

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference EFS ID: 39678708	FOR FURTHER ACTION	See Form PCT/IPEA/416
International application No. PCT/US2020/036936	International filing date (<i>day/month/year</i>) 10 June 2020 (10.06.2020)	Priority date (<i>day/month/year</i>) 11 June 2019 (11.06.2019)
International Patent Classification (IPC) or both national classification and IPC IPC: B64C 29/00, 39/02; B64D 27/24 CPC: B64C 29/0033, 39/024, 2201/042, 2201/108; B64D 27/24, 2027/026		
Applicant GALEN J. SUPPES		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

3. This report is also accompanied by ANNEXES, comprising:

a. (sent to the applicant and to the International Bureau) a total of 36 sheets, as follows:

sheets of the description, claims and/or drawings which have been amended and/or sheets containing rectifications authorized by this Authority, unless those sheets were superseded or cancelled, and any accompanying letters (see Rules 46.5, 66.8, 70.16, 91.2, and Section 607 of the Administrative Instructions).

sheets containing rectifications, where the decision was made by this Authority not to take them into account because they were not authorized by or notified to this Authority at the time when this Authority began to draw up this report, and any accompanying letters (Rules 66.4bis, 70.2(e), 70.16 and 91.2).

superseded sheets and any accompanying letters, where this Authority either considers that the superseding sheets contain an amendment that goes beyond the disclosure in the international application as filed, or the superseding sheets were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in item 4 of Box No. I and the Supplemental Box (see Rule 70.16(b)).

b. (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) _____ containing a sequence listing, in the form of an Annex C/ST.25 text file, as indicated in the Supplemental Box Relating to Sequence Listing (see paragraph 3ter of Annex C of the Administrative Instructions).

4. This report contains indications relating to the following items:

Box No. I Basis of the report

Box No. II Priority

Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Box No. IV Lack of unity of invention

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

Box No. VI Certain documents cited

Box No. VII Certain defects in the international application

Box No. VIII Certain observations on the international application

Date of submission of the demand 12 April 2021 (12.04.2021)	Date of completion of this report 21 June 2021 (21.06.2021)
Name and mailing address of the IPEA/US COMMISSIONER FOR PATENTS MAIL STOP PCT, ATTN: IPEA/US P.O. BOX 1450 ALEXANDRIA, VA 22313-1450, UNITED STATES OF AMERICA Facsimile No. (571)273-8300	Authorized officer ANNA MOMPER Telephone No. 571-270-5788

Box No. I	Basis of the report
1.	<p>With regard to the language, this report is based on:</p> <p><input checked="" type="checkbox"/> the international application in the language in which it was filed.</p> <p><input type="checkbox"/> a translation of the international application into _____ which is the language of a translation furnished for the purposes of:</p> <p><input type="checkbox"/> international search (Rules 12.3(a) and 23.1(b))</p> <p><input type="checkbox"/> publication of the international application (Rule 12.4(a))</p> <p><input type="checkbox"/> international preliminary examination (Rules 55.2(a) and/or 55.3(a) and (b))</p> <p>2. With regard to the elements of the international application, this report is based on (<i>replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report</i>):</p> <p><input type="checkbox"/> the international application as originally filed/furnished, or</p> <p><input checked="" type="checkbox"/> the description: pages _____ as originally filed/furnished. pages* 1-20 received by this Authority on 12 April 2021 (12.04.2021)</p> <p><input checked="" type="checkbox"/> the claims: Nos. _____ as originally filed/furnished. Nos.* _____ as amended (together with any statement) under Article 19 Nos.* 1-20 received by this Authority on 12 April 2021 (12.04.2021)</p> <p><input checked="" type="checkbox"/> the drawings: pages 1-7 as originally filed/furnished. pages* _____ received by this Authority on _____ pages* _____ received by this Authority on _____</p> <p><input type="checkbox"/> a sequence listing - see Supplemental Box Relating to Sequence Listing.</p>
3.	<p>The amendments have resulted in the cancellation of:</p> <p><input type="checkbox"/> the description, pages _____</p> <p><input type="checkbox"/> the claims, Nos. _____</p> <p><input type="checkbox"/> the drawings, sheets/figs _____</p> <p><input type="checkbox"/> the sequence listing (<i>specify</i>): _____</p>
4.	<p>This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since either they are considered to go beyond the disclosure as filed, or they were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in the Supplemental Box (Rules 70.2(c) and (c-bis)):</p> <p><input type="checkbox"/> the description, pages _____</p> <p><input type="checkbox"/> the claims, Nos. _____</p> <p><input type="checkbox"/> the drawings, sheets/figs _____</p> <p><input type="checkbox"/> the sequence listing (<i>specify</i>): _____</p>
5.	<p>This report has been established:</p> <p><input type="checkbox"/> taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rules 66.1(d-bis) and 70.2(e)).</p> <p><input type="checkbox"/> without taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91(Rules 66.4bis and 70.2(e)).</p>
6.	<p>With regard to top-up searches (Rules 66.1ter and 70.2(f)):</p> <p><input checked="" type="checkbox"/> A top-up search was carried out by this Authority on 16 June 2021 (16.06.2021)</p> <p><input checked="" type="checkbox"/> Additional relevant documents have been discovered during the top-up search.</p> <p><input type="checkbox"/> No top-up search was carried out by this Authority because it would serve no useful purpose.</p>
7.	<p>Supplementary international search report(s) from Authority(ies) _____ has/ have been received and taken into account in establishing this report (Rule 45bis.8(b) and (c)).</p>
<p>* If item 4 applies, some or all of those sheets may be marked "superseded."</p>	

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	<u>2-5,8-20</u>	YES
	Claims	<u>1,6,7</u>	NO
Inventive step (IS)	Claims	<u>3-5,8-20</u>	YES
	Claims	<u>1,2,6,7</u>	NO
Industrial applicability (IA)	Claims	<u>1-20</u>	YES
	Claims	<u> </u>	NO

2. Citations and explanations (Rule 70.7)

----- **NEW CITATIONS** -----

US 20090014599 A1 (CYLINDER; DAVID A) 15 January 2009 (15.01.2009) , Entire document
 US 3141633 A (MACKAY JAMES K L) 21 July 1964 (21.07.1964) , Figures 1-6
 US 2448392 A (QUADY JOHN C) 31 August 1948 (31.08.1948) , Figures 1-8

----- **EXPLANATION** -----

Claims **1, 6, and 7** lack novelty under PCT Article 33(2) as being anticipated by Cylinder et al. (US 2009/0014599).

Regarding independent claim 1:

Cylinder discloses a multicopter comprising:an airchassis (110);
 a front tiltwing (160) pivotably coupled to the airchassis configured to transition between hovering (Fig 2B) and cruising (Fig 1B) configurations, the front tiltwing including a first propulsor (163/164) to generate thrust or lift and an aerodynamic lift surface (161/162);
 a counterbalance propulsor system (120) coupled to the airchassis configured to balance the gravitational, aerodynamic, thrust, and lift forces and torques caused by the front tiltwing, the counterbalance propulsor system including a second propulsor (120) configured to generate lift; and
 a control unit (73).

Regarding claim 6:

The discussion above regarding claim 1 is relied upon.
 Cylinder discloses the counterbalance propulsor comprising a midsection rotary wing (120).

Regarding claim 7:

The discussion above regarding claim 1 is relied upon.
 Cylinder discloses the airchassis as part of a fuselage (110).

Claims **1 and 7** lack novelty under PCT Article 33(2) as being anticipated by MacKay (US 3 141 633), or alternatively lacking an inventive step under PCT Article 33(3) as being obvious over MacKay (US 3 141 633) in view of Cylinder et al. ('599).

Regarding independent claim 1:

MacKay discloses a multicopter comprising:
 an airchassis (11);

Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
	<p>a front tiltwing (12) pivotably coupled to the airchassis configured to transition between hovering (Fig 4) and cruising (Fig 11) configurations, the front tiltwing including a first propulsor (21-28) to generate thrust or lift and an aerodynamic lift surface (12);</p> <p>a counterbalance propulsor system (17) coupled to the airchassis configured to balance the gravitational, aerodynamic, thrust, and lift forces and torques caused by the front tiltwing, the counterbalance propulsor system including a second propulsor (120) configured to generate lift; and</p> <p>a control unit (a manual and/or computerized unit is required for operation of the various features).</p> <p>However, should the applicant be of the opinion that a computerized unit is not provided, Cylinder teaches a UAV with a computerized control unit (73).</p> <p>It would have been obvious to a person having ordinary skill in the art at the time the invention was filed to have modified MacKay to use a computerized control unit as taught by Cylinder for the predictable advantage of enabling pilot-less flight, allowing flights into areas which are not safe for on-board occupants.</p> <p>Regarding claim 7:</p> <p>The discussion above regarding claim 1 is relied upon.</p> <p>MacKay discloses the airchassis as part of a fuselage (11).</p> <p>Claim 2 lacks an inventive step under PCT Article 33(3) as being obvious over the prior art as applied in the immediately preceding paragraph and further in view of MacKay (US 3 141 633), alternatively in view of Cylinder et al. ('599), in view of Quady et al. (US 2 448 392).</p> <p>Regarding claim 2:</p> <p>The discussion above regarding claim 1 is relied upon.</p> <p>MacKay discloses a total lift surface area including a plurality of lift generating surfaces defining a lift path and including a single fuselage (11) and the front tiltwing (12).</p> <p>MacKay does not disclose an arm mechanically connecting the tiltwing to the fuselage and the tiltwing forward of the airchassis.</p> <p>Quady teaches a tiltwing (81/83) on arms (73) forward of the fuselage (51).</p> <p>It would have been obvious to a person having ordinary skill in the art at the time the invention was filed to have modified MacKay to use a forward tiltwing on arms as taught by Quady as this is a functionally equivalent means for tilting the wings and propulsors for VTOL flight</p> <p>Claims 3-5 and 8-20 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest:</p> <p>Claim 3: a passive actuation to a default failsafe descent configuration;</p> <p>Claim 5: a swaywing below the airchassis and pivotably coupled thereto;</p> <p>Claim 8: the tiltwing configured to be aerodynamically actuated to a pseudo-hovering configuration (although passive actuation is known, it would not be obvious to modify devices such as MacKay and Cylinder);</p> <p>Claim 9: a liftpath having a rectangular approximately flat aerodynamically contiguous surface; or</p> <p>Claim 17: first and second failsafe methods with the specified lift and thrust ratios;</p> <p>In combination with the other limitations of the claim(s).</p> <p>Claims 1-20 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.</p>

Box No. VII **Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:

The description contains the following defect(s) in the form or contents thereof:

The description lacks reference characters used within the drawings (e.g. 27, 50).

Claims **8-10, 12, 13, 15, and 17** contain(s) the following defect(s) in the form or contents thereof:

Claim 8, line 3, a comma should follow "upward force";

Similarly for claims 9 (line 9), 10 (line 2), 12 (line 3), and 17 (line 3) to separate clauses;

Claim 9, line 7, "or aft the lifting" should be --or aft of the lifting--;

Claim 13, line 1, a comma should follow "claim 10" to separate the clauses;

Similarly for claim 15;

Claim 13, line 2, "air chassis" should be --airchassis-- for consistency;

Claim 13, line 2, "pitotably" should be --pivotably--.

Box No. VIII **Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Claims **2, 5, and 9-20** are objected to under PCT Article 6 as lacking clarity because claims **2, 5, and 9-20** are indefinite for the following reason(s):

Claim 2 recites a single fuselage, however it is unclear whether this is part of the airchassis of claim 1 or additional.

Claim 5 recites a "swaywing." The term is not understood as the figures do not depict a "wing" and the term is not known in the art.

Similarly for claims 13 and 20.

Claim 9 recites the tiltwing configured to transition to the cruising configuration, however does not provide a configuration to transition away from.

Claim 9 recites "a surface" in line 8, however it is unclear how this surface relates to the surfaces recited in the claim.

Claim 10 recites "said lifting surface a single fuselage," however it is unclear as to what this refers.

Claim 13 recites "an air chassis," however it is unclear whether this is the same as the fuselage of claim 10.

Claim 14 recites "the tiltwing propulsor," however it is unclear as to which of the "at least one" propulsors this refers.

