Jan. 19, 1932. R. F. HALL 1,841,804

AIRPLANE

Filed April 21, 1930 2 Sheets-Sheet 1

Fig. 1.

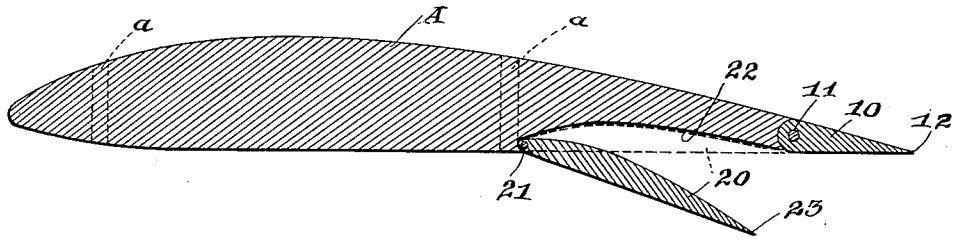


Fig. 2.

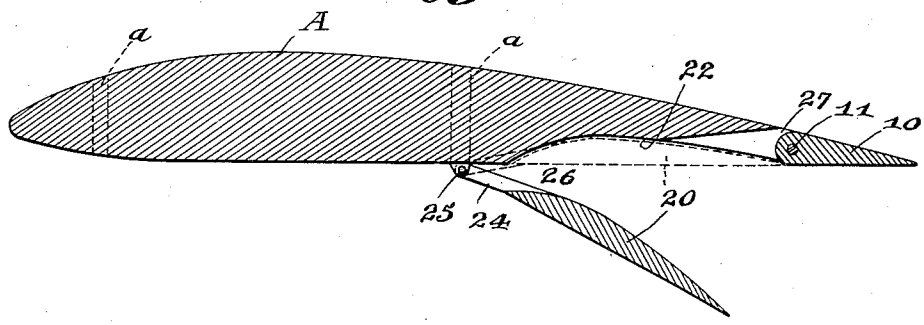
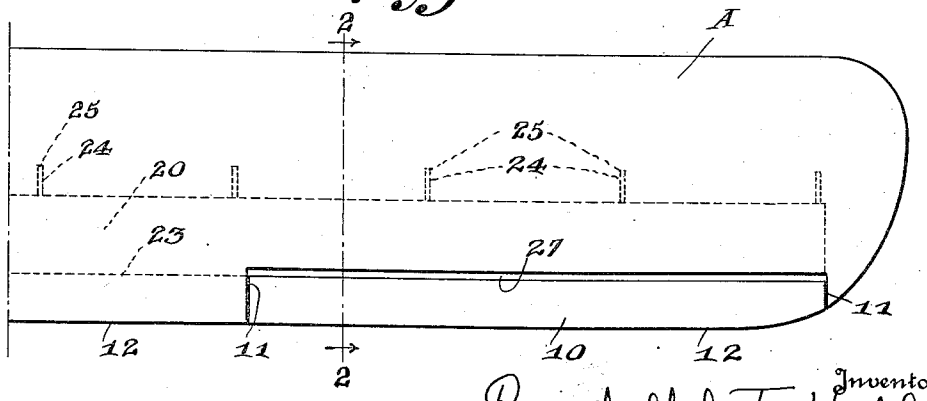


Fig. 3.



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Fig. 4.

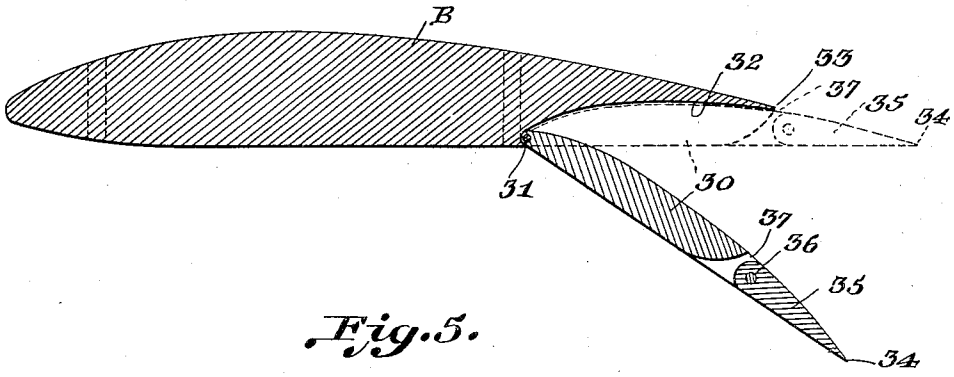


Fig. 5.

