July 28, 1936. H. ALFARO 2,049,188

AEROPLANE

Filed Sept. 15, 1933 3 Sheets-Sheet 1

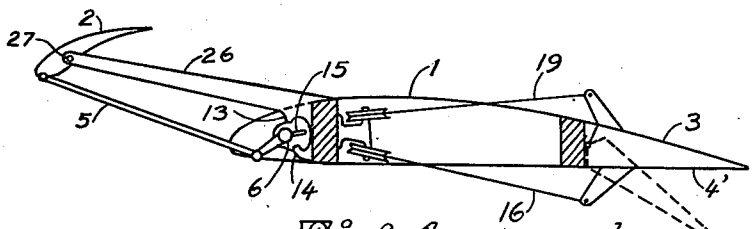


Fig. 1

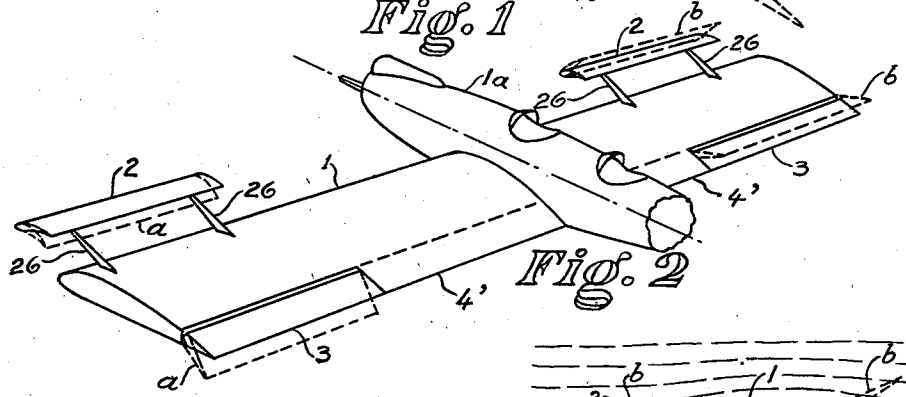


Fig. 2

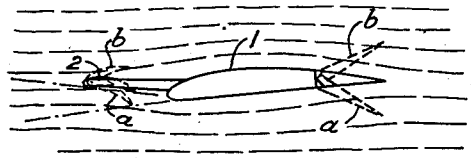


Fig. 4

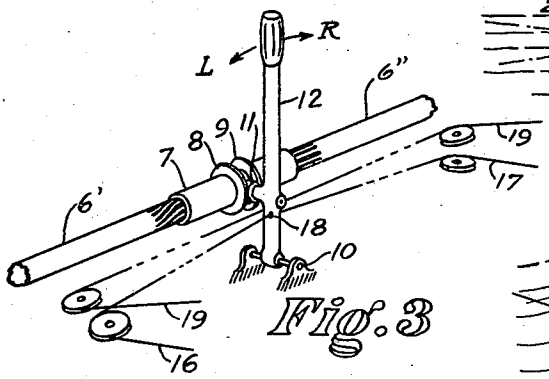


Fig. 3

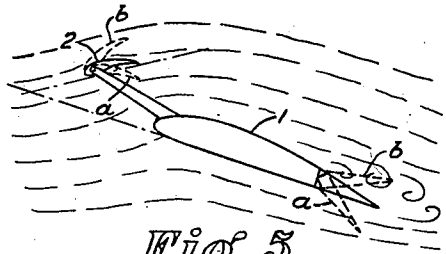


Fig. 5

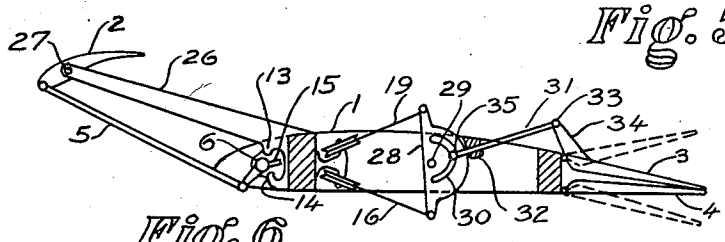


Fig. 6

INVENTOR.

