Oct. 7, 1930. R. H. UPSON 1,777,593

AIRPLANE

Filed June 16, 1928 2 Sheets-Sheet 1

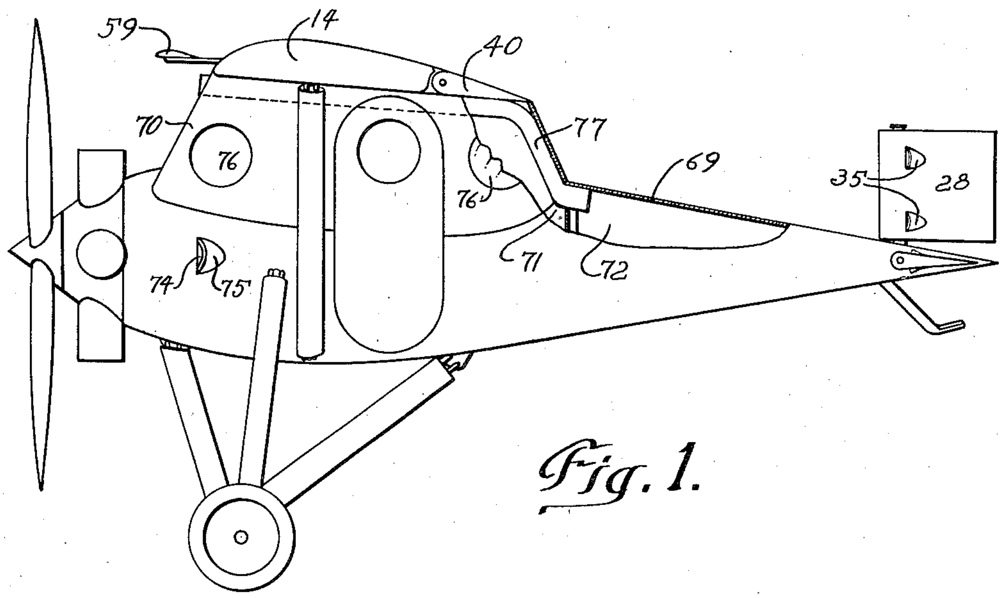

Fig. 1.

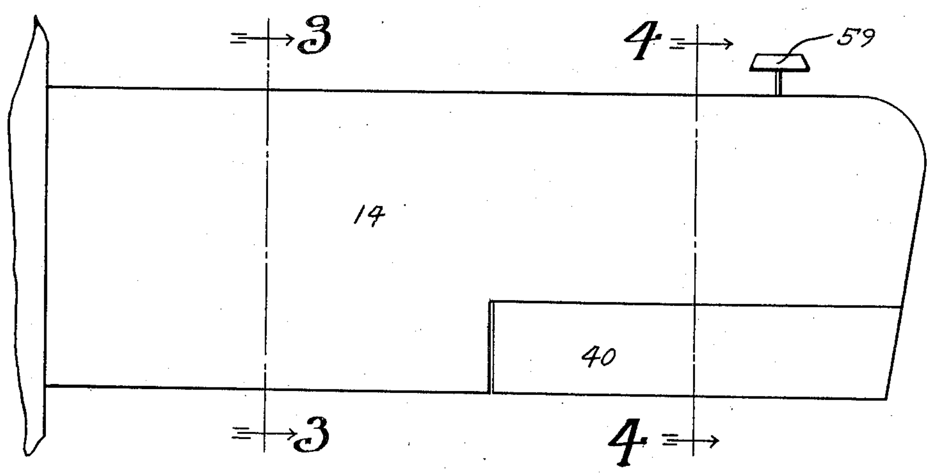

Fig. 2.

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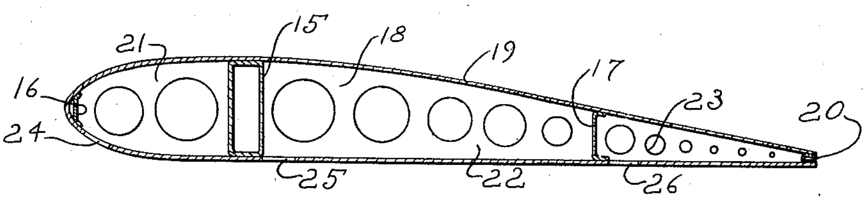

Fig. 3.

