



ПАТЕНТНО ВЕДОМСТВО НА РЕПУБЛИКА БЪЛГАРИЯ



ПАТЕНТНО ВЕДОМСТВО НА РЕПУБЛИКА БЪЛГАРИЯ

ДОКЛАД ОТ ПРОУЧВАНЕ

ПРОУЧВАНЕ ВХ. № СпИС-71/ 11.01.2023 г. "Вертикално излитащ и кацащ летателен апарат с вертикално овално крило и двигатели с променлива векторна тяга"

I. Уточнен класификационен индекс по МПК

B64C39; B64C29; B64C27

II. ОБЛАСТ НА ПРОУЧВАНЕ:

Минимален обхват на проучване

Вид класификация:

МПК

Класификационен индекс:

B64C39; B64C29; B64C27

Бази данни, в които е извършено проучването

IPAS; esp@cenet; Epoque Net

III. Релевантни документи

Категория	Цитиране на документите с посочване на релевантните части	Релевантни претенции
A	US3640489 (A) публикуван на 08.02.1972 г. KARL JAEGER	1-4
A	US10960978 (B2) публикуван на 30.03.2021 г. BELL HELICOPTER TEXTRON INC [US]; TEXTRON INNOVATIONS INC [US]	1-4
A	JP2014240242(A) публикуван на 25.12.2014 г. FUJI HEAVY IND LTD	1-4
A	RU2515823 (C1) публикуван на 20.05.2014 г. MIKHAILOV SERGEI VLADIMIROVICH [RU]	1-4
A	CN106741910 (A) публикуван на 31.05.2017 г. HEFEI BRANCH SHANGHAI SHUNDONG TECH CO LTD	1-4
A	US10814974 (B2) публикуван на 27.10.2020 г. AMERICAN AVIATION TECH LLC [US]	1-4
A	US5213284 (A) публикуван на 25.05.1993 г. WEBSTER STEVEN N [US]	1-4



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Категория на документа

X – документът е от особено значение; претендираното изобретение няма новост или изобретателска стъпка, когато документът се разглежда самостоятелно

Y – документът е от особено значение; претендираното изобретение няма изобретателска стъпка, когато документът се комбинира с един или повече други документи и тази комбинация е очевидна за специалист в областта

A – документ, отразяващ нивото на техниката, който не е от особено значение

D – документ, цитиран в описанието

O – неписмено разкриване, използване, прилагане, докладване или демонстриране

P – документ, публикуван преди датата на подаване в България, но след приоритетната дата

E – по-рано подадена българска заявка, но публикувана на или след датата на подаване

L – документ, който може да предизвика съмнение относно приоритета на претенциите или който е цитиран с цел установяване датата на публикация на друг документ или друга специална причина (както е посочено)

& – документ от една патентна фамилия

Дата: 16.01.2013 г.

Име: Десислава Иванова

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Старши експерт ДЕЗИПМПД



ПАТЕНТНО ВЕДОМСТВО НА РЕПУБЛИКА БЪЛГАРИЯ

СТ А Н О В И Щ Е

ОТНОСНО: предварително проучване на изобретение за новост на “Вертикално излитащ и кацащ летателен апарат с вертикално овално крило и двигатели с променлива векторна тяга“

СпИС – 71/11.01.2023 г.

Към искането за проучване са приложени описание, претенции и чертеж.
Формулирани са една независима и три зависими претенции.

Съгласно патентните 1-4 претенции проучването се отнася до вертикално излитащ и кацащ летателен апарат с вертикално овално крило и двигатели с променлива векторна тяга, включващ модулно водоустойчиво тяло, шаси, модул за глобална система за позициониране, като шасито е кръстообразно състоящо се от две пресичащи се опори, в чиито периферии са фиксирани вътрешните повърхности на вертикално овално крило, като на хоризонталната опора са монтирани двигатели с променлива векторна тяга.

