AIRPLANE

Filed Oct. 23, 1933 3 Sheets-Sheet 1

Fig. 1.

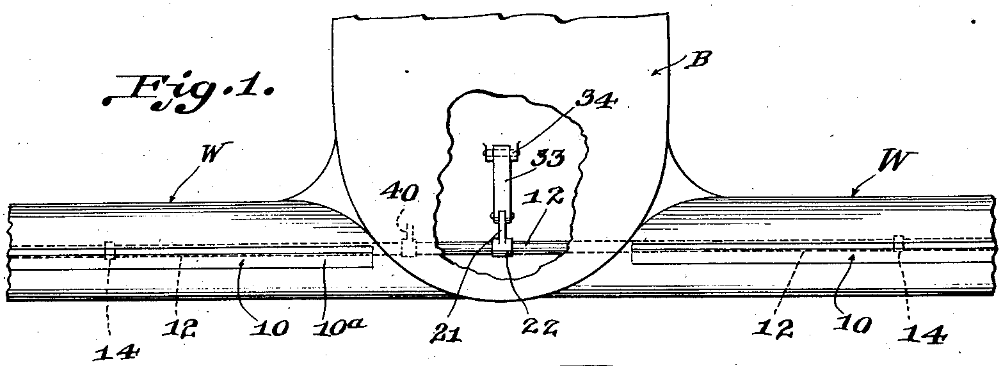
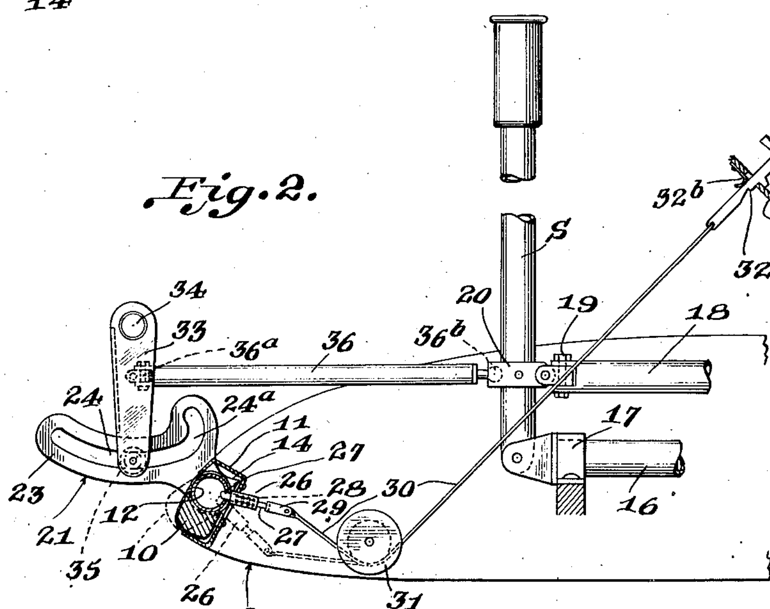



Fig. 2.



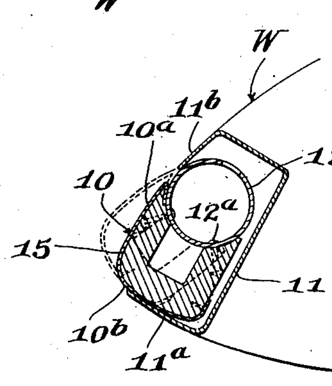




Fig. 3.

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Fig. 4.

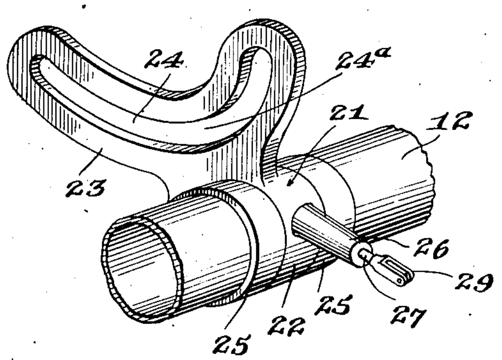



Fig. 5.

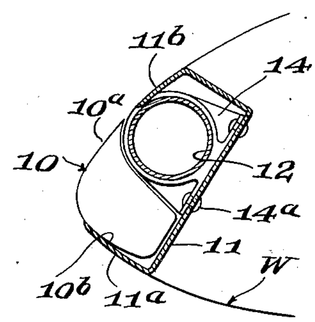



Fig. 6.

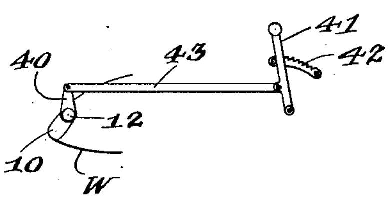
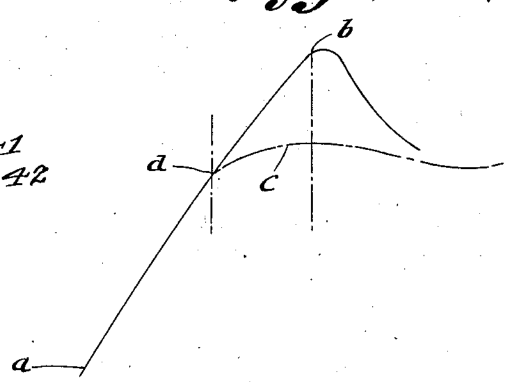



Fig. 7.

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April 14, 1936. R. F. HALL 2,037,626

AIRPLANE

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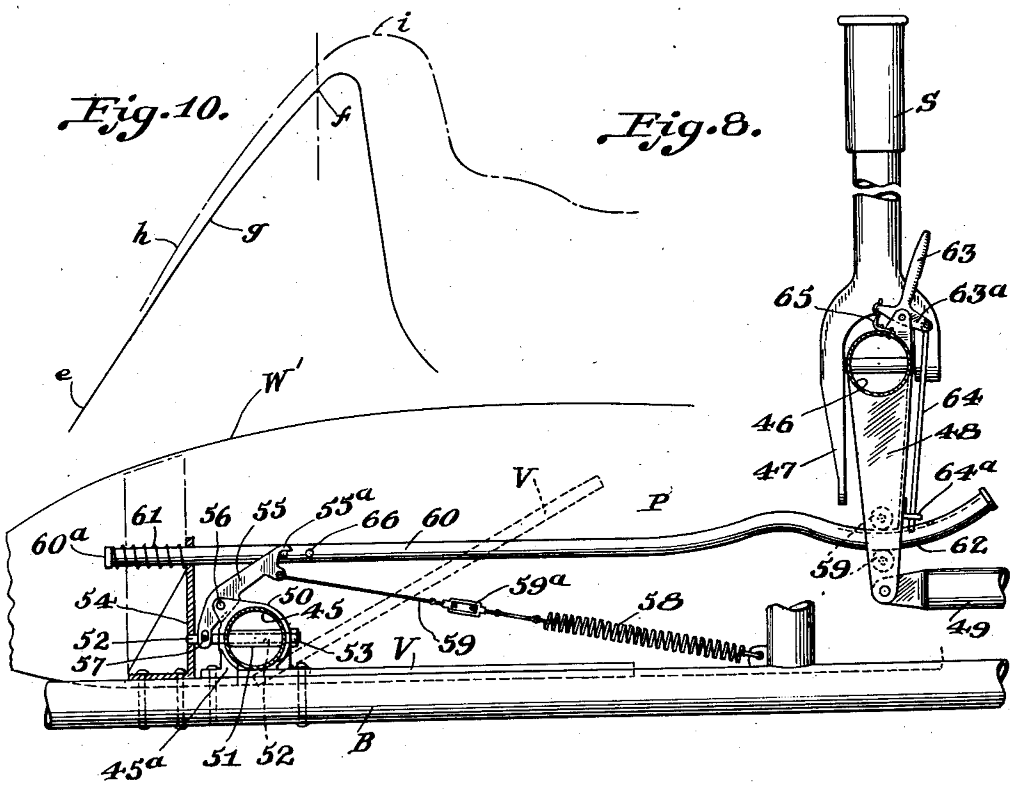