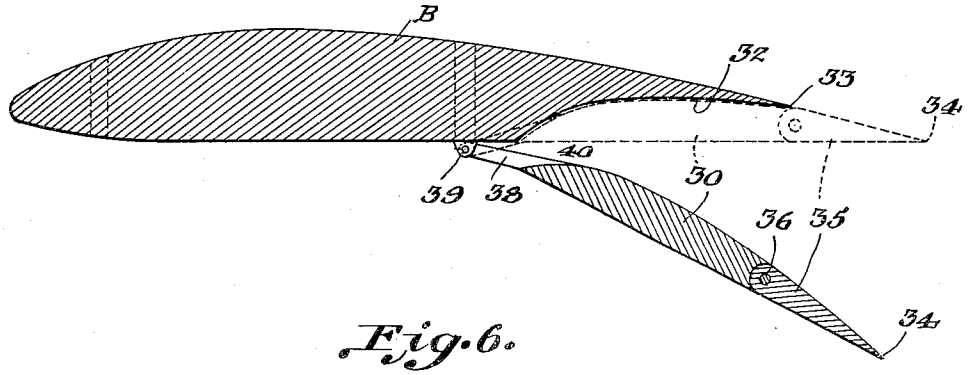


Fig. 6.

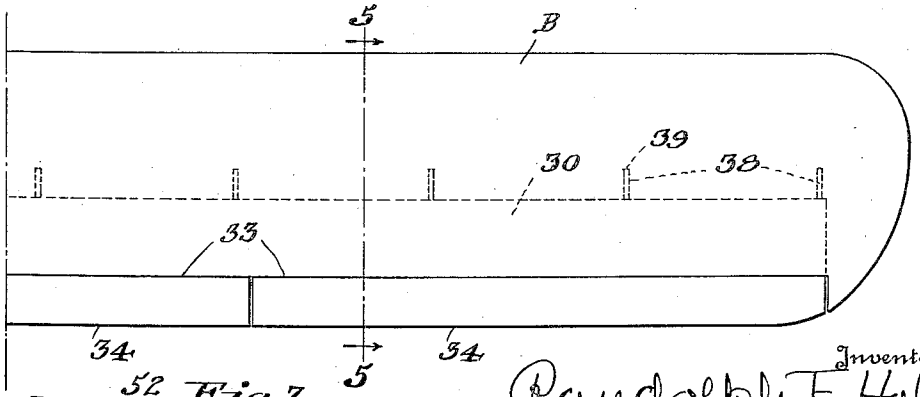
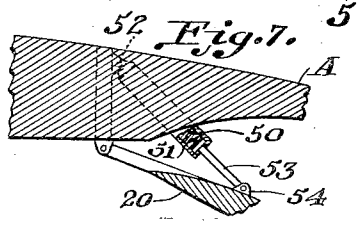


Fig. 7.



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Patented Jan. 19, 1932 1,841,804

UNITED STATES PATENT OFFICE

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AIRPLANE

Application filed April 21, 1930. Serial No. 446,008.

This invention relates to certain improvements in airplanes; and the nature and objects of the invention will be readily recognized and understood by those skilled in the arts involved in the light of the following explanation and detailed description of the accompanying drawings illustrating what I at present consider to be the preferred embodiments or mechanical and aerodynamical 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.

The invention is primarily and particularly directed to the solution of certain problems and the substantial elimination or material reduction of certain difficulties encountered with and inherent in airplane lift surfaces, wings, and airfoils, (hereinafter referred to generally as wings) of those so-called "variable" lift or "high-lift" types characterized generally by the provision of a portion of the wing, usually although not necessarily a trailing edge portion, as vertically swingable, to form in effect what may be generically termed a "flap" portion, for varying the camber of the wing, and hence the lift developed by the wing. With such types of wing, for normal, high-speed flight therewith, the vertically swingable portion or flap thereof, is in upwardly swung, camber decreasing position. When it is desired to increase the lift characteristic of the wing, the flap is swung downwardly to position increasing the camber of the wing with resulting increase in drag and decrease in speed; the camber and resulting decrease in speed being variable between normal, raised position of the flap and ordinarily its maximum lowered position. Such types of wing, while of utility under various flight conditions, are of especial value for reducing the speed and permitting better taking-off and landing with an airplane, in order to reduce the ground runs required and materially reduce the hazards of high speed landings. A wing of this type enables a material decrease in low speed of an airplane through increase in lift capacity of the wing, while retaining and without lowering, the normal high speed of which the airplane with normal wing section is capable, through the ability of the flap to restore the high speed section and camber of the wing.

With the flat types of wing, however, variation of the camber to vary the lift, through the medium of the vertically swingable camber changing flap portion of the wing, causes a relatively large or extensive center of pressure travel or movement for the wing, and this condition is established in a high degree in those generally used forms of flap type wings in which the flap varies the camber of both the upper and the lower surfaces of the wing. Large center of pressure travel or movement in such types of wing, results in the establishment of conditions affecting and disturbing stability and effective control, and also necessitate structural complications in an effort to care for such conditions and others arising therefrom. With the flap portion of such a wing in lowered, camber and lift increasing positions, the center of pressure on the wing moves or travels rearwardly, the extent of this rearward travel increasing as the flap is lowered, and such rearward center of pressure travel or movement disturbs and adversely affects longitudinal stability and renders the lateral control, as well as other control, more difficult and less effective. Thus, the advantageous results and desired performance of this type of wing are negatived or materially detracted from by the foregoing stability, control, and structural difficulties and disadvantages, so that the practical value and efficiency of the type in actual use is substantially lowered thereby.