Heraclio Alfaro

BY

Evans & Wiley.

ATTORNEYS

July 28, 1936. H. ALFARO 2,049,188

AEROPLANE

Filed Sept. 15, 1933 3 Sheets-Sheet 2

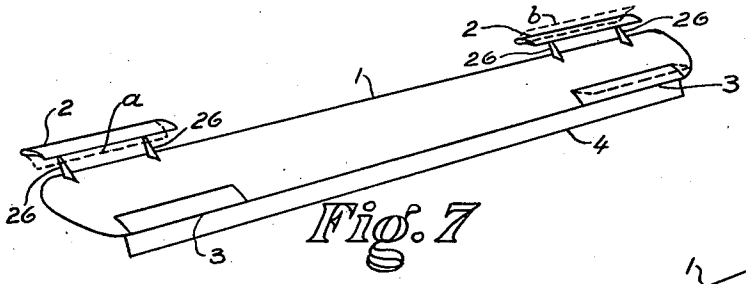


Fig. 7

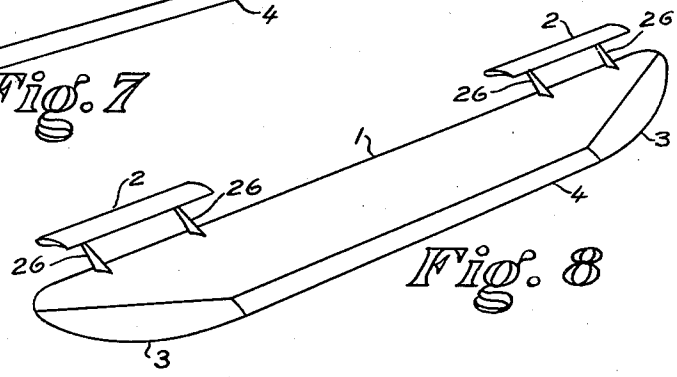


Fig. 8

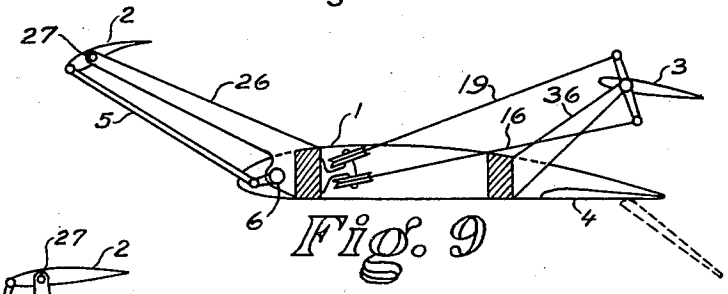


Fig. 9

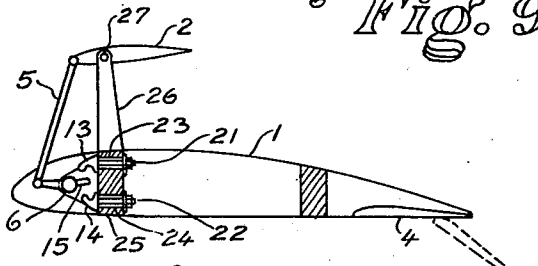


Fig. 10

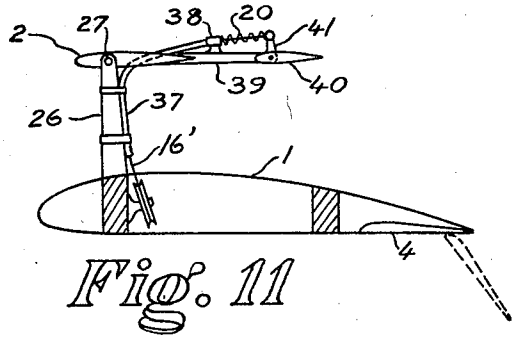


Fig. 11

INVENTOR.
Heraclio Alfaro

BY

Evans & McCoy

ATTORNEYS

July 28, 1936. H. ALFARO 2,049,188

AEROPLANE

Filed Sept. 15, 1933 3 Sheets-Sheet 3

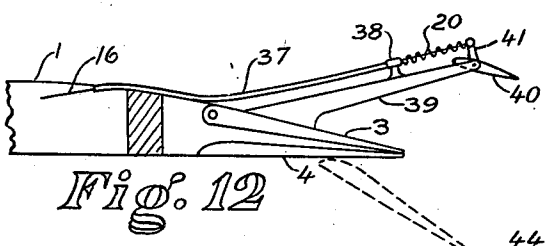


Fig. 12

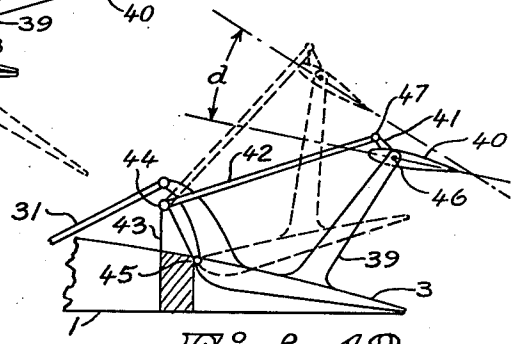


Fig. 13

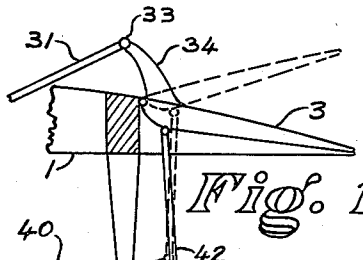
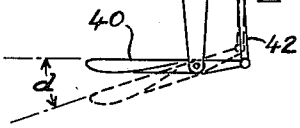


Fig. 14



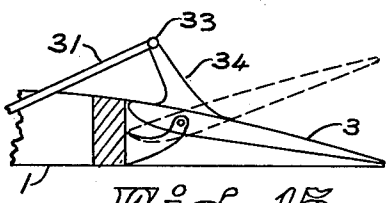


Fig. 15

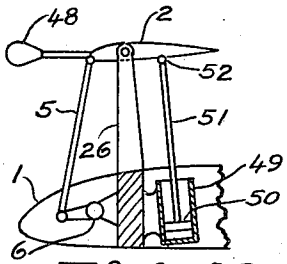


Fig. 16

INVENTOR.
Heraclio Alfaro
BY
Evans & Mecy
ATTORNEYS

Patented July 28, 1936

2,049,188

UNITED STATES PATENT OFFICE

2,049,188

AEROPLANE

Heraclio Alfaro, Cambridge, Mass.

Application September 15, 1933, Serial No. 689,603

3 Claims. (Cl. 244—29)

This invention relates to aeroplanes and more particularly to means of lateral or rolling control.

One object of this invention is to provide a quickly responsive lateral or rolling control for aeroplanes.

Another object is to provide a lateral control which maintains its effectiveness when flying at angles above that of stalling.

A further object is to provide a lateral control in which the creation of detrimental yawing moments is greatly reduced.

Still another object of this invention is to obtain the above mentioned results by means of control elements which increase the lift of the low wing instead of decreasing the lift of the high wing.

