To all whom it may concern:

Be it known that we, ORVILLE WRIGHT and JAMES M. H. JACOBS, citizens of the United States of America, residing at Dayton, county of Montgomery, and State of Ohio, have invented certain new and useful Improvements in Airplanes, of which the following is a full, clear, and exact description.

The present invention relates to airplanes and particularly to aerfoils used in the construction thereof, and also to the control of aerfoils.

It is among the objects of the present invention greatly to increase the lift of the aerofol thereby permitting considerably lower flying speeds than heretofore possible.

A further object is to increase the lift of the aerofol without making it necessary to fly with the fuselage of the airplane inclined to the horizontal a relatively large amount. This permits the airplane to take off or land with its fuselage in a more nearly horizontal position and hence a landing chassis of lower height may be used.

A further object is to move nearly equalize the drift of the two opposite wings of an airplane while maintaining lateral balance.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein preferred forms of embodiments of the invention are clearly shown.

In the drawings:

Figs. 1, 2 and 3, show the general nature of the flow about a conventional aerofol in three positions, respectively, normal flying position, greatest lift position and when at an angle exceeding that for greatest lift;

Fig. 4 shows the profile of an aerofol embodying the present invention disposed to produce a greater lift than could be obtained with the conventional type, said aerofol having a flap forming a part of its lower surface, the upper surface remaining fixed;

Fig. 5 shows the profile of this aerofol disposed to produce a lesser lift;

Fig. 6 shows the same aerofol in normal flying position;

Figs. 7 to 10 show another form of the invention shown in Figs. 4 to 6, in which portions of both the upper and lower surfaces of the aerofol include flaps;

Fig. 11 shows a modification wherein the lower flap is hinged upon the upper flap;

Fig. 12 is a fragmentary perspective view of an airplane having aerofol panels and controls embodying the present invention; and

Fig. 13 is a fragmentary sectional view of an aerofol flap construction.

Referring to Figs. 1, 2 and 3, 20 designates the profile of a conventional aerofol having an upper surface represented by line 21 and a lower surface represented by line 22, said lines joining at the leading and trailing edges of the aerofol 20. In Figs. 1 to 6, line 23 denotes the normal direction of air current assumed to be the horizontal.

It is generally understood in aeronautics that the smaller the angle of incidence of a given aerofol, the smaller the lift within the range of flying angles. It has also been established that the greater the angle of incidence of the same aerofol, the greater the lift up to a certain well defined limit. This limit is that angle at which the air flow over the upper surface of the aerofol ceases to be in the form of a continuous stream and commences to eddy above the rear portion. These premises are illustrated graphically in Figs. 1, 2 and 3 of the drawings.

It will be noted that in Figs. 1 and 2, the air streams represented by lines A, A', and B and B' are substantially smooth flowing currents divided by the front edge of the aerofol 20 and passing along the upper and lower surfaces 21 and 22 fairly close thereto. In Fig 2 the stream B is illustrated as following a path over the trailing edge at a little distance therefrom. This illustration depicts very clearly what is actually the case and the zone marked "low pressure" is at a pressure which is somewhat below atmospheric. It is understood that the aerofol is lifted due to the difference in pressure on the upper and lower surfaces.

In Fig 2, the aerofol is shown at position
of greatest lift. What the angle of incidence is for this position will of course depend on the aspect ratio of the particular aerofoil chosen for illustration. If the angle of incidence exceeds a certain value the lift is partially destroyed as shown in Fig. 3. The upper current line B of Fig. 2 now breaks into a series of eddies C, C, C, C, etc., which swirl off into the air leaving new ones to be continually formed. Since the low pressure above the surface 21 is partially destroyed, the lift of the aerofoil decreases. This certain value of the angle of incidence at which the air stream above the upper surface 21 breaks is called the critical angle of a bubble point.

It is also well known that the lift of an aerofoil may be increased by increasing its camber within certain limits in excess of which the upper air stream will break into eddies and the partial vacuum above the upper surface will be destroyed. One form of the present invention discloses means and a method for increasing lift by changing the camber of the whole aerofoil, but only of its lower surface leaving the camber of the upper surface fixed, that is having the conventional form. Fig. 6 shows the profile of an aerofoil 50 having an upper surface 31 and a lower surface including a leading portion 32 and a trailing portion 33 which is carried by a flap 54 pivoted at 55. When flap 54 is folded the aerofoil takes the conventional form as shown in Fig. 1.

In Fig. 4, the aerofoil is inclined and the flap 34 is dropped to produce a very great lift. The inclination and the spread of the flap depending on the type of section and aspect ratio. E denotes the upper stream line which forms a swirl at E' not above the surface 31 but well beyond the trailing edge of the aerofoil, F denotes the lower stream line which forms a swirl also beyond the trailing edge forming similar eddies as the eddies like E' drift away and are dissipated. The low pressure zone marked in Fig. 4 remains undestroyed because the camber of upper surface 31 is not increased and the surface 31 stays in position to prevent the breaking of the upper stream line E into eddies above the surface 31. The eddies are not formed except back of the trailing edge where their presence does not affect the lift. The zone above flap 34 is practically a dead air space so far as known. As the static pressure on the upper and lower sides of this zone remains the same there is practically no effect on the lift. By actual test of several types of sections it has been found that the lift of an aerofoil embodying the present invention is very much greater than can be obtained with the conventional type.