A main characteristic of the present invention is the design, arrangement, and construction of an airplane wing of the "variable lift" flap type, in which the location of the flap and its design and relation to the wing as a part thereof, are such that the center of pressure travel or movement for the wing through the full operating range of the flap from normal raised, camber decreasing, and high speed position, to maximum lowered, camber and low speed position is relatively

small, so that, the normal stability and control effectiveness and efficiency for the wing in normal flap raised, high speed position, is not materially impaired or disturbed with the flap in its lowered, camber and lift increasing positions; and further so that the structural difficulties and complications attendant large center of pressure travel for the wing are substantially eliminated.

A further characteristic of the invention resides in the location and mounting of the flap at the under side of the wing to form a portion of the wing lower surface, in such a manner that vertical swinging of the flap varies the camber of the wing lower surface only, the upper surface camber of the wing being and remaining fixed and unchanged; and a feature of the invention consists in the design of the wing and the under side thereof to receive the flap, as and forming a part of the wing, and in the cooperating design of such under flap and its location and mounting on and relative to the wing, for the purpose of obtaining from such wing the hereinbefore referred to advantages and results in operation and performance.

The "variable lift" wing of the flap types also presents certain serious problems and difficulties in the mounting and in the efficient operation of lateral control surfaces or ailerons, on such a flap carrying wing, and these problems and difficulties are intensified with a wing having the flap at the under side of the wing in accordance with a characteristic of the present invention, and especially where, in accordance with another characteristic of the invention, the flap is located at and along and forms a part of the trailing edge portion of the wing. The flap offers an obstruction to the free mounting and installation of lateral control surfaces or ailerons at the trailing edge of the wing and results in structural and mechanical complications, while from the aerodynamic and control standpoints the flap forms an interfering and obstructing medium to proper airflow to and action on the lateral control surfaces, thus materially reducing the effectiveness and efficiency of such control surfaces.

Another feature and characteristic of the invention consists in the design and mounting of the flap on such flap types of wing, and in the cooperating design of the wing and mounting of a lateral control surface or aileron thereon, such that the camber varying flap in all positions throughout its operating range permits free and necessary uninterrupted or unobstructed flow of air to the lateral control surface or aileron to enable effective and efficient operation of such surface, and in which a structural simple and efficient mounting is possible for both the wing flap and the lateral control surface or aileron.

The invention is further featured by structurally and mechanically simple and efficient design and arrangement for a "variable lift" wing of the flat type having the foregoing characteristics and others to be hereinafter brought out, which enables the wing to be practically manufactured, and makes such types of wing available for general use with various types and designs of airplanes.

With the foregoing general features, characteristics and results in view, as well as certain others which will come to light from the following explanation, the invention consists in certain novel features in design, and in combinations, arrangements, and construction of elements thereof, as will be more fully and particularly referred to and specified hereinafter.

Referring to the accompanying drawings, in which similar reference characters refer to corresponding elements and parts throughout the several figures thereof:

Fig. 1 is a diagrammatical view in vertical transverse section through a wing embodying an arrangement and relative mounting of an under-flap and aileron on and with respect to the wing, in accordance with the invention, the under-flap being shown in its lowered, camber increasing position in full lines, and in normal raised position shown by dotted lines.

Fig. 2 is a diagrammatical view in vertical transverse section, taken as on the line 2—2 of Fig. 3, through a wing, under-flap and aileron, mounted and relatively arranged in accordance with the invention, in which the under-flap is mounted to form an air displacement passage between the wing and flap in lowered position of the latter, and in which an air displacement slot is formed through the wing adjacent the aileron, the flap being shown by full lines in lowered position and in dotted lines in normal, raised position.

Fig. 3 is a top plan view, more or less diagrammatical, of the wing of Fig. 2.

Fig. 4 is a diagrammatical view in vertical transverse section through a wing, under-flap and aileron arrangement and mounting of the invention, in which the aileron is mounted on the under-flap and the latter is formed with an air displacement slot therethrough, the under flap and aileron being shown by full lines in lowered position and by dotted lines in normal raised position.

Fig. 5 is a diagrammatical view in vertical transverse section, taken as on the line 5—5 of Fig. 6, through a wing, under-flap and aileron arrangement of Fig. 4, but with the under flap slot eliminated and with the under flap mounting on the wing to form the passage between flap and wing of the form of Fig. 2, the under flap and aileron being shown by full lines in lowered position and by dotted lines in normal raised position.