One more object is to provide lateral control elements, the operation of which, to obtain the desired action, requires little effort upon the part of the operator.

A further object is to provide a controlling mechanism which is of simple and dependable construction, which is of light weight, and which may be manufactured at small cost.

With the above and other objects in view, the invention may be said to comprise the construction as illustrated in the accompanying drawings hereinafter described and particularly set forth in the appended claims, together with such variations and modifications thereof as will be apparent to one skilled in the art to which the invention appertains.

Reference should be had to the accompanying drawings forming a part of this specification in which,—

Figure 1 shows in section a wing provided with a flap and the means of lateral control comprising this invention;

Fig. 2 is a perspective view of the wing shown in Fig. 1;

Fig. 3 is a fragmentary view showing the controlling mechanism;

Figs. 4 and 5 are diagrammatic views showing the behavior of the floating auxiliary airfoil for two different wing angles;

Fig. 6 is a sectional view showing the invention applied to a wing having a full span flap at its trailing edge;

Fig. 7 is a perspective view of the wing shown in Fig. 6;

Fig. 8 shows in perspective the invention applied to a wing having ailerons of the skew type;

Figs. 9 and 10 are sectional views showing various forms of lateral control devices embodying the invention;

Figs. 11 to 16 inclusive are sectional views showing various devices for counterbalancing auxiliary airfoils and ailerons.

