Jan. 7, 1936. G. E. BARNHART 2,026,728

AIRFOIL CONSTRUCTION FOR AIRPLANES

Filed March 25, 1933 3 Sheets-Sheet 1

FIG. 1.

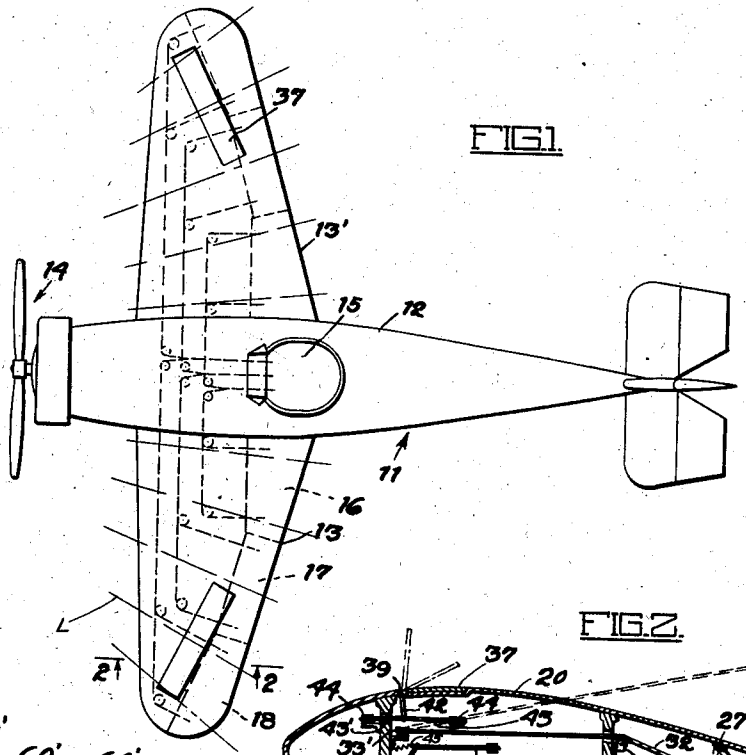
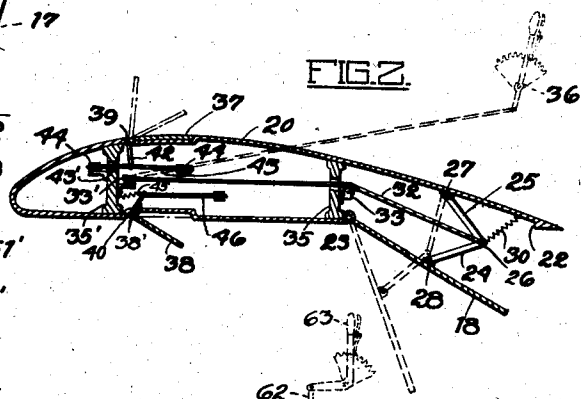


FIG. 2.



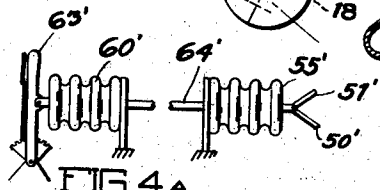


FIG. 4A.

FIG. 3.

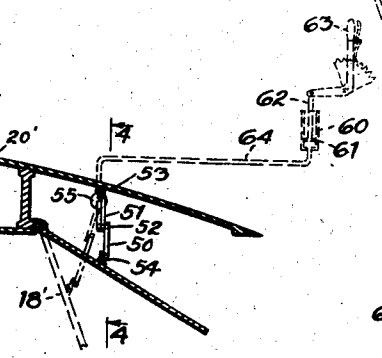
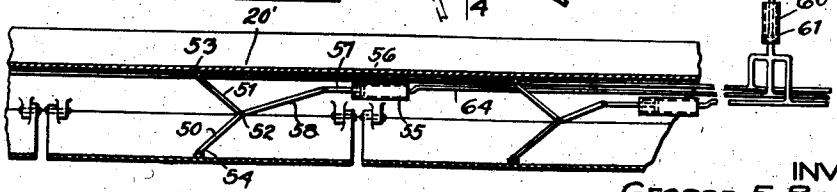


FIG. 4.