Fig. 6 is a top plan view, more or less diagrammatical, of the arrangement and form of wing, under flap and aileron, of Fig. 5.

Fig. 7 is a fragmentary view, more or less diagrammatical, partly in vertical section and partly in elevation, of a wing of the form of Fig. 2, arranged for automatic operation of the wing under flap, yielding mechanism being shown normally forcing the wing flap to lowered positions.

I have selected as an example, and more or less diagrammatically illustrated in Fig. 1 of the accompanying drawings, a variable lift wing of the flap type as presenting and embodying a possible aerodynamic and design expression of certain broad principles and features of my invention. In this example I provide a wing A, which I have diagrammatically illustrated in transverse vertical section, of any suitable or desired airfoil section and of any well known or other desired type of construction, which may or may not include the usual forward and rear longitudinal beams or spars *a* indicated by dotted lines in Fig. 1 of the drawings. The wing A is provided with the ailerons or lateral control surfaces 10 at opposite ends thereof and forming portions of the wind trailing edge in the usual manner as will be clear by reference to Fig. 1 in connection with Fig. 3 of the drawings, only one of the ailerons 10 being here shown. The ailerons 10 may be of any desired type but may preferably be provided with the well known leading edge forms of aileron balance (not shown). Each aileron 10 is pivotally mounted for vertical swinging on a horizontal axis formed by the pivots 11, and extends inwardly for a portion only of the span of the wing in the form here shown, although if desired the ailerons 10 may together extend for the full span of the wing. Any desired or suitable aileron operating mechanism (not shown) is provided for the control of ailerons 10, as will be readily understood by those skilled in the art and hence it is not deemed necessary of illustration herein.

In accordance with a broad feature and principle of my invention, a rear portion of the under side of the wing A adjacent but spaced forwardly from the trailing edge thereof, is formed by a vertically swingable under flap forming member 20, which in the example hereof is of airfoil section and in its normal raised position lies within a recess 22 in the under side of the wing and with the under surface of member 20 forming a part of the under surface and carrying out the normal contour and airfoil section of, the wing A. The under flap 20 is pivotally mounted at 21 for vertical swinging on an axis substantially along its forward or leading edge, and extends rearwardly to and terminates in the trailing edge 23 which is spaced forwardly a distance from the trailing edge 12, of which the ailerons 10 form a part (see Fig. 3), of the wing A.

In the specific example hereof, the under flap 20 is pivotally mounted on an axis located aft or to the rear of the longitudinal center or axis of the wing A, that is, for example, at the rear beam location *a* of the wing, and extends rearwardly to terminate with its trailing edge 23 spaced forwardly from the wing trailing edge 12. The under flap 20 is of such a chord that its trailing edge 23 lies either forwardly of or at the forward or pivotally mounted leading edge of each aileron 10, so that the under flap in normal raised position, shown by dotted lines in Fig. 1, clears the ailerons 10 and permits free and normal vertical swinging thereof on pivots 11 without interference from the under flap, and so that the under flap is freely swingable on its pivot 21 without interference from the ailerons 10.

The under flap 20, preferably, although not necessarily extends substantially the full span of wing A and the trailing edge portion which is a fixed structure with the exception of the aileron 10 forming a part thereof, extends rearwardly beyond and overhangs the under flap 20, a distance substantially equal to the chord of the ailerons 10, as will be clear by reference to Figs. 1 and 3 of the drawings. The invention is not limited, however, in all respects to such overhang distance or to such relative aileron chord, as the under flap can be mounted with its trailing edge 23 spaced forwardly from the ailerons, or its chord can be decreased, or it can be pivotally mounted on an axis farther forward of the wing than that here shown, all to the end of increasing the extent of wing overhang, if desired or found expedient. Following, however, what I at this time believe to be a preferred and aerodynamically more efficient relative mounting of the under flap 20 on and with respect to wing A, the extent or distance of the overhang of the wing trailing edge portion should be less than the chord of the under flap 20, but again it is not my intention to limit the invention in all respects and every form thereof to an under flap chord greater than the extent or overhang distance of the wing trailing edge portion.

The under flap 20 is vertically swingable on the pivot 21, by any of the known or other suitable operating mechanisms (not shown) from its normal raised position, shown by dotted lines in Fig. 1, in recess 22 and within the normal high speed section and contour of wing A, to lowered position increasing the camber of the wing under surface only, the upper surface camber of the wing remaining fixed, as will be clear from the full line position of under flap 20 in Fig. 1. With the

under flap 20 in its lowered, under surface camber increasing positions, such as the full line position of Fig. 1, the wing A has in effect an increased angle of attack, but due to the unchanged and unbroken upper surface camber the wing profile adapts itself more efficiently to the airflow and "burbling" is therefore retarded which materially increases the lift of the wing, all while doing so without a large or appreciable center of pressure movement from that of the normal section and contour of the wing A. In lowered positions of the under flap 20, as well as in normal raised position thereof, the ailerons are freely normally operable, which together with the design and relative mounting of the under flap secures for the wing effective lateral control. From lowered, camber increasing, low speed positions of the under flap 20, such flap is upwardly swingable by its operating mechanism (not shown), to normal position shown by dotted lines in Fig. 1, in recess 22 and within and forming a part of the normal wing section, to return or convert the wing A to its normal high speed section.

