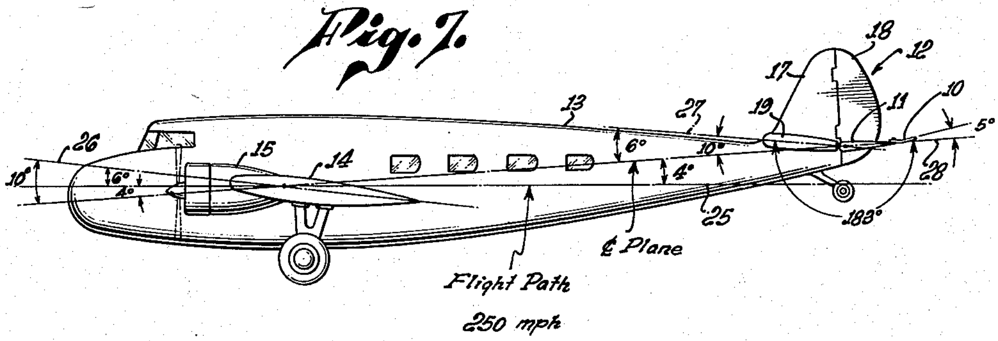
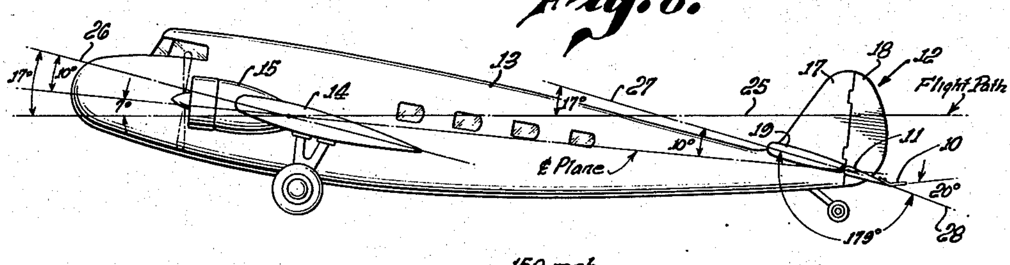


Fig. 8.



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2,656,132

STABILIZING TAB

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4 Claims. (Cl. 244—75)

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The application relates to the control of airplanes and has particular reference to a construction for automatically stabilizing the flight of an airplane.

The stabilizing of airplanes during flight has been the result of research and design over a long period of time which has resulted in adaptation of several expedients looking toward one means or another to effect automatic stabilization. Although theoretically the automatic stabilizing principle is one capable of effecting automatic stabilization under ordinary circumstances, so many practical objections exist that the principle has had but limited application. Where spring load forces have been resorted to the loading of such forces has needed to be so strong as to be objectionable to control by the pilot while the plane is on the ground. Other objections to the spring loading principle include the inability of avoiding destructive flutter of a spring loaded tab. There is also the inability to keep bearing friction on hinged devices to a sufficiently low value to make the system satisfactorily workable. More important still is the constant hazard of ice causing the hinges to freeze up, thereby temporarily rendering the stabilizing mechanism inaccurate and which, when subject to sudden deicing, may have a catastrophic result in the manipulation and control of the airplane.

It is therefore among the objects of the invention to provide a new and improved automatic stabilizing device for airplanes which is substantially weather-proof and frictionless in that it is capable of operation without contact of any frictionally engaging surfaces.

Another object of the invention is to provide a new and improved automatic stabilizing device for airplanes which is particularly light in weight, thereby having virtually no effect upon the lifting ability or balance of the airplane resulting from weight distribution.

Still another object of the invention is to provide a new and improved stabilizing device which is substantially proof against the accumulation of ice thereon, thereby making it equally effective under all weather conditions.

Still further among the objects of the invention is to provide a new and improved stabilizing device of inherently resilient characteristics, the effect of which may be varied by the rate of air flow against the device without the necessity of depending upon the pilot to manipulate controls against heavy spring load pressure.

The objects include the provision of a stabilizing device of such simple design that it can be readily applied to virtually any type of airplane in that the airplane need not be specially designed so as to employ the device. That is to say, the airplane may be one of more or less conventionally standard construction or of novel design such as the canard type airplane, the device moreover being of such inexpensive character as to add virtually no greater cost to the airplane either because of the cost of the material itself or the installation of the device on the airplane.