Към всеки двигател с променлива вертикална тяга са куплирани две съосни витла.
Вертикалното овално крило е елипсовиден пръстен.

Вертикалното овално крило е с несиметричен аеродинамичен профил.

Задача на изобретението е да се обезпечи вертикално излитащ и кацащ летателен апарат с вертикално овално крило и двигател с променлива тяга, за да се предотврати периферното крилно въздушно съпротивление и да се увеличи товароносимостта му.

При извършеното проучване се установи наличие на известни от предшестващото състояние на техниката документи, отразяващи нивото на техниката, които са посочени в приложения доклад от проучване и които не са противопоставими по новост на обекта на проучване, а именно:

- **US3640489 (A) публикуван на 08.02.1972 г.**, който разкрива самолет с вертикално излитане и кацане (VTOL) имащ фюзелаж с форма на диск с множество ъглово разположени възли за генериране на подемна сила. Всеки възел се състои от ротор над или наравно с фюзелажа, компресор във фюзелажа, който вкарва въздух отгоре, и дюза под фюзелажа за изтласкване на въздуха от компресора в струя. Дюзите могат да се въртят във всяка посока. Така, според настройките на дюзите, самолетът може да се издига или потъва вертикално и да се движи във всяка хоризонтална посока.
- **US10960978 (B2) публикуван на 30.03.2021 г.**, който разкрива самолет, способен на вертикално излитане и кацане, стационарен полет и полет напред, включващ затворено крило, което осигурява повдигане, когато въздухоплавателното средство е в полет напред, фюзелаж, поне частично разположен в периметъра на затвореното крило, и една или повече спици, свързващи затворено крило към фюзелажа. Един или повече двигатели или мотори са разположени в или прикрепени към затвореното крило, фюзелажа или спиците. Три или повече витла са близо до водещия ръб на затвореното крило или едната или повече спици, разпределени по дължината на затвореното крило или на едната или повече спици и функционално свързани



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към един или повече двигатели. Витлата осигуряват повдигане, когато самолетът е във вертикално излитане и кацане и неподвижен полет, и осигуряват тяга, когато самолетът е в полет напред.

- **JP2014240242 (A)** публикуван на **25.12.2014 г.**, който разкрива летателно превозно средство с вертикално излитане и кацане състоящо се от множество вътрешни роторни единици (RU11-RU14), разположен върху първа обиколка, отделена от центъра на корпуса на самолета на предварително определено разстояние; множество външни роторни единици (RU21-RU24), подредени върху втора обиколка, отделена от центъра на корпуса на самолета на предварително определено разстояние, по-голямо от предварително определеното разстояние; и средства за управление за задвижващо управление на вътрешните роторни единици и външните роторни единици. Плаването на корпуса на самолета се извършва чрез работа главно на вътрешните роторни блокове (RU11-RU14), а управлението на положението на корпуса на самолета се извършва чрез работа главно на външните роторни блокове (RU21-RU24).
- **RU2515823 (C1)** публикуван на **20.05.2014 г.**, който разкрива самолет включващ рама, свързана без трансмисия с носещ тънък диск, оборудван със сгъваеми радиални лопатки на центробежен вентилатор, шарнирно свързан с горната повърхност на диска. Регулируемите лопатки на аксиалния вентилатор са разположени, като ръбовете на диска се превръщат в ротор във вертикален полет и в кръгло крило при хоризонтален полет. Остриетата на дисковото задвижване, сгъваеми наравно с долната повърхност на диска, са разположени под диска, като дискът се върти от реактивния газ на двигателя. Двигателите са закрепени към гореспоменатата рамка чрез перки за управление на полета.
- **CN106741910 (A)** публикуван на **31.05.2017 г.**, който разкрива блюдообразен безпилотен летателен апарат с формата на чиния състоящ се от обвивка с форма на чиния, батерия, витло и блок за управление на гравитационния център, при което горен контролен контейнер е свързан към горната част в обвивката с форма на чиния, горен двигател е фиксиран към долната част на горния контролен контейнер и долната част на горния двигател е свързана с горен аерокрил; и долен контролен контейнер е свързан към долната страна в корпуса с форма на чиния, долен двигател е свързан към горната част на долния контролен контейнер, горната част на долния двигател е свързан с долно крило и долният част от долния контролен контейнер е свързан с облачна палуба.
- **US10814974 (B2)** публикуван на **27.10.2020 г.**, който разкрива самолет, способен на вертикално излитане и кацане (VTOL) и траверсен полет. Въздухоплавателното средство включва фиксирана външна конструкция, включваща най-малко общо цилиндрично крило, имащо вътрешно тяло, разположено в рамките на фиксираната външна конструкция. Определено е пространство между вътрешното тяло и фиксираната външна структура. В това пространство има едно или повече