Claim 17 recites a multicopter comprising thrusts and lift, and ratios thereof, however a structure cannot be defined by such forces.

Claim 17 recites "the front tiltwing propulsor lift" in line 5, however the language of the claim renders unclear how this feature relates to the rest of the arrangement.

Claim 17, in view of lines 8-11, lines 12-14 should be reviewed to ensure the front tiltwing propulsor lift being greater than the total multicopter thrust is the correct arrangement of forces.

CLAIMS

1. A multicopter comprising: an airchassis;
a front tiltwing pivotably coupled to the airchassis and configured to transition between a hovering configuration and a cruising configuration, the front tiltwing including: a) a first propulsor configured to generate at least one of a tiltwing propulsor thrust or a tiltwing propulsor lift and b) an aerodynamic lift surface;
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 a control unit.
2. The multicopter of claim 1, further comprising: a total aerodynamic lift surface area including a plurality of lift generating surfaces defining a liftpath, the plurality of lift generating surfaces including: a single fuselage; the front tiltwing; and an arm mechanically connecting the front tiltwing to the fuselage;
wherein the front tiltwing is a single front tiltwing positioned forward of the airchassis; the front tiltwing configured to generate a first lift force that is less than half a second lift force generated by the total aerodynamic lift surface area.
3. The multicopter of claim 1, wherein the airchassis, front tiltwing, and counterbalance propulsor system are transitionable through passive actuation to a default failsafe descent configuration, the failsafe descent configuration conducive to landing without catastrophic damage to at least one of the airchassis, front tiltwing, counterbalance propulsor system, and a payload.
4. The multicopter of claim 3, wherein the counterbalance propulsor system provides negligible thrust while the airchassis, front tiltwing, and counterbalance propulsor system are in the failsafe descent configuration and wherein the counterbalance propulsor system is aft the front tiltwing.
5. The multicopter of claim 1, further comprising a swaywing, a swaywing total wetted surface area, and a swaywing total liftpath surface area,
the swaywing located below the airchassis and pivotably coupled to the airchassis and the swaywing total liftpath surface area is greater than one third the swaywing wetted surface area.
6. The multicopter of claim 1, the counterbalance propulsor system further includes a midsection rotary wing.
7. The multicopter of claim 1, wherein the airchassis is part of a fuselage.

8. The multicopter of claim 1, wherein the front tiltwing is configured to be aerodynamically actuated to a pseudo-hovering configuration to provide a dampened descent by a pseudo-hovering upward force said pseudo-hovering upward force a combination of lift and drag.

9. An aerial vehicle comprising a plurality of lift-generating surfaces, the plurality of lift generating surfaces configured to form, in a cruising configuration, a liftpath having a rectangular approximately-flat aerodynamically-contiguous surface;

the plurality of lift-generating surfaces comprising a lifting body surface and a tiltwing;

the tiltwing: a) pivotably coupled to the lifting body surface, b) comprising at least one tiltwing propulsor, c) configured to transition to the cruising configuration, and d) disposed fore or aft the lifting body in all flight configurations;

wherein the liftpath is configured to enable flight and defines a surface comprising a lateral width and a longitudinal length said longitudinal length greater than the lateral width.

10. The aerial vehicle of claim 9 wherein the aerial vehicle is a multicopter, the tiltwing is a single front passively-adjusting tiltwing in front of the lifting body surface said lifting body surface a single fuselage, and at least one counterbalance propulsor;

wherein lift provided by the front passively-adjusting tiltwing is less than half the total multicopter weight.

11. The multicopter of claim 10 wherein the front passively-adjusting tiltwing is freely rotatable relative to the single fuselage within a predetermined angular range around a tiltwing axis.

12. The multicopter of claim 10 comprising two propulsors on the front passively-adjusting tiltwing, two arms mechanically connecting the single fuselage to the front passively-adjusting tiltwing, and wherein the at least one counterbalance propulsor is two rear propulsors said two rear propulsors set at an angle relative to the single fuselage.

13. The multicopter of claim 10 the single fuselage comprising a swaywing pivotably connected to an air chassis pivotably connected to the single front passively-adjusting tiltwing.

14. The multicopter of claim 10 comprising a control system capable of configuring the multicopter for a failsafe landing where greater than eighty percent of lift on the multicopter is generated by the tiltwing propulsor.

15. The aerial vehicle of claim 9 the liftpath defining air angles of attack between 0 and 3 degrees.

16. The aerial vehicle of claim 9 comprising structural or control surfaces extending from the rectangular approximately-flat aerodynamically-contiguous surface.

17. A landing method for landing a multicopter comprising a plurality of failsafe methods; the multicopter comprising a front tiltwing, a vehicle center of gravity, a front tiltwing propulsor thrust, a front tiltwing propulsor lift, a front tiltwing propulsor force said front tiltwing propulsor force being a vector sum of the front tiltwing propulsor thrust and the front tiltwing propulsor lift, a ratio of front tiltwing propulsor thrust to lift, the front tiltwing propulsor lift, a total multicopter lift, a total multicopter thrust, a first failsafe configuration, and a second failsafe configuration;

a first failsafe method comprising: transitioning the front tiltwing to a first failsafe configuration wherein the total multicopter 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 multicopter thrust; and

a second failsafe method comprising: transitioning the front tiltwing to a second failsafe configuration wherein the front tiltwing propulsor lift is greater than one third of the total multicopter lift and the front tiltwing propulsor lift is greater than the total multicopter thrust.

18. The landing method of Claim 17, wherein passive aerodynamic actuation performs at least one of the first failsafe method and the second failsafe method.

19. The landing method of Claim 17, including a third failsafe method, the third failsafe method comprising: transitioning a midsection rotary wing from a fixed wing position to a rotary position, the midsection rotary wing coupled to and extending above an airchassis, the midsection rotary wing also coupled to a power supply and a control unit and increasing power supplied by the power supply to the midsection rotary wing prior to landing; wherein the rotary wing produces over eighty percent of the total multicopter lift one second before landing.

20. The landing method of Claim 19, further comprising:

transitioning a swaywing from a cruising position to a hovering position, the swaywing configured to transition between a cruising configuration and a hovering configuration, the swaywing including a fuselage compartment, a swaywing arm, and a lifting body surface, the swaywing located below the airchassis and mechanically connected to the airchassis through at least one lateral axis bearing by the swaywing arm, the swaywing configured to transition between the cruising configuration and the hovering configuration.

MULTICOPTER WITH IMPROVED PROPULSOR AND FAILSAFE OPERATION
CROSS REFERENCE TO RELATED APPLICATIONS

[1] This application is a continuation-in-part of Provisional Applications Ser. No 63/019,278 filed on May 2, 2020 entitled "Multicopter with Improved Propulsor and Failsafe Operation", Ser. No 63/016,362 filed Apr. 28, 2020 entitled "Multicopter with Improved Propulsor and Failsafe Operation", Ser. No 62/ 944,506 filed Dec. 6, 2019 entitled "Multicopter with Passively-Adjusting Tiltwing", Ser. No 62/879,003 filed Jul. 26, 2019 entitled "Passively-Adjusting Tiltwing", Ser. No 62/ 862,237 filed Jun. 17, 2019 entitled "High Speed Drone", and Ser. No 62/ 860,152 filed Jun. 11, 2019 entitled "High Speed Drone" and Non-Provisional Application 16/783,319 filed on Feb. 6, 2020 entitled "Multicopter with Improved Failsafe Operation". All of the above-listed applications are incorporated by reference in their entirety herein.

FIELD

[2] The present invention relates to vertical takeoff and landing (VTOL) aerial vehicles capable of transitioning to the equivalent of fixed-wing flight. More specifically this invention relates to multicopters with improved failsafe operation through use of a front tiltwing and to motors and structures useful for the aerial vehicles.

BACKGROUND

[3] This invention is a VTOL vehicle with significantly improved energy efficiency as compared to other VTOL vehicles. Benefits include lower cost vehicles, passive flight stability features, and reduced energy consumption. Additionally, use of light weight motors, structures, and jet engines further improves speed and efficiency.

[4] Preferred tiltwings of this invention include passively control and stability; often, passive control includes indirect control using a propeller to change vehicle velocity relative to air wherein the relative velocity of air controls tiltwing position. Baldwin (US Patent 7,059,562) performed early work on this topic and describes a wing "wherein the lift unit is freely rotatable". A tiltwing has both a propulsor and lift-generating wing-like surfaces.

SUMMARY OF THE INVENTION

[5] A transition VTOL tiltwing has a number of forces causing the tiltwing to transition from propulsor lift to propulsor thrust. Examples of torques acting on a tiltwing include torques from the center of gravity (CG), from aerodynamic forces, and from a propulsor motor (hereafter, "propulsor"). The tiltwing's pitch and respective propulsor force vector of this invention include passively-adjusting mechanisms such that increasing velocity leads to more thrust. Thrust is the horizontal vector of propulsor force; lift is the vertical vector. The

pitch of the fuselage may actively controlled by a number of methods, the most common of which is the rotational speed of a counterbalance propulsor (or propulsors). The pitch of the fuselage may be controlled by liftpath lift when cruising with a front tiltwing propulsor.

[6] A feature that distinguishes the embodiments of this invention from other art is a front tiltwing that can operate to land safely in the event of failure of all other vehicle propulsors.

BRIEF DESCRIPTION OF THE DRAWINGS

[7] Fig. 1 is an illustration of a dicopter version of a multicopter in VTOL position with a swaywing fuselage compartment.

[8] Fig. 2 is an illustration of a dicopter version of a multicopter in cruising position.

[9] Fig. 3 is an illustration of a dicopter version of a multicopter in failsafe pseudo-hovering position (10) using a front propulsor.

[10] Fig. 4 is an illustration of a dicopter version of a multicopter in cruising position with single truss airchassis; this is also a belly-landing failsafe configuration (11).

[11] Fig. 5 is an illustration of parts of a tricopter version of a multicopter.

[12] Fig. 6 is the tricopter with a freewing fuselage compartment in cruising position.

[13] Fig. 7 is the tricopter with the freewing in a loading (or unloading) position.

[14] Fig. 8 is a multicopter with a front tiltwing, lower swaywing, and control hardware.

[15] Fig. 9 illustrates three perspectives of a passively transforming rotary wing with passive twisting axis in radial direction and angular pivot to form a swept wing.

[16] Fig. 10 is a failsafe landing algorithm for "a-c failsafe modes".

[17] Fig. 11 is a quadcopter with a single front tiltwing in front of a single fuselage.

[18] Fig. 12 is an algorithm for changing steady-state velocity for a front tiltwing vehicle.

[19] Fig. 13 is an illustration of a bias torque electromagnet actuator.

[20] Fig. 14 is a tiltwing with a flap in position to bias the tiltwing to higher pitch.

[21] Fig. 15 is a tiltwing quadcopter a plurality of surfaces connecting to form a liftpath.

[22] Fig. 16 is an illustration of an aerial vehicle designed around a liftpath.

[23] Fig. 17 is an illustration of a pendular midsection propulsor with swaywing.

[24] Fig. 18 is a pendular midsection configured to approach airchassis for cruising.

[25] Fig. 19 is an illustration of a pendular midsection propulsor.

[26] Fig. 20 is a dicopter with arm connecting a swaywing where transforming of swaywing to cruising position lowers the midsection propulsor relative to the airchassis.

[27] Fig. 21 is a swept-wing cruising-position rotary wing on a multicopter.

[28] Fig. 22 illustrates slot on partial diagram of a stator disc.

[29] Fig. 23 is a single-circuit stator disc with a) outside and b) inside terminals (505).

