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(54) **VERTICAL TAKEOFF AND LANDING AIRCRAFT USING HYBRID ELECTRIC PROPULSION SYSTEM AND CONTROL METHOD THEREFOR**

SENKRECHT STARTENDES UND LANDENDES FLUGZEUG MIT HYBRID-ELEKTRISCHEM ANTRIEBSSYSTEM UND STEUERUNGSVERFAHREN DAFÜR

AÉRONEF À DÉCOLLAGE ET À ATTERRISSAGE VERTICAUX UTILISANT UN SYSTÈME DE PROPULSION ÉLECTRIQUE HYBRIDE ET PROCÉDÉ DE COMMANDE ASSOCIÉ

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Description

FIELD OF THE INVENTION

[0001] The following embodiments relate to a vertical take-off and landing (VTOL) aircraft using a hybrid-electric propulsion system.

DESCRIPTION OF RELATED ART

[0002] A vertical take-off and landing aircraft based on a rotary wing, such as a helicopter, does not need separate takeoff and landing facilities and equipment, but has lower high-speed flight performance, high-altitude performance, and flight endurance performance than an equivalent fixed-wing aircraft.

[0003] Compared to a fixed-wing aircraft for which various propulsion systems-from an electric motor to a jet engine-are possible, a vertical take-off and landing (VTOL) aircraft which depends only on the shaft horsepower of an engine has a limited selection of appropriate propulsion systems as the weight of the aircraft decreases.

[0004] In particular, a reciprocating engine that is widely used in a small aircraft with a maximum takeoff weight (MTOW) of about 10 Kg to about 300 Kg has a very small output-to-weight ratio of about 2. Therefore, in order to supply power needed for vertical take-off and landing, an engine needs to be very bulky, and the propulsion system is excessively heavier compared to an empty weight of the aircraft. Thus, it is difficult to obtain a payload and endurance time required for a mission.

[0005] Therefore, a propulsion system using a battery and an electric motor is widely used in a small aircraft. However, due to limitations of the current technology on batteries with low energy density, it is impossible to provide sufficient endurance time required for a mission.

[0006] A long endurance flight requires an energy source with high specific energy and a power device capable of converting the said energy where as a vertical take-off and landing requires an energy source with high specific power and a device capable of converting the said power.

[0007] However, an energy source or a power generating device with both high specific energy and high specific power doesn't exist, so in general, an energy source and a power generating device with high specific energy are installed in an aircraft.

[0008] Since vertical take-off and landing of an aircraft need much energy, and a propulsion system including a power generating device should be designed to supply sufficient power even during the vertical take-off and landing, such a configuration significantly increases the total weight of the propulsion system beyond the weight needed for a flight, causing an increase in weight of the aircraft and inefficiency of the propulsion system.

[0009] Recent and continuing efforts include utilizing an energy source with high specific energy and an energy source with high specific power at the same time to decrease the weight of the propulsion system, increase efficiency, and provide longer endurance time.

[0010] In addition, with respect to vertical take-off and landing, vertical take-off and landing is a significantly less stable flight method, as understood by the aircraft related parties. Vertical takeoff and landing aircraft inevitably undergo the process of taking off in the vertical direction and transitioning to cruise flight. However, this transition process is significantly less stable and dangerous. In particular, the tiltrotor type vertical take-off and landing aircraft has an inevitable structural problem of tilting their driving source in the air in an unstable manner when the aircraft has yet to reach a stable cruise flight mode.

[0011] For example, in the case of the V-22 Osprey, a typical tiltrotor aircraft operated by the US Marines, there are many cases of crash during the transition after takeoff, and there were even massive demonstrations in Okinawa, Japan, against the deployment of the Osprey due to controversy over its stability. (Refer to "Japan requests US Forces to review the deployment of Osprey in Okinawa," Kyunghyang Shinmun, dated August 5, 2013,
http://news.khan.co.kr/kh_news/khan_art_view.html?art_id=201308052211075, and
"100,000 of public protest in Japan against 'Osprey' [Analysis] Opposition against the deployment of US-made troublemaker, a vertical take-off and landing aircraft, in Okinawa," Pressian, dated September 10, 2012,
http://www.pressian.com/news/article.html/no=64120#09T0) In other words, the public is also aware of the lack of flight stability of the tilting vertical take-off and landing aircraft as compared to many other fixed-wing aircrafts.

[Prior Art Documents]

[Patent Document]

[0012]

- (Patent Document 1) KR 10-2011-0112402 A
- (Patent Document 2) KR 10-1667330 B1
- (Patent Document 3) KR 10-1615486 B1
- (Patent Document 4) KR 10-1638964 B1
- (Patent Document 5) US 2018/178921
- (Patent Document 6) WO 2020/184934
- (Patent Document 7) KR 20180116849
- (Patent Document 8) US 2013/134264

[0013] In particular, patent document 5 discloses an aircraft provided with a hybrid electric propulsion system which comprises an engine which is supplied by a fuel tank to drive a generator. The latter converts the power of the engine into electrical energy which is stored in a battery by means of an electric power controller (comprising an AC/DC electric converter). The battery supplies power, by means of a motor driver to an electric motor which is intended to drive the propellers of the aircraft. In particular, the propulsion system comprises a battery management system (BMS) configured to prevent the overcharging of the battery. The BMS is provided with an electric current measuring unit to detect the electric power that the mort driver receives from the battery, so that the BMS can enable or stop the current supply to the motor by switching a connection unit which connects the battery to the motor driver.

[0014] Patent Document 6 discloses an aircraft provided with a hybrid electric propulsion system which has a first variable pitch control device configured to control a pitch of a lift propeller to generate lift in the aircraft, and a second variable pitch control device configured to control a pitch of a thrust propeller. In particular, the pitch control devices are configured to adjust an angle of attack of the corresponding propellers.

[0015] Patent Document 7 discloses a drone having a propeller which is activated to rotate by a first driving unit (such as an electric motor) that is connected to the hub of the propeller. In particular, the drove is provided with a variable pitch propeller to drive the drone in the take-off and landing operations.

[0016] Patent Document 8 discloses an aircraft having an electric motor to drive the rotor of the aircraft and also an engine to drive a propeller. Further, the gear box of the engine can be connected to the electric motor by means of a clutch.

DETAILED DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

[0017] Thus, the technical problem of this invention is to provide vertical take-off and landing aircraft and the control method using a hybrid-electric propulsion system that can efficiently utilize available energy by solving a large difference in thrust between vertical take-off and landing and cruise flight.

[0018] As implied in the above background, the invention can fundamentally exclude mechanical structures for tilting by avoiding tiltrotor method. This allows the aircraft to increase the flight range instead of reducing the weight. In addition, stable vertical take-off and landing and cruise flight can be implemented by excluding the tilting process of the driving source.

TECHNICAL SOLUTIONS

[0019] The invention is set out in the appended set of claims.

[0020] According to the invention, the present disclosure provides a vertical take-off and landing aircraft using a hybrid-electric propulsion system as defined in claim 1.

[0021] A control method for the vertical take-off and landing aircraft using a hybrid-electric propulsion system is defined in claim 5.

[0022] An alternative vertical take-off and landing aircraft using a hybrid-electric propulsion system is defined in claim 9.

[0023] Optional features of the invention are set out in the dependent claims.

[0024] Details of other embodiments are included in the detailed description and drawings.

EFFECTS OF THE INVENTION

[0025] The hybrid vertical take-off and landing aircraft and the control method according to an embodiment as described above may reduce a power loss even if the power generated from the engine is delivered to the second propeller during vertical take-off and landing by maintaining a feathering state, control the desired thrust by adjusting the angle of attack of the second propeller at the transition mode altitude during transition mode, and generate a necessary thrust by adjusting the angle of attack of the second propeller during cruising flight.

[0026] Also, the hybrid vertical take-off and landing aircraft and the control method according to an embodiment may, with the installation of a clutch unit when a fixed angle of attack propeller is adopted, reduce the power loss by blocking the power delivered from the engine to the second propeller during vertical take-off and landing, adjust the engine thrust by controlling the engine control unit using the clutch unit to deliver the power to the second propeller at the transition mode altitude during transition mode, deliver the power to the second propeller with the clutch unit during cruising flight and distribute and utilize an energy efficiently by aligning the first propeller for vertical take-off and landing with the traveling direction of the aircraft.

[0027] In an embodiment, the first propeller may be used during the aircraft vertical climb or descent for take-off and landing, output power from the engine, generator, and the power management unit may be used simultaneously for the operation of the first propeller to reduce a capacity of the battery, thus battery weight may be reduced, and the weight of the aircraft may be reduced in proportion to the battery reduction.

[0028] Also, the hybrid vertical take-off and landing aircraft and the control method according to an embodiment of the application invention may fundamentally exclude mechanical structures for tilting by avoiding tiltrotor method, through which the weight of the aircraft may be reduced and the flight range may be increased. In addition, stable vertical take-off and landing and cruising flight may be implemented by excluding the tilting process of the driving source. Specifically, the mechanical mechanism by which a conventional tiltrotor aircraft performs tilting is quite complex and flight control difficulties during tilting have reduced flight stability, whereas the hybrid vertical take-off and landing aircraft and the control method according to an embodiment of the application invention may increase the thrust slowly with pitch control of the propeller and perform a stable transition mode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

- FIG. 1 is a diagram for describing a pitch control propeller mounting type of a hybrid vertical take-off and landing aircraft according to an embodiment.
- FIG. 2 is a diagram for describing a clutch unit mounting type of a hybrid vertical take-off and landing aircraft according to an embodiment.
- FIG. 3 is a schematic diagram of a hybrid vertical take-off and landing aircraft according to an embodiment.
- FIG. 4 and FIG. 5 are diagrams showing an example of a hybrid vertical take-off and landing aircraft according to an embodiment.
- FIG. 6 and FIG. 7 are diagrams showing other example of a hybrid vertical take-off and landing aircraft according to an embodiment.
- FIG. 8 and FIG. 9 are diagrams showing another example of a hybrid vertical take-off and landing aircraft according to an embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

[0030] The merits and characteristics of the invention, and a method of achieving them will become apparent with reference to the embodiments described later in detail together with the accompanying drawings.

[0031] Hereinafter, embodiments of the invention will be described in detail with reference to the accompanying drawings. The embodiments described below are illustratively shown to aid understanding of the invention, and it should be understood that the invention may be variously modified and implemented differently from the embodiments described herein. However, when it is determined that a detailed description of a related publication function or component may unnecessarily obscure the subject matter of the invention while describing the invention, the detailed description and detailed diagrams thereof will be omitted. In addition, the accompanying drawings may not be drawn to scale to aid understanding of the invention, and the sizes of some components may be overstated.

[0032] Terms such as first and second may be used to describe various components, but the components may not be limited by the terms. The terms may only be used for the purpose of distinguishing one component from other components. For example, without departing from the scope of the rights of the invention, a first component may be named as a second component, and similarly, a second component may be named as a first component.

[0033] The terms to be described later are those established in consideration of functions in the invention, which may vary according to the intention or practice of the manufacturer, the definition should be made based on the contents throughout the specification.

[0034] The same reference symbol refers to the same component throughout the specification.

[0035] Hereinafter, a hybrid vertical take-off and landing aircraft and the control method according to an embodiment is described with reference to FIG. 1 to 5. FIG. 1 is a diagram for describing a pitch control propeller mounting type of a hybrid vertical take-off and landing aircraft according to an embodiment.

[0036] A hybrid vertical take-off and landing aircraft according to an embodiment is configured, including an aircraft (1), an engine (10), a generator (20), a power management unit (40), a battery management system (60), a motor (80), a first and second propeller (81, 82) and a control unit (50).

[0037] The aircraft (1) may be a configuration having a fixed-wing (4) on a body (2) as shown in FIG. 4 to 9.

[0038] The engine (10) may be installed on the aircraft (1), more specifically on the fixed-wing (4) and may generate power by burning fuel.