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Jan. 7, 1936. G. E. BARNHART 2,026,728

AIRFOIL CONSTRUCTION FOR AIRPLANES

Filed March 25, 1933 3 Sheets-Sheet 2

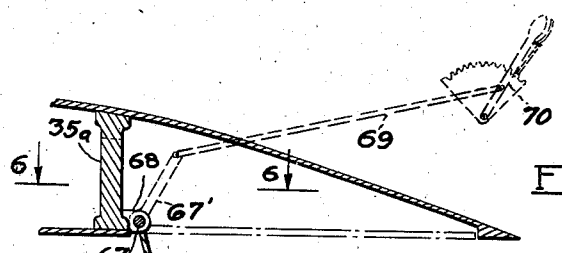


FIG. 5.

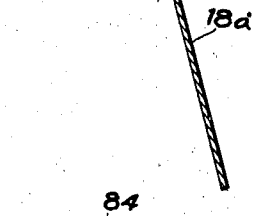
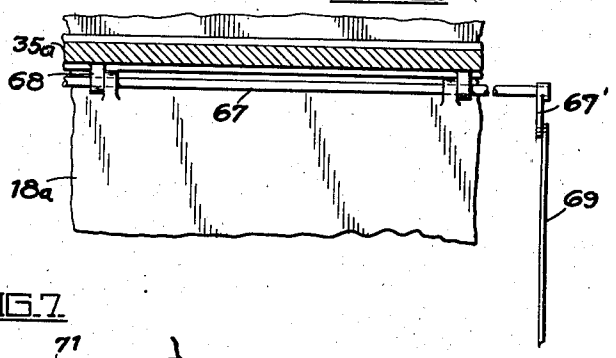


FIG. 6.



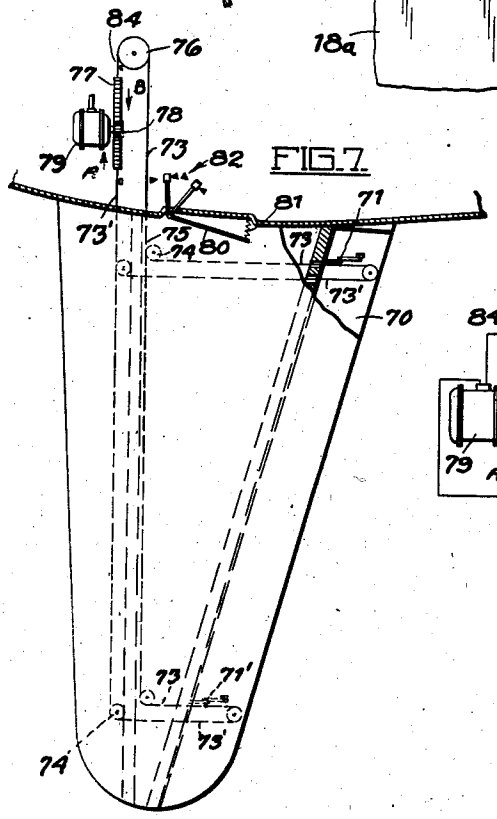


FIG. 7.

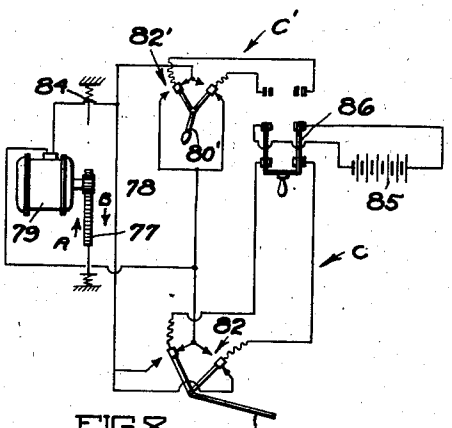


FIG. 8.