In this specification, as well as in the following claims, the word "floating" means self aligning or feathering, with relation to the air flow. "Floating airfoil" means an airfoil so pivoted that, when exposed to an air flow it will align itself substantially edgewise to the stream and will receive a very small or no air reaction perpendicularly to the air stream. "Auxiliary airfoil" means an airfoil that is so related to a lifting unit that by its proximity it influences the flow about said lifting unit so as to change appreciably its lift and drag characteristics. "A floating auxiliary airfoil" is a floating airfoil as above described that can become an auxiliary airfoil as herein described when properly offset from its normal floating position.

"Up-going" or "up-moving ailerons" are those which have upward motion only from their normal position.

"Full span flap" means one of which the span is not limited by the presence of ailerons. It may not exactly have the same total span as the wing, since it is preferable to allow some distance for rounded wing tips, etc. Fig. 7 shows a typical full span flap. The term "body" is to be understood to mean the main fuselage or nacelle of the aircraft or part where most of its vital elements and main weights are concentrated.

"Servo vane" means a vane designed to do some work, as for instance the vane **40** shown in Figs. 11, 12 and 13, where said vane exerts partly or wholly the force necessary to deflect the auxiliary airfoils **2** or the ailerons **3**, out of their normal position.

The conventional type of lateral control of present day airplanes does not provide satisfactory action when flying at or near the angle of attack corresponding to the maximum lift. My invention contemplates means to obtain satisfactory lateral or rolling control at high angles of attack, including angles of stall and angles above that of stall.

I have found that, by properly placing an auxiliary airfoil in the forward part of the wing and by pivoting it forward of its center of pressure so as to allow it to float freely in the air flow, the lift and drag characteristics of a wing at any angle are not very materially altered. I have found that, by deflecting angularly the auxiliary airfoil from this floating position, the lift and drag characteristics of a wing can be substantially altered, especially at the higher angles. I have found also

that the change is proportional to the amount and direction of the deflection of the auxiliary airfoil.

I also discovered that by properly locating two pivoted auxiliary airfoils of suitable size near the tips of a wing, and by allowing both airfoils to float simultaneously in the air flow, when the two airfoils are offset angularly relative to each other a powe ful rolling moment is created. This effect can be utilized for lateral or rolling control of aeroplanes by the use of such auxiliary airfoils alone or in combination with conventional lateral control devices. If used alone, the location of the auxiliary airfoils may be different than when such auxiliary airfoils are used in combination with other lateral control devices.

The auxiliary airfoils alone, when properly located, give satisfactory control at low angles (high speed), having an action comparable to that of ordinary outside ailerons with floating characteristics.

When used in combination with other means of lateral control, the auxiliary airfoils function mainly at the higher angles of attack.

I have found also that at certain angles of attack the rolling control obtainable is increased by limiting the floating action of the auxiliary airfoil. For instance, at the higher angles of attack, as shown in Fig. 5, the auxiliary airfoil 2 floats at a rather pronounced negative angle relative to the wing. If the auxiliary is deflected angularly from that position in either direction, the lift is increased.

Although it is not increased equally when deflected in either direction, this feature reduces the available rolling control. A stop limiting the negative deflection of the auxiliary airfoil will greatly increase the rolling moment for a given deflection of the control lever.

Similarly, at the smaller angles of attack of the main wing, for certain locations of the auxiliary airfoil, the lift is reduced for any deflection of the auxiliary airfoil. A stop limiting the positive deflection of the auxiliary airfoil may improve conditions in some cases.

I found also that by means of pivoted vanes suitably actuated I could reduce the loads necessary to operate the controls.

