United States Patent [19]

O'Neill et al.

[11] **3,836,099**

[45] **Sept. 17, 1974**

[54] **AIRFOIL CAMBER CHANGE SYSTEM**

[75] Inventors: **Edward T. O'Neill,** Renton; **William M. Brennan,** Edmonds, both of Wash.; **Gerhard K. Kriechbaum,** Hagnau, Bodensee, Germany

[73] Assignee: **The United States of America as represented by the Secretary of the Navy,** Washington, D.C.

[22] Filed: **Sept. 28, 1973**

[21] Appl. No.: **401,746**

[52] **U.S. Cl.** **244/44**

[51] **Int. Cl.** **B64c 3/48**

[58] **Field of Search** ..... 244/42 R, 44

[56] **References Cited**

UNITED STATES PATENTS

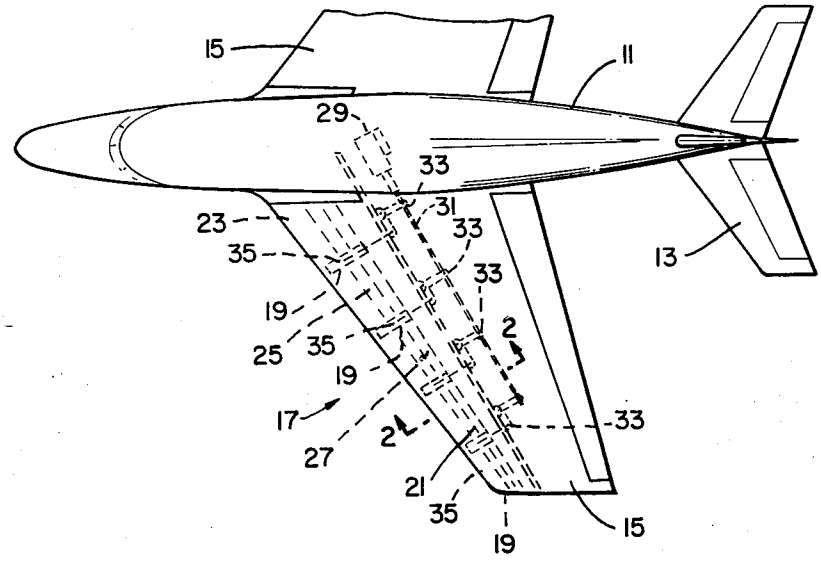
1,567,531	12/1925	Magni	244/44
1,880,019	9/1932	Harper	244/44
2,022,806	12/1935	Grant	244/44

Primary Examiner—Trygve M. Blix
Assistant Examiner—Jesus D. Sotelo
Attorney, Agent, or Firm—R. S. Sciascia; Charles D. B. Curry

[57] **ABSTRACT**

An airfoil camber change system for changing the camber of the leading or trailing edges of airfoils. The system includes a flexible continuous upper surface, a lower surface comprising a plurality of slidable overlapping segments and one or more actuation mechanisms. The actuation mechanism includes a plurality of bell cranks and links that are operatively connected to the upper and lower airfoil surfaces. A primary actuator is provided to drive the actuation mechanisms. When the system is driven the actuation mechanism changes the camber profile and maintains proper separation and support of the upper and lower surfaces. The profile is changed by bending the upper constant length surface and shortening the lower surface by increasing the overlap of the slidable overlapping segments.