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AIRFOIL CONSTRUCTION FOR AIRPLANES

Filed March 25, 1933 3 Sheets-Sheet 3

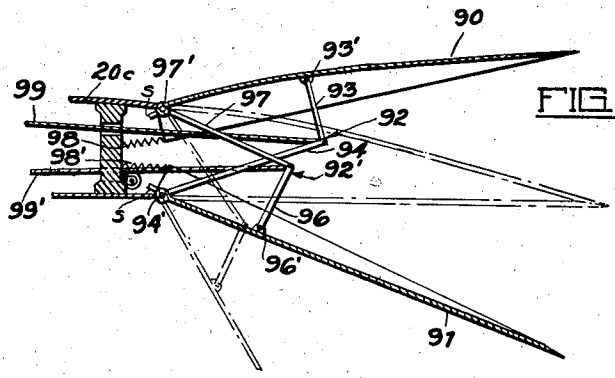


FIG. 9.

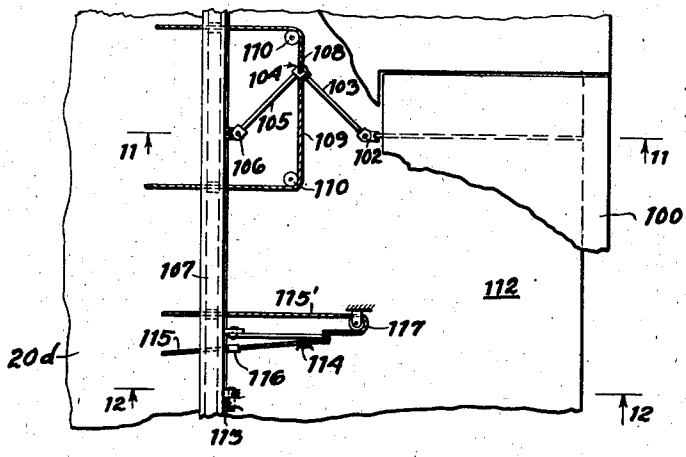


FIG. 10.

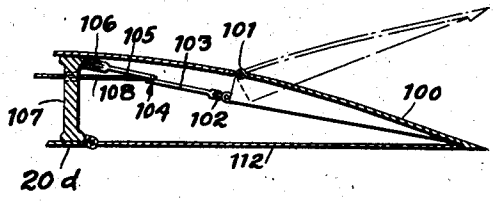


FIG. 11.

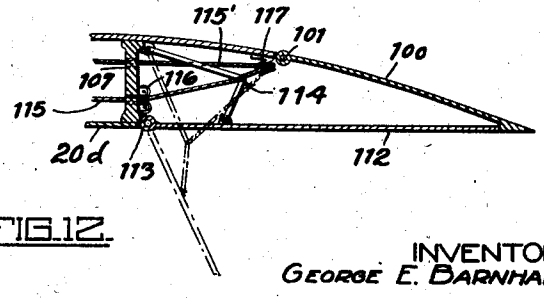


FIG. 12.

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UNITED STATES PATENT OFFICE

2,026,728

AIRFOIL CONSTRUCTION FOR AIRPLANES

George E. Barnhart, Pasadena, Calif.

Application March 25, 1933, Serial No. 662,747

2 Claims. (Cl. 244—29)

This invention has to do in a general way with the construction of airplanes, and is more particularly related to improvements in the construction of the wings or airfoils which facilitate the control of the airplane and reduce the hazards in landing and taking off.

More specifically my invention contemplates a flap which is mounted in the wing structure for swinging movement relative to the substantially rigid portion of the wing, and is particularly related to mechanism for controlling such a flap.