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With these and other objects in view, the invention consists in the construction, arrangement and combination of the various parts of the device whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims and illustrated in the accompanying drawings.

In the drawings:

Figure 1 is a side elevational view of a conventional airplane having a single vertical fin and rudder showing the stabilizer tab extending off the trailing edge of an elevator.

Figure 2 is a plan view of the airplane shown in Figure 1 wherein only necessary controls are illustrated in the interest of clarity.

Figure 3 is a perspective view of the empennage section of the airplane shown in Figure 1.

Figure 4 is a perspective view of the stabilizer device prior to attachment to the airplane.

Figure 5 is a cross-sectional view of a stabilizer and elevator to which the stabilizer tab has been applied.

Figure 6 is a diagrammatic illustration showing a side elevational view of an airplane in forward balanced flight at an assumed rate of speed of 200 miles per hour.

Figure 7 is a view similar to Figure 6 showing the position assumed by the lifting surfaces of the airplane at one stage of stabilization at a speed of 250 miles per hour.

Figure 8 is a view similar to Figure 6 where the speed is 150 miles per hour.

In order to understand the operation of the invention herein disclosed and the advance and improvement effected by the automatic stabilizing principle involved in use of the device described, a brief review of practices already known and to some degree prevalent in the stabilizing of airplanes is herein set forth.

One well-known principle of stabilizing an airplane about its longitudinal axis is to balance an aerodynamic force tending to nose the airplane upward against an equal and opposite aerodynamic force tending to nose the airplane downward, the upward force varying approximately as the square of the speed, and the downward force varying to a lesser degree in that it is constant under a given set of circumstances and not altered at all by speed changes.

The principle might be better illustrated by the example of an airplane flying at 200 miles per hour in which the moments of aerodynamic forces exerted by the wing and tail are balanced about the center of gravity of the entire airplane under which circumstances a state of equilibrium exists. A required condition of this state of balance or equilibrium is that the aerodynamic force on the tail tending to "nose down" the airplane is the resultant of two forces on the tail, namely, one tending to decrease the lift of the tail causing a nosing of the airplane upwardly offset by an equal and opposite aerodynamic force tending to increase the lift of the tail causing a nosing of the airplane downwardly. The "nose upward" force is the result of air impinging on a portion of the tail at a constant angle of attack and with the angle of attack held constant forces from the impinging air will vary as the square of the change in air speed. By way of example, a one-pound force on the lifting surfaces at 200 miles per hour will be 1.56 pounds at 250 miles per hour and .56 pound at 150 miles per hour.

The "nose down" force is the result of air impinging upon that portion of the tail consisting of a stabilizer tab, the angle of attack of which will vary. The angle of attack of the stabilizer tab will depend upon the speed and force of the impinging air and the angle will therefore vary inversely as the square of the change in speed. Described as angular quantities, for example, the angle of attack of the stabilizer tab which at rest may be in the neighborhood of 15 degrees may be 9 degrees at 150 miles per hour, 5 degrees at 200 miles per hour and 3.2 degrees at 250 miles per hour. The principle involved in this variation of the angle of attack as a result of speed change maintains the "nose down" force essentially constant in spite of speed changes.

Assuming the airplane to be balanced with respect to the forces or in equilibrium at a speed of 200 miles per hour, should the speed be increased to 250 miles per hour, the "nose down" force remains constant but the "nose up" force increases 56 per cent. The net lift of the tail will thereby be reduced causing the airplane to shift "nose upward," which position will cause the speed of the airplane to diminish until it has reduced to 200 miles per hour at which time the "nose up" force and the "nose down" force are equal and the balance or equilibrium is re-established.

The method of stabilization just described has had small acceptance in the past due to undesirable influences inherent in the physical means of obtaining the desired reactions. Restated briefly the undesirable influences include fluttering of the stabilizer tab, inability to maintain it ice-free and difficulty of manipulating heavy spring loads.

A more specific illustration of the method above referred to involves the application of a large spring force to the elevator in a manner such that the angle and lift of the elevator tend to increase thereby creating an effective force nosing the airplane down. The constant spring force on the elevator in one particular manner of stabilization is arranged to be counteracted by a decreased angle of the stabilizer in those cases where the airplane is equipped with an adjustable stabilizer or a small tab or portion of the elevator located at the trailing edge of the elevator, in which position it is rigidly inclined downwardly in the path of air, wherein air impinging upon it results in the trailing edge of the elevator being forced upwardly an amount equivalent to the opposing spring force. Under ideal circumstances stability is attained by the arrangement described. However, spring forces on the control system must be so strong as to be objectionable to the pilot while the airplane is on the ground.

