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HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,  
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,  
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,  
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SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,  
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,  
ZW.

[Continued on next page]

(54) Title: VERTICAL TAKEOFF AND LANDING (VTOL) AIR VEHICLE

	EFFECTOR	GRAPHIC
1. PITCH	SYMMETRIC PITCH CYCLIC (NOSE UP POSITIVE)	
2. ROLL	ASYMMETRIC CYCLIC AND ELEVON (RIGHT ROLL POSITIVE)	
3. YAW	ASYMMETRIC COLLECTIVE (NOSE RIGHT POSITIVE)	
4. THRUST	SYMMETRIC COLLECTIVE (FORWARD POSITIVE)	

**Fig. 3A**(57) Abstract: A flight control apparatus for fixed-wing air-  
craft includes a first port wing (115) and first starboard wing  
(120), a first port swash plate (145) coupled between a first  
port rotor 155) and first port electric motor (135), the first  
port electric 5 motor (135) coupled to the first port wing  
(115), and a first starboard swash plate (150) coupled  
between a first starboard rotor (130) and first starboard elec-  
tric motor (140), the first starboard electric motor (140)  
coupled to the first starboard wing (120).



**(84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

**Published:**

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

**(88) Date of publication of the international search report:**

14 May 2015

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/36863

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B64C 29/02 (2015.01)

CPC - B64C 29/02

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8): B64C 29/02 (2015.01)

CPC: B64C 29/02

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

IPC(8): B64C 29/00, G05D 1/00 (2015.01)

CPC: B64C 29/00, B64C 19/00, B64C 19/02 USPC: 244/7.00B, 244/17.13, 701/31.4

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

PatBase; ProQuest Dialog; Google Patents; Google Web; Google Scholar

Search Terms: pitch, tilt, four%, front, rear, motor%, rotor%, engine%, powerplant%, yaw%, control%, induc%, pivot%, tilt%, swing%, rotat%, asymmetr%, collective%, cyclic%,

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y --- A	US 2005/0178879 A1 (Mao). 18 August 2005 (18.08.2005). Fig. 1; para [0030], [0039].	1-18, 30, 32 ----- 31
Y --- A	US 2011/0180673 A1 (Lim). 28 July 2011 (28.07.2011). Figs. 1-2; para [0023]-[0024].	1-18, 30, 32 ----- 31
Y	US 3,181,810 A (Olson). 04 May 1965 (04.05.1965). Figs. 1, 10-12; col 4, ln 44-51, 64-69; col 9, ln 25-27; col 9, ln 69-col 10, ln 6; col 10, ln 7-33.	7-16, 18
Y	US 2011/0303795 A1 (Oliver). 15 December 2011 (15.12.2011). Fig. 1A; para [0074], [0077].	2-4, 32
Y	US 2,961,189 A (Doak). 22 November 1960 (22.11.1960). Fig. 1; col 2, ln 62-72.	5-6
Y	US 2,151,128 A (Looney). 21 March 1939 (21.03.1939). Fig. 3; col 2, ln 47-50.	17
Y	US 5,062,587 A (Wernicke). 05 November 1991 (05.11.1991). Fig. 1; col 2, ln 48-49.	6

☐ Further documents are listed in the continuation of Box C.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

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Date of mailing of the international search report

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# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/36863

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

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

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

Group I: Claims 1-6, directed to a flight control apparatus for a fixed-wing aircraft having port and starboard swash plates coupled between the rotors and electric motors.

Group II: Claims 7-18, directed to a method of flight control for fixed-wing aircraft by generating opposing rotor rotational moments via actuation of swash plates to induce a roll.

Group III, Claims 19-26, directed to a method of vertical take-off and horizontal flight of a fixed-wing aircraft.

\*-See extra sheet\*-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:  
1-18 and 30-32
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

\*-Continuation of Box III-Observations where unity of invention is lacking\*-

Group IV, Claims 27-29, directed to a method of fixed-wing aircraft control by providing rotor blade pitch control for port and starboard rotors in the form of longitudinal and lateral cyclic control and collective pitch control.

Group V, Claims 30-32, directed to a fixed-wing aircraft having port and starboard wings lacking in-flight controllable surfaces.

The inventions listed as Groups I-V do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Group I requires the special technical features of a first port swash plate coupled between a first port rotor and a first port electric motor and a first starboard swash plate coupled between a first starboard rotor and a first starboard electric motor, not required by Groups II-V

Group II requires the special technical features of a method of flight control for fixed-wing aircraft, including inducing a left roll of a fuselage, generating in a first port rotor a negative rotational moment, and generating in a first starboard rotor a positive rotational moment, not required by Groups I, III-V.

Group III requires the special technical features of a method of vertical take-off and horizontal flight of a fixed-wing aircraft, including generating thrust in first port and starboard rotors on first port and starboard wings, respectively, to induce vertical takeoff of a fuselage.

Group IV requires the special technical features of a method of fixed-wing aircraft control including providing rotor blade pitch control to first port and starboard rotors coupled to first port and starboard wings, respectively, the rotor blade pitch control for the first port and starboard rotors each selected from the group consisting of longitudinal cyclic control, lateral cyclic control and collective pitch control to induce pitch, roll and yaw moments, respectively; wherein fixed-wing aircraft pitch, yaw and roll moments are accomplished without the benefit of control surfaces on a wing, not required by Groups I-III, and V.