- [30] Fig. 24 a-c) are single-circuit stator discs having air (or water) cores and shielding, d) is a single-circuit stator disc with a solid core with holes for fluid flow, e) is a rotor disc having propeller baffles to induce flow, and f) is a rotor disc with a lip to reduce flux leakage.
- [31] Fig. 25 is a paired configuration of single-circuit stator discs to achieve >1.5 loops.
- [32] Fig. 26 is a stacked-disc stator hub connected to a vessel surface.
- [33] Fig. 27 is a tricopter with a rear tiltwing in a) hover and b) cruise configurations.
- [34] Fig. 28 a) is a stator comprising a fast stator stack and a slow stator stack with b) fast and slow rotors designed to engage the fast and slow stators.
- [35] Fig. 29 illustrates a stator disc and rotor disc with larger inside:outside diameter ratio.
- [36] Fig. 30 is a hybrid electric-fuel engine with a cross section of the scoop and nozzle.
- [37] Fig. 31 is perspectives of a rotor-disc configuration for a hybrid electric-fuel engine with a larger propeller stator, relative to compressor stator, to provide higher propeller torque.
- [38] Fig. 32 illustrates separate components of the Fig. 30 engine.
- [39] Fig. 33 is an algorithm to optimally switch from electric to ramjet propulsion.
- [40] Fig. 34 illustrates a structural body fabricated from two bodies showing a) the two bodies, b) cross sections of the two bodies, and c) and the structural body cross section.
- [41] Fig. 35 is a fabricated male-component body with an alternative connector.
- [42] Fig. 36 is a structural beam made by injection molding a body that contains a longitudinal tensile device showing a) the beam and b) a beam cross section.

DESCRIPTION OF INVENTION

- [43] Figs. 1-4 illustrate a multicopter comprising a multicopter airchassis 2; a forward tilting body 3 pivotably connected [bearing 4] to the airchassis 2 and configured to pivot between a first position 5 associated with a hover flight mode and a second position 6 associated with a forward flight mode. A forward propulsor 7 is part of the front tiltwing 8; wherein the forward propulsor 7 is configured to aerodynamically actuate through a range of motion along with the forward tilting body 3 due to aerodynamics about the front tiltwing 8.
- [44] The forward propulsor 7 is configured for failsafe operation to vertically land without lift from other propulsors such as a midsection propulsor 12 or second forward propulsor 13.
- [45] A further embodiment of the multicopter comprises a second forward propulsor 13 coupled to the forward tilting 8 (see Fig. 2) wherein the forward propulsor 7 and the second forward propulsor 13 comprise a twin engine configuration 14 on the front tiltwing 8. 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 and embodiments

apply to multicopters ranging from dicopters to vehicles with more than four propulsors.

[46] Figs 5-7 illustrate tricopter components including a freewings 18 for payloads.

[47] The preferred embodiment is a multicopter comprising: a) an airchassis; b) a front tiltwing pivotably coupled to the airchassis and configured to transition between a hovering configuration and a cruising configuration, 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.

[48] The aerodynamic lift surface of the front tiltwing 3 is configured to: a) approach a near-perpendicular position relative to the airchassis 2 (see Fig. 1) in the hovering configuration 5 and b) approach a near-parallel position relative to the airchassis 2 (see Figs. 2, 4, and 15) in the cruising configuration 6. The multicopter further comprises a power supply (110, Fig. 8) configured to control the thrust and lift by providing a variable amount of power to the front tiltwing wherein the control unit is in communication with the power supply, the control unit having at least one sensor, a processor, and memory storing instructions thereon. When executed by the processor, control unit calculates at least one of the rate of descent, yaw angle, roll angle, pitch angle or altitude of the front tiltwing based on data provided to the processor by the at least one sensor; and the control unit adjusts at least one of the rate of descent, yaw angle, roll angle, pitch angle or altitude by regulating the amount of power provided to the first propulsor by the power supply via a control signal.

[49] As illustrated by Fig. 8, the power supply (110 or 112) and control unit (111 or 113), may be on the tiltwing, on the airchassis 2, or on other locations including redundant and interconnected configurations. Example sensors include a GPS sensor, level indicator, and velocity indicator; it is common for the sensors to be built into the control unit (111 or 113).

[50] Propulsors may provide lift and thrust; lift is an upward force and thrust is a horizontal force. The total propulsor force is the vector sum of thrust and lift. During steady-state flight, total lift needed to sustain flight is equal to the total multicopter weight.

[51] In the hovering configuration, the first propulsor of the front tiltwing and the second propulsor of the counterbalance propulsor system are configured to counterbalance the gravitational force acting through the center of gravity of the multicopter. Here, a propulsor may be one or more of the group: propeller, fan, rotating blade, or exhaust nozzle. In the cruising configuration, the front tiltwing's propulsor generates more thrust than lift, and the

front tiltwing's aerodynamic lift surface generates lift.

[52] 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 to at least one of the airchassis, front tiltwing, counterbalance propulsor system, and a payload. Typically, passive actuation is movement due to a balance of forces (and torques) including at least gravity acting on a center of gravity and aerodynamic forces (from velocity and descent). Optional passive actuation does not preclude use of actuators. Payloads include passengers. Catastrophic is defined in terms of passenger safety and highly expensive vehicle damage; by example, loss of human life is catastrophic and damage greater than 20% of the value of the vehicle would be catastrophic.

[53] Preferably, the multicopters of this invention have three failsafe modes of descent, including: a) mostly vertical powered by the front tiltwing, b) mostly vertical powered by a midsection rotor, and c) mostly horizontal powered by the front tiltwing ("a-c failsafe modes"). The failsafe descent is typically triggered by a failure of a propulsor, and so, power from propulsors other than the one power descent is negligible. Fig. 10 provides an algorithm for using the a-c failsafe modes; a key failsafe aspect is to "dampen" "a)" and "b)" vertical (pseudo-autorotation) descent modes where dampen means to slow done without overdoing propulsor lift which could lead to out of control roll, yaw, or pitch.

[54] Preferred embodiments include a swaywing or freewing which positions at a location that both a) provides for easier loading and b) reduces resistance to hovering aerodynamics of propulsors producing lift. Figs. 1-4, 8, 17, and 20 illustrate swaywings 26.

[55] "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; surfaces that are longer than wide. Structural or control surfaces such as actuators (38), arms (39, 40, 41, 99), support surfaces (43), wing or blade sections (90, 53), stabilizers (116), and rudders (117) (see Figs. 1, 8, 20, and 21) may extend from a liftpath. A preferred swaywing has a total wetted surface area and a swaywing total liftpath area where the swaywing total liftpath surface area is greater than one third the swaywing wetted surface area. The swaywing is located below the airchassis and pivotably coupled to the airchassis.

[56] A midsection rotor is the preferred counterbalance propulsor due to failsafe landing configurations and due to the ability to of the rotary wing to fold to a fixed wing

configuration with a conversion mechanism illustrated by Fig. 9 and a fixed-wing position on a vehicle illustrated by Fig. 21. Preferred midsection rotor transition is by aerodynamic actuation where a stopped rotor leads to the fixed-wing position and rotation leads to the rotary wing configuration. A catch 84 may lock a first blade 69 in position relative to the fuselage (or airchassis) when aerodynamic forces cause rotation in a direction reverse that for lift generation; where after, the aerodynamic forces twist the second blade 70 about a radial axis 88 from the rotary wing position 89 to a fixed wing position 90. Movement of the second blade 70 in the angular direction 85 forms a swept wing. Preferably, the midsection rotor is of a design without a swashplate, and 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 rotor during descent with an increased in power five to fifteen seconds before landing to dampen landing soften the landing. The pseudo-hovering configuration is one in which a rotary wing or propulsor of a high ratio of upward force relative to weight (e.g. the high ratio is >0.4) passively positions above a fuselage of a lower ratio of upward force relative to weight. The upward force is a sum of lift and drag vertical vectors. 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. The front tiltwing is blocked from having a lower pitch (more nose up is more positive) than the airchassis by devices such as the airchassis 2 of Figs 1-8.

[57] Characteristics of these 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. 3) to facilitate control/stability.

[58] Preferably aerial vehicles, including multicopters, comprise a plurality of longitudinally-extending lift-generating surfaces 327 forming a total aerodynamic lift surface area (see Fig. 15), the plurality of longitudinally-extending lift-generating surfaces including tiltwings, arms and lifting bodies such as fuselages, freewings, and swaywings as illustrated by Figs. 2, 4, 6, 15, and 27. The tiltwing may be fore or behind the lifting body. More preferably a multicopter comprises the fuselage, the front passively-adjusting tiltwing, and an arm mechanically connecting the front passively-adjusting tiltwing to the fuselage with the plurality of longitudinally-extending lift-generating surfaces forming a liftpath 121 in a

cruising configuration with the front tiltwing being a single front tiltwing in front of a single fuselage. Typically, lift provided by the front passively-adjusting tiltwing is less than half the lift provided by the total aerodynamic lift surface area. The plurality of surfaces align to form a liftpath.

[59] Swaywings and freewings of this invention are types of fuselages. For vehicles without a swaywing or freewing, the airchassis is part of the fuselage.

[60] **Three Failsafe Modes and Midsection Rotary Wing** - The afore-mentioned a-c failsafe modes are a plurality of failsafe methods for landing a multicopter where the multicopter comprises a front tiltwing, a vehicle center of gravity, a front tiltwing propulsor thrust, a front tiltwing propulsor lift, a front tiltwing propulsor force, a ratio of tiltwing propulsor thrust to lift, a front tiltwing propulsor lift, a total multicopter lift, a total multicopter thrust, a first failsafe method, and a second failsafe method. The first failsafe method comprises transitioning the front tiltwing to a position wherein the total multicopter 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 multicopter thrust. The second failsafe method comprises transitioning the front tiltwing to a position where the front tiltwing propulsor lift is greater than one third of the total multicopter lift and the tiltwing propulsor lift is greater than the total multicopter thrust. 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.

[61] The third failsafe method comprises transitioning a midsection rotary wing from a fixed wing position to a rotary position where the midsection rotary wing is coupled to and extends above an airchassis, and the midsection rotary wing is coupled to a power supply and a control unit. Preferred pseudo-autorotation increases and maintains lift from a propulsor or blade to >70%, preferably >80%, of the multicopter weight at least one second before impact.

[62] The Pseudo-autorotation method increases power to propulsor just prior to landing, the rate of descent is decreased while the yaw/roll/pitch increase has not had adequate time to catastrophically roll, flip, or spin the vehicle. Just prior to landing is about 8 seconds prior to landing, but could be greater or less depending on the specific situation. Preferably, yaw is controlled by aerodynamic forces acting on vanes 114 of a duct 115 surrounding the midsection rotary wing or a tiltwing propeller, whereby the vanes 114 are configured such that aerodynamic forces on the vanes 114 provide partial yaw control.

[63] Fig. 4 illustrates a configuration for the first failsafe method while Fig. 3 illustrates a

configuration for the second failsafe method. For a vehicle without a swaywing (e.g. Fig. 15), the configuration for the first and second failsafe methods are the same with the vehicle point upward in the tiltwing's hover failsafe landing configuration.

[64] 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.

[65] **A Most-Preferred Multicopter** - Fig. 10 illustrates a multicopter. Preferably, the tiltwing power supply (110) and control unit(111) are in addition to a airchassis power supply (112) and control unit (113) so as to provide for redundancy power, control, and propulsion therein allowing either the tiltwing or midsection rotary wing to land the multicopter. Preferably, propulsor ducts (114) have counter-torque duct vanes (115) along inner surfaces oriented to bend downwash air in a direction opposite the direction of travel of the rotor or propellor blade passing adjacent to the vanes (115). A vertical stabilizer (116) provides stability on a location to mount a rudder (117). Most preferably, the stabilizer (116) and rudder (117) are attached to an aft swaywing arm (40) in a manner that provides primarily roll control in the hovering configuration and primarily yaw control in the cruising configuration. Similarly, a stabilizer (116) with rudder (117) may be attached to the upper surface of the front tiltwing (8) to provide roll and yaw control.

[66] Preferably at least one aileron (118) is on the front tiltwing (8) configured to provide roll control, most preferably including enabling of yaw control from propeller downwash. A flap (362) on the front tiltwing (8) may also be used to bias pitch.

[67] Fig. 10 also identifies hardware for failsafe algorithm control comprised of: a) an airchassis (2); b) a single front tiltwing (8) extending in front of the airchassis (2) said front tiltwing (8) comprising a tiltwing propulsor configuration (7), an aerodynamic lift surface (347), a tiltwing power supply (110), and a tiltwing control unit (111) said control unit (111) comprising a control signal to control the tiltwing thrust such as a speed control system controlling power to the propulsor and communication by hard wire or transmitter-receiver communication.

[68] More preferred operation is a) wherein the hovering configuration (5) comprises a balancing of downward force on the center of gravity, lift from the front tiltwing (8), and lift from the counterbalance propulsion configuration.

