Oct. 17, 1939. E. F. ZAP 2,176,809

JET CONTROLLED AIRFOIL

Filed March 11, 1938 3 Sheets-Sheet 1

Fig. 1.

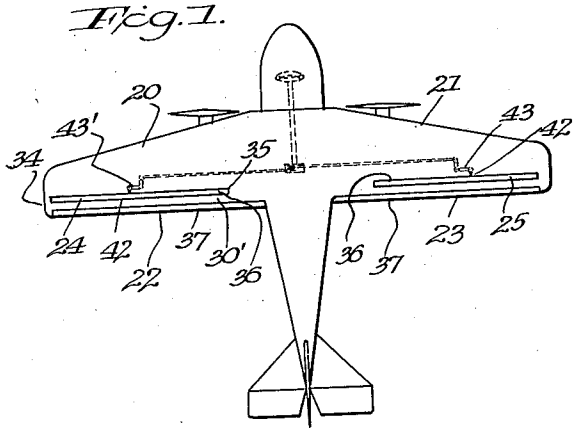
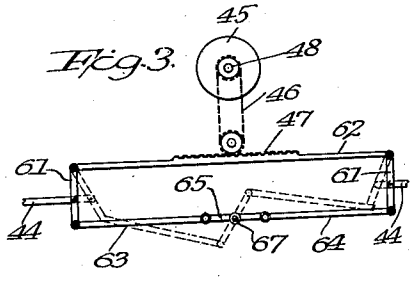


Fig. 3.



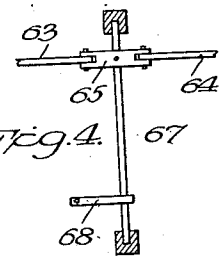


Fig. 4.

Fig. 2.

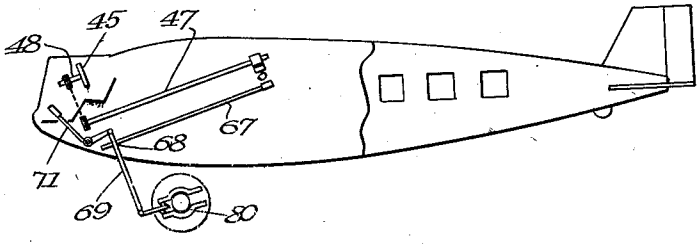


Fig. 5.

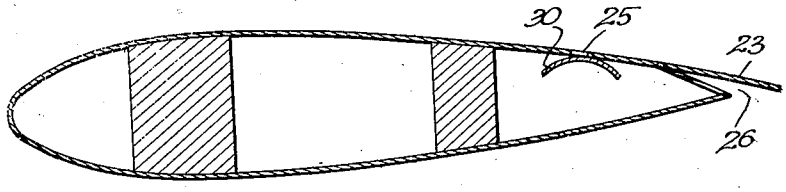
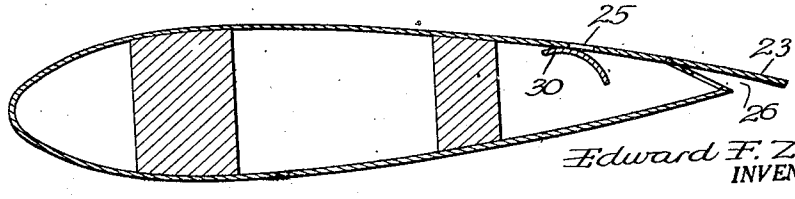


Fig. 6.



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Oct. 17, 1939. E. F. ZAP 2,176,809

JET CONTROLLED AIRFOIL

Filed March 11, 1938 3 Sheets-Sheet 2

Fig. 7.

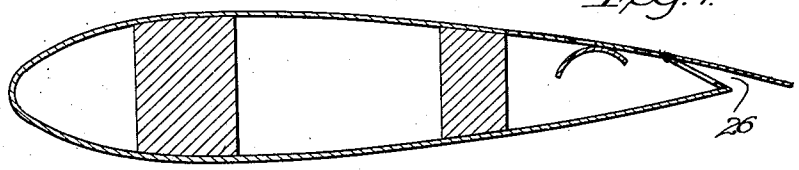


Fig. 8.