[0039] The generator (20, ISG: Integrated starter generator) may be connected to the engine (10) and may generate power by operating with engine output.

[0040] The generator (20) may also function as a starter, and thus, which in turn provides power to the generator (20) to start the engine (10).

[0041] The power management unit (40, PMU: Power Management Unit) may manage the power, in more detail, may manage generated power, dump power, and battery charging power.

[0042] The battery management system (60) may be configured including a primary battery (62) and the power supplied from the power management unit (40) may be charged to the primary battery (62).

[0043] The motor (80) may be installed on the fixed-wing (4) or the body (2), and may be operated by receiving power from the battery management system (60).

[0044] The first propeller (81) may be operated by the motor (80). The first propeller (81) may be installed in a vertical direction and may be installed to tilt to an appropriate slope, depending on the flight purpose of the aircraft (1).

[0045] The second propeller (82) may be operated by the engine (10).

[0046] As shown in FIG. 1, the second propeller (82) may be equipped with a pitch control unit (100), and the angle of attack of the second propeller (82) may be adjusted with pitch control unit (100).

[0047] As shown in FIG. 2, a clutch unit (102) is positioned between the engine (10) and the second propeller (82), and the clutch unit (102) is configured to disconnect or connect power from the engine (10) to the second propeller (82).

[0048] The control unit (50) is configured to control the operation of the engine (10), the generator (20), the motor (80), and the second propeller (82).

[0049] The control unit (50) may be implemented by an engine control unit (30), the power management unit (40), a master control unit, an aviation control system

(90), and a flight control computer (FCC).

[0050] The engine control unit (30) may control the number of revolutions of the engine (10) and, more specifically, may control the output of the engine (10) by opening and closing the throttle servo (12).

[0051] The master control unit may collectively control the aircraft (1), and the aviation control system (90) and the flight control unit may control the operation of the aircraft (1), for example, It may be used to control speed, pressure, communication, and attitude of the aircraft.

[0052] The control unit (50) may control the motor (80) to simultaneously supply power from the above generator (20) and the power management unit (40) and the battery management system (60) to the motor (80) during the aircraft (1) vertical take-off and landing.

[0053] The hybrid vertical take-off and landing aircraft according to an embodiment of the invention configured as described above may use the first propeller (81) during the aircraft (1) vertical climb or descent for take-off and landing, and reduce battery capacity by simultaneously using power output from the engine (10), generator (20), and the power management unit (40) to operate the first propeller (81).

[0054] Accordingly, the hybrid vertical take-off and landing aircraft according to an embodiment may reduce the weight of the battery and reduce the weight of the aircraft in proportion to the battery reduction.

[Description of Symbol]

[0055]

- 1: Aircraft 2: Body
- 4: Fixed-wing 10: Engine
- 12: Throttle Servo 14: Fuel System
- 20: Generator 22: Sensor
- 30: Engine Control Unit 40: Power Management Unit
- 50: Master Control Unit 60: Battery Management System
- 62, 94: First and Second Battery 70: Electronic Speed Control Unit
- 72: Power Line 74: Load Detection Line
- 80: Motor 81, 82: First and Second Propeller
- 90: Aviation Control System 92: Control Actuator
- 94: Second Battery 100: Pitch Control Unit
- 102: Clutch Unit

MODE(S) FOR CARRYING OUT THE INVENTION

[0056] Hereinafter, an example of electronic control of a control unit (50) will be described with reference to FIG. 1.

[0057] A hybrid vertical take-off and landing aircraft according to an embodiment uses a first propeller (81) during vertical take-off and landing. First, an engine (10) receives fuel from a fuel system (14) according to the control of an engine control unit (30) and outputs power.

[0058] A generator (20) may be controlled by a control unit (50), and may be operated by the power to produce electricity.

[0059] The power generated by the generator (20) may be managed by a power management unit (40), for example, it may be distributed to those that require power, monitored whether the power is overproduced, and may be controlled to reduce engine (10) output through the engine control unit (30) when the power is overproduced.

[0060] The power management unit (40) may provide power to a battery management system (60), the battery management system (60) may charge some power to a first battery (62) and some other power to the motor (80).

[0061] The hybrid vertical take-off and landing aircraft according to an embodiment is equipped with multiple number of motor (80) and an electronic speed control unit (70) per motor (80).

[0062] Each of the electronic speed control unit (70) receives power from the battery management system (60), and each of the electronic speed control devices (70) individually controls the speed of each motor (80) under the command of the control unit (50) or an aviation control system (90), and stabilize the attitude of the aircraft (1).

[0063] A pitch control unit (100) may adjust the angle of attack of a second propeller (82) even if the second propeller (82) is operated by connected to the engine (10) and maintain the blade of the second propeller parallel to the traveling direction of the aircraft. In other words, the angle of attack is brought close to 90 degrees, thereby reducing power loss generated by the engine (10) even when the second propeller (82) is operated.

[0064] Also, the pitch control unit (100) may adjust the angle of attack of a second propeller (82) even if the second propeller (82) is operated by connected to the engine (10) and maintain the blade of the second propeller vertical to the traveling direction of the aircraft. In other words, the angle of attack is brought close to 0 degrees, thereby reducing power loss generated by the engine (10) even when the second propeller (82) is operated.

[0065] By controlling the pitch control unit (100), the control unit (50) may be controlled to reduce the thrust of the second propeller (82) does not affect the flight of the aircraft (1) by any chance during vertical take-off and landing. More specifically, the angle of attack of the second propeller (82) may be controlled to be close to 0 degrees, whereby the thrust by the second propeller (82) becomes "0", which may not affect the flight of the aircraft (1). Thereafter, by adjusting the angle of attack of the second propeller (82) to have a positive value, gradual thrust may be obtained. Since the angle of attack of the second propeller (82) is close to "0", even if the second propeller rotates with the maximum power of the engine, no thrust is generated, and the maximum power generated by the engine may be used for power generation. In addition, with regard to flight stability and obtaining gradual thrust, adjusting the angle of attack of the second propeller (82) to a positive value near 0 degrees may be preferable to reducing the value near 90 degrees.

[0066] The hybrid vertical take-off and landing aircraft according to an embodiment may use the second propeller (82) when performing a transition mode or a cruising flight.

[0067] The hybrid vertical take-off and landing aircraft according to an embodiment may adjust the desired thrust by adjusting the angle of attack of the second propeller (82) at the transition mode altitude during transition mode.

[0068] Similarly, the hybrid vertical take-off and landing aircraft according to an embodiment may generate the necessary thrust by adjusting the angle of attack of the second propeller (82) during cruising flight.

[0069] More specifically, the hybrid vertical take-off and landing aircraft according to an embodiment during transition mode between vertical take-off and landing or cruising flight may gain thrust gradually by adjusting the angle of attack of the second propeller (82) slowly from 80 to 90 degrees or near 0 degrees angle to around 25 degrees. This allows the aircraft according to the invention to slowly and safely enter the cruising flight from the transition mode, and may dramatically reduce the problem of traditional tiltrotor aircraft having poor flight stability during transition mode. Furthermore, when adjusting the thrust with the pitch control as described above and controlling the power connection between the engine and the second propeller with the clutch, it is possible to avoid wear of the clutch, which may occur when the clutch is excessively used to adjust the rotational speed of the second propeller.

[0070] Furthermore, in an embodiment, the aircraft may gain a thrust reversal by adjusting the angle of attack of the second propeller (82) to have a negative value. The aircraft thereby may take-off and land against the tail wind blowing forward from the rear of the aircraft during vertical take-off and landing in a stable manner.

[0071] Also, in an embodiment, the aircraft may control the pitch for each of the multiple of second propellers (82), thereby the pitch value of the second propeller may be adjusted differently in the vertical take-off and hovering state, allowing loitering in the air and changing the traveling direction.

[0072] In this way, the hybrid vertical take-off and landing aircraft may actively adjust the angle of attack of each second propeller (82) to have a negative or positive value at 0 degrees, thereby achieving a stable take-off and landing and increasing flight stability during the vertical take-off to transition climb stage and from the descent transition to vertical landing stage. This will prevent the induction motion sickness of passengers inside the aircraft in vertical take-off and landing. This prevents motion sickness and so on among passengers inside the aircraft. The above effects are examples, and it is evident that the effects of this invention are not limited thereto.

[0073] Furthermore, a wind direction or wind volume sensor (not illustrated) may be fixed at a prescribed position of the fixed-wing (4) of the vertical take-off and landing aircraft. Preferably, the wind direction or wind volume sensor may be fixed at the end of the fixed-wing (4) to provide sensing of the degree of wind blowing from which side relative to the aircraft, and the angle of attack of each second propeller (82) may be actively adjusted to provide stable vertical take-off and landing.

[0074] Assuming a drag ratio of 10 when the aircraft (1) is in flight, the thrust required for cruising may be one-tenth the level of a vertical climb or vertical descent, and approximately one-fifth the level of acceleration or dash flight.

[0075] In other words, a lot of energy is required during the aircraft (1) vertical climb or descent, but energy consumption may be relatively low when the aircraft (1) is in transition mode or cruising flight, resulting in dump energy. The dump energy may be electric energy, and such dump power may be charged to the first battery (62).

[0076] The control unit (50) may increase the thrust of the second propeller (82) when the aircraft (1) is in a cruising flight or transition mode, and the dump power generated by the generator (20) may be controlled to be charged in the first battery (62) of the battery management system (60). The charging of the first battery (62) may further increase the flight time of the aircraft (1).

[0077] The aircraft in an embodiment may use both the first propeller (81) and the second propeller (82) during the transition mode, and the ratio of the electric energy supplied to the first propeller (81) and the mechanical energy supplied to the second propeller (82) according to the flight type may be controlled by the control unit (50).

[0078] Also, the aircraft in an embodiment may be equipped with a clutch unit when a fixed angle of attack propeller is adopted, which will be described with reference to FIG. 2. FIG. 2 is a diagram for describing a clutch unit mounting type of a hybrid vertical take-off and landing aircraft according to an embodiment.

[0079] The control unit (50) is configured to control the operation of the clutch unit to disconnect the power connection between the engine (10) and the second propeller (82) of the aircraft (1) during the vertical take-off and landing.

[0080] In an embodiment, the clutch unit (102) may be operated during the aircraft (1) vertical take-off and landing, may block the power from the engine (10) to the second propeller (82), thereby reducing power loss. The control unit (50) is configured to control the operation of the clutch unit (102).

[0081] Also, all of the mechanical energy generated by the engine (10) may be supplied to the generator (20) to increase the electricity generation, which may enable a large capacity and stable power supply to the motor (80). Furthermore, since the first propeller (81) is operated in a good manner with the stable operation of the motor (80), vertical climb or vertical descent of the aircraft (1) may be implemented more smoothly.

[0082] Each motor (80) is equipped with the electronic speed control unit (70).

[0083] Each of the electronic speed control units (70) receives power from the battery management system (60), and each of the electronic speed control units (70) individually controls the speed of each motor (80) under the command of the control unit (50) or the aviation control system (90), and stabilize the attitude of the aircraft (1).

[0084] During the transition mode, the clutch unit (102) may be operated at the transition mode altitude to connect the engine (10) and the second propeller (82) to allow the second propeller (82) to increase the thrust. The engine (10) may control the engine control unit (30) to adjust the engine output, and may deliver the power of the engine (10) to the second propeller (82) with the clutch unit (102) during cruising flight.

[0085] In an embodiment, the first propeller (81) may be tilted to coincide with the traveling direction of the aircraft during cruising flight, thereby efficiently distributing and using energy.

[0086] FIG. 3 is a schematic diagram of a hybrid vertical take-off and landing aircraft according to an embodiment. Descriptions that are redundant with the technical description will be omitted.

[0087] The engine (10) may be equipped with the pitch control unit (100) or clutch unit (102).