Throughout the accompanying drawings the main airfoil or wing is indicated by the reference numeral 1, the body by the numeral 1*a*, the auxiliary airfoils by the numeral 2, the ailerons by the numeral 3, the independently controlled lift increasing flap by the numeral 4. This flap can be of any type, a sliding pivoted flap being shown in Figs. 9, 10, 11 and 12; a straight hinged flap being shown in Figs. 1, 2 and 8, and a whole span flap being shown in Figs. 6, 7, 9, 10, 11 and 12. In these views the flap is shown in dotted lines in its extended position.

As illustrated in Figs. 1 and 2, the wing 1 may be provided with auxiliary airfoils 2 and ailerons 3 combined for lateral control. The rear portion 4' of the center part of the wing shown in Fig. 2 between the ailerons may be hinged to serve as a flap and, as shown in Fig. 2, the hinged portion of the wing at its trailing edge consists of the ailerons 3 and the intermediate flap 4', the ailerons being disposed near the tips of the wing while the flap occupies the space between the ailerons.

As shown in Fig. 1, a link rod 5 associates the pivotal movements of the airfoils 2 to those of a connecting shaft 6. This shaft, as shown in Fig. 3, is divided in two parts or sections 6' and 6''. In order to provide the desired action the two sections of this shaft are splined. The splines of section 6' are helical, while those of section 6'' are straight. An internally splined sleeve 7 provided with two spaced circumferential flanges 8 and 9 fits on the splines of both sections 6' and 6'' and is slidable axially on them. A pilot's control lever 12 imparts axial movements to the sleeve 7. Said lever is pivotally supported at 10 to swing in a plane parallel to the axis of the shaft 6 and carries a roller 11 which engages between flanges 8 and 9 of the sleeve. When the lever is moved to the left L or to the right R, the sleeve 7 moves accordingly in the same direction. It can be seen that an axial adjustment of sleeve 7 imparts a rotative movement to shaft section 6', which varies the angular relationship of the two sections 6' and 6'' of the connecting shaft 6 without restricting the rotation of the complete shaft as a whole. Means is thus provided for changing the angle of attack of one of the auxiliary airfoils relative to the other without restricting their floating as a unit relative to the main wing.

When it is desired to limit the angular movements of the auxiliary airfoils, stops 13 and 14, shown in Figs. 1, 6 and 10, are provided for each of the two sections 6' and 6'' of the connecting shaft. These stops are in the path of pegs 15, one of which is rigidly attached to each of said shaft sections and projects between stops 13 and 14. The stops 13 and 14 may be made adjustable. As shown in Fig. 10, the stops 13 and 14 are integral with bolts 21 and 22, and these bolts pass through oversize holes 23 and 24 in the wing spar 25. The stops can therefore be secured tight to spar 25 at any desirable position within the limits permitted by the oversize holes.

When the auxiliary airfoils are used in combination with other means of lateral control the control lever 12 governs also the said other means of lateral control by acting on cords 16 and 17 attached to it at 18, the cords passing over suitable guide pulleys and to the adjustable controlling elements, for example the ailerons 3.

A cord 19, as shown in Figs. 1 and 3, is led over suitable pulleys and is attached at one end to one aileron and at its opposite end to the other aileron in order to associate the motions of the two ailerons in the usual way. As shown in Figs. 11 and 12, the connecting cord 19 may be replaced by a spring 20 which maintains a tension on the cord 16'.

In Figs. 4 and 5 the wing and lateral control devices are shown and the air stream indicated for a low angle and for a high angle of attack. In these views the airfoil and aileron are shown in dotted lines in their uppermost and lowermost position, the lowermost position being indicated by the letter "*a*" and the uppermost position by the letter "*b*".

Figs. 6 and 7 show a combined control, including an auxiliary airfoil 2 and up-moving ailerons 3. The flap used is a full span flap of the split hinged type. In Fig. 6 one of the ailerons and the actuating devices connected to the cords 16 and 19 are shown, it being understood that the opposite ailerons have identical actuating devices connected to cords 17 and 19. The cords 16 and 19 are attached at their ends to rocker arms 28 which are pivotally supported at 29, each having an arcuate slot 30. The upper half of the arcuate slot of each rocker arm is concentric with the pivotal axis 29 and the lower half of the slot