6 Claims, 3 Drawing Figures



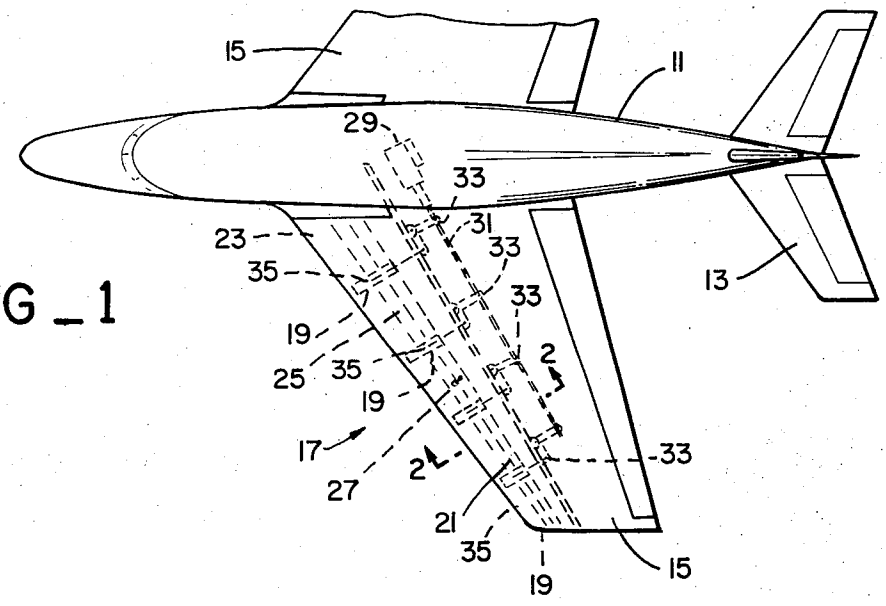


FIG_1

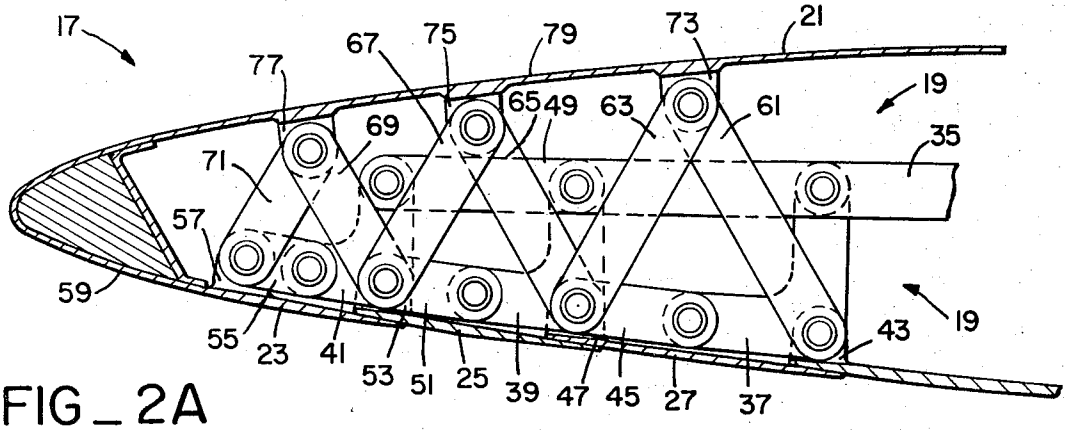


FIG_2A

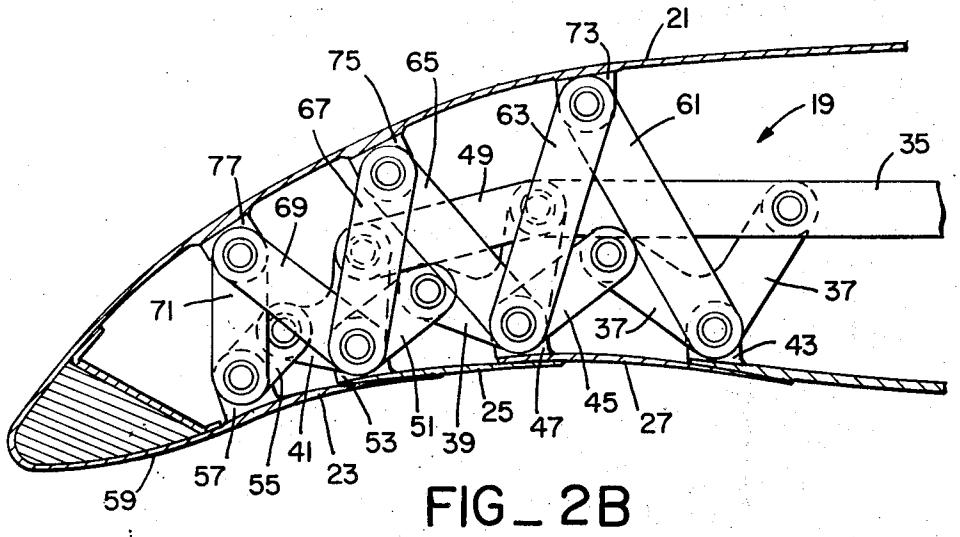


FIG_2B

AIRFOIL CAMBER CHANGE SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an airfoil camber change mechanism and more particularly to an airfoil camber change mechanism that is rapid acting and provides a continuous smooth airfoil and a high degree of airfoil support.