[0088] The pitch control unit (100) is configured to adjust the angle of attack of the second propeller (82), and the clutch unit (102) is configured to disconnect or connect the power delivered from the engine (10) to the second propeller (82). Both clutch unit (102) and pitch control unit (100) may be equipped together (not illustrated).

[0089] The generator (20) is further equipped with a sensor (22), and the sensor (22) is connected to the power management unit (40). The sensor (22) monitors the generator (20), and the control unit (50) determines whether the current power generation is appropriate based on the first detection value.

[0090] The control unit (50) may control the opening of the throttle servo (12) through the engine control unit (30) in the event of insufficient power production, thereby increasing the number of engine rotations.

[0091] Conversely, when the power is overproduced, the control unit (50) may control the throttle servo (12) to close through the engine control device (30), thereby reducing the number of engine rotations.

[0092] In the hybrid vertical take-off and landing aircraft according to an embodiment, several motors (80) are installed, and then electronic speed control unit (70) is equipped for each motor (80). Each electronic speed control unit (70) individually controls the speed of each motor (80) according to the command of the control unit (50), thereby stabilizing the attitude of the aircraft (1).

[0093] Also, the first battery (62) of the battery management system (60) supplies power to each electronic speed control unit (70). On the other hand, each electronic speed control unit (70) receives power by being connected to the second battery (94) through a power line (72).

[0094] The second battery (94) may provide power to drive the control actuator (92). The control actuator (92) may be driven by receiving a command from the aviation control system (90). The control actuator (92) can operate various apparatus required for flight of the aircraft (1), for example, can operate a rotary wing or a tail wing. The second battery (94) may be charged with electricity from the power management unit (40).

[0095] A load of the power line (72) varies depending on the power consumption of each electronic speed control unit (70). A load detection line (74) is connected to the power line (72), and the load detection line (74) detects a load value formed on the power line (72) as a second detection value, and is provided to the power management unit (40) or the control unit (50).

[0096] When the second detection value increases, it is be determined that power consumption increases, and in this case, the control unit (50) controls to increase the engine output of the engine (10). On the other hand, when the second detection value decreases, it is determined that power consumption decreases, and the engine output of the engine (10) is controlled to decrease.

[0097] In an embodiment, the aircraft may detect the power consumed to operate the first propeller (81) in real time and control the engine output of the engine (10) to generate optimum power.

[0098] Hereinafter, various embodiments of the hybrid vertical take-off and landing aircraft according to an embodiment will be described with reference to FIG. 4 to 9.

[0099] FIG. 4 and FIG. 5 are diagrams showing an example of a hybrid vertical take-off and landing aircraft according to an embodiment. FIG. 4 is a plan view of the aircraft (1), and FIG. 5 is a side view of the aircraft (1).

[0100] As shown in FIG. 4 and FIG. 5, fixed-wings (4) may be provided on both front sides of the body (2), motors (80) may be installed approximately perpendicular to the front and rear of the body (2), each motor (80) may be installed with the first propeller (81), the engine (10) can be installed horizontally on both fixed-wings (4), and each engine (10) may be installed with the second propeller (82).

[0101] FIG. 6 and FIG. 7 are diagrams showing other example of a hybrid vertical take-off and landing aircraft according to an embodiment. FIG. 6 is a plan view of the aircraft (1), and FIG. 7 is a side view of the aircraft (1).

[0102] As shown in FIG. 6 and FIG. 7, fixed-wings (4) may be provided on both sides of the body (2), motors (80) may be installed approximately perpendicular to the front and rear of the body (2), each motor (80) may be installed with the first propeller (81), the engine (10) can be installed horizontally on both fixed-wings (4), and each engine (10) may be installed with the second propeller (82). In addition, the engine (10) and the second propeller (82) may be further installed at the rear of the aircraft (1).

[0103] FIG. 8 and FIG. 9 are diagrams showing another example of a hybrid vertical take-off and landing aircraft according to an embodiment. FIG. 8 is a plan view of the aircraft (1), and FIG. 9 is a side view of the aircraft (1).

[0104] As shown in FIG. 8 and FIG. 9, fixed-wings (4) may be provided on both rear sides of the body (2), motors (80) may be installed approximately perpendicular to the front and rear of the body (2), each motor (80) may be installed with the first propeller (81), the engine (10) can be installed horizontally on both fixed-wings (4), and each engine (10) may be installed with the second propeller (82).

[0105] The hybrid vertical take-off and landing aircraft according to an embodiment may be applicable even if the structure of the aircraft (1) varies, as described with reference to FIG. 4 to 9.

[0106] Although the embodiments of the invention have been described with reference to the accompanying drawings, those skilled in the art to which the invention pertains will understand that the invention may be implemented in other specific forms without changing the technical idea or essential features.

INDUSTRIAL APPLICABILITY

[0107] The hybrid vertical take-off and landing aircraft and the control method according to an embodiment of the invention may be used to control flights such as vertical take-off and landing, transition mode, and cruising flight.

[0108] Accordingly, the invention may be used to provide vertical take-off and landing aircraft and the control method using a hybrid-electric propulsion system that can efficiently utilize available energy by solving a large difference in thrust between vertical take-off and landing and cruise flight.

[0109] Also, the invention can fundamentally exclude mechanical structures for tilting by avoiding tiltrotor method. This allows the aircraft to increase the flight range instead of reducing the weight. The invention may also be used to implement stable vertical take-off and landing and cruising flight by excluding the tilting process of the driving source.

Claims

1. A vertical take-off and landing aircraft using a hybrid-electric propulsion system comprising:

a body (2) wherein a fixed-wing (4) is arranged on the body (2);
an engine (10) installed on the aircraft (1) and configured to generate power by burning fuel;
a generator (20) configured to use the power generated by the engine (10) to generate electric power;
a power management unit (40) configured to distribute and provide the electrical power to each component of the aircraft;
a battery management system (60) configured to receive power from the power management unit (40) and configured to charge a first battery (62);
multiple motors (80) arranged on the fixed-wing (4) and configured to receive power from the battery management system (60);
a first propeller (81) configured to be operated by the corresponding motor (80);
a second propeller (82) configured to be operated by the engine (10);
a control unit (50) configured to control the operation of the engine (10), the generator (20), the motor (80), and the second propeller (82);
an electronic speed control unit (70) equipped for each motor (80) and configured to individually control the speed of each motor (80) according to the command of the control unit (50);
wherein the first battery (62) of the battery management system (60) is configured to supply power to each electronic speed control unit (70);
wherein
the control unit (50) configured to control the power to be supplied to the motor (80) simultaneously from the generator (20) and the power management unit (40) and the battery management system (60) during the vertical take-off and landing of the aircraft (1); and
the motor (80) arranged on the fixed-wing (4) and configured to facilitate the first propeller (81) to generate thrust in a first direction;
the engine (10) arranged on the aircraft (1) and configured to facilitate the second propeller (82) to generate thrust in a second direction;
the first direction and the second direction being configured to be not identical directions to each other;
characterized in that
said vertical take-off and landing aircraft using a hybrid-electric propulsion system further comprises a pitch control unit (100) configured to adjust the angle of attack of the blades of the second propeller (82) to generate a desired thrust during the vertical take-off and landing of the aircraft;
wherein the generator (20) is equipped with a sensor (22), the sensor (22) being connected to the power management unit (40) and being configured to monitor the generator (20), wherein the control unit (50) is configured to determine whether the current power generation is appropriate based on a first detection value;
wherein each electronic speed control unit (70) is configured to receive power by being connected to a second battery (94) through a power line (72);
wherein the power line (72) has a load that varies depending on the power consumption of each electronic speed control unit (70);
wherein said vertical take-off and landing aircraft using a hybrid-electric propulsion system further

comprises a load detection line (74) connected to the power line (72), the load detection line (74) being configured to detect a load value formed on the power line (72) as a second detection value, which is provided to the power management unit (40) or the control unit (50); so that, when the second detection value increases, it is determined that power consumption increases and the control unit (50) is configured to control to increase the engine output of the engine (10), when the second detection value decreases, it is determined that power consumption decreases, and the engine output of the engine (10) is configured to be controlled to decrease.

2. The vertical take-off and landing aircraft using a hybrid-electric propulsion system of the claim 1, wherein the control unit (50) configured to reduce and control the thrust of the second propeller (82) so as not to affect the flight of the aircraft (1) by any chance during the vertical take-off and landing of the aircraft (1).

3. The vertical take-off and landing aircraft using a hybrid-electric propulsion system of the claim 1, wherein the control unit (50) configured to control and disconnect the power connection between the engine (10) and the second propeller (82) during the vertical take-off and landing of the aircraft (1).

4. The vertical take-off and landing aircraft using a hybrid-electric propulsion system of the claim 1, wherein the control unit (50) configured to increase the thrust of the second propeller (82) during cruising flight or transition mode of the aircraft (1), and the dump power generated by the generator (20) is controlled to be charged in the battery (62) of the battery management system (60).

5. A control method for the vertical take-off and landing aircraft using a hybrid-electric propulsion system comprising:

a first step in which a power is generated by burning fuel with an engine (10);
a second step in which an electrical power is generated by operating a generator (20) with the power of the engine (10);
a third step in which the electrical power is distributed and provided to each component of the aircraft (1) by a power management unit (40);
a fourth step in which a portion of the electrical power is used to charge a first battery (62) of a battery management system (60);
a fifth step of operating a first propeller (81) with a motor (80);
and

a control unit (50) being configured to control the power to be supplied to the motor (80) simultaneously from the generator (20) and the power management unit (40), and the battery management system (60) during the vertical take-off and landing of the aircraft (1); and
the motor (80) being arranged on the fixed-wing (4) and configured to facilitate a first propeller (81) to generate thrust in a first direction; and
the engine (10) being arranged on the aircraft (1) and configured to facilitate a second propeller (82) to generate thrust in a second direction;
the first direction and the second direction being configured to be not identical directions to each other; and
wherein an electronic speed control unit (70), equipped for each motor (80), individually controls the speed of each motor (80) according to the command of the control unit (50); wherein the first battery (62) of the battery management system (60) supplies power to each electronic speed control unit (70);
said control method being **characterized in that**:

a pitch control unit (100) being configured to adjust the angle of attack of the blades of the second propeller (82) to generate a desired thrust during the vertical take-off and landing of the aircraft (1);
wherein with a sensor (22), equipped to the generator (20) and connected to the power management unit (40), monitors the generator (20), wherein the control unit (50) determines whether the current power generation is appropriate based on a first detection value;
wherein each electronic speed control unit (70) receives power by being connected to a second battery (94) through a power line (72); wherein a load of the power line (72) varies depending on the power consumption of each electronic speed control unit (70);
a load detection line (74), connected to the power line (72), detects a load value formed on the power line (72) as a second detection value, which is provided to the power management unit (40) or the control unit (50);
so that, when the second detection value increases, it is determined that power consumption increases and the control unit (50) controls to increase the engine output of the engine (10), when the second detection value decreases, it is determined that power consumption decreases, and the engine output of the engine (10) is controlled to decrease.

6. The control method of the claim 5, wherein the thrust of the second propeller (82) does not affect the flight of the aircraft (1) by any chance during the vertical take-off and landing of the aircraft (1).

7. The control method of the claim 6, wherein the control unit (50) is configured to control and disconnect the power connection between the engine (10) and the second propeller (82) during the vertical take-off and landing of the aircraft (1).

8. The control method of the claim 6, wherein the thrust of the second propeller (82) is configured to increase during cruising flight or transition mode of the aircraft (1), and the dump power generated by the generator (20) is controlled to be charged in the battery (62) of the battery management system (60).