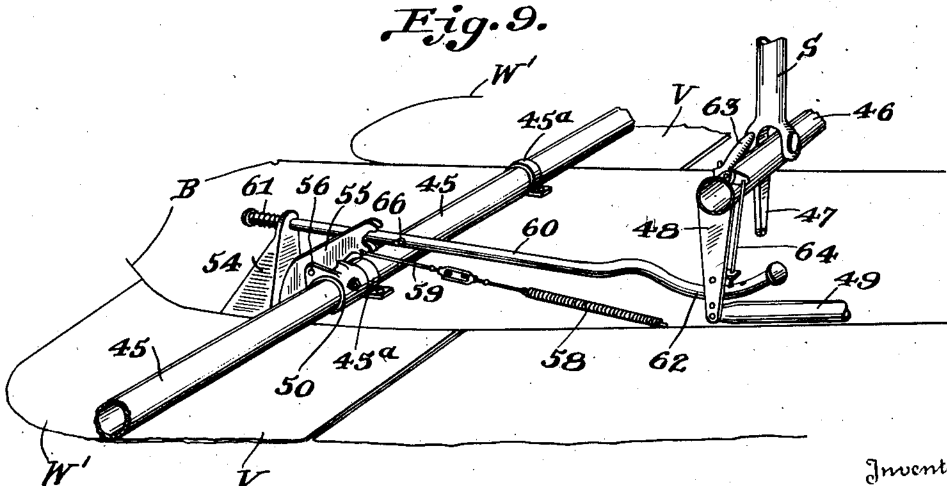


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Patented Apr. 14, 1936 2,037,626

# UNITED STATES PATENT OFFICE

2,037,626

## AIRPLANE

Randolph F. Hall, Kenmore, N. Y.

Application October 23, 1933, Serial No. 694,866

32 Claims. (Cl. 244—12)

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

The invention is specifically concerned with the airfoils or lift surfaces forming the wings and/or the control surfaces of an airplane, and is directed generally to the reduction of certain aerodynamic inefficiencies and limitations and of certain flight hazards that are encountered as a result of certain design factors and aerodynamic characteristics of such wings and control surfaces.

An airfoil or wing having an airfoil section and design characteristics that result in a sudden loss of lift when the wing attains the stall angles of attack, as indicated by the sudden break and relatively sharp drop in the lift curve for such a wing, may be generally efficient with a high maximum lift value, but due to the sudden loss of and drop in lift at and beyond the stall angles, an airplane with the wing has a tendency to and will spin easily. Such tendency to readily go into the spin from stall conditions is a constantly present and inherent hazard of a serious character with such wings.

On the contrary, an airfoil or wing that has design characteristics such that the lift curve is relatively flat at and beyond the stall to indicate but small and slow lift loss, will not easily or readily cause a spin, but such a wing is usually inefficient with a low maximum lift value, and therefore generally undesirable, notwithstanding the reduction in spin tendencies.

Attempts have been made to design an airfoil or wing that will retain high efficiency with high maximum lift value but with reduced spin causing tendencies, by modifying a high efficiency wing whose lift curve breaks suddenly at the stall condition, through sharpening or otherwise altering and redesigning the leading edge or nose portion of the wing, so as to give the wing a lift curve that is flat at the stall condition and thereby lessen the danger of the spin with the wing stalled. However, while such modification of a wing will change its characteristics so that its lift curve is flattened at the stall condition, and the hazard of the spin will be reduced at the stall, a permanent sacrifice in lift and a reduction in efficiency of the wing results.

It is a general object and a feature of my invention to provide for the modification during flight of a normally efficient, airfoil or wing having a normally high maximum lift value, when the wing is under flight conditions leading to the spin in order to temporarily change the wing characteristics to reduce the tendency of the wing to cause a spin, and for the restoration of the wing to its normal characteristics upon removal of the spin inducing flight conditions, so that, the normal efficiency and lift of the wing is retained and permanent loss in maximum lift of the wing is avoided during normal flight conditions, without such modification.

A further object of the invention is to provide for controllably modifying the leading edge or nose of an airfoil or wing during flight, and particularly with the wing at high angle of attack flight approaching the stall condition in order to at will modify the airfoil or wing characteristics to those that will give the wing a lift curve that is flattened at its peak, so as to reduce the hazards of the spin with the wing at stall flight condition, as well as changing the wing characteristics by such modification for other purposes and results, such as control.

Another object of the invention is to provide for the modification of the characteristics of an airfoil or wing, through the medium of a nose or leading edge member or members projectable and retractable by the pilot to change and vary or modify the shape and contour of the nose or leading edge portion of the airfoil or wing; and further, to provide such a nose or leading edge member that is projectable and retractable under the control of the pilot for the purpose of breaking up and removing ice that may form on the airfoil or wing leading edge.

The invention is further characterized by and holds as another general object, the application of the broad principles of the modification in flight of the characteristics of an airfoil or wing for the purposes hereinbefore expressed, to airfoils or wings generally of the so-called high or variable lift types; and especially, to wings of such types that include air displacement slots or passageways, by the control of the air displacement through such a slot or passageway to modify the wing characteristics so as to give the wing a lift curve flattened at the peak.

Another important object and feature of my invention, is the operative association of the means or medium for modifying the airfoil or wing of an airplane, with the pilot actuated longitudinal or elevator control therefor, in such a manner as to result in wing modification as the longitudinal control approaches the position for stall condition of the wing; and further in detachably associating the wing modifying means with the control, so that such means may be released from the control at will, with the modifying means either remaining in its position at the time of disengagement, or returning to its normal inactive or neutral position, as may be desired.

With the above general objects, features and results in view, as well as certain others not specifically referred to but which will be readily recognized and apparent from the following explanation, my invention consists in certain novel features in design and in combination and construction of elements, all as will be more particularly referred to and specified in detail hereinafter.

Referring to the accompanying drawings:—

Fig. 1 is a view in front elevation, somewhat schematic, of a portion of the fuselage and opposite wings of an airplane, in which the wings embody a projectable and retractible nose member for changing the shape or contour of the nose or leading edge of the wings, portions of the pilot controlled mechanism for operating such members being more or less diagrammatically shown.

Fig. 2 is a view, more or less schematic, in side elevation of the pilot control mechanism and the wing nose member actuating mechanism associated therewith, and showing the wing in outline with the projectable nose member and its mounting in the wing in vertical section, the nose member being shown by dotted outline in its projected position.

Fig. 3 is a detail transverse vertical section through the projectable nose member and its mounting, of Fig. 2, with the projected position of the member indicated by dotted lines.

Fig. 4 is a detail perspective view of the guide crank on the nose member shaft, together with the lock for releasably engaging the guide crank to the nose member shaft.

Fig. 5 is a detail view in side elevation of a support bearing for the nose member shaft, and its mounting in the wing, the shaft being shown in cross section.

Fig. 6 is a more or less diagrammatic view in side elevation of the pilot operated control for projecting and retracting a nose member independently of the pilot control mechanism operation of the member, for the purpose of breaking up ice formation on the leading edge of the wing.

Fig. 7 is a graph showing the wing lift curves for the wing of Figs. 1 and 2, with the nose member in normal retracted position, and in projected position.

Fig. 8 is a more or less diagrammatic view in side elevation of the pilot controlled mechanism for opening and closing the inlet vane of the air displacement passage of a variable lift wing, a portion of the wing with the passage inlet vane and fuselage structure being shown in outline with the vane open position indicated in dotted lines.

Fig. 9 is a somewhat schematic view in perspective of the mechanism of Fig. 8 in relation to the fuselage and opposite wing vanes of an airplane, the airplane fuselage, wings and wing vanes being partially shown and indicated diagrammatically in partial outline.

