Nov. 18, 1969 P. R. L. B. DORAND 3,478,987

JET FLAPS

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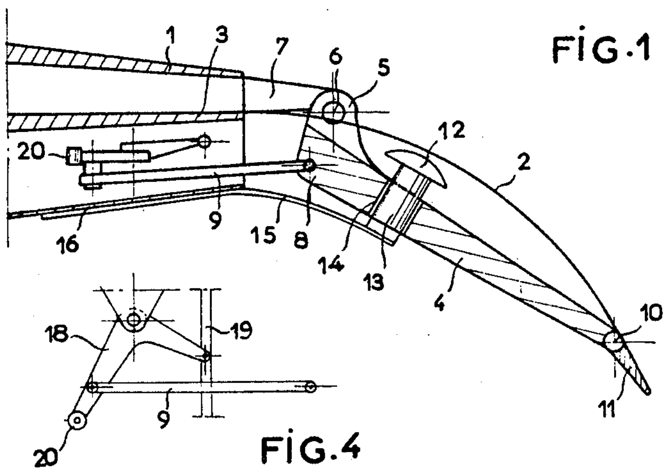

FIG.1

FIG.4

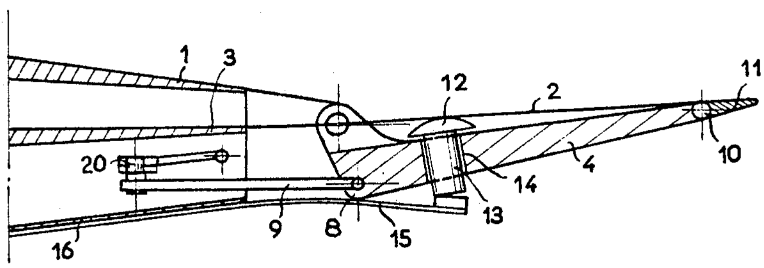

FIG.2

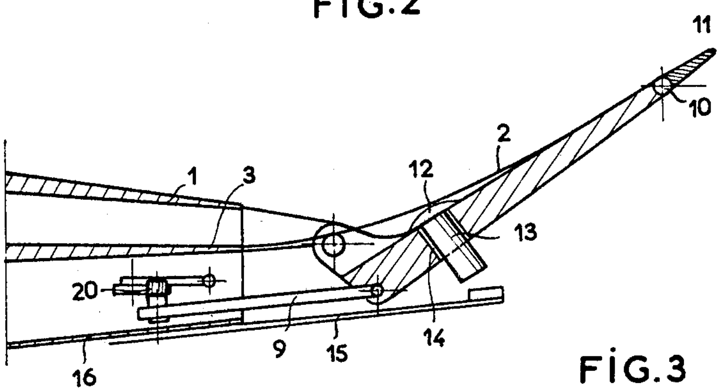

FIG.3

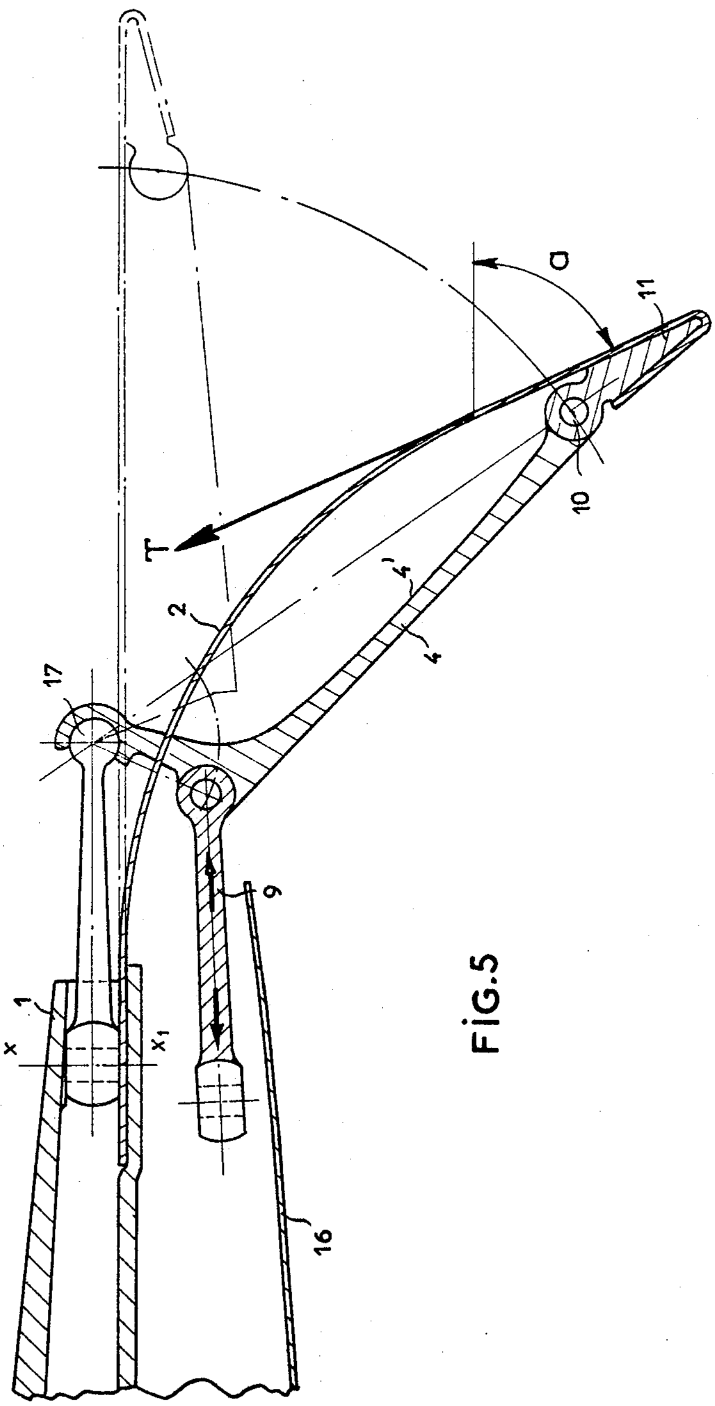

FIG.5

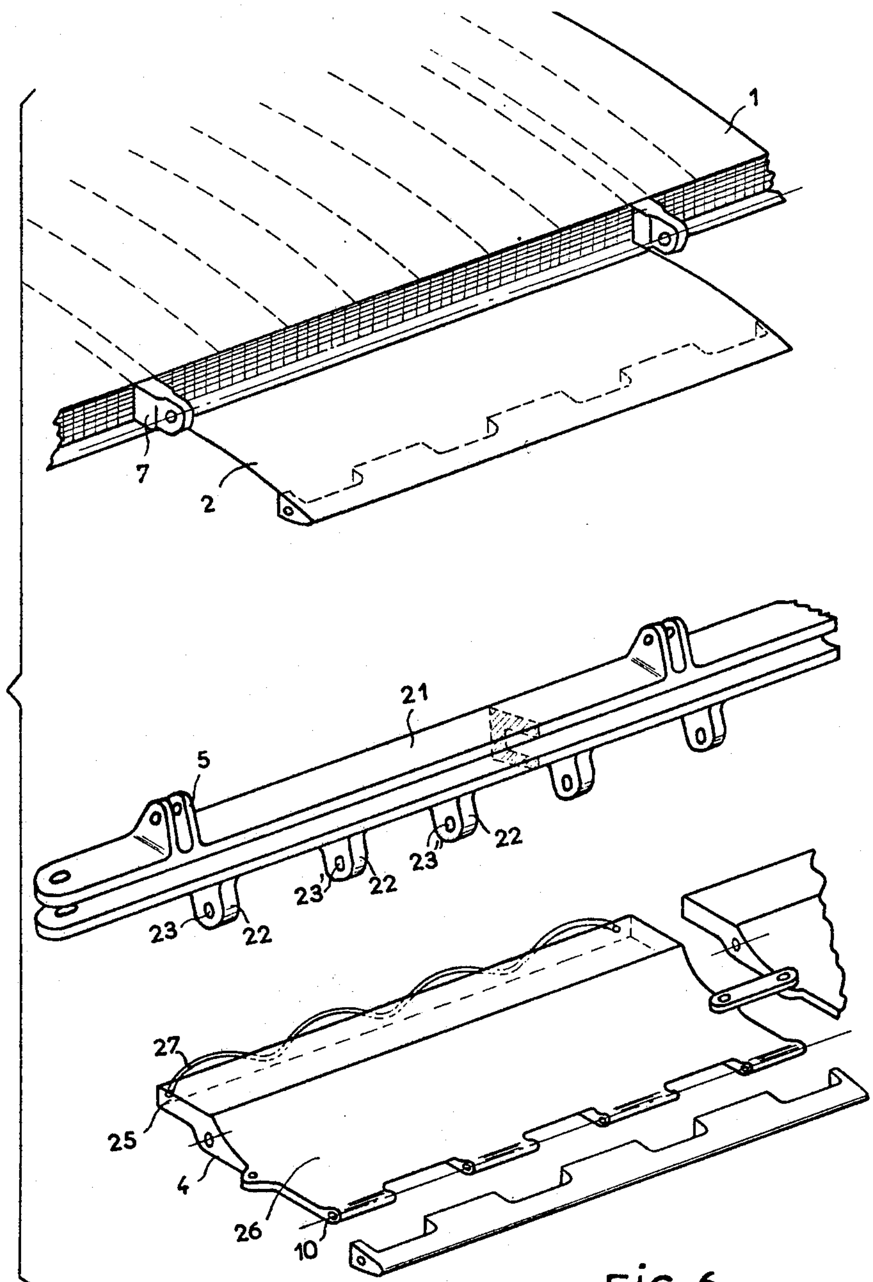

FIG.6

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JET FLAPS

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Int. Cl. B64c *9/38*
U.S. Cl. 244—42 14 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to jet flaps and controllable means for varying the deflection of the jetstream thereof, applicable to aerofoils. It resides in means for controllably varying the effective contour of an aerodynamic surface behind the jet slit, so that the stream can be deflected either up or down to provide lift control. It is applicable to wings of aircraft or helicopter rotor blades, in which there is a supply of gas or air to constitute a jet stream from a spanwise elongated jet slit.

SUMMARY OF INVENTION

The invention resides in means for controllably varying the curvature of a flexible aerodynamic surface which is mounted as a continuation of one lip or wall of the jet slit, so that the surface can be flexed up or down (concavely or convexly as seen from the jet), the means including a rigid flap structure which is hingedly attached to the main aerofoil, the trailing edge of which has the jet slit, the surface being attached to the main aerofoil at its leading edge, and to the hinged structure at its trailing edge, in such a manner that it assumes the required concave or convex contour when the structure is swung up or down.

There is already known a device capable of varying the sense of vertical direction of such a jet which consists of a variable profile flap attached to the lower edge of the jet slit and which, when curved downwardly and rearwardly, deflects the jet downward by "Coanda effect" by which a jet of fluid tends to cling to a convex surface provided the radius of curvature of such a surface is sufficiently great in relation to the dimensions of the jet normal to such surface. On the other hand, when such a flap is curved upward, it simply acts as a vane and deflects the jet upward.

