July 30, 1946. E. F. ZAP 2,404,895

VARIABLE WING CONSTRUCTION

Filed Jan. 19, 1942 2 Sheets-Sheet 1

Fig. 1.

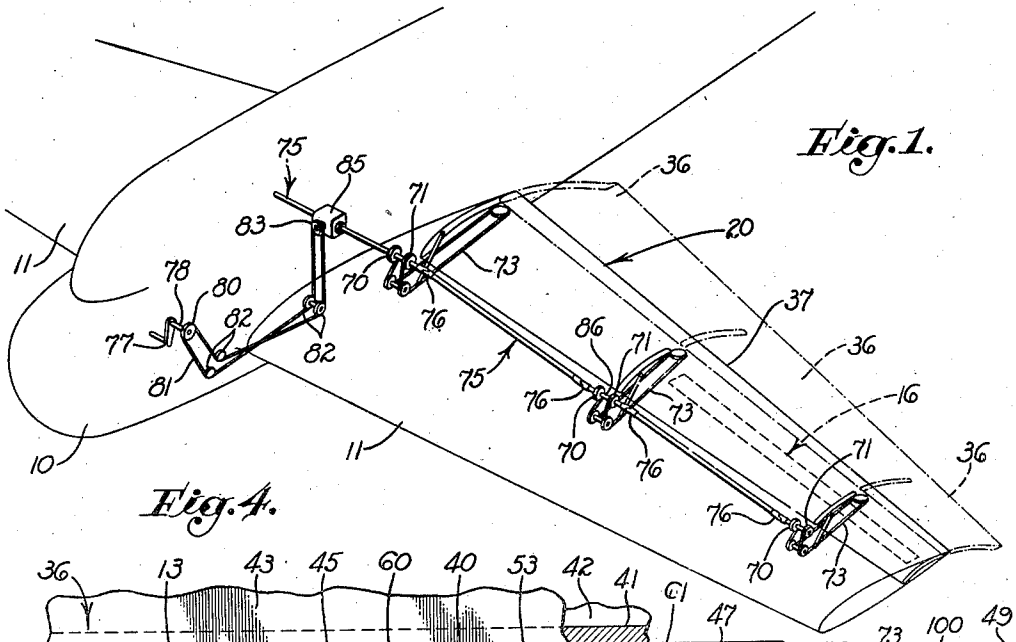


Fig. 4.

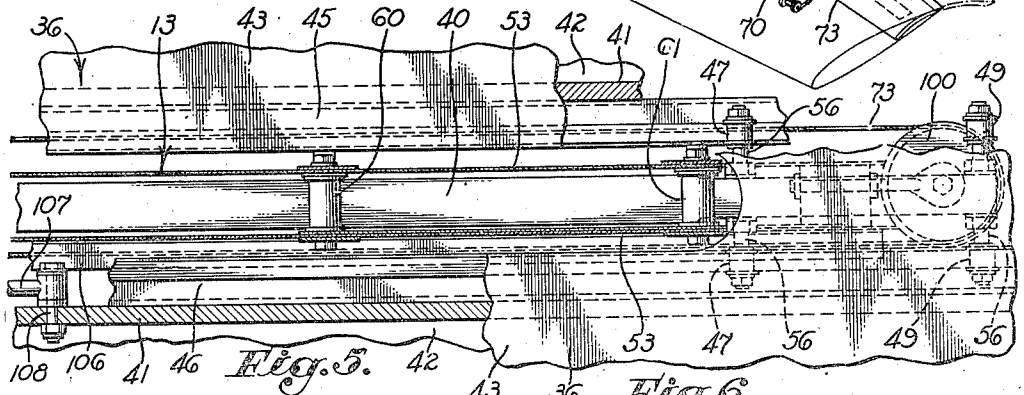


Fig. 5.