Fig. 10 is a graph showing the wing lift curves for a wing of Figs. 8 and 9 with the wing vane closed and with the vane in open position for air displacement through the wing passage.

In one possible embodiment expressing aerodynamically and mechanically the broad principles and a basic feature of my invention, by which the performance characteristics of an airfoil or wing are changed and modified by the pilot in flight to those characteristics that will give the wing a lift curve flattened at the peak or stall condition, I have provided for varying or modifying the shape or contour of the nose or leading edge portion of an airfoil or wing as the stall condition is approached in order to attain such wing characteristic modification. Such embodiment by which modification or change in wing nose or leading edge shape and contour is obtained, is broadly adapted generally to various types of wings both of the conventional forms having fixed performance characteristics, and to the various forms of the so-called variable or high lift wings, but in the particular example of such embodiment illustrated in Figs. 1 to 7 of the accompanying drawings, I have selected a conventional type of wing and have embodied this feature of my invention therein.

For instance, I have selected in the present example for purposes of explanation, referring now to Fig. 1 of the drawings in particular, an airplane that includes the usual or other desired body or fuselage B and the opposite wings W extending therefrom and which may be taken as forming a low wing monoplane, or as the lower wings of a biplane or multiplane wing cellule, although it is to be understood that no particular wing arrangement is essential to the feature of my invention now under discussion. The wings W may be of the conventional or other suitable or desired construction to provide wings of the fixed or constant performance characteristics type, and are preferably of a design and airfoil section having a relatively high efficiency and a high maximum lift value, with a lift curve that corresponds to the lift curve *a* of Fig. 7, that breaks suddenly at its peak *b* and drops sharply at the stall condition.

In carrying out the invention, I provide a member **10** in the nose or leading edge portion of each wing W disposed longitudinally thereof and mounted for projection from and retraction to a normal position in the wing carrying out and defining the normal shape and contour of the nose or leading edge as a part of the normal airfoil section of the wing that has the lift curve *a* of Fig. 7. In projected position the member **10** of a wing so changes or modifies the shape and contour of the leading edge or nose of the wing as to change the performance characteristics of the wing to modify the lift curve thereof as will be more fully explained hereinafter.

The projectable nose or leading edge member **10** for a wing can be mounted in or on a wing in a variety of ways, but I have illustrated as an example in Figs. 2, 3, and 5, of the drawings, one possible efficient and practical mounting which requires a minimum of structure and calls for a minimum of structural reorganization and modification in the construction of a wing. In such mounting, a channel member **11** is provided in the nose or leading edge portion of a wing W, and extends longitudinally therealong with its forward open side opening through the nose of the wing. Such a channel 11 may, as in the example hereof, have its lower side flange 11a, at or forming a portion of the lower or under skin of the wing nose, and its upper side wall or flange bent or extended downwardly over the open side of the channel to form the wall 11b at or forming a portion of the wing nose. (See Figs. 3 and 5). By this channel formation and mounting, a slot or opening is formed longitudinally of and through the nose of the wing between channel flanges 11a and 11b, to receive and through which the wing nose member 10 when mounted in the channel 11, can be projected.

The nose member 10 of a wing is mounted on and carried by a shaft 12 within the channel 11, which shaft is suitably rotatably supported in the channel for rocking to project and retract member 10. For instance, I have shown shaft 12 as of tubular form and mounted in and extended longitudinally of the wing nose channel 11, in suitable bearings 14 in which the shaft is journaled for rotation. Such a shaft bearing 14 is shown in Fig. 5 of the drawings in particular, and is suitably fixed, in the present example, to the bottom or base wall of the channel 11, as by bolts, rivets or other fastening means 14a. Any required number of the bearings 14 for a shaft 12 can be provided at suitably spaced intervals in and along a channel 11. The shaft 12, in its bearings, is so located and positioned within the channel 11, as to lie partly beneath and covered by the channel wall 11b, with the adjacent edge of wall 11b forming substantially a running fit therewith, or at least in such close proximity thereto as to substantially close the channel along the edge of flange 11b. The lower portion of the shaft is thus disposed extended beyond and below channel flange or wall 11b at the opening through the nose of the wing W.

The nose or leading edge member 10 takes the form in the example here given, of a strip of wood or other suitable or desired material that is fitted along one edge, its upper edge, to the shaft 12, and is suitably secured and fixed to the shaft for movement therewith as the shaft is rocked, by the rivets, bolts or the like 12a, as shown in Fig. 3 of the drawings. The nose member 10 extends along the shaft for the length or span of the wing nose opening or slot as defined by the channel 11, and may be suitably cut away or slotted at and around the shaft bearings 14 for operating clearance, as indicated in Fig. 5 of the drawings. The size and dimensions of the nose members 10 are such that when in normal retracted position, the member substantially fills and occupies the space within the channel 11 below the shaft 12 to close the opening or slot in the wing, with the forward outer side 10a thereof forming a portion of and carrying out the normal contour or upper covering of the wing nose. The lower or under side or edge 10b of the nose member 10, in normal retracted position may extend a slight distance outwardly beyond the lower channel flange 11a in continuation of the wing under surface and in effect defining the normal shape and contour of the wing leading edge, as will be clear by reference to Figs. 2, 3, and 5, of the drawings

Preferably, the leading edge or nose member 10 has sliding and frictional engagement with the lower or under side flange or wall 11a of channel 11, so that there is a sliding fit between such flange and the lower or under side face 10b of the nose member 10. If desired, as shown in the example hereof, in Figs. 2 and 3, of the drawings, the outer side 10a and the under side 10b of the nose member may be covered with a suitable resilient material 15, such as rubber or the like, in order to prevent the entry of dirt, water, and other foreign matter into the channel 11, and also to give a desired frictional engagement between under wall 10b of member 10 and flange 11a of the channel that will retain the nose member in an adjusted position.

The contour and shape of the nose member 10 for a wing W, is such that with the member in its normal retracted position, a nose or leading edge portion for the normal wing section and contour is presented, that will give the wing performance characteristics with a wing lift curve corresponding to curve $a$—$b$, of Fig. 7; while with the nose member 10 in its projected position as indicated by dotted lines in Figs. 2 and 3, the shape and contour of the nose or leading edge portion of the wing is changed to so modify the wing performance characteristics as to result in a lift curve corresponding to the lift curve $a$—$c$, of Fig. 7. By rocking shaft 12, the nose member 10 is projected and retracted to change the shape of the wing nose and thereby modify the airfoil section and contour of the wing and consequently the wing performance characteristics. With the wing W given as the example hereof, the normal and retracted position of the nose member 10 presents the wing as of high efficiency with high maximum lift value but with the lift curve $a$—$b$, breaking suddenly at the peak or stall condition of the wing, so that the wing has a strong spinning tendency as a characteristic at and beyond the stall.

An airplane, such as indicated in Fig. 1 as equipped with wing or wings W having the nose modifying members 10 and the characteristics above outlined, will with the normal sections (members 10 retracted) spin easily under stall conditions, but such spinning characteristics can be materially reduced and the hazard lessened by projecting the nose members 10 as the airplane approaches the wing stalled condition, so that the wings W are modified to give lift curves corresponding to curve $a$—$c$ of Fig. 7, having the flattened peak for the stall condition, and then maintaining such modified characteristics at and beyond the stall.