From the foregoing it is apparent that the aerofoil embodying the present invention is of such form as to permit greatly increasing the angle of incidence of the underside of the aerofoil without inclining to a very large extent the part of the aerofoil directly attached to the fuselage. The advantage which results is that the lift may be greatly increased while the fuselage of the airplane having such aerofoils is flying almost in normal or streamline position. Furthermore the airplane may take off and land while its fuselage is move nearly in a horizontal position and hence a landing chassis of lower height may be used.

An airplane having wings constructed in accordance with Fig. 4 could be controlled by pulling down the flap of the right wing further than the flap of the left wing and vice versa. Fig. 4 may represent the condition of the left wing while the right wing may be disposed as shown in Fig. 5 to produce a lesser lift. But since the lift increases with the lift it is desirable to provide means for more nearly equalizing the drift on both sides of the airplane. The form of the invention now to be described is particularly directed toward maintaining equal drift on both sides of the airplane while maintaining lateral balance.

Referring to Figs. 7 and 12, showing a practical application of the invention to an airplane, 50 designates an airplane supported in flight by left wing 51 and right wing 51 which are similarly constructed. Wing 51 includes a portion 52 fixed to fuselage 53, and flaps 54 and 55 hinged at 56. Flap 54, the lower flap, corresponds to flap 34 of Fig. 4, and flap 55, the upper flap, operates as an aileron in conjunction with the lower flap. Flaps 54 and 55 when folded and in the position shown in Figs. 7 form with the portion 52, the conventional type of aerofoil, flaps 54 and 55 forming the trailing portions of the aerofoil. Flaps 54 and 55 are preferably hinged back of the median line of the aerofoil and intermediate the upper and lower surfaces.

Flap 54 is provided with horn 57, and flap 55 with horns 58 and 59 with which controlling cables are connected. Spring 60 connects flaps 54 and 55, spring 60 being at least strong enough to overcome the weight of flap 54. Air pressure may be depended upon to force flap 54 against flap 55 when the horn 57 is released.

The prime numbered parts of wing 51 correspond to the similarly numbered parts of wing 51.

Horn 57 is connected by cable 61 with winding drum 62 which is mounted on shaft 63 carrying sprocket 64 connected by chain 65 with sprocket 66. Sprocket 66 is mounted on shaft 67 carrying crank 68 and ratchet 69, cooperating with pawl 70. Elements 84, 85 and 66 are shown as belt connected for sake of clearness, but it will be understood that preferably these elements are positively

geared as described. It will also be understood that the winding drum 62 may be power operated, if desired, that is, driven by the airplane engine or by a separate motor. The control stick 90 may be power operated if desired. The horn 57' is connected with drum 62 by a similar cable 61'. Before cables 61 and 61' reach the drum 62 they must pass, respectively, around pulleys 71 and 72 and 71' and 72', and then pass together around pulley 73 supported by aileron control shaft 74 and then together through said shaft 74.

Shaft 74 has bearings at 75 and 76 and carries sector 77 which supports pulleys 72 and 72'. Wire 80 which passes around pulley 81 connects horn 58 with sector 77 preferably adjacent the axis of pulley 72; and wire 80' passing around pulley 81' similarly connects horn 58' and sector 77. Wire 82 passing around pulleys 83 and 83' connects horns 59 and 59'.

Control stick 90 is pivoted at 91 upon shaft 74 and is connected at 92 and 93 respectively with elevator control cables 94 and 95. It is apparent that sidewise movement of stick 90 will operate the flaps 55 and 55' as ailerons in the usual manner. By tying the lower flaps 54 and 54' respectively with 55 and 55', the two sets of flaps 54—55 and 54'—55' will together operate as ailerons, either when flaps 54—55 and 54'—55' are closed or when opened to increase the lift.

By turning the crank 67 counter-clockwise the drum 62 will wind up cables 61 and 61' at the same time and equal amounts, thereby separating the flaps 54—55 and 54'—55' respectively, simultaneously and equal amounts. This is desirable since the lift on both sides of the fuselage should be the same when flying straight ahead. This arrangement of flaps is shown in Figs. 8 and 12, the upper flaps 55 and 55' remaining in normal position. The pawl 70 is intended to maintain ratchet 69 and therefore flaps 54 and 54' in the desired position of adjustment with respect to the upper flaps. Of course for decreasing the angle between flaps 54—55 and 54'—55' the crank 67 must be turned in the opposite or clockwise direction.