It is a primary objection of this invention to produce a control mechanism for actuating flaps and the like in the airfoil structure which is completely enclosed within the wing or airfoil structure. Through the use of an enclosed mechanism of this nature, I provide a structure which does not interfere in any way with the stream line of the airfoil, thereby avoiding the introduction of wind resistance which would otherwise result from mechanism projecting beyond the airfoil surface. Furthermore, by enclosing the mechanism within the wing, I am able to use parts of lighter weight in the control mechanism since the parts are not subjected to wind stresses during the travel of the airplane.

The flaps contemplated by this invention are what may be termed a split trailing edge type in that they are pivotally mounted in the trailing edges of the wings so that the trailing edges of the flaps are substantially coincident with the trailing edges of the wings, the flaps being pivoted along axes which lie a substantial distance ahead of the trailing edges. These flaps, as was pointed out above, will find their most extensive use during landing and taking off in that when they are lowered or swung downwardly from the wing, they increase the head resistance and the lift, and decrease the air speed of the plane.

For most satisfactory operation, I have found that the flaps must be constructed so as to permit their being swung downwardly at an angle in excess of 40° with their normal folded position. It is, therefore, a further object of this invention to produce a control mechanism of the class described which is capable of swinging the flaps downwardly at angles in excess of 40°.

Although the control mechanism contemplated by this invention may be manually operated or adapted for manual operation, I consider it a further object of the invention to produce a control mechanism which operates automatically within certain limits, depending upon the air speed of the airplane or the wind pressure around the airplane which is a function of the air speed. In other words, the automatic feature of my invention contemplates the provision of means which will automatically lower the flaps when the air speed of the plane decreases beyond a predetermined limit or which will automatically raise or fold the flaps when the air speed exceeds a predetermined limit. In other words, in taking off, the air speed is relatively low and the flaps are in a lowered position thereby increasing the lift which assists in attaining high elevation within a short distance relative to the ground so that a plane built for normally high speeds can be easily maneuvered to obtain ample "clearance" elevation before it passes the boundary of even small landing fields. When the speed of the airplane has reached the predetermined speed limit, mentioned above, the automatic means referred to are effective to withdraw the flaps without any attention whatsoever from the pilot. When the plane is being maneuvered for landing, the pilot will cut off the motor, and when the velocity of the airplane decreases to a predetermined point, the flaps will be automatically lowered, which further reduces the velocity so that the airplane can be landed in safety. This feature is obviously very valuable in planes which are designed and built for extremely high speed.

Since the flap, or flaps, contemplated by this invention, are preferably constructed so as to extend the full length of the wing, I have devised a novel aileron construction which permits a full length flap of this nature, and my invention, therefore, further contemplates such an aileron construction. In this connection, it is a further object of this invention to produce an aileron of the class described which is disposed at an angle other than 90° with the direction of the flight or is substantially normal to the line of air flow across the wing in the tip portion where the aileron is located.

My invention also contemplates a novel flap type of aileron mounted on the trailing edge of the wing in the upper surface thereof, and control means for actuating such an aileron.

It is a still further object of this invention to produce a control mechanism of the class described which is of simple form and construction; is light in weight; and has a minimum of operating parts.

It is a further object of this invention to produce a control mechanism of the class described which is formed so that the pressure or force required to open the flap will remain substantially constant at all times irrespective of the wind pressure against the flap. In other words,

it is an object of this invention to produce a control mechanism in which the power ratio of the flap operating means increases as the flap is opened so as to compensate for the increasing pressure against the flap as it is swung downwardly into the wind.

The details in the construction of a preferred form of my invention, together with other objects attending its production, will be best understood from the following description of the accompanying drawings which are chosen for illustrative purposes only, and in which—

Fig. 1 is a plan view which illustrates, more or less diagrammatically one form of flap construction and flap control mechanism contemplated by this invention;

Fig. 2 shows an airfoil section which may be considered as having been taken in a plane represented by the line 2—2 in Fig. 1;

Fig. 3 is an airfoil section showing a modified form of control mechanism;

Fig. 4 is a sectional view which may be considered as having been taken in a plane represented by the line 4—4 in Fig. 3;

