March 18, 1941. H. D. FOWLER 2,235,146

AIRPLANE

Filed June 22, 1938 3 Sheets-Sheet 1

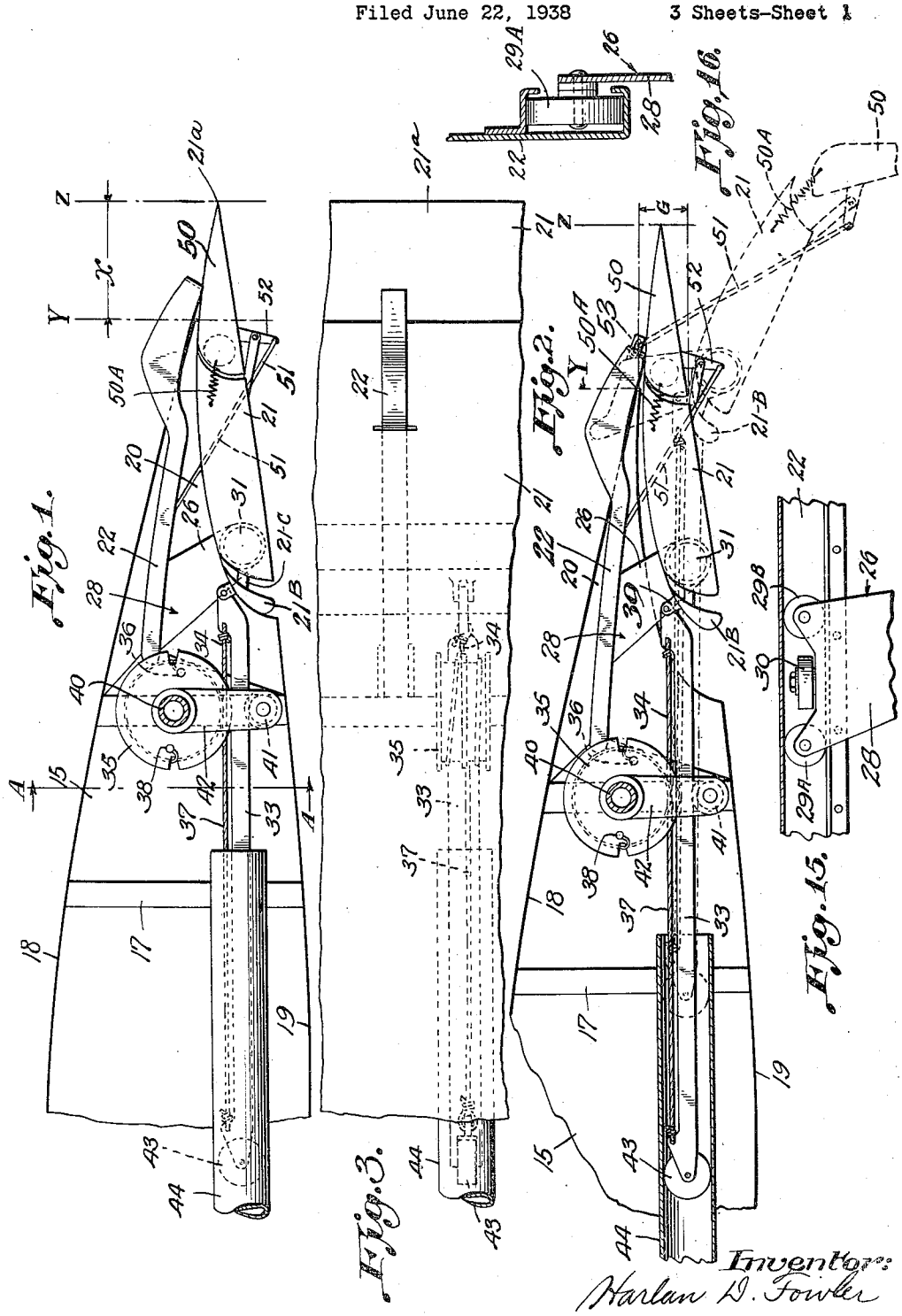


Fig. 1.

