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CN 201678040 U **JP 100100998 A**
US 20110049295 A1 **US 20070215750 A1**
KR 1020110011923 A

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INT CL **B64C**
Other: **WPI, EPODOC, TXTUS0, TXTUS1, TXTUS2, TXTUS3, TXTUS4, TXTEP1, TXTGB1, TXTWO1**

(54) Title of the Invention: **Apparatus for methods relating to an unmanned aerial vehicle**
Abstract Title: **A dual-function landing gear and rotor protector for a UAV**

(57) An unmanned aerial vehicle (UAV) includes at least one rotor 6 driven by a motor 4 that is mounted to a housing 12. A dual-function member is connected to the housing and comprises an arm 8 and a beam 10. The dual-function member is movable between a first position where it acts as a landing gear and a second position where it acts as a rotor protector. A control means is arranged to control movement of the member. The control means may include a processor (40, fig 5) and a sensor (44, fig 5) for determining height from ground. The processor may determine to move the member to one or other of the positions based on the height of the UAV. Reconfiguration of the landing gear as a rotor protector prevents the view of a camera carried by the UAV from being obscured and allows a strong and light rotor protector without significant added weight. A rotor protector or landing gear may include a dampening means to absorb forces of impact.

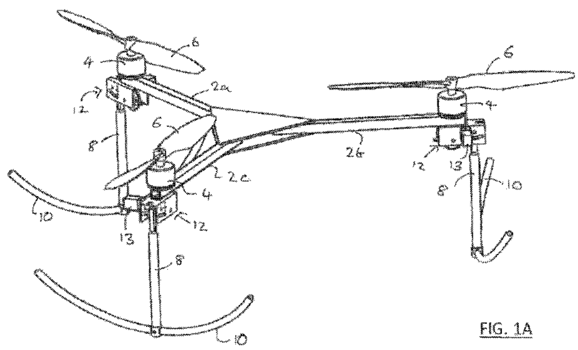


FIG. 1A

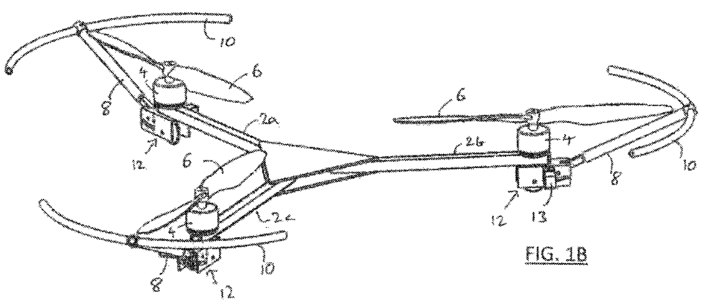


FIG. 1B

GB 2483881 A

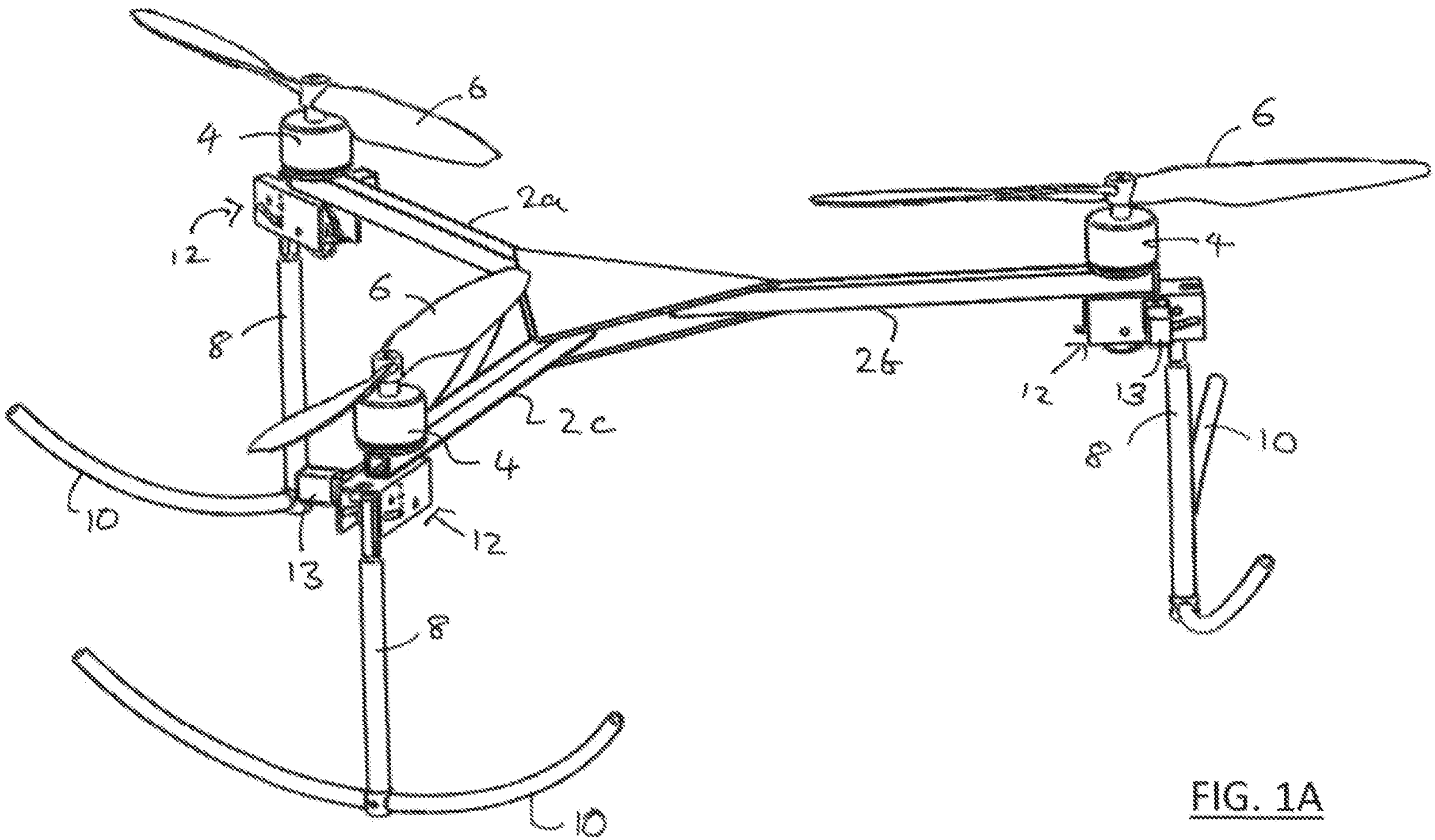


FIG. 1A

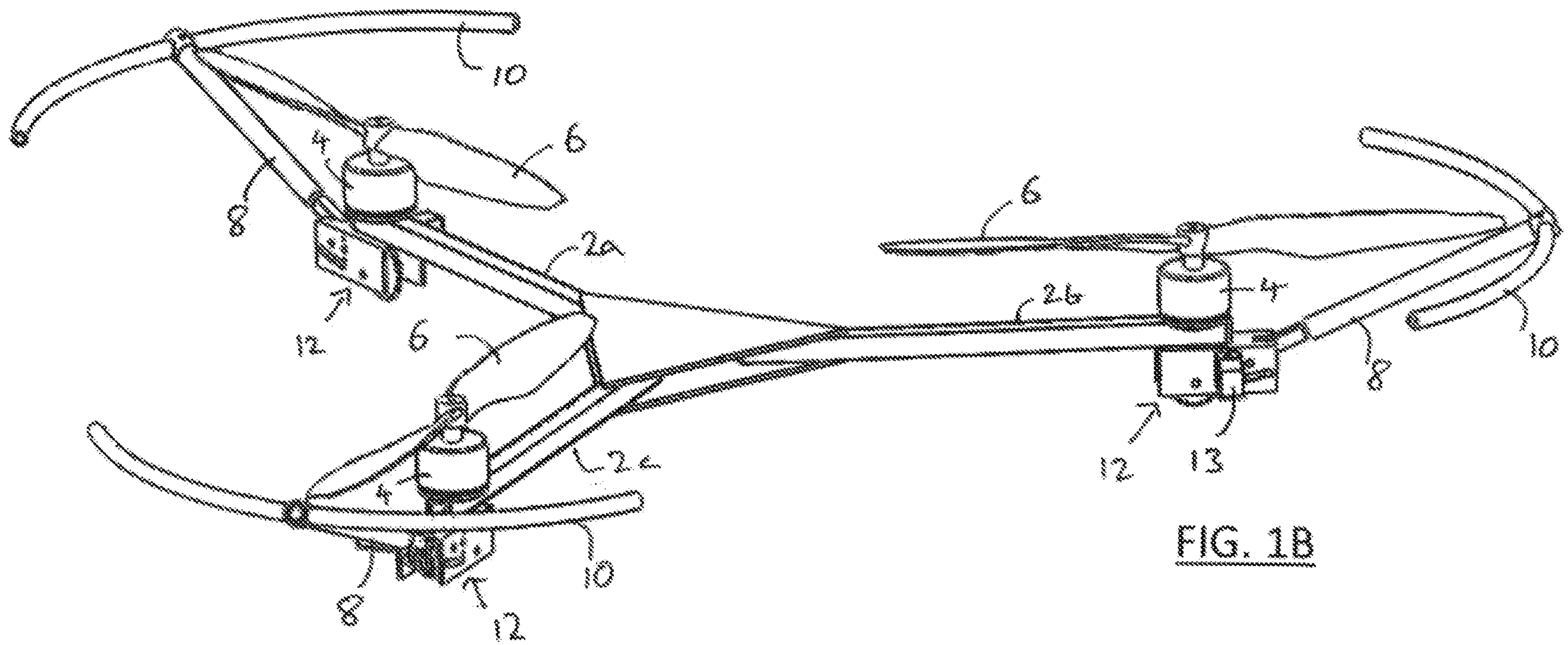


FIG. 1B

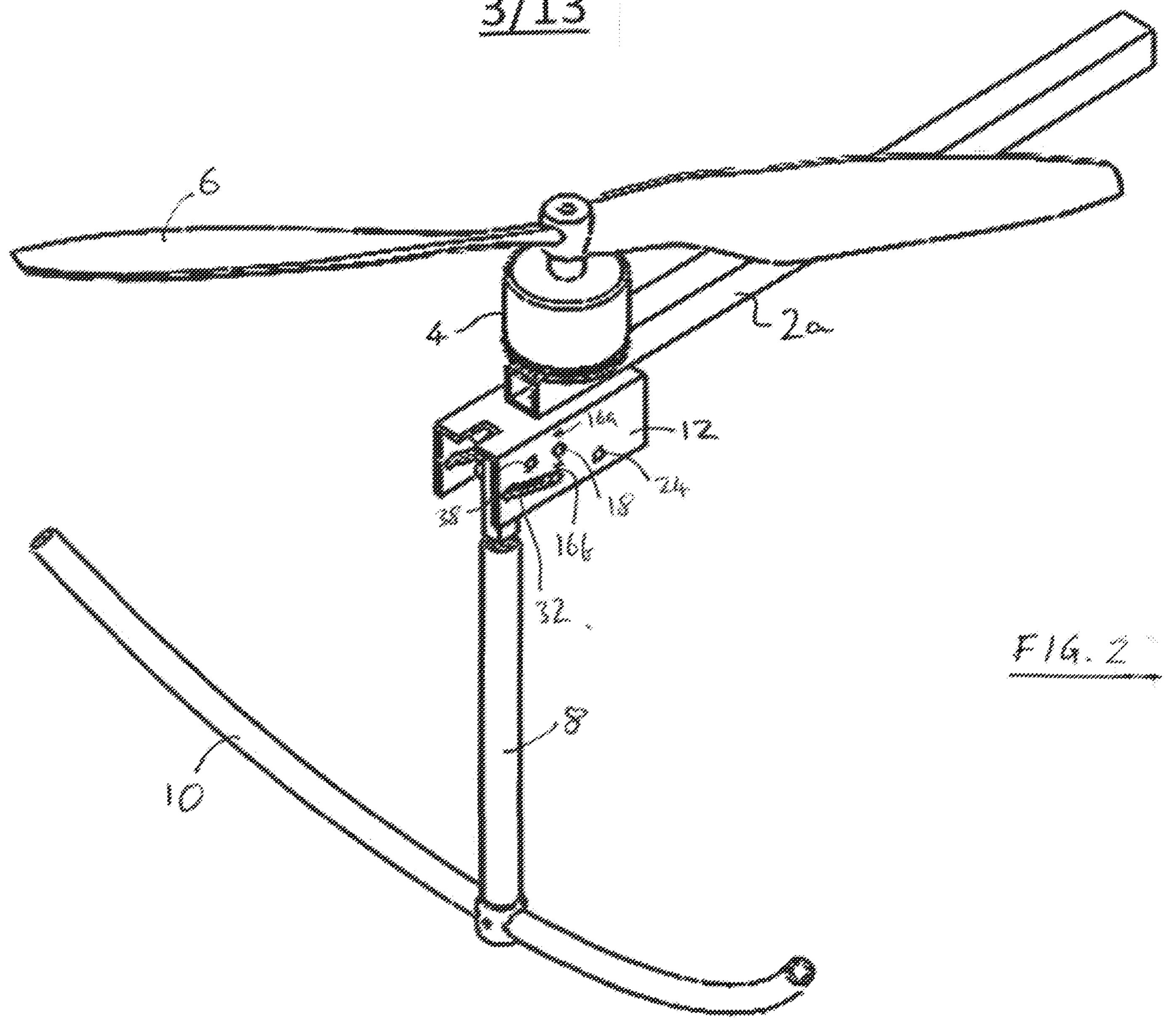


FIG. 2

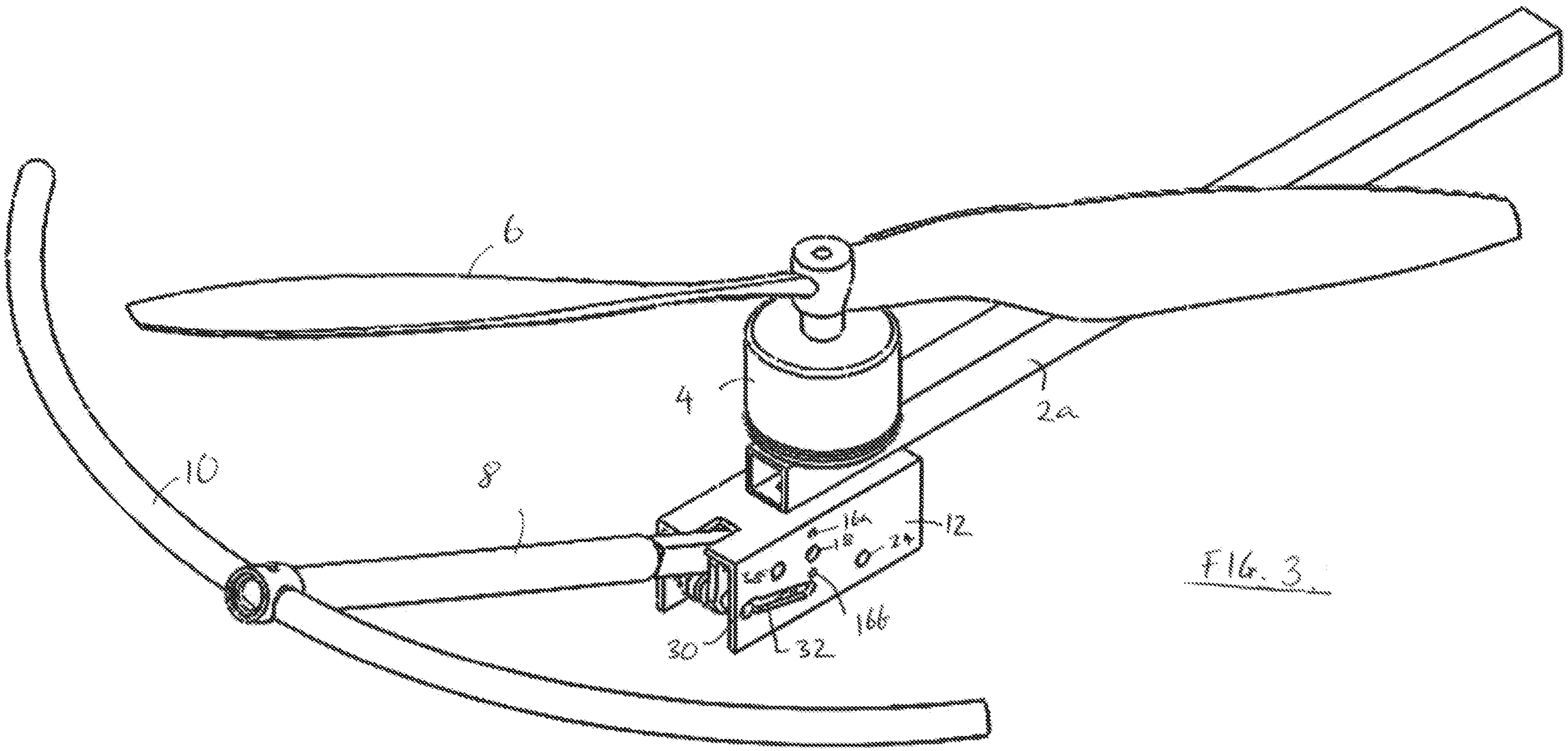


FIG. 3.