[69] **Biased Actuator** - Fig. 13 illustrates a preferred actuator to provide position control; it is preferred since the electromagnet coil 364 creates a force but does not lock the actuator

in position which is important in event of coil 364 failure for a system with passive control. The actuator is comprised of: a) an electromagnetic coil 364 with control system said coil connected to the fuselage and b) a internal electromagnet core rod 365 said rod having a first end attached to a device for positioning and a second end attached to a spring (or functional equivalent of the spring) and a section of continuously increasing ferromagnetic strength from a first end to a maximum before continuously decreasing to the second end.

[70] Optionally, the spring may be removed or reduced in tensile force from the preferred actuator in an alternative actuator embodiment. The actuator acts as a damper, the rod 365 is a moving component that moves within a stationary electromagnetic coil 364. The first end 366 of the core rod is mechanically connected to provide torque on, by example, the tiltwing shaft 312. This optional configuration can be used both to dampen and to bias the tiltwing pitch. In this embodiment, application activation of the magnetic coil while at a vertical thrust position biases the tiltwing with negative torque toward a position with a forward thrust vector useful for initial acceleration. When the tiltwing is at or near its minimum angle/pitch, activation of the coil will bias the tiltwing with a positive torque force useful to pull out of a nose-down loss of forward lift. The control system is a feedback control system based on a set point such as rate of change of altitude relative to rate of velocity change.

[71] **Pendular Midsection Rotary Wing** - The optional configuration has the front tiltwing pivotably connected to a forward portion of the airchassis, and the counterbalance propulsor system pivotably connected rearward of where the front tiltwing is pivotably connected to the airchassis. A passive roll control embodiment comprises a midsection propulsor 12, such as a rotary wing 53, and a pendular connection 101. By example, a socket 102 and ball 103 form a pendular connection 102 which is mechanically connected to a vehicle with an arm 96 and a flexible arm 104. The motor 105 of the midsection rotor may serve as both a pendular weight and part of the structure. Here, the weight of the motor 105 may create a pendular movement in the spanwise direction. Either the Fig. 19 air chassis 2 or Fig. 18 arm 96 may connect to the socket 102; the socket may be donut shaped.

[72] Hinge joints 107, see Fig. 17, may connect the airchassis 2 or arm 96 to other vehicle components. A pendular hinge joint 108 may also provide an alternative pendular connection 101 that only has pendular action in a single plane.

[73] **Swaywing Positioning** - Passive activation of the optional swaywing may be configured to complement the tiltwing's inherent stability for these a-c failsafe modes. Here, the methods include transitioning a swaywing from a cruising position to a hovering position where the swaywing is configured to transition between a cruising configuration and a

hovering configuration. The swaywing includes a fuselage compartment, a swaywing arm, and a lifting body surface; and the swaywing is located below the airchassis and mechanically connected to the airchassis through at least one lateral axis bearing by the swaywing arm.

Fig. 4, Fig 3, and Fig. 1 illustrates the swaywing positions consistent with the first, second, and third failsafe methods, respectively.

[74] The swaywing may be connected to the front tiltwing at a location between a rearward end of the tiltwing's aerodynamic lift surface and a midpoint of the tiltwing's aerodynamic lift surface (see Figs. 1 and 8). The swaywing arm is a forward extension of the swaywing and the swaywing moves about the at least one lateral axis bearing. The swaywing further comprises a swaywing lateral-axis bearing connecting the swaywing to the swaywing arm where the swaywing is configured to swing in the aft and upward directions relative to the airchassis. Preferably, the swaywing arm is an aft swaywing arm and a forward swaywing arm is connected at one end to the swaywing via a lateral-axis bearing where the swaywing arm is connected at the other end to a) the airchassis via a lateral axis bearing (Figs. 3 and 4), or c) a front tiltwing via a lateral axis bearing (Figs. 1 and 10).

[75] **Plurality of Surfaces Forming Liftpath** - A preferred embodiment is a multicopter comprising a single front passively-adjusting tiltwing in front of a single fuselage, a tiltwing propulsor, at least one counterbalance propulsor, a plurality of longitudinally-extending lift-generating surfaces 327 (see Fig. 15), and a total multicopter weight. When transitioned to cruising, the plurality of longitudinally-extending lift-generating surfaces forms a liftpath wherein lift provided by the front passively-adjusting tiltwing is less than half total multicopter weight.

[76] Preferably: a) the front passively-adjusting tiltwing is freely rotatable relative to the fuselage within a predetermined angular range around a tiltwing axis, b) the multicopter comprises two propulsors on the front passively-adjusting tiltwing, two arms mechanically connecting the fuselage to the front passively-adjusting tiltwing where the at least one counterbalance propulsor is two rear propulsors said two rear propulsors set at an angle relative to the fuselage, c) the fuselage comprises a swaywing pitotably connected to an airchassis pitotably connected to the sing front passively-adjusting tiltwing, and d) control system is capable of configuring the multicopter for a failsafe landing where greater than eighty percent of lift on the multicopter is generated by the tiltwing propulsor.

[77] **Forces, Torques, and Passive Activation** - A preferred embodiment may be defined in terms of designs that use inherent forces and torques for actuation. Here, a preferred multicopter comprises: a fuselage, a fuselage first propulsor, a wing 1, and a first tiltwing

propulsor 2 statically connected to the wing 1 forming a passively-adjusting tiltwing 3, wherein a bearing mechanically couples the tiltwing and the fuselage said tiltwing freely rotatable relative to the fuselage within a predetermined angular range around a tiltwing axis (4), said tiltwing having i) a mass centroid, ii) an area centroid, iii) a mass centroid torque distance being the distance between the mass centroid and the tiltwing axis, iv) an area centroid torque distance being the distance between the area centroid and the tiltwing axis, and v) a tiltwing centroid ratio said centroid ratio being the mass centroid torque distance divided by the area centroid torque distance, wherein the value of the tiltwing centroid ratio is between 0.2 and 5. Aerodynamic and gravitational forces produce torques about the tiltwing axis said torques comprising a positive tiltwing center of gravity force torque, a negative impacting air aerodynamic force torque, and a third positive torque, and wherein thrust of the fuselage first propulsor relative to thrust of the first tiltwing propulsor controls the pitch of the fuselage.

[78] Preferably: a) the third positive torque is one from a list comprising (i) torque resultant of force of the first tiltwing propulsor said first tiltwing propulsor having a motor axis of rotation below the tiltwing axis, (ii) torque resultant of a spring having a first end connected to the fuselage and a second end connected to the tiltwing, (iii) torque resultant of a variable force electromagnetic damper with a first end connected to the fuselage and a second end connected to the tiltwing, and (iv) torque resultant of tiltwing propulsor prop slipstream impacting a back-side concave surface of the wing 1; b) the multicopter comprises a total vertical takeoff thrust and a total multicopter weight wherein thrust from the tiltwing during vertical takeoff is less than half the total vertical takeoff thrust and lift force from the tiltwing is less than half the total multicopter weight; c) for multicopters with maximum cruising velocities is between 100 and 350 mph the tiltwing centroid ratio is between 0.5 and 3.0; d) the multicopter comprises a fuselage second propulsor wherein the fuselage first and second propulsors are set at an angle between 50 and 85 degrees relative to the median angle of the lower surface of the fuselage; e) said first tiltwing propulsor 2 has a motor axis center of rotation 9 and a tiltwing axis 4 center of rotation wherein the motor axis 9 is below the tiltwing axis 4 said passively-adjusting tiltwing having a center of gravity where in the vertical thrust configuration 5 said center of gravity is at or below the tiltwing axis 4, and wherein, a thrust of the tiltwing motor 2 produces a positive torque around the tiltwing axis 4 said positive torque producing force toward the vertical thrust configuration 5, gravity action on the center of gravity generates a zero to positive torque around the tiltwing axis 4, and the impacting air from horizontal flight produces a negative torque around the tiltwing axis 4; f)

the multicopter comprises a fuselage second propulsor said first and fuselage second propulsors being electric motors turning propellers, and g) the plurality of longitudinally-extending lift-generating surfaces 327 forms a liftpath comprising: a cabin, said cabin having an average cabin length, a cabin average width, and a cabin average height; the lift path having a width greater than six tenths the cabin average width and said lift path having a length greater than seven tenths the cabin average length; said lift path having a front third with a front average pitch, a back third with a back average pitch, and a middle third with a middle average pitch; wherein the back average pitch is 1 to 3 degrees less than the front average pitch.

[79] **Preferred Motor** - The preferred motor has a high power density and simple, inexpensive modular design. That preferred motor is based around a stator embodiment that may be used in both motor and generator applications. The stator discs 514 and stacked-disc configurations 521 or 523 may be used in generators in synchronous configurations.

[80] The preferred motor comprises a stator system. The stator system comprises a plurality of stator discs configured to rotate about a common axis. Each stator disc of the plurality of stator discs is spaced apart and 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 circuit radial-direction tracks, a plurality of angular-direction tracks, and a plurality of terminals. Example stator discs are provided by Figs. 23, 24, and 29. The term "stacked-disc configuration" is used to describe the preferred stator system will examples illustrated by Figs. 26, 28, 30, 31, and 32.

[81] A circuit busbar connects the plurality of stator discs to a controller. 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; the at least one rotor positioned in one of the gaps between each stator disc of the plurality of stator discs.

[82] Preferably: a) the circuit busbar further comprises a stationary shaft 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 flowing cooling fluid, and d) each stator disc of the plurality of stator discs includes a plurality of stator-disc cores 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 simply that material

through with 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.

[83] Preferably: a) the motor comprises a plurality of induction circuits on each stator disc of the plurality of stator discs of the stator system; 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 stators 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. 25) said 1.5 loop stacking 528 comprising two of the each stator discs 502 adjacently mounted on the circuit busbar 506 forming adjacently-mounted sections cumulatively forming an induction circuit 510 comprising four radial-direction tracks 503, an inner conductive angular-direction track 504, and an outer conductive angular-direction track 504.

[84] Several options exist for the at least one rotor system. The rotor system may include: a conductive metal disc, a primary coil coupled to a rotating secondary coil and attached to a housing, an induction circuit (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. Preferred stator disc configurations include: a three phase configuration comprising three angular orientations of the stator discs 502 aligned along the common axis 507, a six phase configuration comprising six angular orientations of the stator discs (#02) aligned along the common axis, a two phase configuration comprising two angular orientations of the stator discs aligned along the common axis 507, and a four phase configuration comprising four angular orientations of the stator discs 502 aligned along the common axis.

[85] Preferably: a) 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 and b) at least one of the circuit sections of the induction circuit includes a conductive track extension 518 and a conductive discontinuity 519 adjacent the conductive track extension. The conductive track extension, two of the radial direction tracks, one of the angular direction tracks and the conductive discontinuity form a perimeter that surrounds a the stator-disc core. Also, a conduction lip 554 on a rotor disc may be used to provide flux shielding (see Fig. 24f). Fig. 24 b-c illustrates the conductive track extensions

518 and discontinuities 519. 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.

[86] 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).

[87] As common in the science, symmetry is preferred in design such as disc sections being axially symmetric around the axis of rotation 507. Also, a constant change/interval in angular orientations is preferred for the induction motor phase configurations. Figs. 26 and 28 illustrate stacked-disc configurations with changes in disc angular orientations to facilitate phased induction motor operation.

[88] **Motor Torque and Speed** - Certain applications require rotary device power of different torque or speed, where optimal applications match torque and power curves with applications. Embodiments of this invention can use the same busbar and axis of rotation to drive stators that engage rotors operating at different speeds and torques.

[89] Preferred 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. From a torque perspective, preferred 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. The at least one stator disc of the slow grouping has a larger average outside diameter than the average outside diameter of the at least one stator disc of the fast grouping, and the at least one rotor of the slow grouping generates a greater torque than the at least one rotor of the fast grouping.

[90] As the outside radius of the slow grouping 521 increases, the inside diameter may also

increase with an outside:inside radii ratio decreasing as per the discs of Fig. 29.

[91] **Hybrid Fuel-Electric Engine** - A hybrid electric-fuel engine is enabled by the motor torque embodiments of the previous paragraph. That engine provides speed and weight advantages for the preferred multicopter embodiments.

