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(54) Ornithopter

(57) The ornithopter has at least one wing 2 pivotally interconnected with a support 3, said wing being articulated and adapted to be adjustable by an operator so as to achieve a first attitude (Figs 2, 4) wherein the wing's leading edge is substantially linear in a first view and substantially bowed in a second view and so as to achieve a second attitude (Figs 3, 5) of a narrower wing span wherein the leading edge is substantially Z-shaped in both first and second views. The wing is multi-sectional, having an elbow "A" and wrist "B" joint being hinged to form a compound cantilever.

The narrowing of the wing span on flexion is accommodated by the articulation of the wing wherein the elbow joint of the wing slides backwards and the wrist joint moves forward relative to the support of the device and, on wing extension the moves are reversed.

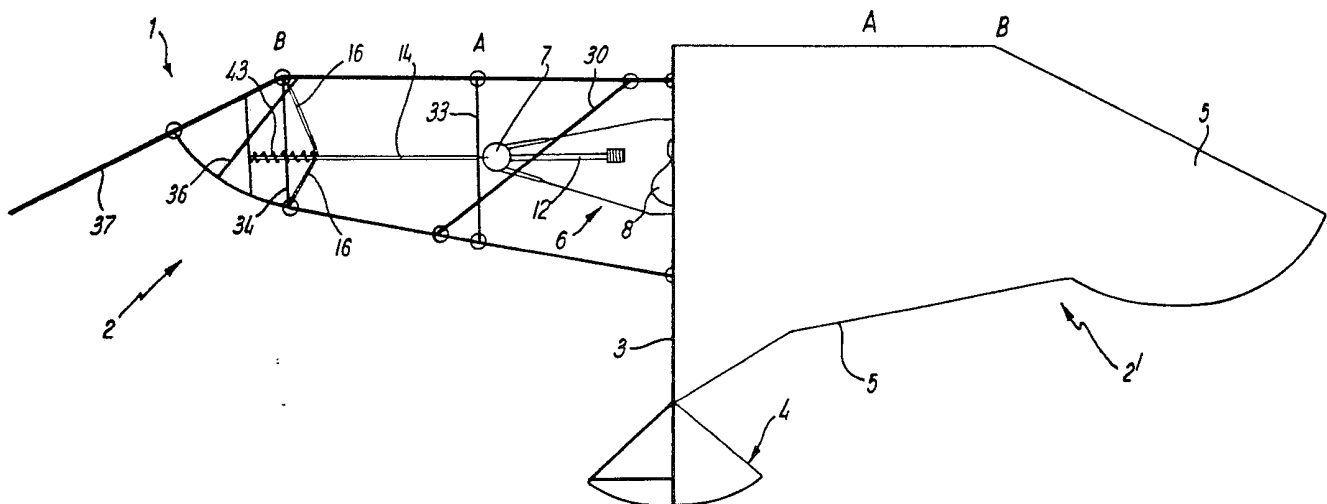


Fig 2

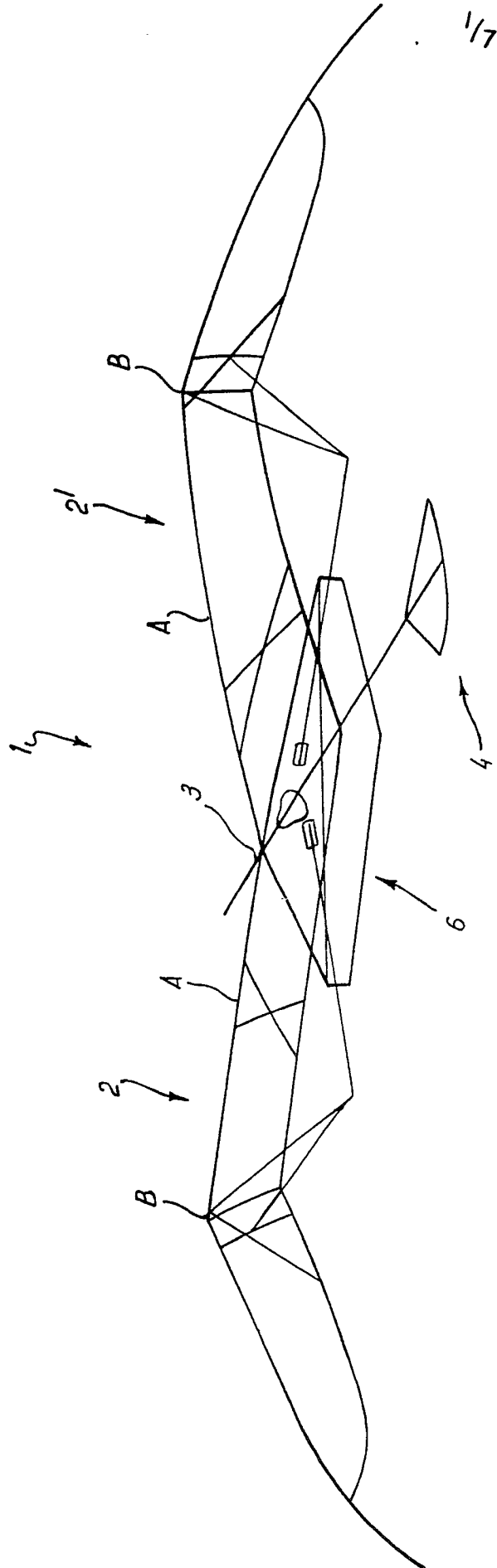
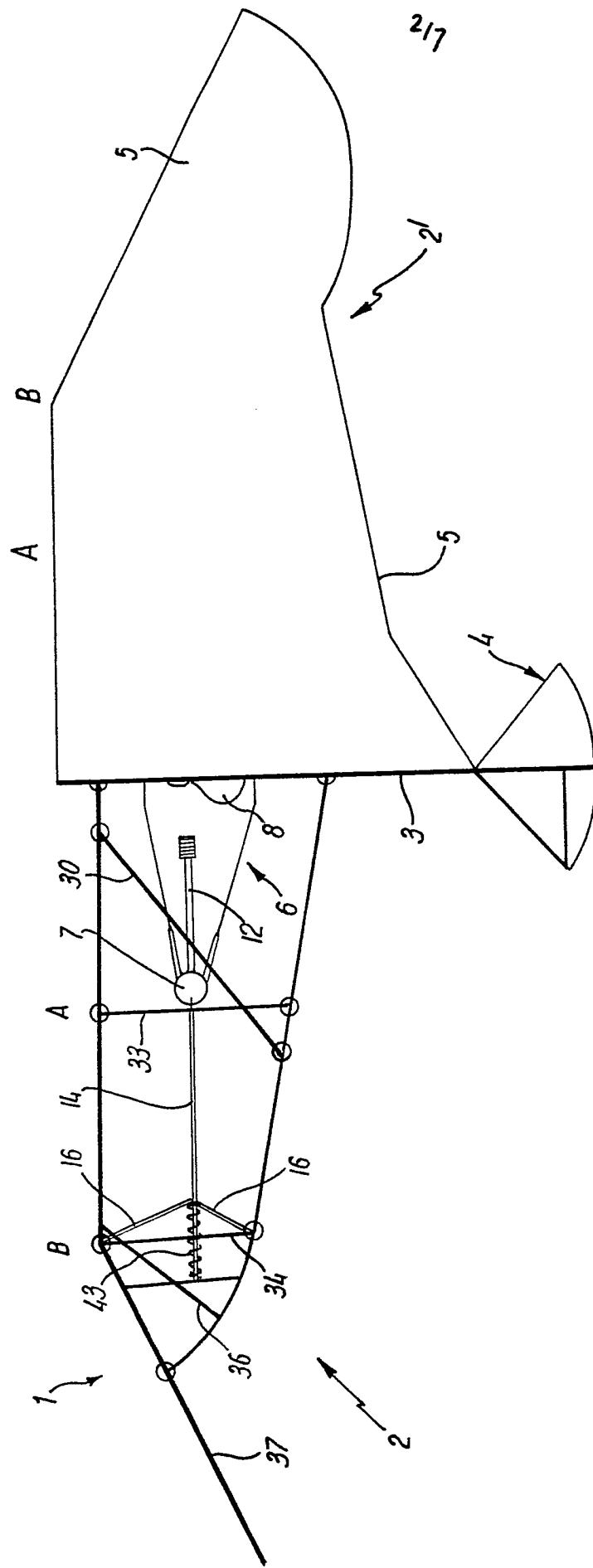
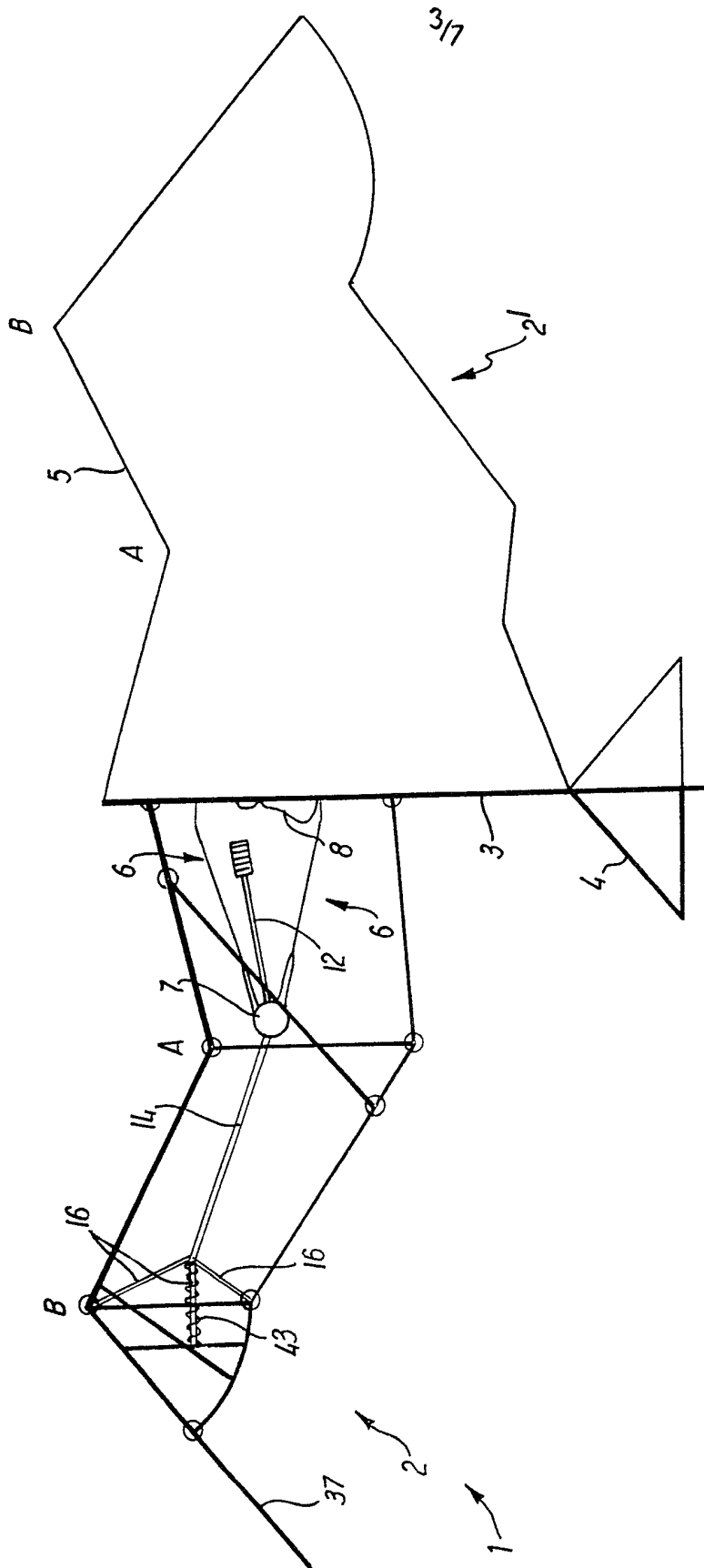
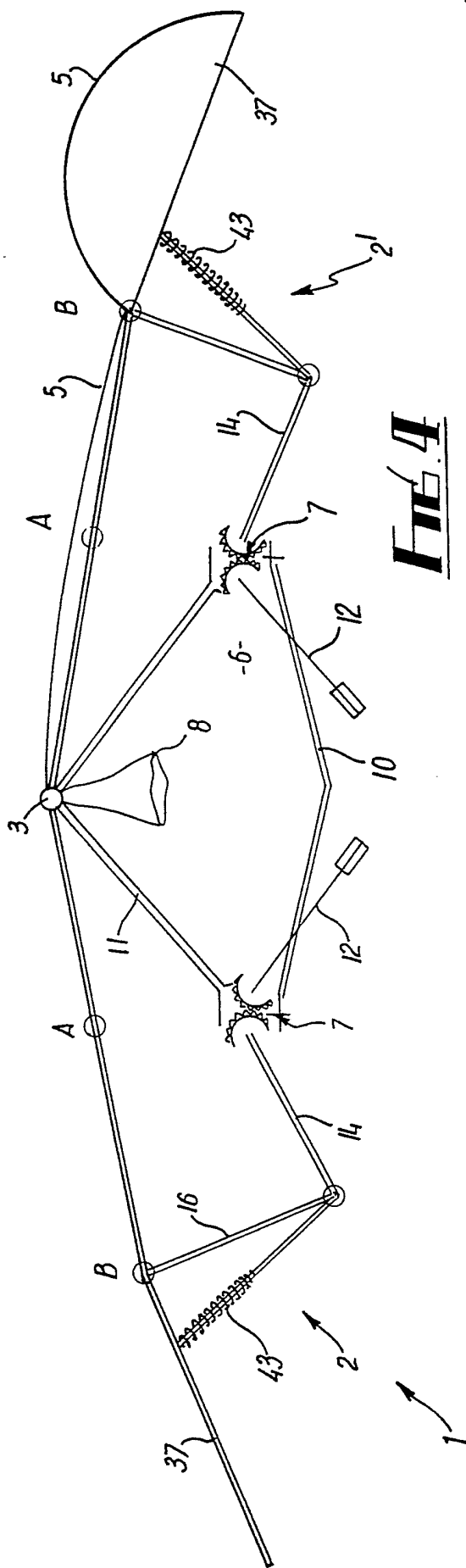


