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(54) **Title:** FLAT PLATE AIRFOIL PLATFFORM VEHICLE

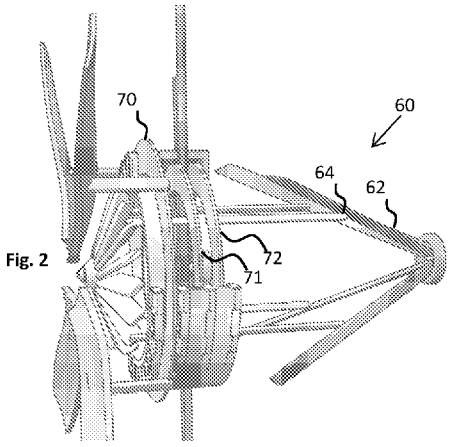

Fig. 2

(57) **Abstract:** A motor (more-broadly, induction device) is based around stacked rotor and stator boards rather than coils. The advance is analogous to using circuit boards rather than wires. Distinct advantages exist when the circuit board motor embodiment is combined with a novel open- burner combustor to form a hybrid electric-fuel jet engine (a culmination of three embodiments). The preferred application of the hybrid fuel-electric engine is in highly efficient (high lift-to- drag) aircraft utilizing towed platforms having high surfaces areas for both generating lift and collecting solar energy. The final combination yields advantages for an aerial platform towed via a front hinge joint that enables both vertical takeoff/landing and advantageous failsafe landing options. The aircraft is preferably powered by the hybrid electric-fuel jet engine.

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FLAT PLATE AIRFOIL PLATFFORM VEHICLE

CROSS REFERENCE TO RELATED APPLICATIONS

[1] This application is a continuation-in-part of Provisional Appl. Ser. No. 63/212,138 filed on 18-JUN-2021 entitled " Pod-Based Towed Platform Drone", Ser. No. 63/279,397 filed 15-NOV-2021 entitled "Multicopter with Improved Propulsor and Failsafe Operation", App. No. PCT/US21/16392 filed on 03-FEB-2021 entitled " Flat Plate Airfoil Platform Vehicle", and App. No. US17/591034 filed on 02-FEB-2022 entitled “Hybrid Engine and Aircraft Application”. The above-listed applications are incorporated by reference in their entirety herein.

FIELD

[2] The present invention relates to effective lifting body designs for aerial drones and light-weight propulsion systems including light-weight motors. More specifically this invention relates to with emphasis on flight efficiency, VTOL drones, hybrid electric-fuel engines, solar power, and methods of improved safety and energy efficiency.

BACKGROUND

[3] Alternative approaches to design can enable paths of innovation. The embodiments of this document apply continuity equation approaches to aircraft, electric motors, and engines with the resulting surface-based analyses and control volumes leading to parallel paths of innovation. In aerial drone technology the paths of innovation have both originated and converged to provide lighter-weight and more-efficient aircraft and respective propulsors. Extended discussions are available in above-cited priority art.

SUMMARY OF THE INVENTION

[4] Embodiments of the present invention use flat plate airfoils with stability enhanced by towing via contiguous spanwise axial joints near the leading edge of the airfoils. Preferred hybrid-electric engines use motor architectures analogous to applying circuit board design approaches to rotors and stators which are coupled with jet-turbine-type engines that replace combustor walls with rotating blade and aerodynamic containment of combustion pressures.

BRIEF DESCRIPTION OF THE DRAWINGS

[5] Fig. 1 is an illustration of flying towed platform train with insert of solar cell array.

[6] Fig. 2 is a cutaway view of a hybrid electric-fuel engine with open-burner engine.

[7] Fig. 3 is a cross section of a hybrid electric-fuel engine.

[8] Fig. 4 are cross section view of various blade configurations for open-burner engine.

[9] Fig. 5 illustrates cross sections of: a) A composite truss with belt tensile element, b) 3D-printed injection mold connections, and c) 3D-printed injection mold of a structural beam.

[10] Fig. 6 is a single-circuit stator disc with a) outside, b) inside terminals, and c) two disc stacking to form 1.5 loop coils.

[11] Fig. 7. are cross section view of various surfaces of stator system induction circuits.

[12] Fig. 8 illustrates various induction circuits, core, and shielding configurations.

[13] Fig. 9 illustrates a stator and rotor in fast stack and slow stack configurations.

[14] Fig. 10 is an illustration of 3-phase stacked induction configurations (stator or rotor).

[15] Fig. 11 illustrates various transformer drone and liftpath embodiments.

[16] Fig. 12 illustrates configurations form platform train to transformer drone.

[17] Fig. 13 illustrates platform liftpath with pair of tiltwings on a forward joint.

[18] Fig. 14 illustrates a transformer drone with trailing end slot for mounting pods.

[19] Fig. 15 is an illustration of a transformer drone with a towed platform compartment.

[20] Fig. 16 illustrates conductive laminate sheets and connections.

[21] Fig. 17 is a flying towed platform train of Fig. 1 illustrating lead vehicle, primary aerial towed platform, and second aerial towed platform as disconnected units.

[22] Fig. 18 is an illustration of a flat plate airfoil aircraft with four stacked platforms on the primary flat plate airfoil platform.

[23] Fig. 19 is an illustration of part of one side of an aerial towed platform as a) two sides stacked one top the other and b) a single side.

[24] Fig. 20 is an illustration of the trailing end of the side with a lower guide and bumper.

[25] Fig. 21 is an illustration of flying towed platform train.

[26] Fig. 22 is an illustration of a towed aerial platform attached above a fuselage.

[27] Fig. 23 is an illustration of an aerial drone with a towed platform compartment.

[28] Fig. 24 is an illustration of a transformer drone in three failsafe configurations.

[29] Fig. 25 is two illustrations of alternative transformer drone configuration.

[30] Fig. 26 is an algorithm for active control of platform pitch relative to wing pitch.

[31] Fig. 27 is a quadcopter with two front tiltwings.

[32] Fig. 28 is a quadcopter with tiltwing, middle wing, and trailing edge wing.

[33] Fig. 29 is a front view of a hybrid electric fuel ramjet engine.

[34] Fig. 30 illustrates views of rotating combustor nozzle in compressor blade assembly.

[35] Fig. 31 illustrates alternative views of Fig. 2 hybrid electric-fuel engine, including: a) an exploded view, b) a trailing end perspective, and c) a leading end perspective.

[36] Fig. 32 provides a) an alternative perspective view of the Fig. 10b induction device and b) an exploded view of the Fig. 10b induction device.

[37] Fig. 33 illustrates a coupling of an excitation means with an induction circuit system.

DESCRIPTION OF INVENTION

[38] An aerial vehicle with propulsor and according to various aspects of this present invention in the most-preferred form employs: 1) an airframe with the following features: a) an aerial towed platform, b) a liftpath comprising a tiltwing pivotably coupled to a lifting body surface, and c) a pseudo-autorotation failsafe configuration comprising a front tiltwing and 2) a preferred propulsor with the following features: a) a hybrid electric-fuel jet engine comprising an open motor core, b) an induction device comprising circuit board inductors, and c) an open-burner engine 60. Fig. 1 illustrates the preferred vehicle with the preferred propulsor, and Fig. 3 illustrates the preferred propulsor in greater detail.

[39] Preferred Propulsor – The preferred propulsor comprises an open-burner engine 60, said engine comprising compressor blades 61, expander blades 62, and a combustion pressure volume 63. The combustion pressure volume comprises a fluidic radial surface (versus a solid wall of traditional combustors). The engine is configured so that rotating blades (compressor, expander, or a combination) contain at least one third of the fluidic radial surface. Optionally, the rotating blades may contain at least one half of the fluidic radial surface. Optionally, at least half the fluidic radial surface is contained by aerodynamic forces; wherein, the aerodynamic forces are produced by a combination of rotating blades and air flowing around the engine. As illustrated by Figs. 2, 4, and 31; the blades extend radially and longitudinally; the longitudinal component of the extension provides radial surface containment. Stator walls may also provide solid wall containment to supplement the aerodynamic radial surface containment.

[40] Preferably, at least half the said volume 63 is either not contained by a surface or contained by a combination of a compressor comprising the compressor blades 61 and expander comprising the expander blades 62; and, rotation of the compressor blades is coupled (e.g. by a coupling 64) with a rotation of the expansion blades. A coupling means may be s selected from the group comprising: a shaft, a connection at the outer radius of rotation of at least one of the expander blades, and a magnetic induction device such as an electric motor; the compressor may be selected from the group comprising: a turbine, a propeller, and a fan; the expander may be selected from the group comprising: a turbine, a propeller, and a fan; the engine may be selected from the group comprising: a jet engine, a gas turbine, and hybrid electric-fuel jet engine; and the engine may be configured to produce propulsion, shaft work, electromotive force, or other useful forms of power.

[41] Preferably, the compressor is a leading compressor, the expander is a trailing expander, and the combustion pressure volume 63 is longitudinally located between the

compressor and expander. More preferably, the engine comprises a plurality of pressure volumes including an outer pressure volume and an inner pressure volume; the inner pressure volume is fully contained in the outer pressure volume and has a higher pressure than the outer pressure volume. Combustion occurs in the inner pressure volume; and said inner pressure volume has an inner expander trailing the inner pressure volume, and the outer pressure volume as an outer expander trailing the outer pressure volume.

[42] Preferably, the preferred propulsor comprises a hybrid engine capable of transitioning from electric-only power for takeoff to fuel combustion for extended range or speed; it is configured for flight with or without fuel use. The hybrid engine comprises an electric motor with a rotor (herein, rotor is an electric rotor as in "stator and rotor") and a combustor; the electric motor comprises an open motor core positioned around a longitudinal axis of rotation where air flows through said open motor core to the combustor and where said hybrid engine is configured to transition from electric-powered propulsion to propulsion with both electric and jet power. More preferably, the combustor is located between a leading compression section and a trailing expansion section. The leading compression section may be connected to a first rotor 71; the trailing expansion section may be connected to a second rotor 72; and the motor is configured to transfer power from the second rotor to the first rotor. The electric motor is an induction device that may be configured to: a) initiate propeller rotation, b) supplement jet engine power, c) recover energy from propeller rotation as a generator, and d) transfer power from a trailing expander to a leading compressor through induction forces. A plurality of rotors in the engine may be enabled with a fast stator and a slow stator (see Fig. 9). A slow stator could be coupled to a propeller through a slow rotor (a third rotor 70).

[43] Preferably, the combustor of the hybrid engine comprises a combustor configured to sustain fuel combustion (combustion expansion) in air having entering velocities greater than mach 0.8 followed by additional expansion in a bell nozzle 407 trailing the combustor. The bell nozzle is configured to expand combustion gases. A compression blade assembly is preferably configured absorb an impulse force generated by acceleration of gases during combustion (see Fig. 3). Preferred configurations include: a) a motor configured to initiate propeller rotation, b) a motor configured to supplement jet engine power, c) a generator configured to recover energy from propeller rotation, and d) an induction device configured to transfer power from a trailing expander to a leading compressor. Air enters the combustor along compressor blades 415 that may be powered by the impulse of combustion near the combustion bell 418; or alternatively, the compressor blades may be powered by electrical energy such as would be provided by solar panels on an aircraft.