By the reduction, in a wing of the variable lift, flap type, of the center of pressure travel of the wing as a whole, the control problems are simplified and a lighter weight construction for the under flap is made possible, which results in less inertia of a movable part and reduces the danger of flutter. The fixed upper surface of the wing permits greater wing rigidity and together with the foregoing and other results and advantages, make possible an increased general application of this type of wing to aircraft, especially to so-called high performance types of airplanes.

A design, arrangement and mounting of an under flap 20 in a wing of the invention of the form of Fig. 1, is more or less diagrammatically disclosed in Figs. 2 and 3 of the drawings, in which an air displacement passage or space is formed between the under surface of wing A and the under flap 20 when the latter is in its lowered, wing under surface camber increasing positions. This is accomplished in the present example by providing the under flap 20 with a series of spaced arms 24 extending forwardly from the front or leading edge of under flap 20, and pivotally mounting the forward ends of these arms to the wing A at points 25, so that the under flap 20, is mounted on wing A for swinging on an axis remote from the leading edge of the under flap, as will be clear by reference to Fig. 2 of the drawings in particular.

By the above mounting and arrangement, when the under flap 20 is swung downwardly from its normal raised position, to the lowered full line position of Fig. 2, increasing the camber of the wing under surface, the leading edge of flap 20 moves downwardly away from the wing A, so that a gap or space 26 is formed between the under surface of wing A and the leading edge of the flap, which causes and permits rearward flow of air between the wing A and the under flap 20. This rearward flow of air between the wing A and under flap 20, passes under and acts on the ailerons 10 and materially increases the effectiveness and efficiency of the lateral control surfaces with the wing A in the flap lowered, low speed condition, as will be readily apparent. The obstruction to free flow of air to the under side of the ailerons by the under flap in lowered positions with resulting reduction and impairment in lateral control effectiveness, is thus substantially eliminated. The recess 22 in the under side of wing A, which forms in effect a portion of the air passage between the wing and the flap in lowered position, can be designed with a contour and size to deflect and direct the airflow in a particular manner to increase the efficiency of the wing and lateral control, as may be desired or found expedient.

Attention is here called to the further fact that by the remote pivot or hinge mounting 24—25 for the under flap 20, as shown in Fig. 2, a flap of given chord can be lowered a greater distance below the main, fixed portion of the wing A in the downwardly swung positions of the flap, so that, in effect a greater area of the air-flow is acted upon by the flap, as compared to such flap when mounted with its leading edge located in lowered positions at the under side of the wing, as in Fig. 1. Thus, an under flap of smaller chord, performs the work substantially of a flap of larger chord mounted as in Fig. 1 with the leading edge thereof located at the under side of the wing and no air gap or space therebetween. The remote pivot mounting for the under flap 20 secures an increase in lift with the use of a smaller and lighter weight flap, as well as increasing the effectivenes of the lateral control surfaces or ailerons.

A further feature is disclosed in Fig. 2 for increasing the effectiveness of the lateral control with the remote pivot or hinge type of under flap mounting, although this feature may be considered as optional and not as an essential requirement limiting the invention in all cases and respect to its inclusion. Such feature embodies the provision of a slot or passage 27 through the trailing edge portion of the wing A adjacent and along the leading edge of each aileron 10, which slot opens through the rear or trailing portion of the wing recess 22 and extends and decreases in width rearwardly and upwardly through the wing to discharge through the upper surface thereof, as will be clear by reference to Figs. 2 and 3. The under flap 20 in its normal raised position within wing recess 22, closes the lower or intake end of slot 27 (see dotted line position of under flap 20 in Fig. 2), but the slot is opened with the under flap in its lowered positions and some of the air flowing

between the wing A and lowered under flap 20 is forced upwardly through the slot and discharges therefrom above the adjacent aileron 10. This increases the airflow directly above the aileron which removes a portion of the boundary layer of air and further retards burbling with resulting increase in the aileron effectiveness. With the aileron 10 lowered, the under flap being in lowered position, flow of air through slot 27 tends to withhold burbling and greater lift is obtained, while with the aileron up the cross flow through the slot tends to reduce the lift. In this manner the slot 27 is believed to increase the lateral control effectiveness in the combination and relation with the remote pivot or hinge mounting of the under flap 20, when such flap is in its lowered positions.