In the adaptation of the wing nose modification form of my invention to an airplane, my invention includes as a further feature, the operation of the nose members 10 from and in accordance with the pilot actuation of the pilot's control for the airplane. For instance, referring now to Figs. 1 and 2 of the drawings, the operating shaft 12 for the nose members 10 of opposite wings W, is continuous and extends as a single shaft across and through the airplane body or fuselage B, from wing to wing. A usual or other desired pilot's control mechanism for the airplane, includes, referring here to Fig. 2 of the drawings, a control stick S pivotally mounted at the forward end of a torque tube 16 for fore and after movement independently of such tube, and for lateral swinging to rock or rotate tube 16 in a bearing or bearings 17 fixed in the fuselage. The torque tube 16 connects through suitable mechanism (not shown) with the usual lateral control surfaces or ailerons (not shown) for actuation in the conventional manner by lateral swinging of the control stick S. A push-pull tube 18 that connects with the usual longitudinal control or elevator (not shown) of the airplane, is coupled at its forward end by the universal joint 19 to the pivotally mounted ring or yoke 20 on the control stick S above the connection of the stick with torque tube 16. Fore and aft swinging of stick S actuates the push-pull tube 18 in the usual or conventional manner to swing the elevator for the airplane upwardly as the stick S is pulled rearwardly and to swing the elevator downwardly as the stick is moved forwardly. As such operation is purely conventional and well known in the art, it is not deemed essential to illustrate the elevator in operative connection with tube 18 and control stick S.

As one possible manner of carrying out the operable connection of the wing nose members 10 with the pilot's control mechanism for cooperative functioning in accordance with the invention, I provide a guide crank 21 on the nose member shaft 12 at a point thereon intermediate the shaft section in the fuselage B and substantially in fore and aft alinement with the control stick S. This guide crank, referring here particularly to Figs. 2 and 4, embodies a hub portion 22 rotatably mounted on shaft 12, and the vertically disposed forwardly extended guide plate 23 having the curved slot 24 formed therein. The hub 22 of guide crank 21 is mounted on the shaft 12, in the present instance, confined between suitable fixed collars or opposite shaft bearing members 25 (see Fig. 4) to maintain the guide crank in proper position on the shaft against displacement axially thereof. Extending rearwardly from hub 22 and carried thereby is a tubular casing 26, through which a locking pin 27 slidably extends. The channel 11 is cut away for a suitable distance around rearwardly extending casing 26 to permit vertical swinging of the casing as the shaft 12 is rocked, as shown by Fig. 2 of the drawings. A coil spring 28, as shown in Fig. 2, is confined in casing 26 around pin 27, and continuously acts to force this locking pin 27 inwardly into engagement with the shaft 12. A suitably positioned bore, or bores, is formed through the wall of shaft 12 to receive and through which pin 27 may extend under the action of spring 28 to releasably lock hub 22 and guide crank 21 to the shaft, as will be clear from Fig. 2, in which pin 27 is in position locking guide crank 21 to the shaft 12. By drawing pin 27 outwardly of casing 26 against spring 28, the pin is withdrawn from a shaft bore to release the guide crank 21 for rotation of shaft 12, independently thereof.

For operating locking pin 27 to release and lock guide crank 21 from and to shaft 12, I provide a manual control for the pilot, that includes a flexible cable 30 secured at one end to a fork 29 at the rear or outer end of locking pin 27, and which extends rearwardly and downwardly around a guide pulley 31, referring here to Fig. 2 of the drawings. Flexible cable 30 then extends upwardly from pulley 31 to a suitable location in the fuselage or body of the airplane convenient to the pilot, such as on the dash or instrument board indicated at D, where the cable is connected to the end of a T-handle 32 mounted slidably on or through dash D. This T-handle 32 in its maximum downward or inward position on dash D releases locking pin 27 for projection by spring 28 into locking engagement extended through a bore of shaft 12 and releasably securing the guide crank 21 to the shaft, as shown in Fig. 2. By pulling or drawing handle 32 upwardly or outwardly of dash D a sufficient distance, the locking pin 27 is withdrawn, by flexible cable 30, from locking engagement with shaft 12 to release guide crank 21 for rotation of the shaft independently thereof.

The T-handle is provided with a notch 32*a* for engaging over the dash when the handle is withdrawn to its locking pin releasing position, and a flat spring or the equivalent 32*b* continuously bears upon handle 32, so as to force notch 32*a* into dash D engagement when the handle reaches its locking pin releasing position. Thus, with the handle notch 32*a* engaging dash D and held by spring 32*b*, the locking pin 27 is maintained disengaged from shaft 12 to release guide crank 21 from the shaft, until the handle is released by the operator.

The wing nose members 10 are placed in operative association with the pilot's control for actuation by fore and aft movements of the control stick S by the pilot in longitudinally controlling the airplane, through the medium of the guide crank 21 mounted on the nose member shaft 12. As an example of such operative association to carry out this feature of my invention, I provide a crank 33, referring to Figs. 1 and 2, swingably mounted on a suitable horizontal fixed axis formed by a pin or shaft 34 fixed to suitable body or fuselage structure (not specifically shown) above and transversely of crank guide 21. This crank 33 depends from and is swingable on its axis 34 in a fore and aft direction in substantially the vertical plane of guide crank 21, and has its lower free end provided with a roller 35 that is movably received and fitted in the curved slot 24 of crank guide plate 23. The depending crank 33 is operatively coupled with the pilot's control stick S by the link 36 that is connected at its forward end to crank 33 by the universal coupling 36*a*, and at its opposite or rear end to the stick carried ring or yoke 20, by the ball and socket coupling 36*b*. Thus, as control stick S is swung fore and aft for longitudinal control, the crank 33 is correspondingly swung to move the roller 35 longitudinally of crank guide 21 in the curved slot 24.

With the control stick S in its neutral longitudinal control position and the wing nose members 10 in their normal retracted positions, all as shown in Fig. 2 of the drawings, the crank 33 is in a vertical position with its lower end carrying roller 35 disposed intermediate the fore and aft length of slot 24 of the guide crank 21. The guide crank slot 24 is so formed and designed, in the instant example that the major length thereof from its forward end rearwardly to approximately the point indicated at 24*a* is on a curve defined by an arc concentric with the center of crank bearing or axis 34, as will be clear from Fig. 2, while the slot 24 from the point 24*a* rearwardly abruptly changes direction upwardly and is more sharply curved and non-concentric with the center of crank 33 axis 34. Now, assume the guide crank 21 locked to shaft 12 by the locking pin 27, and the several elements in the relative positions of Fig. 2. Forward longitudinal control movement of stick S from neutral position (downward elevator movement) will, through link 36, swing crank 33 forwardly, but as the guide slot 24 forwardly is concentric with crank axis 34, the roller 35 on crank 33 will move forwardly in the slot without rocking or swinging the guide crank 21 to rock the shaft 12.

Rearward longitudinal control movement of stick S from neutral position (upward elevator movement) will swing crank 33 rearwardly and move its end mounted roller 35 rearwardly through slot 24. As the slot 24 is concentric with crank axis 34 rearwardly from crank 33 neutral position to point 24a, no movement of guide crank 21 will result during the corresponding rearward movement of stick S and crank 33, but when this rearward movement is continued and roller 35 enters the sharply upwardly curved portion of slot 24 rearwardly of point 24a, then the rearward moving crank 33 and roller 35 will engage the slot walls to force the rear portion of guide plate 23 downwardly and rearwardly to rock the guide crank 21 upwardly and rotate the shaft 12 to swing and simultaneously project the opposite wing nose members 10 outwardly to their wing nose modifying positions as indicated by dotted lines in Figs. 2 and 3. Forward movement of the control stick S back to neutral will, through roller 35 in slot 24, return guide crank 21 to its normal position and rotate shaft 12 to swing wing nose members 10 inwardly to their normal retracted positions.

In the arrangement here presented, the curved portions of the guide slot 24 are so formed and designed that there is no movement of and wing nose modification by nose members 10 during flight conditions that correspond to forward movements of control stick S from neutral. Similarly, during flight conditions corresponding to rearward movement of control stick S from neutral, up to point 24a in slot 24 of the guide crank 21, there is no movement of nose or leading edge members 10 from their normal, retracted positions in the wings W. This point 24a in the slot 24 of the guide crank 21 corresponds to a rearward control stick movement that through actuation of the longitudinal control (elevator), developes a condition of flight for the airplane approaching the stall. Such flight condition may be generally represented as between the points *d* and *b* on the normal lift curve for a wing W, of Fig. 7. Thus, further rearward movement of control stick S with rearward swinging of crank 33, engages roller 35 with the abruptly changing curvature of slot 24, rearwardly from point 24a, and results in a rapid rotation of shaft 12 to quickly simultaneously project the opposite wing nose or leading edge members to their extended and wing characteristic modifying positions.

