Feb. 23, 1932. R. F. HALL 1,846,965

AIRPLANE

Filed July 16, 1930 3 Sheets-Sheet 1

Fig. 1.

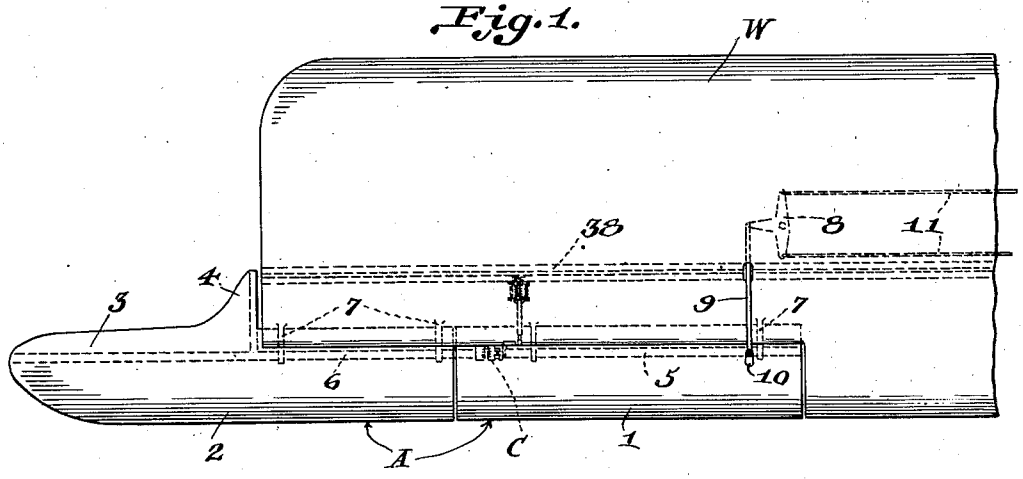


Fig. 2.

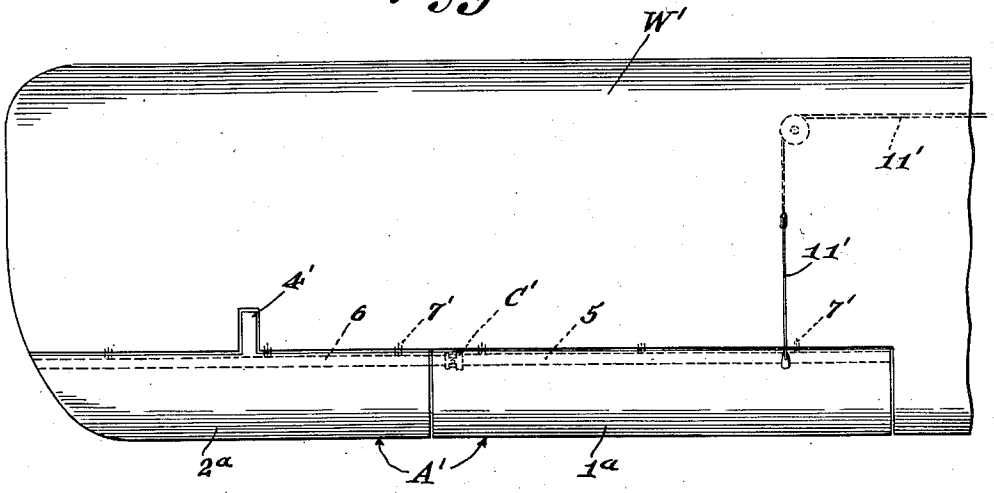
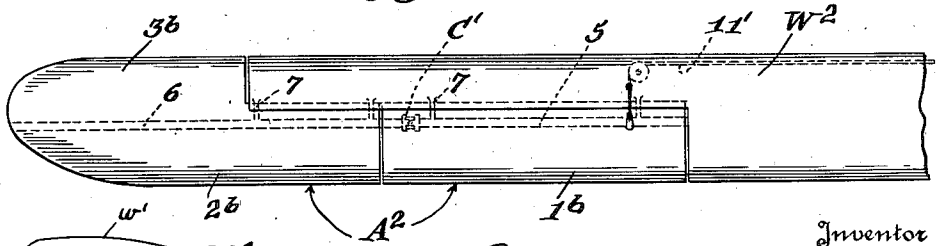


Fig. 3.



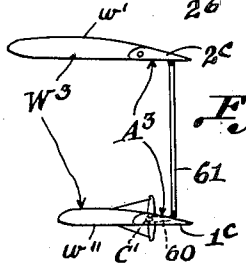


Fig. 4.

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AIRPLANE

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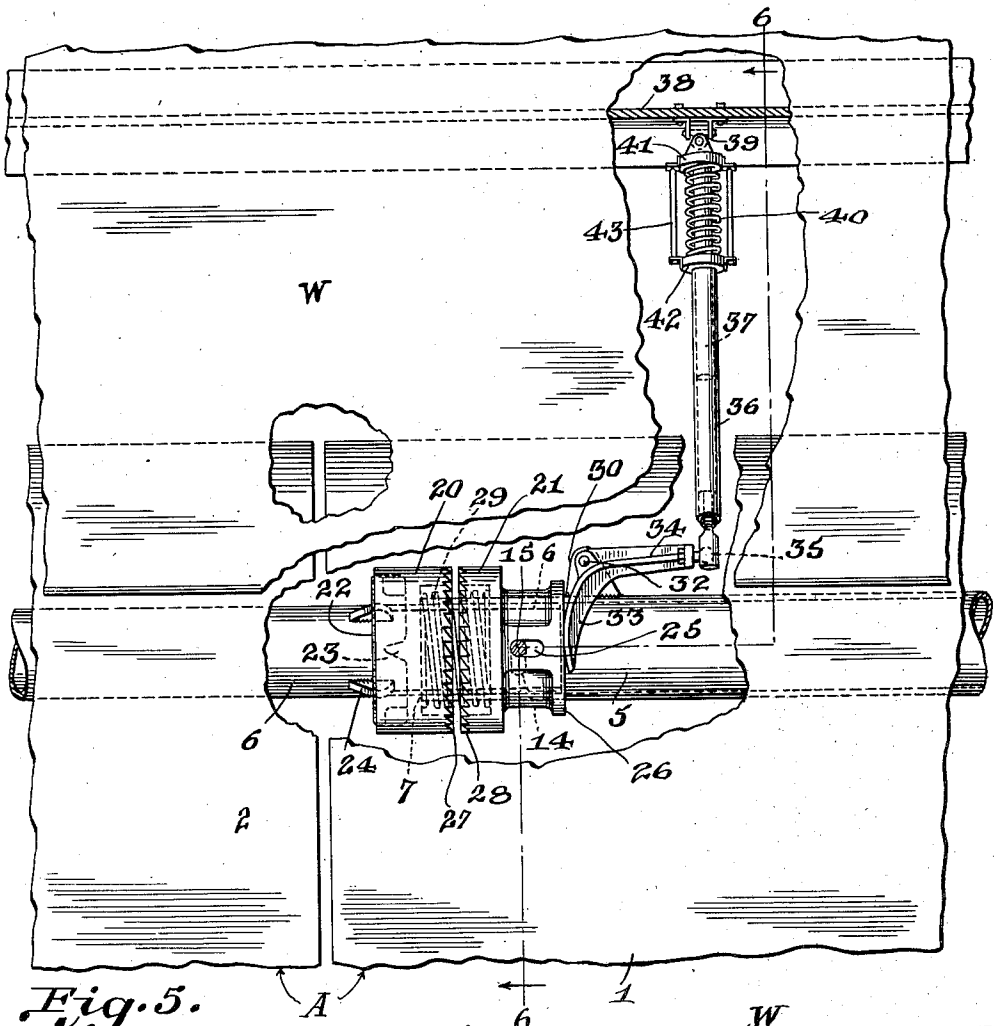
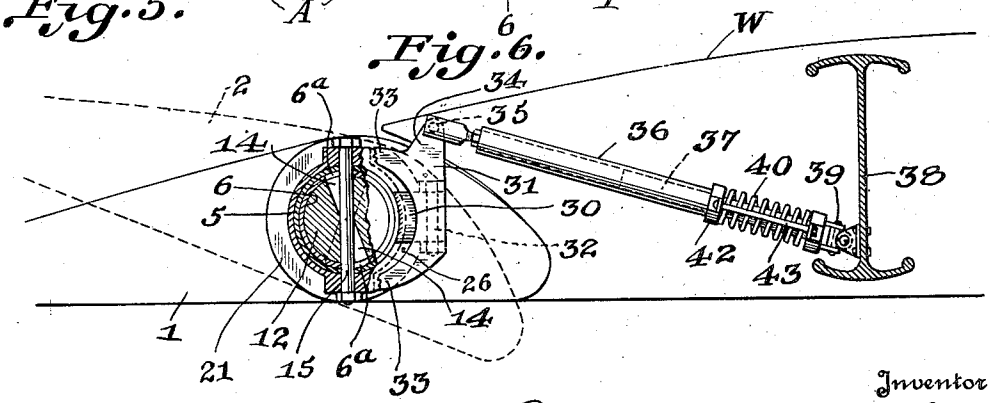


