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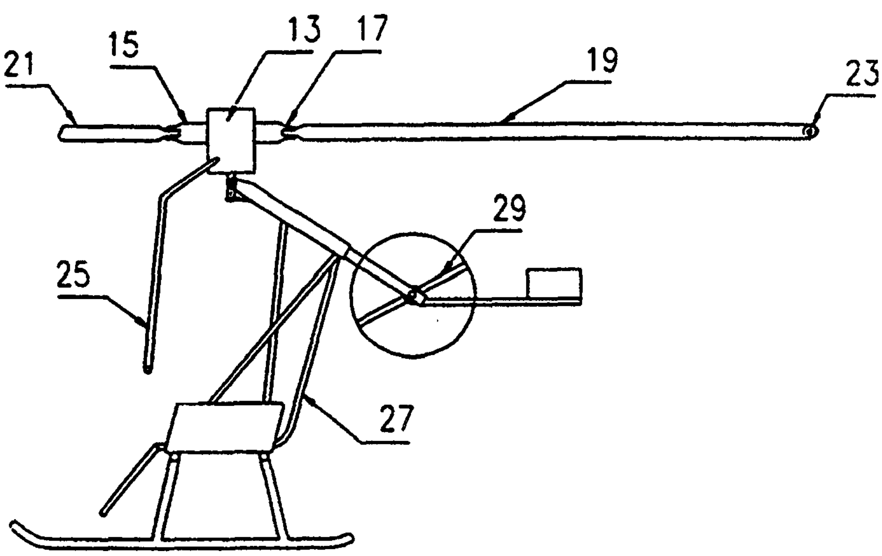

(57) Abstract

A modular helicopter system in the form of a kit of parts comprises a single rotor hub and a plurality of other helicopter components said plurality of other helicopter components including two or more components having the same function which components are interchangeable and from which an appropriate selection can be made in order to assemble a helicopter configured for a particular type of mission.

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MODULAR HELICOPTER SYSTEM

This application relates generally to helicopter systems and more specifically to a lightweight modular utility helicopter system.

Background of the Invention

Existing helicopters have been designed to meet specific mission requirements. The engine, rotor blade design, rotor diameter and airfoil shapes (namely, chord width and camber), gear box and power train, and the structure of the helicopters have been designed to meet fixed, mission-dictated specifications.

Different types of mission require different types of helicopters. There are missions in which people and/or cargos need to be transported different distances and at various altitudes and departure and landing elevations. It is known that conventional helicopters have poor flight characteristics at high altitudes due to both decreasing engine thrust and decreasing aerodynamic lift. One solution for improving the flight characteristics of high altitudes is through the use of hydrogen peroxide thrusters, which do not require atmospheric oxygen; thus, there is no thrust degradation with increase in altitude.

It is also known that a conventional helicopter has a poor cost-per-hour-per-payload weight if used for a mission other than the one for which its design was optimised. For example, in many cases helicopters are flown on short utility missions by one pilot where either the payload capacity or flight endurance, or both, may greatly exceed the mission requirement. Today, as energy costs and pollution are important considerations in any transportation system, it is essential that individual systems be developed and optimised for air transportation. Any off-optimum configuration for a given mission is inefficient. The use of hydrogen peroxide rather than fossil fuels is ecologically advantageous. Hydrogen peroxide decomposes into water vapor and gaseous oxygen; thus, the exhaust from the thrusters purifies rather than pollutes the atmosphere.

The use of hydrogen peroxide engines in the tips of the rotor blades has been proposed in lightweight helicopters. One such system is described in US-A-4.071,206 and US-A-4,473,199.

It is of course well known that during the design of a basic aircraft type variations in its individual components can be made in order to produce variants of the aircraft type for particular types of mission. It is also of course well known to carry out factory or hangar conversions of existing aircraft types and variants for specific purposes but maintaining the basic fuselage.

Proposals have been made described in "Aerospace International" published by The Royal Aeronautical Society, September 1997, volume 24, No.9. for a multirole mission adaptable air vehicle (MRMAAV) using modular reconfigurable components but the same basic fuselage.