The projected or extended position of the leading edge or nose member 10 of a wing W, modifies the shape and contour of the wing nose or leading edge portion and changes the flow of air about the wing to vary the wing performance characteristics to those that will give a lift curve having the flattened peak *c* as represented in Fig. 7. Such flattening of the wing curve means that the normal force curve is flattened so that the airplane during a spin will have the forces acting on the tips of the opposite wings W more nearly in balance and that thereby the violence of the spin is reduced and recovery from the spin is facilitated. The projection of the leading edge or wing nose members 10 under flight conditions represented by the point *d* on the lift curve of Fig. 7, avoids the break in the lift curve *a*—*b*, and materially lessens the tendency of the airplane to enter the spin, although delay projection of members 10 to modify the wing will permit attainment of approximately maximum lift to allow slower speed of flight. Even though delayed nose or leading edge member projection may cause a break in the lift curve, the wing characteristics will have been changed thereby from those of curve *a*—*b*, to those of curve a—*d*—*c*, which is flatter and which condition becomes the measure of the spin with the improved conditions as referred to above.

With the foregoing arrangement and operative relationship between the leading edge or nose members 10 and the pilot's control of the airplane, the projection of the leading edge members takes place by the movement of the longitudinal control to place the airplane in the flight condition approaching the stall, as may be predetermined by the shape and curvature of the guide crank slot 24, and upon movement of the longitudinal control to bring the airplane from the flight condition of or approaching stall, the leading edge or nose members 10 are retracted to restore the normal airfoil section and contour to the wings. Thus, under such an arrangement the actuation of the leading edge modifying members may be said to be automatic and not dependent upon the initiative or judgment of the pilot, but only upon the flight condition that the pilot imposes upon the airplane by the longitudinal control. It thus becomes possible to utilize a wing of high efficiency with maximum lift value but having a sharply breaking lift curve at the stall condition with the resultant spin tendency, throughout the flight range up to the stall, and then automatically upon approach to the stall to modify the wing characteristics to those with which the spin tendency is materially reduced. Similarly, and automatically, upon leaving the stall condition of flight, the wing is restored to its normal performance characteristics and performance efficiency.

By varying the shape or curvatures of the guide crank slot 24, or the characteristics of an equivalent element, the leading edge or nose modifying members can be projected and retracted at any desired points in the flight range as may be desired. For instance, it may be found desirable to modify the shape of a wing nose or leading edge at low angles of attack to increase airplane flight speed, or to vary or change other performance characteristics, and my invention is not limited in any way in its generic phases to the arrangement and functioning of the given example, or to the particular form of the leading edge members and the contour or shape changes that they may make in the wing leading edge portion or nose, or to the particular flight condition that they may be designed to change or modify.

The operation of the leading edge or nose modifying members 10 by the pilot's control stick S in the normal actuation of such stick for airplane control, can be discontinued at will by the pilot, through withdrawal of locking pin 27, from engagement with shaft 12, by the handle 32. Such withdrawal of pin 27 disconnects the guide crank 21 from operating shaft 12, and the control stick S is then actuated without imparting rotation to shaft 12, the guide crank 21 merely freely rotating on and independently of shaft 12. When disconnected from the leading edge members 10, the pilot's control is operable without wing modification throughout the flight range. Due to the frictional engagement, and in the example hereof, the resilient covering 15, on a leading edge member 10, such a leading edge member can be moved to an adjusted position and when disconnected from the pilot's control will normally remain in such position throughout the flight range. It is thus possible for the pilot to set or adjust a leading edge member in flight by moving it to the adjusted position by the pilot's control and then disconnecting guide crank 21 from shaft 12 by withdrawing locking pin 27. The leading edge member or members 10 may then be re-engaged with the pilot's control by releasing pin 27 and letting spring 28 force the pin into the bore in shaft 12 when the guide crank 21 is rotated by control stick S to align pin 27 with the shaft bores. Any desired number of pin 27 receiving bores may be provided in and spaced at desired intervals around shaft 12 for engagement by the locking pin to obtain any desired adjustment of the control stick S and guide crank 21 in relation to shaft 12 and the position of a leading edge member 10.

As a further feature of this form of my invention provision for utilizing the leading edge or nose member 10 of a wing for breaking up ice formation on the leading edge of a wing, is made. I prefer to provide a separate means under the control of the pilot for projecting and retracting a leading edge member 10 for this purpose, although the longitudinal control would suffice. For example, with the arrangement of Fig. 1, I mount a crank or horn 40, referring to Fig. 6 in connection with Fig. 1, on the shaft 12 within the body B, and then mount an operating handle or lever 41 at a suitable location in the body B for convenient manual actuation by the pilot. The handle 41 cooperates with a locking quadrant 42 by which it may be held releasably in any position to which swung in the conventional manner. The crank 40 on shaft 12 is operatively connected with handle lever 41 by suitable linkage, such as the link 43 of Fig. 6. Thus, rocking or swinging the handle lever 41 by the pilot, when guide crank 21 is disconnected from shaft 12, will through link 43 and crank 40, rock shaft 12 and project and retract the leading edge members 10 to break up and remove ice formations on the wing leading edges. Attention is further directed to the use of the handle lever 41 to move the leading edge members to and maintain them in any desired adjusted positions.

A leading edge or nose member 10 for a wing may extend for the full span of a wing or for any part of the span and any desired number of such members can be provided along the span of one or more wings, with suitable interconnecting means. Such a modifying member or members, may be located in the leading edge of a usual horizontal stabilizer of the longitudinal control surfaces and connected with the pilot's control mechanism, for balance or stability purposes; such a surface being broadly equivalent to a wing within the disclosure of my invention.

The broad principles of wing performance characteristic modification by and in accordance with the flight condition imposed upon an airplane by the pilot through the actuation of the longitudinal control, as exemplified basically by the arrangements disclosed in Figs. 1 to 7 and hereinbefore described, are also applicable to the so-called high or variable lift wings that embody an air displacement passage controlled by a vane, flap or the like. An application of the principles of the invention to such type wing is disclosed in Figs. 8 and 9, in which a wing W' has been selected as an example. The wing W' is of the type having an air displacement passage P (see Fig. 8) extending rearwardly therethrough, with the forward inlet end of passage P formed through the under surface of the wing and controlled by the vertically swinging vane or flap member V. Such type of high or variable lift wing is disclosed in my U. S. Patents numbered 1,559,091; 1,875,593; and 1,916,475, to which reference may be had for an explanation of the design, construction and functioning of the type, although it is to be clearly understood that my invention is not limited in its application to this particular type and construction of variable lift wing.

The air passaged wing W' has the vane V mounted within the wing at the inlet end of passage P, on a horizontal shaft 45 that extends spanwise through the wing along the forward edge or side of the passage inlet through the under surface of the wing. The shaft is suitably mounted and supported in fixed bearings for rotation to vertically swing the vane that extends rearwardly therefrom across the inlet opening, to and from position closing such opening. The closed position of a vane V is shown by full lines in Fig. 8 and in passage inlet opening position by dotted lines. The vane can be automatically or manually swung to open and close the passage and control air displacement, all as explained in my above referred to U. S. patents, for the purpose of varying the lift developed by the wing W'.

In the example of Figs. 8 and 9, I have more or less diagrammatically shown portions of an airplane that includes the usual body or fuselage B and the opposite wings W' extending therefrom. The vane shaft 45 for the wings W' is shown in this instance as a continuous shaft extending between the opposite wings W' and transversely across and through the airplane body B, in which suitable bearings 45*a* may be provided in which the shaft 45 is journaled, as will be clear by reference to Fig. 9 in particular. The opposite wing vanes V are thus simultaneously swinging with shaft 45 in the functioning thereof to control displacement of air into and through passage P.