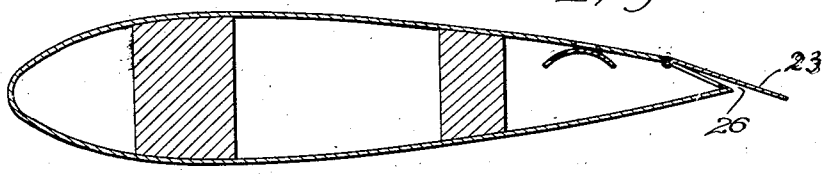


Fig. 9.

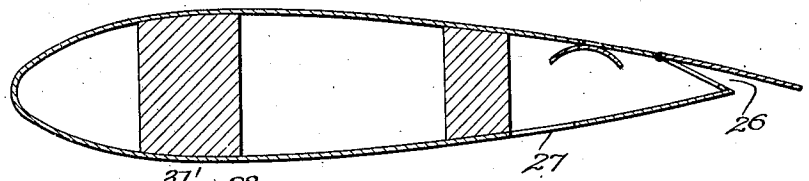
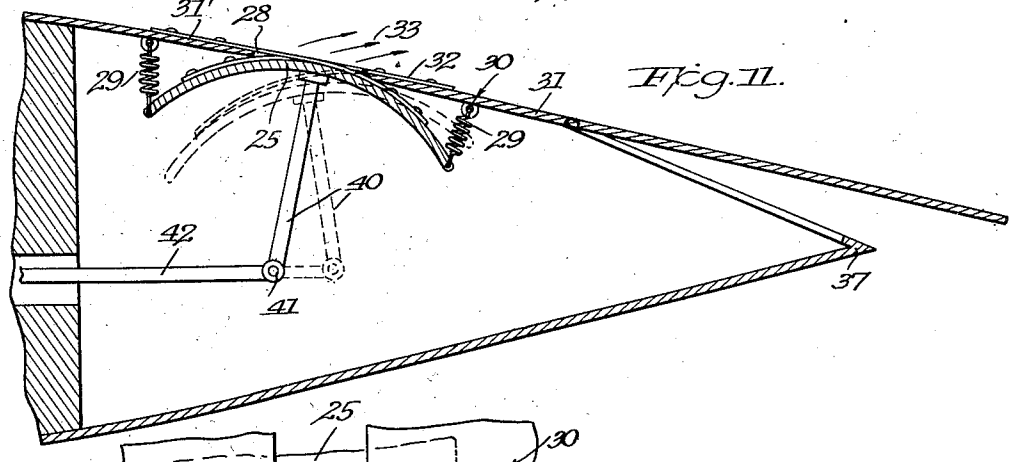


Fig. 11.



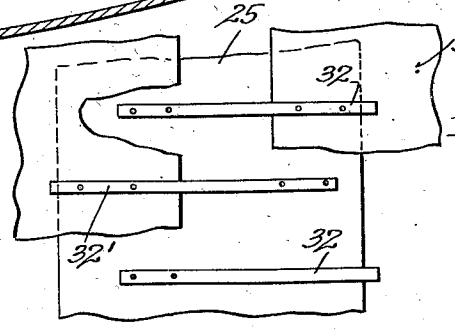


Fig. 10.

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Oct. 17, 1939. E. F. ZAP 2,176,809