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въртящи се пръстеновидни колела, които създават тяга, достатъчна за постигане на повдигане на самолета.

- **US5213284 (A)** публикуван на **25.05.1993** г., който разкрива летателно средство с обикновено кръгла или дискова планова конфигурация осигуряващо възможност за вертикален полет чрез два концентрични комплекта повдигащи вентилатори или перки. Всеки от двата комплекта може да включва определен брой отделни пръстени от лопатки, но и двата комплекта са еднакви по площ и се въртят срещуположно, за да осигурят почти еднакви обеми на въздушния поток и по този начин по същество компенсират всяка реакция на въртящ момент, дължаща се на въртенето на комплектите лопатки. Няколко двигателя са осигурени в предпочитаното изпълнение, като един двигател осигурява мощност на комплектите вентилатори за повдигане, а други двигатели осигуряват тяга за хоризонтален полет.

НОВОСТ

В нито един от намерените при проучването документи не е разкрито техническо решение за вертикално излитащ и кацащ летателен апарат с вертикално овално крило и двигатели с променлива векторна тяга, което да съдържа всички технически признаци на обекта на проучването.

Експертизата счита, че обектът на проучването **отговаря на изискванията за новост, съгласно чл. 8 от Закона за патентите и регистрацията на полезните модели (ЗПРПМ).**

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US005213284A

United States Patent [19][11] **Patent Number:** **5,213,284****Webster**[45] **Date of Patent:** **May 25, 1993****[54] DISC PLANFORM AIRCRAFT HAVING VERTICAL FLIGHT CAPABILITY**

[76] **Inventor:** Steven N. Webster, P.O. Box 426
Sleepy Hollow, Long Creek, Mossy
Head, Fla. 32434

[21] **Appl. No.:** 772,904

[22] **Filed:** Aug. 5, 1991

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 395,358, Aug. 17, 1989, abandoned.

[51] **Int. Cl.⁵** B64C 29/00

[52] **U.S. Cl.** 244/23 C; 244/12.2

[58] **Field of Search** 244/23 C, 12.2, 23 B,
244/53 R, 60, 17.19

[56] References Cited**U.S. PATENT DOCUMENTS**

2,863,621	12/1958	Davis	244/23 C
2,935,275	5/1960	Grayson	244/23 C
3,312,425	4/1967	Lennon et al.	244/12.2
3,774,865	11/1973	Pinto	244/23 C
4,014,483	3/1977	MacNeill	244/23 C
5,039,031	8/1991	Valverde	244/12.2