The airplane includes as mounted in the usual manner within the body or fuselage B, the pilot actuated control mechanism which may be of the more or less conventional type to include the pilot's control member or stick S that is swingable laterally for lateral control and fore and aft for longitudinal control, of the airplane. Such control mechanism includes the transversely disposed torque tube 46 suitably journaled in fixed horizontal position for rotation by the control stick S that is pivotally mounted thereon and extends upwardly therefrom. The control stick S is swingable laterally of the fuselage on tube 46 independently thereof, and is swingable in a fore and aft direction to rock or rotate torque tube 46. The control stick S has a depending arm 47 that is connected to the lateral control surfaces or ailerons (not shown) of the airplane, while the torque tube 46 has an arm or crank 48 depending therefrom adjacent one end thereof, which is connected at its lower end to a rearwardly extending push-pull tube 49 leading to the longitudinal control surface or elevator (not shown) for the airplane.

Following the broad principles of my invention as exemplified in connection with Figs. 1 to 7, the wing passage controlling vanes V are operatively associated with the pilot's control mechanism for functioning by certain longitudinal control actuating movements of the control stick S. In carrying out this association in the particular example here presented, a collar fitting 50 is fixed on and around the tube shaft 45 within body B in substantial forward alinement with the torque tube crank 48, and a tube or casing 51 is provided that extends diametrically through shaft 45 and the opposite forward and rear sides of collar 50. A locking pin 52 is freely slidably mounted in and extending through casing 51 and at its rear outer end is provided with a nut 53 that forms an adjustable stop limiting forward movement of the pin. At the forward side of and spaced a distance from collar fitting 50 on shaft 45, a bracket or plate member 54 is mounted in fixed position on suitable body or fuselage structure B, and is provided with a suitable bore or opening in its forward vertical wall alined with and for removably receiving the forward end of pin 52, as clearly shown in Fig. 8 of the drawings. The relative arrangement of vanes V, shaft 45 and pin 52 is such that with the vanes V in closed, downwardly swung position, the pin 52 is alined with the bracket 54 bore, and with the pin forwardly extended into the bracket bore, the shaft 45 and vanes V are releasably locked in passage inlet closing position (see Fig. 8).

An operating crank 55 is provided for the locking pin 52, and is pivotally mounted on a horizontal bearing 56 at the upper forward side of collar fitting 50, and intermediate the ends of the crank 55, so that the crank extends forwardly and downwardly to and is forked over pin 52 to which it is pivotally connected by end slots fitted loosely over a transverse pin 57 on the sliding locking pin 52. (See Fig. 8.) The opposite or rear end of crank 55 extends rearwardly and upwardly above shaft 45 and terminates in the rearwardly notched or hooked end 55$a$. By swinging the rear end 55$a$ of crank 55 vertically the pin 52 is slid to and from locking engagement with bracket 54. The locking pin operating crank 55 is maintained normally in position with its rear end swung or pulled downwardly to force the locking pin 52 forwardly into position engaged in bracket 54 to lock vanes V in closed position, by a retractile spring 58 connected at its rear end to fuselage structure B and at its forward end connected to the upper end of crank 55 above shaft 45, by a cable 59. A suitable turnbuckle or the like 59$a$, is interposed in cable 59 for the purpose of varying the tension or pull exerted by spring 58 on the crank 55.

The lever 55 is operatively coupled with the longitudinal control or elevator operating arm 48 of the pilot's control by a tube 60 that is horizontally disposed with its forward end slidably received in and supported by the upper end of bracket member 54 above shaft 45, and extends rearwardly to and is supported between upper and lower rollers 59 (see Fig. 8) mounted on the inner side of elevator operating crank arm 48 adjacent the lower end of this crank. The forward end of tube 60 extends a distance forwardly of bracket 54 and a coiled expansion spring 61 is loosely mounted thereon between the headed or capped end 60$a$ of the tube and the bracket 54. The rear end of the tube 60 extends a distance rearwardly beyond the neutral and substantially perpendicular position of elevator operating crank 48, and the rear length of tube 60 from a point spaced forwardly of crank 48 to the rear end of the tube is vertically curved at 62 through an arc concentric with the axis of torque tube 46 on which crank 48 swings. Thus, with crank 48 unconnected with tube 60, this crank can swing fore and aft for longitudinal control surface or elevator operation without imparting movement to the tube 60, as the crank rollers 59 will ride freely on the curve portion 62 of the tube and independently of the tube.

A suitable mechanism is provided for releasably locking the elevator crank 48 to the tube 60, and in this instance takes the form of a lever handle 63 pivotally mounted on the upper end of crank 48 and having a cross head 63$a$ disposed at the lower end thereof in a direction transverse of torque tube 46. The rearwardly extended end of arm 63$a$ is connected to the upper end of a vertically disposed rod 64 that is slidably confined adjacent its lower end to crank 48 by a guide 64$a$ and which rod in lowered position has its lower end received in one of a series of bores or holes along the upper side of tube 60 in order to lock the tube to the crank 48. With rod 64 in locking engagement with tube 60, fore and aft swinging of crank 48 will move the tube 60 forwardly and rearwardly on and through bearing bracket 54. A flat spring 65 is mounted at the upper end of crank 48 and is engaged by the forward end of handle lever cross arm 63$a$ to hold the handle lever 63 in either its position lowering rod 64 into locking engagement with tube 60, or in its position raising rod 64 from locking engagement with tube 60.

The forward and rearward movements of tube 60 past the upper notched or hooked end 55$a$ of crank 55, imparted to tube 60 by fore and aft swinging of elevator control crank 48, are utilized to actuate and control the locking pin operating crank 55. A pin or stud 66 is provided extending from the side of tube 60 adjacent crank 55 and positioned on the tube to be spaced a distance rearwardly from crank 55 with tube 60 in its normal position when the pilot's control is in neutral elevator or longitudinal control position. Forward swinging of control stick S (downward elevator movement) with the rod 64 engaging and locking tube 60 to the elevator crank 48, will pull or draw tube 60 rearwardly, compressing spring 61, and move tube pin 66 rearwardly from crank 55. During such operation, the crank 55 is in its normal position swung downwardly by spring 58 to hold locking pin 52 in engagement with bracket 54 and maintain the passage vanes V in their downwardly swung positions closing passage P inlet.

When the control stick S is swung rearwardly (upward elevator movement), past normal neutral position, the tube 60 is moved forwardly by the forward swinging of elevator control crank 48, and the pin or stud 66 on tube 60 is moved forwardly toward crank 55. Continued rearward swinging of stick S moves pin 66 into engagement with the notched or hooked end 55$a$ of crank 55, and pin 66 swings or rocks the crank forwardly. Forward rocking of crank 55 withdraws pin 52 from locking engagement with bracket 54, and releases shaft 45 and vanes V for upward, passage inlet opening swinging. As the tube 60 continues to move forwardly by forward swinging of stick S, the pin 66 engaged with crank 55, further rocks this crank against and into engagement with collar fitting 50, and then rocks or rotates shaft 45 together with crank 55 as a unit, to swing the vanes V upwardly to open the inlets to wing passages P for flow of air thereinto to modify the performance characteristics of wings W'. Forward swinging of stick S back to neutral will draw tube 60 rearwardly to release pin 66 from crank 55 and permit spring 58 to rotate shaft 45 to return vanes V to passage closing position, and finally will continue to swing crank 55 on shaft 45 to throw pin 52 forwardly into rocking engagement with bracket 54.

The relative movements or timing of the various elements above described may, of course, be varied to meet the particular conditions of each airplane and wing design and in accordance with the particular performance results sought but in the example here given, the wing or wings W' have a normal lift curve with the passage P closed by vanes V, represented by the lift curve *e—f*, of Fig. 10. Thus, the normal wing W' has performance characteristics that give high efficiency with high maximum lift values, but with a sudden break in the lift curve at the stall condition with the resulting spin tendencies.