Fig. 5.

Fig. 6.



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AIRPLANE

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Fig. 7.

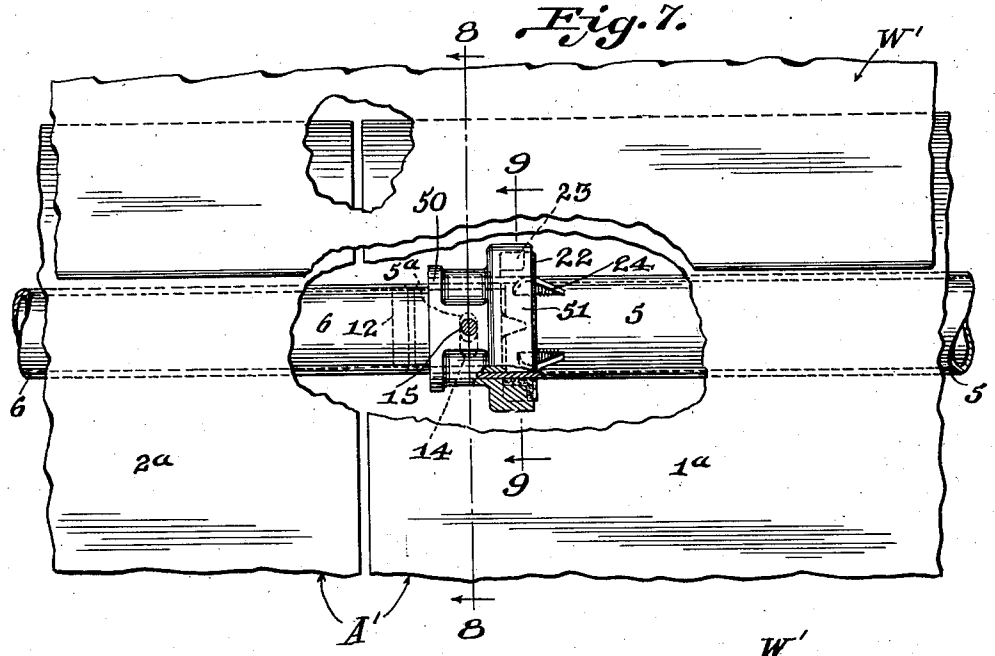


Fig. 8.

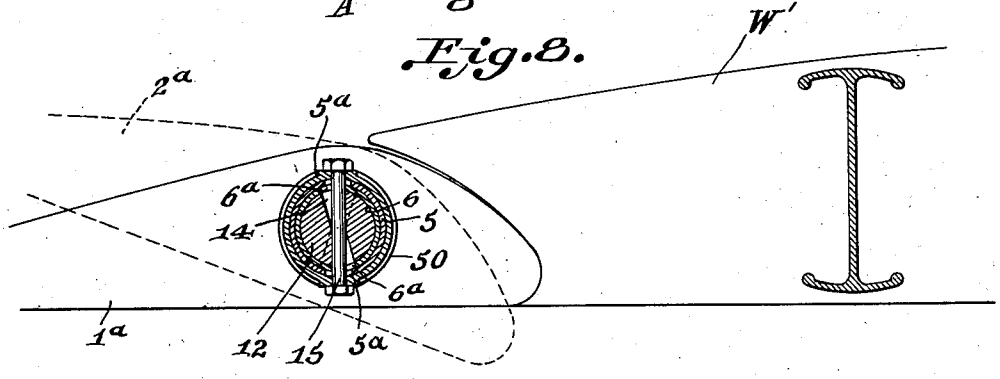
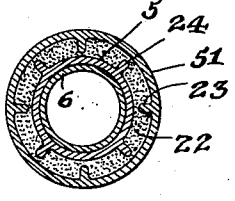


Fig. 9.



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Patented Feb. 23, 1932

1,846,965

UNITED STATES PATENT OFFICE

RANDOLPH F. HALL, OF ROCHESTER, NEW YORK

AIRPLANE

Application filed July 16, 1930. Serial No. 468,405.

This invention relates to certain improvements in airplanes; and the nature and objects of the invention will be readily understood by those skilled in the art in the light of the following explanation and detailed description of the accompanying drawings illustrating what I at present believe to be the preferred embodiments or mechanical and aerodynamic expressions of my invention from among various other forms, designs, arrangements, combinations and constructions of which the invention is capable within the spirit and the scope thereof.

In the so-called floating types of ailerons or lateral control surfaces for an airplane, the ailerons or control surfaces are free to float with and be adjusted by and in accordance with the airflow acting thereon, in order to increase the control effectiveness of the ailerons and the resulting efficiency of the airplane lateral control with the airplane in or approaching the condition of stall. The increased lateral control effectiveness of the floating types of ailerons with the airplane in the condition of stall or near stall, is mainly due to and arises from the fact that under stall or near stall conditions the airflow acts upon the ailerons to cause them to float or swing upwardly, thereby adjusting the ailerons to position, under the low speed of stall or near stall, for increased control effectiveness when actuated to laterally control the airplane, and particularly increasing the effectiveness of down aileron movements. In certain designs and arrangements of such floating ailerons the range or extent of the floating movement is limited or restricted, and in other arrangements such floating movement is unlimited within design and aileron mounting limits; while the floating movement in some instances is dependent upon the position of the aileron control operating mechanism, for example the ailerons only being free to float with the operating control within a range of neutral position, and in still other instances the arrangement is such that the ailerons are free to float for and throughout the entire range of aileron operating control movement and positions.