2. Description of the Prior Art

Most prior airfoil camber change systems have employed relatively slow moving members that have not been subjected to high air ram forces. These relatively low speed systems have not provided the rapid time response required by high performance aircraft. In addition, these prior systems do not provide sufficient airfoil support to prevent deflection of the skin or airfoil panels. Some prior systems have employed rapid acting flaps. However, these systems have used single hinged flaps that presented abrupt changes in airfoil curvatures. The present invention overcomes these disadvantages by providing an airfoil camber change system that is rapid acting, has a smooth airfoil, has high strength and is particularly useful in high performance aircraft.

SUMMARY OF THE INVENTION

Briefly, the present invention comprises an airfoil camber change system for changing the camber of the leading or trailing edges of airfoils. The system includes a flexible continuous upper surface, a lower surface comprising a plurality of slidable overlapping segments and one or more actuation mechanisms. The actuation mechanism includes a plurality of bell cranks and links that are operatively connected to the upper and lower airfoil surfaces. A primary actuator is provided to drive the actuation mechanisms. When the system is driven the actuation mechanism changes the camber profile and maintains proper separation and support of the upper and lower surfaces. The profile is changed by bending the upper constant length surface and shortening the lower surface by increasing the overlap of the slidable overlapping segments.

STATEMENT OF THE OBJECTS OF THE INVENTION

An object of the present invention is to provide an airfoil camber change system that provides rapid camber changes.

Another object of the present invention is to provide an airfoil camber change system that provides a smooth airfoil.

Still another object of the present invention is to provide an airfoil camber change system that rigidly supports the airfoil surfaces.

Still another object of the present invention is to provide an airfoil camber change system that may be subject to high air ram forces such as encountered on high performance aircraft.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic plan view of an aircraft employing the airfoil camber change system of the present invention;

FIG. **2A** is a side elevation of the airfoil camber change system of FIG. **1** when in the undeflected position; and

FIG. **2B** is a side elevation of the airfoil camber change system of FIGS. **1** and **2A** when in the deflected position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. **1** is schematically illustrated an aircraft having a body **11,** tail section **13** and wings **15.** The airfoil camber change system **17** is shown on the leading edge of the wing **15.** However, it is to be understood that the airfoil camber change system of the present invention may be also used to change the camber of the trailing edge of the wing. Moreover, the basic system is not limited to aircraft but may be used where contour change is desired. The airfoil camber change system **17** includes a plurality of similar spaced apart actuation mechanisms **19,** an upper flexible continuous airfoil surface **21,** a plurality of overlapping segments **23, 25, 27** forming the lower airfoil surface. Actuation of the system **17** is initiated by primary actuator **29** driving push-pull rod **31** which actuates bell cranks **33** which moves actuation links **35** in a push-pull manner. It is to be understood that many different types of primary actuation may be employed.

In FIGS. **2A** and **2B,** taken at section **2—2** of FIG. **1,** is illustrated the side elevation of the airfoil camber change system **17** including upper surface **21,** a plurality of overlapping segments **23, 25** and **27** forming the lower surface and actuation mechanism **19.** The actuation mechanism **19** includes a plurality of bell cranks **37, 39** and **41.** Bell crank **37** is rotatably mounted on lug **43** and one leg of the bell crank is rotatably mounted on actuator link **35** and the other leg is rotatably attached to one end of link **45.** The other end of link **45** is rotatably mounted on lug **47** that is rigidly attached to the first slidable overlapping segment **27.** Bell crank **39** is rotatably mounted on lug **47** and one leg of the bell crank is rotatably mounted on the end of actuator link **35** and to one end of actuator extension link **49.** The other leg of bell crank **39** is rotatably mounted on one end of link **51** which has its other end rotatably mounted on lug **53** which is rigidly attached to the second slidable overlapping segment **25.** Bell crank **41** is rotatably mounted on lug **53** and one leg of the bell crank is rotatably mounted on the other end of extension link **49.** The other end of bell crank **41** is rotatably mounted on one end of link **55** which has its other end rotatably mounted on lug **57** which is rigidly attached to the third overlapping segment **23.** The last overlapping segment **23** is attached to the leading edge **59.** A plurality of spacer links **61, 63, 65, 67, 69** and **71** are provided to support the upper and lower airfoil surfaces and to maintain the desired airfoil thickness. One end of spacer link **61** is rotatably mounted on lug **43** and the other end is rotatably mounted on lug **73** which is rigidly attached to upper surface **21.** One end of link **63** is rotatably mounted on lug **47** and the other end is rotatably mounted on lug **73.** One end of link **65** is rotatably mounted on lug **47** and the other end is rotat-