The present invention relates to a simple and effective means of obtaining the upward and downward deflection with a variable profile flap of this type. It also enables the flap to be used in the event of failure of the supply of jet fluid under pressure, e.g., when the aircraft is in gliding flight. The device is characterised by the fact that it consists of a flap structure which can be moved upward or downward and which the an upper effective surface which will vary in contour in accordance with this movement. This upper surface may be of a flexible material such as sheet steel, or be made up of a series of articulated sections, whilst the underside of the flap comprises a rigid flap structure which is pivotally mounted on the aerofoil, the upper surface being attached to the flap structure at or near its trailing edge; such attachment may be direct, or it may be through the medium of a secondary flap or tab constituted by a freely hinged trailing edge element to which the upper surface is attached.

In one form of the invention, the upper surface consists of a flexible strip (e.g. of sheet metal) attached by its leading edge to the lower edge of the jet slit, whilst the rigid flap structure is hinged at or near its leading edge

2

about an axis situated aft of the jet slit and in line or nearly in line with the lower edge of the slit with which it is parallel. Also, the trailing edge of the flexible strip is preferably attached to a small tab-like element which is freely hinged to the trailing part of the flap structure.

By way of examples, the following description and attached drawings represent the device according to the invention.

FIGURES 1, 2 and 3 show the variable flap assembly according to one form of the invention, in vertical section, in three different positions.

FIGURE 4 is a plan view of part of the control system proposed to be used in this first example.

FIGURE 5 is a vertical section of another construction, by way of example, of the invention.

FIGURE 6 is an exploded view, in perspective, of a further form of construction of the flap assembly.

As shown in FIGURES 1 to 3, the variable shape flap, designed to deflect a jet emitted through a jet slit **1** in the trailing edge of a wing or helicopter rotor blade, consists of a metallic strip **2**, thin enough to be flexible, with its leading edge fixed at **3** to the lower edge of the jet slit **1**, this strip **2** forming the upper surface of the flap. The underside of the flap consists of a rigid flap structure **4**, on the upper side of which are attached hinge fittings such as **5** near the leading edge of the flap assembly which is attached by a hinge pin **6** to lugs **7** fixed to the wing or rotor blade and extending aft therefrom. The hinge pin **6** is situated in line or nearly in line with the lower edge of the jet slit, i.e., in line with the strip **2** when it is not flexed (or a little above this line as indicated in FIGURE 5). Generally speaking, the flap is intended to be made up of relatively short separate spanwise sections in order to avoid being subjected to the flexure of the wing or rotor blade; also the hinge elements **5**, **7** would be situated in fore-and-aft line with wing ribs, the lugs **7** may be forming part of such ribs. A connecting rod **9**, which forms part of the flap control system described below, is articulated at **8** to the rigid structure **4**.

A tapered section tab-like element **11** is hinged at **10** to the rear edge of the rigid structure **4** and to this element is attached the flexible strip **2**, for example in the manner shown in FIGURE 5 where the trailing edge of the strip **2** is folded around flap **11** and welded to this latter in such a way as to remain firmly fixed to it when the strip **2** is flexed. By this arrangement, when the connecting rod **9** is moved forward or backward (as in FIGURES 1 and 3 respectively), the strip **2** is flexed and the element **11** assumes a position, under the effect of the stress in the strip **2**, in which the upper surface of the element **11** is at a tangent to the curve of the strip at its trailing edge. In order to make the jet flow follow the contour of the curved strip **2** when it is directed downward (FIGURE 1), the minimum radius of the curve must, according to experimental data, be greater than ten times the height of the jet (i.e. the vertical dimension of jet slit **1**); under these conditions, in order to obtain maximum downward deflection of the streamline, all that is required is that the strip **2** should be moved downward to obtain the desired degree of deflection *a* (see FIGURE 5) with a curvature within the criterion mentioned above. When the flap is deflected upward (FIGURE 3), the positive pressure exerted by the jet on strip **2** tends to press it against the rigid structure **4**, the profile of which can be designed to allow the strip **2** to flex to an optimum curvature; as shown in FIGURE 5, the upper profile **4'** of structure **4** may be made concave for this purpose.