Fig. 3.

Fig. 2.

Fig. 16.

Fig. 15.

Inventor:
Harlan D. Fowler

March 18, 1941. H. D. FOWLER 2,235,146

AIRPLANE

Filed June 22, 1938 · 3 Sheets-Sheet 2

Fig. 4.

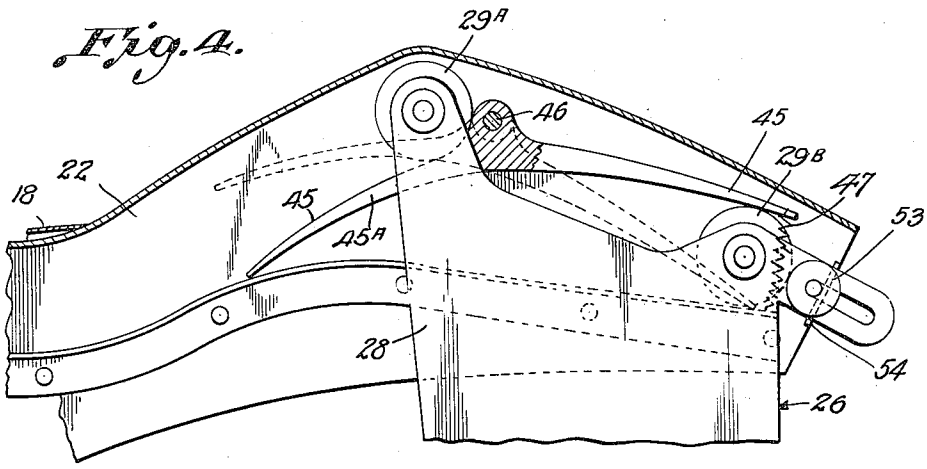


Fig. 5.

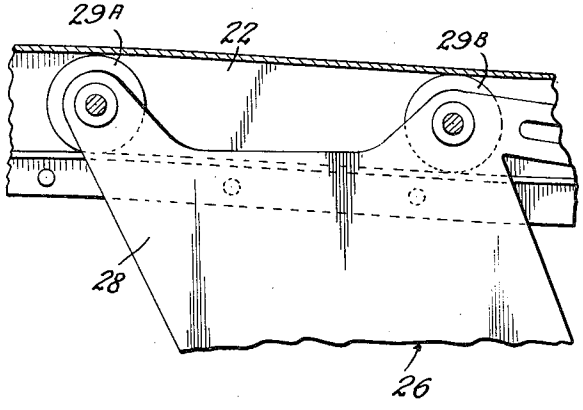


Fig. 6.

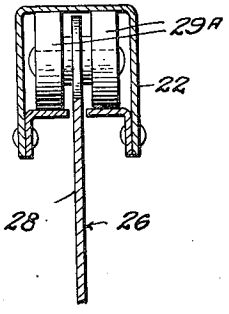


Fig. 7.