Fig 1

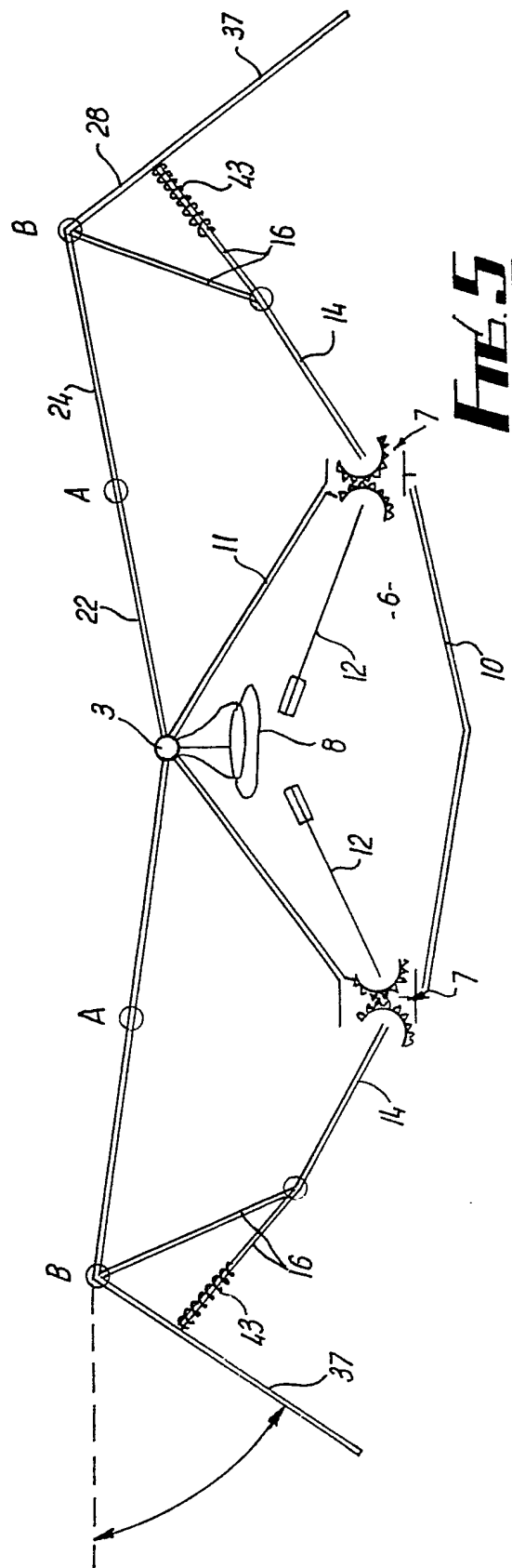


FILE 2

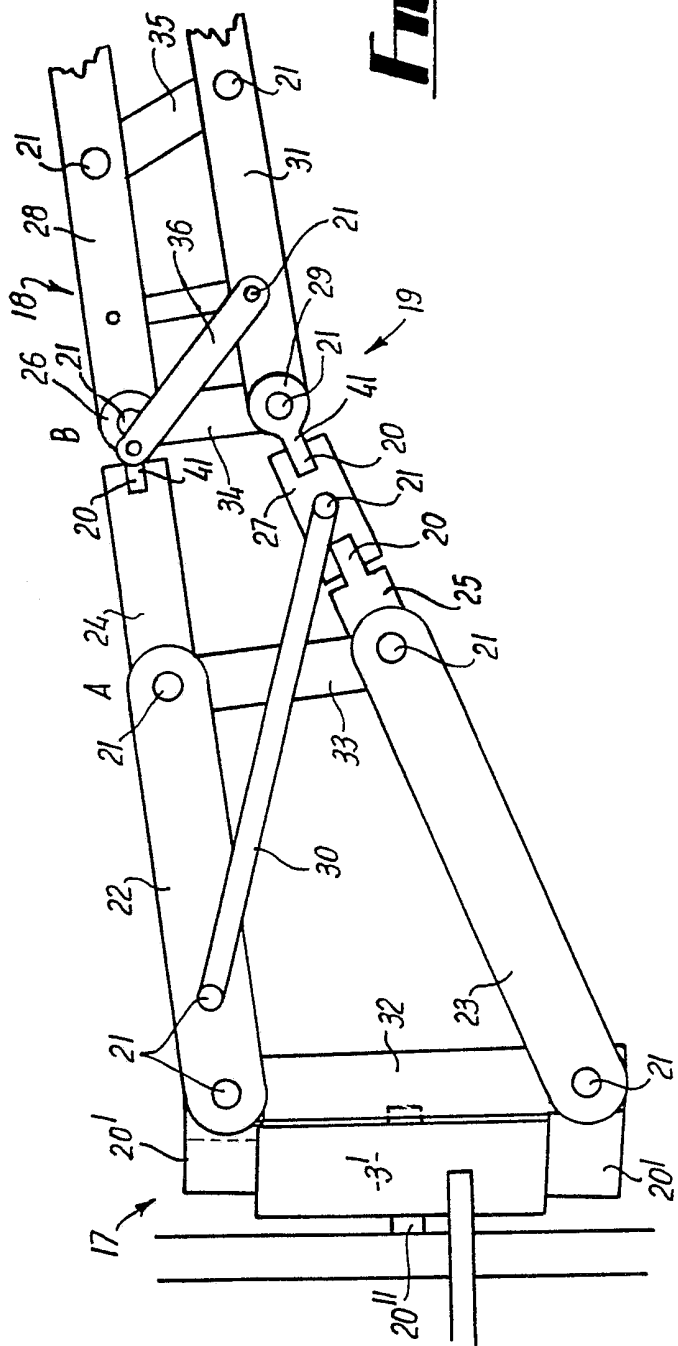




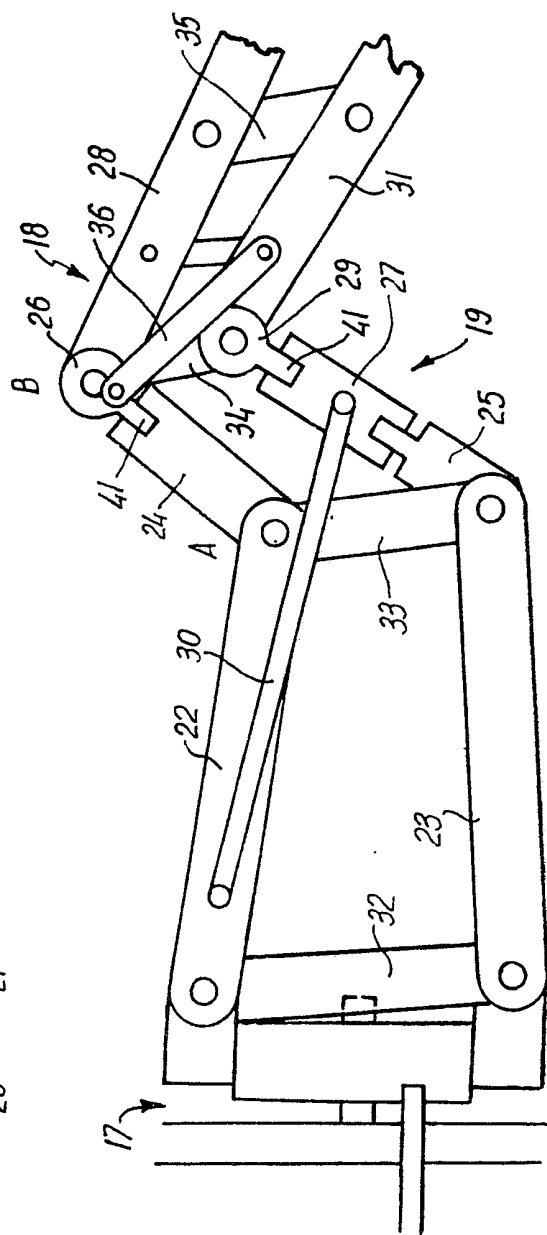
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FILE 5