is eccentric with respect to the pivotal axis. Rods 31, which are slidably mounted in rigid bearings 32, are connected at their rear ends by pivots 33 to arms 34 rigidly connected to the ailerons 3. The forward end of each rod 31 has a portion 35 engaging in the arcuate slot 30 of the rocker arm, suitable means, such as a small roller, being provided to reduce friction and wear. When the rocker arm 28 is rotated in a clockwise direction from the position shown in Fig. 6 the movement of the end portion 35 into the concentric part of the slot 30 does not impart any endwise movement to the rod 31, and the aileron 3 remains stationary. When, however, the rocker arm 28 is rotated in a counter-clockwise direction from the position shown in Fig. 6 forward endwise movement is imparted to the rod 31 by the eccentric part of slot 30 and aileron 3 moves upward toward the position indicated by dotted lines. Since the rocker arms 28 and the control lever 12 are connected by the cord 16, the motions of the auxiliary airfoils and those of the ailerons are properly correlated.

Fig. 8 shows the same arrangement as Figs. 1 and 2, except that the ailerons are of the "skew" type instead of the conventional type.

Fig. 9 shows an aileron 3 mounted pivotally on standards 36 and actuated by cords 16 and 19 in the same way as the aileron shown in Fig. 1. The previously described connection of the actuating cord 16 to the control lever 12 relates the motions of the ailerons to that of the auxiliary airfoils.

If desired, the ailerons may be omitted. In the arrangement shown in Fig. 10 there are no conventional ailerons, the lateral control being obtained entirely by the motions of the auxiliary airfoils 2, which are placed near the tips of the wing as shown in Fig. 2.

Fig. 11 shows a means of reducing the force required to operate an auxiliary airfoil which can be applied to any of the auxiliary airfoils herein illustrated. As shown in Fig. 11, a cord 16' passes through a flexible tube 37. One end of said tube butts against a stop 38 rigidly attached to an arm 39, which is attached rigidly to the auxiliary airfoil 2 and carries a pivotally mounted vane 40 at its end. The cord 16' extending from the control stick is attached to arm 41 rigidly attached to vane 40. The cord 16', together with the spring 20, controls the motions of vane 40.

The cord 16' is attached to the control stick in the same way as cord 16 previously described, and a similar operating connection is provided for the opposite airfoil. When the auxiliary airfoils are used in combination with other means of lateral control, both cords 16 and 16' are attached to the control stick at, or nearly at, the same point. When the vane 40 is rotated clockwise from the position shown in Fig. 11, the air striking it will exert a force tending to rotate the auxiliary airfoil 2 anticlockwise. The reverse will happen when vane 40 is rotated in the opposite direction.

Fig. 12 shows a way of almost entirely eliminating the effort on the part of the pilot necessary to operate an up-going aileron. This may be combined with the auxiliary ailerons in front. The vane 40 is actuated by the cord 16 in the same manner as described in connection with Fig. 11. The cord 16 corresponds to cord 16' and numerals 37, 38 and 39 correspond to the elements to which the same numerals are applied in Fig. 11. When the vane 40 is rotated clockwise the air pressures exerted upon it will cause the aileron 3 to be projected outwardly from the contour of the wing, which will provide the required aileron action.

Fig. 13 shows another way of diminishing the effort required to operate ailerons actuated by mechanism such as shown in Fig. 6. The vane 40 is held from rotation by a rod 42 which is connected at opposite ends to an arm 41 fixed to vane 40 and to a standard 43 rigidly fixed to the main structure by pivots 44 and 47. When the aileron 3 is moved upwardly by the rod 31, the link 42 causes the vane 40 to swing about its pivot 46 in a direction to increase its angle of attack, as shown in dotted lines in Fig. 13, where "*d*" indicates the increase in angle of attack. This causes the air stream to exert a force on the vane 40 which assists in moving the aileron upwardly from its normal position in which it conforms to the contour of the main wing.

Other arrangements of vane 40 can be provided, locating it at other points forward or below the hinge of aileron 3. Fig. 14 shows one of such arrangements where the indicated reference numerals apply to the parts corresponding to those indicated by the same numerals in Fig. 13.