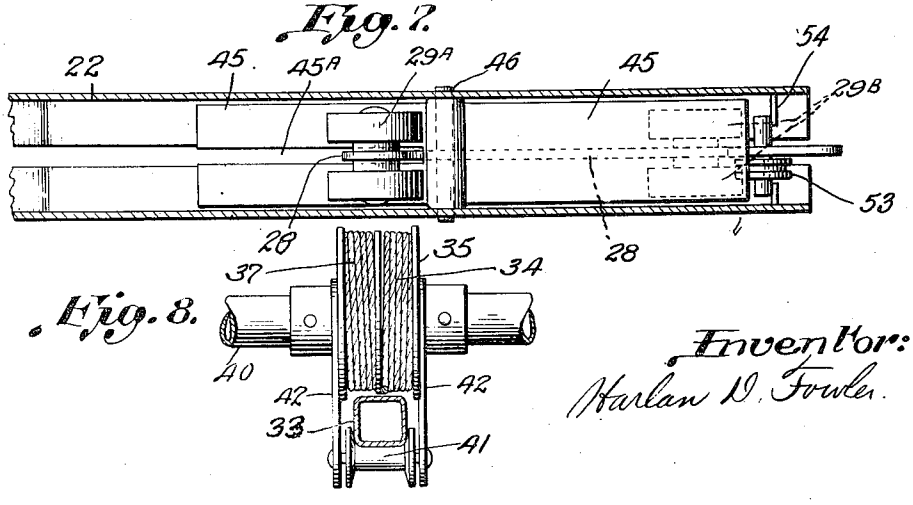


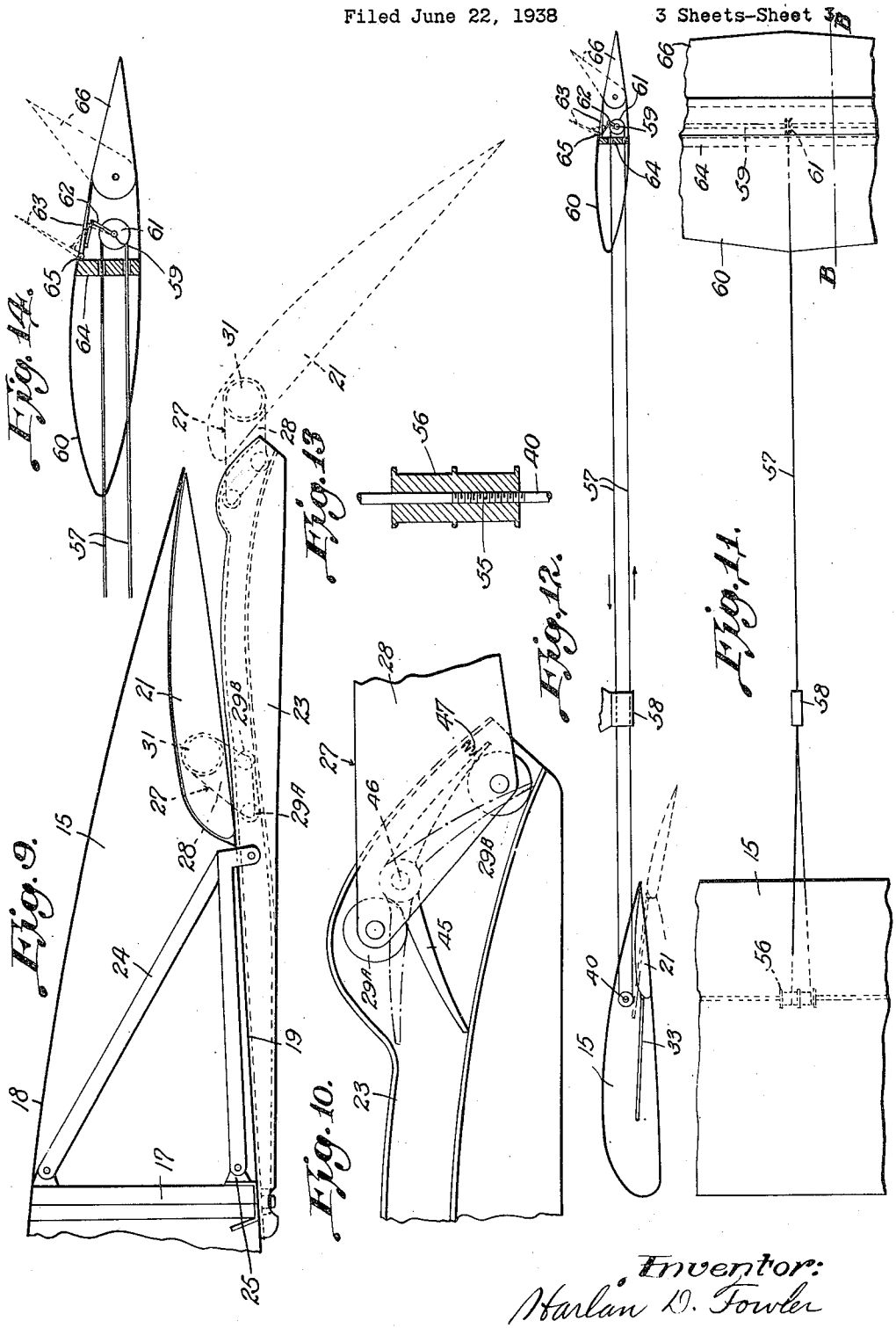
Fig. 8.