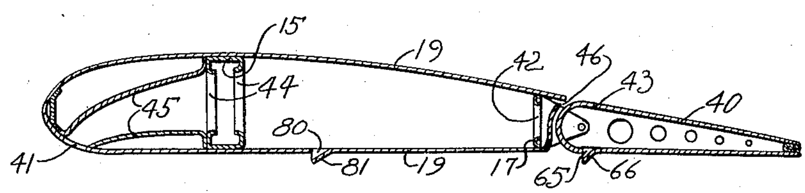

Fig. 4.

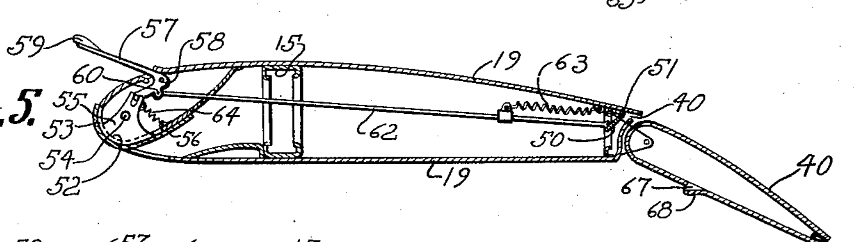

Fig. 5.

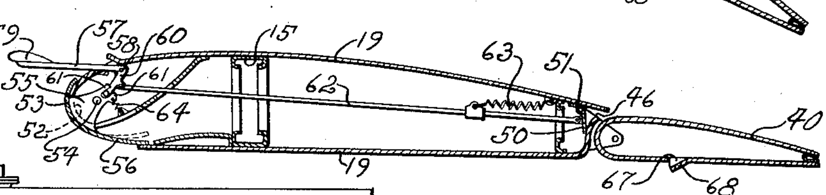

Fig. 6.

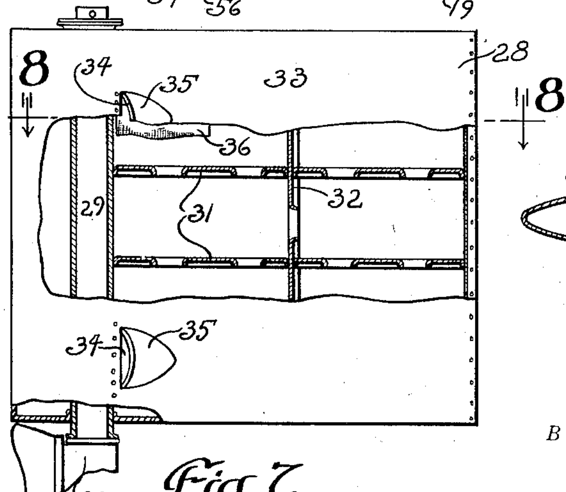

Fig. 7.

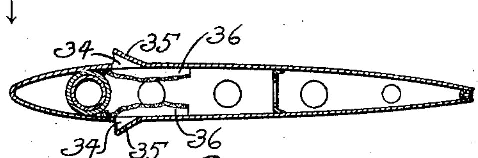

Fig. 8.

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UNITED STATES PATENT OFFICE

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AIRPLANE

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This invention relates to airplanes and particularly to those in which certain sections thereof are provided with a metal or like stress transmitting skin or covering, the principal object being the provision of means for maintaining such skin or covering in its normal position and preventing undesirable deflection of the same.

Another object is to provide means for maintaining the interior of an airfoil section under a pressure commensurate with the maximum pressure at any time present on the exterior of such section.

Another object is to provide an airfoil section, the interior of which is divided into a plurality of separated compartments, and providing means for maintaining each compartment with an internal pressure substantially equal to the maximum exterior pressure which at any time may be acting upon the same.