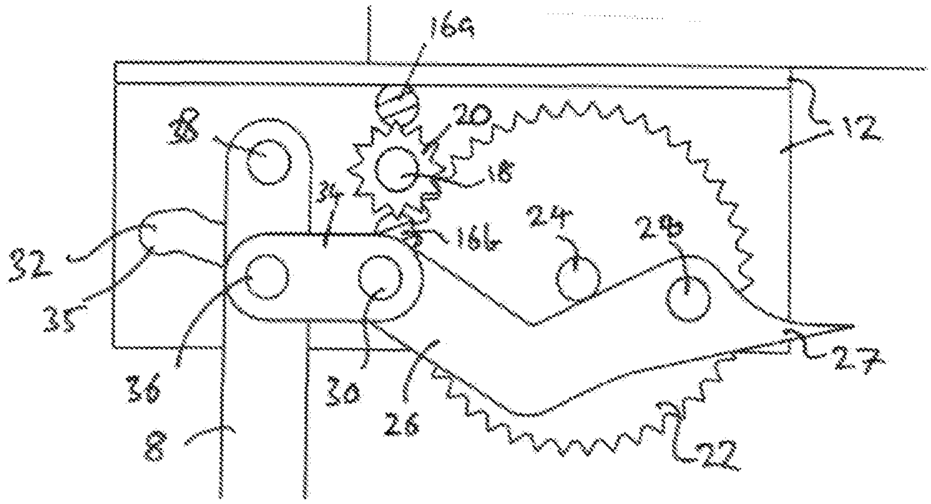


FIG. 4C

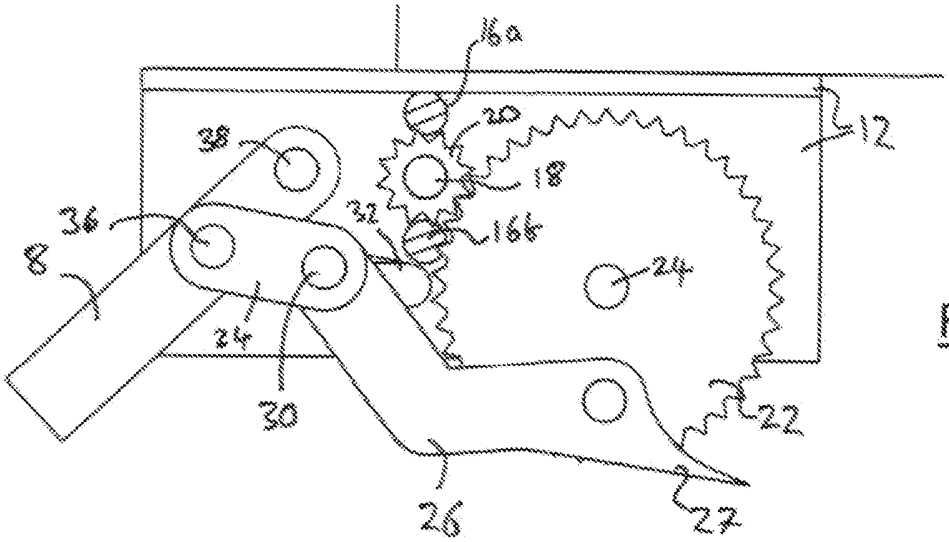


FIG. 4B

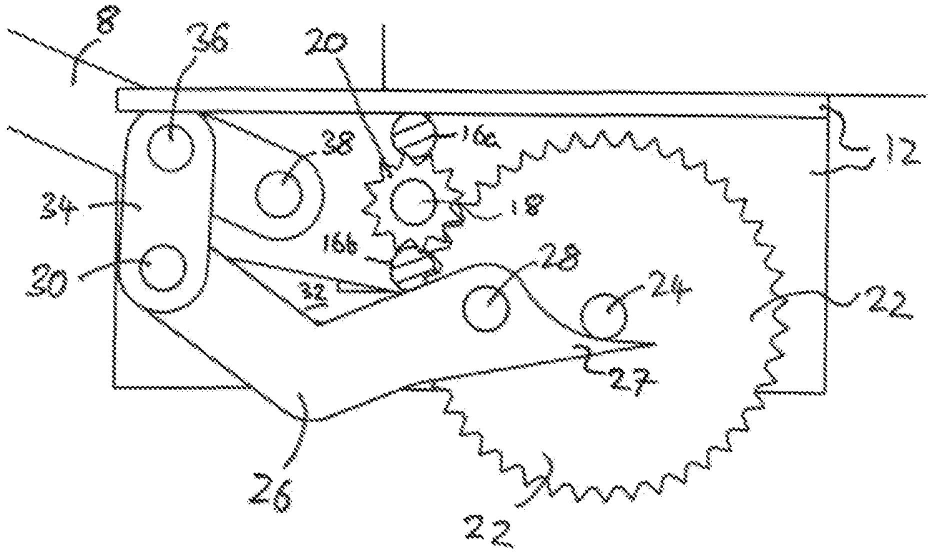


FIG. 4A

FIG. 5

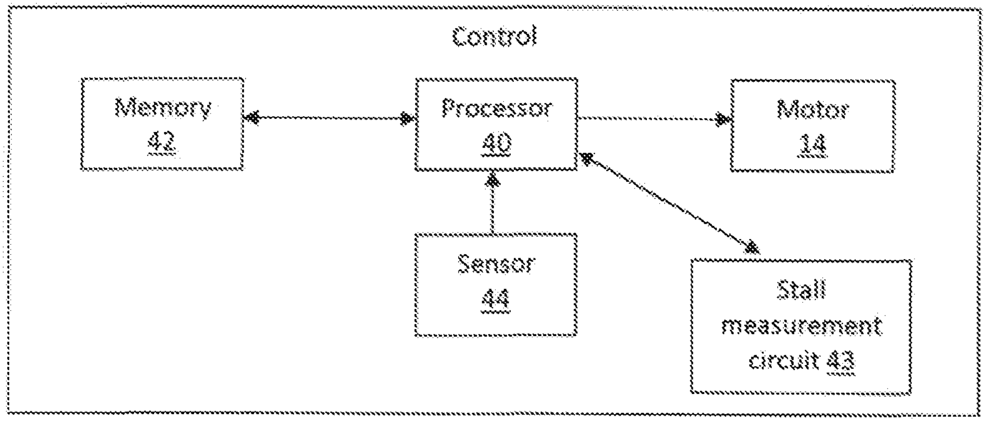

Control
Memory
42
Processor
40
Motor
14
Sensor
44
Stall
measurement
circuit 43

FIG. 6

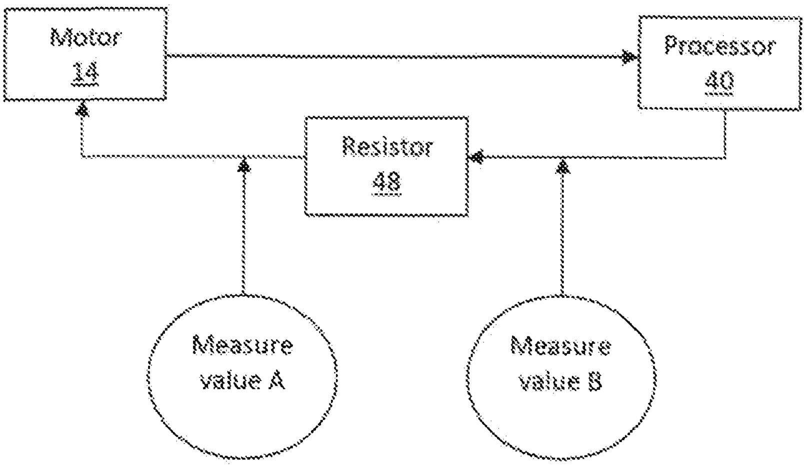
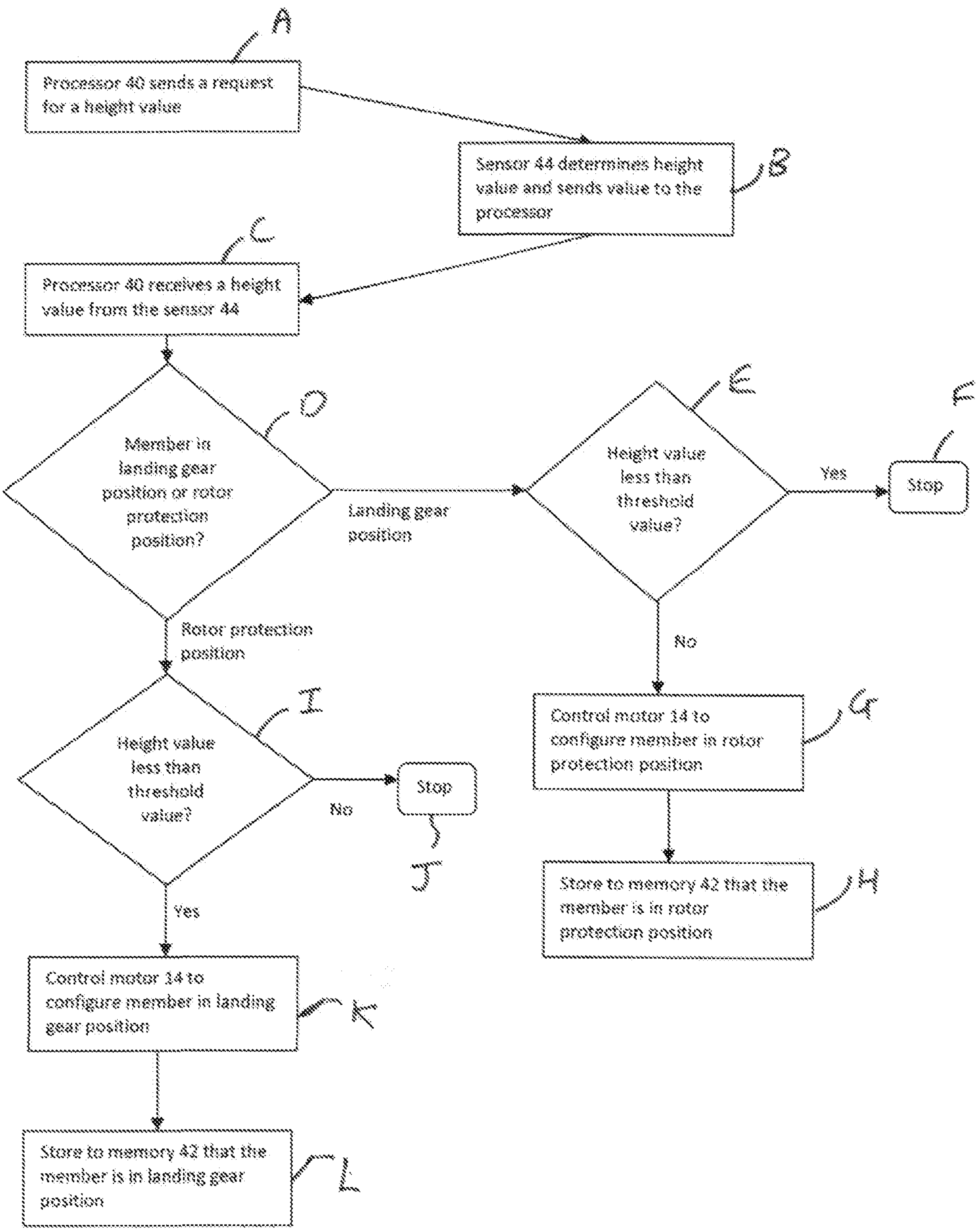