9. A vertical take-off and landing aircraft using a hybrid-electric propulsion system comprising:

a body (2) wherein a fixed-wing (4) is arranged on the body (2);
an engine (10) installed on the aircraft (1) and configured to generate power by burning fuel;
a generator (20) configured to use the power generated by the engine (10) to generate electric power;
a power management unit (40) configured to distribute and provide the electrical power to each component of the aircraft;
a battery management system (60) configured to receive power from the power management unit (40) and configured to charge a first battery (62);
a motor (80) arranged on the fixed-wing (4) and configured to receive power from the battery management system (60);
a first propeller (81) configured to be operated by the motor (80);
a second propeller (82) configured to be operated by the engine (10);
a control unit (50) configured to control the operation of the engine (10), the generator (20), the motor (80), and the second propeller (82);
an electronic speed control unit (70) equipped for each motor (80) and configured to individually control the speed of each motor (80) according to the command of the control unit (50); wherein the first battery (62) of the battery management system (60) is configured to supply power to each electronic speed control unit (70); and
the control unit (50) configured to control the power to be supplied to the motor (80) simultaneously from the generator (20) and the power management unit (40) and the battery management system (60) during the vertical take-off and landing of the aircraft (1);
and
the motor (80) arranged on the fixed-wing (4) and configured to facilitate the first propeller (82) to generate thrust in a first direction;
the engine (10) arranged on the aircraft (1) and configured to facilitate the second propeller (81) to generate thrust in a second direction;
the first direction and the second direction being configured to be not identical directions to each other; and

characterized in that

said vertical take-off and landing aircraft using a hybrid-electric propulsion system further comprises a clutch unit (102) positioned between the engine (10) and the second propeller (82) and configured to disconnect or connect the power delivered from the engine (10) to the second propeller (82);
wherein the control unit (50) is configured to control the operation of the clutch unit (102);
wherein the control unit (50) is configured to control the power connection between the engine (10) and the second propeller (82) during the aircraft (1) take-off and landing through the clutch unit (102);
wherein the generator (20) is equipped with a sensor (22), the sensor (22) being connected to the power management unit (40) and being configured to monitor the generator (20), wherein the control unit (50) is configured to determine whether the current power generation is appropriate based on a first detection value;
wherein each electronic speed control unit (70) is configured to receive power by being connected to a second battery (94) through a power line (72);
wherein the power line (72) has a load that varies depending on the power consumption of each electronic speed control unit (70);
wherein said vertical take-off and landing aircraft using a hybrid-electric propulsion system further comprises a load detection line (74) connected to the power line (72), the load detection line (74) being configured to detect a load value formed on the power line (72) as a second detection value, which is provided to the power management unit (40) or the control unit (50);
so that, when the second detection value increases, it is determined that power consumption increases and the control unit (50) is configured to control to increase the engine output of the engine (10), when the second detection value decreases, it is determined that power consumption decreases, and the engine output of the engine (10) is configured to be controlled to decrease.

Patentansprüche

1. Senkrecht startendes und landendes Flugzeug mit hybrid-elektrischem
Antriebssystem, umfassend:

einen Körper (2), wobei ein Starrflügel (4) auf dem Körper (2) angeordnet ist;
ein Triebwerk (10), das auf dem Flugzeug (1) installiert und darauf ausgelegt ist, durch Verbrennen von Kraftstoff Energie zu erzeugen;
einen Generator (20), der darauf ausgelegt ist, die von dem Triebwerk (10) erzeugte Energie zu verwenden, um Strom zu erzeugen;
eine Energiemanagementeinheit (40), die darauf ausgelegt ist, den Strom an alle Bauteile des Flugzeugs zu verteilen und diese damit zu versorgen;
ein Batteriemanagementsystem (60), das darauf ausgelegt ist, Energie von der Energiemanagementeinheit (40) zu erhalten und darauf ausgelegt ist, eine erste Batterie (62) zu laden;
mehrere Motoren (80), die auf dem Starrflügel (4) angeordnet und darauf ausgelegt sind, Energie von dem Batteriemanagementsystem (60) zu erhalten;
einen ersten Propeller (81), der darauf ausgelegt ist, von dem entsprechenden Motor (80) betrieben zu werden;
einen zweiten Propeller (82), der darauf ausgelegt ist, von dem Triebwerk (10) betrieben zu werden;
ein Steuergerät (50), das darauf ausgelegt ist, den Betrieb des Triebwerks (10), des Generators (20), des Motors (80) und des zweiten Propellers (82) zu steuern;
einen elektronischen Drehzahlregler (70), der für jeden Motor (80) eingebaut und darauf ausgelegt ist, die Drehzahl jedes Motors (80) entsprechend des Steuerbefehls des Steuergeräts (50) individuell zu steuern; wobei die erste Batterie (62) des Batteriemanagementsystems (60) darauf ausgelegt ist, jeden elektronischen Drehzahlregler (70) mit Energie zu versorgen;
wobei
das Steuergerät (50) darauf ausgelegt ist, die dem Motor (80) zuzuführende Energie während des senkrechten Startens und Landens des Flugzeugs (1) gleichzeitig über den Generator (20) und die Energiemanagementeinheit (40) und das Batteriemanagementsystem (60) zu steuern; und
der Motor (80) auf dem Starrflügel (4) angeordnet und darauf ausgelegt ist, es dem ersten Propeller (81) zu erleichtern, in einer ersten Richtung Schub zu erzeugen;
der Motor (10) auf dem Flugzeug (1) angeordnet und darauf ausgelegt ist, es dem zweiten Propeller (82) zu erleichtern, in einer zweiten Richtung Schub zu erzeugen;
wobei die erste Richtung und die zweite Richtung darauf ausgelegt sind, nicht miteinander identische Richtungen zu sein;
dadurch gekennzeichnet, dass
das genannte senkrecht startende und landende Flugzeug mit hybrid-elektrischem Antriebssystem außerdem eine Blattverstellsteuerung (100) umfasst, die darauf ausgelegt ist, den Anstellwinkel der Blätter des zweiten Propellers (82) anzupassen, um während des senkrechten Startens und Landens des Flugzeugs einen gewünschten Schub zu erzeugen;
wobei der Generator (20) mit einem Sensor (22) ausgestattet ist, wobei der Sensor (22) an die Energiemanagementeinheit (40) angeschlossen und darauf ausgelegt ist, den Generator (20) zu überwachen, wobei das Steuergerät (50) darauf ausgelegt ist, basierend auf einem ersten Erfassungswert zu bestimmen, ob die Stromerzeugung angemessen ist;
wobei jeder elektronische Drehzahlregler (70) darauf ausgelegt ist, durch Anschluss an eine zweite Batterie (94) über eine Stromleitung (72) Energie zu erhalten;
wobei die Stromleitung (72) eine Last aufweist, die abhängig vom Stromverbrauch jedes elektronischen Drehzahlreglers (70) variiert;
wobei das senkrecht startende und landende Flugzeug mit hybrid-elektrischem Antriebssystem außerdem eine an die Stromleitung (72) angeschlossene Lasterkennungsleitung (74) umfasst, wobei die Lasterkennungsleitung (74) darauf ausgelegt ist, einen auf der Stromleitung (72) entstandenen Lastwert als einen zweiten Erfassungswert zu erkennen, der der Energiemanagementeinheit (40) oder dem Steuergerät (50) zur Verfügung gestellt wird;
so dass, wenn sich der zweite Erfassungswert erhöht, festgestellt wird, dass der Stromverbrauch steigt und das Steuergerät (50) die Steigerung der Triebwerkleistung des Triebwerks (10) steuert, so dass die Triebwerkleistung sich erhöht, und, wenn der zweite Erfassungswert sich verringert, festgestellt wird, dass der Stromverbrauch abnimmt und das Steuergerät die Reduzierung der Triebwerkleistung des Triebwerks (10) steuert.

2. Senkrecht startendes und landendes Flugzeug mit hybrid-elektrischem Antriebssystem nach Anspruch 1, wobei das Steuergerät (50) darauf ausgelegt ist, den Schub des zweiten Propellers (82) so zu verringern und zu steuern, dass der Flug des Flugzeugs (1) während des senkrechten Startens und Landens des Flugzeugs (1) in keiner Weise beeinträchtigt wird.

3. Senkrecht startendes und landendes Flugzeug mit hybrid-elektrischem Antriebssystem nach Anspruch 1, wobei das Steuergerät (50) darauf ausgelegt ist, die Stromverbindung zwischen dem Triebwerk (10) und dem zweiten Propeller (82) während des senkrechten Startens und Landens des Flugzeugs (1) zu steuern und zu unterbrechen.

4. Senkrecht startendes und landendes Flugzeug mit hybrid-elektrischem Antriebssystem nach Anspruch 1, wobei das Steuergerät (50) darauf ausgelegt ist, den Schub des zweiten Propellers (82) während des Reiseflugs oder des Übergangsbetriebs des Flugzeugs (1) zu steigern und die vom Generator (20) erzeugte überschüssige Leistung gesteuert wird, um in die Batterie (62) des Batteriemanagementsystems (60) geladen zu werden.

5. Steuerungsverfahren für das senkrecht startende und landende Flugzeug mit hybrid-elektrischem Antriebssystem, umfassend:

einen ersten Schritt, bei dem eine Leistung durch Verbrennen von Kraftstoff mit einem Triebwerk (10) erzeugt wird;
einen zweiten Schritt, bei dem Strom durch den Betrieb eines Generators (20) mit der Leistung des Triebwerks (10) erzeugt wird;
einen dritten Schritt, bei dem der Strom an alle Bauteile des Flugzeugs (1) mittels der Energiemanagementeinheit (40) verteilt und zur Verfügung gestellt wird;
einen vierten Schritt, bei dem ein Teil des Stroms dazu verwendet wird, eine erste Batterie (62) eines Batteriemanagementsystems (60) zu laden;
einen fünften Schritt des Betriebs eines ersten Propellers (81) mit einem Motor (80); und
ein Steuergerät (50), das darauf ausgelegt ist, die dem Motor (80) zuzuführende Energie während des senkrechten Startens und Landens des Flugzeugs (1) gleichzeitig über den Generator (20) und die Energiemanagementeinheit (40) und das Batteriemanagementsystem (60) zu steuern; und
wobei der Motor (80) auf dem Starrflügel (4) angeordnet und darauf ausgelegt ist, es einem ersten Propeller (81) zu erleichtern, in einer ersten Richtung Schub zu erzeugen; und
wobei der Motor (10) auf dem Flugzeug (1) angeordnet und darauf ausgelegt ist, es dem zweiten Propeller (82) zu erleichtern, in einer zweiten Richtung Schub zu erzeugen;
wobei die erste Richtung und die zweite Richtung darauf ausgelegt sind, nicht miteinander identische Richtungen zu sein; und
wobei ein elektronischer Drehzahlregler (70), der für jeden Motor (80) eingebaut ist, die Drehzahl jedes Motors (80) entsprechend des Steuerbefehls des Steuergeräts (50) individuell steuert; wobei die erste Batterie (62) des Batteriemanagementsystems (60) jeden elektronischen Drehzahlregler (70) mit Energie versorgt;
wobei das genannte Steuerungsverfahren **dadurch gekennzeichnet ist, dass**:

eine Blattverstellsteuerung (100) darauf ausgelegt ist, den Anstellwinkel der Blätter des zweiten Propellers (82) anzupassen, um während des senkrechten Startens und Landens des Flugzeugs einen gewünschten Schub zu erzeugen (1);
wobei mit einem in den Generator (20) eingebauten Sensor (22), der an die Energiemanagementeinheit (40) angeschlossen ist, der Generator (20) überwacht wird, wobei das Steuergerät (50), basierend auf einem ersten Erfassungswert bestimmt, ob die Stromerzeugung angemessen ist;
wobei jeder elektronische Drehzahlregler (70) Energie durch den Anschluss an eine zweite Batterie (94) mittels einer Stromleitung (72) erhält; wobei eine Last der Stromleitung (72) abhängig vom Stromverbrauch jedes elektronischen Drehzahlreglers (70) variiert;
Wobei eine Lasterkennungsleitung (74), die an die Stromleitung (72) angeschlossen ist, einen auf der Stromleitung entstandenen Lastwert (72) als einen zweiten Erfassungswert erkennt, der der Energiemanagementeinheit (40) oder dem Steuergerät (50) zur Verfügung gestellt wird;
so dass, wenn sich der zweite Erfassungswert erhöht, festgestellt wird, dass der Stromverbrauch steigt und das Steuergerät (50) die Steigerung der Triebwerkleistung des Triebwerks (10) steuert, und, wenn der zweite Erfassungswert abnimmt, festgestellt wird, dass der Stromverbrauch sinkt und die Verringerung der Triebwerkleistung des Triebwerks (10) gesteuert wird.