Another object is to provide a new and novel wing slot for airplane wings.

Another object is to provide a new and novel form of wing slot for airplane wings which at the same time will maintain an internal pressure on the wing.

Another object is to provide a novel type of wing slot for airplane wings which will be operative only during those intervals when such slots are beneficial.

Another object is to provide a wing slot for airplane wings with automatically actuated means for closing and opening the same to the passage of air to obtain optimum operating conditions.

A further object is to provide an airfoil section with means for maintaining the interior thereof under pressure, automatically actuated valve mechanisms being provided to accomplish the same.

The above being among the objects of the present invention, the same consists in certain features of construction and combinations of parts to be hereinafter described with reference to the accompanying drawing, and then claimed, having the above and other objects in view.

In the accompanying drawing which illustrates suitable embodiments of the present invention, and in which like numerals refer to like parts throughout the several different views,—

Fig. 1 is a more or less diagrammatic side elevation of the airplane.

Fig. 2 is a plan view of one of the wings of the airplane shown in Fig. 1.

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 2.

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 2.

Figs. 5 and 6 are sectional views showing two positions of a modification of the construction shown in Fig. 4.

Fig. 7 is a partially broken side elevation of a rudder.

Fig. 8 is a sectional view taken on the line 8—8 of Fig. 7.

In airplane construction it is desirable, because of the deterioration to which fabric covering is subjected due to the elements, to employ a metal covering. The chief disadvantage of metal covering at the present time is the increase in weight thereof over the conventional fabric covering. This has been minimized to some extent in some constructions by utilizing the metal covering as a stress transmitting member. The usual mode of accomplishing this is to corrugate or rib the covering parallel with the direction of movement, thus imparting strength to the wing in that direction which permits the use of a lesser number of ribs, but such corrugated or ribbed construction of the covering does not aid in increasing the strength of the wing along the length thereof or at an appreciable angle to the corrugations or ribs. The use of the metal covering as a stress transmitting member may be greatly increased, and thereby allow a decrease in the ultimate weight of a metal covered wing, by the employment of unribbed or uncorrugated metal covering so that such covering may transmit stresses in all directions, thereby permitting the internal bracings and load carrying members to be materially reduced in size and weight over those necessary in fabric and corrugated metal covered constructions.

However, heretofore there have been certain disadvantages apparent in the employment of a plain metal covering caused primarily by the fact that such covering is easily flexed between its lines or points of support so that under a change of air pressure on the wing, from a positive pressure to a negative pressure, or vice versa, the metal covering is caused to flex or vibrate and results in a snapping noise not unlike that which occurs when the bottom of an oil-can is pressed. One of the principal objects of the present invention is to eliminate this effect and may be accomplished as indicated in Figs. 3, 7 and 8.

As indicated in Fig. 3, the wing may be provided with a load carrying spar 15 of metallic construction, a nose-stiffening member 16 and a supplementary spar 17. Extending between and secured to the members 15, 16 and 17 are a plurality of spaced rib members 18. A plain metal skin or covering 19 is provided over and secured to the ribs 18 and members 15, 16 and 17, the covering extending to the rear end of the ribs 18 where it may be connected together as at 20. The spar 15 may be made imperforate, as shown, as may also the supplementary spar 17, thus forming the interior of the wing into three spaced chambers 21, 22 and 23, each substantially air tight and sealed from each other.

In accordance with the present invention I form an opening 24 in the nose of the wing at or near the point where the maximum positive air pressure is normally exerted thereon, and form openings 25 and 26 in the lower walls of the chambers 22 and 23 respectively at the points thereon where the maximum positive air pressure is exerted on such walls. The result is that during flight of an airplane provided with the chambers apertured, as indicated, the interior of each chamber is subjected to the maximum pressure which acts on the exterior of its surfaces and thus insures the metal covering against being depressed at any time due to a pressure acting on the exterior thereof. I find that this effectively prevents any injurious snapping action of the covering whatsoever.

