This invention relates to wings of airplanes with variable aerodynamic characteristics, so that they can be modified by the pilot during flight for giving best service during the various maneuvers. The invention includes the use of my novel modification by way of quasi ailerons for obtaining lateral control.

My novel airfoil modification device has a great many advantages, all of which cooperate with each other so as to make each single advantage of peculiar value. It requires control displacement motions and control forces of moderate magnitude. It acts quickly and without undue delay. It includes in its effects a very quick and thorough lift elimination or lift spoiling, so conveniently obtained that it is feasible and contemplated to connect the control for lift spoiling with the control for the wheel brakes, so that the lift is automatically spoiled whenever the wheel brakes are actuated, and the wheel brake action thereby multiplied in effectiveness. My wing control is free from icing troubles, because in neutral position no narrow passages remain open and give opportunity for ice to deposit.

My wing modifying device can be used for replacing the conventional ailerons. It offers then the considerable advantage of partly or even wholly eliminating the unfavorable yawing moment associated with the creation of a lateral moment by conventional ailerons. That is to say, my novel lateral control does not tend to turn the airplane about a vertical axis so that the wing lifted up is retarded.

My novel lateral control offers distinct advantages in cooperation with flap means serving as high lift devices. It permits extending such flaps all way from one tip to the other, leaving them fully operative throughout the entire span. It does not restrict the flaps or the region of their full operativeness to extend from the inner end of one aileron or quasi aileron to the inner end of the other aileron or quasi aileron only.

Another advantage of my control used in such cooperation resides in a changelessness of the control capacity for equal displacement of the control. The control capacity is different according to whether the airfoil is in its high lift or in its low drag condition in such manner that the control capacity is larger with high lift, that is at low speed, than with low drag, that is at high speed. That is a considerable advantage. For with conventional airplanes, there is an excess of lateral control at high speed, inviting the danger of over-control, and there is a scarcity of lateral control at low speed, interfering with good maneuverability just when that is most desired.

My control ameliorates both defects. It is the object of my invention to provide for airfoil lift variation means having all these advantages, or any of them by itself or in combination.

That is accomplished by providing the wing with slot means adapted to emit at the top side of the airfoil an air jet in forward direction, that is opposite to the direction of air flow. That jet may be turned on or off by the pilot. As an alternative and further improvement, forwardly directed jets and rearwardly directed jets are provided, and are put under the control of the pilot. The slot means extend substantially in spanwise direction. A single passage may often be sufficient, but the invention can also be used with multiple or branched passages serving as slots. The slot is preferably positioned behind the major portion of the airfoil section. For lateral control, at least two such jet emitting slots are contemplated, one at each wing, preferably extending into the tip regions. It is preferred to employ forwardly and rearwardly discharging exits at each side, and to create a lateral control moment by simultaneously discharging a forwardly directed jet on one side and a rearwardly directed jet on the other. During the later phases of landing, the lift of both wings is spoiled by discharging a forwardly directed jet on both sides. The contact between the ground and the moving or motionless airplane is thereby greatly improved.

These and other desirable objects and advantages of the present invention will be illustrated in the accompanying drawings and described in the specification, certain preferred embodiments being disclosed by way of illustration only; for, since the underlying principles may be incorporated in other specific devices, it is not intended to be limited to the ones here shown, except such limitations are clearly imposed by the appended claims.

In the drawings, like numerals refer to similar parts throughout the several views, of which—

Fig. 1 represents the top view of an airplane incorporating my invention,
Fig. 2 represents a partial vertical longitudinal cross section through the same airplane,
Fig. 3 represents an elevational rear view of a portion of the control transmitting gear,
Fig. 4 shows some members of gear Fig. 3 in top view,
Figs. 5 to 8 represent a cross section through the wing of Fig. 1, on line 4—4, depicting several
characteristic positions of the lateral control device and of the high lift device or flap employed, the Fig. 9 represents a cross section fully analogous to Fig. 5, of a modified design, having a branched rather than a single slot passage.

Fig. 10 represents a fragmentary plan view of the mechanism of Fig. 9 seen from above, and Fig. 11 represents the same in chordwise vertical cross section and partly elevation. Fig. 12 is a partial cross section through the wing corresponding to Fig. 11, but showing a variation of the slot exit closing device. Figs. 13 and 14 show the upper portion of Fig. 12 with the slot closing device in different characteristic positions.