6. Steuerungsverfahren nach Anspruch 5, wobei der Schub des zweiten Propellers (82) den Flug des Flugzeugs (1) während des senkrechten Startens und Landens des Flugzeugs (1) in keinem Fall beeinträchtigt.

7. Steuerungsvefahren nach Anspruch 6, wobei das Steuergerät (50) darauf ausgelegt ist, die Stromverbindung zwischen dem Triebwerk (10) und dem zweiten Propeller (82) während des senkrechten Startens und Landens des Flugzeugs (1) zu steuern und zu unterbrechen.

8. Steuerungsverfahren nach Anspruch 6, wobei der Schub des zweiten Propellers (82) darauf ausgelegt ist, sich während des Reiseflugs oder Übergangsbetriebs des Flugzeugs (1) zu steigern und die vom Generator (20) erzeugte überschüssige Leistung gesteuert wird, um in die Batterie (62) des Batteriemanagementsystems (60) geladen zu werden.

9. Senkrecht startendes und landendes Flugzeug mit hybrid-elektrischem Antriebssystem, umfassend:

einen Körper (2), wobei ein Starrflügel (4) auf dem Körper (2) angeordnet ist;
Ein Triebwerk (10), das auf dem Flugzeug (1) installiert und darauf ausgelegt ist, durch Verbrennen von Kraftstoff Energie zu erzeugen;
einen Generator (20), der darauf ausgelegt ist, die von dem Triebwerk (10) erzeugte Energie zu verwenden, um Strom zu erzeugen;
Eine Energiemanagementeinheit (40), die darauf ausgelegt ist, den Strom an alle Bauteile des Flugzeugs zu verteilen und diese damit zu versorgen;
ein Batteriemanagementsystem (60), das darauf ausgelegt ist, Energie von der Energiemanagementeinheit (40) zu erhalten und darauf ausgelegt ist, eine erste Batterie (62) zu laden;
einen Motor (80), der auf dem Starrflügel (4) angeordnet und darauf ausgelegt ist, Energie von dem Batteriemanagementsystem (60) zu erhalten;
einen ersten Propeller (81), der darauf ausgelegt ist, von dem Motor (80) betrieben zu werden;
einen zweiten Propeller (82), der darauf ausgelegt ist, von dem Triebwerk (10) betrieben zu werden;
ein Steuergerät (50), das darauf ausgelegt ist, den Betrieb des Triebwerks (10), des Generators (20), des Motors (80) und des zweiten Propellers (82) zu steuern;
einen elektronischen Drehzahlregler (70), der für jeden Motor (80) eingebaut und darauf ausgelegt ist, die Drehzahl jedes Motors (80) entsprechend des Steuerbefehls des Steuergeräts (50) individuell zu steuern; wobei die erste Batterie (62) des Batteriemanagementsystems (60) darauf ausgelegt ist, jeden elektronischen Drehzahlregler (70) mit Energie zu versorgen;
und
das Steuergerät (50), das darauf ausgelegt ist, die dem Motor (80) zuzuführende Energie während des senkrechten Startens und Landens des Flugzeugs (1) gleichzeitig über den Generator (20) und die Energiemanagementeinheit (40) und das Batteriemanagementsystem (60) zu steuern;
und
den Motor (80), der auf dem Starrflügel (4) angeordnet und darauf ausgelegt ist, es dem ersten Propeller (82) zu erleichtern, in einer ersten Richtung Schub zu erzeugen; den Motor (10), der auf dem Flugzeug (1) angeordnet und darauf ausgelegt ist, es dem zweiten Propeller (81) zu erleichtern, in einer zweiten Richtung Schub zu erzeugen;
wobei die erste Richtung und die zweite Richtung darauf ausgelegt sind, nicht miteinander identische Richtungen zu sein; und
dadurch gekennzeichnet, dass
das genannte senkrecht startende und landende Flugzeug mit hybrid-elektrischem Antriebssystem außerdem eine Kupplungseinheit (102) umfasst, die zwischen dem Triebwerk (10) und dem zweiten Propeller (82) positioniert und darauf ausgelegt ist, die von dem Triebwerk (10) dem zweiten Propeller (82) zur Verfügung gestellte Energie ein- oder auszuschalten;
wobei das Steuergerät (50) darauf ausgelegt ist, den Betrieb der Kupplungseinheit (102) zu steuern;
wobei das Steuergerät (50) darauf ausgelegt ist, die Stromverbindung zwischen dem Triebwerk (10) und dem zweiten Propeller (82) während des senkrechten Startens und Landens des Flugzeugs (1) über die Kupplungseinheit (102) zu steuern;
wobei der Generator (20) mit einem Sensor (22) ausgestattet ist, wobei der Sensor (22) an die Energiemanagementeinheit (40) angeschlossen und darauf ausgelegt ist, den Generator (20) zu überwachen, wobei das Steuergerät (50) darauf ausgelegt ist, basierend auf einem ersten Erfassungswert zu bestimmen, ob die Stromerzeugung angemessen ist;
wobei jeder elektronische Drehzahlregler (70) darauf ausgelegt ist, durch Anschluss an eine zweite Batterie (94) über eine Stromleitung (72) Energie zu erhalten;
wobei die Stromleitung (72) eine Last aufweist, die abhängig vom Stromverbrauch jedes elektronischen Drehzahlreglers (70) variiert;
wobei das senkrecht startende und landende Flugzeug mit hybrid-elektrischem Antriebssystem außerdem eine an die Stromleitung (72) angeschlossene Lasterkennungsleitung (74) umfasst, wobei die Lasterkennungsleitung (74) darauf ausgelegt ist, einen auf der Stromleitung (72) entstandenen Lastwert als einen zweiten Erfassungswert zu erfassen, der an die Energiemanagementeinheit (40) oder das Steuergerät (50) übertragen wird;
so dass, wenn sich der zweite Erfassungswert erhöht, festgestellt wird, dass der Stromverbrauch steigt und das Steuergerät (50) die Steigerung der Triebwerkleistung des Triebwerks

(10) steuert, so dass die Triebwerkleistung sich erhöht, und, wenn der zweite Erfassungswert sich verringert, festgestellt wird, dass der Stromverbrauch abnimmt und das Steuergerät die Reduzierung der Triebwerkleistung des Triebwerks (10) steuert.

Revendications

1. Aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride comprenant :

   un corps (2) dans lequel une aile fixe (4) est agencée sur le corps (2) ;
   un moteur à combustion (10) installé sur l'aéronef (1) et configuré pour générer de l'énergie en brûlant du combustible ;
   un générateur (20) configuré pour utiliser l'énergie générée par le moteur à combustion (10) afin de générer de l'énergie électrique ;
   une unité de gestion de l'énergie (40) configurée pour distribuer et fournir de l'énergie électrique à chaque composant de l'aéronef ;
   un système de gestion de batterie (60) configuré pour recevoir de l'énergie de l'unité de gestion de l'énergie (40) et configuré pour charger une première batterie (62) ;
   de multiples moteurs (80) agencés sur l'aile fixe (4) et configurés pour recevoir de l'énergie provenant du système de gestion de batterie (60) ;
   un premier propulseur (81) configuré pour être actionné par le moteur (80) correspondant ;
   un second propulseur (82) configuré pour être actionné par le moteur à combustion (10) ;
   une unité de commande (50) configurée pour commander le fonctionnement du moteur à combustion (10), du générateur (20), du moteur (80) et du second propulseur (82) ;
   une unité de commande de vitesse électronique (70) équipée pour chaque moteur (80) et configurée pour commander individuellement la vitesse de chaque moteur (80) selon la commande de l'unité de commande (50) ; dans lequel la première batterie (62) du système de gestion de batterie (60) est configurée pour alimenter en énergie chaque unité de commande de vitesse électronique (70) ;
   dans lequel
   l'unité de commande (50) est configurée pour commander l'énergie devant être fournie au moteur (80) provenant simultanément du générateur (20) et de l'unité de gestion de l'énergie (40) et du système de gestion de batterie (60) pendant le décollage et l'atterrissage verticaux de l'aéronef (1) ; et
   le moteur (80) est agencé sur l'aile fixe (4) et configuré pour aider le premier propulseur (81) à générer une poussée dans une première direction ;
   le moteur à combustion (10) est agencé sur l'aéronef (1) et configuré pour aider le second propulseur (82) à générer une poussée dans une seconde direction ;
   la première direction et la seconde direction étant configurées pour ne pas être des directions identiques entre elles ;
   caractérisé en ce que
   ledit aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride comprend en outre une unité de commande de pas (100) configurée pour régler l'angle d'attaque des pales du second propulseur (82) afin de générer une poussée souhaitée pendant le décollage et l'atterrissage verticaux de l'aéronef ;
   dans lequel le générateur (20) est équipé d'un capteur (22), le capteur (22) étant connecté à l'unité de gestion de l'énergie (40) et étant configuré pour surveiller le générateur (20), dans lequel l'unité de commande (50) est configurée pour déterminer si la génération d'énergie actuelle est appropriée ou non en fonction d'une première valeur de détection ;
   dans lequel chaque unité de commande de vitesse électronique (70) est configurée pour recevoir de l'énergie en restant connectée à une seconde batterie (94) par l'intermédiaire d'une ligne électrique (72) ;
   dans lequel la ligne électrique (72) a une charge qui varie en fonction de la consommation d'énergie de chaque unité de commande de vitesse électronique (70) ;
   dans lequel ledit aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride comprend en outre une ligne de détection de charge (74) connectée à la ligne électrique (72), la ligne de détection de charge (74) étant configurée pour détecter une valeur de charge formée sur la ligne électrique (72) comme seconde valeur de détection, qui est fournie à l'unité de gestion de l'énergie (40) ou à l'unité de commande (50) ;
   de telle sorte que, lorsque la seconde valeur de détection augmente, il est déterminé que la consommation d'énergie augmente et l'unité de commande (50) est configurée pour commander l'augmentation de la sortie de moteur à combustion du moteur à combustion (10), lorsque la seconde valeur de détection diminue, il est déterminé que la consommation d'énergie diminue, et la sortie de moteur à combustion du moteur à combustion (10) est configurée pour être commandée afin d'être réduite.

2. Aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride selon la revendication 1, dans lequel l'unité de commande (50) est configurée pour réduire et commander la poussée du second propulseur (82) de manière à ne pas affecter le vol de l'aéronef (1) en aucun cas pendant le décollage et l'atterrissage verticaux de l'aéronef (1).

3. Aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride selon la revendication 1, dans lequel l'unité de commande (50) est configurée pour commander et déconnecter la connexion électrique entre le moteur à combustion (10) et le second propulseur (82) pendant le décollage et l'atterrissage verticaux de l'aéronef (1).

4. Aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride selon la revendication 1, dans lequel l'unité de commande (50) est configurée pour augmenter la poussée du second propulseur (82) pendant le vol de croisière ou le mode de transition de l'aéronef (1), et l'énergie de décharge générée par le générateur (20) est commandée de façon à être chargée dans la batterie (62) du système de gestion de batterie (60).