In the forms and arrangements of the flap type of variable lift wing presented in Figs. 1 to 3 of the drawings, the design locates the lateral control surfaces or ailerons as mounted on and carried by the main fixed structure of the wing, with the under flap 20 terminating and located forwardly of the wing trailing edge 12. Another design, form and relative arrangement of wing, under flap and lateral control surfaces is disclosed in Figs. 4 to 6 of the drawings, in which the lateral control surfaces are mounted on and carried by the under flap.

Referring now to Fig. 4 of the drawings, taken in connection with Fig. 6 thereof, a wing B is disclosed as having the rear or trailing edge portion thereof undercut or formed with the rearwardly open recess 32 in the under side thereof and the wing terminating in the trailing edge 33. An under flap 30, in the example hereof of airfoil section, is pivotally mounted at its leading or forward edge by the pivot 31, to the under side of wing B at the forward end of wing recess 32, and in normal raised position the under flap 30 lies in recess 32 within the normal contour and airfoil section of wing B, so that the under side of the flap 30 forms a portion of the under surface of the normal wing, as will be clear by reference to the raised position of flap 30 shown by the dotted outline in Fig. 4. The under flap 30 in the form of wing here shown extends substantially throughout the span of wing B (see Fig. 6) and has a chord such that the flap extends rearwardly a distance beyond the fixed wing structure trailing edge 33, to terminate in the trailing edge 34 (see Fig. 6) which in normal raised position of the flap, forms in effect the trailing edge of the wing B in normal high speed contour and airfoil section thereof.

At each outer or tip end of wing under flap 30, an aileron 35 is mounted in a recess therein, on the pivots 36, with the aileron extending inwardly a distance of the span, although if desired the ailerons of a wing B can extend for the full span thereof. The trailing edge of each aileron 35 terminates substantially alined with and forming a part of the under flap trailing edge 34 (see Fig. 6), although the invention is not so restricted, and the chord of the aileron happens in the example hereof to be substantially equal to the distance the under flap 30 extends beyond the trailing edge 33 of the fixed structure of the wing B. Thus, with the under flap 30 in the normal raised dotted line position of Fig. 4, the aileron 35 is normally freely operable without interference from the fixed wing structure for lateral control of the wing in the normal high speed position and section thereof. In this connection, although the invention is not restricted in all forms thereof to such relative proportions, it is at present considered that in the preferred design and relative mounting of the under flap 30 on wing B, the main structure of the wing should extend for more than half the chord of the under flap, as will be clear from the disclosure of Fig. 4 of the drawings.

Any suitable mechanism (not shown) of the usual or other type for operating wing flaps can be provided for vertically swinging the under flap 30 carrying the ailerons 35, together with any suitable or known aileron operating mechanism (not shown) for actuating the ailerons in any and all positions of the under flap 30. By the arrangement shown, the ailerons are operable in all positions both normal raised and lowered of the under flap, and in the latter positions of the under flap the ailerons are subjected to and lie in the air-flow for effective lateral control of the wing. However, for the purpose of increasing the lateral control efficiency, although the invention is not restricted to the use thereof, a slot 37 is formed through the under flap 30, along and adjacent each aileron 35, so that flow of air takes place therethrough with the under flap in its lowered positions, above and rearwardly over the adjacent aileron, so that the effectiveness of the lateral control in flap lowered positions of the wing is increased, as will be readily apparent to those skilled in the art.

In Figs. 5 and 6 of the drawings, the wing design and arrangement of Fig. 4 is disclosed with the remote pivot or hinge mounting embodying the arms 38 and pivots 39 at the under side of the wing, in order to form the gap or space 40 for flow of air between the under side of wing B and the flap 30, with the latter in lowered wing under surface camber position (see Fig. 5), as explained previously in connection with the wing of the invention disclosed in Figs. 2 and 3. By the use of the air passage forming remote hinge mounting of the under flap 30, the effectiveness of the lateral control is increased due to the flow of air above the ailerons, and with this mounting it becomes unnecessary to utilize the under flap slot 37 of Fig. 4.

While the under flaps of the wings here disclosed are adapted to manual control and operation as hereinbefore referred to, they are also designed for automatic operation by and in accordance with the airflow conditions acting thereon, and the invention contemplates and includes such automatic operation. For example, in Fig. 7 of the drawings, I have shown a fragmentary view of the wing of the form of Fig. 2, in which one possible arrangement for carrying out the automatic operation of the under flap 20, is disclosed. This arrangement interposes a compression spring 50 between the wing A and the under flap 20, which spring continuously exerts a force downwardly on the flap tending to swing the same downwardly and maintain it in lowered, camber increasing, high lift and low speed position. Such a spring can be housed in a cylinder 51 pivotally mounted at 52 to the wing A, and act upon a plunger 53 which is pivotally connected at 54 to the under flap 20. In operation the spring 50 forces and maintains flap 20 lowered during low speed or high angle of attack of the wing, while under high speed, low angle of attack of the wing, the increased pressure at the under side of the flap forces the same upwardly compressing spring 50 and maintains the flap in its raised position. In the place of the spring arrangement shown pneumatic or hydraulic means can be employed, or the flap can be so arranged as to be swung by variations in airflow pressures alone and without the use of any positive acting means for aiding the operation.