With the present types of floating ailerons serious difficulties arise from the mounting and location of such ailerons, thus materially detracting from and offsetting the beneficial and desirable control results possible with the floating aileron. When a floating aileron is mounted and located conventionally, that is at the conventional aileron location, the lift and efficiency of the wing is substantially decreased because of the movement of the aileron in its normal, neutral position, by the airflow from alinement with and interrupting the carrying out of the wing contour and camber by the trailing edge section of the wing. On the other hand, if the floating aileron is removed from conventional aileron location, and for example, mounted to materially overhang the wing tip, or located in outward extension thereof, then the drag is increased and the overall wing span seriously added to, while structural and weight complications result in properly mounting and bracing a floating aileron so located. Again, if the floating aileron is located and mounted removed or remote from a wing, the structural complications and increased drag remain, with the possible added aerodynamic difficulty of inter-surface interference between the wing and the removed or remote aileron, which must necessarily be located at least relatively proximate to, even though spaced from the wing.

My present invention aims to substantially eliminate or materially reduce the foregoing general and other difficulties and inefficiencies encountered with the floating types of ailerons, as well as other control surfaces, by the provision of a novel and efficient design, arrangement and mounting of lateral control surfaces or ailerons for an airplane, in which the aerodynamic and control effectiveness of the floating type of control surface or aileron are obtained, particularly with the airplane approaching or in the condition of stall, while the advantages and efficiencies of the conventional or non-floating types of ailerons are retained, during and with the airplane in normal flight attitudes and under and substantially throughout the range of normal flight conditions.

A control surface of the invention, such

as an aileron or lateral control surface, is fundamentally characterized by the design and formation of the total control surface into a non-floating conventional, positively operated and controlled section, and a floating section operatively associated and coupled therewith but free within determined limits to float independently thereof and have its position adjusted by the action of the airflow under certain conditions, and to be positively operated and controlled by and together with the non-floating section, under certain conditions and during certain controlled movements of the non-floating section, the floating and non-floating sections then together operating as a single unit control surface.

A feature of the invention, particularly in the case of a lateral control surface or aileron, resides in the mounting of the control surface with the floating section thereof located at the relatively inefficient tip portion of a wing, and the non-floating, directly and positively controlled and operated section mounted conventionally on the wing inwardly and in continuation of the floating section, so as to practically eliminate the wing efficiency reducing effect of a floating aileron in such position, and secure from the floating and adjustment of the floating section by the airflow the increased control effectiveness in the condition of stall or near stall, as well as the tendency of the floating section to retard or delay the stalling of the wing tip portion, which is considered as reaching a condition of stall in advance of the remaining portion of a wing.

Another feature of my invention is presented by a control surface, such as an aileron, formed of a floating section and a non-floating conventionally operated and directly controlled section, which sections are so coupled together and operatively associated that the floating section is free under the slow speed conditions of stall or near stall, to float or swing upwardly relative to the non-floating section, and which in such adjusted position is then positively operated by and with the non-floating section on downward movements of the latter, the sections then together functioning as a single unit surface with increased control effectiveness on down movements thereof.

As a further feature the invention provides the opposite floating sections of the opposite ailerons of a lateral control system, for both up and down movement together with the positively operated non-floating sections as they are swung upwardly and downwardly, respectively, when the floating sections have floated and are swung upwardly to airflow adjusted positions under the conditions of stall or near stall, so as to increase control effectiveness, and substantially balance the drag from the opposite floating sections tending to avoid the evolution of the spin, with the airplane under stalled conditions.

Another feature resides in the mechanisms for operatively associating and coupling the floating and non-floating sections forming the control surface of the invention, by which the desired functioning and control thereof in accordance with the principles of the invention, is obtained in an efficient manner; and in the design, construction and mounting of such mechanisms to insure positive reliable operation under conditions of service, with mechanical simplicity and minimum weight; and further in the design and construction of such coupling mechanisms by which they are capable of and adapted to mounting and installation as a unit on an airplane in cooperation with the conventional control surfaces thereof for converting such surfaces to the floating type.

The invention includes as another feature thereof the arrangement and mounting of a control surface embodying the floating and non-floating sections, adapted for a wing cellule of the multiplane type, in which the non-floating section is mounted on one wing and the floating section on another wing of the cellule, with mechanism of the invention operatively coupling and associating the floating and non-floating sections for operation in accordance with the requirements and to secure the results of the invention.

With the foregoing general objects, features and results in view, as well as certain others which will be apparent from the following explanation, the invention consists in certain novel features in design, construction, mounting, and combination of elements, as will be more fully and particularly referred to and specified hereinafter.

Referring to the accompanying drawings:

Fig. 1 is a view in top plan of one form of aileron or lateral control surface embodying the operatively coupled floating and non-floating sections of the invention mounted in conventional aileron location on a wing with a portion of the outer floating section overhanging the wing tip; a portion only of the wing and a conventional aileron operating control mechanism being shown, and the opposite side of the wing and the opposite aileron of the wing being omitted.

Fig. 2 is a view in top plan of a portion of a wing and conventional aileron operating control mechanism, with another form and mounting of aileron of the invention mounted thereon in conventional aileron location, in which the outer floating section terminates at and does not overhang the adjacent wing tip; and further showing a modified form of coupling mechanism of the invention operatively connecting the floating and non-floating sections.

Fig. 3 is a top plan view of another form of

lateral control surface or aileron of the invention mounted and arranged on a wing of the high aspect ratio type, in which the outer floating section of the aileron provides an outer or tip extension in continuation of the wing, a portion only of the wing and a conventional aileron operating control mechanism being shown.

Fig. 4 is a view, more or less diagrammatical, in end elevation, of a form and arrangement of lateral control surface of the invention mounted on a biplane wing cellule, in which the floating section is mounted on the upper wing, the non-floating, positively directly operated and controlled section on the lower wing, and coupling mechanism of the invention operatively connects and associates such sections forming the total control surface.

Fig. 5 is an enlarged view in top plan of the coupling mechanism of Fig. 1 operatively connecting the inner positively controlled non-floating aileron section and the outer floating section of the aileron, with the sections and the coupling mechanism in normal neutral control position, a part of the wing and aileron sections only being shown with portions thereof broken away.

Fig. 6 is a vertical transverse section through a portion of the coupling mechanism taken as on the line 6—6, of Fig. 5, and showing other portions of the mechanism in elevation, with a portion of the wing and the aileron sections indicated only in outline, and showing by dotted lines the upwardly floated position of the floating section and relative positions of portions of the coupling mechanism.

Fig. 7 is an enlarged view in top plan of the form of coupling mechanism of Fig. 2 connecting the floating and non-floating sections of the aileron with the sections and coupling in normal neutral control position, a portion only of the wing and aileron sections being shown with parts thereof broken away.

Fig. 8 is a vertical, transverse section taken as on the line 8—8 of Fig. 7, with a portion of the wing and aileron sections indicated diagrammatically in outline only, and showing by dotted lines the upwardly floated position of the floating section and relative positions of the coupling mechanism.

Fig. 9 is a transverse section taken on the line 9—9 of Fig. 8, through the coupling mechanism showing the shock absorbing connection therebetween.

Several possible designs, arrangements, and mountings of control surfaces of the lateral control or aileron types incorporating the principles of my invention, together with several different embodiments of mechanism for operatively associating and coupling the floating and non-floating sections of such control surfaces for functioning in accordance with the invention, are disclosed and described herewith only as examples to illustrate the principles and several features of the invention, and not to restrict its application to these particular aerodynamical and mechanical expressions thereof. It is recognized that the invention is capable of a variety of other expressions for carrying out the broad principles and several features thereof, and such other expressions are contemplated by the invention and included within its scope. Further, while in the examples and expressions thereof here shown, the invention is embodied in and applied to lateral control surfaces or ailerons, it is to be clearly understood that the principles and certain features thereof are adapted to aircraft control surfaces generally, as will be recognized by those familiar with the aircraft art.