File 6



FILE

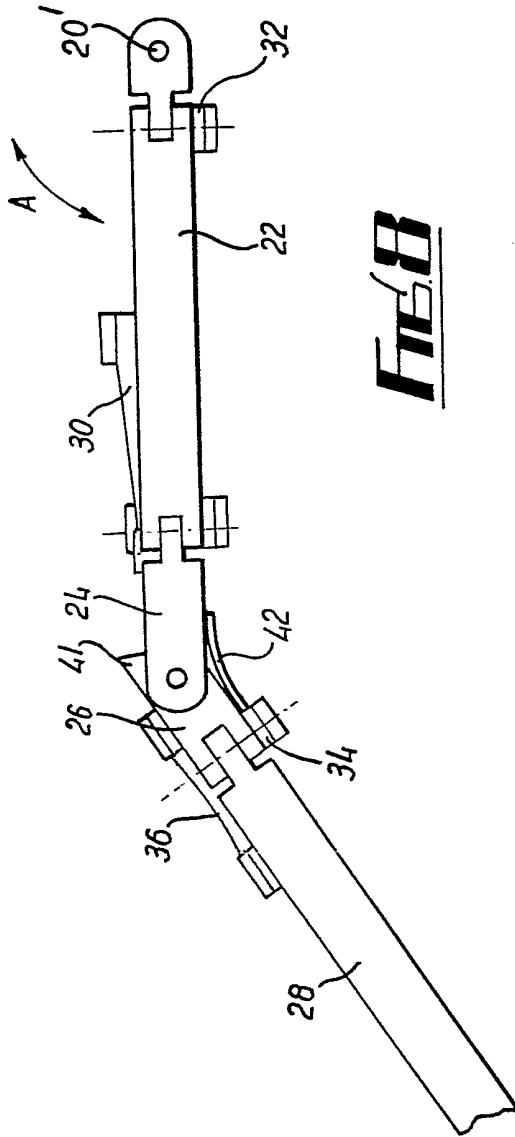


Fig. 8

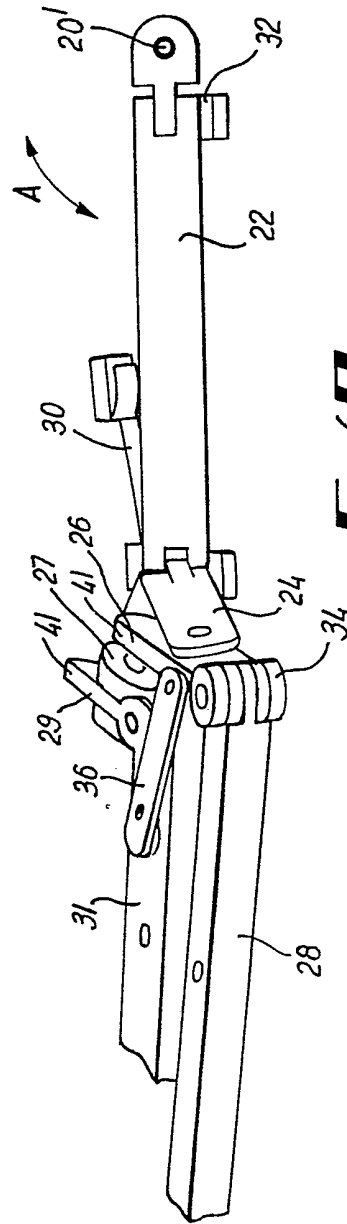
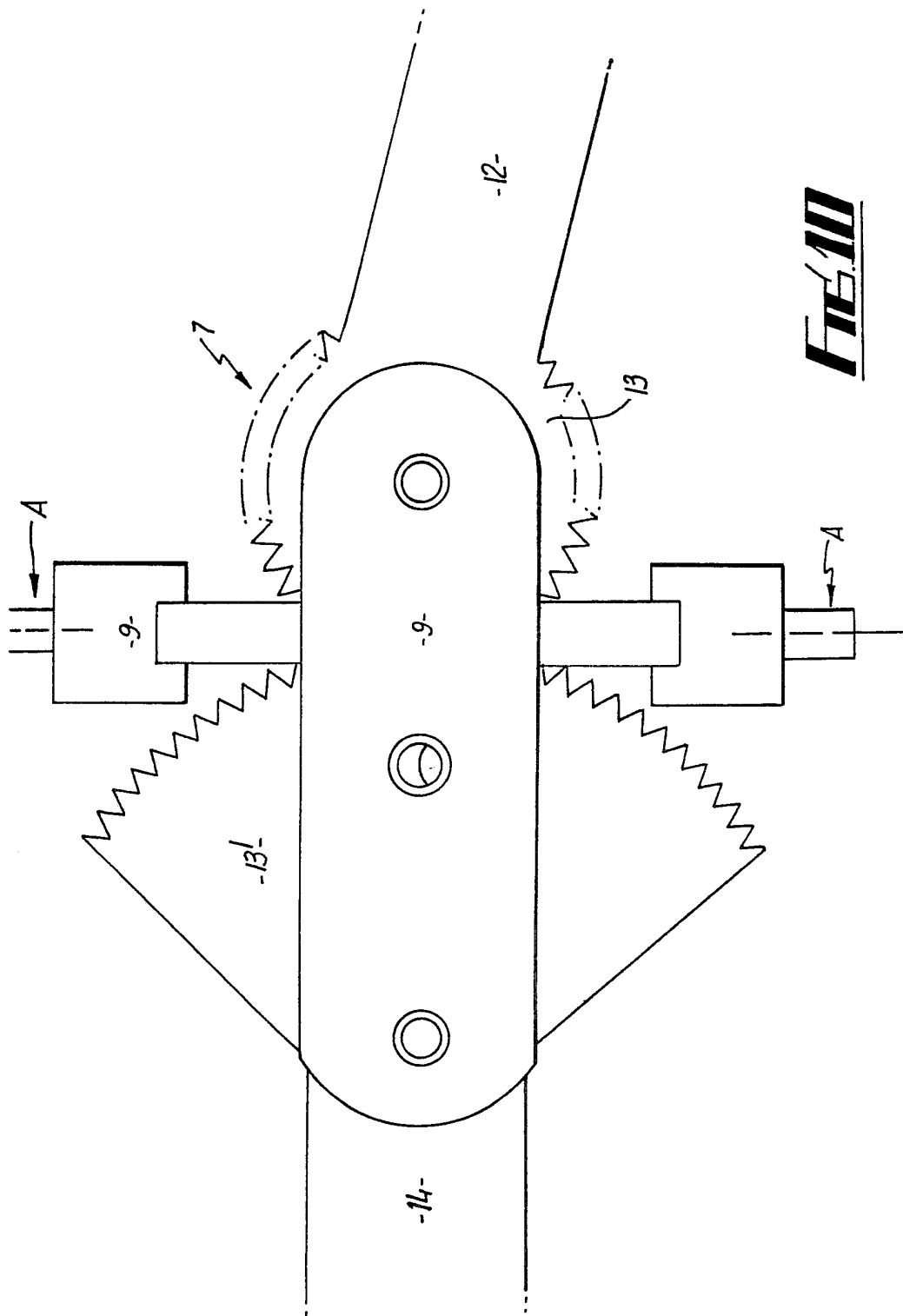