Following the teachings of the invention, certain of the difficulties inherent in the flap types of variable lift wing are materially reduced or practically eliminated, and wings of such types are provided in which a minimum center of pressure travel is obtained, while lateral control is simplified and the effectiveness and efficiency of the lateral control of the wing is increased, especially in the flap lowered, camber increasing positions of the wing The efficiency and performance of such wings is increased and structurally they are rendered practical of manufacture and safe in use. All of the foregoing contribute to and make possible general application of this type of wing to aircraft, in order to utilize and obtain the many advantages thereof.

It is evident that various changes, modifications, variations, substitutions, additions, and eliminations might be resorted to without departing from the spirit and scope of my invention, and hence I do not wish to limit or restrict myself to the exact and specific disclosures hereof.

Desiring to protect my invention in the broadest manner legally possible, what I claim, is:

1. In a variable lift wing of the flap type, in combination, an aileron mounted at the trailing edge portion of the wing, the wing formed with a recess in the under side thereof forwardly of said aileron, and a flap member mounted at the under side of the wing for vertical swinging and having its trailing edge terminating forwardly of but adjacent to said aileron, the flap member in raised position disposed in said recess within and forming a part of the normal contour and airfoil section of said wing and in downwardly swung positions increasing the under surface camber of the wing, said aileron freely operable in all positions of said flap member.

2. A variable lift wing of the flap type formed with a recess in the under side thereof spaced forwardly from the wing trailing edge, a wing camber changing flap member mounted on the under side of the wing and forming a portion of the wing under surface for vertical swinging to vary the under surface camber of the wing, the trailing edge of said flap member spaced forwardly from the wing trailing edge a distance less than the chord of said flap, and said flap member in normal raised position disposed in the wing recess within and forming a part of the normal wing contour and airfoil section for the wing and in downwardly swung positions increasing the under surface camber and contour of the wing.

3. A variable lift wing of the flap type having a wing camber varying flap member pivotally mounted at the under side of the wing and forming a portion of the normal wing under surface, said flap member downwardly swingable to increase the wing under surface camber and left developed by the wing and said flap member formed in downwardly swung positions to establish an air displacement passage between the under side of the wing and the flap for flow of air rearwardly above the flap member.

4. A variable lift wing of the wing camber varying flap type having a flap member at the under side thereof in normal position forming a part of the wing under surface and downwardly swingable from the wing to increase the camber of the wing under surface, said flap member pivotally mounted on the wing for vertical swinging on an axis spaced forwardly from the leading edge of the flap member whereby a gap is established between the leading edge of the flap member and the under surface of the wing with the flap member in downwardly swung positions for rearward displacement of air between the under surface of the wing and said flap member.

5. In a wing, in combination, an aileron, a flap member at the under side of the wing spaced forwardly from said aileron and downwardly swingable to positions increasing the under surface camber of said wing, and said flap member pivotally mounted for vertical

swinging on an axis spaced forwardly from the leading edge of the member, said flap member in downwardly swung positions having its leading edge spaced from the wing to form a passage for rearward flow of air between the wing and flap and under said aileron.

6. In a wing, in combination, an aileron on the wing, a flap member mounted at the under side of the wing forwardly of said aileron and in normal position forming a portion of the wing under surface, said member downwardly swingable from normal position to lowered positions increasing the wing under surface camber and spaced from the wing to form a passage for rearward flow of air between the member and the wing and rearwardly beneath said aileron.

7. In a wing, in combination, an aileron mounted on the wing, a wing flap mounted at the under side of the wing forwardly of said aileron and in normal raised position forming a portion of the normal under surface contour of the wing, said flap downwardly swingable from normal position to lowered positions increasing the wing under surface camber and spaced from the wing to form a passage between the flap and the wing for rearward flow of air therebetween and at the under side of said aileron, and the wing formed with a slot therethrough along and adjacent the forward side of said aileron for forcing air upwardly therethrough to the upper side of said aileron with the flap in lowered positions.

8. In an airplane wing, a flap member mounted at the under side of the wing and forming a portion of the normal under surface contour thereof, and said member provided with forwardly extended spaced arms pivotally mounted at their forward ends to the wing for downward swinging of the member on an axis remote from the leading edge thereof to lowered positions spaced from the wing and forming a passage between the under side of the wing and the flap for rearward flow of air.

9. In a variable lift wing of the flap type, a wing camber varying flap member pivotally mounted at the under side of the wing and extending rearwardly beyond the wing trailing edge a distance less than one-half the chord of the flap member, said member freely vertically swingable to vary the wing under surface camber.