If the control stick is moved in the direction of arrow 96 the flaps 54 and 55 will be moved down to increase the lift on the left side as shown in Fig. 9 while flaps 54' and 55' will move up as shown in Fig. 10 to decrease the lift on the right side. In this manner the airplane is caused to maintain the lateral balance while at the same time giving more nearly equal drift on both wings. In normal flight both pairs of flaps return to the position shown in Fig. 8 with the angle between the flaps remaining the same.

Therefore it is seen that the camber of the lower surface of the aerofoil may be changed without changing the camber of the upper surface simply by operating the winding drum. Then the camber of both surfaces of the aerofoil can be changed whether or not the winding drum is stationary and this latter adjustment can be made without changing the setting made by the first adjustment.

While in Fig. 12, the wings of the airplane are shown as having flaps extending the whole length of wing portions fixed to the fuselage, it is to be understood that certain trailing portions of the wings may be relatively fixed while other portions comprise flaps constructed and arranged in accordance with the present invention. In other words, the wings may be said to have flaps forming part or all of the trailing portions thereof.

Fig. 11 is a modified form of aerofoil in which the lower flap 54' is hinged at a different point 56' from the hinge 56 of flap 55'.

Fig. 13 shows one manner of constructing the flaps 54 and 55. Since the space between these flaps has no function the inner surfaces of these flaps need no covering, therefore the ribs of the flaps may be made nearly as deep as the total depth of both flaps except where joined to the spars. In Fig. 13, flap 54 includes spar 100 supporting a plurality of overhanging ribs 101 covered by covering 102. Flap 55 includes spar 103 supporting a plurality of overhanging ribs 104 covered by covering 105. When the flaps are folded these ribs 101 and 104 telescope past one another somewhat as the blades of an ax. The advantage is that the flaps may be more substantially constructed than where the rib depth is about equal to the depth of the flap.

While the forms of mechanism herein shown and described, constitute preferred forms of embodiment of the present invention, it is to be understood that other forms might be adopted all coming within the scope of the claims which follow.

What we claim is as follows:

1. In an aerofoil, means for changing either the camber of its upper surface or the camber of its lower surface independently of one another.

2. In an airplane control, the combination with an aerofoil having flaps forming, respectively, the trailing portions of its upper and lower surfaces; of means for moving said flaps relative to each other, and means for moving said flaps relative to the aerofoil while keeping the angle between the flaps constant.

3. In an airplane control, the combination with an aerofoil having flaps forming, respectively, the trailing portions of its upper and lower surfaces; of means for separating...
said flaps; and means for moving said flaps with respect to the aerofoil without changing the relation between the flaps.

4. In an airplane control, the combination with an aerofoil having flaps forming, respectively, the trailing portions of its upper and lower surfaces; of means for moving the lower flap without moving the upper flap while maintaining said flaps in fixed angular relation.

11. In an airplane control, the combination with an airplane having right and left wings, each of said wings having upper and lower flaps forming, respectively, trailing portions of the upper and lower surfaces of said wings; of means for moving the lower flaps independently of the upper flaps; and a second means for moving the upper and lower flaps together while maintaining said flaps in fixed angular relation.

12. In an airplane control, the combination with an airplane having right and left wings, each of said wings having upper and lower flaps forming, respectively, trailing portions of the upper and lower surfaces of said wings; of means for moving said lower flaps; and means for moving the upper and lower flaps on the right wing in one direction and the upper and lower flaps on the left wing in the opposite direction and vice versa.

13. In an airplane control, the combination with an airplane having right and left wings, each of said wings having upper and lower flaps forming, respectively, trailing portions of the upper and lower surfaces of said wings; of means for moving the lower flaps simultaneously in the same direction; and means for moving the upper flaps on the right wing in one direction and the upper flaps on the left wing in the opposite direction and vice versa.

14. In an airplane control, the combination with an airplane having right and left wings, each of said wings having upper and lower flaps, forming respectively, trailing portions of the upper and lower surfaces of said wings; of means for moving the lower flaps on both sides of the airplane simultaneously in the same direction; and means for moving the upper and lower flaps on one side of the airplane in one direction and the upper and lower flaps on the other side of the airplane in the opposite direction.

15. In an airplane control, the combination with an airplane having right and left wings, each of said wings having upper and lower flaps forming, respectively, trailing portions of the upper and lower surfaces of said wings; of means for moving the lower flaps independently of the upper flaps; and means for moving the upper flaps on the right and left wings in opposite directions.

16. In an airplane control, the combination with an airplane having right and left wings, each of said wings having upper and lower flaps forming, respectively, trailing portions of the upper and lower surfaces of said wings; of means for moving the lower flaps independently of the upper flaps; and a second means for moving the upper and lower flaps together.
flaps on both sides of the airplane simultaneously equal amounts in the same direction; and means for moving the flaps on one side of the airplane in one direction and the flaps on the other side of the airplane in the opposite direction while maintaining fixed the angular relation between the sets of upper and lower flaps.

In testimony whereof we hereto affix our signatures.

ORVILLE WRIGHT.
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Witness:
A. C. LEHMAN.