Inventor:
Harlan D. Fowler.

March 18, 1941. H. D. FOWLER 2,235,146

AIRPLANE

Filed June 22, 1938 3 Sheets-Sheet 3



Inventor:
Harlan D. Fowler

Patented Mar. 18, 1941 2,235,146

UNITED STATES PATENT OFFICE

2,235,146

AIRPLANE

Harlan D. Fowler, Baltimore, Md.

Application June 22, 1938, Serial No. 215,092

7 Claims. (Cl. 244—42)

This invention relates to airplanes and, more particularly, to a novel variable wing and correlated auxiliary elevator construction.

It is commonly accepted that, in order to increase the speed of airplanes, wing area must be reduced and that, in order to provide for decreasing the take-off distance, for a rapid rate of climb and for safe landing speeds, effective wing area should be increased. In order to meet these two conflicting requirements one of the solutions offered is that in which the wing is divided into two portions—a main wing and an auxiliary wing movably positioned with respect to the trailing edge of the main wing. The present invention relates to this group of auxiliary wings and includes a novel relative arrangement of main and auxiliary wings, novel means for mounting and connecting the two, whereby the latter can slide rearwardly with respect to the main wing, novel shapes for increasing the effectiveness and availability of the auxiliary wing, novel means for controlling the auxiliary wing, the provision of an auxiliary elevator and means for automatically controlling the auxiliary elevator in response to variations in position of the auxiliary wing.

The principal object of the invention is to provide in conjunction with a cambered wing novel means for increasing the flexibility of speed of an airplane under power whereby the best take-off distance, rate-of-climb, altitude and landing conditions may be obtained without decreasing the maximum possible speed.

Another principal object of the invention is to provide means for increasing the chord of the auxiliary wing with respect to the chord of the main wing thereby obtaining a substantially greater increase in the lifting ability of the wing as a whole whereby the area of the fixed wing may be decreased with a consequent increase in speed of the airplane.

A more specific object of the invention is to provide means for positioning the auxiliary wing intermediately between the full open and full closed positions whereby variable lift to drag or speed ratios may be obtained.

A further specific object of the invention is to provide novel means for substituting the trailing edge of the auxiliary wing when in retracted position for the trailing edge of the main wing.

A further specific object of the invention is to provide a novel combined auxiliary wing and flap, the use of which provides increased airplane speed and lift flexibility over those heretofore known.

Other specific objects of the invention are to provide an auxiliary elevator on the horizontal tail surfaces, means for operably linking the auxiliary elevator with the auxiliary wing, and novel means for jointly controlling the auxiliary elevator and auxiliary wing.

Other and more specific objects and advantages of the invention will be apparent from the following specification, claims and from the drawings illustrating a preferred embodiment of the invention, in which:

Fig. 1 is a vertical, cross-sectional view of a conventional aircraft wing embodying an auxiliary airfoil in closed position and supporting means therefor.

Fig. 2 is a section similar to Fig. 1 showing the auxiliary airfoil in partly and fully extended positions.

Fig. 3 is a plan view partly broken away, of the wing, showing the relation of the track, the operating torque shaft and push and pull rod control;

Fig. 4 is an open side view of the rear end of the track, showing the tripper arrangement;

Fig. 5 is an open side view of the trolley within the track;

Fig. 6 is a vertical cross-sectional view, and Fig. 7 a horizontal cross-sectional view of the mechanism shown in Fig. 4;

Fig. 8 is a cross-sectional view on the section A—A of Fig. 1 illustrating the relative position of the push and pull rod to the control drum;

Fig. 9 is an open side view of an alternative arrangement of the supporting track on the under side of wing;