Motor
14
Processor
40
Resistor
48
Measure
value A
Measure
value B

FIG. 7


A
Processor 40 sends a request for a height value
Sensor 44 determines height value and sends value to the processor
B
C
Processor 40 receives a height value from the sensor 44
D
Member in landing gear position or rotor protection position?
Landing gear position
E
Height value less than threshold value?
Yes
Stop
F
No
Control motor 14 to configure member in rotor protection position
G
Store to memory 42 that the member is in rotor protection position
H
Rotor protection position
I
Height value less than threshold value?
No
Stop
J
Yes
Control motor 14 to configure member in landing gear position
K
Store to memory 42 that the member is in landing gear position
L

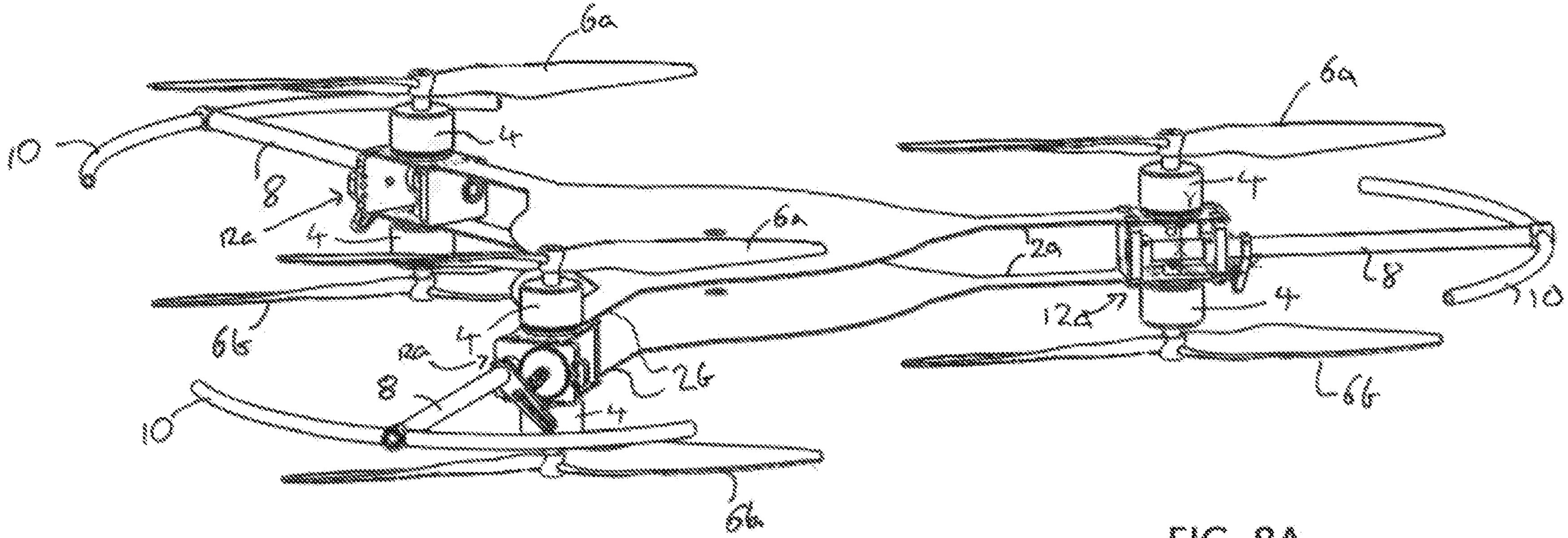


FIG. 8A

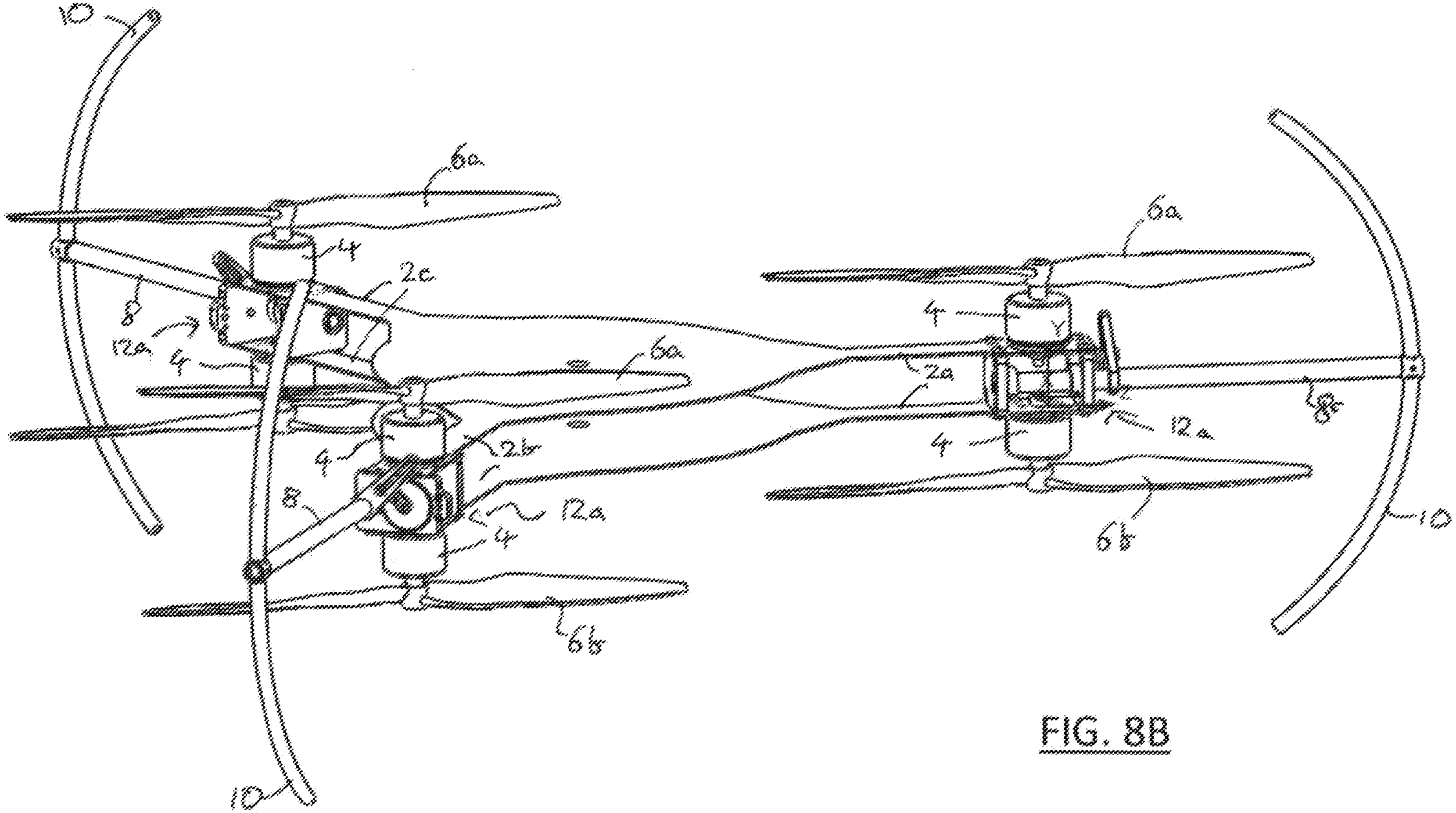


FIG. 8B

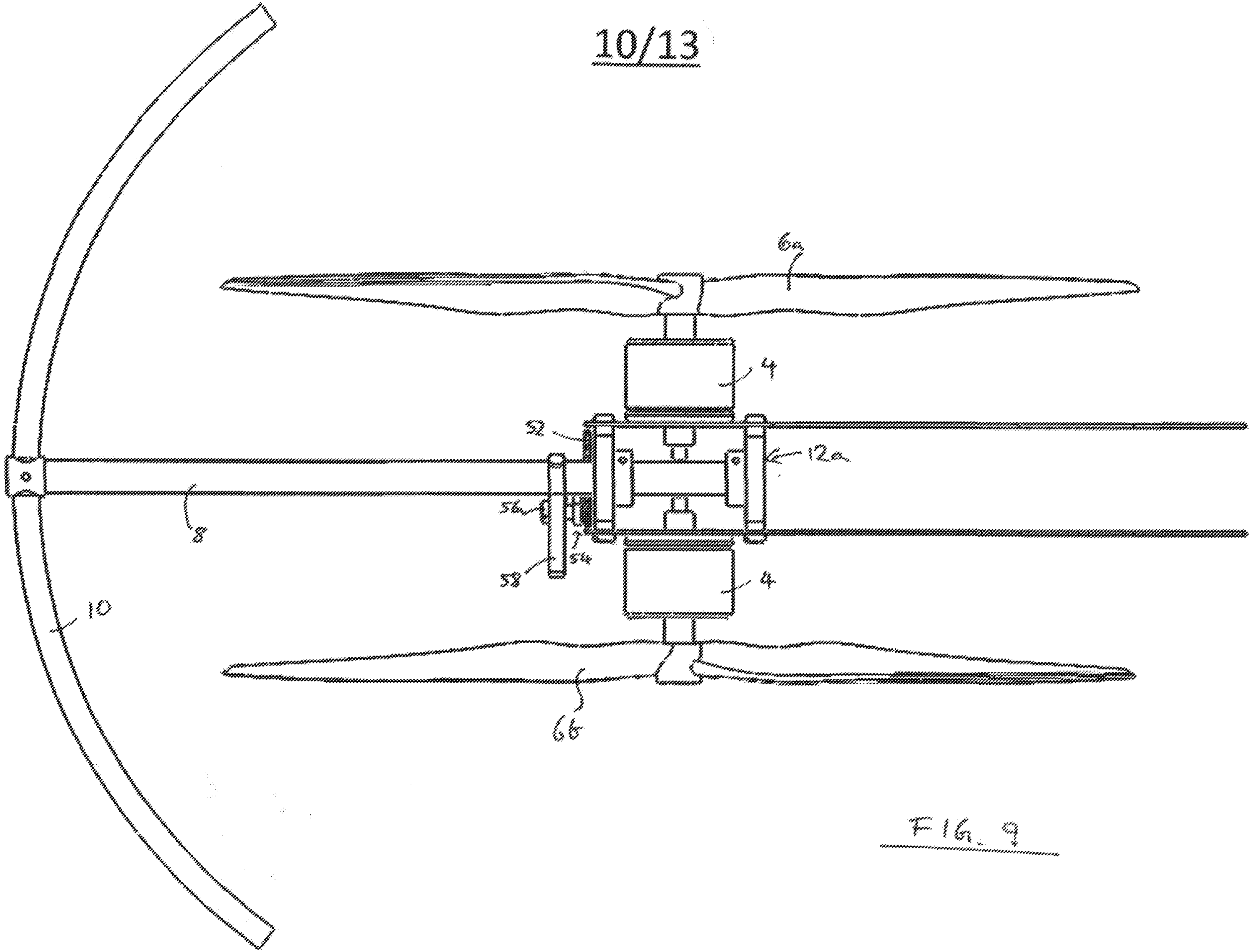


FIG. 9

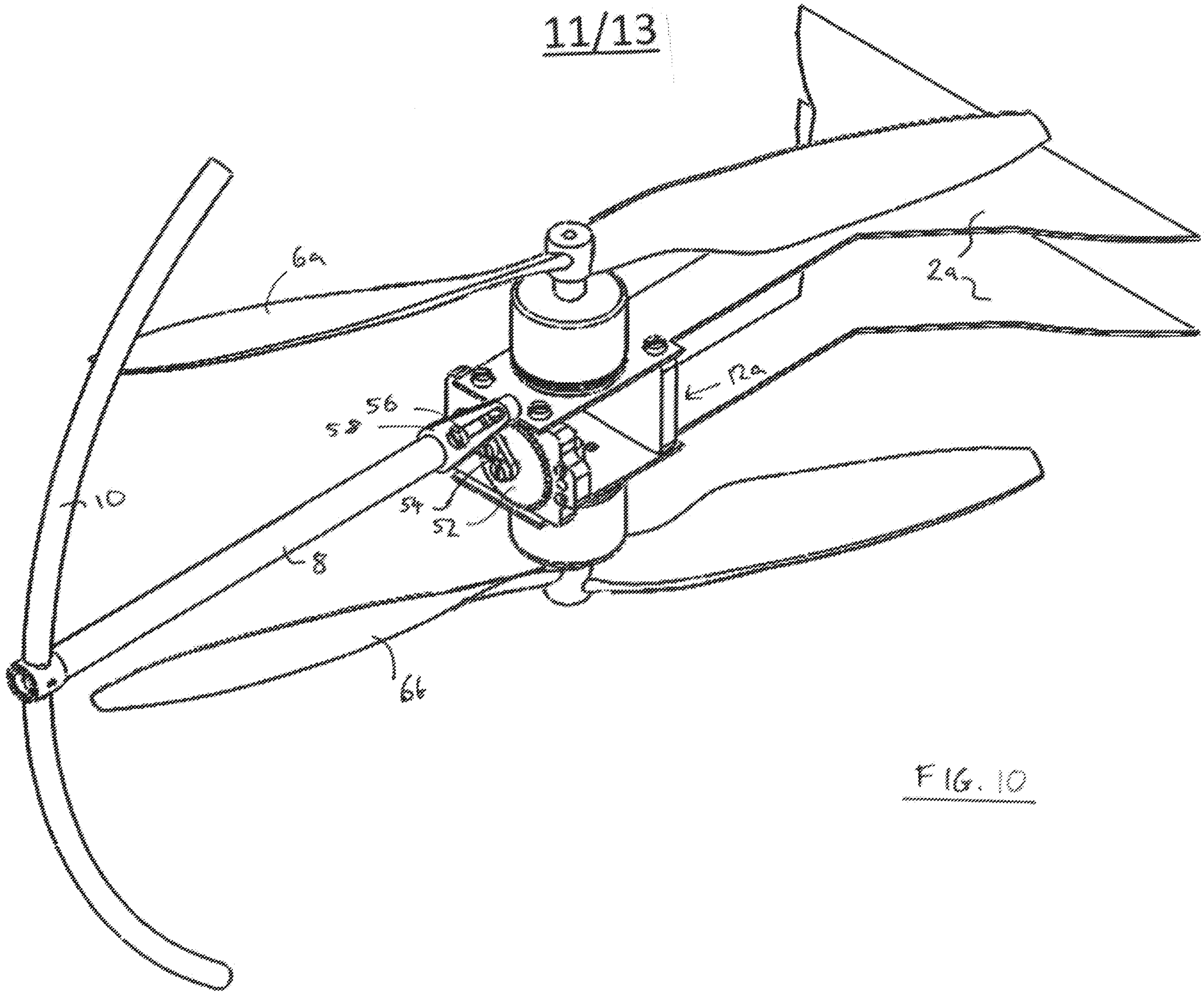


FIG. 10

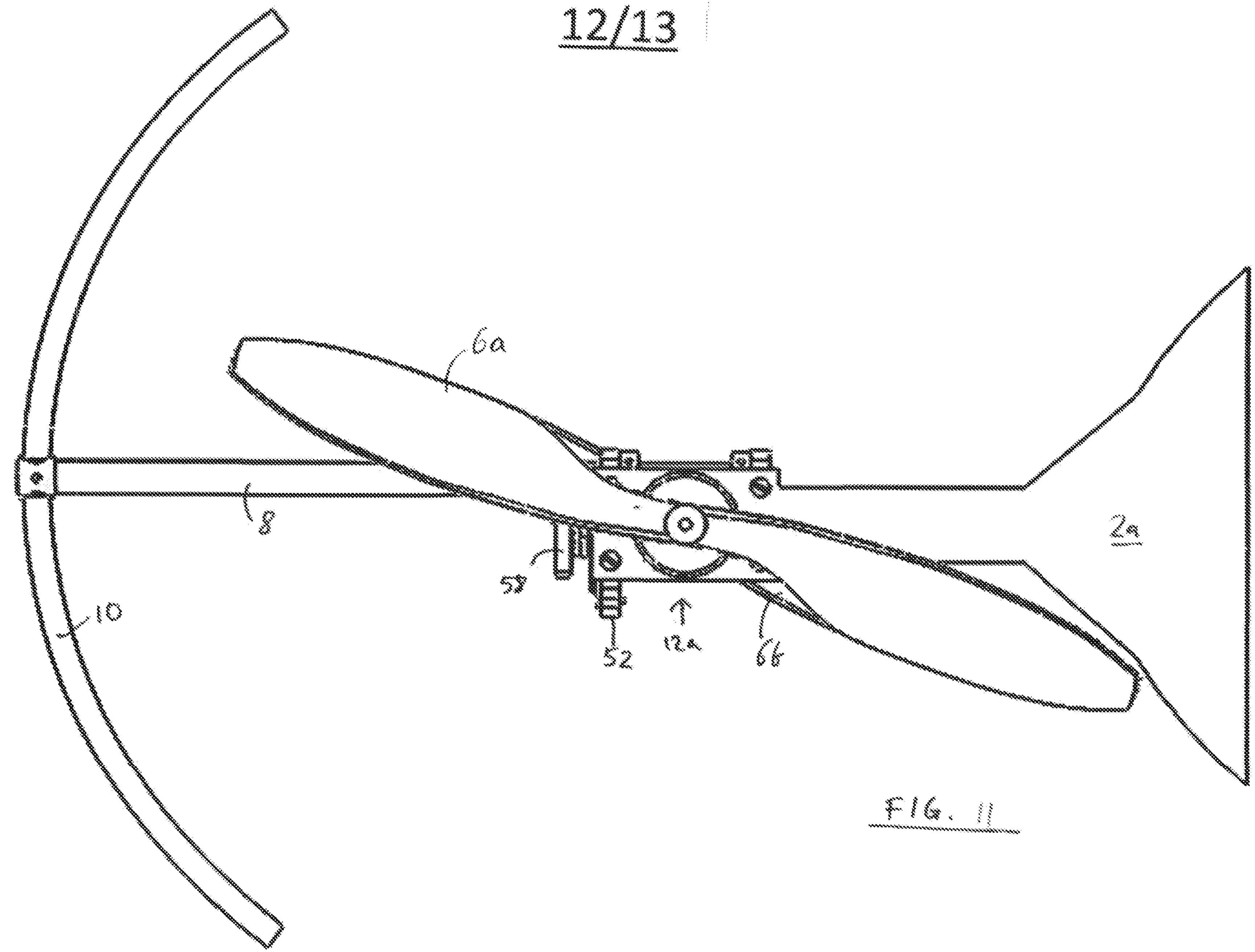


FIG. 11

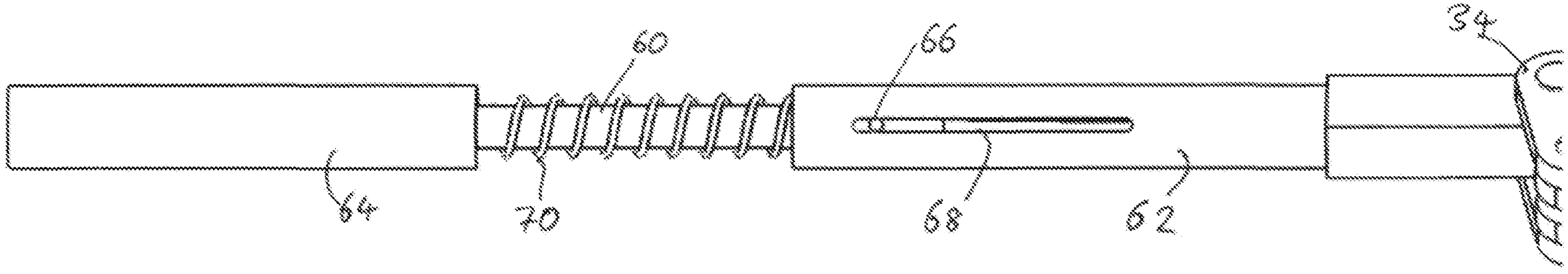


FIG. 12

APPARATUS FOR AND METHODS RELATING TO AN UNMANNED AERIAL VEHICLE

The invention relates to apparatus for an unmanned aerial vehicle (UAV). The invention also relates to a method of determining to move a member for a UAV, and to a computer program for performing the steps of the method.