Fig. 4A is a diagrammatic view showing a modified form of pressure operated flap actuating means;

Fig. 5 is a fragmentary airfoil section showing another form of flap operating mechanism;

Fig. 6 is a plan section taken in a plane represented by the line 6—6 in Fig. 5;

Fig. 7 is a fragmentary plan section with parts broken away showing part of a fuselage and a wing, and illustrating a preferred form of automatic flap control contemplated by this invention;

Fig. 8 is a wiring diagram showing one manner of controlling the flap actuating mechanism shown in Fig. 7;

Fig. 9 is a fragmentary airfoil section showing another modified form of my invention;

Fig. 10 is a fragmentary plan view of a wing or airfoil showing another form of flap and aileron construction with a modified form of control mechanism;

Fig. 11 is a sectional elevation taken in a plane represented by the line 11—11 in Fig. 10; and

Fig. 12 is a sectional elevation taken in a plane represented by the line 12—12 in Fig. 10.

More particularly describing the invention as herein illustrated, reference numeral 11 indicates an airplane comprising a fuselage 12, and wings 13 and 13'. The fuselage is equipped with a propeller unit generally indicated by reference numeral 14, and is provided with a cockpit indicated at 15.

In the airplane shown in Fig. 1, the wings are equipped with a flap unit shown as comprising a plurality of flaps which I may refer to as an inner flap 16, an intermediate flap 17, and a tip flap 18. By arranging the flap unit in this manner, I may form the inner and outer flaps so that they "wash" or load the air inwardly toward the center of the wing which carries the intermediate flap. However, it is to be understood that a single flap extending the entire length of the wing, may be employed and that such flap may embody the characteristics of any one of the three flaps shown. In other words, I may employ a flap which extends the entire length of the wing wherein the leading edge of the flap converges from a point nearest the fuselage toward the trailing edge of the wing, or the flap may be one in which the leading edge of the flap is parallel with the trailing edge of the wing, or the flap may be one in which the leading edge converges from a point nearest the tip toward the trailing edge of the wing, each of these flaps having the attending advantages for the particular use for which the plane is designed.

It is another feature of the flap construction, contemplated by this invention, that the flap is of the split trailing edge type in that it normally cooperates with a substantially fixed portion 20 of the wing to form a stream line airfoil section. In other words, the wing may be considered as having a flap opening 22 disposed at or near the trailing edge and, as shown in Figs. 2 and 3, the flap indicated by reference numeral 18 is pivotally mounted as indicated at 23 along the front or leading edge of the flap opening 22. The flap is of a width such that when it is in a closed or normal flying position its trailing edge engages and closes the trailing edge of the flap opening.

The present invention, however, is more particularly concerned with the flap operating mechanism than it is with any specific type of flap, and in Fig. 2 I show one preferred form of flap operating mechanism which comprises a pair of links, or a plurality of pairs of links, indicated at 24 and 25, such links being pivotally connected at 26 to form a hinge.

The "free" end of the link 25 is pivotally attached to a brace member or other suitable support in the substantially fixed portion 20, as indicated at 27, and the "free" end of the link 23 is pivotally connected to the flap 18 as indicated at 28. This hinge member, made up of links 24 and 25, is constructed so that when it is in a folded position it is effective to close the flap, and when it is opened it is effective to swing the flap downwardly. It is one feature of this mechanism that it is capable of opening the flap to an angle in excess of 40°.

Although various means may be employed to actuate the hinge member, I show in Fig. 2, a construction which is simple and easy to operate. In this construction, the flap is urged toward a closed position by means of a tension spring 30 interposed between the hinge member and the fixed portion of the wing, and is adapted to be swung downwardly to an open position by opening the hinge member through the medium of a cable, or other flexible member, 32, which is shown as being attached to the pivot point of the hinge member and extends over pulleys 33 and 33' mounted on suitable rigid elements such as the spars 35 and 35' of the airfoil. This cable extends over other suitable pulleys, not shown, until it is brought to a convenient point in the cockpit where it is attached to a lever member 36.