A different method or scheme of stabilization is one in which a tab on the trailing edge of the elevator is spring loaded in a direction upward at the trailing edge, the upward angle placing a down load on the trailing edge of the elevator which results in a "nose down" force on the airplane.

The expedient resorted to for the elimination of the defects and objectionable features of conventional stabilizing mechanisms herein referred to consists of the installation of a stabilizer tab 10 shown by itself in perspective in Figure 4. In Figures 1, 2 and 3 the stabilizer tab, which may appropriately be referred to as a feather, is shown attached to an elevator 11 located one on each side of an empennage section 12 of a conventional monoplane. The monoplane to which the stabilizer tab has been applied includes a fuselage 13, main wings 14 and 14', engines 15 and 15' and the empennage section 12. The main wings are illustrated as including ailerons 16. The empennage may be assumed to comprise a vertical fin 17 having a rudder 18 thereon. Stabilizers or stabilizer wings 19 and 19' extend laterally from the vertical fin 17 and are provided at their trailing edges with the elevators 11 upon which are mounted the stabilizer tabs 10.

The stabilizer tab in each instance consists of a very thin sheet of material, commonly a resilient metal which is sprung initially to the shape illustrated in Figure 4. The sheet of material may assume any convenient geometric pattern so long as it is a sheet of sufficient surface area spring pressed angularly with respect to the elevator so as to present a different angle of attack than the elevator whether the angle of attack might be positive or negative or, in other words, in either a downward or upward direction.

Although more finished means may be employed for attaching the stabilizer tab to the elevator, a simple expedient lies in providing an edge 20 along one side of the stabilizer tab which, as suggested in the drawings, may be fastened to the elevator by a line 21 of rivets. It will be noted that in a type of plane like that shown in Figures 1, 2 and 3 where the empennage section is in the rear, the stabilizer tab is initially directed upwardly which is a direction contrary to the position most usually assumed by the elevator, namely, downwardly with respect to the center line of the main stabilizer.

An understanding of the operation of the device here involved which will be described in conjunction with Figures 6, 7 and 8 will be improved when it is understood that the stabilizer tab 10 may be mounted as illustrated in Figure 5. As there shown the main stabilizer 19 has an elevator 11 hingedly mounted at the trailing edge of the stabilizer and the elevator has the stabilizer tab riveted to its trailing edge by a line 21 of rivets. The stabilizer tab is bent in an upward curve as viewed in Figure 5. When the airplane is on the ground, for example, the stabilizer tab will have an upwardly extending position 10', somewhat comparable to that illustrated by the dotted line position in Figure 5. As there shown the stabilizer tab presents an obliquely directed surface to the air stream and is maintained in the position shown by the inherent resilience of the material. For practical considerations the tab is here shown as formed in a continuous curve from the edge 20 which is tangent to the upper surface of the elevator upwardly and outwardly to a free end 22. The stabilizer tab, it should be understood, can be successfully made of any one of a number of materials, preferably metals that can be heat treated so as to maintain a resilient curved form which will curl up to the position 10' at rest and which will gradually flatten out to a position as flat as that illustrated by the dotted position 10'' of Figure 5.

Reference is made particularly to Figures 6, 7 and 8 to illustrate the principle of stabilization to which the stabilizer tab 10 contributes an important part. Figure 6 shows the airplane in the position assumed in balanced flight at an assumed speed of 200 miles per hour. The fuselage 13 reveals a center line 25 which is horizontal and indicates the flight path to be on a horizontal plane. The main wing 14 is tilted so that a center line 26 of the wing makes an angle of incidence of 10 degrees to the center line 25. In this balanced condition the angle of attack, namely, the angle of the wing with respect to the path of impinging air is also 10 degrees.

The empennage section 12 consisting of the parts already described in connection with Figures 1, 2 and 3 shows a center line 27 of the stabilizer 19 as tilted to a 10-degree angle of incidence which also presents a 10-degree angle of attack in the position illustrated in Figure 6. A center line 28 of the elevator 11 is in alignment with the center line of the stabilizer which, for the purpose of distinction, may be termed the main stabilizer 19. These center lines may aptly be described as making an angle of 180 degrees with respect to each other.