However, as far as the applicant is aware no-one has previously conceived the fundamental idea for a helicopter system of providing the versatility and simplicity of arranging for only the rotor head to be the non-interchangeable component of a helicopter, all of the other components being in practice, or potentially readily interchangeable according to the intended mission, so that the single rotor head forms the basis of a kit of parts in which one or more of the other components are supplemented by components having the same function but having differing performances and which are readily interchangeable, in particular such basic components as the rotor blades and/or the fuselage.

The present invention overcomes the deficiencies and inefficiencies of known helicopters when used on missions other than those for which they were optimally designed.

The advantages of the present invention will be more clearly understood from the following description taken together with the drawings.

Summary of the Invention

According to the present invention there is provided a modular helicopter system in the form of a kit of parts comprising a single rotor hub and a plurality of other helicopter components said plurality of other helicopter components including two or more components having the same function which components are interchangeable and from which an appropriate selection can be made in order to assemble a helicopter configured for a particular type of mission. In the basic modular helicopter system (MHS) of the invention individual aircraft can be adapted and changed to fulfill the different mission requirements by the use of easily replaceable modular components. One basic rotor hub is used in all configurations. Alternative sets of rotor blades and/or fuselages can be attached to this system according to the mission requirements. Reaction engines with different thrust ratings and rotor blades with different lift and drag characteristics can be selected and optimised to meet specific mission profiles, load and speed requirements, and flight levels and base elevations. A selection of tail sections for directional control may be provided. The modular helicopter system of the present invention may consist of a basic rotor hub, two control systems (one for manned flight and one for unmanned flight), various sets of rotor blades, assorted reaction engines (thrusters), a section of fuselages, various types of tail sections for directional control, and a "fail-safe" system for unmanned robotic flight.

It will be understood that the modular helicopter system of the invention is physically a kit of parts from which an appropriate selection can be made in order to assemble a helicopter configured for a particular mission. Upon accomplishment of the mission, the helicopter can, if desired, be disassembled or partly disassembled and become again a kit of disassembled parts, or, if a different type of mission is in prospect, the helicopter can be modified using suitable components from the kit appropriate for the intended new mission.

Specific embodiments of the present invention will now be described by way of example with reference to the accompanying drawings:

Brief Description of the Drawings

Figure 1 is a schematic representation of a basic lightweight helicopter;

Figure 2 is a side view of a rotor hub used in the helicopter of Figure 1;

Figures 3A-3C are schematic representations of control systems used in the helicopter system of Figure 1;

Figures 4A-4C are schematic representations of different rotor blades which may be used in the helicopter system of Figure 1;

Figure 5 is a schematic showing of a hydrogen peroxide thruster which may be used on the rotor blades of Figure 4;

Figures 6A-6C disclose different fuselage constructions which may be used with the helicopter system of Figure 1;

Figure 7 is a schematic of a typical tail rotor which may be used with the helicopter system of Figure 1;

Figure 8 discloses a movable thrust engine mounted on a standard tail book;

Figure 9 is a view taken through the lines 9-9 of Figure 8;

Figure 10 is a drawing of a further embodiment of a thrust engine which may be used on the tail boom; and

Figure 11 is a schematic representation of a controllable air rudder which may be mounted on a tail boom.

Detailed Description of the Preferred Embodiments.

Referring to Figure 1, helicopter system 11 includes rotor hub 13 having blade attachment points 15 to 17 to which rotor blades 19 and 21 are removably secured. Manual control lever arm 25 is removably secured to rotor hub 13, as is fuselage 27 and tail rotor 29.

The basic system as shown in Figure 1 is described in the above-mentioned US-A-4,071,206. The "portability" feature of this patent is retained in the present invention and is improved on in that the lever arm can be removed for pilot-less flight, as described below.

Referring to Figure 2 rotor hub 13, including blade attachment points 15 and 17, is shown in greater detail. It is to be understood that the same rotor hub may be used in all of the modular configurations of the present invention.