Fig. 10 is an open side view of the tripper arrangement at the end of the track shown in Fig. 9;

Fig. 11 is a partially diagrammatic plan view of the means by which the auxiliary elevator deflection is coordinated with the movement of the auxiliary airfoil;

Fig. 12 is a view partially in vertical section and partially diagrammatic of the structure shown in Fig. 11;

Fig. 13 is an open sectional view of the drum mechanism shown in Fig. 11;

Fig. 14 is an enlarged vertical cross-sectional view of the tail surfaces taken on the line B—B, Fig. 11;

Fig. 15 is an open sectional view of an alternative arrangement of the trolley using a horizontal roller to guide the side thrust aginst the track; and

Fig. 16 is a vertical cross-sectional of a track

showing an alternative design for a channel section in which a single row of rollers may be employed.

For the purpose of illustration, I have shown a conventional main wing or airfoil 15, including a rear spar 17, to which conventional ribs, not shown, may be attached, the upper and lower wing skins 18 and 19 being attached to these ribs in a conventional manner. A trailing portion 20 of the main wing 15, of relatively small cross-sectional area, may be provided with a recess in its lower surface within which an auxiliary airfoil or flap 21 may be accommodated. The trailing edge 21A (Fig. 1) of the auxiliary airfoil 21 forms the trailing edge Z of the normal wing contour for a portion of its chord indicated by X to the cut-back trailing edge of portion 20 of the main wing 15 at Y.

In order to support the auxiliary wing 21, I have shown the trailing portion 20 as arranged to accommodate trolley beam 22 which may be suitably secured to the rear spar 17. The spar 17 may be braced by substantial compression ribs (not shown) of conventional construction to resist the vertical loads from the trolley beam to the spar, such vertical loads being greatest when the auxiliary airfoil is in the full extended position.

Optionally the trolley beam may be differently shaped as at 23 (Fig. 9) to provide means for mounting it beneath the main wing 15. In this construction the beam 23, which except for the means of attachment to the main wing may be identical with beam 22, may be connected intermediate its ends to a truss 24, the upper portion of which may be secured to the upper end of the rear spar 17 and the lower portion of which, at its inner end, may be secured to a fitting 25 connected to the lower end of the spar 17.

The auxiliary airfoil 21, which extends along the span of the wing 15, is movably mounted on trolley beams 22 or 23 by means of trolleys 26 or 27, each of which consists of a plate 28, two vertical rollers 29A and 29B at extreme ends to resist and transmit the forces from the auxiliary airfoil 21, and optionally as shown in Fig. 16 with one horizontal roller 30 at the center for lateral guidance within the trolley beam. Where lighter construction may be used, the beam and rollers may be halved as shown in Fig. 16. Rollers 29A and 29B and 30 are adapted to ride within the rectangular confines of beams 22 or 23. The plate 28 is secured to a spar 31 which runs the entire length of the auxiliary airfoil 21 and to which may be fastened conventional ribs, not shown. Trolleys 26 or 27 are arranged to slope forward of the leading edge of the auxiliary airfoil 21 so that when the flap is in fully extended position they project forward to the trailing edge of the main wing and thus reduce the exposed rear length of the trolley beam 22 or 23.

It will be obvious from a comparison of the structure shown in Fig. 9, with that shown in Fig. 1, that the two are essentially similar, the principal difference being that in the embodiment shown in Fig. 9, with the trolley beam 23 placed beneath the main wing 15 and auxiliary wing 21 the trolley 26 of Fig. 1, must be turned upside down as shown at 27 in Fig. 9.