FOREIGN PATENT DOCUMENTS

0678700 1/1964 Canada 244/23 C
2648504 2/1978 Fed. Rep. of Germany 244/23 C

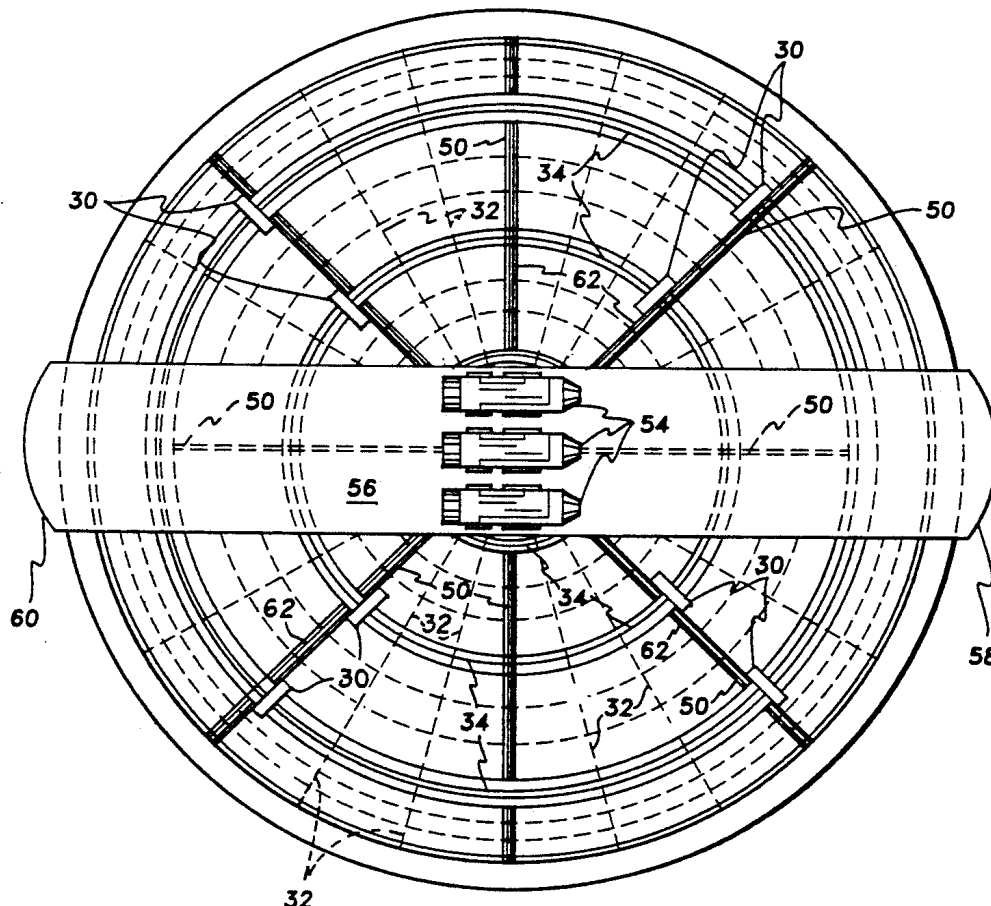
Primary Examiner—Joseph F. Peters, Jr.

Assistant Examiner—Christopher P. Ellis

Attorney, Agent, or Firm—Richard C. Litman

[57] ABSTRACT

An aircraft having a generally circular or disc planform configuration provides the capability of vertical flight through two concentric sets of lifting fans or blades. The two sets may each include a number of individual rings of blades, but both sets are equal in area and rotate oppositely in order to provide nearly equal volumes of airflow, and thus essentially offset any torque reaction due to the rotation of the blade sets. Several engines are provided in the preferred embodiment, with one engine providing power to the lift fan sets and other engines providing thrust for horizontal flight. Other novel features are also disclosed, such as a peripheral aerodynamic control system, power transmission system, and surface vane system. An alternate embodiment includes a peripheral passenger or cargo area, with more conventional rearwardly located aerodynamic controls for horizontal flight.