A UAV often includes surveillance apparatus such as a camera and is employed in a growing number of contexts. Although perhaps their primary use has been in the fields of military security and policing, their use is growing in such fields as animal migration watching, land and crop surveying, and resource or lost item searching and rescue operations, as well as by hobbyists.

A known kind of UAV includes landing gear to facilitate a stable landing. Often the landing gear may limit the space for a camera and may obscure the field of view of the camera.

UAVs may be costly and carry important information. There is risk that a UAV may impact upon surrounding architecture. Damage to one rotor causes failure of the whole propulsion system of a UAV. It is desired to minimise risk of damage to rotors.

It is also desirable for the weight of a UAV to be low, since this affects the weight of the payload, which may be a camera or other device, that a UAV can carry and the range of the UAV. It is known to provide a foam rotor guard to protect rotors, which is lightweight but not strong.

It is an object of the present invention to provide a UAV with strong and lightweight rotor protection. It is also an object of the present invention to address the problem of obscuring of the field of view of a camera.

According to a first aspect of the invention, there is provided apparatus for an unmanned aerial vehicle (UAV), comprising a member movable between a landing gear position and a rotor protection position, and a control means arranged to control movement of the member. Thus, the member can advantageously function as both landing gear and to protect a rotor. Since when the UAV is airborne the member can be moved out of the landing gear position, it does not obscure a camera. As the member is dual-function, there is a weight saving. Thus the addition of a rotor protector does not necessitate it being made of foam to maintain a low weight – strong rotor protection can be provided. Further advantageously, a manufacture need manufacture only a single product, rather than separate rotor protection and landing gear products. Embodiments of the invention are reconfigurable landing gear.

The control means may comprise an electric motor for moving the member and circuitry for controlling operation of the electric motor. The circuitry may include means for determining to move from one of the landing gear position and the rotor protection position to the other of the landing gear position and the rotor protection position. In other words, the circuitry may include means for selecting the landing gear position or the rotor protection position for the member. This determination or selection might be based on height from ground, a selection made by a flight control unit, or based on an instruction received from a user via remote control, optionally via the flight control unit.

The control means may comprise a sensor configured to determine a value indicative of the height of the sensor from ground, wherein the control means is configured to control movement of the member in dependence on a result of a comparison with a threshold value.

The control means may be configured to control movement of the member so that, when the member is in the rotor protection position, the member moves to the landing position. The control means may be configured to control movement of the member so that, when the member is in the landing position, the member moves to the rotor protection position.

The member may comprise an arm for attachment to a control mechanism in a UAV, and an impact member fixedly attached to the arm. The arm may include a dampening means for at least partially absorbing force applied longitudinally to the arm.

The control means may be configured to control movement of the member by moving the arm substantially in the vertical plane. Alternatively, the control means may be configured to control movement of the member by rotating the arm, thereby to rotate the impact member.

There may be provided a UAV comprising such apparatus. The UAV may have an airframe supporting an array of a plurality of rotors, each rotor having associated therewith apparatus mentioned above. The UAV may have an airframe supporting an array of a plurality of rotor arrangements, each rotor arrangement comprising a pair of coaxial rotors and an individual motor for each rotor, each rotor of a coaxial pair being arranged to contra-rotate, wherein each rotor arrangement has associated therewith apparatus mentioned above.

According to a second aspect of the present invention, there is provided a method comprising providing the above mentioned apparatus for attachment to an unmanned aerial vehicle.

According to a third aspect of the present invention, there is provided a method of determining to move a member of an unmanned aerial vehicle, comprising the steps of determining to move the member between a landing gear position and a rotor protection position, and causing the member to move based on a result of the determining. The method may comprise a step of receiving a value indicative of the distance of the unmanned aerial vehicle from ground, wherein the determining to move the member comprises comparing the value with a threshold value. There is also provided a computer program stored on a computer readable medium comprising instructions which, when run on a processor, causes the processor to perform the method.

According to a fourth aspect of the invention, there is provided apparatus for determining to move a member of an unmanned aerial vehicle, comprising determining means for determining to move the member between a landing gear position and a rotor protection position, and a processing means for causing the member to move in dependence on a result of the determining.

According to a fifth aspect of the present invention, there is provided apparatus for an unmanned aerial vehicle, comprising landing gear or protective means for protecting a rotor, comprising dampening means for impact force absorption. The landing gear or the protective means may comprise an arm and an impact member, the arm including the resiliently compressive means arranged for at least partly absorbing impact force longitudinal to the arm. The impact member may comprise a guard member for extending at least partly around a rotor. The resiliently compressive means may comprise a spring.

Embodiments of the present invention are now described, by way of example only, with reference to the company drawings in which:

Figure 1A is a perspective view of a tri-rotor UAV, having apparatus in accordance with a first embodiment with dual-function members located to function as landing gear;

Figure 1B is a perspective view of the tri-rotor UAV of Figure 1A, with the dual-function members instead located to protect rotors;

Figure 2 is a perspective view of parts of the tri-rotor UAV of Figure 1A, including a dual-function member located to function as landing gear;

Figure 3 is a perspective view of the parts of the tri-rotor UAV shown in Figure 2, with the dual-function member instead located to protect a one of the rotors;

Figures 4A to 4C are schematic views of a mechanism that moves the dual-function member between a landing gear position shown in Figure 3 and a rotor protection position shown in Figure 3;

Figure 5 is a block diagram indicating elements of control circuitry that operates to control movement of the dual-function member

Figure 6 indicates elements of a stall measurement circuit;

Figure 7 is a flow diagram indicating steps that take place in moving the dual-function member;

Figure 8A is a perspective view of a UAV having apparatus in accordance with a second embodiment of the invention, with a dual-function member in a rotor protection position;

Figure 8B is a perspective view of the UAV shown in Figure 8A, with the dual-function member in a landing gear position;

Figure 9 is a side view of the UAV of Figure 8B;

Figure 10 is a perspective view of the UAV of Figure 8B;

Figure 11 is a plan view of the UAV of Figure 8A; and

Figure 12 is a view of a part of the dual-function member in accordance with an embodiment.

Like parts are denoted by like reference numerals throughout.

Referring to Figure 1A, the UAV shown is a rotorcraft having an airframe comprising three limbs 2a, 2b, 2c, each limb extending radially from a central region such that ends of the limbs form an equilateral triangular array. The UAV includes a flight control unit coupled to a gyroscope, a magnetometer, an accelerometer, a power supply, a transmitter, a receiver and a camera (none of which are shown in the Figures). A rotor arrangement, comprising a rotor motor, indicated at 4, and a rotor, indicated at 6, driven by the rotor motor 4, is mounted on the end of each limb 2a, 2b, 2c. The rotor motor 4 is coupled to the power supply and also to the flight control unit via a respective electronic speed controller (not shown).

A housing 12 is mounted on the underside of each limb 2a, 2b, 2c beneath each of the rotors 6 with a motor 13 attached to the outside of the housing 12 and having a drive shaft extending through an aperture (not shown) of the housing 12. A dual-function member is associated with each housing 12 and comprises an arm 8 joined at a first end to a cross-beam 10. A second end of the arm 8 pivotably attached to the housing 12 within the housing 12.

Each dual-function member is located in a landing position in Figure 1A in which the dual function member functions as landing gear for the UAV. Each dual-function member is movable from the landing gear position to a rotor protection position in which the respective rotor is protected from impact on environmental structures. The UAV is shown in Figure 1B with the dual-function member in the rotor protection position. The UAV includes a control means (not shown in Figure 1) operative to determine when the dual-function member should move from one of the landing gear position and the rotor protection position to the other of these positions and to move the dual-function member appropriately.

Figure 3 shows in greater detail parts of the UAV shown in Figure 1 with the dual-function member in the landing position. The UAV has mounted on it a control means for controlling movement of the dual function member, comprising a control mechanism for reversibly moving the dual-function member between the rotor protection position and the landing gear position, and control circuitry for controlling the control mechanism. Referring additionally to Figure 5a, the motor 14, is mounted on the outside of the housing 12 by fixing means, in this non-limited example in the form of bolts 16a, 16b, extending between sides of the housing 12. The motor 14 is controllable to drive a drive shaft 18 on which is mounted a first gear 20. A second gear 22, which is larger than the first gear 20, is mounted on the housing 12 for rotation about an axel 24 and is coupled to the first gear 20. The axel 24 extends between sides of the housing for stability. The ratio of the gears 20, 22 results in a low amount of torque being required to move the dual function member, such that the motor 14 can be small and lightweight.