In the arrangement of the form of my invention shown in Figs. 8 and 9, the vanes V, as hereinbefore explained, are maintained locked in closed position throughout forward control stick S movements (down elevator movements) from neutral control position, and this condition is also maintained through a certain extent of rearward control stick movement (up elevator movements—increased attack angle) from neutral. However, the pin or stub **66** on tube **60** is so spaced rearwardly from and positioned relative to crank end **55***a*, that when the rearward control stick movement reaches that position representing an approach to the stalled flight condition, say corresponding to the point *g* on the lift curve *e—f*, then the crank **55** has been rotated to disengage locking pin **52** from bracket **54**, and the vanes V are rotated to open the wing air displacement passages P. Opening the wing passages P causes flow of air into and displacement through the wings W' and modifies their performance characteristics to flatten the peak of the lift curve and give these wings a lift curve represented by the curve *h—i*, of Fig. 10. The wings W' are thus modified to increase lift with a more rounded lift curve, delayed stall, and earlier lift recovery. These conditions, of course, materially reduce the hazard of the spin and in the event of a spin facilitate recovery therefrom. Thus, as in the example of the broad principles of the invention as explained in connection with Figs. 1 to 7, the wing characteristics are modified by longitudinal control actuation by the pilot to place the airplane approaching or in the stall condition, and the wing characteristics are restored to normal by longitudinal control actuation to remove the airplane from such conditions.

Preferably, as hereinbefore referred to, the tube **60** is provided with a series of spaced bores or holes along the curved portion **62** for selectively receiving the locking rod **64**. By such an arrangement the pilot can adjust the longitudinal or elevator control in relation to the vane or lift control through varying the distance between tube pin **66** and the crank **55** with the longitudinal control in neutral position. Thus, the flight condition at which modification of the wing characteristics will take place as represented by the position of the longitudinal control corresponding to such a condition can be predetermined.

When desired, the control mechanism can be disengaged from the vane operating tube **60**, by swinging handle lever **63** to raised rod **64** to disengage tube **60**, the flat spring **65** then holding lever **63** in such position until released. With the crank **48** disengaged from tube **60**, the longitudinal or elevator control is operable independently of and without actuating tube **60**, crank **48** then merely freely moving over the curved portion **62** of tube **60** on the rollers **59**. Under the foregoing conditions the vanes V are held in normal, passage closing and inactive position by spring **58**, crank **55** and locking pin **52** engaged in bracket **54**.

With the longitudinal control disconnected from the lift or vane V control, if it is desired that the vanes V be operable for opening and closing the wing passages, the stop nut **53** may be adjusted on the locking pin **52** to maintain this pin from locking engagement with bracket **54**, in which event the vanes are free floating except as restrained by the spring **58**, the tension of which can be adjusted as may be required by the turnbuckle **59***a*. The vanes when free floating as described are also operable by the pilot's control when crank **48** is connected by rod **64** with tube **60** in the same manner as described in connection with the vanes when locked by pin **52** in their closed positions.

While I have shown a variable lift wing of the passaged type in accordance with my previously mentioned U. S. patents, my invention is not in all respects limited thereto, as its broad principles are adapted to any of the variable lift wings, including the leading edge slotted types familiar in the art. Further, the leading edge modification form of Figs. 1 to 7, may also be used together on a wing with the passageway control of Figs. 8 and 9, if so desired.

It will also be evident that various changes, modifications, substitutions, additions and eliminations might be resorted to in the several illustrated examples of the various features of my invention, without departing from the spirit and scope of the invention, and hence, I do not desire to limit myself in all respects to the exact and specific disclosures hereof.

What I claim is:

1. In combination in an airplane having a longitudinal control mechanism, a wing having a normal contour and airfoil section, a movable member on the wing for changing the wing normal contour and airfoil section to a contour and section with which the peak of the lift curve for the wing is modified, and means operatively coupling said wing mounted movable member with the longitudinal control mechanism for moving said member to change the wing contour and airfoil section when the longitudinal control is actuated to longitudinally control and place the airplane in flight condition approaching the stall.

2. In combination in an airplane including a pilot actuated longitudinal control mechanism, a wing having a normal contour and airfoil section, means on the wing operable to change the wing contour and section to one with which the peak of the lift curve for such wing is modified, and mechanism operatively coupling the longitudinal control with said wing contour changing means for operating the latter to change the wing contour and section and modify the peak of the wing lift curve when the control mechanism attains a predetermined position for longitudinally controlling the airplane.

3. In combination, in an airplane including a pilot actuated longitudinal control means, a wing, means on the wing operable to change the wing contour and modify the peak of the lift curve for such wing, mechanism operatively connecting the longitudinal control with said wing contour changing means for operating the latter to change wing contour when the longitudinal control means is actuated to a predetermined position, and means controlled by the pilot for disconnecting said mechanism from the longitudinal control means for operation of said wing contour changing means independently of longitudinal control means actuation.

4. In an airplane wing, a member mounted in and defining the normal leading edge contour of the wing, said member mounted for projection from the wing to modify the wing leading edge

contour, pilot controlled means for projecting and retracting said member operatively connected therewith, and independent means for releasing said pilot controlled means from operative connection with said member.

5. In an airplane wing, a member mounted on and defining the normal leading edge contour of the wing, said member mounted for projection from normal position to modify the normal leading edge contour, pilot actuated means for projecting and retracting said member from and to normal leading edge contour defining position, said pilot actuated means releasable from operative association with said member, and independent means operable to adjust and releasably lock said member in any desired adjusted setting.

6. In combination in an airplane including a pilot actuated longitudinal control therefor, a wing a projectable member in the leading edge of the wing for changing the leading edge contour of the wing to modify the wing characteristics, and mechanism operatively connecting said member with the longitudinal control for projecting said member by movement of the longitudinal control at and beyond a predetermined position of such control for purposes of longitudinally controlling the airplane.

7. In an airplane having a pilot actuated longitudinal control, a wing having a passage for flow of air therethrough, means for controlling flow of air through said passage, and mechanism operatively connecting the longitudinal control with said means to operate the latter to increase air flow through the passage when the longitudinal control has been actuated to a predetermined position for the purpose of longitudinally controlling the airplane.

8. In combination in an airplane including a pilot actuated longitudinal control therefor, a wing having a passage for flow of air therethrough, a member for opening and closing said passage to control airflow therethrough, mechanism operatively connecting the longitudinal control with said member for actuating the member to open the passage when the longitudinal control is moved for longitudinal control purposes to a position placing the airplane in a flight condition approaching the stall.

9. In combination, in an airplane including a pilot operated longitudinal control therefor, a wing providing a passage for flow of air therethrough, a member operable to open and close said passage, mechanism operatively coupling the longitudinal control with said passage opening and closing member for actuating said member to open the passage when the longitudinal control is moved to a position placing the airplane in a predetermined flight condition and to actuate the member to close the passage when the control is moved to remove the airplane from such flight condition, and means for disconnecting said mechanism from the longitudinal control.

10. In an airplane including a pilot actuated longitudinal control, a wing, a member on the wing movable to change the contour of the wing and modify the lift curve for the wing to flatten the peak of such curve, mechanism coupling the longitudinal control with said movable member for moving the member by actuation of the longitudinal control, and the said mechanism operated to move said wing contour changing member from its normal position only when the longitudinal control is moved to a position approaching the stall condition for the airplane.

11. The combination in an airplane of a wing, a pilot operated longitudinal control for the airplane including a fore and aft swinging control lever, a member movably mounted on the wing for modifying the wing contour, and operative connections between said wing member and said fore and aft swinging control lever, said connections actuating said wing member to modify wing contour when the control lever is swung rearwardly to a predetermined position but permitting swinging of said lever forward of such predetermined position independently of and without actuating said wing member.

12. In an airplane having means for the longitudinal control thereof, the combination of, a wing having an airfoil section variable in flight to modify the wing to one having the lift curve flattened at the peak, with means operatively associated with said wing for varying its airfoil section, and said means connected with and actuated by longitudinal control operation of said control means to change the wing section in accordance with the longitudinal control imposed on the airplane.