In the neutral position shown in FIGURE 2, in which the jet exerts no pressure on the strip **2**, the upper surface of which is parallel to the jet, the strip **2**, not now flexed and therefore not in chordwise stress, may tend to flutter, disturbing the jet flow and perhaps doing other mischief. To obviate flutter, the strip **2** is proposed to be supported by a mushroom shaped component **12**, the stem **13** of which passes through an aperture **14** in the structure **4** and is pressed upward by a leaf spring **15**, the other extremity of which is attached to the underside of the wing or rotor blade.

When strip **2** is flexed downward (FIGURE 1), it is no longer in contact with the head of the component **12** owing to its natural curvature, which is thus not affected. On the other hand, when the flexure is upward (FIGURE 3), the load on the spring **15** is released and the component **12** falls back through the aperture **14** and does not affect the curvature of strip **2**.

In the case where hot gas, for example from a jet engine, is supplied to jet slit **1**, its temperature will exceed that of the flap structure. In order to allow for spanwise thermal expansion of the jet slit, sufficient lateral play is provided in the hinge elements **5–7**. According to the example represented in FIGURE 5, the simple hinge articulation in FIGURES 1 to 3 is replaced by ball and socket type articulations which provide for this spanwise accommodation.

It will be noticed that, when the strip **2** is flexed, it exercises forces which give rise to a tangential component T (FIGURE 5) producing a couple which reacts on the control system and tends to pull the connecting rod **9** back to its original position. In the case of helicopter blades, the control mechanism shown in FIGURE 4 compensates this reaction on the controls by centrifugal force. To achieve this, the control mechanisms of each variable shape flap section, which are housed within the rotor blade at **16** (FIGURES 1, 2 and 3), comprise a bellcrank **18** pivoted on a vertical axis. One arm of the bellcrank is articulated to a rod **19** which runs parallel to the span of the rotor blade and constitutes a control rod, whilst the other arm is articulated to the previously described connecting rod **9**. The extremity of this latter arm of the bellcrank **18** carries a balance-mass **20**; centrifugal force acting upon this mass, when the blade is in rotation, acts upon connecting rod **9** in the opposite direction to that of force T, in such a way that the effort required to move the control is reduced; the control system being, so to speak, "assisted" by the centrifugal force acting upon the balance mass **20**.

FIGURE 6 shows one construction of flap assembly in which the efficiency of the flap is improved by a spring loaded telescopic arrangement. In this example, the structure **4** is made in two parts; the leading edge is formed by a U-sectioned portion **21** which has the fittings **5** hinged to the lugs **7** of the rotor blade (as previously described) and, on its underside, lugs **22, 22′** . . . comprising openings **23, 23′** . . . to allow for the passage of a spanwise cable which is used to anchor it to the rotor blade or its root fitting in order to resist the action of centrifugal force; the cable may be replaced by a torsion bar. The complementary edge part **25** of the structure **4** slides into the U-sectioned portion **21**, and one or more springs, for example a sinuous leaf spring **27** is inserted between the edge **25** and the portion **21** in order to urge the main flat part **26** of structure **4** toward the rear, thus tensing strip **2**. The edge of the part **26** of the structure **4** is pierced so that the structure may be anchored by spanwise cable to the rotor blade or its root in order to resist the action of centrifugal force. The adjacent sections of a flap assembly may be interconnected by articulated connecting links **29**.

I claim:

1. A controllably variable jet flap arrangement of the kind in which an aerofoil is provided with a jet slit at its trailing edge, comprising:

a rigid flap structure hinged to the aerofoil on a spanwise axis which is located aft of the slit

a flexible surface member attached at its leading edge in continuation of a wall of the jet slit and at its trailing edge to the trailing edge of the flap structure

operating means to swing the flap structure on its hinge up or down from a neutral position in which said surface member is in a plane parallel with the direction of the jet stream, such swinging causing said surface member to flex respectively concavely or convexly as viewed from the jet stream whereby the stream is deflected either up or down.

2. Arrangement according to claim **1** further including a trailing edge tab-like element freely hinged to said flap structure and inter-attaching said surface member and said flap structure.