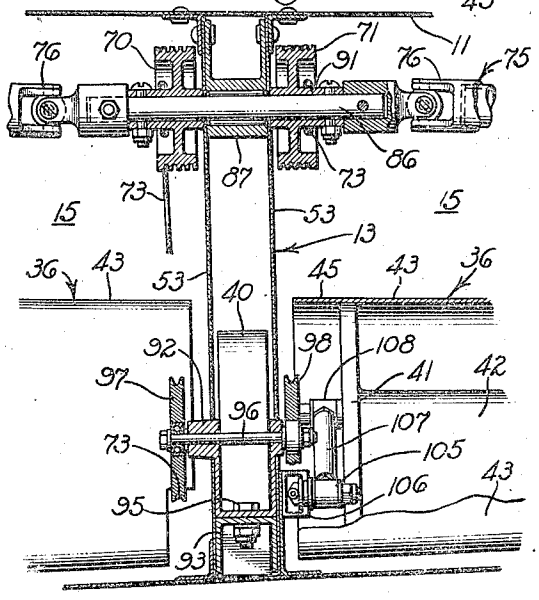
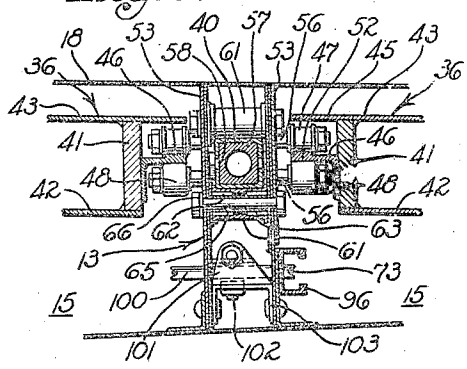


Fig. 6.



INVENTOR
EDWARD F. ZAP

BY
HARRIS, KIECH, FOSTER & HARRIS

FOR THE FIRM
ATTORNEYS

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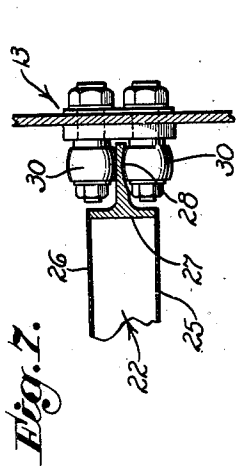

Fig. 7.

Fig. 3.

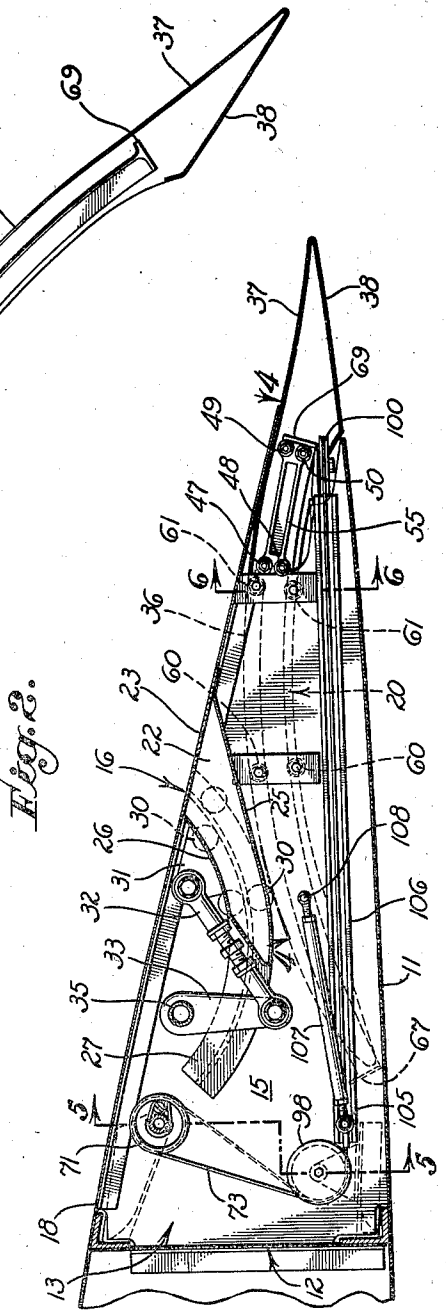

Fig. 2.

INVENTOR
EDWARD F. ZAP
BY
HARRIS, KIECH, FOSTER & HARRIS
FOR THE FIRM
ATTORNEYS

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VARIABLE WING CONSTRUCTION

Edward F. Zap, Los Angeles, Calif.

Application January 19, 1942, Serial No. 427,237

8 Claims. (Cl. 244—42)

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My invention relates to the construction of airplane wings and more particularly relates to mounting and controlling relatively movable parts of variable wings. By way of example, the present invention will be described as directed specifically to improvements on the structure disclosed in my copending application Serial No. 352,516, entitled "Airplane wing construction," and the present invention will therefore have the objects set forth in that application. It will be understood, however, that the principles exemplified herein may be applied to other types of wings and features of the new construction may be employed apart from the arrangement as a whole.