[92] Here, the preferred motor comprises a hybrid electric-fuel engine 530, the hybrid electric-fuel engine 530 connected to a fuel tank 537 containing fuel 538. A fan or propeller is connected to the at least one rotor of the slow grouping. A compressor is connected to the at least one rotor of the fast grouping, the compressor including: a) an air entrance and an air exit, b) the air exit being in fluid communication with a combustion chamber, c) a combustion chamber configured to allow air to mix with fuel to produce flue gas in the combustion chamber, and d) a nozzle configured to allow the flue gas to exit the hybrid electric-fuel engine with expansion under pressure against inside surfaces of the nozzle.

[93] The circuit busbar 506 may be a shaft connected to an aerial vehicle. The preferred high-torque stator busbar 206 is an annulus with air flowing through the hole of the annulus as illustrated by Fig. 31 with preferred stator discs of Fig. 29. An example of a housed compressor 533 is an axial compressor turning inside a scoop. Preferably, a continuous internal surface progresses from the hole of the busbar annulus to the scoop to the combustor and through the nozzle to an exit from the motor. Thrust is transferred across the inside surface of the nozzle; a design method reduced to practice by heuristics of rocket, jet, and ramjet designs. Combustion enables jet propulsion by increasing the temperature of an air mixture under pressure, therein creating a larger volume of air at the combustion pressure for aerodynamic propulsion power than the power required to compress the air into the combustor. The preferred size and shape of the nozzles is bell-shaped and of an exit size so as to discharge the flue gas at a pressure between 1.0 and 1.2 times ambient pressure.

[94] The hybrid fuel-electric engine comprises a propulsion mechanism, the propulsion mechanism providing thrust by an electric-powered rotating blade, combustion-enabled nozzle jet propulsion, or the combination of electric-powered rotating blade and combustion-enabled nozzle jet propulsion. The preferred compressor is a turbine compressor. A turbine expander may be used where the turbine expander is mechanically connected to the turbine compressor. More preferred is a hybrid electric-fuel ramjet engine mechanism absent an expander where compression is by a scoop 541 located in front of the combustion chamber.

[95] Ramjets cannot operate at zero vehicle velocity, and so, this embodiment uses an electric-powered propulsor (e.g. propeller connected to a high-torque rotor) at lower velocity. Fig. 33 illustrates an algorithm for beneficial operation of the hybrid electric-fuel engine.

[96] A Bernoulli tube is an example of how a scoop and nozzle can connect to efficiently compress then expand a gas. Changing pressure of air is a vital step in ramjet and jet operation, with the goal being compression at a lower temperature than expansion.

[97] Preferred is for the scoop to surround at least part of the compressor forming a housed compressor 539 having a turbine with blades 542 of larger radial length at the compressor entrance and blades of smaller radial length at the compressor exit.

[98] The hybrid fuel-electric engine may use other motors than the motor embodiments of this invention. A preferred hybrid electric-fuel engine comprises an at least one electric motor, a propeller, a compressor, and a ramjet system. The motor preferably has a fast stator, a fast rotor, a slow stator, a slow rotor and a longitudinal axis of rotation; the engine further comprising: a) the at least one electric motor comprising; b) the slow rotor rotating the propeller around the longitudinal axis of rotation; c) the fast rotor rotating the compressor around the longitudinal axis of rotation; d) the hybrid electric-fuel engine 530 connected to a fuel tank 537 containing fuel 538; e) the ramjet system comprising a scoop, a combustion chamber, and a nozzle; f) the compressor including an air entrance 534 and an air exit 535, the air exit 535 in fluid communication with the scoop to form an air flow path; and g) the air flow path flowing from the scoop to the combustion chamber to the nozzle to an ambient environment exit. The combustion chamber is configured to allow air to mix with fuel to produce flue gas in the combustion chamber, where no shaft connects a rotating expander to the axial-flow compressor. Optionally: a) the compressor is an axial-flow compressor, b) the compressor is a turbine compressor preferably with blades of the turbine compressor project from an outer rotating surface inward, c) the propeller comprising a plurality of propeller blades connected to the slow rotor said propeller blades extending radially outward from the slow rotor, d) the propeller is a fan, and e) the slow stator in an annulus configuration with the propeller blades extending radially outward from the annulus configuration with air flowing through the annulus configuration to the scoop.

[99] An advantage of this design is minimal restriction of air flow which enables reducing of compressor compression of the feed to the ramjet system at higher velocities. Methods known in the art to control combustion and expansion in a ramjet may be directly applied herein to allow one familiar with the art to reduce this embodiment to practice. This embodiment uses electric-power compression and a scoop inlet as the entrance to the ramjet combustion chamber at lower velocities, such as velocities between 100 and 450 mph. At lower velocities, ramjet operation is inefficient and at higher velocities the supplementing of compression with electrical power is not needed.

[100] At higher velocities the momentum of impacting air will compress air to enable the ramjet propulsion mechanism. The optimal balance of compressor compression versus air-momentum compression progresses from only compressor compression at zero velocity to mostly, or totally, air-momentum compression at higher velocity (e.g. >450 mph). Control of optimal operation of the hybrid electric-fuel engine may be reduced to a control algorithm.

[101] The hybrid electric-fuel engine preferably comprises a control algorithm and a sensor, the sensor providing an electrical input to the controller with the electrical input functionally related to the second derivative of the propulsion thrust relative to axial compressor (or propeller) power input. The algorithm (see Fig. 33) comprises the progressive steps of a) engage the propeller, b) engage the compressor, c) ignite the ramjet burner, d) shut down the propeller, e) balance compressor versus scoop compression, and f) optionally to convert to 100% ramjet thrust. The velocity set points for progressing through the steps varies with details of the design, but can be determined the afore-mentioned second derivative function.

[102] Specifying in greater detail, the hybrid electric-fuel engine comprises a propeller backwash average velocity, a compressor backwash average velocity, a ramjet startup velocity, a propeller shutdown velocity, and a maximum velocity with an algorithm sequence of: the propeller is engaged as the primary thrust for takeoff, the compressor is engaged until the compressor backwash average velocity is about equal to the propeller backwash average velocity, the velocity is increased, the ramjet burner is ignite at the startup velocity, the velocity is increased, the propeller is shut down at the propeller shutdown velocity, velocity is increased wherein the compressor duty/power is adjusted based on proximity to the minimum of the second derivative of the propulsion thrust relative to axial compressor power input, the velocity is increased, and the compressor is shut down at the compressor shutdown velocity therein feeding air into the ramjet only through scoop aerodynamics.

[103] This algorithm is summarized by Fig. 33. Here, shutdown is further defined as a) setting power input to zero and allowing free rotation, b) providing only sufficient power so as to eliminate the longitudinal drag component, or c) braking of rotation with folding of blades reward about a hinge connection to a hub of rotation.

[104] The ramjet version (no turbine expansion) of the hybrid fuel-electric engine has advantages of simplicity (reduced cost) and potential for reduced lost work. A second law analysis of engine operation directly relates lost work to irreversible processes. Turbine and compressor operation have definitive and significant lost work while Bernoulli-tube type of compression and expansion has minimum lost work. The optimization of the ramjet version of this invention includes optimizing the nozzle shape and size to reduce the lost work of

mixing of exhaust with ambient air where exhaust port size is increased to be greater than but approaching a targeted vehicle velocity; wherein, the exhaust area will tend to be larger than the air intake area.

[105] In a pandemic environment, commercial flights can be highly impacted by spreading of a virus. The embodiments of this invention have advantage for energy and cost effective jet-speed flights of smaller passenger payload. It is possible to use the air handling system of a aircraft to spread vaccine through airborne water droplets. In a highly evolved species, the species has a defense against a virus where transmitted fluids (e.g. airborne droplets) that unavoidably contain biological information to spread a virus, also have biological information to fight the virus. Here the transmitted virus biological information acts as a catalyst to stimulate production of the virus-fighting biological information. Such biological information would be in the fluids of these highly evolved species, and the air handling system could circulate actual airborne fluids from species or replicated airborne fluid compositions.

[106] **Fluid Propulsion Devices** - In addition to aerial propulsion, embodiments of this invention are useful to induce fluid flow. An alternative motor embodiment is a fluid propulsion device. The preferred motor is where: a) each stator disc of the plurality of stator discs includes stator disc cores, b) the circuit busbar is a shaft connected to a surface, c) the rotor system includes a stacked-disc rotor with at least partially open core discs with the stacked disc rotor is inductively coupled to the shaft and configured to rotate around the shaft, d) a fluid flows axially through the stator-disc cores of the plurality of stator discs, and e) the fluid flows through the at least partially open core discs of the stacked-disc rotor. Flow is induced by the stacked-disc rotor 544 by deflective surfaces that are substantially built-in rotor blades 550 to induce propulsion. Fig. 26 illustrates a stacked-disc stator as a hub for mounting a propeller on a naval vessel.

[107] Preferably: a) at least partially open-core discs of the stacked-disc rotor induce fluid flow through the stator disc cores of the plurality of stator discs where the disc have built-in propulsor surfaces 550; b) the fluid propulsion device is a propulsor for a naval vessel; c) a housing surrounds the propulsion blades with a housing entrance end, a housing exit end, and with propulsor blades connected to the stacked-disc rotor; d) the stacked-disc rotor further comprises a stator-disc stator water pump; e) the stator-disc stator water pump is in an electric appliance such as a washing machine or dishwasher; and f) the stator disc stator water pump is configured to produce a hydraulic force, wherein the hydraulic force is capable of turning a water sprayer in a dishwasher.

[108] Preferred rotor discs have both passages through the core 515 for fluid to flow and

blades 550 to induce the flow. Its design is a compromise between a) a flat surface that minimizes clearance and median gap between induction coils of the stator 501 and the rotor surface and b) turbine-type blades with curvature designed to cause flow.

[109] Fluid flow through the cores 515 serves multiple purposes, including cooling and reducing viscous forces due to movement of a rotor next to a stator. Also, the air/liquid/fluid "pump" of this embodiment may resemble an axial-flow turbine-type pump or centrifugal pumps connected in series through a common rotary shaft.

[110] **Assembly and Fabrication** - Assembly of the stacked-disc axial-flow embodiments of this invention can be performed by a number of methods. One method is to have the outer unit hinge together to encase the shaft 531 and discs of the center unit. Another method is to slip stator discs through the gaps of a rotor, align the rotor with the stator discs about an axis of rotation, slip a busbar shaft 531 through the holes of the discs where the holes have slots 553 (see Fig. 22) through which connective clips on the busbar fit. A matching key of on the connective clips allows a twisting action (same direction as rotor rotation) to friction fit the connective clips to the disc's terminals 505. The connection clips are designed to connect the disc terminals 505 to appropriate live controller circuits on the busbar.

[111] The busbar may connect the disc circuits in series or in parallel. Preferably, the busbar connects the disc circuits in series by alternating the ground and live wire connection along the busbar's axial length and at locations of connectivity to the discs. Washers may be used as a locking device. By example, an eighth turn latch mechanism latching with a turn in the direction of motor rotation (e.g. a partial thread).

[112] A method for joining 3D-printed smaller structures to form a structural body may be used to produce multicopter surfaces at larger scales. A preferred structural body is comprised of a first body 250 and a second body 251 with a connector 252 having a duct 253 for flow of thermoset resin between body mold cavities 254 said cavities 254 open to an injection port 255, said duct 253 open to flow between the first body 250, and second body 251. This is illustrated by Fig. 34.

[113] Fabrication steps required to make the structural body include: a) fabricating the first body 250 and second body 251 by a method such as 3D printing, b) connecting the bodies with the connector, c) injecting a curing-type resin (e.g. thermoset resin) into the injection part with flow of the resin through the cavities 254 and duct, and d) allowing the resin to set forming a polymer in the cavities 254 which are a mold for the resin.

[114] Examples of connectors 252 include a ferrule connector (Fig. 34) and male inserts held in place by friction (Fig. 35). A slot 256 may be used to facilitate slipping a male

connector of the first body 250 into the female counterpart of the second body 251. The female counterpart comprises a space conforming to the male connector 252 as is common in the art. Also, the female counterpart must be open to the cavity in the second body.

[115] Preferably, the structural body contains at least one vent port 257 at an upper portion of the a mold cavity 254 to allow gases to escape therein allowing resin to more-effectively fill the cavities 254. The joining surface of connecting bodies may have multiple connectors; and the connectors may have shapes and locations that better enable 3D printing. Vent ports 257 should be located at mold locations distant from the injection port 255.