5. Procédé de commande pour l'aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride comprenant :

une première étape dans laquelle l'énergie est générée en brûlant du combustible avec un moteur à combustion (10) ;
une seconde étape dans laquelle de l'énergie électrique est générée par l'actionnement d'un générateur (20) avec l'énergie du moteur à combustion (10) ;
une troisième étape dans laquelle l'énergie électrique est distribuée et fournie à chaque composant de l'aéronef (1) par l'unité de gestion de l'énergie (40) ;
une quatrième étape dans laquelle une partie de l'énergie électrique est utilisée pour charger une première batterie (62) d'un système de gestion de batterie (60) ;
une cinquième étape d'actionnement d'un premier propulseur (81) avec un moteur (80) ;
et
une unité de commande (50) étant configurée pour commander l'énergie devant être fournie au moteur (80) provenant simultanément du générateur (20) et de l'unité de gestion de l'énergie (40), et du système de gestion de batterie (60) pendant le décollage et l'atterrissage verticaux de l'aéronef (1) ; et

le moteur (80) étant agencé sur l'aile fixe (4) et configuré pour aider un premier propulseur (81) à générer une poussée dans une première direction ; et
le moteur à combustion (10) étant agencé sur l'aéronef (1) et configuré pour aider un second propulseur (82) à générer une poussée dans une seconde direction ;
la première direction et la seconde direction étant configurées pour ne pas être des directions identiques entre elles ; et
dans lequel une unité de commande de vitesse électronique (70), équipée pour chaque moteur (80), commande individuellement la vitesse de chaque moteur (80) selon la commande de l'unité de commande (50) ; dans lequel la première batterie (62) du système de gestion de batterie (60) alimente en énergie chaque unité de commande de vitesse électronique (70) ;
ledit procédé de commande étant **caractérisé en ce que** :

une unité de commande de pas (100) est configurée pour régler l'angle d'attaque des pales du second propulseur (82) afin de générer une poussée souhaitée pendant le décollage et l'atterrissage verticaux de l'aéronef (1) ;
dans lequel avec un capteur (22), dont le générateur (20) est équipé, et connecté à l'unité de gestion de l'énergie (40), il surveille le générateur (20), dans lequel l'unité de commande (50) détermine si la génération d'énergie actuelle est appropriée ou non en fonction d'une première valeur de détection ;
dans lequel chaque unité de commande de vitesse électronique (70) reçoit de l'énergie en restant connectée à une seconde batterie (94) par l'intermédiaire d'une ligne électrique (72) ; dans lequel une charge de la ligne électrique (72) varie en fonction de la consommation d'énergie de chaque unité de commande de vitesse électronique (70) ;
une ligne de détection de charge (74), connectée à la ligne électrique (72), détecte une valeur de charge formée sur la ligne électrique (72) comme seconde valeur de détection, qui est fournie à l'unité de gestion de l'énergie (40) ou à l'unité de commande (50) ;
de telle sorte que, lorsque la seconde valeur de détection augmente, il est déterminé que la consommation d'énergie augmente et l'unité de commande (50) commande l'augmentation de la sortie de moteur à combustion du moteur à combustion (10), lorsque la seconde valeur de détection diminue, il

est déterminé que la consommation d'énergie diminue, et la sortie de moteur à combustion du moteur à combustion (10) est commandée de façon à être réduite.

6. Procédé de commande selon la revendication 5, dans lequel la poussée du second propulseur (82) n'affecte en aucun cas le vol de l'aéronef (1) pendant le décollage et l'atterrissage verticaux de l'aéronef (1).

7. Procédé de commande selon la revendication 6, dans lequel l'unité de commande (50) est configurée pour commander et déconnecter la connexion électrique entre le moteur à combustion (10) et le second propulseur (82) pendant le décollage et l'atterrissage verticaux de l'aéronef (1).

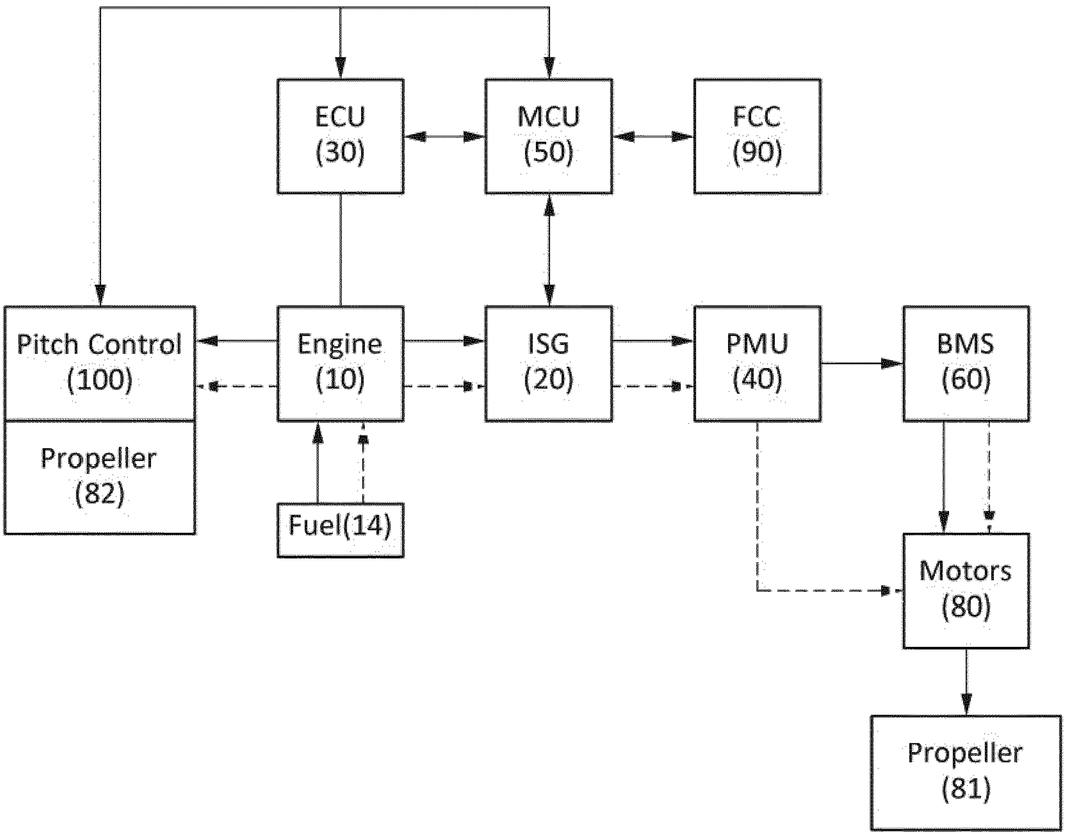
8. Procédé de commande selon la revendication 6, dans lequel la poussée du second propulseur (82) est configurée pour augmenter pendant le vol de croisière ou le mode de transition de l'aéronef (1), et l'énergie de décharge générée par le générateur (20) est commandée de façon à être chargée dans la batterie (62) du système de gestion de batterie (60).

9. Aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride comprenant :

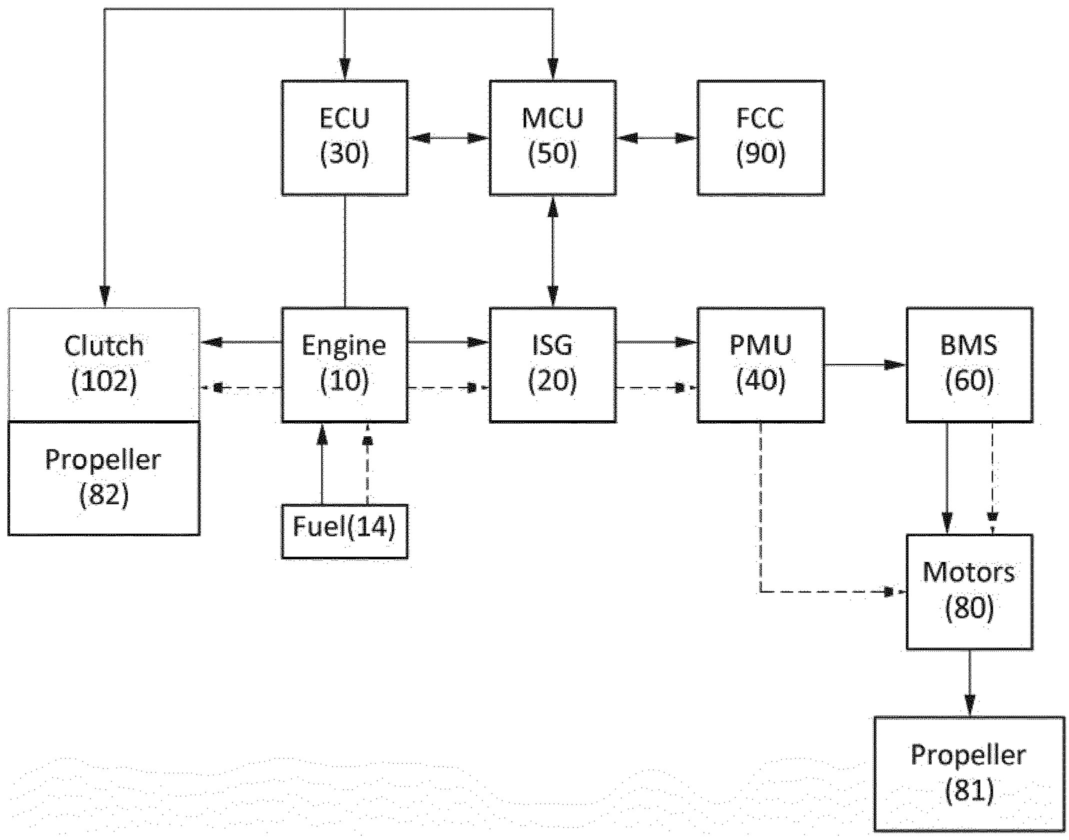
un corps (2) dans lequel une aile fixe (4) est agencée sur le corps (2) ;
un moteur à combustion (10) installé sur l'aéronef (1) et configuré pour générer de l'énergie en brûlant du combustible ;
un générateur (20) configuré pour utiliser l'énergie générée par le moteur à combustion (10) afin de générer de l'énergie électrique ;
une unité de gestion de l'énergie (40) configurée pour distribuer et fournir de l'énergie électrique à chaque composant de l'aéronef ;
un système de gestion de batterie (60) configuré pour recevoir de l'énergie de l'unité de gestion de l'énergie (40) et configuré pour charger une première batterie (62) ;
un moteur (80) agencé sur l'aile fixe (4) et configuré pour recevoir de l'énergie provenant du système de gestion de batterie (60) ;
un premier propulseur (81) configuré pour être actionné par le moteur (80) ;
un second propulseur (82) configuré pour être actionné par le moteur à combustion (10) ;
une unité de commande (50) configurée pour commander le fonctionnement du moteur à combustion (10), du générateur (20), du moteur (80) et du second propulseur (82) ;
une unité de commande de vitesse électronique (70) équipée pour chaque moteur (80) et configurée pour commander individuellement la vitesse de chaque moteur (80) selon la commande de l'unité de commande (50) ; dans lequel la première batterie (62) du système de gestion de batterie (60) est configurée pour alimenter en énergie chaque unité de commande de vitesse électronique (70) ;
et
l'unité de commande (50) configurée pour commander l'énergie devant être alimentée au moteur (80) provenant simultanément du générateur (20) et de l'unité de gestion de l'énergie (40) et du système de gestion de batterie (60) pendant le décollage et l'atterrissage verticaux de l'aéronef (1) ;
et
le moteur (80) agencé sur l'aile fixe (4) et configuré pour aider le premier propulseur (82) à générer une poussée dans la première direction ;
le moteur à combustion (10) agencé sur l'aéronef (1) et configuré pour aider le second propulseur (81) à générer une poussée dans la seconde direction ;
la première direction et la seconde direction étant configurées pour ne pas être des directions identiques entre elles ; et
caractérisé en ce que
ledit aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride comprend en outre une unité d'embrayage (102) positionnée entre le moteur à combustion (10) et le second propulseur (82) et configurée pour déconnecter ou connecter l'alimentation délivrée du moteur à combustion (10) au second propulseur (82) ;
dans lequel l'unité de commande (50) est configurée pour commander le fonctionnement de l'unité d'embrayage (102) ;
dans lequel l'unité de commande (50) est configurée pour commander la connexion électrique entre le moteur à combustion (10) et le second propulseur (82) pendant le décollage et l'atterrissage de l'aéronef (1) par l'intermédiaire de l'unité d'embrayage (102) ;
dans lequel le générateur (20) est équipé d'un capteur (22), le capteur (22) étant connecté à l'unité de gestion de l'énergie (40) et étant configuré pour surveiller le générateur (20), dans lequel l'unité de commande (50) est configurée pour déterminer si la génération d'énergie actuelle est appropriée ou non en fonction d'une première valeur de détection ;
dans lequel chaque unité de commande de vitesse électronique (70) est configurée pour recevoir de l'énergie en restant connectée à une seconde batterie (94) par l'intermédiaire d'une ligne électrique (72) ;

dans lequel la ligne électrique (72) a une charge qui varie en fonction de la consommation d'énergie de chaque unité de commande de vitesse électronique (70) ;
dans lequel ledit aéronef à décollage et à atterrissage verticaux utilisant un système de propulsion électrique hybride comprend en outre une ligne de détection de charge (74) connectée à la ligne électrique (72), la ligne de détection de charge (74) étant configurée pour détecter une valeur de charge formée sur la ligne électrique (72) comme seconde valeur de détection, qui est fournie à l'unité de gestion de l'énergie (40) ou à l'unité de commande (50) ;
de telle sorte que, lorsque la seconde valeur de détection augmente, il est déterminé que la consommation d'énergie augmente et l'unité de commande (50) est configurée pour commander l'augmentation de la sortie de moteur à combustion du moteur à combustion (10), lorsque la seconde valeur de détection diminue, il est déterminé que la consommation d'énergie diminue, et la sortie de moteur à combustion du moteur à combustion (10) est configurée pour être commandée afin d'être réduite.