JET CONTROLLED AIRFOIL

Filed March 11, 1938 3 Sheets-Sheet 3

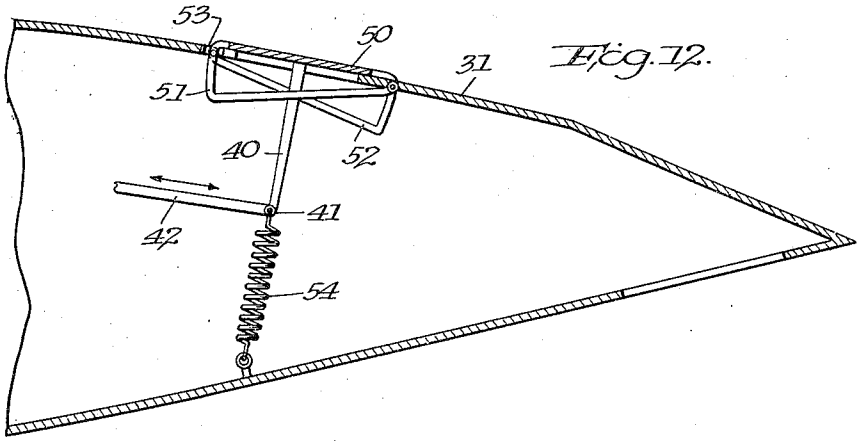


Fig. 12.

Fig. 13.

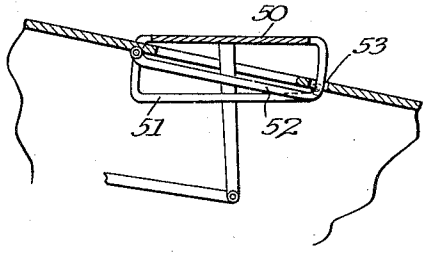


Fig. 14.

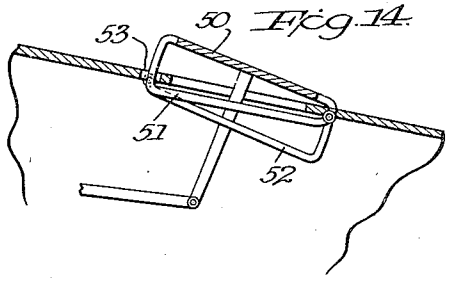


Fig. 15.

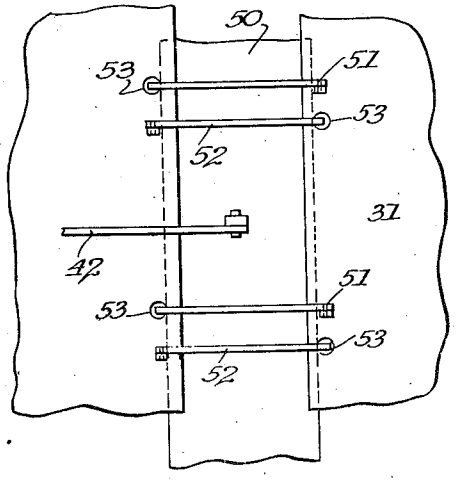


Fig. 16.

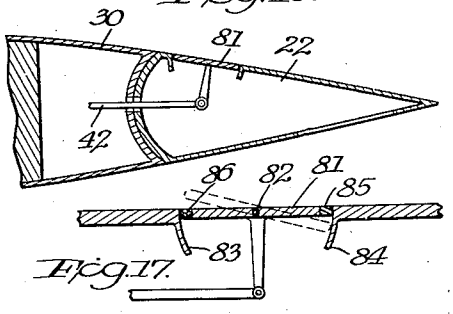


Fig. 17.

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Patented Oct. 17, 1939 2,176,809

UNITED STATES PATENT OFFICE

2,176,809

JET CONTROLLED AIRFOIL

Edward F. Zap, West Chester, Pa.

Application March 11, 1938, Serial No. 195,381

2 Claims. (Cl. 244—40)

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 through 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 changeableness 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,

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,

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 upwardly,

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 edges **37**, said flaps extending all way to the tips **34**. The inside of the wings communicates 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 **30** or of external cover members **50**. 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 **29** 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 **28** 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 rearwardly, in that the forward portion **30'** of cover **30** together with the wall portion **31'** of wall **31** form an air exit guide emitting 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 for transport planes. In difficult 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 **40** 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 axle 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 airplane with the corresponding bellcrank **43'** on the left side, through the intermission 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 spoiling 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 aerodynamic 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 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 **81** 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 edges **86**. The cover **81** 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 moveable 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 moveable 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.

EDWARD F. ZAP.