Group V requires the special technical features of a fixed-wing aircraft, comprising a fuselage, a first port wing and a first starboard wing extending from opposite sides of the fuselage, the first port wing and first starboard wing lacking in-flight controllable surfaces, not required by Groups I-IV.

The only technical features shared by Groups I-V that would otherwise unify the groups are a fixed-wing aircraft including first port and starboard wings, and first port and starboard rotors coupled to the first port and starboard wings, respectively. However, these features do not represent a contribution over the prior art, because the shared technical features are anticipated by US 2005/0178879 A1 to Mao (hereinafter 'Mao').

Mao teaches a fixed-wing aircraft (represented by fuselage 10 in Fig. 1; para [0030]) including first port and starboard wings (12a and 12b, respectively, in Fig. 1; para [0030]), and first port and starboard rotors (22a and 22b, respectively, in Fig. 1; para [0030]) coupled to the first port and starboard wings, respectively (as shown in Fig. 1).

As the common technical features of Groups I-V were known in the art at the time of the invention, they cannot be considered to be common technical features that would otherwise unify Groups I-V.

The only technical features shared by Groups I, III, and V that would otherwise unify the groups are a fixed-wing aircraft including first port and starboard wings, first port and starboard rotors, coupled to the first port and starboard wings, respectively, wherein the first port and starboard rotors are driven by electric motors. However, these features do not represent a contribution over the prior art, because the shared technical features are anticipated by Mao.

Mao teaches a fixed-wing aircraft (represented by fuselage 10 in Fig. 1; para [0030]) including first port and starboard wings (12a and 12b, respectively, in Fig. 1; para [0030]), and first port and starboard rotors (22a and 22b, respectively, in Fig. 1; para [0030]) coupled to the first port and starboard wings, respectively (as shown in Fig. 1), wherein each of the rotors may be driven by an electric motor (para [0039]).

As the common technical features of Groups I, III, and V were known in the art at the time of the invention, they cannot be considered to be common technical features that would otherwise unify Groups I, III, and V.

The only technical features shared by Groups II-III, and V that would otherwise unify the groups are a fixed-wing aircraft including first port and starboard wings, and first port and starboard rotors coupled to the first port and starboard wings, respectively, with a fuselage between the port and starboard wings. However, these features do not represent a contribution over the prior art, because the shared technical features are anticipated by Mao.

Mao teaches a fixed-wing aircraft (represented by fuselage 10 in Fig. 1; para [0030]) including first port and starboard wings (12a and 12b, respectively, in Fig. 1; para [0030]), and first port and starboard rotors (22a and 22b, respectively, in Fig. 1; para [0030]) coupled to the first port and starboard wings, respectively (as shown in Fig. 1), with a fuselage (10 in Fig. 1; para [0030]) between the port and starboard wings.

As the common technical features of Groups II-III, and V were known in the art at the time of the invention, they cannot be considered to be common technical features that would otherwise unify Groups II-III, and V.

\*-Continued on next extra sheet\*-

*.\*-Continued from previous extra sheet-.\**

The only technical features shared by Groups II-IV that would otherwise unify the groups are a method for controlling vertical take-off and/or horizontal flight in a fixed-wing aircraft. However, these features do not represent a contribution over the prior art, because the shared technical features are anticipated by Mao.

Mao teaches methods for controlling a fixed-wing aircraft (represented by fuselage 10 in Fig. 1; para [0030]) in both vertical take-off (referred to as "hover mode;" Abstract; para [0031]) and horizontal flight (Abstract; para [0032]).

As the common technical features of Groups II-IV were known in the art at the time of the invention, they cannot be considered to be common technical features that would otherwise unify Groups II-IV.

*The only technical features shared by Groups I-II and V that would otherwise unify the groups are a fixed-wing aircraft including first port and starboard wings, first port and starboard rotors coupled to the first port and starboard wings, respectively, and swash plates coupled between the first port and starboard rotors, respectively, and the first port and starboard wings, respectively. However, these features do not represent a contribution over the prior art, because the shared technical features are obvious over Mao in view of US 2011/0180673 A1 to Lim (hereinafter 'Lim').*

Mao teaches a fixed-wing aircraft (represented by fuselage 10 in Fig. 1; para [0030]) including first port and starboard wings (12a and 12b, respectively, in Fig. 1; para [0030]), and first port and starboard rotors (22a and 22b, respectively, in Fig. 1; para [0030]) coupled to the first port and starboard wings, respectively (as shown in Fig. 1). Mao does not expressly teach swash plates coupled between the first port and starboard rotors, respectively, and the first port and starboard wings, respectively. However, Lim teaches upper and lower swash plates (108, 110, respectively in Fig. 2; para [0024]) coupled between each of the port and starboard wings (both 101 in Fig. 1; para [0023]) and the port and starboard rotors (both 102 in Fig. 2; para [0023]). It would have been obvious to one having ordinary skill in the art that the fixed-wing aircraft taught by Mao could have been modified to use swash plates for maneuverability.

As the common technical features of Groups I-II, and V were known in the art at the time of the invention, they cannot be considered to be common technical features that would otherwise unify Groups I-II, and V.

Therefore Groups I-V lack unity under PCT Rule 13.