【Fig. 1】


ECU
(30)
MCU
(50)
FCC
(90)
Pitch Control
(100)
Propeller
(82)
Engine
(10)
ISG
(20)
PMU
(40)
BMS
(60)
Fuel(14)
Motors
(80)
Propeller
(81)

【Fig. 2】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(30)
MCU
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Clutch
(102)
Engine
(10)
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(20)
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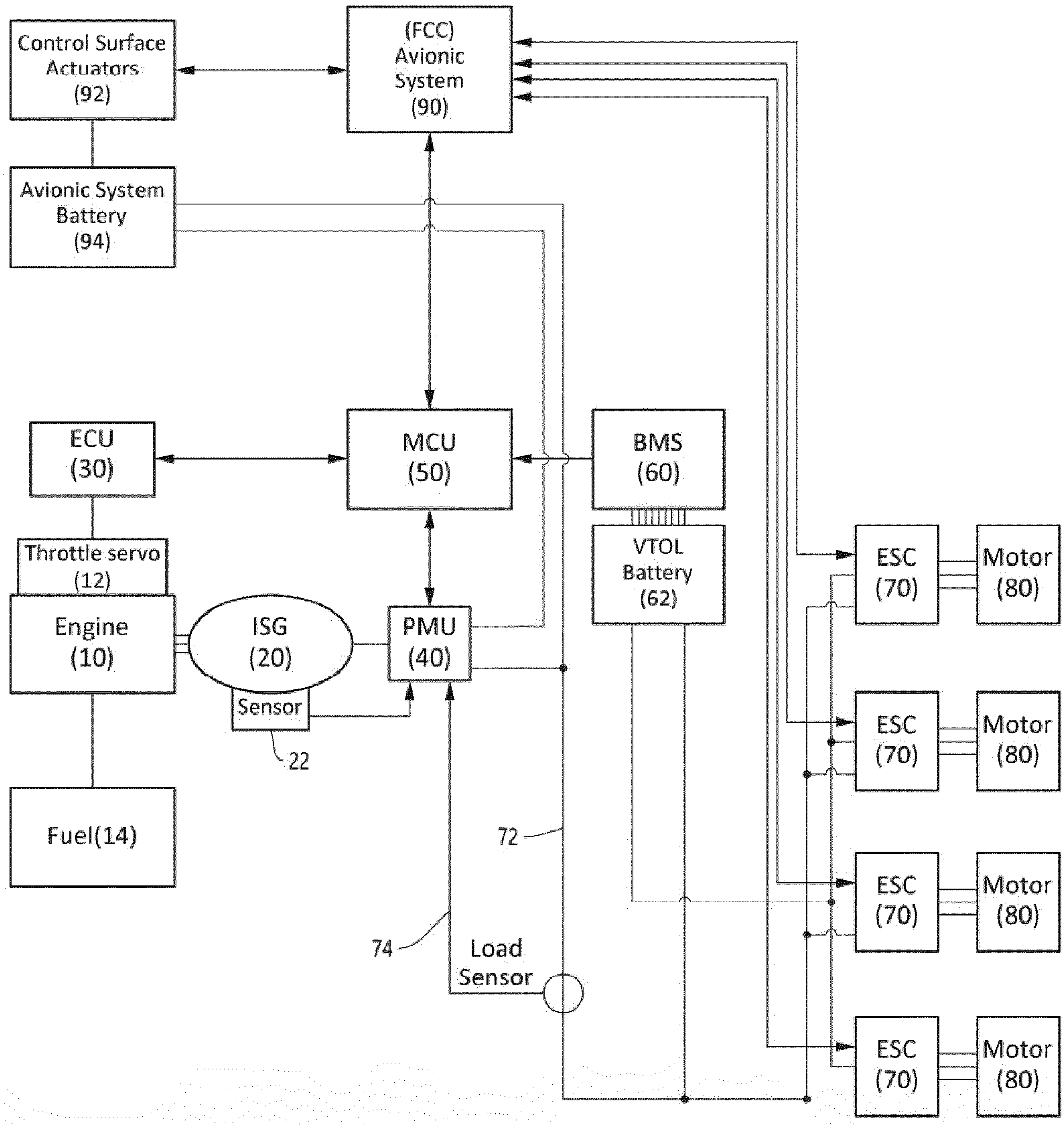
BMS
(60)
Propeller
(82)
Fuel(14)
Motors
(80)
Propeller
(81)

【Fig. 3】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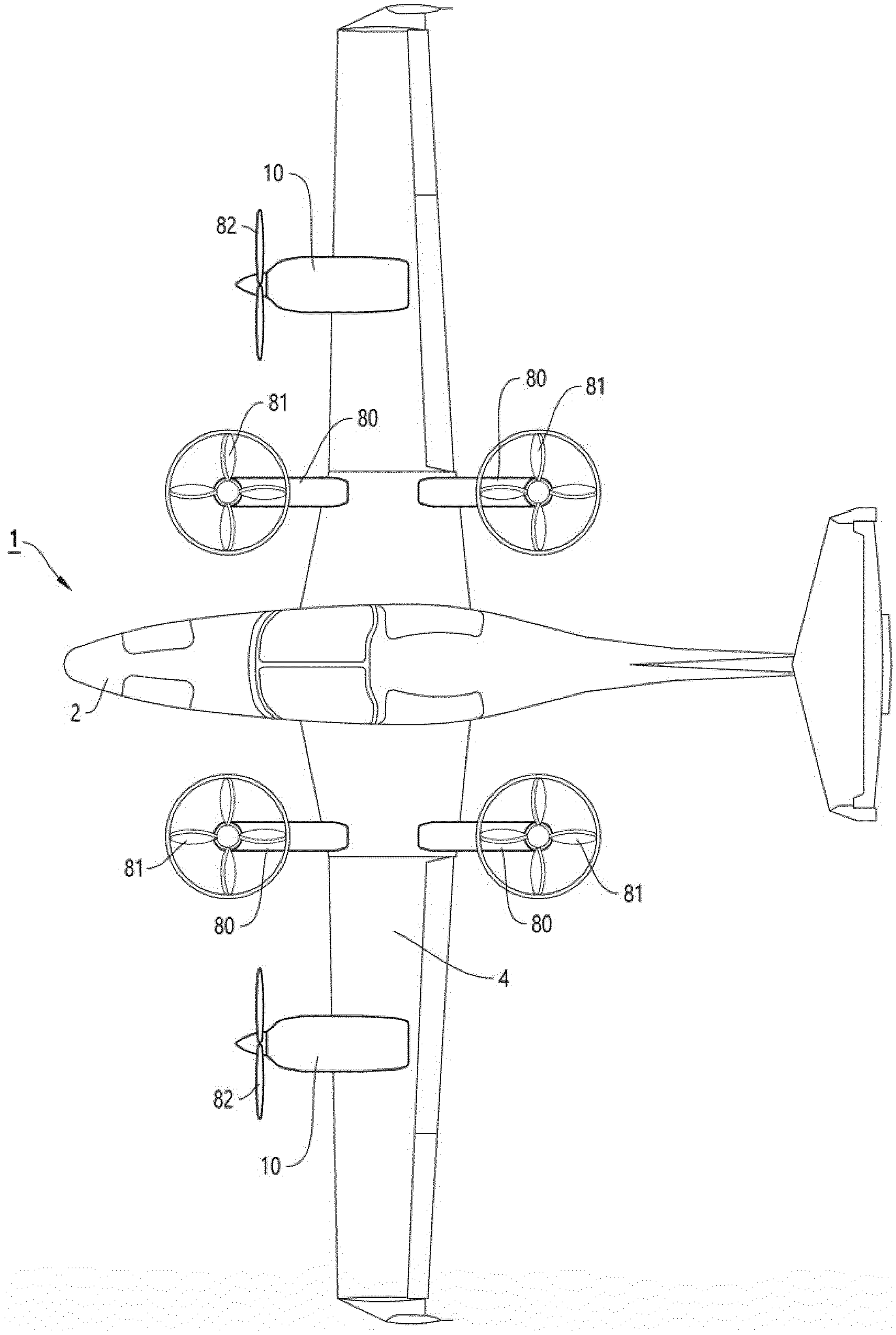
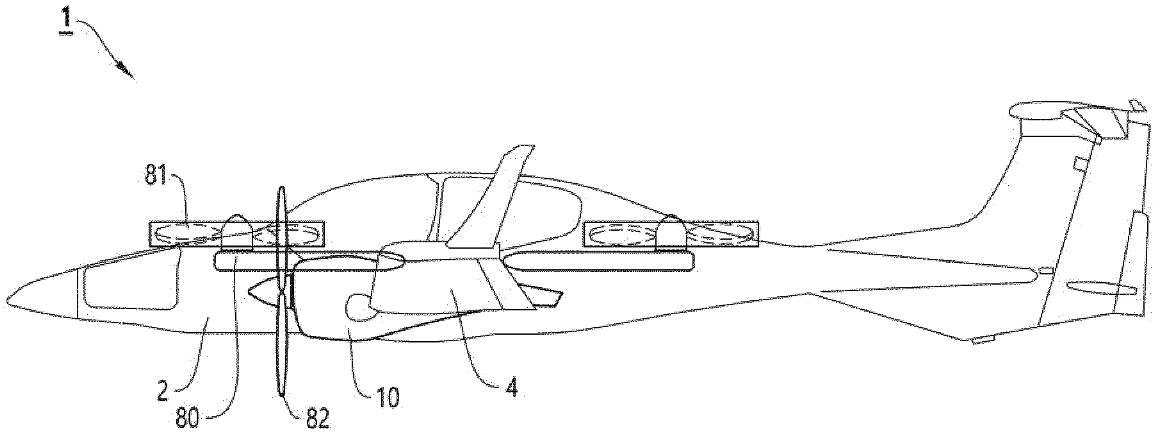
(FCC) Avionic System (90)
Avionic System Battery (94)
ECU (30)
MCU (50)
BMS (60)
Throttle servo (12)
VTOL Battery (62)
Engine (10)
ISG (20)
PMU (40)
Sensor
22
Fuel(14)
72
74
Load Sensor
ESC (70)
Motor (80)
ESC (70)
Motor (80)
ESC (70)
Motor (80)
ESC (70)
Motor (80)