The openings 24, 25 and 26 may, as will readily be apparent, be formed as a plurality of separate and independent openings, or each may comprise a slot extending continuously from one end of the wing to the other, or for any portion of the length thereof. It will also be apparent that the interior of the wing may be divided into any number of chambers that may be found desirable, and each of the chambers provided with its own opening or openings, and in some cases, it may be found desirable to form the interior of the wing into one single chamber, or in a plurality of chambers extending transversely of the length of the wing. One or more of such chambers may also or alternatively take air from a duct such as 77 in Fig. 1 which connects with a proper source of pressure, and it will be obvious that the principle here disclosed may be applied to any such modification with the same beneficial results.

Where the present invention is applied to the rudders or elevators in which the surfaces thereof may be alternately subjected to either a positive or negative pressure, the application of the maximum pressure acting on the exterior thereof to the interior thereof may be taken care of as indicated in Figs. 7 and 8. As indicated in those figures, a rudder indicated generally as 28 is shown, which is pivotally supported on a post 29 suitably supported as at 30. The interior structure of the rudder may comprise a plurality of apertured ribs such as 31 and apertured cross members 32. The ribs 31 and members 32 are covered by a plain metal sheeting 33. In accordance with the present invention I form one or more openings 34 in the covering 33 on each side of the rudder at a point thereon at or adjacent to the point at which the maximum exterior pressure may act upon it, and I preferably provide a scoop such as 35 for directing the air into each of the openings 34. It will be recognized that when the rudder is turned to turn the airplane, one side surface thereof will be subjected to a negative pressure, and in order to prevent the air entering the opening or openings 34 on one side of the rudder during such a time from escaping through the opening 34 on the opposite side of the rudder, I provide on the interior of the rudder a fabric or like flap 36 secured at one edge adjacent the corresponding opening 34 and positioned so as to overlap the same. These flaps 36 permit ready entrance of air into the interior of the rudder on that side upon which a positive pressure is acting, but the flaps cooperating with the openings on the side where the negative pressure is acting are moved to cover the corresponding opening and thereby close the opening to the passage of air through the same. This effectively insures a positive pressure being present on the interior of the rudder at all times.

The ailerons 40 may be subjected to an internal pressure in much the same manner as the main section of the wing, except that in view of the relatively small size thereof the interior thereof may be treated as a single chamber or compartment or else may be divided transversely of their length into several compartments. In Fig. 4 the aileron 40 is shown as being provided with an opening 65 adjacent the point of maximum external pressure thereon during flight so that such pressure may be transmitted to the interior of the same. This pressure may be increased by providing a scoop such as 66 for each opening 65 so that the air flowing against the same will maintain the internal pressure in excess of any external pressure acting on the aileron. While the provision of such a scoop 66 will normally be unnecessary where an opening such as 65 is provided at the point where the greatest external pressure acts upon an airfoil section, in those cases where it may be found impossible or undesirable to place the opening at the point of greatest external pressure and instead found necessary or desirable to place it at some intermediate point, such as the opening 67 in Figs. 5 and 6, the provision of a scoop such as 68 in such a case is desirable in order that the pressure within the aileron may be increased over that pressure acting on the surface adjacent the opening 67 to at least equal the maximum external pressure acting on the section at any point. The construction disclosed in respect to the aileron 40 may, of course, be applied to a full wing section or part thereof.

The same principles of internal pressure may be found desirable for use in connection with the fuselage. One mode of accomplishing this is illustrated in Fig. 1 in which the fuselage 69 is provided with a cabin 70. In the particular construction shown, the interior of the fuselage is divided into two separate compartments 71 and 72, the compartment 71 including the cabin 70. The interior of the compartment 71 may be maintained under internal pressure by the provision of openings such as 74 in the surface thereof for which co-operating scoops 75 may or may not be provided as desired. Ordinarily, however, in view of the fact that this compartment is adapted for the carrying of passengers, such openings 74 and scoops 75 may be undesirable in view of loss of pressure in the compartment which would result if one of the windows 76 were opened during flight. The compartment 72, however, not being adapted for the carrying of passengers, is preferably maintained under internal pressure. One mode of accomplishing this is shown in connection with the chamber 72, the particular means provided consisting of a duct 77 connecting the interior of the chamber 72 with the exterior surface of the plane at a point where a maximum air pressure is normally present.