15 Claims, 5 Drawing Sheets

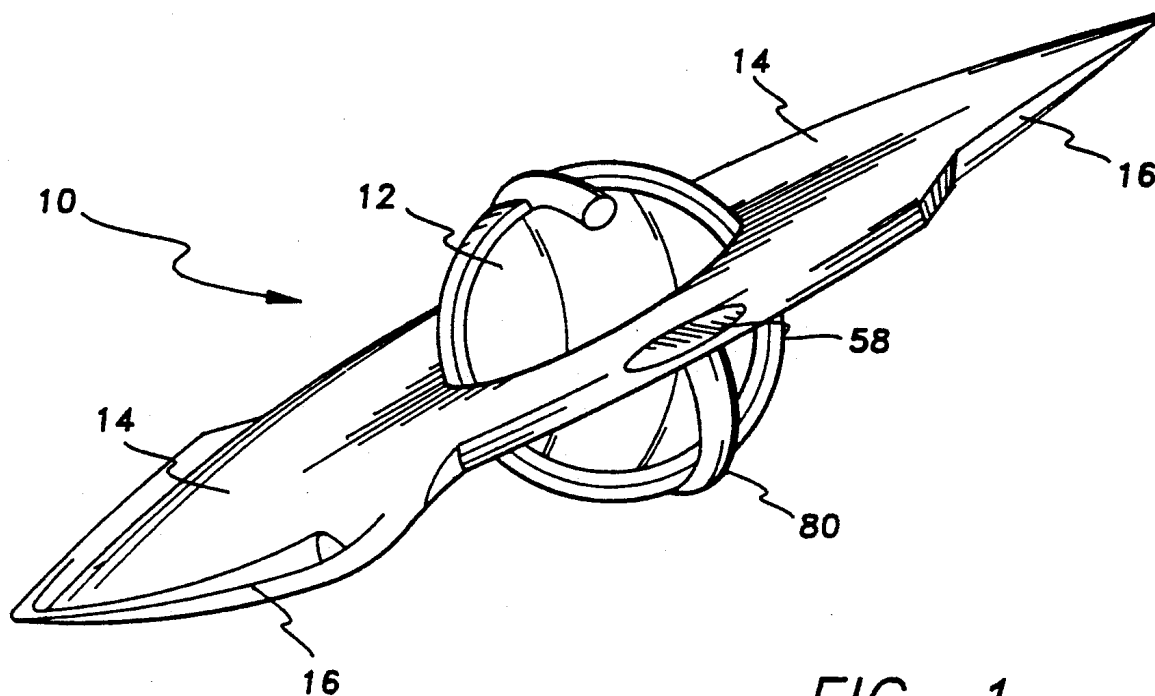