One form and embodiment of a lateral control surface or aileron incorporating and carrying out the principles of my invention is illustrated in Fig. 1 of the accompanying drawings, in which the aileron A of the invention is mounted on the wing W at and forming a portion of the wing trailing edge in accordance with conventional aileron location practice, and extends in the present instance outwardly a distance from and overhanging the adjacent wing tip. The aileron A comprises the inner section 1 having a section or profile in continuation of and carrying out the section of wing W to form a trailing edge portion therefor in the usual manner, and the outer, floating section 2 alined with inner section 1 in outward continuation thereof and having the extended wing tip overhaging portion 3 formed with the forwardly extended static balance portion 4 at and adjacent the wing tip. The outer floating section 2 is preferably formed with the outer extended tip overhanging portion 3 thereof symmetrical in section, while the inner portion along the wing W is formed of a section carrying out the wing section and similar to the section of the adjacent inner aileron section 1 with which it alines.

The aileron A and the sections 1 and 2 of which it is formed, are pivotally mounted for vertical swinging on the wing W around the horizontal axis formed by their axially alined longitudinal beams 5 and 6, respectively, located adjacent the leading edges of the sections, by the hinge fittings 7 carried by the wing W on which beam 5 and 6 are pivotally mounted. In the example hereof, the wing W extends a distance rearwardly over the leading edge of aileron A in accordance with one form of conventional aileron mounting.

The inner section 1 of the aileron A is directly positively actuated and controlled by the pilot in the usual manner through the medium of conventional or other suitable pilot operated aileron control mechanism.

For example, I happen to show the portion of a conventional aileron control mechanism which includes the crank 8 mounted on the wing W and operating a push and pull rod 9 extending rearwardly and outwardly through the wing to a control horn 10 on the upper side of aileron section 1, together with the control wires 11 leading from crank 8 to the cockpit control (not shown), so that actuation by the pilot of the cockpit control will raise and lower aileron section 1 on its hinges 7 in the usual manner. It is understood, of course, that a similar aileron A is mounted at the opposite end of the wing (not shown) and that the control mechanism above described is duplicated at the opposite side of the wing in operative connection with such aileron section 1 (not shown) there mounted. The opposite aileron sections 1 are thus differentially operated for lateral control by the pilot actuated aileron operating mechanism in the well known and understood conventional manner, and it is not deemed necessary to show the opposite aileron A and connected operating mechanism which is a mere duplication of the aileron A and operating mechanism as shown in Fig. 1 of the drawings.

Following and in accordance with the principles of my invention, the outer section 2 of aileron A, is free to float and swing vertically within determined limits, independently of the inner, non-floating positively controlled section 1, under certain airflow conditions and in certain positions of the inner section 1, and to be actuated by and swung with the inner section 1 as a unit control surface or aileron A during certain controlled movements of the inner section 1. This is accomplished in the present example through the medium of a coupling mechanism, designated generally in the drawings by the reference letter C, permitting floating of section 2 independently of section 1, and automatically operated to releasably couple and connect section 2 with section 1, by and upon certain controlled movements of the latter with the sections 1 and 2 in certain relative positions with respect to each other.

In the design, arrangement and mounting of sections 1 and 2 forming aileron A, referring now to Figs. 5 and 6 of the drawings in connection with Fig. 1, the outer end of beam 5 of inner section 1 terminates a distance inwardly from the adjacent ends of the sections and the clearance space therebetween, and the inner end of beam 6 of outer section 2 extends inwardly to and a distance into the outer end of beam 5 which rotatably receives the same. In this manner the coupling mechanism C operatively mounted on the telescoped and rotatably engaged ends of beams 5 and 6, is located within aileron section 1, spaced inwardly and removed from the space between the sections, with the coupling protected from the elements and the effect of snow and ice, or other foreign matter.

The floating outer section 2 of aileron A, is mounted through the medium of its beam 6, for limited vertical swinging or floating independently of and with respect to inner section 1, by limiting the rotation of beam 6 in the outer end of beam 5 of section 1. The beams 5 and 6 are preferably the usual metal tubes, and the inner end of beam 6 which is rotatably received in beam 5, is provided with an internal plug or reinforcing block 12 (see Fig. 6) suitably fixed therein, having a vertical slot 14 extending therethrough and elongated in opposite directions from the vertical above and below the center of the beam, respectively, and transversely or circumferentially thereof, as will be clear upon reference to Fig. 6 in connection with Fig. 5 of the drawings. The beam 6 end within beam 5 is formed with elongated slots 6*a* therethrough (see Fig. 6), alined and coextensive with the opposite upper and lower ends, respectively, of slot 14, and a vertical pin or bolt 15 is mounted in fixed position on and extending transversely through beam 5, which is provided with suitable upper and lower alined bores to snugly and tightly receive the pin, with the pin or bolt 15 disposed in and extending vertically through the slot 14 in block 12 and the opposite upper and lower slots 6*a* in beam 6 alined with the ends of slot 14, respectively.

By this arrangement, the end of beam 6 is rotatable in the beam 5, and section 2 is vertically swingable independently of section 1, within the limits defined by the extent of opposite elongation of slot 14 in block 12 and alined slots 6*a* of beam 6, and the vertical pin 15 fixed on beam 5 and extending through such slots. The inner positively operated and controlled, non-floating section 1 of aileron A, in normal neutral position as shown by full lines in Fig. 6 of the drawings and also in Fig. 5, locates and positions the pin or bolt 15 in vertically disposed position, and the outer floating section 2 of aileron A in its normal position in alinement with the inner section 1, locates and positions the slot 14 of block 12 in its beam 6, with pin 15 engaged by the block and holding beam 6 and section 2 against downward swinging from normal position alined with section 1 in its normal neutral control position. In the foregoing normal alined, neutral control position of sections 1 and 2 forming aileron A, the slot 14 of block 12, is disposed with the upper half elongation thereof extended rearwardly and the lower half elongation extended forwardly (see Fig. 6), so that with the inner non-floating section 2 held in its normal neutral control position, the outer, floating section 2 is free to float or swing upwardly independently of inner section 1, until pin 15 is engaged by the opposite sides of slot 14,

to the dotted line position of section 2 and slot 14 in block 12 as shown by Fig. 6. From this upwardly swung position the floating section 2 is free to float or swing downwardly to normal position, and the extent of independent swinging or floating of section 2 is determined by the characteristics of the particular wing employed and by the degree of control desired, in the present instance section 2 being free to float through approximately 10°.

In the neutral control position of inner aileron section 1 with the outer floating section 2 in its normal lowered position alined with section 1, as shown by full lines in Fig. 6, upward swinging or raising of inner section 1 by the cockpit control mechanism will, due to the pin 15 and slot 14 in block 12, cause the outer floating section 1 to simultaneously swing upwardly with the inner section, while upon downward swinging or lowering of the inner section 1, the outer floating section 2 will not lower or swing downwardly therewith until pin 15 has moved through slot 14 to engage the opposite sides thereof, after which independent movement of section 1 (about 10° in the instant example), outer section 2 will then swing downwardly with section 1.

When the wing W on an airplane reaches or approaches a condition of stall and with the inner section 1 of aileron A in its normal neutral control position (full line position of Fig. 6), the resulting airflow conditions act upon outer aileron section 2 and cause it to float upwardly with respect to section 1, into the dotted line position of Fig. 6. In such position and under the conditions of stall when the cockpit control mechanism is actuated for lateral control, upon downward swinging or lowering of inner section 1 of aileron A, due to the relative positions of pin 15 and slot 14, the raised outer section 2 lowers or swings downwardly simultaneously with the inner section, remaining of course in relative raised position with respect to the inner section. The control effectiveness of down aileron movements under the conditions of stall are thus increased and rendered more effective due to the raised position and increased downward swing of outer aileron section 2. On the other hand, neglecting the coupling mechanism hereinafter described, upward swinging or raising of the inner non-floating aileron section 1, with outer section 2 raised under the conditions of stall, will not raise outer section 2 until pin 15 has traversed slot 14 of block 12 and engaged the opposite sides thereof, after which section 2 will raise and swing upwardly with section 1, as will be clear by reference to the raised dotted line position shown in Fig. 6.