3. Arrangement according to claim **1**, in which the said flap structure is profiled concavely on that side thereof to which lies the flexible member whereby to accommodate said member when it is correspondingly flexed.

4. Arrangement according to claim **1** in which, in its neutral position, said flexible member extends out of contact with said flap structure between its leading and trailing margins, further comprising:

a component movably supported by the rigid flap structure and adapted to be resiliently pressed against said flexible member in its neutral position to check flutter of said member.

5. Arrangement according to claim **1**, in which there is a plurality of sections, each comprising flap structure and flexible member, such sections being coaxially hinged in a spanwise axis.

6. Arrangement according to claim **1**, including hinge arrangements such as to accommodate differential thermal expansion as between the aerofoil and the hinged structure.

7. Arrangement according to claim **1**, combined with a helicopter rotor blade, further comprising:

operating means for the controlled swinging of the hinged structure and a balance mass susceptible to centrifugal force in rotation of the rotor and arranged to impose load on said operating means in opposition to reactive loads set up by the jet deflectors.

8. Arrangement according to claim **1**, in which the flexible member is a sheet of metal.

9. Arrangement according to claim **8**, in which said sheet of metal is attached to the aerofoil in rearward continuation of the lower wall of the jet slit.

10. Arrangement according to claim **1**, in which the flexible member is an assembly of inter-articulated elements.

11. Arrangement according to claim **1**, in which the flap structure comprises portions which interengage telescopically chordwise and are spring-urged towards telescopic-extension so that the flexible member is tensed resiliently.

12. A controllably variable jet flap arrangement according to claim **1** comprising a flexible surface member made of a thin sheet of metal attached to the inner surface of the lower wall of the jet slit in rearward continuation thereof, and a rigid flap structure made of a plate arranged below said flexible surface member, means for hinging said plate on a spanwise axis located aft of the jet slit and above the upper surface of the plate, whereas the operating means to swing the structure comprise at least one push-pull rod articulated to the plate on an axis located near its lower forward edge below said spanwise axis, said plate further having a trailing edge tab-like element freely hinged to the rear edge of said plate, the trailing edge of said flexible surface member being attached to said tab-like element in such a manner that the tab-like element takes up a position determined by the flexure of the said flexible member and tangential thereto.

13. A controllably variable jet flap arrangement according to claim **12** wherein the aerofoil is a helicopter rotating blade and wherein the articulated push-pull rods are arranged in a hollowed lower part of the aerofoil also containing crank levers arranged in a plane parallel to the plane of symmetry of the slit and pivoted on an axis normal to said plane, a control rod parallel to the trailing edge of the aerofoil and articulated to one end of each of said crank levers, and a balance mass attached to the other end of said levers to compensate the reaction forces transmitted to the operating mechanism by the hinged flap arrangement due to the action of the jet on said flap.

14. A controllably variable jet flap arrangement according to claim **1** comprising a flexible surface member made of a thin sheet of metal attached to the inner surface of the lower wall of the jet slit in rearward continuation thereof, and a rigid flap structure made of a plate arranged below said flexible surface member and having an upper concave surface to accommodate said member when flexed upwardly, brackets arranged on the rear edge of the aerofoil and projecting rearwardly therefrom, said brackets provided with ball and socket type articulations for hingedly connecting the forward edge of the rigid plate with said brackets, said articulations being offset upwardly with respect to the said upper surface of the plate and located approximately in the plane of the Inner surface of the lower wall of the slit, the

operating means comprising push-pull rods located in a hollowed lower part of the aerofoil and articulated to the plate on an axis located near its lower forward edge, said plate having a trailing edge tab-like element freely hinged to the rear edge of said plate, the rear edge of the flexible metal sheet surface member being folded around the rear edge of said tab-like member and attached to the upper and lower surface thereof whereby the tab-like element takes up a position determined by the flexure of the flexible member and tangential thereto.

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244—17.25