The auxiliary airfoil 21 in retracted position nestles within the recess below the trailing portion 20 of the wing 15, its under surface forming a continuation of the curvature of the underside of the main wing 15. In order to move the auxiliary airfoil to desired positions is provided a rod 33 to the rear end of which is secured a cable 34 which in turn is wrapped around drum 35 to which it may be secured as by bolt 36. To the forward end of the rod 33 is secured a second cable 37 which is also wrapped around drum 35, but in a direction reverse to that of cable 34, and it may be secured thereto as by bolt 38. The rear end of rod 33 may be pivotally secured to the front portion of the auxiliary airfoil 21 by a fitting 39. The drum 35 is locked to a control torque shaft 40, which may be manually operated from the pilot's seat through any suitable and convenient means, not shown, to vary the position of the auxiliary airfoil 21. Rotation of the drum 35 in a counter-clockwise direction pulls upon cable 37 and therefore pushes the rod 33 backward and thus extends rearwardly the auxiliary airfoil. Cable 34 unwinds from drum 35 as rod 33 moves backward. A reverse turning of control torque shaft and hence of the drum pulls upon cable 34 and moves the flap 21 forward to close it. Push and pull rod 33 is supported at a point adjacent to the drum 35 by a roller 41 suspended by two plates 42 which are free to swing about the center of the drum and thus permits a true alignment of rod 33 to the drum 35 throughout its entire length of movement. The front end of rod 33 may be provided with a roller 43 which guides the rod through a tube 44 secured to the rear spar 17.

Auxiliary airfoil 21 may be made up into two parts, i. e., with a leading edge airfoil 21B secured in fixed relationship by bracket 21C to the auxiliary airfoil 21 thereby forming a slot. When auxiliary airfoil is closed, or nearly so, there is practically no airflow between 21B and 21, but when the airfoil 21 is in fully extended position the airflow is accelerated and thereby increases the lift over the wing which is in addition to the gap G (Fig. 2) which also increases the lift. It will be obvious to anyone skilled in the art that the shape of the slot functions on the principle of the venturi and, since it is fixed within the auxiliary airfoil 21 which is in turn relatively fixed to the trailing edge of the main wing, serves to increase the velocity of the airflow through the combined wing and auxiliary airfoil combination to thereby accelerate the boundary layer of air, and therefore the negative pressure over the upper surface of the main wing. There is also a slight increase in positive pressure over the lower surface.

As shown in Fig. 2 in full lines it is contemplated that the lifting power of the wing may be varied within wide limits. To this end the beams 22 or 23 may be shaped in any preferred manner with a comparatively large curvature within a predetermined distance to obtain a cam effect, movement of the trolleys 26 or 27 therein rearwardly first causing the upper surface of the auxiliary airfoil 21 to move along and in approximate contact or, in other words, in measurably close clearance with the under surface of the trailing edge 20 of the main wing 15, thus in effect creating a main wing of larger area without bringing into force the effects created by use of the space G or of the slot between portions 21 and 21B of the auxiliary airfoil. At the same time the effect of the shaping of the beams 22 or 23 is to maintain very low angles, from 3° to 10° between the chord lines of the auxiliary airfoil and that of the main wing during at least (or substantially within) the first

half of the rearward movement of the auxiliary airfoil. This combined relationship gives a higher lift with a low drag, thus producing a more efficient airplane under certain circumstances than the normal main wing type of design.

As the flap approaches the end of its rearward movement means are provided whereby a large angular setting and spaced relationship may be quickly attained by the use of cam 45 shown inclosed in the rear end of beam 22 or 23. The under side of cam 45 is shaped to conform to the enclosed curvature of the rectangular hollow confines of beam 22 or 23 and is hinged as at 46. The cam 45 may be held in open position by spring 47 thus maintaining a position as shown by the broken lines in Fig. 4. As the rear roller 29B in moving rearwardly approaches the hinged center 46 it contacts and raises the rear end of the cam thus lowering its forward end and opening a passage way through which roller 29A is guided upwardly and quickly causing an increase in the angle of incidence of the auxiliary airfoil 21. Slot 45A in the cam permits plate 28, which supports roller 29A, to project therethrough.