Fig. 9

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Device for Use in Flying

This invention relates to a device for use in flying, particularly the type of device commonly known as an ornithopter which is a machine designed to "fly" by means of powered wings acting like those of a bird.

There have been many flying devices in which the wings are designed to imitate or simulate the action of a bird's wing, but such devices have not proved successful as they have been unable to achieve a wing structure that can flex and extend, beat, pitch and/or pivot so as to provide the various wing attitudes required for soaring, beating and gliding flight.

According to the present invention there is provided a device for use in flying having at least one wing pivotally interconnected with a support, said wing being articulated and adapted to be adjustable by an operator so as to achieve a first attitude wherein the wing's leading edge is substantially linear in a first view and substantially bowed in a second view and so as to achieve a second attitude of a narrower wing span wherein the leading edge is substantially Z-shaped in first and second views.

The wing is pivotally interconnected with the support, the pivotal interconnection being so arranged to allow beating and rotation of the wing; with the pivotal interconnection comprising a horizontal pivotal pin with cam means to prevent an over-extended upstroke and a rotational pivotal pin with cam means to prevent excessive backward or forward rotation.

Preferably, said wing is multi-sectional having wrist and elbow joint and being hinged to form a compound cantilever structure, wherein the free end of one cantilever arm supports a second cantilever arm.

Preferably, the narrowing of the wing span on flexion is accommodated by the articulation of the wing wherein the elbow joint of the wing slides backwards and the wrist joint moves forward relative to the support of the device and on wing extension, the moves are reversed.

Preferably, the compound cantilever structure is supported by one or more supporting means chosen from biasing means in the form of a flat spring biasing the wing upwardly and bracket means in the form of a subwing assembly.

Preferably, an extension of said sub-wing assembly extends to the wrist joint.

Preferably, an extension of said sub-wing assembly extends to a wing tip, each wing including a wing tip having a finger member extending freely and distally.

Preferably, said extension of the sub-wing assembly to the wing tip is provided with a biasing means, biasing the wing tip to a horizontal position; the biasing means may be in the form of a coiled spring acting as a shock absorber

returning the wing tip to the near-horizontal on stroke reversal.

Preferably, said wing comprises a leading edge and a trailing edge, each edge comprising a number of pivotally interconnected edge members, the wing being held in cantilever fashion by stops in the pivots between edge members.

The edges of said wing are interconnected one to another by pivotally attached cross-members, which are either substantially at right angles and or obliquely attached to the edge members.

On the trailing edge, one edge member is linked to adjacent edge members by horizontal pivotal pins, and on the leading edge, at least one joint between edge members has a horizontal pivotal pin. Most preferably, at least one horizontal pivotal pin of the trailing edge and one horizontal pivotal pin of the leading edge are provided with the aforementioned stops.

The device may have an undercarriage including a harness for the operator and supporting the sub-wing assembly, which brackets the wing structure and with which the operator controls wing movement.

The support may comprise the undercarriage and a central body member, from which the undercarriage is suspended and which terminates rearwardly in a tail portion.

Preferably, a manipulative joint to control wing articulation includes a gear system having a first gear section interconnected with a second gear section, said gear sections being held in an interconnecting attitude by a

pivotally held bracket.

Preferably, said gear sections are lockable in position such that gear movement is not possible.