[44] Induction Device – An induction device is a stator system coupled to a reaction element such as a rotor system. A preferred induction device is a motor, but in the broader sense, the induction device of this invention is a device that uses induction circuits on boards to generate electromagnetic induction forces to move reaction elements. Example induction devices are: rotary motors, generators, brakes, dampers, linear motors, rotary induction motors, servos, axial flux rotary motors, and surrogate solenoid devices; and the stator system is configured to generate electromagnetic forces consistent with these devices. Example reaction elements are: rotors, sliders, lever arms, ferromagnetic rods, circuits, and other conductive surfaces configured to generate induced current. Preferred inductions devices have modular designs. Said inductor device may also be referred to in part, or in entirety, as: a stator system, an induction circuit, or an inductor circuit board.

[45] The preferred motor comprises a stator system. The stator system comprises a plurality of stator discs 521 523 configured about a common axis. Stator discs of the plurality of stator discs may be spaced apart, defining gaps therebetween, and each stator disc of the plurality of stator discs includes an induction circuit wherein the induction circuit does not cross itself along the common axis. The induction circuit comprises a plurality of radial-direction tracks 503, a plurality of angular-direction tracks 504, and a plurality of terminals; said induction circuit extending terminal-to-terminal. Fig. 8 provides example discs. Figs. 9 and 10 illustrate stacked-disc configurations where discs are parallel and configured to direct magnetic flux in a path through adjacent cores of adjacent stator discs.

[46] A circuit busbar 506 connects the plurality of stator discs to a controller 513. The circuit busbar provides electric power to the plurality of stator discs. A rotor system is axially aligned with the plurality of stator discs. The rotor system includes at least one rotor 403; the at least one rotor positioned in one of the gaps between stator discs of the plurality of stator discs.

[47] Preferably: a) the circuit busbar further comprises a stationary shaft 531 or a housing; b) a rotary device is one from a list comprising an electric motor, an electric generator, a pump, a propulsor, propeller, a hybrid jet engine, a rotating shaft, a synchronous electric motor, and an asynchronous electric motor; c) the rotary device includes a sensor, a source of electrical power, a control unit, and a cooling fluid flowing adjacent to disc surfaces, and d) each stator disc of the plurality of stator discs includes a plurality of stator-disc cores 516 through which at least one of ferromagnetic composite, ferromagnetic metal, air, and water may be housed. Example cooling fluids are ambient air or ambient water. A core material is a material through which an electromagnet induces magnetic flux. A core may be a

ferromagnetic material, air, water, or essentially any material. The properties of the core impact the properties of the flux generated by an electromagnet. The rotary device's control unit and sensor, with connection to the power supply, may be combined in a motor control unit 513. Preferably, the cooling fluid flows in the gaps between stator boards; the cooling fluid flows along the interface surface between stator boards and gaps. In a preferred configuration, more than half of electrical resistance heat flows directly from the circuit to a cooling fluid across said interface surface. This direct flow may include flow through electrical insulation and is distinguished from indirect flow such as heat flow that goes through a core material between the circuit and cooling fluid.

[48] Several options exist for the at least one rotor system. The rotor system may include: conductive metal surfaces (e.g. discs) 524 , a primary coil coupled to a rotating secondary coil and attached to a housing, an induction circuit 545 510 (a continuous conductive track from connector to connector), a permanent magnet, and a magnetic bearing through interaction with stator induction circuits 510. The preferred rotor system is configured to be turned via electromagnetic induction forces in two-phase, three-phase, four-phase, or six-phase induction motor configurations; said configurations comprising distinct angular orientations of the stator discs 502 aligned along the common axis.

[49] Preferably, the induction circuit further comprises multiple circuit sections 516, each circuit section including two radial-direction tracks 503, one angular-direction track 504, and a stator-disc core 515. Stated in an alternative manner, the induction circuit comprises a sequence 590 of a radial-direction track coupled to an angular-direction track, said sequence extending along a surface between said stator system. A fluid (e.g. air) separates rotor and stator surfaces. At least one of the circuit sections of the induction circuit may include a conductive track extension 518 and a conductive discontinuity 519 adjacent the conductive track extension. The conductive track extension 518, two of the radial direction tracks, one of the angular direction tracks and the conductive discontinuity 519 form a perimeter that surrounds the stator-disc core. Also, a conduction lip on a rotor disc may be used to provide flux shielding. The conductive discontinuity 519 may be between conductive track extensions 518 from the two radial-direction tracks 503 or between outer ends of radial-direction tracks 503 and a conductive track adjacent to the stator disc's outer perimeter. As illustrated by Fig. 6, the induction circuit comprises a sequence of a radial-direction track coupled to an angular-direction track in a repeated sequence in the angular direction.

[50] The circuit tracks are preferably conductive metal (e.g. copper) strips where electrical insulation is applied to the outer surface of the metal as known in the science to prevent

electric current flow outside the metal strips. An example fabrication method is comprised of: a) laser cutting the induction circuit 510 from sheet metal, b) dip coating of the induction circuit 510 in a resin that forms an insulating layer, and c) injection molding of the stator-disc core 515 between the sides of the induction tracks at locations where it is desired to have electromagnet core material (often referred to as a composite core).

[51] As common in the science, symmetry is preferred in design, such as disc sections being substantially axially symmetric around the axis of rotation 507. Terminal connections and odd-numbered sequences may not be symmetric. Also, a constant change/interval in angular orientations is preferred for the induction motor phase configurations.

[52] Optionally, motors comprise a slow grouping and a fast grouping , each of the slow 521 and fast groupings 523 including at least one stator disc of the plurality of stator discs and at least one rotor of the rotor system; wherein the rotor system further includes at least two rotors; wherein the at least one stator disc of the slow grouping has a different number of circuit sections within the induction circuit than the number of circuit sections within the induction circuit of the at least one stator disc of the fast grouping; and wherein the at least one rotor of the slow grouping rotates at a different speed than the at least one rotor of the fast grouping.

[53] Preferably: a) the motor comprises a plurality of induction circuits; b) the plurality of stator discs are fabricated by at least one of 3D printing, metal stamping, laser cutting of sheet metal, or pressing of a metal wire; c) two stator discs from the plurality of stator discs are adjacently mounted on the circuit busbar forming a 1.5 loop stacking, the 1.5 loop stacking having an induction circuit with four radial direction tracks, an inner angular direction track, and an outer direction track, and d) the motor comprises a 1.5 loop stacking 528 (see Fig. 6c). Preferably, longitudinally-adjacent induction circuits 528 share common and continuous electromagnet cores. More preferably, except for where the induction circuits cross, conductive tracks of the back induction circuit are configured longitudinally thicker to reach the same surface for heat transfer; therein, maintaining a configuration that minimizes passing of circuit resistance heat through core material. Fig. 10 illustrates multiple pairs of adjacent induction circuits configured to generate magnetic fields at different phase angles.

[54] Preferably, the stator system comprises a first induction circuit having first axial tracks and a second induction circuit having second axial tracks; the first axial tracks parallel to the second axial tracks. The axial tracks form perimeters around most of the cores; and preferably, induction circuits in rotors and stators are geometrically similar forming core perimeters of similar size and geometry which leads to induction of current flow in the rotor

induction circuits. For a three phase induction motor, rotors with induction circuit are preferably in a sequence of first phase 591, second phase 592, and third phase 593 with a repeat of that sequence 591 592 593 (see Fig. 32). Preferably, pairs of rotor boards are placed between pairs of stator boards except for single stator boards on the ends. An iron backplate may be placed on the two longitudinal ends of a stacked stator system; the iron backplate may have thickness conforming to provide a constant magnetic flux density; and a coil may be places around a portion of iron backplate to provide excitation voltage. Here, flow of current is to be distinguished as an organized current versus random Eddy currents.

[55] A control unit 513 may be used to change from one rotor electrical connection configuration to another. Disks need not be of uniform thickness, could become increasingly thin on outer radius for a rotor, stator can actually meet to stop leakage (see Fig. 7i).

[56] Adjacent induction circuits may be configured to generate magnetic fields at different phase angles. A preferred generator is an induction generator and comprises a rotor of substantially the same configuration as the stator, only the rotor is configured to rotate (see Fig. 10). If excitation current is provided to the rotor by a means connected to the rotor control unit (see Fig 10), power is provided by the stator. If excitation current is provided to the stator, power is provided by the rotor. Excitation may be provided by configurations known in the science, such as: a) shunt or self excited, b) excitation boost system, c) permanent magnet augmentation, and d) auxiliary winding. Figs. 10a and 10b illustrate a three-phase configuration with three pairs of adjacent induction circuit discs. Whether an inner busbar (Fig. 10a) or outer busbar (Fig. 10b), and the configurations may be a rotor or a stator; whereby, the phase angles and induction circuit core sizes of a rotor-stator combination should match such as illustrated by Fig. 10. In the motor mode of operation, the stator control unit controls power to stator and the stator control unit connects terminals the two terminals of each induction circuit. For an induction circuit has repeats an sequence of angular-direction duct connected to a radial-direction duct every 90 degrees, the phases of a 3-phase are offset 30 degrees. Fig.10 illustrates a S1S2R1R2-S3S1R3R1-S2S3R2R3 sequence, where S is stator, R is rotor, and 1-3 are phases. The phase offset is the degrees in the repeated pattern divided by the number of phases. Fig. 8g provides an alternative rotor configuration comprised of inner and outer circular induction tracks connected with radial tracks; this configuration is simpler, but does not allow for generator operation.

[57] While instant document commonly refers to the stator disc as a circuit board inductor on which preferred induction devices are based, the geometries of circuit boards are not limited to discs. The more-general specification comprises angular-direction tracks that are

in a plane of rotation at a specific radius. Radial-direction tracks may deviate from said plane of rotation. The boards have board-fluid interface surfaces of symmetry about an axis (i.e. axial symmetry) in a configuration that allows rotation of a rotor at low tolerance (i.e. spacing) next to a stator board. In a more-general embodiment, the degrees of rotation of the rotor may approach zero at a high radial dimension, where movement of the rotor approaches being linear relative to the stator board (i.e. a linear motor). Likewise, the induction circuit may extend to increasingly low degrees in the angular direction where angular and radial dimensions appear as length and width dimensions. Fig. 7 provides radial cross section views and axis (i.e. front) views of stator board inductors alternative to discs.

[58] Circuit board inductor construction of devices has a number of performance advantages, and preferred devices are configured to provide at least one of the group: a) improved heat transfer by transferring over half if circuit resistance heat directly across the interface surface (versus through a core material), b) ease of creating diverse configurations to optimally direct magnetic fluxes by repelling flux fields with conductive particles in a polymer matrix 571 and focusing flux fields with ferromagnetic materials 572 (see Fig. 8h), c) high power densities using thin stators and rotors resulting in high interface areas per volume, d) novel phase angle stacking for induction rotors, e) novel configurations to gradually or suddenly change stator torque or speed/rpm in axial direction to drive different rotors sharing the same stator busbar, f) improved heat transfer by minimizing the amount of electrical insulation in the primary paths of heat transfer, and g) ease of creating diverse configurations with functional devices connected integrated into the rotor construction.