Figures 3A-3C show differing control systems.

Figure 3A shows rotor hub 13 with manual control level arm 25 removably secured thereto.

Figure 3B and Figure 3C show a basic remote control system. Rotor hub 13 includes radio receiver 31, on-board TV-camera 33, fail-safe system controls 100, and electromechanical actuators 35 which provide rotor control. It is to be noted that this system has radio uplinks and video down-links to the ground controller's equipment.

Figure 3C discloses remote control 37 which may be used as ground control and consists of TV receiver and display screen 39, radio receiver/transmitter 41, and instrument panel display 43 which provides rotor speed and other flight data. The equipment used in the remote control system is known and available from various commercial sources.

Although not illustrated, for safety reasons the control system is comprised of multiple transmitters and receivers (typically three) in parallel, each operating on discrete frequencies with continuous carrier waves. The modular helicopter system responds to commands only if all three (or two, at the operator's option) carrier waves of the redundant radio signals from the ground controller are present.

In case the MHS goes out of control or loses radio contact with its ground controller, a fail-safe default mode is automatically activated by control mechanism 100 in rotor hub 13. Fuel flow is restricted by a solenoid valve in the control system to preset a flow rate which will prevent the rotor from temporarily over-speeding when the rotor is unloaded.

After a preset period of time (e.g. five seconds), both main rotor blades 19 and 21 go to flat pitch (i.e. unloaded, zero lift). Should the aircraft be in turning flight at the time of loss of remote control, keel effect and static stability will tend to return the aircraft to an upright position, in straight and level flight. During this preset time delay, selected in advance by the operator, the forward velocity of the MHS will have decreased to approximately zero due to aerodynamic drag and the aircraft will have started to descend. As rate of descent increases, actual angle of attack of the blades will increase slowly due to direction of relative wind, even though blade pitch remains zero relative to the airframe. As angle of attack increases, lift increases. Equilibrium is quickly achieved; lift becomes very slightly less than gross weight and the aircraft descends slowly (100 feet-per-minute, for example). Rate of descent is a function of the preset fuel flow rate programmed in control mechanism 100. This preselected, controlled rate of descent is automatically initiated by default. The MHS descends vertically and slowly, essentially hovering out of ground effect, thus avoiding an uncontrolled crash. Immediately prior to touchdown, ground effect produced slightly increased lift, thus permitting a "soft" landing.

It should be noted that the ground control system of Figures 3B and 3C can also be used for manned (piloted) flights. The pilot can strap on the portable radio ground control system and use radio signals for control even though he is aboard the vehicle. This option is useful in circumstances wherein the aircraft has been configured and used for an unmanned mission and the pilot, upon completion of the mission, desires to fly the machine back to base using radio control.

As previously stated, both the remote and the ground control modules are state-of-the-art components of drone aircraft. The fail safe innovation, not known to be currently installed in existing helicopter systems, is applicable to all helicopters and not merely the helicopter of the present invention. It can be readily developed and installed by anyone skilled in the art of drone controls.

Figure 4 disclosed three different rotor blades A, B and C. Different missions and mission profiles impose different aerodynamic requirements on the rotor blades for optimum performance. Typical parameters which can be controlled in the present system are (i) rotor blade length (rotor diameter), (ii) chord width, and (iii) aerodynamic shape of the airfoil. It is noted that the parameters which may possibly be controlled are not limited to these three specific configurations.

For a combination of high speed and maximum range, an airfoil having good lift-to-drag ratio would be selected. For short missions, and probably for most remote-controlled flights, short rotor blades with a symmetrical airfoil such as the NACA 12, Figure 4C, would be selected. For high altitude flight the degraded aerodynamic flight at high pressure altitudes is of importance; these conditions would dictate use of a longer blade having a greater chord width, such as blade B in figure 4. Regular manned missions would normally use long, thin rotor blades with or without aerodynamic twist, such as blade A of Figure 4.