In the event a plurality of flaps are used, I may connect each pair of flaps (corresponding flaps in opposite wings) to a separate lever so that they can be independently operated, or I may connect the cable from all of the flaps to one pair of main control cables which in turn are connected to a single lever. I may also dispense with the spring 30 and employ two cables, one leading from each side of the hinge member so that the movement of the lever in one direction is effective to open the hinge, and movement in the opposite direction is effective to close the same.

It was pointed out in the early part of the specification that, in addition to the flap control mechanism, this invention contemplates a novel type of aileron which is in the nature of an auxiliary flap. Such an aileron construction may be mounted either on the top surface of the wing or at the bottom surface of the wing, or, a flap

may be mounted on both such surfaces. In Fig. 2, this aileron type of flap is shown as being mounted on both such surfaces. The top aileron is indicated by reference numeral 37, and the bottom aileron is indicated by reference numeral 38. These aileron flaps, unlike the flaps 18, are adapted for reception in the recesses of the wing surface, and are shown as being pivoted at their leading edges as indicated at 39 and 40. It is one feature of this type of aileron that it is mounted between the centers of pressure travel in the wing. In other words, the flap is preferably located substantially between the center of pressure location for high speed travel and the center of pressure location for low speed travel.

It is another feature of the flap 37, that it is disposed or arranged in substantially normal relation to the mean line of air flow across the wing in the particular region where the flap is located. This feature is best illustrated in Fig. 1 but the line of air flow for the region of the aileron is indicated by the reference letter L. It is to be understood, of course, that this arrangement of the aileron may be used in both the top and bottom flaps in the event two flaps are used. For the purpose of illustration, however, the bottom flap in this form of my invention is shown as being arranged in the usual manner where it is normal to the line of travel or parallel to the leading edge of the wing.

For the purpose of actuating the aileron 37, I show the same as being mounted upon a shaft which is provided with a lever member 42 extending through a suitable slot or opening in the wing to a point within the wing. The free end of this lever member 42 is connected to a pair of cables 43 and 43' which extend over pulleys 44 and 44' and additional pulleys (not shown) to a point in the cockpit where they are attached to an operating lever similar to the operating lever 36. The bottom flap 38 is rigidly associated with a lever member 44 and is urged toward a closed position by means of a tension spring 45 and is adapted to be swung to an open position by means of a cable 46. In this particular arrangement, the aileron flaps are adapted for independent operation, but it is to be understood that they may be interconnected for simultaneous operation by means of a suitable link mechanism or by the cable control system.

In Figs. 3 and 4, wherein the wing structure and the flap are identical with the wing structure and flap in Fig. 2, and are indicated by the same reference numerals distinguished by the prime mark, I show a modified form of flap control mechanism. This control mechanism is shown as comprising a pair of links 50 and 51 pivotally connected at 52 to form a hinge. The free ends of these links are connected, for swinging movement, about two axes to the rigid portion 20' of the wing and the flap 18 as indicated at 53 and 54 respectively. In this particular arrangement, the hinge member is arranged to operate in a plane extending along the length of the wing, and since the hinge must swing as a unit during the pivotal movement thereof which opens and closes the flap, it is necessary to employ the double acting pivot units 53 and 54.

This particular type of hinge construction lends itself especially to use in connection with a hydraulic actuating mechanism, and although a cable or other type of actuating mechanism may be employed with this hinge, or a hydraulic mechanism may be employed with the type of hinge shown in Fig. 2, I show in Figs. 3 and 4 a hydraulic cylinder or a plurality of such cylinders indicated generally by reference numeral 55, the cylinder 55 containing a piston 56 which carries a piston rod 57. The outer, or free end, of the piston rod is pivotally attached to a link 58 which in turn is connected to the pivot point 52 of the hinge unit.