[59] A rotor does not have to be continuous; or example, the rotor could be ends of fan blades at a slight angle with at least one blade in a stator board that traverses less than 180 degrees in the angular dimension.

[60] Aerial Vehicle - An aerial vehicle according to various aspects of this present invention employs an aerial towed platform 1 comprising a flat plate airfoil 2 pivotally connected to a propulsion means having a propulsor 3 through a forward joint 4. The flat plate airfoil 2 comprises a sheet 5, a rounded leading edge 6, a trailing edge 7, an average chord length, two sides 8, an average span between the sides 8, and a distributed load. The sheet 5 has an upper aerodynamic surface 9 for generating lift and a lower aerodynamic surface 10 for generating additional lift. The flat plate airfoil's average chord length is greater than its average span.

[61] A preferred distributed load is an evenly distributed load comprising an array 11 of solar cells 12 on the upper aerodynamic surface 9 of the sheet 5 with the array 11 comprising

a circuit 13 connecting the solar cells 12. Preferably, the propulsion means is at least of one of a lead aircraft 14, a linear motor 15, and a tractor. Preferably, the forward joint 4 is at least one of a hinge joint, a pin joint, and a ball joint. Fig. 1. illustrates a lead aircraft 14 pulling the aerial towed platform 1 with a liftpath traversing two pivotable connections. Example sheet 5 materials are a canvas, a metal sheet, a composite sheet, a corrugated plastic, and a corrugated board; all characterized by a low thickness. The flat plate airfoil is an airfoil.

[62] Towed configurations are inherently stable in pitch provided the forward joint 4 is toward the leading edge 6 of the towed platform 1. Preferably, the forward joint 4 is has a lateral axis of rotation in the front 25% of the platform; more preferably within the front 10%of the platform 1, or optionally, extended in front of the leading edge (see Fig. 11). In this configuration, aerodynamic forces generate lift torque that balances load at a steady-state flight pitch without need for active control of the pitch angle.

[63] A rectangular flat plate airfoil that has pitch instability becomes inherently stable when towed via a forward joint. Preferably, the tiltwing 30 has a control means selected from the group: flaps, ailerons 17, elevons, and horizontal stabilizers; the control means 16 controls at least one of roll, pitch, and yaw. Preferably, a pivot resistance device 41 limits the degrees of pitch of the flat plate airfoil 2 relative to the tiltwing 30 to less than 45 degrees. Examples of a pivot resistance devices includes hinge springs, pads 33, bumpers, and springs; all of which functionally limit the degree with which the flat plat airfoil is able to rotate relative to the tiltwing 30. For runway takeoff, the pivotal resistance device limits the nose-up pitch of the tiltwing to less than 20 degrees more than the towed platform, more preferably less than 20 degrees.

[64] A flying towed platform train is comprised of a lead aircraft 14 followed by a primary aerial towed platform 31 followed by at least a second aerial towed platform 33. Platform average thickness is preferably less than one fifth the platform's width, more preferably less than one tenth. Methods known in the science and art may be used to provide smooth and streamlined air flow along platforms in a train sequence. For example, a lateral leading edge of a platform may contact the trailing lateral edge of the body in front of said platform; such a connection is referred to a aerodynamically contiguous.

[65] Embodiments of this invention may be towed by a linear motor 15 propelling along an overhead monorail. A flat platform may be spaced (i.e. comprising a gap) above (or below) a fuselage with the vehicle configured for that space to decrease as velocity increases. A fuselage may have a platform or multiple wings attached on its lower (or upper) surface.

[66] Flat plates attached to a fuselage, preferably, are rectangular and have spans at least

50% greater than the median width of the fuselage 44. Preferred cruising pitch angles are preferably between 0.2 and 5 degrees, and more preferably between 0.5 and 3 degrees. The platforms of Fig. 1 are liftpaths, and sequential platforms may align to form a longer liftpath. Alternative to a front tiltwing, a propulsion means may extend laterally from a hinge joint in the front 25% of the platform and impart advantages of stability for flat platforms that are otherwise unstable in flight (see Fig. 13). Fig. 11 illustrates an aerial vehicle with platforms in cruising, VTOL, and pod configurations.

[67] "Liftpath" is a term used to define efficient lift surfaces other than traditional airfoils; it is described and defined in U.S. Patent 10,589,838 B1 and provisional applications cited therein. Liftpaths include aerodynamically-contiguous surfaces having air angle of attacks from 0 to 3 degrees (leading-edge up surfaces of low pitch) on relatively flat rectangular surfaces that are longitudinally longer than laterally (i.e., spanwise) wide. Structural or control surfaces such as actuators and ailerons (17, 18), arms (24, 26, 42, 43, 46, 47, 140), support surfaces (23), wing or blade sections, stabilizers (16), and rudders (17) (see Figs. 1, 11, and 15) may extend from a liftpath. The swaywing is located below the airchassis and pivotably coupled to the airchassis. Platform 1 88 surfaces 9 10 93 are examples of liftpaths. More preferably, liftpaths have an average platform width greater than ten times an average platform thickness, and liftpahts have median platform lengths greater than the median platform widths.

[68] Front Tiltwing – Three features tend to be common between the aerial towed platforms embodiments of the previous paragraphs and transformer drone embodiments of the following paragraphs. Firstly, the embodiments rely on liftpaths for aerodynamic lift more than laterally-extending fixed wings. Secondly, a front tiltwing is preferred. Thirdly, most transformer drone embodiments have a platform with a forward joint connecting to a front tiltwing. And so, many of the configurations described for a transformer drone may be practiced on a vehicle comprising an aerial towed platform, and visa versa such as illustrated by Fig. 12. Fig. 15 illustrates a drone comprising a towed payload compartment platform 88 and a forward joint 89 similar to the towed platform 1 previously described.

[69] Fig. 12c illustrates a trailing propulsor which has an orientation that is preferably coupled to the orientation of the front tiltwing through a cable, push rod, or other means running along the towed platform.

[70] Fig. 11f illustrates a transformer drone with a payload compartment platform. The transformer drone is a multicopter comprising a multicopter airchassis 102; a forward tilting body 103 pivotably connected [bearing 104] to the airchassis 102 and configured to pivot

between a first position 105 associated with a hover flight mode and a second position 106 associated with a forward flight mode.

[71] The preferred transformer drone embodiment is a multicopter comprising: a) an airchassis; b) a front tiltwing pivotably coupled to the airchassis; the front tiltwing including: (i) a first propulsor configured to generate at least one of thrust or lift and (ii) an aerodynamic lift surface; c) a counterbalance propulsor system coupled to the airchassis, the counterbalance propulsor system configured to balance gravitational, aerodynamic, thrust and lift forces and torques caused by the front tiltwing, the counterbalance propulsor system including a second propulsor configured to generate at least one of thrust or lift; and d) a control unit. Multicopter configurations may include two to more than four propulsors. Figs. 11a and 14 illustrate multicopters with two trailing end propulsors mounted on trailing end wings; Fig. 14 illustrates the additional feature of pod loading and unloading access from trailing edge.

[72] Preferably, aerial vehicles (including multicopters) comprise a plurality of longitudinally-extending lift-generating surfaces 327 forming a total aerodynamic lift surface area; the plurality of longitudinally-extending lift-generating surfaces including tiltwings, arms and lifting bodies such as fuselages with fuselage lifting-body surfaces, freewings, and swaywings as illustrated by Figs. 11 and 15. More preferably a multicopter comprises the fuselage, the front passively-adjusting tiltwing, an arm mechanically connecting the front passively-adjusting tiltwing to the fuselage, and platform surfaces 9 10. The plurality of longitudinally-extending lift-generating surfaces align to form a liftpath in a cruising configuration. Preferably, a single front tiltwing is in front of a single fuselage. Preferred is lift of the front passively-adjusting tiltwing at less than half the lift provided by the total aerodynamic lift surface area. Stated in alternative terms, tiltwing lift is less than half the total multicopter weight. Swaywings and freewings of this invention are types of fuselages. For vehicles without a swaywing or freewing, the airchassis is part of the fuselage.

[73] Preferably, the airchassis, front tiltwing, and counterbalance propulsor system are transitionable through passive actuation to a default failsafe descent configuration, the failsafe descent configuration is conducive to landing without catastrophic damage. A preferred failsafe landing is in a pseudo-autorotation method with a pseudo-hovering configuration. Pseudo-autorotation method means "sort of autorotation method" and refers a moderate power supply to the propeller during descent with an increased in power three to fifteen seconds before landing to soften the landing. A front tiltwing is located in front of the fuselage center of gravity, and the passive stability features of a front tiltwing causes formation of the auto-hovering configuration at forward velocities less than 50 miles per hour

(mph) when there is negligible lift from the counterbalance propulsor and when lift-path lift is inadequate to maintain a cruising configuration.

[74] Characteristics of failsafe landings include one or more of: a) the thrust generated by the first propulsor is increased to a value greater than the pseudo-hovering lift prior to landing, b) the control unit (or pilot) maintains the roll angle between about -20 degrees to about 20 degrees from horizontal, and c) a slight forward velocity during the pseudo-autorotation failsafe (see Fig. 10c) to facilitate control/stability.

[75] A first failsafe method (Fig. 11c) comprises transitioning the front tiltwing to a position wherein the total vehicle lift is more than four times greater than the front tiltwing propulsor lift and the tiltwing propulsor thrust is at least eighty percent of the total vehicle thrust. A second failsafe method (Fig. 11c) comprises transitioning the front tiltwing to a position where the front tiltwing propulsor lift is greater than one third of the total vehicle lift and the tiltwing propulsor lift is greater than the total vehicle thrust (i.e. a ratio of vertical lift to horizontal thrust greater than one). Preferably, passive aerodynamic actuation transitions the tiltwing for the first failsafe method and second failsafe method. The passive aerodynamic actuation is a result of the inherent stability of the front tiltwing against stall where tiltwing propulsor thrust induces the failsafe mode. Preferred pseudo-autorotation increases and maintains lift from a propulsor or blade to >70%, preferably >99%, of the vehicle weight at least one second before impact.

[76] The second failsafe method is enabled by a front tiltwing propulsor force vector that provides a minimum torque about that center of gravity. In general, minimum torque corresponds to the closest distance of approach of the extended force vector being less than half the median width of the aircraft fuselage.

[77] Vehicles of failsafe methods may include aerial vehicles and multicopters. A VTOL vehicle of this invention uses a front tiltwing to transition from VTOL to cruising and to enable a failsafe/emergency landing method. The VTOL vehicles have an airchassis as a support structure that may be part of a fuselage or a separate structure. Embodiments apply to multicopters ranging two to more than four propulsors. Fig. 11 illustrates multiple multicopters capable of achieving VTOL failsafe landings using only a front tiltwing.