After the auxiliary airfoil 21 is moved rearwardly to the best predetermined location for take-off a small flap 50 hinged to the rear of the auxiliary airfoil and otherwise forming a part thereof is caused to deflect downwardly by a connecting rod 51 secured to arm 52 and to a fitting 53 which is slidable in a slotted end of trolley plate 28 (Fig. 4). The fitting 53 may be moved forwardly by contacting stop 54 fixed to the extreme end of trolley beam 22 and will continue to do so until both the auxiliary airfoil 21 and the small flap 50 have reached their outermost positions. As the auxiliary airfoil 21 is retracted the trolley 26 moves forward and relieves the pressure on fitting 53 and permits the small flap 50 to be pulled back into neutral position by spring 50A. The small flap 50 may extend across the entire span of the auxiliary airfoil or only just a portion of it, depending upon the requirements.

As the auxiliary airfoil 21 is extended rearwardly the center of pressure also moves rearwardly which tends to cause the airplane to nose over and thus introduces an unbalanced couple. Up to a reasonable partially extended position of the auxiliary airfoil the nosing over tendency is prevented by directing the trailing edge of the elevators upwardly and thus introducing a counterbalancing moment. However, as the auxiliary airfoil continues to extend to its rearmost position it is advantageous to have an independent control means on the tail surfaces so that the elevator can be used by the pilot for the usually required directional control. This independent control takes the form of a plate or auxiliary elevator 63 mounted on the upper side of the horizontal tail surfaces 60 and preferably hinged as at 65 to the rear spar 64 of the stabilizer in front of the conventional elevator 66. It is contemplated that the pressure of the air shall act directly on surface 63 and not to pass upward through the space left open when the auxiliary elevator is deflected upward. This surface is directly connected to the mechanism operating the auxiliary airfoil in the main wing so that as the latter extends rearwardly and after some predetermined intermediate position the auxiliary elevator surface commences to rise until finally when the auxiliary airfoil is fully extended the auxiliary elevator is also in its full uprised position.

As shown in Figs. 11 to 14 the auxiliary elevator may be controlled by linkage between it and the auxiliary airfoil control shaft 40. To this end a threaded portion 55 on the shaft 40 is engaged by a similarly threaded portion on a spool 56. The two threaded portions are so proportioned that when the auxiliary airfoil 21 is closed the spool 56 is thrust to one side of the threaded portion on the shaft 40, but when the shaft 40 commences to rotate as the auxiliary airfoil opens it screws into the spool without rotating it until the end of the thread is reached or the spool reaches some other predetermined stop at which time the spool rotates with the shaft. Cables 57 connected to the spool 56 pass through a guide 58 to a spool 61 keyed to a shaft 59 mounted on the horizontal tail surface 60. Conventional linkage 62 between the shaft 59 and the auxiliary elevator 63 raises the latter when the shaft is rotated. When the auxiliary airfoil 21 is fully extended the auxiliary elevator 63 has been forced to its most uprised or deflected position. The chord of the auxiliary elevator may be from 10 to 15 percent of the horizontal tail surface chord and may cover from 50 to 100 percent of the horizontal tail span.

In operation, an aircraft having my invention installed may take-off by extending the auxiliary airfoil to a position approximately equal to from three-quarter to seven-eighth of its full out movement with a deflected angle of between 25° and 30° to the chord line of the normal wing. Such position may either be set by the pilot prior to taking-off or by gradually extending it as the take-off is under way until at the instant of take-off it has reached the ideal partially extended position. It is expected that the latter procedure will be more conductive towards reducing the take-off distances of seaplanes. When the aircraft is in the air the auxiliary airfoil may be retracted to a shorter partially extended position, or approximately at twenty-five percent of its full out movement, and climb at a higher rate to a greater altitude or cruise at the most economical lift to drag ratio. When landing the auxiliary airfoil may be extended to the extreme rearward location, where it is definitely retained by the designated limitation of the movement of the control torque shaft, which resists the tendency of the auxiliary airfoil to close because of its aerodynamic negative chord force. Simultaneously the small flap 50 on the auxiliary airfoil is deflected to its fullest extent, at least downward 45° with relation to the chord line of the auxiliary airfoil and at which position its attending opening is also complete in that the leading edge of this small flap is perpendicular below and substantially in line with the edge of the upper surface of the auxiliary airfoil which is broken at that point, as related to the chord line of the auxiliary airfoil, thus introducing the highest lift obtainable with a proportionately high increase in drag. The combined effect is to steepen the glide preparatory to landing and to slow up the speed of the airplane on the ground. Throughout all these variable factors involving the change in lift, drag and center of pressure movement provision has been made for automatically trimming the longitudinal balance and thus insure safe and reliable operation of the airplane.