The piston is adapted to be reciprocated in the cylinder 55 for actuating the flap by means of what I may term a power cylinder 60 which contains a piston 61 having a piston rod 62 adapted for actuation by a lever member 63. The lever member 63 is of course situated convenient to the pilot in the cockpit.

The power cylinder 60 is connected to the flap actuating cylinder 55 through the medium of a pressure fluid conduit 64, and the whole system is filled with a suitable pressure fluid such as oil, glycerin, or the like. In this particular form of my invention, I depend upon the suction, created in the power cylinder by the retraction of the power piston, to withdraw the piston 56 and retract the flaps. It will be understood, however, that I may employ fluid lines to connect both ends of the respective cylinders so that there is positive pressure on the piston 56 for both the opening and closing operation, also that a sylphon bellows or a diaphragm system may be employed as an operating means. A bellows system is shown in Fig. 4A where the bellows, indicated at 55' and 60', are interconnected by a fluid conduit 64'. The bellows 60' is actuated by a lever 63', and the bellows 55' actuates the flap operating links 50' and 51'.

In Fig. 5, I show another modified form of my invention in which the flap, indicated by reference numeral 18a, is rigidly mounted upon a shaft 67 which is rotatably supported by bearing brackets 68 shown as being mounted on a spar 35a, the shaft 67 extending substantially parallel to the axis of the wing. The inner end portion of the shaft 67 is provided with a lever member 67' which is connected through the medium of a link, or system of links, 69, with a manually actuated lever 70. This system provides a simple and compact flap operating mechanism.

It was pointed out in the forepart of the specification as one object of this invention to provide a flap control mechanism which was automatically effective to open and close the flaps, depending upon the air speed of the airplane. Such a system is illustrated in Figs. 7 and 8 wherein the flap indicated by reference numeral 70 is of the general construction referred to above, and is shown as being provided with hinged members indicated at 71 and 71' for opening and closing the flap in the manner described in connection with Fig. 2.

These hinge members are connected at their pivot points to oppositely extending cables 73, 73' associated with suitable supporting pulleys 74. The cables 73 are shown as being united at 75 where they continue as a single cable which extends over a pulley 76 and is connected to a rack 77. The other end of the rack 77 is connected to a similar extension of the cables 73'.

The rack 77 is engaged by a pinion 78 which is keyed to a shaft of a suitable power device, such as a reversible electric motor 79. The current to the motor is adapted to be reversed by means of a vane or other suitable wind pressure mechanism indicated at 80. In this particular form the vane 80 is shown as being pivoted in the side of the fuselage and is pressed outwardly by means of a compression spring 81.

The vane 80 is associated with, or as shown,

is attached to a reversing switch generally indicated by reference numeral 82 whereby the current through the motor is reversed for effecting opposed movements of the rack 77. In operation, the spring 81 is of a strength such that it will resist a predetermined wind pressure against the vane, such pressure resulting from the movement of the plane so that when the plane is standing or moving at slow speeds, the vane 80 is pressed outwardly, closing a circuit through the motor which drives the rack in the direction of the arrow "A" to swing the flap downwardly, such movement of the rack being continued until the end of the rack engages a circuit opening switch indicated at 84. When the plane attains a predetermined speed, the wind pressure against the vane 80 is sufficient to press the vane inwardly against the action of the compression spring thereby closing a reverse circuit through which the motor then drives the rack in the direction of the arrow "B" thereby closing the flap.

In Fig. 8, I show a wiring diagram for one type of circuit which may be used in conjunction with a device of this character. From this diagram it will be noted that the motor 79, when set for automatic operation, is adapted to be driven from a battery 85 through a circuit control switch 86 and a circuit generally indicated at C, such circuit containing the vane actuated control switch 82.

The device is also equipped for manual operation, such operation being effected by throwing the switch 86 to connect the battery with another circuit C'. This last mentioned circuit contains a manually operated reversing switch 82' which is actuated by means of a lever member 80' instead of the vane 80. The lever member 80' will be situated in the cockpit of the fuselage and its actuation will have the same result upon the flaps as the vane actuated switch 82.