[78] A rectangular geometry is defined with a length substantially straight as a streamlined air flow above the surface and a lateral width where said straight streamlined airflow traverses most of the length of the aerial vehicle. This substantially flat rectangular geometry may be within a larger flat surface having lateral and longitudinal extensions beyond that rectangular geometry that serve a variety of purposes.

[79] Flat plate construction can be relatively inexpensive. Other advantages reside in the plate materials. Transparent plates can provide stealth. Laminates with a conductive layer (sheet or grid) sandwiched in insulation can provide electrical connectivity for an aircraft, including control signals superimposed of electrical power transmission (see Fig. 16). Also, sheets may have conductive tracks that are insulated from each other but with ability to connect to electrical devices on the aircraft; this allows for elimination of wires and provides a robustness when tracks are wide and redundant.

[80] The forward joint on a towed platform provides performance advantage by providing stable flight for flat surface lifting bodies that are otherwise difficult to control. This is achieved by having the force on the lifting body be the driving force to a stable the desired configuration (i.e. the desired configuration is the stable configuration). A good metric to identify whether a lifting body surface design is in need of the front hinge joint to enhance stability is the area-weighted L:D of the entire surface of a towed platform. High L:D benefit from the forward joint. Herein, high is defined as >20:1 at the optimal cruising configuration. An area-weighted L:D approximation of $\cos(\Phi) / \sin(\theta)$. (where S is surface area, θ is the angle of a longitudinal tangent line on the surface relative to a vertical line and Φ is the angle of a vertical tangent line to the surface relative to lateral line, lateral is a spanwise dimension). For a horizontal flat surface, L/D is approximately $52.7/\theta$. For a side vertical surface, L/D is zero. For lower surfaces that slope upward toward the tail, the L:D is negative and takes away from performance. The weighting function is $[\cos(\Phi) + 0.01]$ so as to account for low form drag of side surfaces. And so, the lift-weighted L:D is the integral of $[\cos(\Phi) ((\cos(\Phi)+0.01) / \sin(\theta)\, dS]$ divided by the integral of $[\cos(\Phi) ((\cos(\Phi)+0.01) / \sin(\theta)\, dS]$. The preferred towed platforms of the towed platform embodiments an area-weighted L:D greater than 30:1; and more preferably greater than 40:1. The towed platforms of the transform drone embodiments are more relaxed in this metric at 20:1. An alternative metric is to use the actual L:D of the towed platforms or fuselages that are towed by a forward joint.

[81] A vehicle with lateral tiltiwing connected in the front 25% of the lifting body surface (more preferably in or in front of the front 10%) and where over half (over 70% and over 85%) of the total lift (at air angles of attack between 0 and 3 degrees) is from a combination of upper and lower rectangular liftpaths on the lifting body surface. Liftpaths preferably extend at least 75% of the total vehicle length on both the top and bottom of the vehicle; more preferably at least 90% of the total length and at least 90% of the median width. In more general terms, the vehicle is a lifting body surface or combination of a plurality of surfaces that form aerodynamically contiguous and streamlined (laminar) air flow.

CLAIMS

1. A stator system comprising:

an induction circuit, said induction circuit comprising:

a sequence of a radial-direction track coupled to an angular-direction track, said sequence extending along a surface between said stator system and a fluid;

wherein a track is a conductive material and may include electrical insulation on said track's outer surface;

wherein the stator system is configured to generate electromagnetic induction forces.

2. The stator system of claim 1 wherein said stator system is a stator of an induction device; said induction device is selected from the group comprising: a rotary motor, a generator, a brake, a damper, a linear motor, a rotary induction motor, a servo, an axial flux rotary motor, and a surrogate solenoid device.

3. The stator system of claim 1; further comprising a terminal-to-terminal induction circuit; said terminal-to-terminal induction circuit is an induction circuit extending between a first terminal and a second terminal; wherein half or more of the induction circuit's resistance heat transfers directly to said fluid.

4 The stator system of claim 1;

said stator system coupled with a rotor system in an induction motor;

said induction motor comprising adjacent induction circuits, said adjacent induction circuits sharing common and continuous electromagnet cores, said adjacent induction circuits configured to generate magnetic fields at different phase angles.

5. The stator system of claim 1 further comprising:

a plurality of stator discs configured substantially symmetric about a common axis, said stator discs comprising a plurality of terminal-to-terminal induction circuits;

and a plurality of gaps between said stator discs;

wherein said stator system is configured as a stator of a motor, said motor comprising at least one rotor.

6. The stator system of claim 5;

said plurality of stator discs further comprising stator disc cores comprised of materials selected from the group comprising: ferromagnetic composite, ferromagnetic metal, air, and water;

wherein the motor is one selected from the group comprising: a three-phase induction motor, a six-phase induction motor, a two-phase induction motor, a four-phase induction motor.

7. The stator system of claim 1 further comprising a plurality of stator discs configured as a stator of an induction motor,

said induction motor comprising a rotor system, said rotor system comprising a conductive-metal surface.

8. The stator system of claim 1 further comprising a first induction circuit having first axial tracks and a second induction circuit having second axial tracks;

wherein said stator system is configured to generate an electromagnetic field and accelerate a reaction element;

wherein said first axial tracks are parallel to said second axial tracks.

9. The stator system of claim 8 wherein the reaction element is selected from the group comprising: rotor, slider, lever arm, a ferromagnetic rod, circuits, and a conductive surface configured to generate induced current.

10. The stator system of claim 8;

said first induction circuit and said second induction circuit further comprising multiple electromagnetic core perimeters;

said reaction element further comprising a rotor induction circuit and core perimeters of similar size and geometry as the first induction circuit;

wherein the reaction element is an induction rotor configured for flow of current in said rotor induction circuits.

11. The stator system of claim 10;

wherein said rotor induction circuit is one of a plurality of rotor induction circuits;

wherein said plurality of rotor induction circuits are of a configuration selected from the group comprising:

parallel closed-circuit rotor induction circuits,

parallel rotor induction circuits configured at phase angles equal to stator board phase angles,

parallel rotor induction circuits configured to interact with a stationary excitation magnetic field system in an induction generator, said induction generator configured to convert rotational energy to electrical current,

and parallel rotor induction circuits configured to interact at least one core of one of the stator boardss in an induction generator, said induction generator configured to convert rotational energy to electrical current.

12. An engine comprising:

rotating blades, said rotating blades comprising compressor blades and expander blades;

and a combustion pressure volume, said combustion pressure volume comprising a fluidic

radial surface;

wherein rotation of said compressor blades is coupled with rotation of said expander blades;

wherein said engine is configured for the rotating blades to contain at least one third of the fluidic radial surface.

13. The engine of claim 12 further comprising a compressor comprising said compressor blades, an expander comprising said expander blades, and a coupling means;

wherein said coupling means is selected from the group comprising: a shaft, a connection at the outer radius of rotation of at least some of the expander blades, and a magnetic induction device;

wherein said compressor is selected from the group comprising: a turbine, a propeller, and a fan;

wherein said expander is selected from the group comprising: a turbine, a propeller, and a fan;

wherein said engine is selected from the group comprising: a jet engine, a gas turbine, and hybrid electric-fuel jet engine.

14. The engine of claim 12 further comprising an electric motor;

wherein said engine is configured to sustain flight with or without fuel use;

wherein said compressor is a leading compressor, said expander is a trailing expander, and the combustion pressure volume is longitudinally located between said compressor and said expander.

15. The engine of claim 12 further comprising a plurality of pressure volumes, said pressure volumes comprising an outer pressure volume and an inner pressure volume;

wherein the inner pressure volume is fully contained in the outer pressure volume;

wherein the inner pressure volume has a higher pressure than the outer pressure volume;

wherein combustion occurs in the inner pressure volume;

wherein said inner pressure volume has an inner expander trailing said inner pressure volume;

wherein said outer pressure volume as an outer expander trailing said outer pressure volume.

16. A hybrid engine comprising an electric motor with a rotor and a combustor,

said electric motor comprising an open motor core positioned around a longitudinal axis of rotation;

said combustor located between a leading compression section and a trailing expansion section;

wherein air flows through said open motor core to the combustor;

wherein said hybrid engine is configured to transition from electric-powered propulsion to propulsion with both electric and jet power.

17. The hybrid engine of claim 16 further comprising:

a combustor configured to sustain fuel combustion in air having entering velocities greater than mach 0.8,

a bell nozzle trailing the combustor and configured to expand combustion gases, and

a compression blade assembly configured absorb an impulse force generated by acceleration of gases during combustion.

18. The hybrid engine of claim 16;

wherein said leading compression section is connected to a first electric motor rotor;

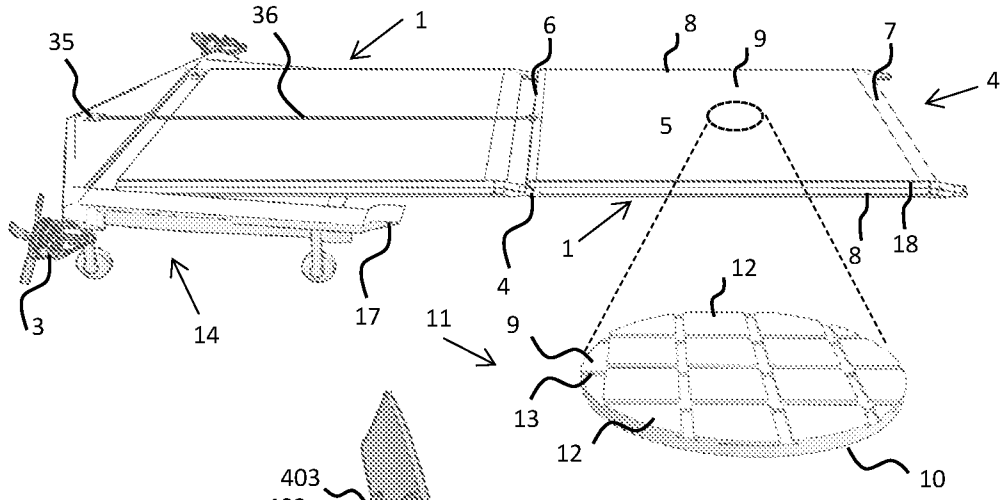
wherein said trailing expansion section is connected to a second rotor;

wherein the motor is configured to transfer power from the second rotor to the first rotor.

19. The hybrid engine of claim 16 wherein electric motor is at least one configuration selected from: a) a motor configured to initiate propeller rotation, b) a motor configured to supplement jet engine power, c) a generator configured to recover energy from propeller rotation, and d) an induction device configured to transfer power from a trailing expander to a leading compressor.

20. The hybrid engine of claim 16 further comprising a fast stator and a slow stator, said slow stator coupled to a propeller through a slow rotor.