For the purpose of approximately simultaneously raising and lowering the outer floating section 2 of aileron A with the inner non-floating section 1 thereof, when the floating section 2 is in its upwardly floating position, while permitting the floating section 2 to float or swing upwardly independently of section 1 with the latter in normal neutral control position, the coupling mechanism C includes means actuated by swinging of section 1 for releasably connecting and coupling section 2 for swinging with section 1, as and forming therewith the unit control surface or aileron A. Through such arrangement the upward swinging of section 1 independently of section 2, with floating section 2 in its upwardly swung or floated position is eliminated and section 2 is swung upwardly and downwardly approximately simultaneously with and by the upward and downward swinging of inner positively actuated inner aileron section 1. Thus, with the oppositely swung ailerons A of wing W, only one of which is here shown, the drag of the opposite floating sections 2 thereof is substantially balanced for all conditions of movement, which balancing of the drag tends to eliminate and avoid the evolution of the "spin" with an airplane under conditions of stall and during lateral control thereof by operation of the ailerons A.

In carrying out the above feature of the invention, in the specific example here shown, the coupling mechanism C, referring now to Figs. 5 and 6 of the drawings, includes a coupling member or sleeve 20 mounted on the beam 6 of floating aileron section 2, adjacent the end of beam 5 of the inner non-floating section 1 of aileron A, and the coupling member or sleeve 21 mounted on and carried by beam 5 of section 1 adjacent sleeve 20, for sliding movement on and axially of beam 5 to and from position in engagement with sleeve 20 releasably connecting beams 5 and 6 and the aileron sections 1 and 2. The coupling sleeve 20 is mounted on beam 6 against axial movement thereof but permitting limited and cushioned rotational movement thereon by a shock absorbing mounting which includes a mass of rubber or the like yielding, resilient material 22, referring to Fig. 9 in particular taken in connection with Fig. 5, pressed and secured in an annular recess around the outer end wall of sleeve 20, with a spaced series of lugs 23 extended inwardly from the wall of the coupling into and embedded in the mass 22, and a similar series of radially disposed lugs 24 spaced around the exterior of beam 6 and extending inwardly into and embedded in the rubber, yieldable mass 22, the lugs 24 alternating with and extending between the coupling lugs 23 (see Fig. 9.) The rubber mass 22 forms a shock absorbing yielding connection between sleeve 20 and beam 5, which permits limited rotational movement of the sleeve in either direction by compressing such mass between the lugs 23 and 24.

The coupling sleeve 21 is slidably mounted

and confined on beam 5 adjacent the outer end of the beam for movement axially thereof, but held against rotational movement on the beam, by the outer ends of the pin or bolt 15 which extend outwardly through the similar upper and lower alined slots 25 (see Fig. 6) disposed longitudinally of the coupling sleeve or member 21 through the inwardly extending reduced diameter portion 26 thereof. The coupling member or sleeve 21 is slidable outwardly to adjacent sleeve 20 on beam 6 for engagement therewith, and inwardly of beam 5 to the disengaged and uncoupled position of Fig. 5, the length of the slots limiting such movements and being such as to permit of engagement of the sleeves 20 and 21. The inner end face of coupling 20 on the beam 6 is formed with a series of serrations or clutch teeth or the like 27 therearound, and the adjacent outer end face of coupling 21 on beam 5, is formed with a similar series of serrations or clutch teeth 28 therearound for engagement and meshing with the teeth 27 of coupling 20 to releasably couple and connect these members or sleeves 20 and 21 and the beams 6 and 5 on which mounted, together for simultaneous rotation, when the coupling sleeve 21 is slid or moved outwardly on beam 5. A coil spring 29 (see Fig. 5) is mounted over beam 5 between the coupling sleeves or members 20 and 21, with its opposite ends seated in suitable recesses formed in the ends of the sleeves, this spring 29 normally tending to force sleeve 21 inwardly on beam 5 to position disengaged from sleeve 20 and disconnecting or uncoupling beam 5 and aileron section 1 from beam 6 and floating aileron section 2.

The coupling sleeve or member 21 is slid or moved outwardly on beam 5 into position engaged with member 20 on beam 6, by rotation of beam 5 to swing the inner aileron section 1 upwardly, through the following mechanism. A support arm or lug 30 is fixed on beam 5 extending from the forward side thereof in horizontal position with beam 5 and aileron section 1 in normal neutral control position. A yoke member 31 is pivotally mounted for horizontal swinging on a vertical pin or pivot 32 carried by the support arm 30. This yoke member 31 includes the upper and lower arms 33 extending horizontally across and spaced from the upper and lower sides, respectively, of beam 5, and bearing at their ends against the inner end face of the reduced diameter portion 26 of coupling member or sleeve 21, as will be clear by reference to Figs. 5 and 6 of the drawings. A yoke operating arm or lever 34 extends from the upper side of yoke 31 adjacent the pivot pin 32, a distance inwardly along, normally substantially parallel with but disposed in a plane above beam 5 (see Fig. 6), and at approximately right angles to the yoke arms 33 (see Fig. 5). The inner end of yoke lever 34 is connected by a ball and socket universal connection 35 to the upper end of a tube member 36 which extends forwardly and downwardly to and telescopically fits over and is slidable on a rod member 37 which is secured and attached at its lower forward end to the lower portion of the rear beam 38 of wing W, by a universal connection 39. A compression spring 40 is mounted over the rod member 37 and confined thereon between a cup 41 fixed at the lower forward end of member 37, and a cup 42 fixed at the lower end of tube member 36 and movable therewith. Opposite rods 43 extend between cups 41 and 42 to prevent separation of telescoping members 36 and 37, but are freely slidable in the cup members to which they are mounted so as to permit compression of spring 43 when member 36 slides downwardly on member 37. Attention is here called to the fact that the compression spring 40 is considerably stiffer than the coupling members disengaging spring 29, for a purpose appearing hereafter.

With the foregoing coupling mechanism, when the inner non-floating aileron section 1 and its beam or axis 5 are in normal neutral control position, the yoke 31 is in position permitting spring 29 to force coupling member or sleeve 21 inwardly on beam 5 out of coupling engagement with coupling member 20 of aileron section 2, as shown by Fig. 5. In this position, the outer floating aileron section is free to float or swing upwardly independently of inner section 1, due to the hereinbefore explained arrangement and relation of slot 14 and pin 15. However, in any position of outer section 2, when beam 5 is rotated by the cockpit control mechanism (not shown) to swing inner aileron section 1 upwardly around beam 5 as an axis, due to the fact that spring 40 is stiffer than coupling spring 29, the upper end of telescoping member 36 is held in position above the axis of rotation of section 1, while the yoke support arm 30 with yoke 31 swings forwardly and downwardly, which causes the yoke 31 and arms 33 thereof to rock outwardly against and force coupling member 21 outwardly on beam 5 into engagement with coupling member 20 on beam 6. Continued upward swinging of beam 5 and aileron section 1 after teeth 27 and 28 of the coupling members are meshed and engaged, simultaneously swings aileron sections 1 and 2 upwardly together. This continued upward swinging after engagement of coupling sleeves or members 20 and 21, with member 21 at its limit of outward movement, is permitted by the telescoping of members 36 and 37 and yielding or compressing of spring 40 between the cups 41 and 42, to permit the yoke 31 operating lever 34 to continued downward swinging with the coupling sleeve or member 21 and arms

33 maintained against further yielding or outward movement. Downward swinging of beam 5, from upwardly swung position thereof, swings the aileron sections downwardly in coupled relation until beam 5 and section 1 reach normal neutral control position, whereupon yoke 31 and arms 33 thereof swing inwardly and spring 29 forces coupling member 21 from engagement with member 20. Thus on upward swinging of section 1, the outer floating section 2 is coupled for swinging therewith, after a slight lag, in the present instance about 2°, for engagement of the members 20 and 21 and meshing of the teeth thereof.