The particular wing construction under consideration here is of the high lift or variable lift type that is changed in configuration in accord with changing operating conditions. Thus, such a wing may be varied temporarily to provide relatively high lift for take-off and again may be varied to provide both increased lift and increased drag for landing. As set forth in said copending application the variable wing of the present type has a hollow portion lying between the rearward spar and the trailing edge, and a trailing flap is mounted in this hollow portion for extension and retraction rearwardly and downwardly from the wing. Preferably the flap is of curved configuration and is mounted for movement outward along a curved path from a retracted position largely, if not entirely, inside the wing, to various positions of extension. To provide for an adequate range of flap movement and yet require relatively little space for mounting means, the flap is movably or retractably mounted on a support that is itself movably or retractably mounted on the wing. The range of movement of the flap in such a construction is the range of relative movement provided between the flap and the support plus the range of relative movement provided between the support and the wing. The contemplated wing construction as set forth in said copending application also includes a novel aileron that is adapted to extend into or retract from the air stream above the wing.

One of the objects of the present improvement is to provide compactness or efficient utilization of space in an airplane wing and at the same time to achieve efficiency and dependability in the mechanism for actuating and controlling the relatively movable parts of the wing. An arrangement is sought that may be confined entirely in the space rearward of the rear spar of

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the wing and hence will involve no necessity for openings through the rear spar. It is contemplated that the means for actuating and controlling the aileron of the wing as well as the means for actuating and controlling the extensible flap of the wing will be restricted to the wing space rearward of the rear spar, neither mechanism interfering with the other.

One of the problems in the described wing arrangement is to provide in the confined rearward space a structurally efficient and thoroughly reliable mechanism for actuating and controlling the flap, such mechanism to be fully effective at all positions of the flap. It is difficult to design a mechanism or linkage that does not at some point of operation become unwieldy or develop unfavorable leverage. One of the objects is to provide a mechanism that meets this problem and yet is adapted to the peculiar space limitations of an airplane wing. In this aspect the invention is characterized by a new combination of pulleys, cables, and guide means for flap actuation.

A group of objects relating to the means for movably mounting the flap in the wing includes the following: to reduce the number of movable flap supports required in my earlier structure; to simplify the construction of such movable supports; to avoid loading such movable supports in any manner tending to develop undesirable torques in the supports; to provide an arrangement in which the movable supports are efficiently related to the rib structure of the wing for transmitting loads thereto; and to provide means for movably mounting the flap on the movable supports in an efficient manner.

The above and other objects of the invention will be apparent in my following detailed description, taken with the accompanying drawings.

In the drawings, which are to be considered as illustrative only:

Fig. 1 is a diagrammatic view of an airplane in perspective showing the principal elements in the system for actuating and controlling the wing flaps;

Fig. 2 is a fore-and-aft section through a wing of the airplane, both the flap and the aileron being retracted;

Fig. 3 is a similar view with the flap and aileron extended;

Fig. 4 is an enlarged view partly in section taken as indicated by the line 4—4 of Fig. 2;

Fig. 5 is a section on an enlarged scale taken as indicated by the irregular line 5—5 of Fig. 2;

Fig. 6 is a section on an enlarged scale taken as indicated by the line 6—6 of Fig. 2; and

Fig. 7 is a section on an enlarged scale taken as indicated by the line 7—7 of Fig. 3.

The drawings show an airplane having a fuselage 10 and a pair of wings 11, the framework of each wing including a rear spar 12 (Fig. 2) and a number of ribs generally designated 13 (Figs. 5 and 6). In each wing the rear spar 12 and the various ribs 13 form what may be termed hollow portions or wing compartments 15. An aileron generally designated 16 is mounted in each wing 11 to move upward through an opening 17 (Fig. 3) in the upper skin 18 of the wing, and a flap generally designated 20 is mounted in the wing to move rearward through an opening 21 in the trailing edge of the wing.