[116] 3D printing of multicopter components provides for rapid prototyping and easy CAD modification with iterations in prototyping; however, the structural properties of most 3D print filaments and resins are inferior to high performance thermoset polymers. A preferred method to realize the benefits of high performance thermoset polymers is to incorporate injection ducts and cavities in the 3D-printed components wherein the cavities are strategically placed at locations and shapes to provide extra strength where needed and wherein the ducts connect the cavities to an entrance and vent port for injecting a reacting thermoset resin. The vent port 257 is smaller (e.g. 0.2 to 1.5 mm dia.) than the injection port 255 (e.g. 2 to 5 mm dia.) so as to accommodate exiting air rather than exiting resin.

[117] A further embodiment is a structural body wherein a longitudinal tension device 258 is in the cavity 254 and the thermoset polymer forms around the tension device 258. Preferably, the tension device 258 is in a deflected position from end-to-end of the structural body. Here, "deflected position" may be created by a vertical bar 259 near the longitudinal midsection of the cavity 254.

[118] Tension may be provided by clips or nuts 260 attached to the tension device 258 that push against the ends of the shell of the mold 254; preferably, an auxiliary structure is used to place tension on the tension device 258 when a resin is injected and cures. Example tension devices 258 are a cable and a belt. For lighter-density foams, use of a belt is advantageous to reduce localized compression forces that could crush the foam. The structural body is configured to form an injection mold around the tension device 258, similar to the first body 250 and a second body 251 as previously described. The polymer or concrete that forms in the mold 254 supplements longitudinal compression strength that vectors into reduced vertical deflection by encasing the tension device 258 in a rigid matrix. Application of this technology is to make stronger and larger parts from smaller 3D printed parts including use to 3D print multicopters and to make light-weight structural beams.

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April 10, 2021

Applicant: Inventor Pro Se Galen J Suppes
Inventor: Galen J. Suppes ("Applicant")
Application No.: PCT/US20/36936
Title: Multicopter with Improved Propulsor and Failsafe Operation
Filed: 12-Jun-2020

Mailstop PCT, Attn: ISA/US
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P.O. Box 1450
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ARTICLE 34 AMENDMENT TO CLAIMS AND SPECIFICATION

Sir:

This letter accompanies replacement claims and an amended specification as described in the following two sections.

I. Specification Amendments Under Article 34

A. Formatting Corrections

Two formatting adjustments were made.

1. An improper paragraph return mark was removed prior to paragraph [37] resulting in previous paragraphs [36] and [37] combining into a single paragraph.
2. A paragraph return was added to previous paragraph [44] so that subsequent paragraph numbering would remain the same as the original specification.

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**B. Amendment of Text Based on Existing Content in Figures and Priority Incorporated
by Reference in Their Entirety**

Paragraphs [55] and [58] were edited based on content of originally figures and based on text of prior. The paragraph [55] edits and suggestions are as follows:

[55] "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; surfaces that are longer than wide. Structural or control surfaces such as actuators (38), arms (39, 40, 41, 99), support surfaces (43), wing or blade sections (90, 53), stabilizers (116), and rudders (117) (see Figs. 1, 8, 20, and 21) may extend from a liftpath. A preferred swaywing has a total wetted surface area and a swaywing total liftpath area where the swaywing total liftpath surface area is greater than one third the swaywing wetted surface area. The swaywing is located below the airchassis and pivotably coupled to the airchassis.

Suggestions on paragraph [55] edits include:

1. The term "aerodynamically contiguous" is the flowing-air equivalent of the term "wetted" for water; both reflecting how the fluid behaves when interacting with the surface. The term "wetted" was/is used repeatedly in paragraph [55]. The term "aerodynamically contiguous" is also a concise way to state that air is "streamlined" over contacting surfaces as if the surfaces were a single surface. Figs. 2, 4, 6, 15, and 27b (below) identify flat surfaces for air to flow over/under rather than through the formed [liftpath] surfaces. Cited priority Appl. No. 63/019,278 uses the terms "streamlined" six times (pages 24, 37, 38, 39, 49, and 49) in reference to the formed cruising configuration. With two cited as follows:

[162] ... when the thruster is not operating, the thruster is in a lower position said lower position optionally being more aerodynamically streamlined with the fuselage ... (page 24)

Transformer Lifting-Body Designs - HS-drone's transformation allows for minimal resistance to vertical downwash in the VTOL position (see Figure 1a)), while providing a streamlined cruising position (see Figure 1c)). (page 37)

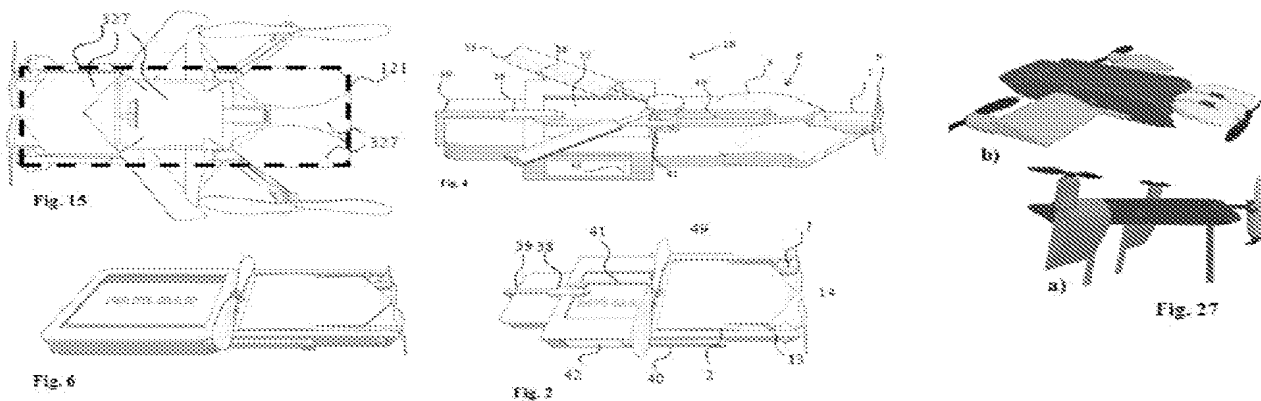
In view of Figs. 2, 4, 6, 15, and 27 and specific a) reference to aligning with a fuselage, b) swaywing, c) reference to 5GAT, and d) the term "transformer drone"; formation of

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an “aerodynamically contiguous” surface is general to the transformation to cruising for any lifting body rather than just a swaywing (this general reference is re-visited with paragraph [58] edits).

2. The term “Rectangular” is re-introduced into paragraph [55] as a liftpath description. The term was used in paragraph [0155] of priority application 16/783,319 per “[0155] ... *The LiftPaths 121 are generally rectangular in shape having a width similar to the fuselage width and a length along most of the fuselage.*” Also the original specification paragraph [55] uses the terms “flat” and “longer than wide” teaching to the prior art characterization as rectangular. Also, Fig. 15 specifically identifies the “liftpath 121” by a dashed-line rectangular area.
3. The term “Structural and control surfaces” is used in a sentence added to amended paragraph [55]. This term is an accurate term to describe the identified surfaces in the cited figures. The names associated with the identifying numbers that are not used in instant application are used in priority Appl. 62/ 944,506 with an “!” before the number. All the number references are used in the cited figures of instant application.

For convenience, the referenced Figs. 2, 4, 6, 15, and 27 are provided *infra*.



The paragraph [58] edits and suggestions are as follows:

[58] Preferably aerial vehicles, including [the-]multicopters, comprise[s] a plurality of longitudinally-extending lift-generating surfaces 327 forming a total aerodynamic lift surface area (see Fig. 15), the plurality of longitudinally-extending lift-generating surfaces including tiltwings, arms and lifting bodies such as fuselages, freewings, and swaywings as illustrated by Figs. 2, 4, 6, 15, and 27. The tiltwing may be fore or behind the lifting body. More preferably a multicopter comprises [ing -a]]the fuselage, the front passively-adjusting tiltwing, and an arm mechanically connecting the front passively-adjusting tiltwing to the fuselage with [-F]]the plurality of longitudinally-extending lift-generating surfaces

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forming[s] a liftpath 121 in a cruising configuration with the front tiltwing being a single front tiltwing in front of a single fuselage. Typically, lift provided by the front passively-adjusting tiltwing is less than half the lift provided by the total aerodynamic lift surface area. The plurality of surfaces align to form a liftpath.

4. The term “aerial vehicles” was re-introduced into paragraph [58]. The term “aerial vehicle” was used rather than “multicopter” prior to December of 2019 (prior art serial numbers 62/879,003; 62/ 862,237; 62/ 860,152). By example, App. No. 62/879,003 dozens of times in the first six pages; applications after October of 2019 simply substituted the term “multicopter” for “aerial vehicles”. The benefits and mechanisms of the specifications of paragraph [58] are not limited to multicopters and the amended paragraph reflects this.
5. The term “lifting body” was re-introduced into the specification in paragraph [58]. The term “lifting body surface 327” was used rather than “lift-generating surface 327” in priority appl. 16/783,319; and in revisions the term “lifting body surface” was replaced with “lift-generating surface”, the latter being more-general and including lifting body surfaces. The terms are substantially interchangeable, with lift-body surfaces debatably being a subset of lift-generating surfaces. The use of “lifting body surfaces” in amended claim 9 (discussed *infra*) makes the language less confusing as an alternative to longer phrases.
6. The phrase “fore or behind” is used in the revised paragraph [58]. The tiltwing fore a fuselage, cabin, freewing, or swaywing is identified repeatedly in the texts and by Figs. 2, 4, and 15. A tiltwing behind the fuselage is substantiated by Fig. 27.

In summary, the amendments to the text do not introduce new content while creating a clarity and conciseness good for communicating of invention embodiments.

C. Deleted Content of Amended Specification

The following two sentences were deleted from paragraph [104] to keep the page count of the specification at 20 pages (save money) and due to judgment that the content adds little to patentable claims.

If is preferred to distribute, to some extent, the exhaust area along the back side of a wing or fuselage, and it is preferred for that area to have a width greater than height to facilitate lifting body surfaces on the upper and lower portions of an engine housing (which may be part of a wing or fuselage). A preferred option is to have the hybrid engine at the rear of a vehicle such as the propeller of Fig. 27; wherein, the high-torque

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stator driving the propeller may be at the aft of the engine with exhaust gases exiting through the hole of high-torque stator annulus.

II. Claim Amendments Under Article 34

A summary of amendments is: claim 1 unchanged; claim 2 amended as new claim; claims 2-6 unchanged; claim 7 amended as new claim; claim 8 unchanged; claim 9 amended as new independent claim, claims 10-20 amended. Details of amendments are as follows:

Claim 2 was substantially, previously claim 9 and is substantiated by paragraph [58] of the original specification with content preserved in the amended paragraph [58]. Amendments are indicated as follows:

2. (currently amended) The multicopter of claim 1, [~~wherein the first propulsor is configured to generate the tiltwing propulsor lift at least twice the tiltwing propulsor thrust in the hovering configuration, and wherein the first propulsor is configured to generate the tiltwing propulsor thrust at least twice the tiltwing propulsor lift in the cruising configuration.~~]

further comprising: a total aerodynamic lift surface area including a plurality of lift generating surfaces defining a liftpath, the plurality of lift generating surfaces including: a single fuselage; the front tiltwing; and an arm mechanically connecting the front tiltwing to the fuselage;

wherein the front tiltwing is a single front tiltwing positioned forward of the airchassis; the front tiltwing configured to generate a first lift force that is less than half a second lift force generated by the total aerodynamic lift surface area.

Claim 7 edits include the deleting of the previous claim 7 with replacement based paragraph [45] “ ... The VTOL vehicles have an airchassis as a support structure that may be part of a fuselage or a separate structure ...” and paragraph [59] “ For vehicles without a swaywing or freewing, the airchassis is part of the fuselage.” Amendments are indicated as follows:

7. (currently amended) The multicopter of claim [6]1, wherein [~~the midsection rotary wing is configured to transition between a fixed wing position and a rotary position~~] the airchassis is part of a fuselage.