Preferably, said sections are each extended into a lever, the second gear section of which may be provided with a hand grip, the first and second interconnections of the subwing assembly attaching to the lever-like extension of the first gear section, such that dorso-ventral movement on the hand grip on the lever-like extension of the second gear section results in wing beat and pivotal movement of the bracket by back and forth movement on the lever-like extension of the second gear section results in wing flexion and extension.

The frame of each wing may be of tubular aluminium or plastics including light alloy, fibre glass, carbon fibre, or any suitable light-weight tubular material of circular or square cross-sectional form. The wings and tail portion are preferably covered by a flexible skin.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

- Fig. 1 is a perspective view of a flying device according to the present invention;
- Fig. 2 is a top plan view of the device of Fig. 1, part-covered and in a first attitude;
- Fig. 3 is a top plan view of the device of Fig. 1, part-covered and in a second attitude;
- Fig. 4 is a front view of the device of Fig. 1, part-covered and in the first attitude;
- Fig. 5 is a front view of the device of Fig. 1, uncovered and in the second attitude;

Fig. 6 is a top plan view of a part of a wing of the device of Fig. 1, uncovered and in a first attitude; Fig. 7 is a top plan view of part of a wing of the device of Fig. 1, uncovered and in a second attitude; Fig. 8 is a front view of corresponding to the view of Fig. 6; Fig. 9 is a front view corresponding to the view of Fig. 7; and, Fig. 10 is the gear system of the manipulative joint according to the present invention.

Referring to the drawings, there is provided a flying device 1 which is manually powered and has a pair of articulate, operator-controlled wings 2,2', adapted so that the device 1 may operate as an ornithopter.

The device 1 comprises an undercarriage 6, a backbone 3, a pair of wings 2,2' and a tail portion 4, all but the undercarriage 6 being covered in a skin 5. The wings 2,2' and tail portion 4 are pivotally attached to the backbone 3 whilst the undercarriage 6 is suspended beneath the point of attachment of the wings 2,2'.

The undercarriage 6 includes a harness 8 for an operator and a pair of upper and a pair of lower tubular alloy rods, 11 and 10 respectively. The rods are arranged in diamond-like form when viewed from the front (see Figs 4 and 5), said upper pair of rods 11 being attached to the backbone 3 near the junction of the wings 2, 2' and the undercarriage 6. The pairs of rods 10, 11 pivotally interconnect with lateral control assemblies each of which have a hand lever 12 that acts through a manipulative gear joint 7 on a subwing assembly. The subwing assembly includes a reciprocal lever 14 which hingedly affixes to three upwardly directed extensions 16 that are attached distally to the wings 2,2'.

Referring especially now to Figs 6 to 9 of the drawings, the frame of each wing 2,2', indicated generally at 17, comprises a leading edge 18 and a trailing edge 19, each of which is formed from a number of edge members connected together by horizontal or vertical pivots, 20 and 21 respectively, the leading edge having four such members 22,24,26,28 and the trailing edge having five 23,25,27,29,31. Joints 20/22, 22/24, 26/28, 20/23, 23/25 and 29/31 are vertically, pivoted, whereas joints 24/26, 25/27, and 27/29 are horizontally pivotted.

Cross-members 30,32-36 interconnect the leading and trailing edges 18,19 forming a three part limb having an elbow joint A and a wrist joint B.

Horizontal pivots 20' connect each wing 2,2' to a side unit 3' of the backbone 3, such pivots allowing the wing 2,2' to move dorso-ventrally. The unit 3' itself is pivotally attached to the backbone at pivot 20" to allow rotation of the limb. Distally, a wing 2,2' includes a single backwardly directed wing tip finger member 37 extending freely from leading edge member 28.

The wings 2,2" are multi-sectional and each forms a compound cantilever structure held by stops 41 in pivots 24/26 and 27/29. The compound cantilever structure removes the need for a king-post from which to suspend the wings 2,2', any king-post or through-fuselage beam also restricting the extent of articulation. The compound cantilever structure is additionally supported by bracket means, in the form of the lever 14 of the subwing assembly and biasing means in the form of a flat spring 42 at the joint between two cantilevers and/or coiled spring 43 connected to the subwing assembly to bias and support each wing 2,2'.

The extended wing attitude, shown in Figs 1, 2 and 4 forms the gliding or soaring attitude. In this first attitude, the leading edge 18 is substantially linear in plan view (Figs 2 and 6) and bowed in front view (Figs 4 and 8) with the wing tip trailing downwardly. The bowing is also largely due to stops 4' in two pivots 24/26 and 27/29, one on the leading edge 18 and one on the trailing edge 19.

In order to imitate bird flight, each wing 2,2' is flexed towards the backbone 3; the foreshortening of the wing is accommodated by the backward movement of the elbow joint A at cross-member 33 and forwards movement of the wrist B at cross member 34 relative to the nose of the device 1 (Figs 3 and 5). The greater the foreshortening, the greater the thrust when beating. In this attitude, the leading edge 18 of each wing 2,2' is substantially Z-shaped in plan view (Figs 3 and 7) and substantially Z-shaped in front view (Figs 5 and 9).

The Z-shaped front view is as a result of the wing 2,2' twisting on flexing such that from the wrist joint B to the wing tip is pitched, the wings tip being pointed downwardly and rearwardly. This wing twist is achieved by a trailing edge member 27 being horizontally pivoted at both ends, one of these joints 27/29 being one of those provided with a stop 41 to restrict the flattening of the frame 17. Hence, flexing of the wing 2,2' creates a wing tip pitch such that there is a perpetual cutting edge with, distally, the trailing edge 19 of the wing 2,2 remaining higher than the leading edge 18. The entire wing 2,2" can be additionally pitched either forward or backward by rotation at pivot 20" with cams 45 provided to prevent excessive rotation.