Fig. 1



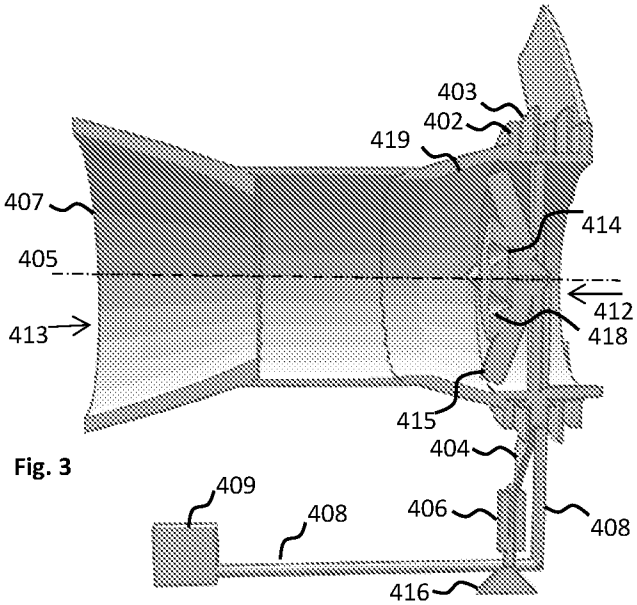


Fig. 3

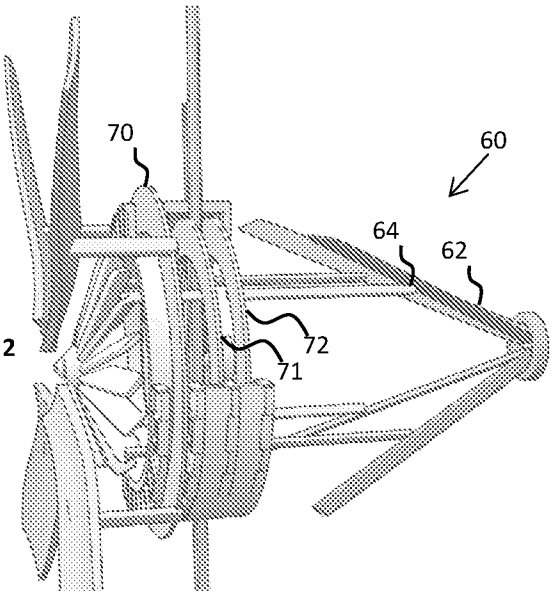


Fig. 2

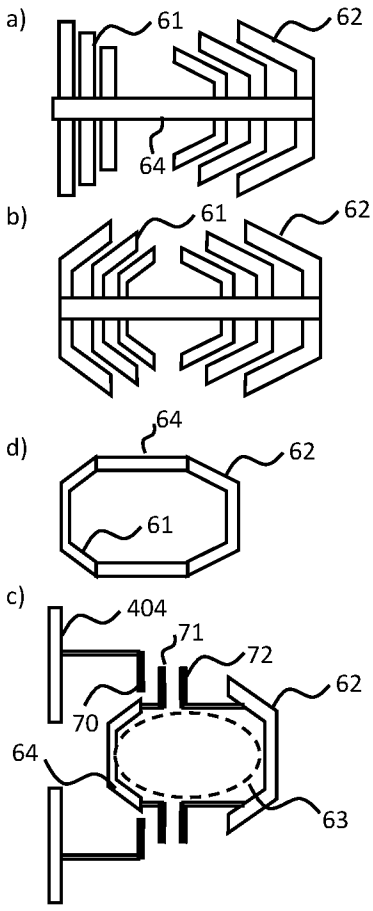


Fig. 4

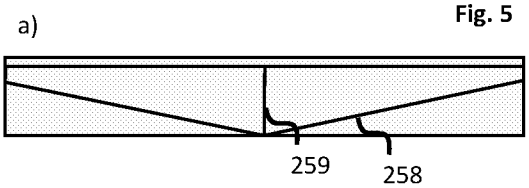


Fig. 5

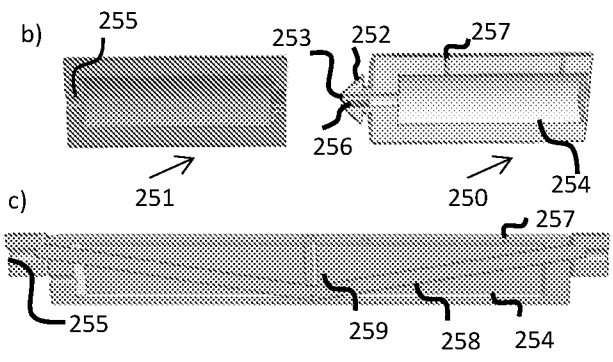


Fig. 6

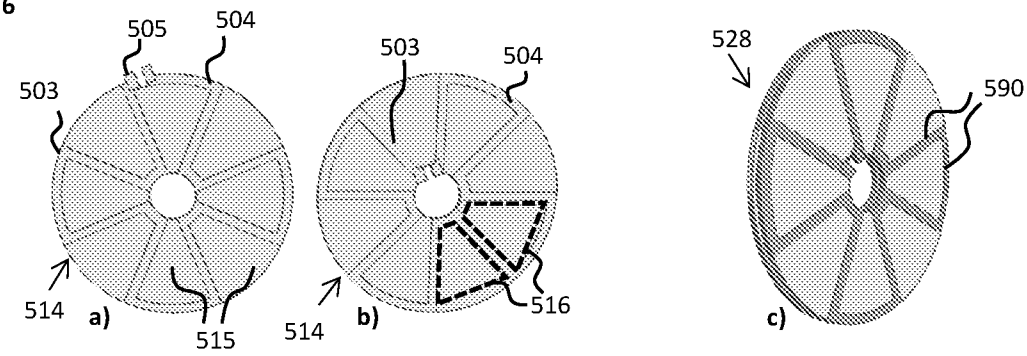


Fig. 7

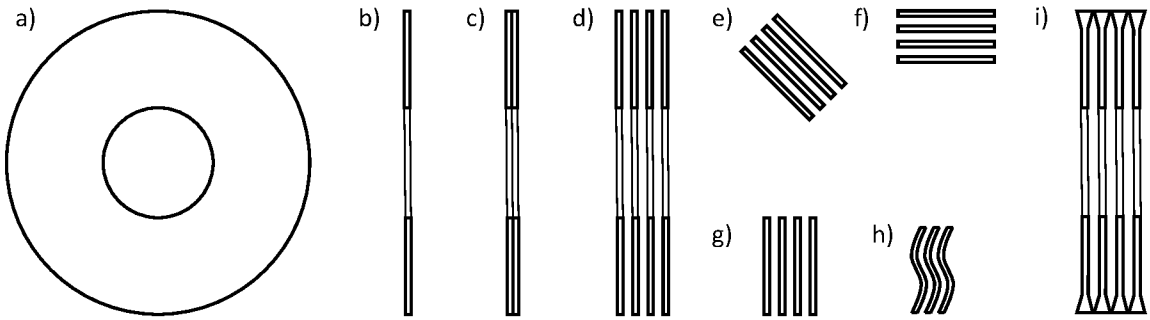


Fig. 8

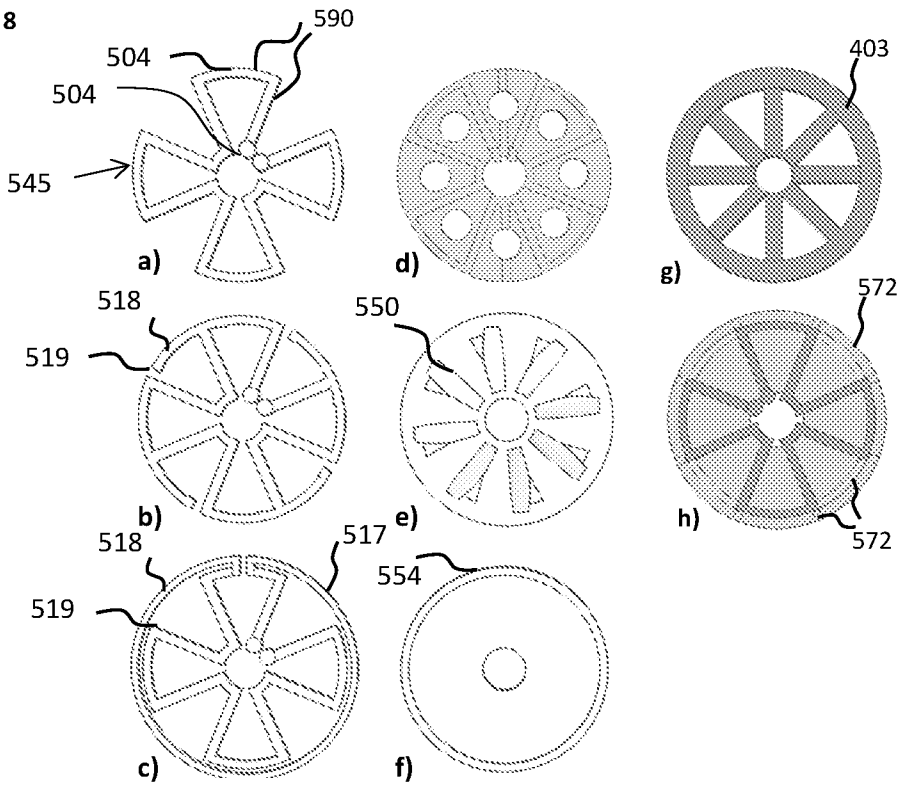


Fig. 10

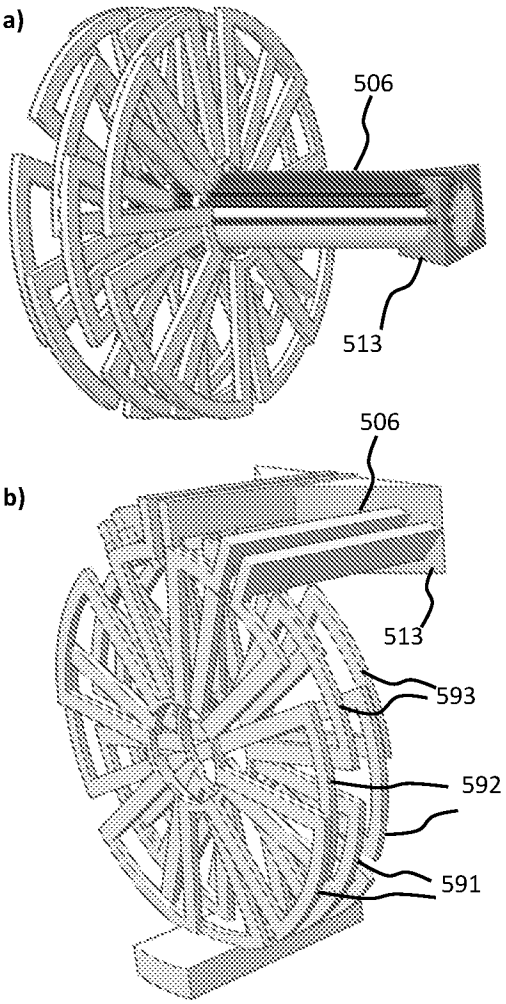


Fig. 9