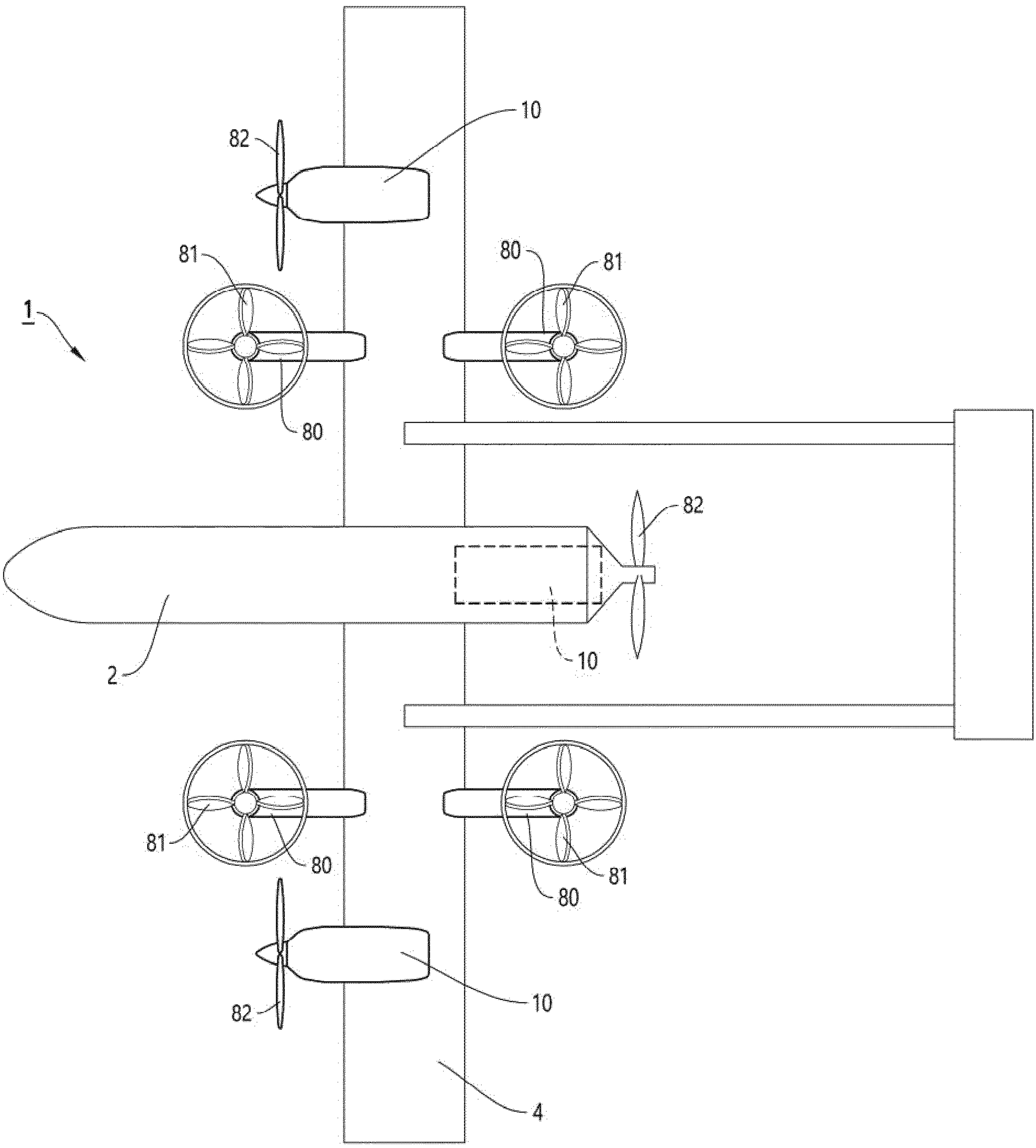
【Fig. 4】



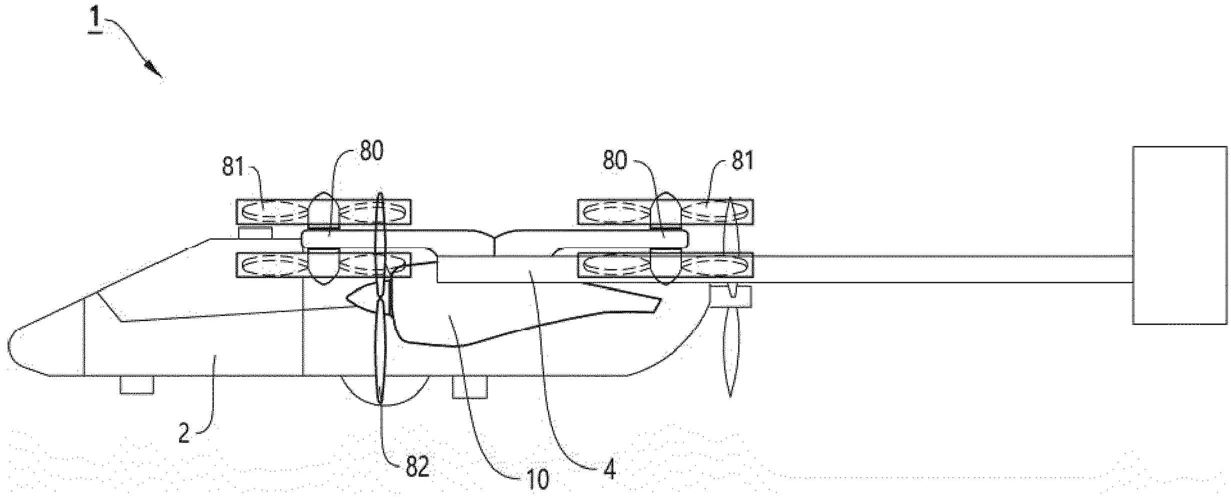
【Fig. 5】


1
81
2
80
82
10
4

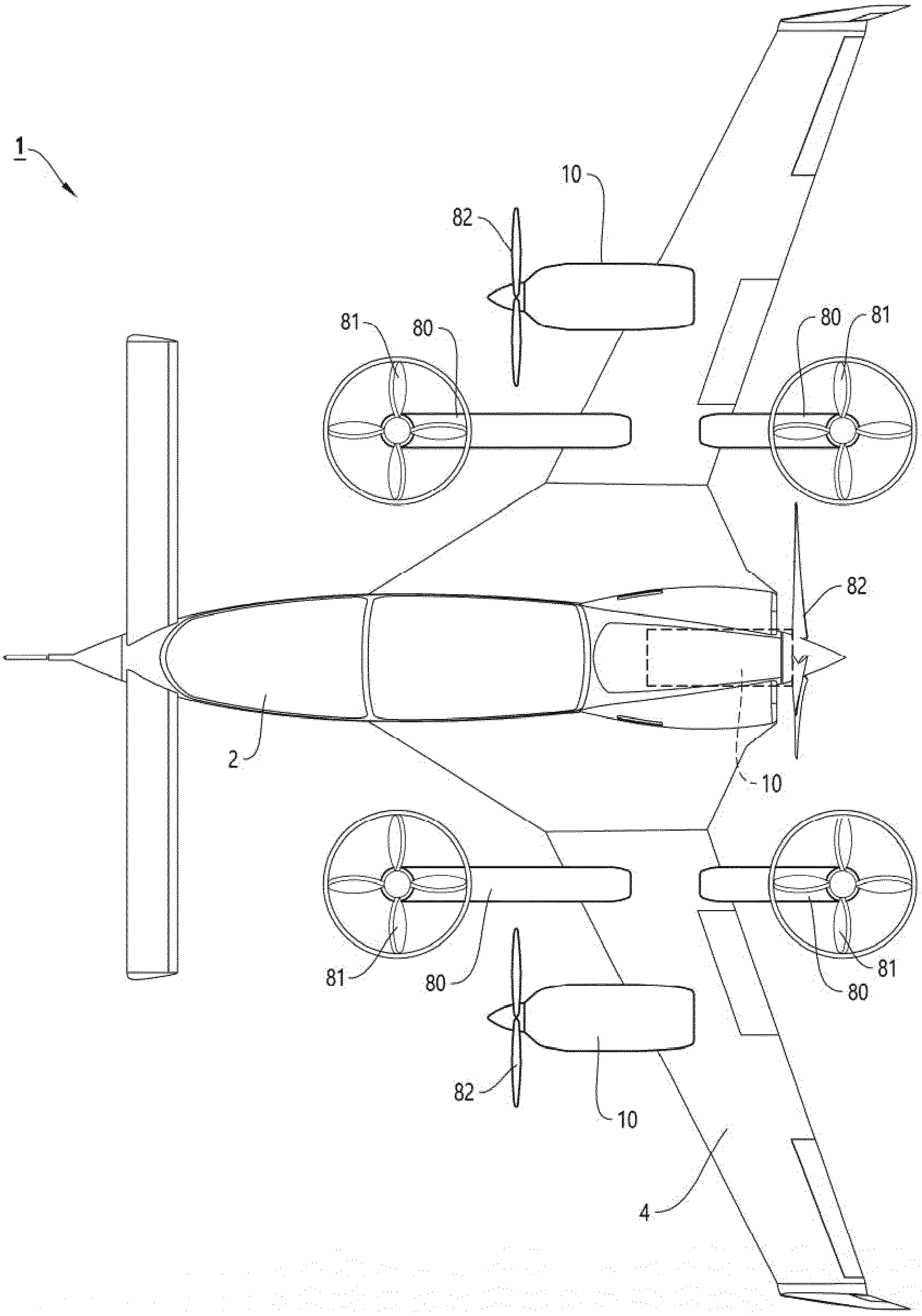
【Fig. 6】



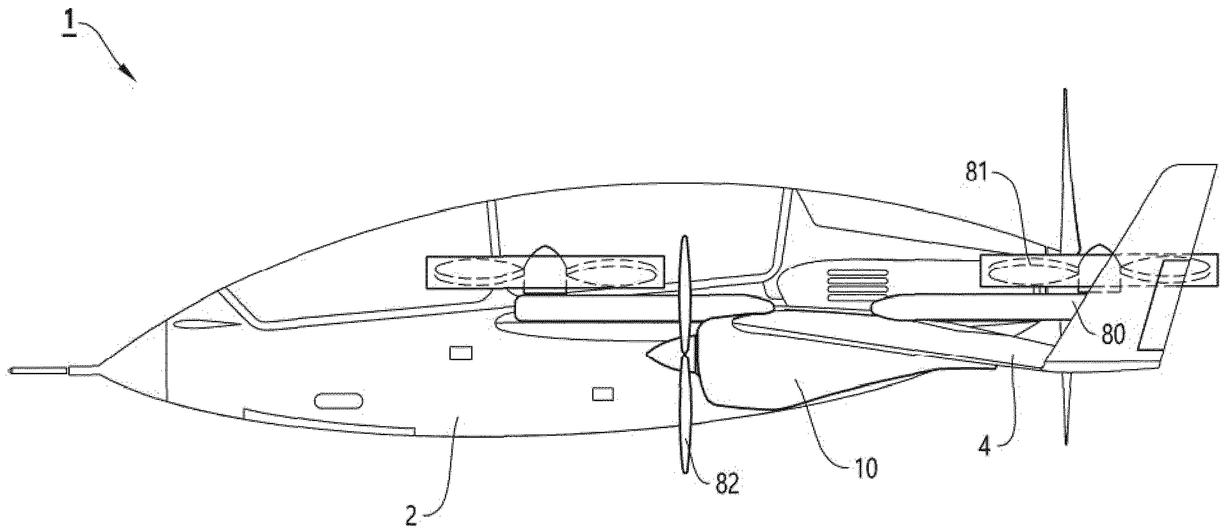
【Fig. 7】



【Fig. 8】



【Fig. 9】


1
81
80
4
10
82
2

REFERENCES CITED IN THE DESCRIPTION

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