Another way of minimizing the air loads in up-going ailerons is by placing the hinge at a suitable distance from the leading edge of aileron 3. This is shown in Fig. 15, where also the reference numerals shown apply to the parts previously described. The air loads in the part of the aileron forward of the hinge tend to counterbalance the loads in the part backward from the hinge.

It may be advantageous to balance the auxiliary airfoil 2 statically. This can be done by placing a weight 48, as shown in Fig. 16, at the end of a member and at a suitable distance from the pivotal axis of the airfoil.

In some instances it may be advisable to incorporate a damper to avoid oscillations of the floating auxiliary airfoil. Fig. 16 shows a cylinder 49, and a piston 50 attached to a rod 51 which is hinged to the auxiliary airfoil 2, through a pivot 52. The cylinder 49 may be left empty or may be filled with any fluid. In some cases the damping effect of the air filled cylinder may be sufficient, otherwise the use of oil or other fluid may be necessary.

From the above description it can be seen that the floating auxiliary airfoil can be used in connection with plain wings or flap wings. In the last case it has the distinct advantage that it allows a whole span flap and therefore provides lateral control without hampering the lift increasing action of the full span flap.

The simplest combination is that of a plain wing with floating auxiliary airfoils to be used as lateral control means. This may be used also in combination with a flap.

In some cases the combination of the floating auxiliary airfoils with regular ailerons with or without differential action may be advantageous. The auxiliary airfoil is very effective at the higher angles of attack and the conventional ailerons of the trailing type, such as shown in Figs. 1 to 5, are quite efficient at the lower angles. The two sets of controlling elements combined have shown a great efficiency throughout all practical flying angles. This arrangement, however, cannot be used with a full span flap. If a flap is used at all it must be placed in the central part of the lifting unit or units, that is, inboard between the two ailerons, as shown in Figs. 1 to 5.

When a full span flap is used, a desirable combination is that of the floating auxiliary airfoils with up-going ailerons, such as shown in Figs. 6,

7, 12, 13, 14 and 15. Another good combination is that shown in Fig. 9, where an outside aileron is used instead of the up-moving type of aileron.

In each case the motions of the auxiliary airfoil are related to those of the ailerons as described.

The use of this system of lateral control with flaps allows: First, the use of a full span flap, and therefore of more efficient means to increase the maximum lift with suitable lateral control at higher angles, a feature previously never obtained; second, a more powerful lateral control, particularly at the lower speeds at which flap equipped airplanes can fly; third, considerable reduction of the detrimental yawing moments and of the resulting spinning tendencies occurring at the low flying speeds attainable with flap equipped airplanes.

It can be seen, therefore, that there is a definite association between the type of lateral control described above and flap equipped wings and that the advantages of this combination are of considerable importance.

Furthermore, it is to be understood that the particular form of apparatus shown and described, and the particular procedure set forth, are presented for purposes of explanation and illustration and that various modifications of said apparatus and procedure can be made without departing from my invention as defined in the appended claims.

What I claim is:

1. In an aircraft, a wing, a swinging airfoil associated with the wing, a servo vane carried by the airfoil, actuating means mounted on the wing, means connecting said actuating means to the servo vane for imparting movement to the vane in one direction, and a spring interposed between the vane and airfoil exerting a force on the vane tending to move it in a direction opposite to that in which it may be moved by said actuating means.

2. In an aircraft, a wing, an up-moving aileron carried by the wing adjacent its trailing edge, a servo vane movably mounted on said aileron, a spring for normally holding said vane in a position in which the air pressure thereon resists upward movement of the aileron, an actuator mounted on the wing, and a connection from said actuator to said vane for moving the vane in opposition to said spring.

3. In aircraft, a main airfoil, two floating auxiliary airfoils mounted thereon, operating mechanism interconnecting said auxiliary airfoils to swing in floating relation, means to actuate the operating mechanism to impart movement to the auxiliary airfoils in opposite directions, stop means for limiting the upward and downward movement of each auxiliary airfoil so that, in normal floating, the up moving airfoil will reach its limit of movement before the down moving airfoil reaches its limit of movement.

HERACLIO ALFARO.