Each of the blades A, B and C contains provisions for internal fuel lines and brackets 45, 47 and 49 on the rotor tips for mounting the hydrogen peroxide thrusters as particularly described in US-A-4,071,206.

Figure 5 is an illustration of a typical hydrogen peroxide H_2O_2 thruster. This particular thruster is adaptable to long, thin blades such as shown in Figure 4A, we well as to broader blades. These thrusters are relatively compact, resulting in an extremely small size and weight for the prime propulsion system used in the present invention, thus enhancing its efficiency and thrust-to-weight ratio. Payload is increased by virtue of the dramatically reduced weight of the propulsion system, as contrasted with reciprocating or turbine engines used in conventional helicopters. As described in the above-mentioned patent, continuous fuel pressure exists by virtue of centrifugal force due to blade rotation.

Referring to Figure 5, liquid hydrogen peroxide is introduced at inlet 49 of thrusters 47 and passed through entrapped catalyst 51, instantaneously decomposing into water vapor (steam) and gaseous oxygen, thus producing thrust at convergent/divergent exhaust nozzle 52 in accordance with Newton's Second Law of Motion. Since the peroxide thruster is not an air-breathing engine, it does not suffer thrust degradation with increasing altitude; it is a rocket, not a jet.

Figures 6A-6C disclose various fuselage configurations. Each configuration includes fuel tanks. Figure 6A discloses fuselage framework 27 and includes pilot's seat 28, similar to that in the aforementioned patent.

Figure 6B discloses fuselage 54, which would be selected for the remote-control version of the helicopter system of the present invention. Included in fuselage 54 is platform 55 for payloads such as cameras and surveying, sensing, or other equipment not requiring "hands-on" human operation or interface.

Fuselage 56 of Figure 6C would be used for missions which include transporting a person on transport grid 27 when the aircraft is remotely controlled. This is useful in circumstances such as performing a rescue mission; a person may be rescued from a dangerous area without additionally endangering the pilot.

Directional control system are shown in Figures 7-11; these systems can be used in either the manned or remote-controlled version of the helicopter of the present invention.

Figure 7 discloses a conventional tail rotor 62 attached to a tail boom 60 and driven by the main rotor via a gear train or belt in the standard fashion. The pitch angle of the tail rotor is also controlled by known techniques.

Figures 8 and 9 disclose a movable thrust engine 63 mounted on tail boom 60 in lieu of tail rotor 62 of Figure 7. Thrust engine 63 is a single miniature peroxide thruster positioned electromechanically to provide a small horizontal thrust vector perpendicular to the longitudinal axis of the helicopter. It receives its commands electrically from any of the control systems described in Figure 3 and its thrust vector can initiate a left- or right-hand turn of the aircraft.

Figure 10 discloses a fixed set of two miniature sideward thrust peroxide engines 65 and 67 which may be mounted on the tail boom. In the same manner, the horizontal thrust vectors are perpendicular to the aircraft's longitudinal axis, one engine initiates a right-hand turn while the other initiates a left-hand turn.

Figure 11 discloses a controllable air rudder 69 which is immersed in the rotor down-wash and the airstream generated by the forward velocity of the aircraft. It, also, can be used in either manned or remote flight.

It should also be noted that a combination of the types of either of the thrusters of Figures 9 and 10 may be used in conjunction with air rudder 69 so as to provide a controlled redundancy if desired. This redundancy may be desired, for example, in case of damage or failure of the conventional tail rotor or its drive train. As is well recognised and feared by all pilots, loss of tail rotor inevitably results in an uncontrolled crash, with forward velocity and an unpredictable angle of impact. A zero-velocity, straight-down, cushioned impact is highly preferably.

A final control system is the complete absence of any tail system. Lateral control in flight is maintained by the normal function of the rotor hub in providing differential angles of attack between the advancing and retreating blades. Since the thrusters are in the rotor tips there is negligible torque feedback to the airframe, as contrasted with conventionally powered helicopters which inherently require torque to turn the blades. Similarly, autorotation is feasible in a tail-less craft because of the absence of torque feedback to the airframe. The only torque feedback during autorotation is the almost negligible friction in the main bearings which suspend the fuselage from the rotor hub.