Various types of so-called wing slots have been developed to prevent the presence of air eddies on the upper surface of the wings at the time an airplane is in or about to go into a stall. These slots are usually employed in connection with wing flaps or ailerons and may consist of an opening between the flap and the main wing so as to permit air to pass from the lower to the upper surface of the wing in order to displace the eddies.

In the present invention I provide a novel form of wing slot that will result in less disturbance in the passage of the wing through the air than in conventional constructions and that will be capable of supplying a greater volume of air at the required point when necessary.

I also provide means wherein the construction may be utilized for effecting a positive internal pressure in the wing, as previously described, as well as providing the wing slots.

Furthermore, I provide a means whereby the wing slots may be automatically opened and closed in accordance with the necessity of their use.

Although the wing generally indicated as 14 in Fig. 2 is provided only with an aileron 40 and no wing flaps, it will be readily apparent in the following description and explanation that the aileron 40 may be extended to also serve as a wing flap, or else that portion of the wing inwardly of the aileron 40 may be formed to provide a wing flap at its trailing edge, and in either case, the sections 3, 4 and 5 may be considered as being taken through either an aileron or a wing flap.

As indicated in Fig. 4, which shows a simple application of the basic idea, an opening 41 is provided in the leading edge similar to the opening 24 illustrated in Fig. 2. The covering 19 rearwardly of the member 17 terminates adjacent the forward edge of the ailerons 40, which may pivot about the pins 43, and the rear edge of the lower portion of the covering 19 is bent upwardly into spaced but adjacent relationship with respect to the rear edge of the upper portion of the cover 19 so as to leave an opening 46 therebetween. The member 17, in line with the aileron 40, is apertured as at 42, and the main spar 15 is apertured as at 44. Extending between the edges of the opening 41 and the edges of the forward aperture 44 I prefer to provide a metal sheeting 45 formed to pass the air through the same with a minimum of disturbance and resistance.

During flight, air entering the opening 41 expands and passes through the length of the wing section and is discharged through the opening 46 adjacent the line of connection between the main body portion of the wing 14 and aileron 40, and this discharge of air is sufficient to prevent the presence of undesirable eddies at or adjacent that point. The opening 46 provided between the rear edges of the covering 19 is of materially lesser dimensions than the opening 41, so that more air is capable of passing through the opening 41 and is capable of being discharged through the opening 46, with the result that a positive pressure is set up within the interior of the wing which serves the same purpose as the interior pressure obtained in the construction described in connection with Figs. 3, 7 and 8. This pressure and flow of air may be increased if deemed necessary or desirable by forming additional openings such as 80 in the lower surface of the wing intermediate its edges and providing such openings with cooperating scoops 81. Where the aileron 40 is spaced from the rear edge of the wing, as indicated in Figs. 4, 5 and 6, a certain amount of air will also be permitted to pass between the lower and upper surfaces of the wing at such point, as in conventional construction, and this may act to supplement the air escaping through the opening 46 from the interior of the wing. The provision of the slot 42 at the particular location shown is, of course, arbitrary, and it may be placed at any other point so as to discharge air at any desired point on the upper surface of the wing, and obviously may be formed as a continuous opening or as a plurality of separate openings.