Fig. 15 represents a plan view of the mechanism of Fig. 12 seen from the inside of the wing, looking upward.

Fig. 16 shows a still other slot closing device in fragmentary cross section analogous to Fig. 5, and Fig. 17 shows the cover member of the same in a like manner but in a larger scale.

In Fig. 1 there is shown an airplane having wings 20 and 21 provided with flaps 22 and 23 at their trailing edge 27, said flaps extending all way to the tips 34. The inside of the wings communicate with the outer air space through upper spanwise extending slot exits 24 and 25 wider near the tips 24 than at their inner ends 35, and through corresponding lower slot entrances 26. Entrance and exit and the inside of the wing communicating therewith, in unison, constitute slot means 36, broadly. The same are positioned behind station 38 of maximum wing thickness. Entrance 26 is adjacent the trailing edge 37, and in rear of the exit 24; the exit 24 is positioned in the rear portion of the wing section.

During steady straight flight, the upper slot exits 24 and 25 are tightly closed by valve means or cover members, and my invention embraces equally the employing of internal cover or valve members 39 or of external cover members 40. In the preferred embodiment shown in Figs. 5 to 12, the internal cover member 30 consists of a cylindrically bent plate, having the cross section of a circular or other arc, and being mounted on the upper wing wall 31 by means of flexible strips 32 and 32', the latter being fastened at their one end to the wing wall 31 and at their other end to the cover 30. Spiral tension springs 28 stretched between the wing wall and the cover pull the cover tightly against the wing wall, and, in the position of the cover drawn in solid lines in Fig. 9, close slot exit 25. Rubber edges 29 assist in making the fit positively close and in preventing the passage of air through the upper exit 24 and 25, so that the slot is closed, blocked, or made ineffective or inoperative, and the formation of ice deposits is also prevented.

The arrangement of the strips 32 makes it possible to roll the cover 30 along the inner side of the wall 31 in a substantially chordwise direction, whereby some of the strips, such as for instance 32, are wound on the cover, and some in opposite relation, such as 32', are unwound. When so rolled into the rearward position drawn in dashed line in Fig. 11, slot exit 25 is opened and, in that the forward portion 30' of cover 30 together with the wall portion 31' of wall 31 form an air exit guide admitting or discharging an air stream or jet tending to flow in rearward or downstream direction as indicated by arrows 33. It has to be clearly understood that opening 25 discharges air, and opening 26 receives air, and not conversely, because the air pressure at the bottom, near 26, is generally larger than at the top, near 25. This necessary condition determines in each single case the final choice of the position of the entrance and exit. Different types of airplanes require individual positioning. The positions shown are acceptable in most cases, but in a few cases, the arrangement of several openings, such as two entrances 26 and 27 in Fig. 9, may solve the question of securing a general pressure drop towards the exit. Fig. 9 results in a branched slot, whereas Fig. 5 shows a single slot, one entrance and one exit only.

The position of covers 30 is put under the control of the pilot by means of a depending lever 45 fastened rigidly to the cover. Hinged to its end 41 is a pushrod 42, connecting it with one end of bell crank 43 swung about a vertical axis and mounted on the fixed wing structure. The other bell crank end hinges to pushrod 44, connecting the bellcrank 43 on the right side of the airfoil with the corresponding bellcrank 43' on the left side, through the intermediate of actuating members. Rod 62 is geared to handwheel 45 by means of sprocket wheels and chain 46 and rack and pinion 47, the handwheel and one sprocket wheel being mounted on shaft 48 and the pinion and the other sprocket wheel being mounted on shaft 40. Rods 63, 65, and 64, hinged together at adjoining ends, form a composite rod parallel to rod 62. Balance rods 61 connect the ends of rod 62 with the end of rod 63 and 64 respectively. Rods 44 are hinged to the centers of balance rods 61. During regular flight, rod 65 is held in horizontal position by shaft 67 mounted on the fixed airplane structure.