At the assumed speed of 200 miles per hour illustrated in Figure 6 the stabilizer tab 10 has been flattened out to an angle of 12 degrees upwardly with respect to the center line 28 of the elevator.

At this speed of 200 miles per hour the stabilizer tab maintained at an angle of 12 degrees to the elevator holds the elevator to the 10-degree angle of attack. In this particular illustration no opposing tab is shown as it might be to present a counteracting force but that force instead may come from a conventional trim tab or adjustability of the main stabilizer angle on those occasions where trim tabs are dispensed with. Balance may further be the result of coincidence of the load on the elevator being such as to maintain balance about the center of gravity of the entire airplane under the chosen conditions of speed and the remainder of the loading. In other words, trim and balance are obtained in the normal way and the force exerted by the stabilizer tab is included in the balancing that is done by the conventional trimming or balancing expedients.

From the balanced condition at 200 miles per hour illustrated in Figure 6 an occasion may arise wherein the pilot noses the airplane over into a dive by pushing the conventional stick forward, which movement depresses the elevator 11 causing the plane to nose over into a dive, which position is held by the pilot until the speed of 250 miles per hour is reached. At this point the pilot may momentarily release his forward pressure on the stick causing an appropriate change in the position of the elevator until the airplane levels out of the dive and is flying on a bodily horizontal flight path as illustrated in Figure 7. This is slightly different from that illustrated in Figure 6 because at the higher speed of 250 miles per hour only a 6-degree angle of attack of the wings and elevator is necessary to supply sufficient lifting force to maintain the airplane aloft. For a 6-degree angle of attack the center line 25 of the airplane will be "nosed down" 4 degrees from the horizontal. Meanwhile the pilot holds the stick forward depressing the elevator enough to hold the nose down in the position illustrated.

Because of the increase in speed to 250 miles per hour the stabilizer tab 10 is depressed to the angle of 5 degrees illustrated in Figure 7 with respect to the center line 28 of the elevator 11.

At this point the pilot may release the stick and since the angle of the stabilizer tab with respect to the elevator is only 5 degrees, the resulting force will depress the elevator to only a 3-degree angle of attack instead of a 6-degree angle of attack. In Figure 7 this is illustrated by the designation of an angular difference between the center line 27 of the stabilizer and the center line 28 of the elevator of 183 degrees. Inasmuch as the angle of attack of the elevator is less by the amount described, there will be less lifting force on the elevator and hence less lifting force on the tail or empennage which will allow the tail or empennage to sink and consequently the airplane to "nose up." In "nose up" position the airplane climbs until by reason of the climb the speed diminishes to 200 miles per hour at which speed the trim state becomes reestablished.

Assuming again a balanced condition of the airplane traveling at a speed of 200 miles per hour at which speed and balance the airplane may be said to be trimmed to fly with the pilot's hands off the controls. From this position let it be assumed that the pilot pulls back the conventional stick raising the elevator 11, which adjustment depresses the tail or empennage section causing the airplane to "nose up" and thus start to climb. Since in that position the airplane is being driven by its source of power against the pull of gravity as well as forwardly, the airplane slows down, the pilot still holding the stick back to adjust the elevator as described until the speed of the airplane reduces to 150 miles per hour. At that speed the inertia is spent, that is to say, decelerated from 200 miles per hour to 150 miles per hour, and resistance of the lifting surface at the higher angle of attack equals the power. The angle of attack to be chosen for example may be assumed to be 17 degrees. In this position of flight the center line 25 of the airplane has a "nose up" position of 7 degrees with respect to horizontal, the pilot holding the airplane in that position by holding the elevator up.

At 150 miles per hour relative air speed the tendency of the pressure of air to flatten the stabilizer tab is diminished and the stabilizer tab as a result of its inherent resiliency bends backwardly toward its initial position until it assumes an angle of 20 degrees with respect to the angle of the center line 28 of the elevator 11. Force of air at 150 miles per hour is still sufficient to prevent the stabilizer tab from assuming the normal position it would have at rest while the airplane is on the ground.