A first linkage 26 is pivotably attached at a first end thereof to the second gear 22 at a first join 28, which is offset from axel 24. As can be seen, the first linkage 26 is v-shaped such that when the position of the arm 8 is such that the dual function member functions as landing gear, as in Figure 4C, the first linkage 26 abuts against the axel 24 to prevent further movement of the first linkage 26. The axel 24 therefore acts as a first stop. This prevents need for the motor 14 to act as a lock to prevent movement of the arm 8 beyond the landing gear position.

The first linkage 26 has extending from its first end a second stop 27 formed integrally with the first linkage 26. The purpose of the second stop 27 is described further below.

A rod 30 extends through an aperture in a second end of the first linkage 26 into a slot 32 in the housing 12. A second linkage 34 has an aperture at a first end thereof with the rod 30 extending therethrough such that the first end of the second linkage 34 can pivot with respect to the second end of the first linkage 26. The second linkage 34 has a second end pivotably attached to the arm 8 at a second join 36. The second end of the arm 8 is attached to the housing 12 at a pivot 38 such that the second join 36 is between the pivot 38 and an opening of the housing 12 from which the arm 8 extends.

The second linkage 34 is attached to the housing 12 at the pivot 38 at a first end of the second linkage 34. The pivot 38 is in the form of a second rod extending between sides of the housing 12.

Figure 4B shows positions of these parts when the dual-function member is between the rotor protection position and the landing gear position. Figure 4C shows the configuration of parts of the control mechanism when the dual-function member is in the rotor protection position. As can be seen, the second stop 27 is shaped so that, when the dual-function member is in the rotor protection position, the second stop 27 abuts against the axel 24. This prevents movement of the dual function member beyond the rotor protection position and also prevents need for the motor to act as a lock to prevent upward movement of the arm 8 beyond the rotor protection position.

The slot 32 includes a recess 35, shown in Figure 4C, at an end thereof remote from the second gear 22 and at a lower side of the slot in which the rod 30 sits when the dual function member is in the rotor protection position. If there is downward force on the dual function member due to impact, the control mechanism self-locks, such that at least some force will be transmitted to the housing 12 rather than to the motor 14, and such that the arm 8 does not reposition whereby to leave the rotor 6 unprotected.

Referring now to Figure 5, each electric motor 14 is controlled with respective control circuitry. The control circuitry 41 comprising a processor 40 coupled to a memory 42, a sensor 44, the motor 14, a stall measurement circuit 43, and a power supply (not shown). The memory 42 stores computer program code, which can be executed by the processor 40 to control the motor 14.

The sensor 44 is configured to determine a value indicative of the height of the UAV from the ground. A non-limited example of a suitable sensor is an ultra sonic sensor. The sensor 44 is configured to respond to requests from the processor 40 to provide a value for the height.

In response, the sensor 44 is configured to determine the value and provide the value to the processor 40. Alternatively, the sensor 44 can be configured to provide the value periodically to the processor 40 without receiving requests.

The control circuitry 41 includes a stall measurement circuit 43, shown in Figure 6, which uses an ampere measuring technique. In the stall measurement circuit 43, the processor 40 is connected to the motor 14 on a first line 46 via a resistor 48. A second line 48 returns from the motor 14 to the processor 40. The circuit 43 includes measurement means configured to measure a first current value on the first line 46 between the resistor 48 and the processor 40 and a second current value on the first line 46 between the resistor 48 and the motor 14. The processor 40 is configured to use the first and second current values to determine whether the dual-function member is in the landing position or the rotor protection position. This is achieved since, the motor 14 has a stall rate that can be measured independently of the direction of the motor. This means that if the motor 14 attempts to move the dual-function member beyond either of these positions, the motor 14 will stall and draw more current, and thus the current values will be different from the current values when the motor 14 is moving the dual-function member. The processor 40, on determining that the dual-function member has moved to the desired position, is configured to control the motor 14 to prevent further movement, for example, to switch off the motor 14. The processor 40 may include a voltage regulator.

Referring to Figure 7, in operation, the processor 40 sends a request at step A for a value for the height of the UAV from ground to the sensor 44. The sensor 44 receives the request, determines the value and provides it to the processor 40 at step B. The processor 40 receives the value of the height of the sensor 44 from the ground at step C.

At step D the processor checks in the memory 42 whether the dual-function member is in the landing gear position or the rotor protection position. The processor 40 then checks at steps E or I, as appropriate whether the height value is less than a predetermined threshold value, for example 1.5m. Step E is performed if the processor 40 has determined that the dual-function member is in the landing gear position at step D. Step I is performed if the processor 40 has determined that the dual-fucntion member is in the rotor protection position at step D. If at step E the processor 40 determines that the height is less than the threshold value, the process ends at step F. If at step E the processor 40 determines that the height is not less than the threshold value, the processor 40 controls the motor so that the dual-function member is moved to the rotor protection position. The processor 40 does this by activating the motor 14, and determining from the stall circuit when the motor dual-function member has reached the rotor protection position. The processor 40 then stores to the memory 42 an indication that the dual-function member is in the rotor protection position.

If at step I the processor 40 determines that the height is less than the threshold value, the processor 40 controls the motor 14 so that the dual-function member is moved to the landing gear position. The processor 40 does this by activating the motor 14, and determining from the stall circuit when the motor dual-function member has reached the landing gear position. The processor 40 then stores to the memory 42 an indication that the dual-function member is in the landing gear position.

Thus, the processor determines the current position of the dual function member, determines whether a change is needed based on the height value, and controls the motor accordingly. In an alternative embodiment, steps described above could be implemented in a different order. For example, steps E and I could be switched each with step D.

Returning to Figure 4a, when the dual function member is in the landing gear position and the processor 40 determines to move it to the rotor protection position, the motor 14 causes the first gear 20 to rotate, which causes the second gear 22 to rotate. Movement of the second gear 22 causes the location of the join 28 to move in a part circular manner, which causes the first linkage 26 to move. The rod 30 at the second end of the first linkage 26 thus moves in the slot 32. Notably, the rod 30 will not move at a uniform speed. A velocity curve of the motion of the rod 30 is sinusoidal, such that low torque is necessary by the motor 14 to initiate rotation of the first gear 20. As a result of need for only low torque, a lightweight, low power motor can be selected for manufacture.

On landing, most of the force from the impact is transmitted to the pivot 38, such that the arm 8 self-locks, preventing repositioning of the dual-function member. In the event of an unstable landing, lateral force towards the central region of the airframe will be transmitted to the axel 24. When the dual-function member is in the rotor protection position, on impact with environmental objects, the force from impact is transmitted to the pivot 38. In the event that the angle of impact is such as to try to push the dual-function member vertically, the stop 29 will prevent such movement.

Preferably, apparatus of the dual-function member and for operation of the dual function member can be provided for easy attachment to a number of different designs of UAVs. For example, the housing 12 may be fixed to the underside of an airframe with screws or bonded. Preferably, the apparatus or the dual function member or a part of the dual function member may be detachable from the UAV. This results in easy carrying of the UAV, for example in a backpack. Suitable detachable attachment means will be apparent to persons skilled in the art. For example, where the housing 12 is fixed to the airframe with screws, it may be easily detached.

In a second embodiment, instead of the end of each limb 2a, 2b 2c having a single rotor mounted thereon, a pair of rotors are mounted on the same axis and arranged to contra-rotate. A UAV with such pairs of rotors is described in International patent publication number WO2009/153588A1, herein incorporated by reference. In this embodiment, rather than the dual-function member being arranged to be raised and lowered, the dual-function member is moved between a landing position and the rotor protection position by 90° rotation of the arm 8 of the dual-function member. As seen in Figures 8A, 8B, 9, 10 and 11, the UAV includes a pair of rotor motors 6a, 6b. The arm 8 extends through a first mounting 50a at a first side of a housing 12a to a second mounting 50b on a second side of the housing 12a and is rotatably mounted thereon. A control means to control turning of the arm 8 is mounted on a housing 12a. The control means includes a control mechanism comprising a gear 52 mounted on a motor (not shown), a link 54, a pin 56 and a slotted arm 58. The link 54 is fixed on the gear 52 so that a portion of the link 54 extends beyond the circumference of the gear 52. The pin 56 extends from the portion of the link 54 orthogonally with respect to the gear 52 and extends into the slot in the arm 58. The slotted arm 58 is fixed at one end to the arm 8 of the dual-function member.

In operation, the motor is controlled by the processor 40 in a similar manner to in the first embodiment, in response to the steps described with reference to Figure 7, to rotate the gear 52. Rotation of the gear 52 by 270° will cause the slotted arm 58 to rotate by substantially 90° about the axis of the arm 8, thereby turning the arm 8 by substantially 90°. Thus the dual-function member can thus be moved from the landing position shown in Figures 8, 9 and 10 to the rotor protection position shown in Figure 10. The dual-function member can be returned to the landing position in a reverse manner. Notably, an angular velocity curve of the rotational movement of the arm 8a is sinusoidal, such that low torque is required to initiate rotation of the gear 52.

In a modification to the second embodiment, the apparatus of the dual-function member and for operation of the dual function member can be provided alongside limbs 2a, 2b, 2c of the airframe rather than within the airframe. Thus the apparatus can be attachable to a number of different designs of UAVs. Preferably, the apparatus or the dual function member or a part of the dual function member may be detachable from the UAV. Suitable detachable attachment means will be apparent to persons skilled in the art. For example, where the housing 12 is fixed to the airframe with screws, it may be easily detached.

In a modification to the first and second embodiments, the processor 40 can operate instead in a semi-autonomous mode, in which it is connected to the flight control for communication therewith. The position of the dual-function member may be controlled by a user via remote control. The position of the dual-function member may also be dependent on other parameters, for example, the processor 40 may receive information on rate of descent from the accelerometer and, on determining that the rate of descent exceeds a threshold value, move the dual-function member to the landing position. In a modification, the flight control unit controls the motor 14 and the processor 14 is absent.