Inasmuch as wing slots, as those described, are necessary as a general rule only at those times in which the angle of the wing approaches the angle of stall, the slots at any other time may be superfluous, and in Figs. 5 and 6, I show means for closing the slots when they are not required. I do this by providing valvular means for the openings 41 and 46 respectively. These valves may take the form illustrated in Figs. 5 and 6 which is as follows: A simple flap valve 50 pivotally supported at 51 is provided adjacent the opening 46 so as to be capable of being moved to close the same, as indicated in Fig. 6. The valve for the opening at the leading edge may be formed in the following manner: The leading edge may be formed with a semi-cylindrical end portion 52 and a valve member be provided having a complementary semi-cylindrical portion 53 overlying the portion 52 and pivotally supported on the same axial center as at 54 by ribbed members such as 55. The valve member is provided with a rearwardly extending portion 56 which closes the opening in the nose when the valve member is turned to bring the rear edge thereof into contact with the covering 19 at the rear edge of the opening in the nose, as indicated in Fig. 6. An arm 57 pivotally supported at 58 and projecting forwardly through the covering 19 is provided at its forward edge with a small surface 59 of airfoil section. The lever 57 is provided with an arm 60 extending downwardly therefrom which is freely engaged between a pair of lugs 61 formed on one of the rib members 55, a rod 62 pivotally connects the flap valve 50 with the arm 60. The edges of the opening in the cover 19 through which the arm 57 projects are formed to provide two stops for limiting the upward and downward movement of the arm 57. The arm 57 and surface 59 are so arranged relative to the wing 14 that during normal angular travel of the wing 14, the air forces acting on the surface 59 tends to move the surface 59 downwardly with the arm 57 about the pivot point 58, or in a counter-clockwise direction as viewed in Figs. 5 and 6. This position of the arm 57 tends to move the arm 60 in the corresponding direction and acting through the lugs 61 tends to move the valve in the nose to the closed position, indicated in Fig. 6, and at the same time acting through the rods 62, tends to move the flap valve 50 to closed position, it being aided in this respect if desired by a coil spring 63. Should the angle of the wing be increased until it approaches its angle of stall, the air forces acting on the surface 59 will at that time be reversed, and acting on the bottom of the surface 59 will move it upwardly until stopped by the upper edge of the opening in the surface 19 through which the arm 57 extends. This movement of the arm 57 acting through the arm 60 will cause the valve portion 56 to move upwardly away from the cooperating portion of the covering 19 and uncover the opening in the nose of the wing, and moving the rod 62 forwardly will open the flap valve 50, thus permitting air to enter the nose and escape through the opening 46 in order to displace the air eddies that tend to build up above the wing at such times.

It is preferable that the connection between the arm 60 and the lug 61 permit a small amount of lost motion so that during normal flight the pressure of the air on the leading edge acting on the portion 56 of the forward valve member will raise the portion 56 an amount sufficient to permit air to enter the interior of the wing so as to maintain the positive pressure previously described. A slight coil spring such as 64 may be provided for limiting or controlling this action, if desired.

The forward valve members and the rear valve members may in practice be provided either as a plurality of single separated members, or continuous members, as may be found most desirable, and manually operated means may be provided, when desired, instead of the automatically actuated means for controlling the valve members, and other formal changes may be made in the specific embodiment of the invention described without departing from the spirit or substance of the broad invention, the scope of which is commensurate with the appended claims.

I claim:

1. In combination with a hollow airfoil having a single thickness stress transmitting skin, means for stiffening said skin by maintaining the interior of said airfoil under a pressure commensurate with the maximum pressure acting on the exterior thereof comprising means for passing air from a point at or near the point of normal maximum exterior pressure thereon to the interior thereof.

2. In an airfoil, a framework, a stress transmitting covering for said framework, and means for stiffening said cover by preventing the air pressure acting on the exterior of said covering from becoming substantially greater than the air pressure acting on the interior thereof comprising means for introducing air to said interior from said exterior.

3. In an airplane, a structural part there-

of comprising a framework and a smooth sheet metal covering therefor, said covering forming a major structural stress transmitting element of said framework and being provided with an opening therein at or adjacent the point of maximum external air pressure acting thereon during flight, and means for maintaining the interior surface of said covering under substantially the full air pressure transmitted thereto through said opening during flight whereby to maintain the character of the stresses acting in said covering during flight.

4. In an airplane, a hollow airfoil surface having openings on each side thereof leading to the interior thereof, and means cooperating with said openings permitting air to enter said surface and normally preventing its escape therefrom.

5. An airplane, a compartment therein, two or more air intake openings each provided with check valves designed so that pressure is transmitted to the interior only through those openings which are at or near a point of maximum pressure acting on said compartment.