It is easily seen that as the handwheel 45 is turned from its neutral position in—say—clockwise direction, rod 62 and hence rods 44 are shifted to the left, rods 63, 64, and 65 remaining in their position. The right hand rod 44 is shifted inwardly, the left hand rod 44 is shifted outwardly. Right hand cover 30 is thereby rolled forwardly, and left hand cover 30' is rolled rearwardly. The right hand cover opens into forwardly or upstreamwise open relation, the left hand cover opens into rearwardly or downstreamwise open relation; the right exit open in forward or upstream relation spilling the lift, the left exit open in rearward or downstream direction augmenting the lift. Hence the right wing is depressed, the left wing is lifted up, and a correct aileron action or lateral moment created.

Shaft 67 carries a crank lever 68 fastened to pushrod 69 connecting wheel brake pedal 71 with wheel brake 80. Hence, as brake pedal 71 is depressed, shaft 67 and hence rod 65 is turned, and in consequence both rods 44 are pulled inwardly. Both covers are rolled forwardly, both open into forward or upstream direction, and hence the lift on both wings is spoiled.

The novel action of my control device is intimately connected with the intensity of the aero-dynamic circulation of the airflow about the wings, a requisite for the creation of the lift according to generally accepted scientific principles. The control action depends and relies on the pressure difference between the slot entrance or entrances and the slot exit. Now, the pressure difference will be larger with flaps 23 extended and in high lift position, such as shown in Fig. 8, than with the flaps in the low lift and small drag position, as shown in Fig. 6. It follows there-
fore that my novel lateral control will be more effective for the high lift position of the flaps than for the low lift position, and consequently more effective at low flying speed than at a large flying speed, a feature much desired by airplane designers.

Figs. 12 to 15 show a modification of my control device, in which external cover members 50 are substituted for the internal cover members 30. In Fig. 12 cover member 50 is shown in neutral or closed position, flush with the wing wall 31. A plurality of pairs of arched rods 51 and 52 extend through the wing wall 31, through apertures 53, the forward end of 52 being hinged to wing wall 31 and its rearward end being hinged to cover 50, and the rearward end of 51 being hinged to the wing wall and its forward end to the cover. Fastened to the cover is a lever 40 hinged to the pushrod 42, and a tension spring 20 is employed to positively draw the cover 50 downwardly, the spring connecting the fixed wing structure with the end of lever 40. If pushrod 42 is shifted rearwardly, cover 50 is turned about its forward edge, and its trailing edge is lifted up, assuming the position shown in Fig. 13, and forming a rearwardly open exit. If pushrod 42 is shifted forwardly, cover 50 is turned or rotated about its rearward edge, and its leading edge is lifted up, as shown in Fig. 14, forming a forwardly open slot exit, 25. The gearing to the cockpit and the aerodynamic action is substantially the same as with the internal cover 30.

Figs. 16 and 17 show a still other variation of the cover mechanism. Cover 51 is mounted turnable about an axle 82 parallel to the slot. Upper wing wall 31 is provided with inwardly projecting cylindrically bent rims 83 and 84, effecting a closing contact with the inwardly turned cover edge 85. This contact is made more intimate and tightness secured by means of hollow rubber edgels 86. The cover 51 in the position drawn in dashed line in Fig. 17 forms an exit open to the left, which would be upstream, as the passing air is supposed to flow from left to right.

In Figs. 16 and 17 the slots, entrance slot as well as exit slots, are not in the fixed portion of the airfoil, as in Fig. 5, but they are in the movable portion of the airfoil, designated as flap 22. The aerodynamic action is the same whether the slots be in the fixed portion or in the movable portion of the wings.

This disclosure is based on a large series of model tests and all statements are well supported by observed facts. I have found that the largest clearance width of the slot fully opened has only to be about 3% of the chord.

I claim:

1. In an airplane, an airfoil having a substantially spanwise extending slot connecting the space over the airfoil with the space below it, a cover member within the airfoil shaped positioned and arranged to roll on and along the upper airfoil wall in a substantially chordwise direction, so as to provide for a forwardly open slot exit, or to close the slot, or to provide for a rearwardly open slot exit, and control means accessible to the pilot and connected with the cover member for rolling the same.

2. In an airplane, an airfoil having a substantially spanwise extending slot connecting the space over the airfoil with the space below it, a cover member within the airfoil shaped positioned and arranged to roll on and along the upper airfoil wall in a substantially chordwise direction, so as to provide for a forwardly open slot exit, or to close the slot, or to provide for a rearwardly open slot exit, spring means for pulling the cover member upwardly and against the upper airfoil wall, and control means accessible to the pilot and connected with the cover member for rolling the same.

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