ably mounted on lug **75** which is rigidly attached to upper surface **21.** One end of link **67** is rotatably mounted on lug **75** and the other end is rotatably mounted on lug **53.** One end of link **69** is rotatably mounted on lug **53** and the other is rotatably mounted on lug **77** which is rigidly attached to upper surface **21.** One end of link **71** is rotatably mounted on lug **77** and the other end is rotatably mounted on lug **57.** It should be noted that the spacer links and the airfoil surface form triangular truss segments which have high strength characteristic. For example, spacer links **63** and **65** along with segment **79,** of upper airfoil surface **21,** form this desired triangular truss configuration. It should be also noted that the spacer links lengths become progressively shorter to conform with the airfoil configuration both in the undeflected position shown in FIG. **2A** and in the deflected position shown in FIG. **2B.**

The operation of the airfoil camber change system of the present invention is as follows. When actuator link **35** is moved to the left, to a predetermined stop position, the actuation mechanism **19** retains the airfoil in the undeflected position shown in FIG. **2A.** It should be particularly noted that due to air pressure on the lower overlapping segments, that the lower legs of the bell cranks and the lower links **45, 51** and **55** are in tension and therefore the pivot connection between these links and the bell crank legs will not buckle during normal operation.

When the actuator link **35** is moved to the right, to a predetermined stop position, then all three bell cranks **37, 39** and **41** rotate clockwise. This reduces the distance between lower lugs **43, 47, 53** and **57** and results in greater overlapping of slidable overlapping segments **23, 25** and **27.** It should be noted that overlapping segments **23, 25** and **27** are flexible and therfore maintain a tight seal and provide a smooth lower airfoil surface. To minimize the discontinuity of the lower surface and to increase flexibility, the trailing edge of movable segments **23, 25** and **27** are made thinner than the leading edges. The legs of the bell cranks **37, 39** and **41** are made progressively shorter to achieve the desired airfoil camber. It should be particularly noted that by changing the lengths of the bell cranks and the links that virtually any camber profile can be achieved. Also, any number of overlapping segments and a corresponding increase or decrease in number of bell cranks and links may be employed. It is to be understood that each of the above described links, lugs and bell cranks may in actual practice comprise pairs of links, lugs and bell cranks. This may be done to provide added strength and more rigid support.

What is claimed is:

1. An airfoil camber change system comprising:

a. an upper airfoil surface made of continuous flexible material;

b. a lower airfoil surface comprising a plurality of overlapping segments;

c. at least one actuation mechanism for simultaneously changing the camber of said upper and lower surfaces;

d. said actuation mechanism including a plurality of elongated spacer means each having one end rotatably mounted on said upper surface and having the other end respectively rotatably mounted on a plurality of first pivot members respectively connected to said plurality of overlapping segments of said lower surface;

e. a plurality of bell cranks respectively rotatably mounted on said plurality of first pivot members;

f. first means operatively interconnecting adjacent bell cranks and adjacent segments;

g. second means for actuating said bell cranks to slide said overlapping segments with respect to each other; whereby

h. during actuation of said second means the camber change of said upper surface is about the same as said lower surface.

2. The system of claim **1** wherein:

a. one leg of each of said plurality of bell cranks being operatively connected to said second means;

b. said first means comprises a plurality of links; and

c. the other leg of said bell cranks being respectively operatively connected to said plurality of links.

3. The system of claim **2** wherein:

a. said second means comprises a plurality of links respectively connecting said one legs of adjacent bell cranks.

4. The system of claim **1** wherein:

a. said upper surface includes a plurality of spaced apart second pivot members;

b. said one ends of first and second adjacent elongated spacer means being rotatably mounted on one of said second pivot members;

c. said one ends of third and fourth adjacent elongated spacer means being rotatably mounted on another of said second pivot members; whereby

d. said plurality of elongated spacer means form a plurality of triangular support structures.

5. The system of claim **1** wherein:

a. said plurality of bell cranks are sequentially of decreasing size.

6. The system of claim **1** wherein:

a. each of said plurality of first pivot members are connected to the leading edge of the overlapping segment to which it is connected.

* * * * *