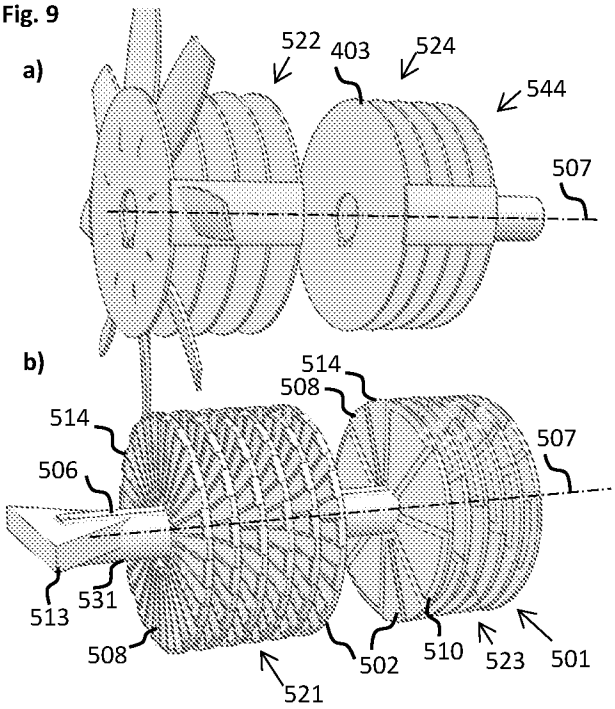


Fig. 11

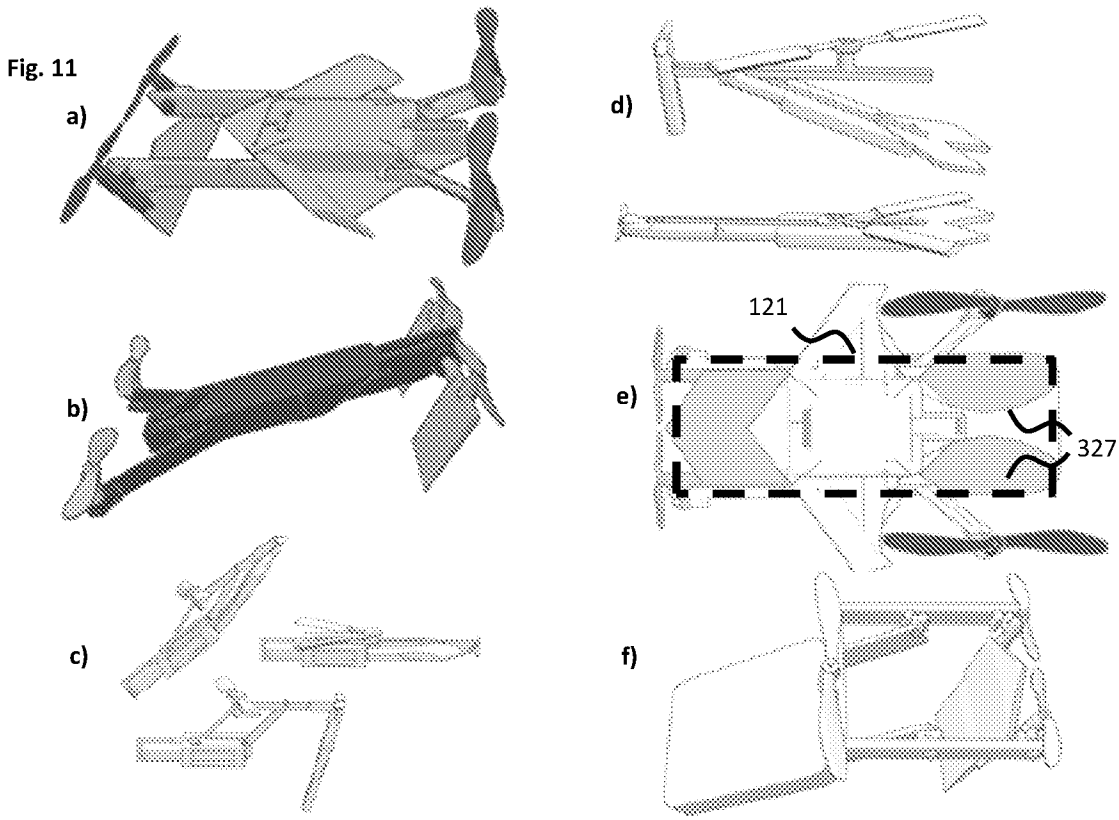
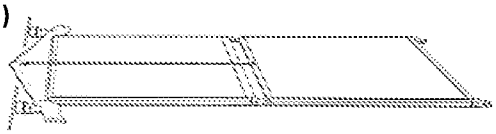


Fig. 12

a)



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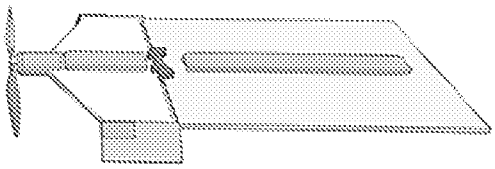


c)

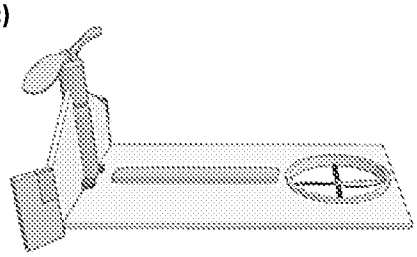


Fig. 13

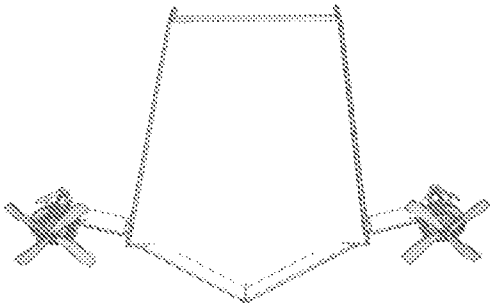


Fig. 14

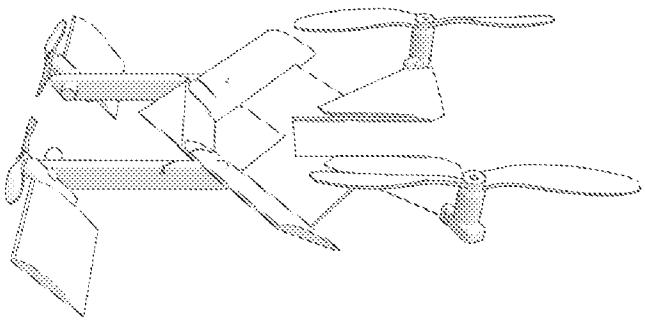


Fig. 15

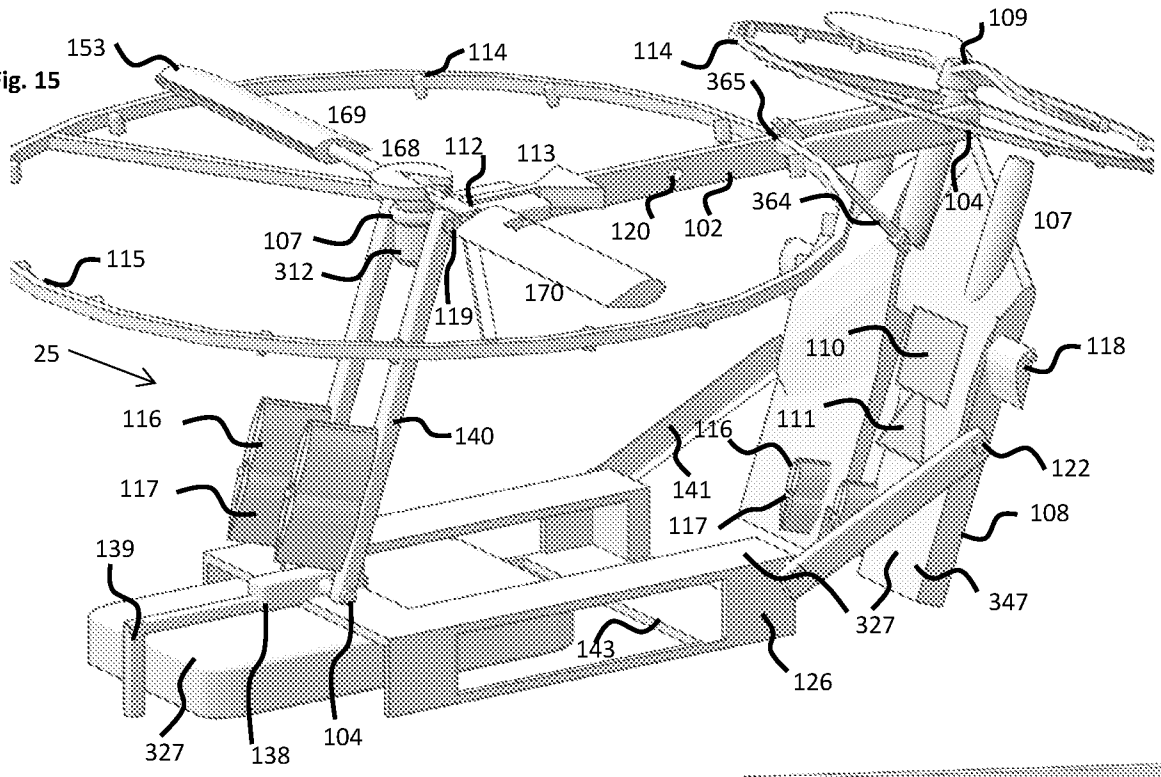
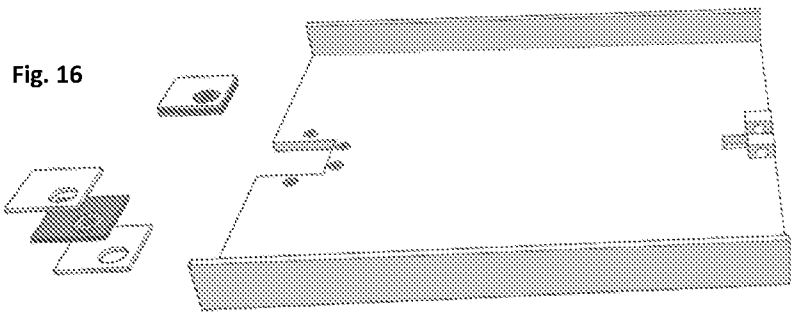