Some helicopter pilots might initially reject the tailless option on the basis of intuition and experience. Actual test flights of the present invention, however, have demonstrated its feasibility and safety, both in powered flight. For autorotation the tail rudder must be tiltable as the airstream goes from bottom to top. While the option is feasible for the present invention, it is emphasised that it is not feasible for conventionally powered vehicles.

The above description and drawings are illustrative only since substitution and/or modification of various components is possible without departing from the invention, the scope of which is to be limited only by the following claims.

CLAIMS

1. A modular helicopter system in the form of a kit of parts comprising a single rotor hub and a plurality of other helicopter components said plurality of other helicopter components including two or more components having the same function which components are interchangeable and from which an appropriate selection can be made in order to assemble a helicopter configured for a particular type of mission.

2. A modular helicopter system as claimed in claim 1 which includes a single subassembly of helicopter components which includes a rotor hub.

3. A modular helicopter system as claimed in claim 2 comprising:

a single rotor hub;

a fuselage supporting said rotor hub;

a plurality of sets of rotor blades, each of said sets having blades which differ in length, chord width, and shape of airfoil;

a hydrogen peroxide engine mounted at the tip of each of said rotor blades; and

means for attaching any selected one of said sets of rotor blades to said rotor hub.

4. The modular helicopter system of claim 3 further comprising:

a tail boom connected to said rotor;

a plurality of directional control means; and

means for attaching any selected one of said directional control means to said tail boom.

5. The modular helicopter system of claim 3 further comprising manual control means; and

means for attaching said control means to said rotor hub.

6. The modular helicopter system of claim 3 further comprising control means, said control means comprising:

a radio receiver, television camera and transmitter and electromechanical rotor control means secured to said rotor hub; and

remote control means comprising:

a television receiver with display screen;

a radio transmitter; and

instrument panel display means.

7. A modular helicopter system as claimed in claim 2 comprising:

a rotor hub;

rotor blades secured to said hub;

a hydrogen peroxide engine mounted on the tip of each of said rotor blades;

a plurality of differently configured fuselages; and

means for attaching any selected one of said fuselages to said rotor hub.

8. The modular helicopter system of claim 7 further comprising:

a tail boom connected to said rotor;

a plurality of directional control means; and

means for attaching any selected one of said directional control means to said tail boom.

9. The modular helicopter system of claim 7 further comprising manual control means; and means for attaching said manual control means to said rotor hub.

10. The modular helicopter system of claim 7 further comprising remote control means comprising:

a radio receiver, television camera and transmitter and electromechanical rotor control means secured to said rotor hub; and

remote control means comprising:

a television receiver with display screen; pilot control means; radio transmitter and instrument panel display means.

11. The modular helicopter system of claim 10 further comprising fail-safe means for adjusting the fuel flow to said engines and the pitch of said rotor blades so as to control the rate of descent of said helicopter.

12. An assembled helicopter when constructed from the modular helicopter system as claimed in any one of the preceding claims.