FIG. 1

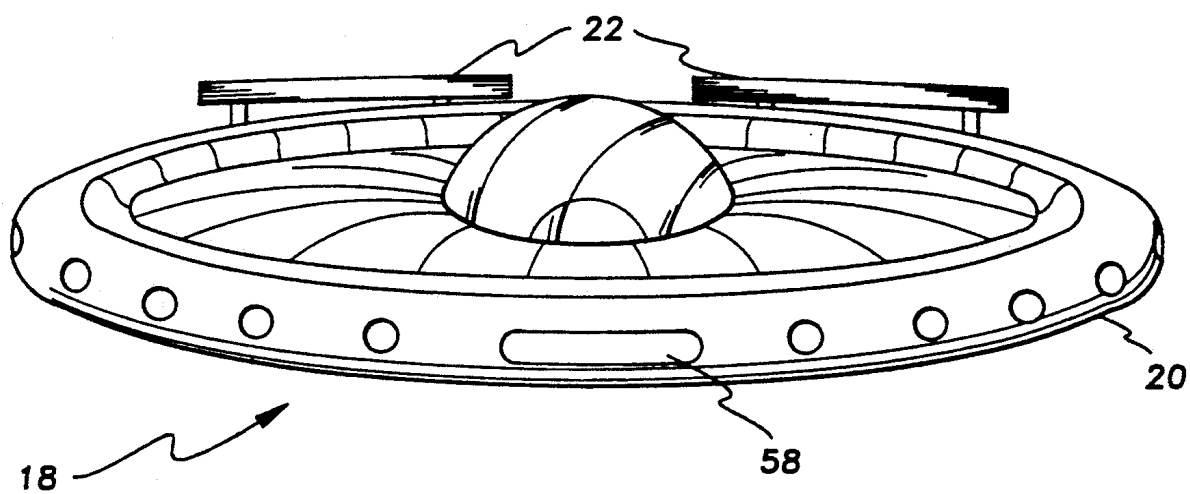


FIG. 2