Claim 9 is a new independent claim (previous independent claim 10 is now dependent). The basis for claim 9 is with the original paragraph [58] and the revised paragraph [58] as discussed in the previous section on specification amendments. Amendments are indicated as follows:

9. (currently amended) [~~The multicopter of claim 1 comprising a plurality of longitudinally-extending lift-generating surfaces forming a total aerodynamic lift surface area; the plurality of longitudinally-extending lift-generating surfaces comprising a~~

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~~fuselage, the front [passively-adjusting] tiltwing, and an arm mechanically connecting the front [passively-adjusting] tiltwing to the fuselage;
the plurality of longitudinally-extending lift-generating surfaces forms a liftpath; and
the front tiltwing is a single front tiltwing in front of [a single] airchassis; wherein lift provided by the front [passively-adjusting] tiltwing is less than half the lift provided by the total aerodynamic lift surface area.]~~

An aerial vehicle comprising a plurality of lift-generating surfaces, the plurality of lift generating surfaces configured to form, in a cruising configuration, a liftpath having a rectangular approximately-flat aerodynamically-contiguous surface;

the plurality of lift-generating surfaces comprising a lifting body surface and a tiltwing;

the tiltwing: a) pivotably coupled to the lifting body surface, b) comprising at least one tiltwing propulsor, c) configured to transition to the cruising configuration, and d) disposed fore or aft the lifting body in all flight configurations;

wherein the liftpath is configured to enable flight and defines a surface comprising a lateral width and a longitudinal length said longitudinal length greater than the lateral width.

Claim 10 is amended from being independent to being dependent on Claim 9. The basis for claim 10 is with the original paragraph [58] which is preserved in the new paragraph [58].

Amendments are indicated as follows:

10. (currently amended) The aerial vehicle of claim 9 wherein the aerial vehicle is a [A] multicopter, the tiltwing is [comprising] a single front passively-adjusting tiltwing in front of the lifting body surface said lifting body surface a single fuselage, [a tiltwing propulsor,]and at least one counterbalance propulsor[; a plurality of longitudinally extending lift-generating surfaces, and a total multicopter weight];

~~[the plurality of longitudinally-extending lift-generating surfaces comprising the single fuselage, the front passively-adjusting tiltwing, and an arm mechanically connecting the front passively-adjusting tiltwing to the single fuselage; wherein the plurality of longitudinally-extending lift-generating surfaces forms a liftpath] wherein lift provided by the front passively-adjusting tiltwing is less than half the total multicopter weight.~~

Claims 11-13 are amended to include “single” before fuselage and passively adjusting tiltwing as recommended through observations of Box No. VIII of the 02-Mar-2021 preliminary search report. Amendments are indicated as follows:

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11. (currently amended) The multicopter of claim 10 wherein the front passively-adjusting tiltwing is freely rotatable relative to the single fuselage within a predetermined angular range around a tiltwing axis.

12. (currently amended) The multicopter of claim 10 comprising two propulsors on the front passively-adjusting tiltwing, two arms mechanically connecting the single fuselage to the front passively-adjusting tiltwing, and wherein the at least one counterbalance propulsor is two rear propulsors said two rear propulsors set at an angle relative to the single fuselage.

13. (currently amended) The multicopter of claim 10 the single fuselage comprising a swaywing pitotably connected to an air chassis pitotably connected to the single front passively-adjusting tiltwing.

Claim 15 is substantially a new claim through edit elimination of previous claim 15. The claim is substantiated by original paragraph [55] which states "'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 surfaces having air angle of attacks from 0 to 3 degrees (leading-edge up surfaces of low pitch) on relatively flat surfaces that are longer than wide.'" Content of original paragraph [55] is preserved in the amended paragraph [55] as discussed in the previous section. Amendments are indicated as follows:

15. (currently amended) [~~A landing method for landing a multicopter comprising a plurality of failsafe methods;~~
~~the multicopter comprising a front tiltwing, a vehicle center of gravity, a front tiltwing propulsor thrust, a front tiltwing propulsor lift, a front tiltwing propulsor force said front tiltwing propulsor force being a vector sum of the front tiltwing propulsor thrust and the front tiltwing propulsor lift, a ratio of tiltwing propulsor thrust to lift, a front tiltwing propulsor lift, a total multicopter lift, a total multicopter thrust, a first failsafe method, and a second failsafe method;~~
~~the second failsafe method comprising transitioning the front tiltwing to a position wherein the front tiltwing propulsor lift is greater than one-third of the total multicopter lift and the tiltwing propulsor lift is greater than the total multicopter thrust; and~~
~~the first failsafe method comprising transitioning the front tiltwing to a position wherein the total multicopter 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 multicopter thrust.]~~

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The aerial vehicle of claim 9 the liftpath defining air angles of attack between 0 and 3 degrees.

Claim 16 is substantially a new claim through edit elimination of previous claim 16. The claim is substantiated by illustrated by actuators (38), arms (39, 40, 41, 99), support surfaces (43), wing or blade sections (90, 53), stabilizers (116), and rudders (117) of Figs. 1, 8, 20, and 21 and by the amended paragraph [55] as discussed in the previous section. Amendments are indicated as follows:

16. (currently amended) [~~The landing method of Claim 15, wherein passive aerodynamic actuation performs at least one of the first failsafe method and the second failsafe method.~~]

The aerial vehicle of claim 9 comprising structural or control surfaces extending from the rectangular approximately-flat aerodynamically-contiguous surface.

Claims 17-20 were substantially previous claims 15-18 as moved to the new numbering through amendment of claims. Edits of the previous claims include Box No. VII antecedent basis observations of the of the 02-Mar-2021 search report. The claims are substantiated by original specification paragraphs [60] through [62]. Amendments are indicated as follows:

17. (currently amended) [~~The landing method of Claim 15 including a third failsafe method, the third failsafe method comprising transitioning a midsection rotary wing from a fixed wing position to a rotary position, the midsection rotary wing coupled to and extending above an airchassis, the midsection rotary wing also coupled to a power supply and a control unit and increasing power supplied by the power supply to the midsection rotary wing prior to landing; wherein the rotary wing produces over eighty percent of the total multicopter lift one second before landing.~~]

A landing method for landing a multicopter comprising a plurality of failsafe methods: the multicopter comprising a front tiltwing, a vehicle center of gravity, a front tiltwing propulsor thrust, a front tiltwing propulsor lift, a front tiltwing propulsor force said front tiltwing propulsor force being a vector sum of the front tiltwing propulsor thrust and the front tiltwing propulsor lift, a ratio of front tiltwing propulsor thrust to lift, the front tiltwing propulsor lift, a total multicopter lift, a total multicopter thrust, a first failsafe configuration, and a second failsafe configuration;
a first failsafe method comprising: transitioning the front tiltwing to a first failsafe configuration wherein the total multicopter 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 multicopter thrust; and

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a second failsafe method comprising: transitioning the front tiltwing to a second failsafe configuration wherein the front tiltwing propulsor lift is greater than one third of the total multicopter lift and the front tiltwing propulsor lift is greater than the total multicopter thrust.

18. (currently amended) [~~The landing method of Claim 17 comprising transitioning a swaywing from a cruising position to a hovering position, the swaywing configured to transition between a cruising configuration and a hovering configuration, the swaywing including a fuselage compartment, a swaywing arm, and a lifting body surface, the swaywing located below the airchassis and mechanically connected to the airchassis through at least one lateral axis bearing by the swaywing arm, the swaywing configured to transition between the cruising configuration and the hovering configuration.~~]

The landing method of Claim 17, wherein passive aerodynamic actuation performs at least one of the first failsafe method and the second failsafe method.

19. (currently amended) [~~The landing method of Claim 18, wherein a front tiltwing is coupled to the airchassis and swaywing.~~]

The landing method of Claim 17, including a third failsafe method, the third failsafe method comprising: transitioning a midsection rotary wing from a fixed wing position to a rotary position, the midsection rotary wing coupled to and extending above an airchassis, the midsection rotary wing also coupled to a power supply and a control unit and increasing power supplied by the power supply to the midsection rotary wing prior to landing; wherein the rotary wing produces over eighty percent of the total multicopter lift one second before landing.

20. (currently amended) [~~The landing method of Claim 17, further comprising controlling a yaw angle via aerodynamic forces acting on a duct having vanes surrounding the midsection rotary wing.~~]

The landing method of Claim 19, further comprising:

transitioning a swaywing from a cruising position to a hovering position, the swaywing configured to transition between a cruising configuration and a hovering configuration, the swaywing including a fuselage compartment, a swaywing arm, and a lifting body surface, the swaywing located below the airchassis and mechanically connected to the airchassis through at least one lateral axis bearing by the swaywing arm, the swaywing configured to transition between the cruising configuration and the hovering configuration.

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III. Suggestions in Support of Amended Claims

A. Review of Previous, Related USPTO Search Reports

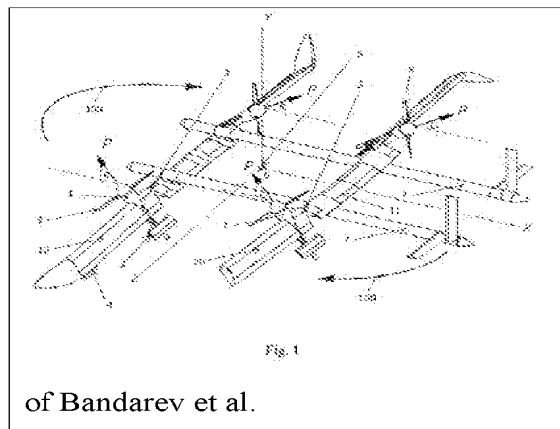
1. Previously reviewed in the 02-Mar-2021 search report and identified as as novel, inventive, and industrially applicable were:
 - a. Claims 1, 3-6, and 8 are in amended claims in original form.
 - b. Claim 10 is substantially same in content, but now dependent on new claim 9.
 - c. Claims 11-14 have minor antecedent correction modifications.
 - d. Claims 15-18 are in amended claims in original form but renumbered as 17-20.
2. Substantially new claims are 2 and 7 are dependent upon 1; and for the reasons claim 1 is allowed, so should claims 2 and 9 be allowed.
3. Independent claim 9 and dependent claims 14 and 15 are new.

B. Suggestions in Regard to Claims 9, 14, and 15

The content of claim 9 was substantially reviewed in the evaluation of U.S. Patent 10,589,838 (which is indirectly included as priority for instant applications through all priority applications dated after October of 2019) and in the Search Report of 02-Mar-2021. In these two search reports, thre patents stand out: Bandarev et al.(US 10,301,016), Groninga et al . (US 2019/003133), and Conca-Garcia (WO 2015/089679).

To overcome Bandarev, Applicant (G. Suppes) limited the claim (Claim 9) of US 10,301,016 to a single front tiltwing in front of a single fuselage. Applicant's limits were more narrow than necessary for the following reasons:

- a. A single rear tiltwing would also overcome the prior art.
- b. The use of the term fuselage could be too limiting, with the term "lifting body surface" or "lift-generating surface" being used in present specification; lifting-body including such items as fuselages, cabins, swaywings, and freewings.



To Overcome Groninga and Conca-Garcia, for the original claim 10 in instant application to overcome Groninga, the 03-Mar-2021 search report cited: a) single front passively-adjusting tiltwing and b) the front tiltwing having less than half the multicopter weight.

While the search response of the original claims overcame prior art, the differences between instant invention are considerably greater than suggested by the 02-Mar-2021 search.