Fig. 16



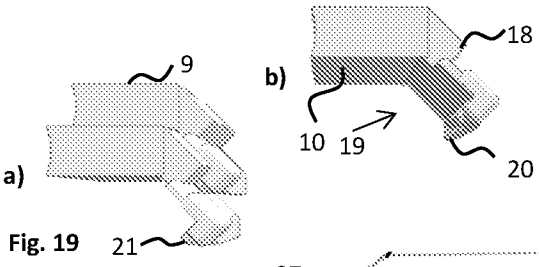


Fig. 19

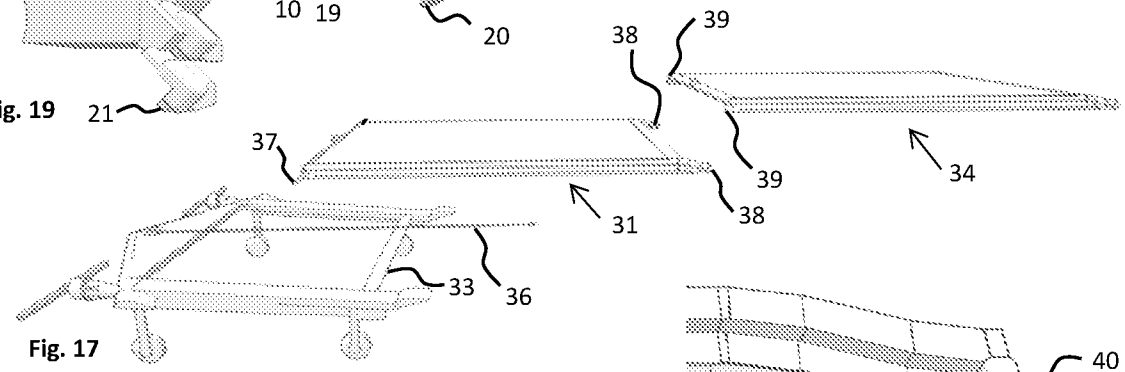


Fig. 17

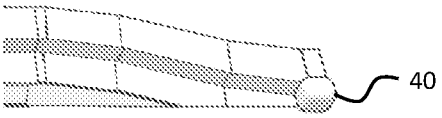


Fig. 20

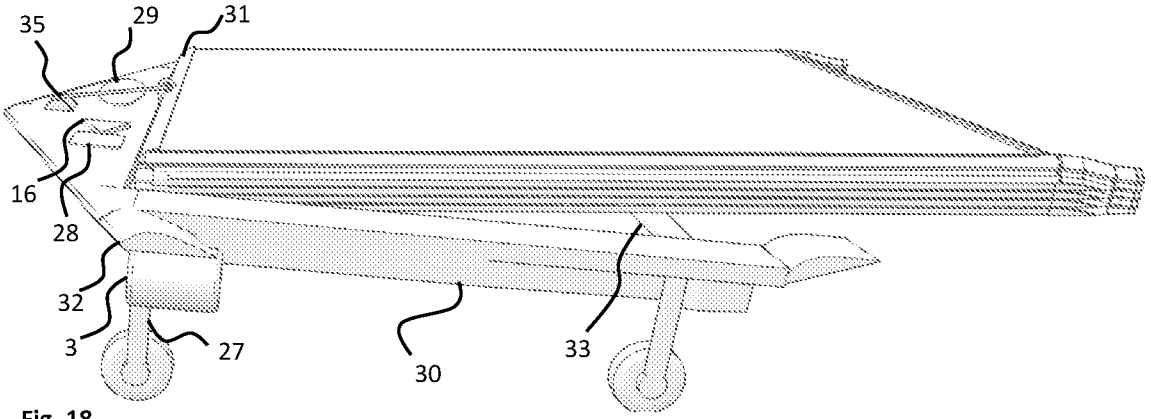


Fig. 18

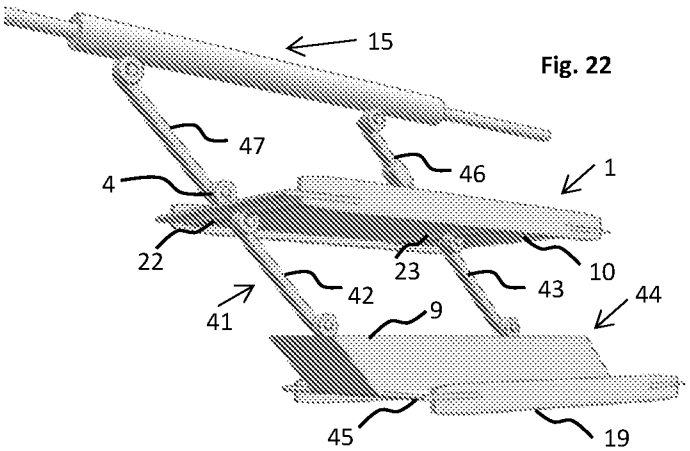


Fig. 22

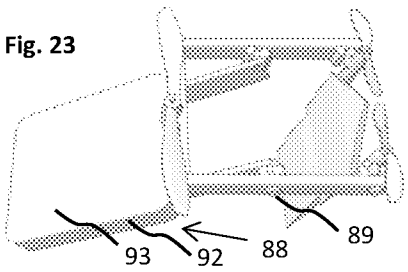


Fig. 23

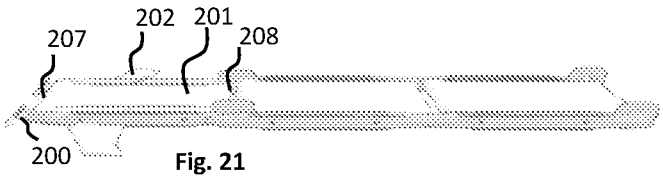


Fig. 21

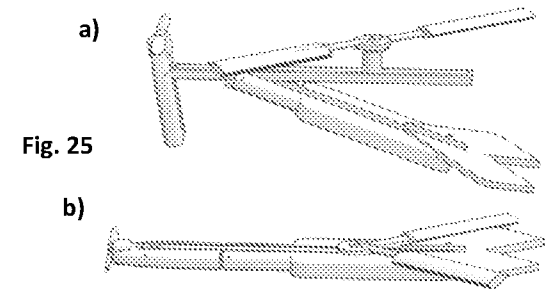


Fig. 25

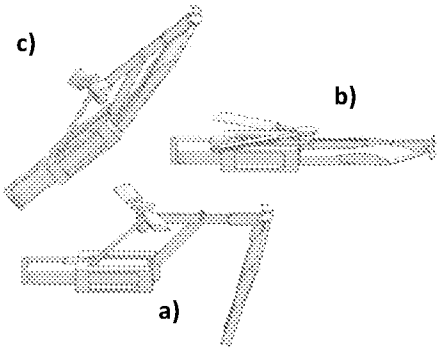


Fig. 24

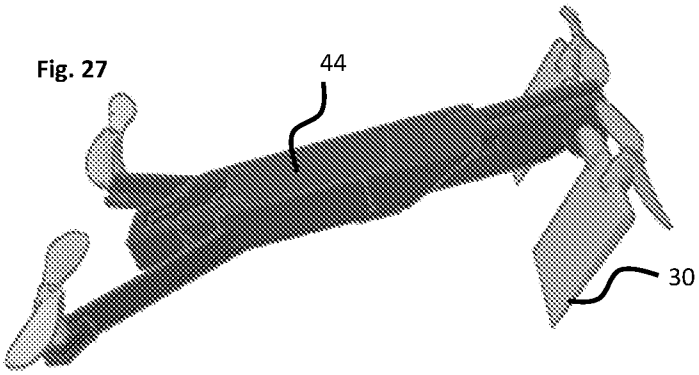


Fig. 27

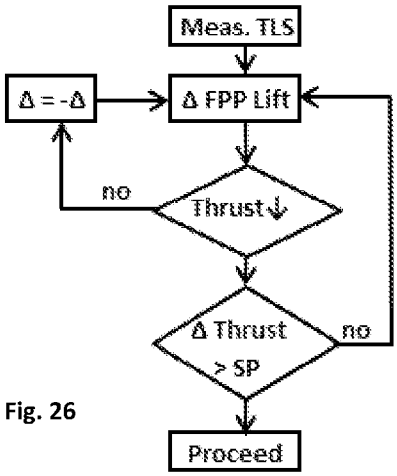


Fig. 26

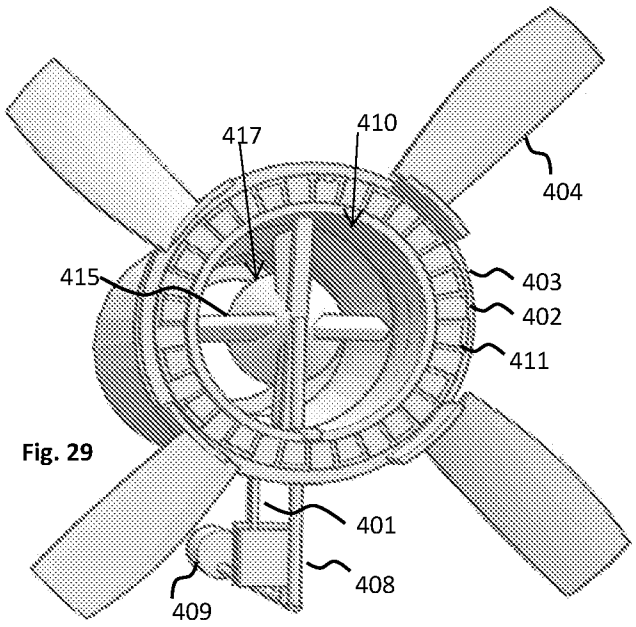


Fig. 29

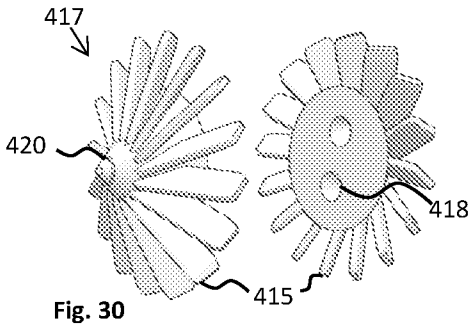


Fig. 30

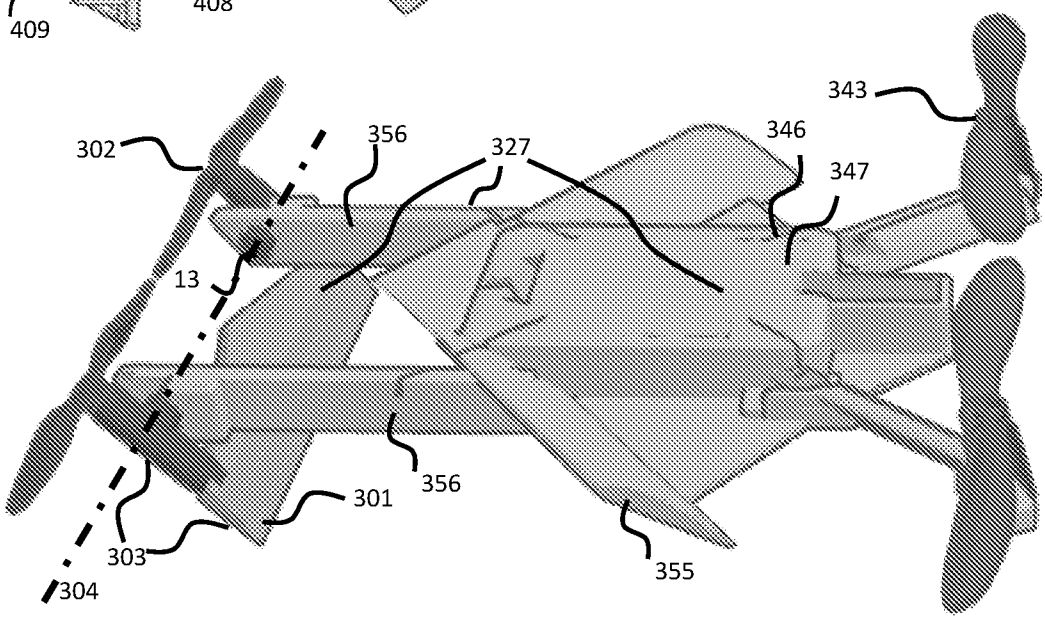


Fig. 28

Fig. 31

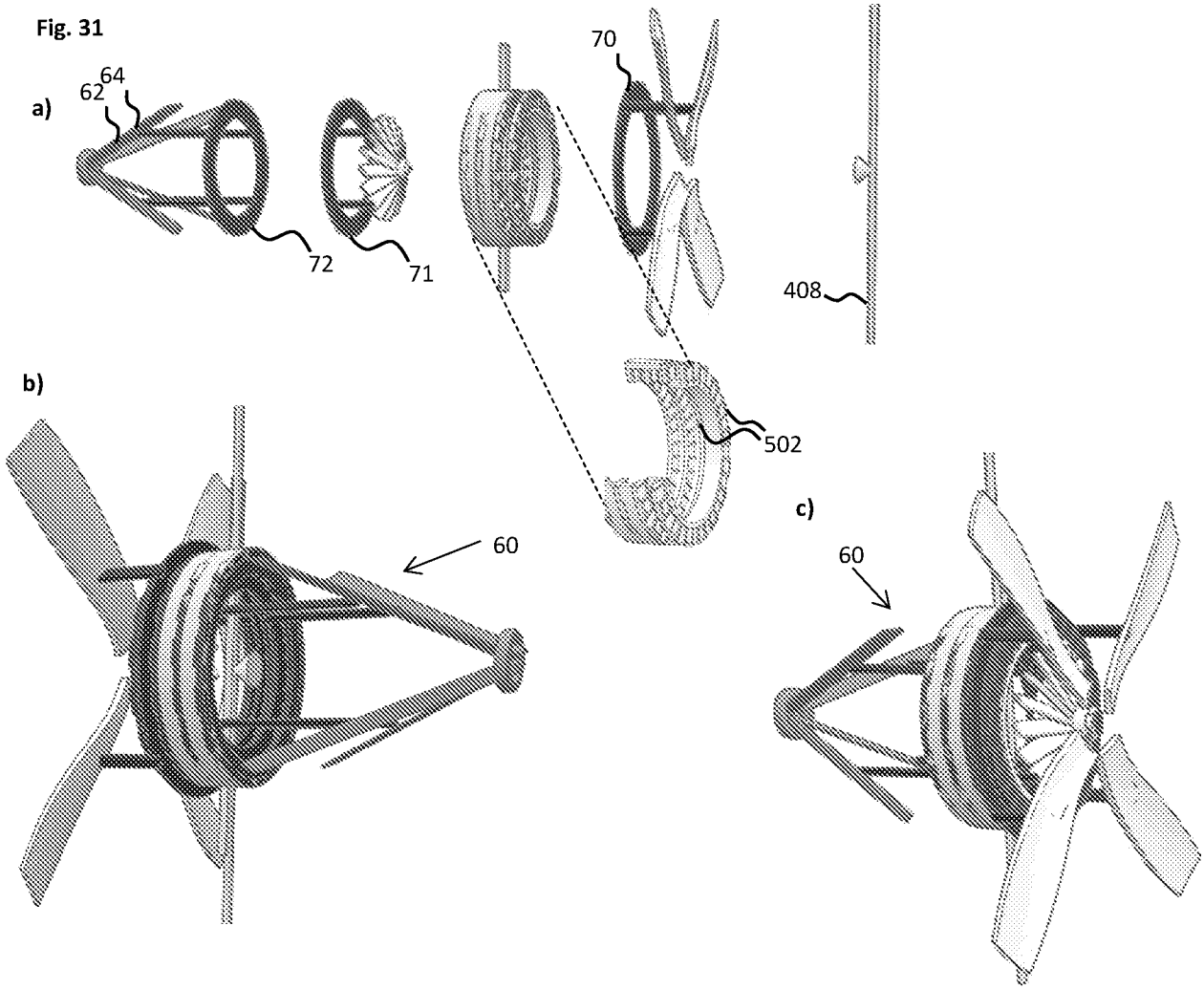


Fig. 32

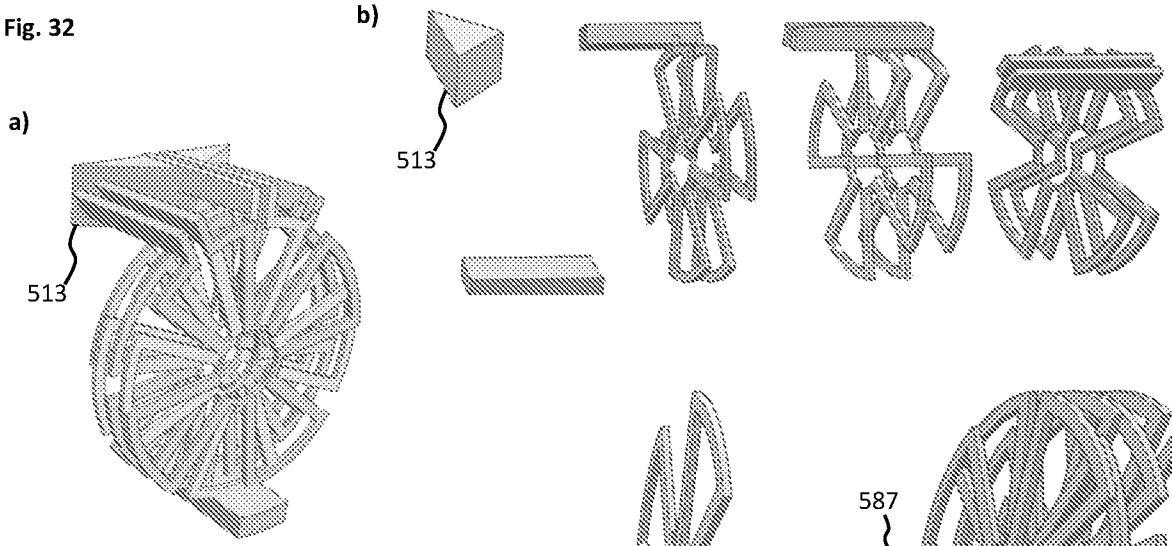
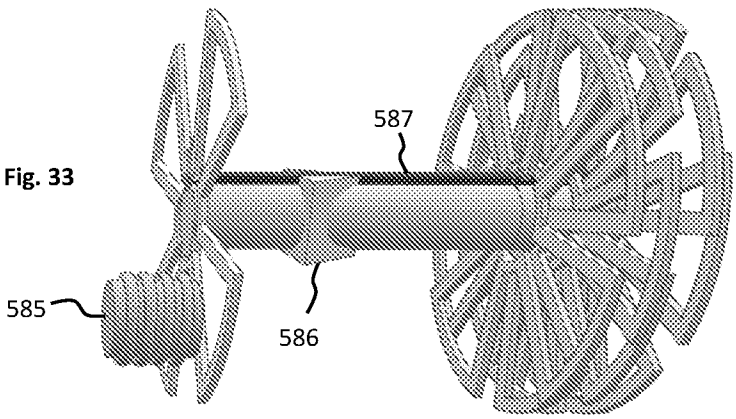


Fig. 33



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/014884

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H02K 3/28; H02K 1/16; H02K 3/04; H02K 3/12; H02K 3/26; H02K 7/09; H02K 21/24 (2022.01)
CPC - H02K 3/28; H02K 1/16; H02K 3/04; H02K 3/12; H02K 3/26; H02K 7/06; H02K 21/24 (2022.05)

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)
see Search History document

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
see Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020/0255128 A1 (SUPPES) 13 August 2020 (13.08.2020) entire document	1-3, 5, 8-11
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Y		4, 6, 7
Y	US 2010/0133929 A1 (SAKAMOTO et al) 03 June 2010 (03.06.2010) entire document	4
Y	US 2010/0295487 A1 (LI et al) 25 November 2010 (25.11.2010) entire document	6
Y	US 6,204,588 B1 (SPRINGER) 20 March 2001 (20.03.2001) entire document	7
A	US 2007/0012026 A1 (DEV) 18 January 2007 (18.01.2007) entire document	1-11
A	US 2019/0201030 A1 (ETHICON LLC) 04 July 2019 (04.07.2019) entire document	1-11
A	US 2019/0081541 A1 (NITTAN VALVE CO. LTD.) 14 March 2019 (14.03.2019) entire document	1-11
P, X	WO 2021/029947 A2 (SUPPES) 18 February 2021 (18.02.2021) entire document	1-11

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 June 2022	JUN 24 2022
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Taina Matos Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/014884

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet(s).

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-11

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/014884

Continued from Box No. III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-11, is drawn to a stator system comprising: an induction circuit, said induction circuit comprising: a sequence of a radial-direction track coupled to an angular-direction track.