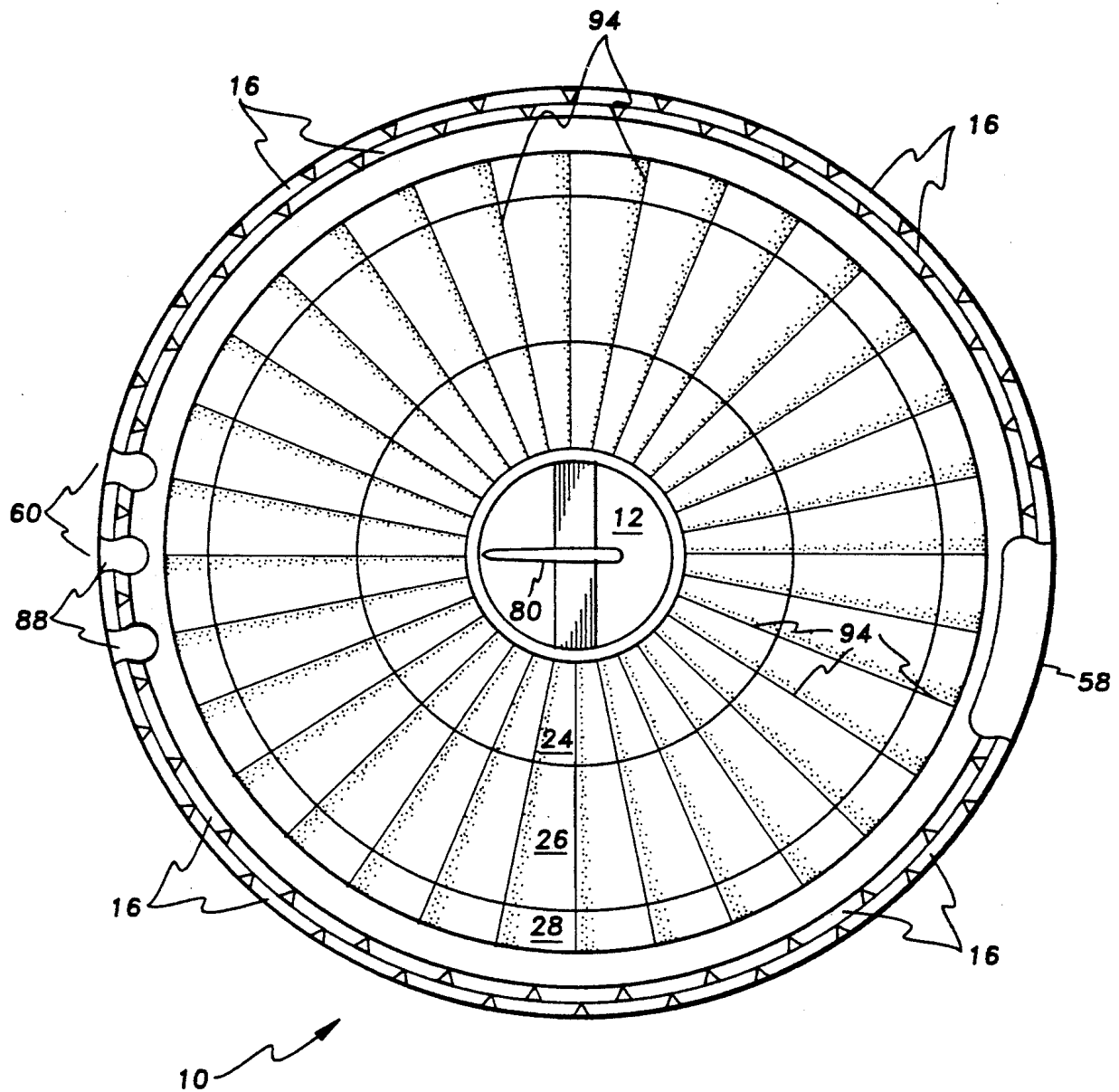


FIG. 3