In the examples described above, the sensor 44 is a Maxbotix LV-EZ0, which can provide data via I2C, pulse width modulation or analogue. The processor 40 is a combination of a L293D H-bridge for regulating the speed and direction of a motor, a micro processing unit in the form of an Arduino Pro Mini 5V, and a voltage regulator. The stall measurement circuit includes a 10 Ohm resistor. Stall measurement values are taken from motor power supply pins on the L293D chip. The motor 14 is a Precision Microdrive 212-112 motor, which rotates at a low speed of 70 rpm and can produce a torque of 0.6kg/cm^2. Alternative components and software may be used.

In a modification to the first and second examples, the arm 8 of the dual-function member includes a dampening means for shock absorption. Referring to Figure 12, the arm, indicated at 8a, includes first, second and third arm portions 60, 62, 64. The first arm portion 60 has an end located within the second arm portion and is partially slidable into the second arm portion 62. The third arm portion 64 is fixedly attached to the first arm portion 60 and extends to attach to the cross-beam (not shown). The first arm portion 60 includes a protrusion 66 extending from one end into a guiding slot 68 in the second arm portion 62. A dampening means in the form of a compression spring 70 is located on the first arm portion 60 so that one end abuts against an end face of the second arm portion 62 and a third end abuts against an end face of the third arm portion 64.

In operation, when a force is applied longitudinally to the arm 8a, the first arm portion 60 slides into the second arm portion 62, with the protrusion 66 sliding in the guiding slot 68. The compression spring 70 is compressed between the end faces of the second and third arm portions 62, 64. When the force is no longer applied, the compression spring 70 resiles to its initial length. When the dual-function member is in the rotor protection position, the compression spring advantageously absorbs, at least in part, shock from impact on environmental structures. When the dual-function member is in the landing position, the compression spring advantageously absorbs, at least in part, shock from impact of landing.

In Figure 12 the end of the second arm portion 62 nearest the airframe is attached to the linkage of the first embodiment. The arm 8a of the second embodiment can also be modified to include such resiliently compressive means. Alternatively or additionally, it is possible for a dampening means for shock absorption to be included in the dual function member elsewhere than in the arm 8a, for example in the cross-beam 10. Notably, the dampening means is not limited to a compression spring. Other kinds of compressive resilient means are suitable.

A dual-function member having such dampening means is a stand-alone feature; it may be included in landing gear or a rotor protection guard that is not dual-function.

Such dampening means, incorporated into a member that is dual function or otherwise, may generally absorb vertical or horizontal force from impact, or a combination of both vertical and horizontal force components on a rotor protector. For example, the member may comprise an arm and an impact member that is pivotably movement relative to the UAV and held in position by biasing means, for example a tension spring pulling the arm against a stop. The member may be pivotably moveable against the biasing means, such that the member returns to its original position following impact. Where the biasing means is a tension spring, on impact such that the tension spring is stretched, the tension spring will dampen the impact. The tension spring will then return to its original configuration, with the arm pulled against the stop. Similar dampening arrangements might be included in a member, be it landing gear, a rotor protector or a dual function member, wherein the member is formed of two pivotably moveable, parts, biased into a particular configuration, but wherein, on impact, the parts are respectively pivotable away from the particular configuration against a biasing means, such as a spring, which urges the parts to return to their original configuration.

Preferably, when the dual function members are in the landing gear position, they are shaped so as to permit a landing on a horizontal ground when the angle of the plane of the airframe from horizontal is greater than 20 degrees, preferably at least 30 degrees. The UAE described as a first embodiment permits landing at an angle of inclination of 30 degrees.

The UAE described as a second embodiment permits landing at an angle of inclination of 37 degrees.

The embodiments described above have been described as or in relation to tri-rotor UAVs whose rotors form an equilateral triangular array. The array does not have to form an equilateral triangle – isosceles or scalar arrays are possible. Also, embodiments are applicable to UAVs with greater or fewer than three rotor or three pairs or coaxial rotors. Notably, embodiments of the invention may be beneficial if applied to a UAV with a single rotor or pair of coaxial rotors, optionally where more than one dual function member and associated respective control means is provided.

Each control mechanism described above has a respect control means configured to control the motor of the control mechanism. In a modification, only one control means need be provided to control all control mechanisms. The control means could be included in the flight control unit.

The applicant hereby discloses in isolation each individual feature described herein and any combination of two or more such features, to the extent that such features or combinations are capable of being carried out based on the present specification as a whole in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein, and without limitation to the scope of the claims. The applicant indicates that aspects of the present invention may consist of any such individual feature or combination of features. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

CLAIMS

1. Apparatus for an unmanned aerial vehicle, comprising:

a member movable between a landing gear position and a rotor protection position; and

a control means arranged to control movement of the member.

2. The apparatus of claim 1, wherein the control means comprises an electric motor for moving the member and circuitry for controlling operation of the electric motor.

3. The apparatus of claim 2, wherein the circuitry includes means for determining to move from one of the landing gear position and the rotor protection position to the other of the landing gear position and the rotor protection position.

4. The apparatus of any one of claims 1 to 3, wherein the control means comprises a sensor configured to determine a value indicative of the height of the sensor from ground, wherein the control means is configured to control movement of the member in dependence on a result of a comparison of the value with a threshold value.

5. The apparatus of claim 4, wherein the control means is configured to control movement of the member so that, if the member is in the rotor protection position, the control means determines to move the member to the landing gear position and moves the member accordingly.

6. The apparatus of claim 4 or claim 5, wherein the control means is configured to control movement of the member so that, if the member is in the landing position, the control means determines to move the member to the rotor protection position and moves the member accordingly.

7. The apparatus of any one of the preceding claims, wherein the member comprises an arm for attachment to an unmanned aerial vehicle, and an impact member fixedly attached to the arm.

8. The apparatus of claim 7, wherein the arm includes a dampening means for at least partially absorbing force applied longitudinally to the arm.

9. The apparatus of claim 7 or claim 8, wherein the control means is configured to control movement of the member by moving the arm substantially pivotingly in the vertical plane.

10. The apparatus of claim 7 or claim 8, wherein the control means is configured to control movement of the member by rotating the arm, thereby to rotate the impact member.

11. An unmanned aerial vehicle comprising the apparatus of any one of claims 1 to 10.

12. An unmanned aerial vehicle having an airframe supporting an array of a plurality of rotors, each rotor having associated therewith the apparatus of any one of claim 1 to 9.

13. An unmanned aerial vehicle having an airframe supporting an array of a plurality of rotor arrangements, each rotor arrangement comprising a pair of coaxial rotors and an individual motor for each rotor, each rotor of a coaxial pair being arranged to contra-rotate, wherein each rotor arrangement has associated therewith the apparatus of any one of claims 1 to 8 and 10.

14. A method comprising:

providing the apparatus of any one of claims 1 to 10 for attachment to an unmanned aerial vehicle.

15. A method of determining to move a member of an unmanned aerial vehicle, comprising the steps of:

determining to move the member between a landing gear position and a rotor protection position; and

causing the member to move based on a result of the determining.

16. A method according to claim 15, further comprising a step of receiving a value indicative of the distance of the unmanned aerial vehicle from ground, wherein the determining to move the member comprises comparing the value with a threshold value.

17. A computer program stored on a computer readable medium comprising instructions which, when run on a processor, causes the processor to perform the method of claim 15 or claim 16.

18. Apparatus for determining to move a member of an unmanned aerial vehicle, comprising:

determining means for determining to move the member between a landing gear position and a rotor protection position; and

a processing means for causing the member to move in dependence on a result of the determining.

19. Apparatus for an unmanned aerial vehicle, comprising:

landing gear or protective means for protecting a rotor, comprising dampening means for impact force absorption.

20. The apparatus according to claim 19, wherein the landing gear or the protective means comprises at least two respectively moveable parts, wherein the dampening means comprises a biasing means, the at least two parts being biased into a relative disposition by the biasing means, at least one of the at least two parts being moveable by impact of an environmental object on the at least one part, the biasing means urging said at least one part to return to said relative disposition.

21. The apparatus of claim 19, wherein the landing gear or the protective means comprises an arm and an impact member, wherein the dampening means is a resiliently compressive means arranged for at least partly absorbing impact force longitudinal to the arm.

22. The apparatus according to any one of claims 19 to 21, wherein the dampening means comprises a spring.

23. Apparatus for, a method of and a computer program for determining to move a member of an unmanned aerial vehicle substantially as hereinbefore described with reference to the accompanying drawings.

24. Apparatus for an unmanned aerial vehicle substantially as hereinbefore described with reference to the accompanying drawings.

25. An unmanned aerial aircraft substantially as hereinbefore described with reference to the accompanying drawings.

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Application No:	GB1015922.6	**Examiner:**	Mr Hal Young
Claims searched:	1-25	**Date of search:**	6 January 2012

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A		KR 1020110011923 A (IAC IN NAT UNIV)
A		CN 201678040 U (WUXI HANHE)
A		US 2011/049295 A1 (EUROCOPTER)
A		JP 10100998 A (JAPAN AVIATION)
A		US 2007/215750 A1 (SHANTZ)

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X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B64C

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, TXTUS0, TXTUS1, TXTUS2, TXTUS3, TXTUS4, TXTEP1, TXTGB1, TXTWO1

International Classification:

Subclass	Subgroup	Valid From
B64C	0025/10	01/01/2006
B64C	0025/32	01/01/2006
B64C	0027/00	01/01/2006
B64C	0039/02	01/01/2006