6. An airfoil of the stressed skin principle of design having an opening in the skin thereof for introducing air into the interior of said airfoil, said airfoil also provided with a second opening for conducting air from the interior of said airfoil to the exterior surface thereof at a point normally under a negative pressure, said openings being so proportioned as to normally maintain the interior of said airfoil under a positive pressure whereby to maintain said skin under tension to increase the rigidity of said airfoil.

7. An airfoil having a sheet metal skin forming a major stress transmitting element of said airfoil, said airfoil having a passage connecting the exterior surface of said skin with the interior surface thereof, the relation of said passage to the pressure areas acting on the exterior of said airfoil being such as to create a pressure difference on opposite surfaces of said skin whereby to maintain the character and direction of the stresses acting on said skin.

8. An airfoil having a sheet metal skin forming a major stress transmitting element of said airfoil, said airfoil having a passage connecting the exterior surface of said skin with the interior surface thereof, the relation of said passage to the pressure areas acting on the exterior of said airfoil being such as to create a pressure difference on opposite surfaces of said skin whereby to normally maintain said skin under tension during flight.

9. An airfoil having a sheet metal skin forming a major stress transmitting element of said airfoil, said airfoil having a passage connecting the exterior surface of said skin with the interior surface thereof, and a forwardly opening scoop cooperating with said passage exteriorly of said skin whereby to force air into said airfoil and create a pressure difference on opposite surfaces of said skin to normally maintain said skin under tension during flight.

10. In an airfoil, a framework, a smooth sheet metal covering for said framework secured thereto and forming a major stress resisting element of said airfoil, said airfoil having an opening therein whereby the air pressure acting on the exterior surface of said covering adjacent said opening is transmitted to the interior surface of said airfoil adjacent said opening, and means for maintaining said pressure on said interior surface during flight whereby to maintain the direction and character of stresses in said covering.

11. In an airplane wing, in combination, a framework and a substantially smooth sheet metal skin enclosing said framework and serving as a major structural stress transmitting element of said wing, said covering having an opening therein substantially at the point of maximum air pressure acting on said wing during flight and being otherwise substantially closed, whereby the interior surface of said skin is constantly subjected during flight to a pressure at least as great as the pressure simultaneously acting upon the exterior surface thereof to maintain the character of the stresses acting on said skin.

12. In an airplane, a substantially closed compartment formed therein having a sheet metal covering forming an exterior surface of said airplane and serving as a major stress transmitting element thereof, said covering having a passageway therethrough connecting the interior surface of said covering with a point exterior thereto at which the pressure of the air in flight is at least as great as the maximum pressure simultaneously acting on said covering, whereby said covering is constantly maintained under tension during flight.

13. In an airplane, a plurality of substantially closed compartments formed therein each having a covering forming an exterior surface of said airplane, said coverings forming a major stress transmitting element of said airplane and each being provided with an opening therethrough connecting the interior surface of each of said coverings with exterior surface thereof at that point thereon at which the maximum air pressure during flight is present, whereby to maintain the interior surface of each of said coverings under a positive outwardly acting pressure to maintain the tension therein.

14. An airfoil having a sheet metal skin forming a major stress transmitting element of said airfoil, said airfoil having a passage connecting the exterior surface of said skin with the interior surface thereof, the rela-

tion of said passage to the pressure areas acting on the exterior of said airfoil being such as to create a pressure difference on opposite surfaces of said skin when said passage is open whereby to normally maintain said skin under tension during flight, and a valve for closing said passage.

15. An airfoil having a sheet metal skin forming a major stress transmitting element of said airfoil, said airfoil having a passage connecting the exterior surface of said skin with the interior surface thereof, the relation of said passage to the pressure areas acting on the exterior of said airfoil being such as to create a pressure difference on opposite surfaces of said skin when said passage is open whereby to normally maintain said skin under tension during flight, a valve for closing said passage, and means controlled by the angle of attack of said airfoil for controlling said valve.

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