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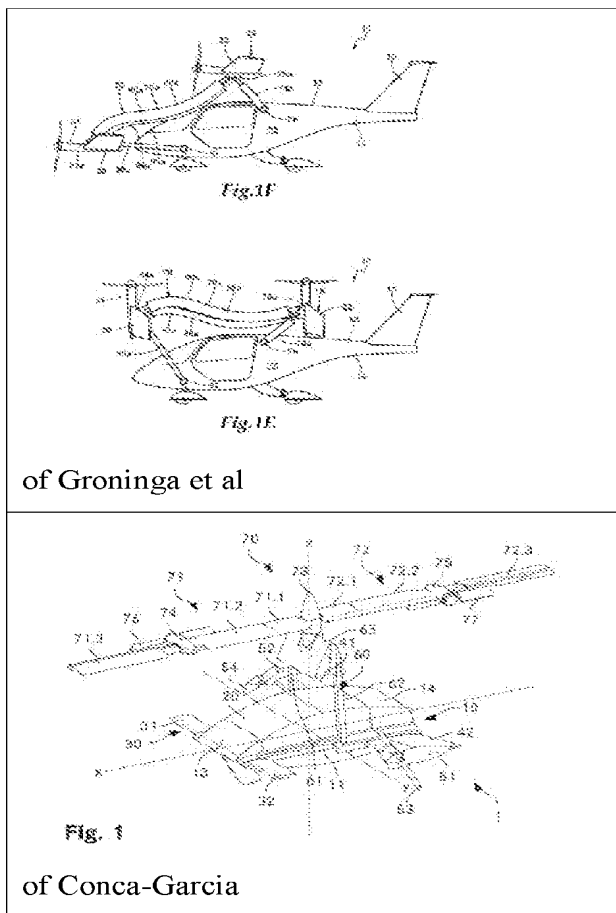
Suggestions of a more-fundamental difference –

A more-fundamental difference of the instant invention is the absence of traditional wings in key embodiments (see Figs. 2, 4, and 6) in the cruising configuration while all of the cited prior art has prominent wings. Efficient aerodynamic lift in the absence of wings is based on: a) more-evenly distributed pressure forces along the lifting body, b) the surface integral of the net pressure forces, and c) air angles of attack¹ between 0 and 3 degrees.

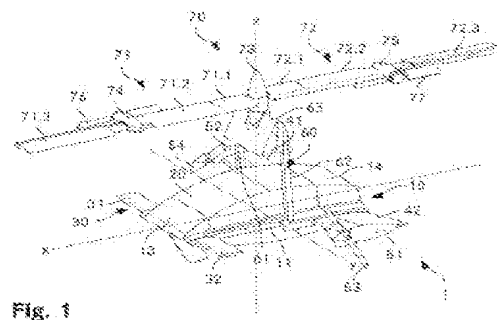
Liftpath – The non-reliance of wings of instant invention is so prominent that the term “Liftpath” was defined and used throughout the specification. Even the tiltwing illustrations are thin and of relatively long chord lengths. Wings for cruising are sparsely mentioned or not mentioned at all.

The following are approaches for a base claim to overcome the prior art:

- a. Prominence of **Liftpath** lift rather than traditional airfoil/wing lift when cruising.
- b. An approximately **flat** liftpath
- c. A substantially **rectangular** flat liftpath
- d. Transition to a substantially flat **contiguous** Liftpath when transitioning to the preferred cruising configuration for the purpose of ultra-high cruising efficiency. (plurality of surfaces form)
- e. **Absence of** traditional airfoil-type **wings**.
- f. A large, flat, horizontal surface would get in the way of air flow for VTOL, and so the Liftpath must be formed substantially **formed after** takeoff and separated before landing.
- g. Front **hinge joint** on the lifting body being towed by a lead propulsor **to overcome pitch instability issues** for an aircraft that is mostly a flat rectangular lifting body.



of Groninga et al



of Conca-Garcia

¹ Lift force is a vector-corrected surface integral of [pressure] X [area] on the surface. At small angles the lift-to-drag ratio (L:D) is 57/[degree of angle]; which is > 19 between 0 and 3 degrees and <19 above 3 degrees. Efficient flight dictates L:D > 19:1 and the 0 to 3 degree range.

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C. Suggestions on Amended Claim 9

The following form the basis for the amended claim 9 (and dependent claims 15 and 16):

Claim 9 is on aerial vehicle not limited to VTOL or a multicopter.

- a. A liftpath is formed from a plurality of surfaces, where the liftpath is:
 - i. rectangular
 - ii. approximately-flat
 - iii. aerodynamically-contiguous
 - iv. (dependent claim 15) defining air angles of attack between 0 and 3 degrees.
- b. The plurality of surfaces include:
 - i. a lifting body surface
 - ii. a tiltwing; the tiltwing
 1. pivotably coupled to the lifting body surface,
 2. comprising at least one tiltwing propulsor,
 3. configured to transition to the cruising configuration, and
 4. disposed fore or aft the lifting body in all configurations
- c. wherein
 - i. liftpath is configured to enable flight
 - ii. defines a surface comprising a lateral width and a longitudinal length said longitudinal length greater than the lateral width.
- d. (dependent claim 16) structural or control surfaces extending from the rectangular approximately-flat aerodynamically-contiguous surface ...

Amended claim 9 reads:

9. An aerial vehicle comprising a plurality of lift-generating surfaces, the plurality of lift generating surfaces **configured to form**, in a cruising configuration, a liftpath having a **rectangular approximately-flat aerodynamically-contiguous surface**;

the plurality of lift-generating surfaces comprising a lifting body surface and a tiltwing; the tiltwing: a) pivotably coupled to the lifting body surface, b) comprising at least one tiltwing propulsor, c) configured to transition to the cruising configuration, and d) **disposed fore or aft the lifting body in all configurations**;

wherein the liftpath is configured to enable flight and defines a surface comprising a lateral width and a longitudinal length said longitudinal length greater than the lateral width.

In bold are the features that distinguish the claim 9 invention from prior art as follows:

1. Relative to Conca-Garcia;

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- a. The liftpath is “approximately-flat” while both the upper and lower surfaces of Conca-Garcia are convex/concave with angles over more than a 3 degree range.
 - b. The tiltwing is disposed fore or aft the lifting body surface “in all flight configurations” while Conca-Garcia includes a tiltwing above the fuselage for takeoff/landing.
2. Relative to Bandarev et al. and Groninga et al:
- a. The aerial vehicle is “configured to form” a rectangular approximately-flat aerodynamically-contiguous surface” where the surfaces formed by Bandarev et al. and Groninga et al are i) not rectangular, ii) not approximately flat, and iii) not aerodynamically contiguous.

Applicant suggests that these same features that overcome the cited prior art also overcome all other prior art.

Dependent claims 10 (and 11-14) further limits claim 9 substantially to the original claim 10 which was reviewed in the first search report of this application.

Dependent claim 15 further defines "approximately-flat" as having angles in a 3 degree range which builds upon the approximately-flat novelty. Dependent claim 16 allows for placing isolated objects on the flat surface. The applicant interprets isolates as meaning the 0-3 degree air angles of attack form fore and aft any isolated objects.

Applicant respectfully suggests that the revised claims meet all three criteria for patentability.

Respectfully Submitted,

/Galen J Suppes /

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CLAIMS

1. A multicopter comprising: an airchassis;

a front tiltwing pivotably coupled to the airchassis and configured to transition between a hovering configuration and a cruising configuration, the front tiltwing including: a) a first propulsor configured to generate at least one of a tiltwing propulsor thrust or a tiltwing propulsor lift and b) an aerodynamic lift surface;

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 a control unit.

2. The multicopter of claim 1, further comprising: a total aerodynamic lift surface area including a plurality of lift generating surfaces defining a liftpath, the plurality of lift generating surfaces including: a single fuselage; the front tiltwing; and an arm mechanically connecting the front tiltwing to the fuselage;

wherein the front tiltwing is a single front tiltwing positioned forward of the airchassis; the front tiltwing configured to generate a first lift force that is less than half a second lift force generated by the total aerodynamic lift surface area.

3. The multicopter of claim 1, wherein the airchassis, front tiltwing, and counterbalance propulsor system are transitionable through passive actuation to a default failsafe descent configuration, the failsafe descent configuration conducive to landing without catastrophic damage to at least one of the airchassis, front tiltwing, counterbalance propulsor system, and a payload.

4. The multicopter of claim 3, wherein the counterbalance propulsor system provides negligible thrust while the airchassis, front tiltwing, and counterbalance propulsor system are in the failsafe descent configuration and wherein the counterbalance propulsor system is aft the front tiltwing.

5. The multicopter of claim 1, further comprising a swaywing, a swaywing total wetted surface area, and a swaywing total liftpath surface area,

the swaywing located below the airchassis and pivotably coupled to the airchassis and the swaywing total liftpath surface area is greater than one third the swaywing wetted surface area.

6. The multicopter of claim 1, the counterbalance propulsor system further includes a midsection rotary wing.

7. The multicopter of claim 1, wherein the airchassis is part of a fuselage.

8. The multicopter of claim 1, wherein the front tiltwing is configured to be aerodynamically actuated to a pseudo-hovering configuration to provide a dampened descent by a pseudo-hovering upward force said pseudo-hovering upward force a combination of lift and drag.

9. An aerial vehicle comprising a plurality of lift-generating surfaces, the plurality of lift generating surfaces configured to form, in a cruising configuration, a liftpath having a rectangular approximately-flat aerodynamically-contiguous surface;

the plurality of lift-generating surfaces comprising a lifting body surface and a tiltwing;

the tiltwing: a) pivotably coupled to the lifting body surface, b) comprising at least one tiltwing propulsor, c) configured to transition to the cruising configuration, and d) disposed fore or aft the lifting body in all flight configurations;

wherein the liftpath is configured to enable flight and defines a surface comprising a lateral width and a longitudinal length said longitudinal length greater than the lateral width.

10. The aerial vehicle of claim 9 wherein the aerial vehicle is a multicopter, the tiltwing is a single front passively-adjusting tiltwing in front of the lifting body surface said lifting body surface a single fuselage, and at least one counterbalance propulsor;

wherein lift provided by the front passively-adjusting tiltwing is less than half the total multicopter weight.

11. The multicopter of claim 10 wherein the front passively-adjusting tiltwing is freely rotatable relative to the single fuselage within a predetermined angular range around a tiltwing axis.

12. The multicopter of claim 10 comprising two propulsors on the front passively-adjusting tiltwing, two arms mechanically connecting the single fuselage to the front passively-adjusting tiltwing, and wherein the at least one counterbalance propulsor is two rear propulsors said two rear propulsors set at an angle relative to the single fuselage.

13. The multicopter of claim 10 the single fuselage comprising a swaywing pitotably connected to an air chassis pitotably connected to the single front passively-adjusting tiltwing.

14. The multicopter of claim 10 comprising a control system capable of configuring the multicopter for a failsafe landing where greater than eighty percent of lift on the multicopter is generated by the tiltwing propulsor.

15. The aerial vehicle of claim 9 the liftpath defining air angles of attack between 0 and 3 degrees.

16. The aerial vehicle of claim 9 comprising structural or control surfaces extending from the rectangular approximately-flat aerodynamically-contiguous surface.

17. A landing method for landing a multicopter comprising a plurality of failsafe methods; the multicopter comprising a front tiltwing, a vehicle center of gravity, a front tiltwing propulsor thrust, a front tiltwing propulsor lift, a front tiltwing propulsor force said front tiltwing propulsor force being a vector sum of the front tiltwing propulsor thrust and the front tiltwing propulsor lift, a ratio of front tiltwing propulsor thrust to lift, the front tiltwing propulsor lift, a total multicopter lift, a total multicopter thrust, a first failsafe configuration, and a second failsafe configuration;

a first failsafe method comprising: transitioning the front tiltwing to a first failsafe configuration wherein the total multicopter 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 multicopter thrust; and

a second failsafe method comprising: transitioning the front tiltwing to a second failsafe configuration wherein the front tiltwing propulsor lift is greater than one third of the total multicopter lift and the front tiltwing propulsor lift is greater than the total multicopter thrust.

18. The landing method of Claim 17, wherein passive aerodynamic actuation performs at least one of the first failsafe method and the second failsafe method.

19. The landing method of Claim 17, including a third failsafe method, the third failsafe method comprising: transitioning a midsection rotary wing from a fixed wing position to a rotary position, the midsection rotary wing coupled to and extending above an airchassis, the midsection rotary wing also coupled to a power supply and a control unit and increasing power supplied by the power supply to the midsection rotary wing prior to landing; wherein the rotary wing produces over eighty percent of the total multicopter lift one second before landing.

20. The landing method of Claim 19, further comprising:

transitioning a swaywing from a cruising position to a hovering position, the swaywing configured to transition between a cruising configuration and a hovering configuration, the swaywing including a fuselage compartment, a swaywing arm, and a lifting body surface, the swaywing located below the airchassis and mechanically connected to the airchassis through at least one lateral axis bearing by the swaywing arm, the swaywing configured to transition between the cruising configuration and the hovering configuration.