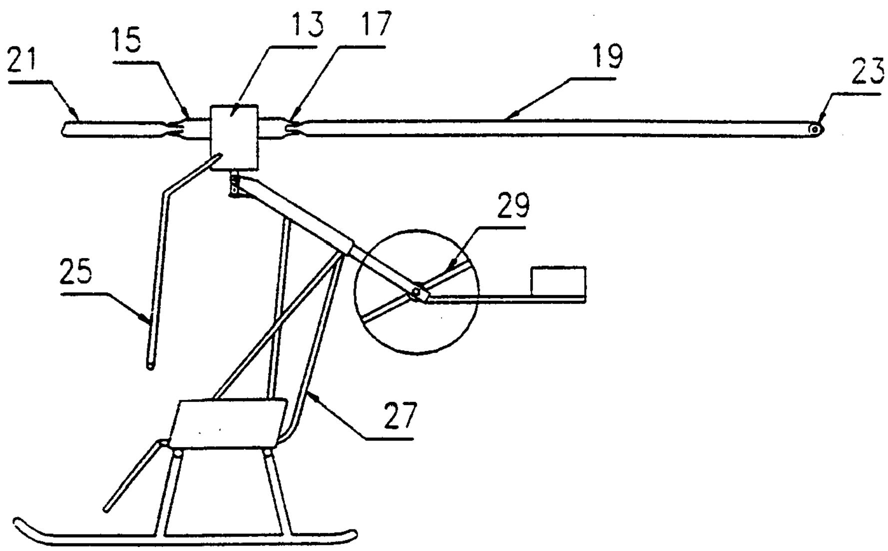

FIG.1

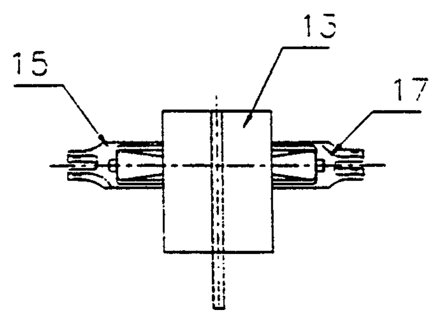

FIG.2

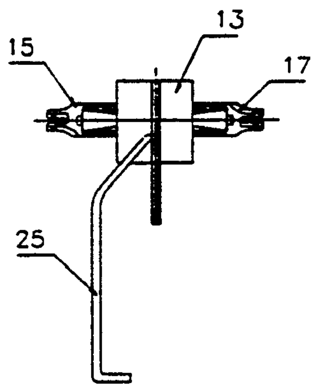

FIG.3A

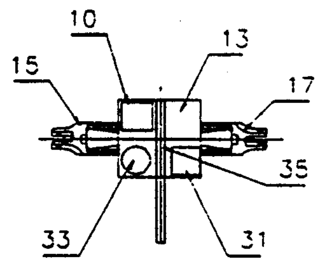

FIG.3B

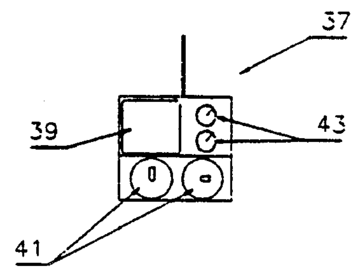

FIG.3C

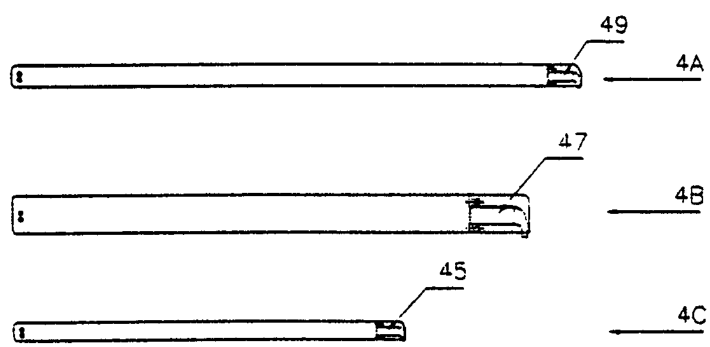

FIG.4

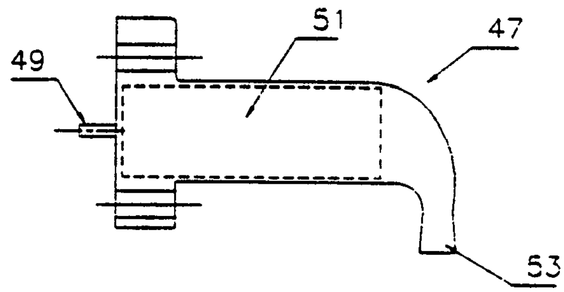

FIG.5

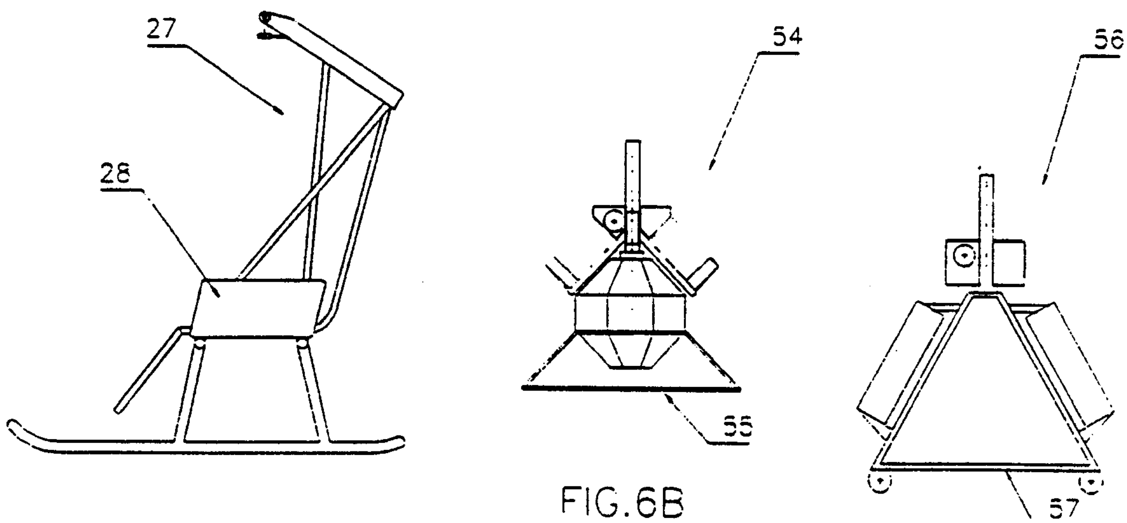

FIG.6A FIG.6B FIG.6C

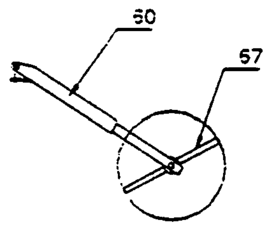

FIG.7

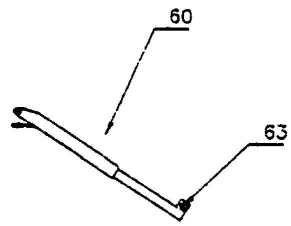

FIG.8

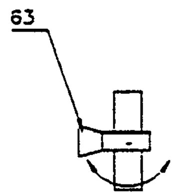

FIG.9

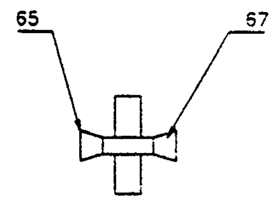

FIG.10

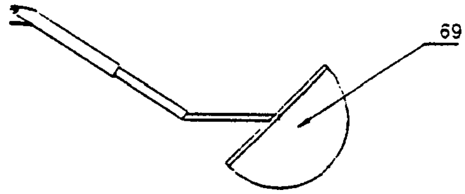

FIG.11

INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/GB 99/01853

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B64C39/02 B64C31/028

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B64C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	FR 2 389 303 A (WESTLAND AIRCRAFT LTD) 24 November 1978 (1978-11-24) page 1, paragraph 1 page 1, line 19 - line 36 page 2, line 11 - line 18 figures ---	1,2,12 7-11
Y	US 4 071 206 A (MAGILL GILBERT W) 31 January 1978 (1978-01-31) cited in the application column 2, line 40 - line 55 column 3, line 59 - line 68 column 5, line 48 - column 6, line 3 figures --- -/--	7-11

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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1 September 1999	07/09/1999

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 478 379 A (KERR JOHN P) 23 October 1984 (1984-10-23) column 2, line 16 - line 23 column 3, line 7 - line 14 figures -----	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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US 4478379	A	23-10-1984	NONE	