Group II, claims 12-15, is drawn to an engine comprising: rotating blades, said rotating blades comprising compressor blades and expander blades.

Group III, claims 16-20, is drawn to a hybrid engine comprising an electric motor with a rotor and a combustor, said electric motor comprising an open motor core positioned around a longitudinal axis of rotation.

The inventions listed as Groups I, II and III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: an induction circuit, said induction circuit comprising: a sequence of a radial-direction track coupled to an angular-direction track, said sequence extending along a surface between said stator system and a fluid; wherein a track is a conductive material and may include electrical insulation on said track's outer surface; wherein the stator system is configured to generate electromagnetic induction forces as claimed therein is not present in the invention of Groups II and III. The special technical feature of the Group II invention: rotating blades, said rotating blades comprising compressor blades and expander blades; and a combustion pressure volume, said combustion pressure volume comprising a fluidic radial surface; wherein rotation of said compressor blades is coupled with rotation of said expander blades; wherein said engine is configured for the rotating blades to contain at least one third of the fluidic radial surface as claimed therein is not present in the invention of Groups I or III. The special technical feature of the Group III invention: an electric motor with a rotor and a combustor, said electric motor comprising an open motor core positioned around a longitudinal axis of rotation; said combustor located between a leading compression section and a trailing expansion section; wherein air flows through said open motor core to the combustor; wherein said hybrid engine is configured to transition from electric-powered propulsion to propulsion with both electric and jet power as claimed therein is not present in the invention of Groups I or II.

Groups I, II and III lack unity of invention because even though the inventions of these groups require the technical feature of an engine comprising a combustor, this technical feature is not a special technical feature as it does not make a contribution over the prior art.

Specifically, US 2007/0012026 to Dev teaches an engine comprising a combustor (Paras. [0080-0081]).

Since none of the special technical features of the Group I, II or III inventions are found in more than one of the inventions, unity of invention is lacking.