10. A variable lift wing of the flap type having a flap member at the under side thereof extending rearwardly beyond the trailing edge of the wing, said member in normal raised position forming a portion of the normal under surface contour of the wing and downwardly swingable to positions increasing the camber of the wing under surface, an aileron mounted on the extended rear portion of said flap member, and the flap member formed with a slot therethrough along and adjacent the forward side of said aileron for discharge of air over the upper side of the aileron with the flap member in lowered positions.

11. A variable lift wing of the flap type having a flap member at the under side thereof extending rearwardly beyond the wing trailing edge, said flap member in normal raised position forming a portion of the normal under surface contour of the wing and downwardly swingable from the wing to positions increasing the camber of the wing under surface, an aileron mounted on the rearwardly extended portion of the flap member, and said flap member formed to provide a space between the under surface of the wing and the flap member in downwardly swung positions of the latter for flow of air rearwardly between the wing and flap member across the upper side of said aileron.

12. A wing having a flap member mounted at the under side of the trailing portion of the wing for vertical swinging, said member in normal raised position forming a portion of the normal under surface contour of the wing and in downwardly swung positions increasing the under surface camber of the wing, and yielding means continuously exerting forces on said flap tending to swing the same downwardly from normal raised position to camber increasing positions, the said flap member automatically actuated by air pressures acting on the under side thereof with the wing under high speed, low attack angle conditions to swing upwardly to raised position against said yielding means.

13. A wing having a flap member mounted at the under side thereof for vertical swinging, said member in raised position forming a portion of the normal under surface contour of the wing and in downwardly swung positions increasing the camber of the wing under surface, and compression spring means interposed between said flap member and the wing and continuously exerting forces on the member for swinging the same downwardly from the wing, said flap member swung downwardly by said compression spring means with the wing under low speed, high attack angle conditions, and forced to and maintained in raised position against said compression spring means by the air pressures acting on the under side thereof with the wing under high speed, low attack angle conditions.

14. A wing having a camber varying flap member mounted at the under side of the trailing portion of the wing for vertical swinging, said member in normal upwardly swung position forming a portion of the under surface of the normal wing contour, said flap member formed and mounted on the wing to provide a forwardly open space between the wing and the member for flow of

air rearwardly therebetween when the flap member is swung downwardly to wing camber increasing positions, and means operatively associated with said flap for continuously exerting forces on the flap to swing the same downwardly to camber increasing positions, the said flap member actuated by air pressures acting thereon with the wing under low attack angle conditions to swing upwardly to raised position against said force exerting means.

15. A variable lift wing of the flap type having a wing camber varying flap member pivotally mounted at the under side of the wing and forming a portion of the wing under surface, the portion of the wing above said flap member fixed, and said flap member downwardly swingable to increase the wing under surface camber and formed to provide a forwardly open space between the wing and such member for flow of air rearwardly between the wing and said member with the latter in downwardly swung, camber increasing position.

16. An airplane wing, a vertically swingable flap member at the under side of the wing, said flap member pivotally mounted for vertical swinging on an axis spaced forwardly from the leading edge of the flap member, and the said flap member in downwardly swung positions disposed with its leading edge spaced from the wing to form a passage for rearward flow of air between the wing and flap member.

17. In an airplane wing, a flap member mounted at the under side of the wing, and means pivotally mounting said flap member to the wing for vertical swinging on an axis spaced forwardly from the leading edge portion of said flap, said flap member downwardly swingable on said means to lowered positions with the flap spaced from the wing to provide a forwardly open passage between the wing and flap.

18. A variable lift wing of the flap type having a flap member at the under side of the trailing portion thereof, said member in normal raised position forming a portion of the under surface of the normal wing contour and downwardly swingable to positions increasing the camber of the wing under surface, an aileron mounted along the trailing edge of said flap member in rearward continuation thereof and disposed rearwardly of the wing trailing edge, said aileron freely vertically swingable with the flap member in normal raised position, and said flap member provided with a slot therethrough along and adjacent the leading edge of said aileron for flow of air rearwardly therethrough and over the upper side of the aileron with the flap member in lowered wing camber increasing positions.

19. A variable lift wing of the flap type having a rear wing flap member vertically swingable to vary the camber of the wing, an aileron pivotally mounted on a trailing portion of said flap member, and said flap member provided with a slot therethrough along and adjacent the leading edge portion of said aileron for flow of air rearwardly therethrough over the upper side of the aileron with the flap member in lowered positions.

Signed at Rochester, New York, this 1st day of April, 1930.

RANDOLPH F. HALL.

CERTIFICATE OF CORRECTION.

Patent No. 1,841,804. January 19, 1932.

RANDOLPH F. HALL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, line 56, and page 2, line 69, for "flat" read flap; page 6, line 103, claim 3, for "left" read lift; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 12th day of July, A. D. 1932.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.