The size and shape of the serrations or teeth 27 and 28 of coupling sleeves or members 20 and 21, may be varied as required to secure the desired results and extent of meshing or coupling lag, for example such teeth can be symmetrical, square or of sharp angle. With teeth of the shape and arrangement here shown, on downward swinging from upwardly swung position of the coupled aileron sections, as long as there is air pressure above floating section 2 forcing downward thereon it will lower with section 1, but if positive means for lowering is desired such symmetrical, square or sharp angle teeth may be employed. Also, to avoid possibility of accidental locking of the coupling mechanism against disengagement, a stop (not shown) can be provided for yoke 31 which will stop swinging thereof when the coupling member teeth are sufficiently engaged or meshed.

In flight the aileron A formed of floating section 2 and directly actuated non-floating section 1, with the above described coupling mechanism operatively associating these aileron sections, operates and functions as follows. With the aileron sections 1 and 2 in alined normal neutral control position, as shown by full lines in Figs. 5 and 6, upward swinging of the inner section 1 causes the coupling mechanism to connect floating section 2 thereto, which section 2 is then swung upwardly simultaneously therewith. On the other hand, downward swinging of section 1 from the normal neutral control position, due to the relative positions of slot 14 and pin 15 (see Figs. 5 and 6) and the fact that yoke 31 does not engage coupling member 21 with member 20, allows section 1 to swing downwardly in advance and independently of outer floating section 2, until pin 15 traverses slot 14 and engages the opposite side thereof, after which section 2 is swung downwardly with section 1. When the airplane on which wing W is mounted approaches or reaches a condition of stall with the inner nonfloating section 1 of aileron A in normal neutral position, the outer floating section 2 of aileron A, floats and is swung upwardly by the action of the airflow thereon to the dotted line position of Fig. 6. Then upon actuation of aileron section 1 to swing the same either upwardly or downwardly for lateral control, due to the coupling mechanism and the relative positions of slot 14 and pin 15 (see Fig. 6), the outer floating aileron section 2 is swung upwardly and downwardly with he inner positively and directly operated inner aileron section 1. Thus, effective lateral control under stalled conditions is secured because of the raised upwardly swung positions of the floating aileron sections 2 of the opposite ailerons A, only one of which is here shown, while the drag from these aileron sections is substantially balanced due to their simultaneous opposite raising and lowering with and by their respective inner sections 1. This balancing of the drag tends to avoid the evolution of the "spin" by lateral control operation under stall conditions.

The shocks and jars of engaging coupling members 20 and 21, as well as those incident to rought controlling or air conditions with the coupling members engaged, are absorbed and cushioned by the yielding connection between beam 6 and coupling sleeve or member 20, heretofore described.

In Fig. 2 of the drawings another design and mounting of an aileron A′ of the invention and comprising the inner non-floating section 1*a* and the outer floating section 2*a*, together with a modified form of coupling C′ for these sections is shown. The aileron A′ is mounted on the wing W′ at the usual trailing edge location for vertical swinging on the hinges 7′ to which the axially alined section beams 5 and 6 are pivotally connected, but in this instance the outer floating section 2*a* of aileron A′ terminates at and forms a part of the wing tip, and does not overhang such tip. A form of conventional aileron actuating mechanism embodying cables 11′, only one of which is shown, attached to the upper and lower sides of inner aileron section 1*a* in the usual manner, operatively connect inner aileron section 1*a* with the usual cockpit control (not shown). If desired the outer floating section 2*a* of aileron A′ is provided with a forwardly extended static balance 4′ located in a slot through the adjacent portion of wing W′.

Another design and mounting of an aileron A^2 of the invention, consisting of the inner non-floating positively actuated aileron section 1*b*, and the outer floating section 2*b*, is shown in Fig. 3 as mounted on a wing W^2 of the high aspect ratio type. In this form of aileron A^2, the outer floating section 2*b* thereof is provided with an outer portion 3*b* extended outwardly from and in continuation of the wing tip and of a chord equal to the chord of the wing W^2. The inner and outer sections 1*b* and 2*b* are mounted by their beams 5 and 6, respectively, on wing hinges

7 similar to the arrangement of Fig. 1, and the inner section 1*b* is connected to the cockpit control mechanism by cables 11′, one of which is here shown. The beams 5 and 6 of aileron sections 1*b* and 2*b*, are operatively associated and connected by a coupling C′ of the invention such as employed with the aileron of Fig. 2, and which is described in detail hereinafter.

The modified form of aileron section coupling C′ as applied to the ailerons A′ and A² of Figs. 2 and 3, is illustrated in Figs. 7, 8 and 9 of the drawings as applied to the aileron A′ of Fig. 2. Referring to Figs. 7, 8, and 9, the beam 6 of outer floating aileron section 2*a* rotatably extends and is received in the outer end of beam 5 of inner aileron section 1*a*. A plug or block 12 is fixed in the inner end of beam 6, and is provided and formed with the slot 14 therethrough, with beam 6 formed with the slots 6*a* therethrough alined with the opposite upper and lower ends, respectively, of slot 14, (see Fig. 8) in a manner similar to that described in connection with coupling C of Figs. 5 and 6. A coupling sleeve or member 50 is mounted on the outer end of beam 5 for limited rotation thereon, and a pin or bolt 15 extends transversely therethrough and through bore 14 of block 12 and bores 6*a* of beam 6, as will be clear by reference to Fig. 8. The bolt 15 holds the member 50 against axial movement on beam 5, but in order to permit of very limited rotation of this member on beam 5 in either direction, the bolt 15 extends through the slightly elongated upper and lower slots or bores 5*a* formed in beam 5 (see Fig. 8). Thus, beam 6 is rotatable with respect to beam 5 within the limits determined by the opposite upper and lower elongation of slot 14, as previously explained in connection with the coupling C of Figs. 5 and 6.

A shock absorbing mounting of coupling member 50 on beam 5 to care for the shocks in operation due to air conditions or rough handling of the controls is provided, similar to that described in connection with coupling C of Figs. 5 and 6. In this instance the coupling member 50 is formed with an enlarged diameter inner end or head 51 provided with an annular recess in its inner end wall into which a mass of rubber or the like 22 is pressed and confined. A spaced series of lugs 23 extend inwardly from the wall of the coupling and are embedded in the rubber mass 22. A similar spaced series of lugs 24 extend radially from and around the exterior of beam 5, and extend into and are embedded in the rubber mass 22 spaced between coupling lugs 23, all as clearly shown by Figs. 7 and 9. Due to the elongated bores or slots 5*a* in beam 5 through which bolt 15 extends, the rubber mass 22 forms in effect a yielding coupling between the member 50 and beam 5, through lugs 23 and 24, which absorbs sudden jolts or shocks to which the aileron sections may be subjected in operation and use.