13. In an airplane including a wing therefor and means for longitudinal control of the airplane, said wing having normal characteristics giving a lift curve for the wing that breaks relatively sharply downward from the peak of the lift curve, means for modifying the normal wing characteristics in flight to those giving a lift curve for the wing that is flattened at the peak of the curve, and means associating the wing characteristic modifying means with the longitudinal control means and actuated by the latter to cause the modifying means to change the wing characteristics to those giving a flattened peak lift curve upon longitudinal control operation of the control means to place the airplane in flight condition approaching stalled flight.

14. In an airplane, including a wing therefor, and means for longitudinally controlling the airplane in flight, in combination; means for changing the contour of the wing in flight to a contour modifying the wing lift curve to flatten the peak of such curve; said wing contour changing means operatively associated with the longitudinal control means and operated to change the wing contour and flatten the peak of the wing lift curve by longitudinal control operation of the control means to a control position at which the airplane approaches the stall; and the longitudinal control means operable for longitudinal control independently of said wing contour changing means in all control positions up to that approaching the stall.

15. In combination, in an airplane including a wing therefor, and means for longitudinally controlling the airplane in flight; means for changing the contour of the wing to modify the lift curve for the wing; mechanism operatively connecting the longitudinal control means with the wing contour changing means for operating the latter to change the wing contour when the longitudinal control means is actuated to a predetermined longitudinal control position; means for disconnecting said mechanism from the longitudinal control means for longitudinal control operation of the latter independently of said contour changing means; and means for operating the wing contour changing means when the longitudinal control means is disconnected from the said contour changing means.

16. In an airplane, in combination, means for longitudinally controlling the airplane in flight,

a wing operable to vary its performance characteristics in flight, and said longitudinal control means operatively associated with the wing for operating the latter to change the wing flight characteristics at a predetermined longitudinal control position and operable independently of said wing through the longitudinal control positions of said control means to said predetermined position.

17. In an airplane wing, a member mounted on and defining the normal leading edge contour of the wing, said member mounted for projection from normal position to positions modifying the normal leading edge contour, and the said member frictionally engaging the wing in projected positions and held in a projected position by such engagement.

18. In an airplane wing, a member mounted on and defining the normal leading edge contour of the wing, said member mounted for projection from normal position to positions modifying the normal leading edge contour of the wing, means for projecting and retracting said member, and the said member frictionally engaging the wing and maintained in any projected position by such frictional engagement.

19. In an airplane wing, a member mounted in and defining the normal leading edge contour of the wing, said member mounted in the wing for projection from normal position to positions modifying the normal leading edge contour of the wing, and said member having a surface that yields locally at the point of pressure application thereto, said surface frictionally engaging and yielding to adjacent wing structure to form a weather seal with the wing along the span of said member.

20. In combination, in an airplane including a wing therefor and a longitudinal control for the airplane, said wing having a passage for flow of air therethrough, a member mounted on the wing for opening and closing said passage, mechanism coupling the longitudinal control with said member for actuating the latter to open the wing passage when the longitudinal control is moved to a longitudinal control position placing the airplane in a predetermined flight condition and to actuate the member to close the passage when the control is operated to remove the airplane from such flight condition, means for disconnecting said mechanism and said member from the longitudinal control, and the said member when disconnected from the longitudinal control operable to open and close the wing passage.

21. In an airplane, in combination, a wing having a passage for flow of air therethrough, means for longitudinally controlling the airplane, a member mounted on the wing and movable to open and close the wing passage, and said longitudinal control means operatively associated with said member for operating the same to open the passage when said means is operated to a position imposing a degree of longitudinal control on the airplane for a predetermined flight condition.

22. In combination, in an airplane, a wing, a member movably mounted on the wing for varying the wing performance characteristics, means for longitudinally controlling the airplane, mechanism operatively associating the longitudinal control means with said movable wing member, and said mechanism providing for moving said member to vary wing performance characteristics during longitudinal control operation of the control means throughout a portion of the control range, and for operation of the control means independently of said wing member through the remainder of the control operating range.

23. In combination in an airplane, a wing, longitudinal control means for normal longitudinal control of the airplane in flight, means on the wing leading edge operable to break away and clear ice formations therefrom, and said ice breaking means coupled with and operated by actuation of the longitudinal control means.

24. In combination in an airplane, a wing, longitudinal control means for normal longitudinal control of the airplane, a member forming the normal leading edge of the wing, said member mounted for projection and retraction to break ice formation from the wing leading edge, and said member coupled with the longitudinal control means for projection and retraction by longitudinal control movements of said means.

25. In an airplane, a wing having a longitudinally disposed passage therein for flow of air rearwardly therethrough, pilot actuated means for normally longitudinally controlling the airplane in flight, means controlling flow of air through said passage, and mechanism operatively connecting the longitudinal control means with said passage flow controlling means to operate the latter to increase air flow through the wing passage when a predetermined degree of longitudinal control is imposed on the airplane.

26. In an airplane having a pilot actuated longitudinal control, a wing having a longitudinally disposed passage therein for flow of air therethrough rearwardly of the wing, pilot actuated means for normally longitudinally controlling the airplane in flight, means controlling flow of air through said passage, and said pilot actuated means operatively coupled with said airflow controlling means whereby longitudinal control operation of the former operates the latter to control flow of air through said wing passage.

27. In an airplane, a wing having an air displacement passage, a member normally closing said passage, means for normally longitudinally controlling the airplane in flight and mechanism operatively coupling said passage closing member with the longitudinal control means whereby operation of the latter to a predetermined longitudinal control position causes said member to open the wing passage for displacement of air therethrough.

28. In an airplane, a wing, means operable to vary the performance characteristics of the wing in flight, control means for controlling the airplane in flight, including a pilot actuated control member, and mechanism operatively associating said wing characteristic varying means with said control means, said mechanism including a link member coupled with said control member, and means coupling said link member with the wing characteristic varying means whereby said latter means is only operated by movement of said control member through a predetermined range of control positions.

29. In an airplane, a wing having an air displacement passage, a member movable to open and close said passage, said member normally in position closing the passage, control means for longitudinally controlling the airplane in flight, said control means including a control actuating member, mechanism associated with said passage closing member for actuation to move the member to open position, and a member coupled with said control actuating member for movement

thereby to engage said passage closing member actuating mechanism at a predetermined longitudinal control position of the control member for moving the passage member to open position.

30. In an airplane, a wing including means for changing the contour of the wing in flight, a shaft for rocking to operate said contour changing means, means for longitudinally controlling the airplane in flight including a control operating member, a lost motion link member operatively coupled with said control operating member, means for rocking said shaft, and said link member operatively engaging said shaft rocking means to rock the shaft and operate the contour changing means only after said control operating member is moved to a predetermined control position.

31. In an airplane, a wing, a wing contour changing member movably mounted on the wing, a rock shaft for moving said member to change the wing contour, a slotted arm on said shaft for rocking the same, a swinging crank arm engaged in said slotted shaft arm, said arm having the slot thereof so curved relative to the axis of swing of said crank that the crank swings independently of the arm through a portion of its swing and engages the arm through the remaining portion of its swing to rock said shaft, a longitudinal control for the airplane including a control actuating member, and means coupling said control actuating member with said swinging crank for actuating the latter by longitudinal control operation of said control member.

32. In an airplane, a wing having an air displacement passage therethrough, a closure member mounted on the wing for swinging to open and close the wing passage, a shaft for swinging said closure member to and from closed position, a crank member associated with said shaft for movement to rock the shaft to open said closure member, means normally maintaining said closure member in passage closing position, means for longitudinally controlling the airplane including a control actuating member, and a rod member coupled with the control actuating member and formed to engage the shaft carried crank member to swing said closure member to passage opening position when said control member is moved a predetermined distance to longitudinally control the airplane.

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