Propulsion is obtained as the wings 2,2' are beaten rapidly whilst in the flexed attitude of Figs 3, 5, 7 and 9; the

down-stroke is the thrusting motion and the up-stroke the recovery stroke. To beat, the wings 2,2' are pivotted around pivots 20', in order to prevent excessive upwards movement of the wing 2,2', a pivot stop 44 projects laterally from side units 3'. In order that the wing tip does not drag on the recovery stroke, spring 42 and/or spring 43 act as shock absorbers; spring 42 and/or 43 are compressed on the continued downwards movement of the wing tip at the point of stroke reversal from the thrust stroke to the recovery stroke and release of the compressed springs 42, 43 biases the wing tip back to the near-flat, restoring the compound cantilever structure.

The control of the wings 2,2' is through the control assemblies and subwing assemblies; an operator moves hand levers 12 dorso-ventrally to beat the wings 2, 2' and backwards and forwards to flex and extend them and to allow the pitch of the wing 2,2' to be controlled through pivots 20".

Referring now to Fig. 10 the control assemblies of the undercarriage 6 each contain a manipulative gear joint 7, alternatively termed a horizontal, pivotal and vertical joint (HPV joint), comprising a gear section 13 to hand lever 12 interconnected with a gear section 13' to the reciprocal lever 14, both gear sections 13,13' being held in the interconnecting attitude by a bracket 9 which pivotally interconnects at A with the pairs of alloy rods 10,11 of the undercarriage 6. The gear sections 13,13' are lockable in one position such that only pivotal movement of the bracket 9 is possible by movement of hand lever 12. This locking is particularly useful for training flights to allow the centre of gravity to be found and so that the device may be used as in a glider-like fashion if so required.

The hand levers 12 are placed such that an operator in the harness 8 reaches downwardly for them. In this position the forward and backward movement necessary for flexion and extension of the wing 2,2' can be restricted and an additional joint may be added to the control assembly, the additional joint (not shown) being in the form of a ratchet released by a button on each hand lever 12.

The tail portion 4 is pivotally attached to the backbone 3' in a similar manner to that of each wing 2,2'. The tail 4 adds stability and control. A control mechanism (not shown) pivots the tail 4 about the axis of the backbone 3 and dorso-ventrally, particularly to aid steering, and a locking mechanism (not shown) locks the tail 4 in a position by means of a spring means and co-operating slot.

Modifications and improvements may be incorporated without departing from the scope of the invention.

CLAIMS

1. A device for use in flying having at least one wing pivotally interconnected with a support, said wing being articulated and adapted to be adjustable by an operator so as to achieve a first attitude wherein the wing's leading edge is substantially linear in a first view and substantially bowed in a second view and so as to achieve a second attitude of a narrower wing span wherein the leading edge is substantially Z-shaped in first and second views.
2. A device according to Claim 1, wherein the wing is pivotally interconnected with the support, the pivotal interconnection being so arranged to allow beating and rotation of the limb with the pivotal interconnection comprising a horizontal pivotal pin with cam means to prevent an over-extended upstroke and a rotational pivotal pin with cam means to prevent excessive backward or forward rotation.
3. A device according to either Claim 1 or 2, wherein said wing is multi-sectional having a wrist and an elbow joint and being hinged to form a compound cantilever structure.
4. A device according to Claim 3, wherein the narrowing of the wing span on flexion is accommodated by the articulation of the wing wherein the elbow joint of the wing slides backwards and the wrist joint moves forward relative to the support of the device and on wing extension, the moves are reversed.
5. A device according to either Claim 3 or 4 wherein the compound cantilever structure is supported by one or

more supporting means chosen from biasing means in the form of a flat spring biasing the wing upwardly and bracket means in the form of a subwing assembly.

6. A device according to Claim 5, wherein an extension of said sub-wing assembly extends to the wrist joint.
7. A device according to Claim 5 or 6, wherein an extension of said sub-wing assembly extends to a wing tip of said wing.
8. A device according to Claim 7, wherein the extension to the wing tip is provided with a biasing means, biasing the wing tip to a horizontal position.
9. A device according to any one of Claims 3 to 8, wherein said wing comprises a leading edge and a trailing edge, each edge comprising a number of pivotally interconnected edge members, the wing being held in cantilever fashion by stops in the pivots between edge members.
10. A device according to Claim 9, wherein the edges of said wing are interconnected by pivotally attached cross-members.
11. A device according to Claim 9 or 10, wherein on the trailing edge, one edge member is linked to adjacent edge members by horizontal pivotal pins and on the leading edge at least one joint between edge members has a horizontal pivotal pin.
12. A device according to Claim 11, wherein at least one horizontal pivotal pin of the trailing edge and one horizontal pivotal pin of the leading edge are

provided with said stops.

13. A device according to any one of the preceding Claims, wherein a manipulative joint to control wing articulation includes a gear system having a first gear section interconnected with a second gear section, said gear sections being held in an interconnecting attitude by a pivotally held bracket.
14. A device accordingly to Claim 13, wherein said gear sections are lockable in position.
15. A device according to any one of Claims 6 to 8 and either Claim 13 or 14, wherein the extensions of the subwing assembly attach to a lever-like extension of the first gear section, such that dorso-ventral movement on a lever-like extension of the second gear section results in wing beat and pivotal movement of the bracket by back and forth movement on the lever-like extension of the second gear section results in wing flexion and extension.
16. A device for use in flying substantially as hereinbefore described with reference to the accompanying drawings.