With the aileron A′ having coupling of the form of C′ between the sections 1*a* and 2*a*, when these aileron sections are in normal neutral control position, referring now to Fig. 8, upward swinging of inner, non-floating section 1*a* will simultaneously swing outer floating section 2*a* up with it, due to the relative positions of bolt 15 and slot 14. Downward swinging of inner section 1*a* from normal neutral position will not swing outer floating section 2*a* downwardly with it until pin 15 traverses slot 14 (see Fig. 8.) In the neutral control positions of sections 1*a* and 2*a*, outer floating section 2*a* is free to float upwardly under wing stalled condition to the position shown by dotted lines in Fig. 8, and in this raised position of section 2*a*, downward swinging of inner section 1*a* simultaneously swings the raised outer section 2*a* downwardly with it, while upward swinging of inner section 1*a* does not swing raised floating section 2*a* upwardly with it until bolt 15 has traversed slot 14, as will be clear by reference to the dotted line position of slot 14 shown in Fig. 8. The coupling C′ while more simple than the coupling mechanism C of Figs. 1, 5, and 6, does not give as effective lateral control under stalled conditions with the floating aileron sections upwardly swung, because not only losing the effect of reduction in lift by up aileron but there is not the drag balancing, due to the fact that when the raised floating aileron section at one side of the wing is lowering there is not a simultaneous and substantially equal raising of the opposite aileron floating section.

The invention by providing ailerons of the forms and mounting arrangements of Figs. 1, 2 and 3 of the drawings, with the floating sections of the ailerons located along the trailing edge of a wing at the outer portion of the span thereof at and adjacent the less efficient tip portion of the wing, and the non-floating directly and positively controlled sections of the ailerons located along the inner portion of the trailing edge of the wing in continuation of the outer floating sections, secures a material reduction in the wing efficency lowering effect of a floating aileron on the more efficient inner portions of the wing, while at the same time eliminating the structural and weight disadvantages of the overhanging or remotely mounted types of floating ailerons. Also, as it is considered that the tip portions of a wing reach a condition of stall in advance of the remaining portion of the span of the wing, the floating aileron sections of the invention adjusted by the airflow are beneficial in retarding the stalling or "burbling" point of the wing.

In connection with the aileron A′ mounting and arrangement of Fig. 2 where the

floating section 2*a* of the aileron is entirely behind wing W′ and inboard or inwardly of the fixed tip of the wing, in the normal flight attitude (low angles of attack of the wing) there is a tendency of the floating section 2*a*, due to pressure differences, to float upwardly and assume a raised position with respect to the wing. The extent of such raising or upward floating will be dependent upon design factors with the wing under normal flight, low attack angle conditions. On the contrary, with the aileron designs and mountings of Figs. 1 and 3, due to the portions of the floating sections overhanging the wing tip and the relatively short extent of floating section extended inwardly behind the wing and in an area of tip wash, the tendency of the floating sections to raise and assume an up position will be practically negligible under normal flight attitude, low attack angle conditions, the floating sections approximately aligning with or being slightly negative thereto.

It is also to be here noted that if desired or found expedient with a control surface of the invention, an initial force can be applied to the floating section of the surface for the purpose of modifying or changing the floating action thereof and the alignment of the floatig section.

The invention, however, is not limited to the designs and mountings of the ailerons of Figs. 1, 2, and 3, but includes the application of an aileron embodying the floating and non-floating sections to a multiplane wing cellule with the aileron sections separated and mounted on different wings of the cellule, while being operatively associated and connected by coupling mechanism for operation in accordance with the principles of my invention. As an example I have selected and more or less diagrammatically illustrated in Fig. 4 of the drawings, a multiplane wing cellule W^3 of the biplane type comprising upper wing *w*′ and lower wing *w*″. On the lower wing *w*″ adjacent the tip portion thereof I mount the positively controlled and directly actuated aileron section 1*c* and on the upper wing the floating section 2*c*, these sections 1*c* and 2*c* forming together the aileron A^3 of the invention. A coupling mechanism of the invention, for example a coupling mechanism of the form of C′ hereinbefore described, is operatively connected with the lower non-floating section 1*c* and is provided with an arm or lever 60 extending operatively therefrom which is connected to the upper floating aileron section 2*c* on upper wing *w*′ by the streamline strut 61. With this arrangement and mounting the operation of the floating section 2*c* and non-floating section 1*c* with which it is operatively connected, is simillar to that described in connection with coupling mechanism C′ and the ailerons A′ and A^2 of Figs. 2 and 3.

The invention further contemplates the formation of a control surface, such as a lateral control surface or aileron, with a non-floating section of zero area so that the total control surface is then formed by the floating section. Such arrangement embodies the application of a coupling mechanism of the invention to a single section control surface to provide such surface for floating in accordance with the principles of the invention. A coupling mechanism embodying the invention, such for example as a mechanism in the form of C or C′ here disclosed, is capable of and intended as a unit for application to a conventional or other type of suitable control surface in order to convert such surface to one of the floating type. The coupling mechanism as a unit can be applied for installation on and coupling with a control surface in use on aircraft or can be incorporated in an aircraft when built.

In connection with the aileron arrangements, it is to be further noted that the floating outer section of the aileron may if desired be arranged to entirely overhang the adjacent wing tip proper, being supported as a cantilever from the inner aileron section beam with the outer floating section beam rotatably telescoping a considerable distance into the inner section beam. If desired to reduce the span of the floating section it may be given a greater chord than that of the adjacent inner, positively controlled section of the aileron, as will be readily apparent.

It is also evident that various changes, modifications, variations, substitutions, additions and eliminations might be resorted to in carrying out and expressing the principles and various features of my invention, and hence I do not desire or intend to limit the invention in all respects to the exact and specific disclosures hereof.

What I claim, is:

1. An aircraft control surface comprising a non-floating section and a floating section, said non-floating and floating sections substantially axially alined.

2. An aircraft control surface formed of substantially longitudinally alined sections and one of said sections free to float with respect to the other of said sections.

3. An aircraft control surface formed of sections substantially longitudinally alined, and mechanism operatively coupling said sections to permit one of said sections to float independently of and with respect to the other of said sections.

4. An aircraft control surface comprising a floating section and a non-floating section, and means operatively connecting said sections with the floating section free to float independently of the non-floating section by the action of airflow thereon under certain conditions, and under certain other condi-

tions, said means actuated to positively couple the floating section to the non-floating section for actuation therewith as a unit.

5. An aircraft control surface comprising a floating section and a non-floating section, means for positively operating the non-floating section, and mechanism operatively associating the floating and non-floating sections with the floating section free to float independently of the non-floating section under certain conditions, said mechanism actuated to positively couple said floating section with the non-floating section under certain other conditions by operation of said non-floating section operating means.

6. In an aircraft, a wing, a control surface mounted on said wing comprising a floating section and a non-floating section, and means operatively coupling said sections with the floating section free to float upwardly independently of the non-floating section when the wing is under stall conditions.

7. In an aircraft, a control surface comprising a floating section and a non-floating section, mechanism operatively associating said sections with the floating section free to float upwardly under aircraft stall conditions, said mechanism coupling the sections for operation together upon actuation of the non-floating section when the floating section is in its upwardly floated position.

8. In an airplane including a multiplane wing cellule, a lateral control surface comprising a non-floating section mounted on one wing of the cellule, a floating section mounted on another wing of the cellule, and means operatively coupling said sections.