While I have described my invention as taking a preferred embodiment, such embodiment is not by way of limitation and it will be understood

that the various parts may be changed without departing from the spirit and scope thereof as set forth in the following claims.

I claim as my invention:

1. An aircraft wing including a normal cambered airfoil having a recess in the rear lower part thereof, a track fixed to said airfoil, an auxiliary airfoil slidable rearwardly with measurably small but gradually increasing angles with respect to said normal airfoil, but relatively fixed to said fixed track, means for moving rearwardly said auxiliary airfoil until its leading edge reaches substantially the extreme rearward position, automatic means comprising a cam within the rear end of said track for quickly increasing the angle of incidence of said auxiliary airfoil relative to said normal airfoil and for producing a spaced relationship between the leading edge of said auxiliary airfoil and the trailing edge of said cambered airfoil.

2. An aircraft wing comprising a cambered airfoil, a track fixed to said airfoil, a trolley movable on said track, an auxiliary airfoil connected to said trolley, and a front and a rear roller on said trolley lying within said track, said track comprising means for guiding said rollers to move said auxiliary airfoil rearwardly to position the leading edge thereof adjacent the trailing edge of the cambered airfoil and a pivoted cam actuated by one of said rollers for rapidly spacing said edges vertically apart and rapidly changing the angle of incidence of the auxiliary airfoil with respect to the cambered airfoil.

3. An airplane comprising an aircraft wing including a normal cambered airfoil having a recess in the rear lower part thereof, an auxiliary airfoil nestling in said recess, means for operating said auxiliary airfoil including a control shaft, a flap mounted on rear portion of auxiliary airfoil; a horizontal tail surface comprising a convential elevator, an auxiliary elevator mounted on the upper side of said stabilizer adjacent said conventional elevator; means for the automatically operating said auxiliary elevator comprising a threaded spool sometimes slidably mounted on the main control shaft and sometimes in locked engagement with said shaft, and linkage between said spool and said auxiliary elevator, the sliding of said threaded parts to be predetermined from the partially extended position of said auxiliary airfoil.

4. An airplane comprising an aircraft wing including a normal cambered airfoil having a recess in the rear lower part thereof, an auxiliary airfoil nestling in said recess; means for operating said auxiliary airfoil including a control shaft, a horizontal tail surface comprising a conventional stabilizer and elevator, an auxiliary elevator mounted on the upper side of said stabilizer adjacent said conventional elevator; means for the automatically operating said auxiliary elevator comprising a threaded spool sometimes slidably mounted on the main control shaft and sometimes in locked engagement with said shaft, and linkage between said spool and said auxiliary elevator, the sliding of said threaded parts to be predetermined from the partially extended position of said auxiliary airfoil.

5. In combination with a cambered airfoil having a recess in the rear lower part thereof, an auxiliary airfoil operatable along said recess, said auxiliary airfoil comprising a slotted leading edge portion, a main body portion, and a trailing edge portion, said trailing edge portion being angularly adjustable with respect to said other portions when said auxiliary airfoil is substantially in its rearmost position.

6. In an airplane in combination with a conventional stabilizer and elevator, an auxiliary elevator mounted for oscillation above said stabilizer, a rotatable shaft within said stabilizer, a spool keyed to said shaft, means for rotating said spool and mechanical linkage between said shaft and said auxiliary elevator.

7. In combination with a cambered airfoil having a recess in the rear lower part thereof, an auxiliary airfoil operable along said recess, said auxiliary airfoil comprising a main body portion and a rear flap forming in part at least a trailing edge portion, and means for angularly adjusting the angular relationship of said flap and said main body portion, said last named means being operable only when said auxiliary airfoil approaches its rearmost position.

HARLAN D. FOWLER.