Each of the ailerons 16 comprises a plurality of aileron panels 22 mounted in successive wing compartments 15, the panels being connected in a unitary manner by a common end plate or deflecting plate 23. Each aileron panel 22 may be of hollow construction with a lower wall 25 and an upper curved wall 26. The upper wall 26 provides what may be termed the curved effective surface of the panel. In the present arrangement it is contemplated that normally each of the ailerons 16 will be sbstantially entirely inside the corresponding wing 11, with the deflecting plate 23 substantially flush with the wing skin 18. For rolling control of the airplane each aileron 16 is movable upward in a curved path having one or more centers or axes of curvature lying above the wing and forward of the aileron. Since the wings 11 shown in Fig. 1 are of tapering planform, the aileron panels 22 may likewise be tapered.

Each of the aileron panels 22 may be mounted in the corresponding wing compartment 15 in any suitable manner providing for movement along the desired curved path. In the present arrangement a curved track or guide member 27 with an outwardly extending flange 28 is mounted on the sides of each aileron panel in moving engagement with four rollers 30 mounted on one of the wing ribs 13. For actuation of the aileron 16 each of the panels 22 may be provided with a small bracket plate 31 to which is pivotally connected one end of an adjustable operating rod 32, the other end of the operating rod being pivotally connected to an arm 33 on an operating shaft 35. Any suitable mechanism may be employed to control the aileron-operating shafts 35 in the two wings.

The flap 20 may comprise a series of flap panels 36 that are individually mounted in successive wing compartments 15, the various panels being connected in a unitary manner by a common trailing member 37 having an air-deflecting surface 38. The flap 20 is curved in cross-sectional configuration and since the wings 11 are tapered in plan form the flap may have the overall configuration of a longitudinal section of a truncated cone. The flap 20 may be adapted to move in a curved path concentric to the cross-sectional configuration of the flap, the common axes of the flap and the flap path being below the wing. Each of the flap panels 36 is movably mounted on two support members 40 and the support members are in turn movably supported by ribs 13 in the wing.

As indicated in Fig. 6, each flap panel 36 has relatively thick side walls 41, a lower wall or skin 42, and an upper wall or skin 43 having a marginal portion 45 overhanging each of the side

walls 41. Mounted on the face of each side wall 41 is a suitable track or guide 46 of the same curvature as the aileron panel, the track being movably engaged by a forward pair of rollers 47 and 48 (Fig. 2) and a rearward pair of rollers 49 and 50 (Figs. 2 and 6). Each of the lower rollers 48 and 50 may be plain, while each of the upper rollers 47 and 49 may be flanged for engaging opposite sides of an upper rib 52 formed in the track or guide 46. The four rollers 47 to 50 are carried by the trailing end of one of the movable flap supports 40 (Fig. 6). In the particular construction shown in the drawings there are three flap panels 36 on each side of the fuselage 10. Two intermediate support members 40 are between successive flap panels each having two sets of rollers 47—50 supporting two adjacent flap panels, while two support members 40 are at opposite sides of the flap assembly each carrying a single set of rollers 47—50. There is substantially no tendency for the flap load to develop torque in the intermediate support members 40. Fig. 6 shows one of the intermediate support members 40, and the side support members are of identical construction except in having only a single set of the rollers. It will be noted that each flap panel is supported in a stable manner by two spaced support members 40.

As indicated in Fig. 6 each support member 40 may be of hollow metal construction square or rectangular in cross section and each of the ribs 13 of the wing structure may be hollow to enclose the corresponding support member. The hollow rib 13 shown in Fig. 6, for example, comprises two spaced plates 53. At the outer trailing end of each support member 40 is a suitable bracket 55 (Fig. 3) having spindles 56 for the rollers 47—50, each of the brackets being formed with a hollow shank 57 that extends into the support member and is secured thereto, for example, by welding 58 applied through apertures in the wall of the support member.

Each of the support members 40 for the flap panels 36 may be slidingly mounted in the corresponding hollow rib 13 in any suitable manner. In the particular construction indicated in Figs. 2 and 6 each support member 40 is in rolling engagement with a forward pair of rollers 60 and a rearward pair of rollers 61, each roller being flanged to engage opposite sides of the support member thereby to confine the support member against lateral movement. Each of the rollers 60 and 61 may be mounted by a needle bearing 62 on an eccentric sleeve 63, the eccentric sleeve being mounted in turn on a bolt 65. A nut 66 on the bolt 65 may be loosened to permit rotation of the eccentric sleeve 63 so that the various rollers 60 and 61 (Fig. 2) may be readily adjusted for snug fit against the support member 40.