9. In an airplane including a multiplane wing cellule, a lateral control surface formed by a non-floating section mounted on one wing of the cellule, a floating section mounted on another wing of the cellule, and mechanism operatively coupling said sections together for simultaneous operation under certain conditions and for floating of the floating section independently of the non-floating section under certain conditions.

10. In an aircraft, a control surface formed by a non-floating section and a floating section, mechanism operatively coupling said sections for operation together under normal flight conditions with the floating section free to float upwardly under stall conditions, and the said mechanism coupling the sections for operation together after upward floating of the floating section.

11. In an airplane, a wing, an aileron mounted on said wing, and said aileron having a portion thereof free to float upwardly with respect to the remaining portion thereof with the wing under conditions of stall.

12. In an airplane, an aileron formed of sections with one of the sections free to float upwardly with respect to the other section when the airplane is under stall conditions, and means operatively coupling the sections for downward swinging together with the upwardly floated section in relative raised position with respect to the other section.

13. In an airplane, an aileron formed of a floating section and a non-floating section, control means for raising and lowering the non-floating section, and coupling mechanism operatively connecting said sections, said coupling mechanism permitting the floating section to swing upwardly independently of the non-floating section with the airplane under stall conditions, and actuated by raising and lowering of the non-floating section to couple the upwardly floated section thereto and swing the same upwardly and downwardly therewith.

14. In an airplane and a wing thereof, an aileron mounted on the wing and formed of inner and outer sections, the outer section free to float upwardly with respect to the wing and the inner aileron section with the airplane under stall conditions.

15. In an airplane and a wing thereof, an aileron mounted along the trailing edge of the wing adjacent the wing tip, said aileron formed by an inner non-floating section and an outer floating section adjacent the wing tip, and means operatively associating said floating and non-floating sections.

16. In an airplane and a wing thereof, an aileron mounted along the trailing edge of the wing adjacent the wing tip, said aileron comprising an inner, positively actuated section and an outer floating section, said outer floating section of the aileron extending outwardly beyond the wing tip, and means operatively associating said sections.

17. In an airplane, the combination with a control surface, of control mechanism for actuating said control surface, said control mechanism including means coupling the control surface therewith and permitting the control surface to float independently of the mechanism within predetermined limits.

18. In an airplane, a control surface, control mechanism for actuating the control surface, said mechanism including a coupling operatively connecting the control surface to the mechanism and permitting floating of the control surface independently of the control mechanism under certain conditions, and shock absorbing means between the coupling and the control surface.

19. In an airplane including a wing thereof, an aileron including a longitudinal beam therefor, said aileron mounted on the wing for vertical swinging around said beam as an axis, the aileron and beam formed of longitudinally alined sections with the adjacent beam section ends rotatably engaged, the end of one beam section formed with a transverse slot therethrough circumferentially elongated, a pin carried by the other beam section end and extending loosely through said slot,

whereby the slotted beam section and the aileron section of which it forms a part is swingable within the limits of said slot independently of the other beam and aileron section.

20. In an airplane including a wing thereof, an aileron mounted on the wing for vertical swinging, said aileron formed of a non-floating section and a floating section operatively associated therewith for swinging independently thereof within predetermined limits, control means connected with the non-floating section for swinging said section, and coupling mechanism carried by said aileron sections and normally disengaging the same, said mechanism actuated by upward swinging of the non-floating section to engage the floating and non-floating sections for swinging together.

21. In an airplane wing, an aileron including a longitudinal beam therefor, said aileron mounted on the wing for swinging around said beam as an axis, the aileron and beam formed of longitudinally alined sections, coupling mechanism operatively connecting said beam sections with one of said sections free to float independently of the other section within predetermined limits, and shock absorbing means between said coupling mechanism and said beam.

22. An aircraft control surface formed of sections with one of said sections free to float independently of the other section within predetermined limits, and yielding shock absorbing means interposed between and operatively associated with said sections.

23. In an airplane wing, an aileron including a longitudinal beam therefor, said aileron mounted on the wing for swinging around said beam as an axis, the aileron and beam formed of longitudinally alined sections, and coupling mechanism operatively connecting the adjacent ends of said beam sections with one of the aileron sections free to float independently of the other within predetermined limits.

24. In an airplane wing, an aileron including a longitudinal beam therefor, the aileron mounted on the wing for swinging around said beam as an axis, said aileron and beam formed of longitudinally alined floating and non-floating sections, coupling means carried by the non-floating section beam, and said floating section beam operatively engaging said coupling means for floating of the said section independently of the non-floating section within predetermined limits.

25. In an airplane wing, an aileron including a longitudinal beam therefor, said aileron mounted on the wing for swinging around said beam as an axis, the aileron and beam formed of longitudinally alined floating and non-floating sections, and the adjacent beam section ends operatively interengaged for relative rotation thereof and swinging of the floating section within predetermined limits independently of the non-floating section.

26. In an airplane wing, an aileron mounted on the wing for vertical swinging, said aileron formed of a non-floating section and a floating section operatively associated therewith for swinging independently thereof within predetermined limits, control means connected with the non-floating section for swinging said section, coupling mechanism carried by said sections for connecting and disconnecting the same, said mechanism embodying a coupling member carried by the floating section, a coupling member carried by the non-floating section and movable thereon to and from position engaging said floating section coupling member, said non-floating section coupling member normally maintained in position disengaged from said floating section member, and means operatively connected between said movable non-floating section coupling member and the wing to cause said member to engage the floating section coupling member when the non-floating section is swung upwardly on and with respect to the wing to engage the floating and non-floating aileron sections for swinging together as a unit.

27. An airplane wing, a control surface pivotally mounted on the wing, said control surface comprising a non-floating section and a floating section operatively associated therewith for swinging independently of the non-floating section within predetermined limits, control means connected with the non-floating section for swinging such section, coupling mechanism carried by said control surface sections and normally disengaging the same for swinging of the floating section independently of the non-floating section, and means controlling said coupling mechanism operated by swinging of said non-floating section to actuate said coupling mechanism to engage said floating and non-floating sections for swinging of the sections together as a unit.

28. An airplane wing, a control surface pivotally mounted on the wing for vertical swinging, said control surface formed of a non-floating section and a floating section, control means for swinging said non-floating section, and coupling mechanism operatively associating said sections for upward swinging of the floating section independently of the non-floating section within predetermined limits in all normal neutral and upwardly swung positions of the non-floating section, said coupling mechanism engaging the sections for downward swinging together with the floating section in relative raised position with respect to said non-floating section.

29. An airplane wing, a lateral control surface pivotally mounted on the wing for vertical swinging on an axis disposed span-

wise of the wing, said control surface divided chordwise of the wing into spanwise alined sections, and one of said sections free to float upwardly with respect to the other section within predetermined limits.

30. An airplane wing, a lateral control surface pivotally mounted on the wing for vertical swinging thereon, said control surface formed of a non-floating section and a floating section free to float upwardly independently of the non-floating section within predetermined limits, control mechanism for swinging the non-floating section, and means operatively associating the floating section with the non-floating section for upward floating of the floating section with respect to the non-floating section with the wing under stall conditions, said means connecting the non-floating section with the floating section for downward swinging thereof together as a unit.

31. An aircraft control surface formed of a non-floating section and a floating section, the floating section free to float independently of the non-floating section within predetermined limits by the action of the airflow thereon, control mechanism for swinging the non-floating section, and means operatively associating the sections whereby upon operation of said control mechanism to swing the non-floating section the floating section is swung by and together with the non-floating section.

Signed at Rochester, Monroe County, New York, this 12th day of July, 1930.

RANDOLPH F. HALL.