At the speed of 150 miles per hour the pilot may release the stick allowing the stabilizer tab in its position 20 degerees to the center line of the elevator to depress the trailing edge of the elevator to 18 degrees which will be 1 degree greater than the angle of attack of 17 degrees of the stabilizer; that is to say, the stabilizer angle with respect to the direction of inflow air will be the sum of the original 10 degrees angle of incidence plus the additional 7 degrees which is the angle upwardly of the center line **25** of the airplane with respect to horizontal. Since the angle of the elevator with respect to the direction of impinging air is greater by 1 degree as a result of the influence of the stabilizer tab in its new position upon the elevator, normally the condition illustrated in Figure 8 will exist. Because of the 18 degree position of the angle of the elevator there will be a greater lifting force on the tail or empennage section causing the tail of the airplane to lift and the airplane to "nose down." As the airplane "noses down" the speed begins to increase until the initial 10-degree angle of attack is reached, inasmuch as that is the angle of attack which will support the airplane when the speed of the airplane is 200 miles per hour, that being a faster speed than the 150 miles per hour speed to which the airplane slowed down. The stabilizer tab will be flattened out to some extent from the 20-degree position illustrated in Figure 8 to the 12-degree position illustrated in Figure 6. At this point the airplane is once again restored to its original balanced trim condition for a 200 miles per hour rate of speed.

It can be said that the stabilizer tab is capable of establishing a "nose down" force but that when the airplane is on the ground and at rest, no force is exerted by the stabilizer tab because there is no force of air impinging upon it. Because such a small amount of movement is involved in the adjustable sheet comprising the stabilizer tab dangerous flutter is eliminated. As before mentioned there is no problem of friction since there are no bearings or hinges to provide for movement. Instead movement is merely the inherent bending of the stabilizer tab as it flattens out under increased force of air or bends back to initial position when the force of air decreases. The flexing of the stabilizer tab as a result of change of speed which occurs many times during flight is sufficient to crack loose ice which might form on the surface under icy circumstances.

As described herein the very important stabilizing effect required to properly balance airplanes which involves the functioning and manipulation of controls directed to wings, elevator and perhaps the main stabilizer is automatically adjusted by a very simple and economical expedient of providing an inherently flexible stabilizer tab of such light weight as not to materially effect the design of the airplane and which because of the simple mode of operation greatly enhances the factor of safety in flying without attendant disadvantages.

It will also be appreciated that the invention described herein contemplates attachment of the resilient oblique tab to the elevator in the same fashion as trim tabs are now attached. Mounted in that manner the tab could be controlled in the conventional manner as trim tabs are controlled. Trim tabs could under those circumstances be eliminated and the resilient tab of the invention employed both for trimming and for stabilizing.

While I have herein shown and described my invention in what I have conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of my invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In an airplane a control surface element extending laterally with respect to the longitudinal axis of the airplane and rotatably secured to said airplane and adapted to present control surface portions thereof in a position opposed to the direction of the path of air impinging thereon whereby an aerodynamic moment is produced about the axis of rotation of the control surface element, and a tab of resiliently deformable material attached to the trailing portion of the control surface element, said tab having a free moving portion directed to a position in said path of air whereby an aerodynamic moment is created on the control surface element in opposition to said first identified aerodynamic moment.

2. In an airplane having a stabilizer, a control surface element rotatably secured to the trailing edge of the stabilizer and adapted to present control surface portions thereof in a position opposed to the flow of air past the stabilizer whereby an aerodynamic moment is produced about the axis of rotation of the control surface element, and a tab of resiliently deformable material attached to the trailing portion of the control surface element, said tab having a free moving portion directed to a position in the flow of air past the stabilizer whereby a progressively variable aerodynamic moment is created on the control surface element in response to relative air speed in opposition to said first identified aerodynamic moment.

3. In an airplane having an empennage section including a main stabilizer and a control surface element on said stabilizer adapted to assume an angle of incidence to the direction of the path of air impinging on the control surface, the combination of an automatic stabilizer device having a variable effect upon the airplane dependent upon the relative air speed, said device comprising a member having a body of inherently resilient sheet material fastened to the control surface element, said body having a normally curved shape extending obliquely outwardly relative to the control surface and with a concave side of the curve presented to said path of air.

4. In an airplane having a substantially horizontal airfoil section extending laterally with respect to the longitudinal center line of the airplane and rotatably mounted on the airplane on a horizontal axis, a secondary control surface element comprising an inherently resilient free-moving tab having a fixed line of attachment at one edge thereof to the trailing portion of the airfoil and normally presenting control surface portions thereof in a position opposed to the flow of air past the airfoil whereby an aerodynamic moment is adapted to be produced on the airfoil section at said line of attachment of the secondary control surface element.

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