In Fig. 9, I show another modified form of the invention in which the trailing edge of the substantially fixed portion 20c of the wing may be considered as having been split to form two flaps 90 and 91. These flaps are formed so that when they are in a closed position they cooperate to form a streamlined airfoil section. For the purpose of actuating these flaps, I employ two sets of hinged links generally indicated at 92 and 92'.

The hinge unit 92 has one leg 93 connected to the flap 90, as indicated at 93', and the other leg 94 is connected to a point 94' on the substantially rigid portion of the airfoil. Similarly the hinge unit 92' comprises a leg 96 connected to the flap 91 as indicated at 96' and a leg 97 pivotally connected to the wing section as indicated at 97'. These flaps are urged toward a closed position by means of tension springs 98 and 98' and are adapted to be independently opened by means of cables 99 and 99'. Inward movement of the flaps is limited by stops S.

In Figs. 10 to 12 inclusive, I show another modified form of double flap construction in which I have shown an upper flap 100 situated on the tip of the wing adapted for use as an aileron. This flap, as indicated in Fig. 11 is pivoted in the substantially rigid portion of the wing as indicated at 101 and is connected through a double action hinge 102 to one leg 103 of a link hinge unit 104. The other leg 105 of this link hinge unit is connected through a double hinge 106 with a rigid portion of the wing such as the upper edge of the rear spar 107. The hinge unit 104 is adapted to break in a plane which extends along the length of the wing and is moved in opposite directions by means of cables 108 and 109 extending over pulleys 110 and additional pulleys (not shown) to a point in the cockpit where they can be actuated by a suitable lever.

In addition to the aileron flap 100, the substantially rigid wing portion 20d is equipped with a bottom flap 112 pivoted to the rear spar as indicated at 113 and adapted to be folded downwardly from the wing by means of a hinge link unit 114 which is similar both in construction and operation to the hinge link unit described in connection with Fig. 9. Instead of employing a tension spring to close the flap 112, however, I use a pair of cable members 115 and 115' which extend in opposite directions from the pivot point of the hinge over pulley guide means 116 and 117.

It will be observed in this construction just described, that the hinge unit, which operates the top flap, works in a plane which is disposed at right angles to the plane in which the hinge unit actuating the bottom flap works.

It was pointed out in the forepart of the specification that one object of the invention was to produce a flap control or flap actuating mechanism which was formed so that the pressure or force required to open the flap remains substantially constant at all times, or more specifically one in which the power ratio of the flap operating means increases as the flap is opened, thereby maintaining uniform stresses in the cable or other means provided for operating the flap actuating mechanism. This object is accomplished, in this form of my invention, by means of the hinge link unit, the mechanical advantage of which increases as the hinge is opened.

It is to be understood that, while I have herein described and illustrated one preferred form of my invention, the invention is not limited to the precise construction as described above, but includes within its scope whatever changes fairly come within the spirit of the appended claims.

I claim as my invention:

1. In combination with an airplane wing having a substantially fixed portion: flap means swingably mounted on the underside of said wing at the trailing edge thereof and extending substantially the full span of said wing; means for actuating said flap means; an auxiliary vane hinged to the under surface of said wing ahead of said flap means; and means for actuating said auxiliary vane, said flap means comprising a plurality of flaps having their leading edges positioned so as to wash the air stream from the root and tip of the wing toward an intermediate portion thereof.

2. In combination with an airplane wing having a substantially fixed portion: flap means swingably mounted on the underside of said wing at the trailing edge thereof and extending substantially the full span of said wing; means for actuating said flap means; an auxiliary vane hinged to the under surface of said wing ahead of said flap means; and means for actuating said auxiliary vane, said flap means comprising a plurality of flaps having their leading edges positioned so as to wash the air stream from the root and tip of the wing toward an intermediate portion thereof, and said auxiliary vane being positioned so as to divert a part of the air stream toward the said intermediate portion of the trailing edge.

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