It is apparent that the described arrangement for mounting the flap 20 will permit the flap to move from a retracted position shown in Fig. 2 to an extreme extended position shown in Fig. 3, and it will be noted that the relatively extensive range of movement on the part of the flap corresponds to the range of relative movement provided between the flap and the various support members 40 plus the range of relative movement provided between the support members 40 and the airplane wing 11. As indicated in Fig. 3, the inner end of each support member 40 may be provided with a stop 67 to engage the forward pair of rollers 60 for the purpose of limiting the outward movement of the support member, and each of the curved tracks or guides 46 may be

formed with integral stops 68 and 69 to cooperate with the rollers 47—50 for cooperation with the corresponding set of rollers 47—50. The pairs of rollers 60 and 61 may be termed primary rolling means and the sets of rollers 47—50 may be termed secondary rolling means.

The flap 20 may be actuated by any suitable mechanism including the control arrangement set forth in my previously mentioned copending application Serial No. 352,516. The present construction, however, is characterized by the use of pairs of cable spools 70 and 71 for each of the flap panels 36, the pairs of spools being so arranged that one spool plays out a flexible means such as a cable 73 while the other spool winds in the cable. The various pairs of cable spools 70 and 71 in each wing may be mounted on a flap-operating shaft 75 that is divided into sections by universal joints 76. To operate the two shafts 75 in the two wings of the airplane the pilot may turn a crank 77 (Fig. 1) on a stub shaft 78 carrying a sheave 80. An endless cable 81 engaging the sheave 80 passes under various idlers 82 and around a driven sheave 83 on a gear box 85. A suitable worm (not shown) and cooperating worm gear (not shown) in the box 85 drive the two shafts 75.

Fig. 5 shows a section 86 of one of the flap-operating shafts 75 journaled in a bearing 87 inside one of the hollow ribs 13, the section of shaft carrying a pair of cable spools 70 and 71 on opposite sides of the rib. Each of the cable spools 70 and 71 has a screw 88 (Fig. 3) engaged by a loop 90 on the end of the cable 73 and the cable passes around the hub of the spool and through an aperture to the spool periphery. Inside the rib 13 below the shaft section 86 (Fig. 5) a bracket 92 is mounted on a base 93 by one or more bolts 95. The bracket 92 carries a spindle 96 extending through the rib and two vertical pulleys 97 and 98 are mounted on opposite ends of the spindle. Finally, a substantially horizontal pulley 100 (Figs. 2 and 6) is mounted on a bracket 101 near the trailing edge of the wing, the bracket being secured by one or more bolts 102 to a base 103 lying inside the rib. The cable 73 from the cable spool 70 in Fig. 5 passes under the vertical pulley 97, around the horizontal pulley 100, under the vertical pulley 98, and onto the second cable spool 71, rotation of the shaft causing one spool to play out the cable 73 and the other spool to wind up the cable at a corresponding rate.

For the purpose of operatively connecting a flap panel 36 with a cable 73, the cable may be attached to a pivot member 105 (Figs. 2 and 5) that is movable along a track or guide 106, the track or guide 106 being mounted one one side of the rib 13 to conform with the cable path between the vertical pulley 98 and the horizontal pulley 100. One end of an adjustable link or operating rod 107 (Fig. 5) is mounted on the pivot member 105 and the other end of the operating rod is pivotally connected to a stud 108 on a side wall 41 of the flap panel.

It is apparent that rotation of the crank 77 by the pilot will cause the three operating cables 73 in each wing (Fig. 1) to shift the corresponding pivot members 105 forward or rearward to cause corresponding forward or rearward movement of the panels 36 of the flap 20. Since the wing is of tapered configuration and since I prefer to have the flap 20 always extend the wing configuration at each wing station in proportion to the chord of the wing itself at the station, the three

flap panels will range over operating paths of different lengths and the three pairs of cable spools 70 and 71 for operating the three flap panels will be correspondingly of different diameters.

A feature of the present invention readily apparent in Figs. 2 and 3 is that both the means for mounting and controlling the aileron 16 and the means for mounting and controlling the flap 20 are contained in the portion of each wing between the rear spar 12 and the trailing edge of the wing, none of the operating and controlling mechanism extending through the spar. It will be noted that the aileron and associated mechanism are complementary to the flap and associated mechanism in the sense that complementary zones of the hollow portion of the wing are occupied by the two combinations.

Since the specific arrangement described herein for the purpose of disclosure suggests various changes and substitutions under my basic concepts, I reserve the right to all such departures from my description that properly lie within the scope of the appended claims.

I claim as my invention:

1. In an aircraft, the combination of: a main wing with a rear spar and spaced ribs forming rearward wing compartments; a plurality of flap panels mounted in said compartments, said flap panels being interconnected at their rearward portions to form a unitary flap assembly; support means at an end of said flap assembly; and intermediate support means between successive panels in said flap assembly, each of said support means being mounted on one of said ribs for movement between a retracted position largely inside the wing and an extended position largely outside the wing, the panels of said flap assembly being mounted on said side and intermediate support means for fore-and-aft movement relative thereto and relative to the wing between positions largely inside the wing with the support means retracted and positions largely outside the wing with the support means extended, each of said intermediate support means movably supporting two successive panels in the flap assembly.

2. In an aircraft, the combination set forth in claim 1 in which the means for mounting each flap panel on a support means includes rolling means carried by the support means and cooperating guide means carried by the panel in engagement with and guided by said rolling means.

3. In an aircraft, the combination of: a main wing with hollow ribs spaced to form rearward wing compartments; a plurality of flap panels mounted in said compartments, said flap panels being interconnected at their rearward portions to form a unitary flap assembly; support means at an end of said flap assembly; intermediate support means between successive panels in said flap assembly, each of said support means being mounted in one of said hollow ribs for movement between a retracted position largely inside the rib and an extended position largely outside the wing; and means mounting said panels on said side support means and said intermediate support means for fore-and-aft movement relative thereto and relative to the wing between positions largely inside the wing with the support means retracted and positions largely sutside the wing with the support means extended, the adjacent sides of two of said panels being supported by one of said intermediate support means.

4. In an aircraft, the combination of: a wing with a spar and spaced ribs, said ribs extending

longitudinally of the aircraft to adjacent the trailing edge of said wing and with said spar forming compartments closed at the bottom by said wing and open at the trailing edge of said wing; a plurality of flap panels, one of said panels being mounted in each of said compartments and said panels being interconnected at their rearward portions to form a unitary flap assembly; end support means at an end of said assembly; intermediate support means between adjacent of said panels; means mounting each of said end and intermediate support means on one of said ribs for fore-and-aft movement relative to said associated rib; and means mounting said panels on said end and intermediate support means for fore-and-aft movement relative thereto, each of said intermediate support means supporting the adjacent ends of adjacent panels.

5. In an aircraft, the combination of: a wing with spaced ribs, said ribs extending longitudinally of the aircraft to adjacent the trailing edge of said wing and forming compartments therein closed at the bottom by said wing and having an opening in the trailing edge of said wing; an aerodynamic member mounted in each of said compartments for movement through said opening; a flexible means in each of said compartments operatively connected to one of said aerodynamic members for inducing fore-and-aft movement of said member; a shaft mounted on each of said ribs; a pair of spools mounted on each of said shafts, said spools of each pair being in adjacent of said compartments and said spools being adapted to wind and unwind said flexible means; means to rotate one of the spools in a direction to wind in the flexible means and simultaneously to rotate the other spool in a direction to play out the flexible means and vice versa; and means including a pulley near said opening to guide said flexible means in an operating path.

6. In an aircraft, the combination of: a wing with spaced ribs, said ribs extending longitudinally of the aircraft to adjacent the trailing edge of said wing and forming compartments therein closed at the bottom by said wing and having an opening in the trailing edge of said wing; an aerodynamic member mounted in each of said compartments for movement through said opening; a flexible means in each of said compartments operatively connected to one of said aerodynamic members for inducing fore-and-aft movement of said member; a shaft mounted on each of said ribs; a pair of spools mounted on each of said shafts, said spools of each pair being in adjacent of said compartments and said spools being adapted to wind and unwind said flexible means; means to rotate one of the spools in a direction to wind in the flexible means and simultaneously to rotate the other spool in a direction to play out the flexible means and vice versa; and means including a pulley near said opening to guide said flexible means in an operating path, said pulley being spaced from said spools a distance at least equal to the extent of movement of the associated aerodynamic member.

7. A combination according to claim 1 wherein said spaced ribs lie between said panels when said panels are in retracted position.

8. A combination according to claim 3 wherein said hollow spaced ribs lie between said panels when said panels are in retracted position.

EDWARD F. ZAP.