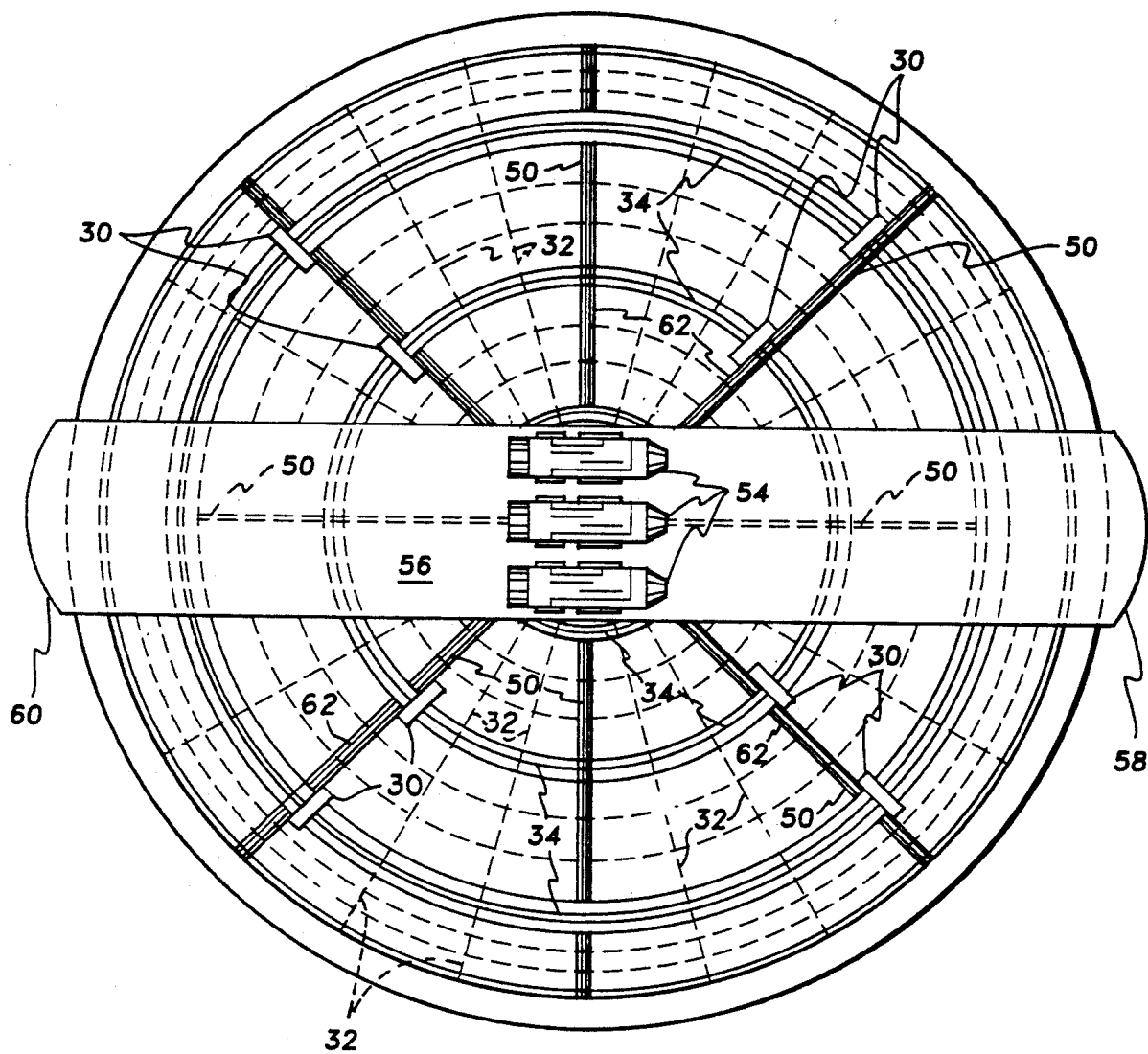
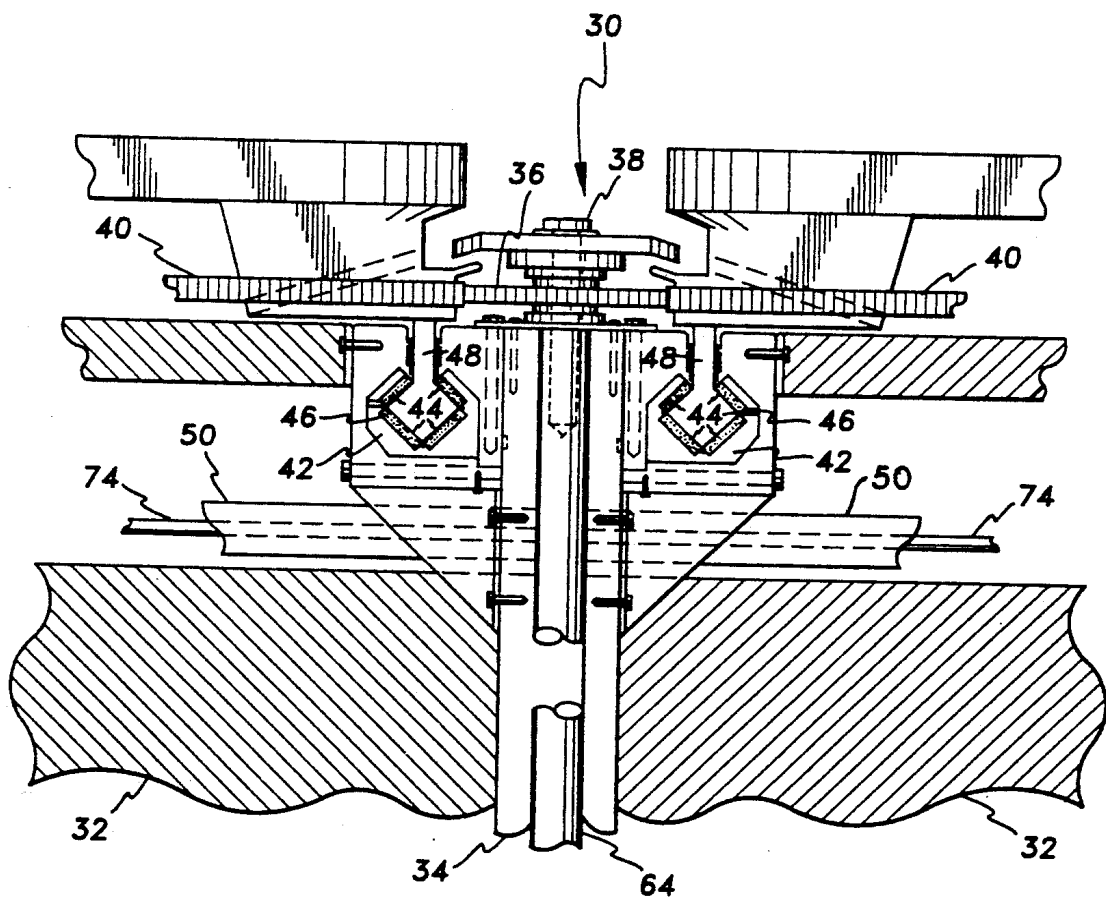
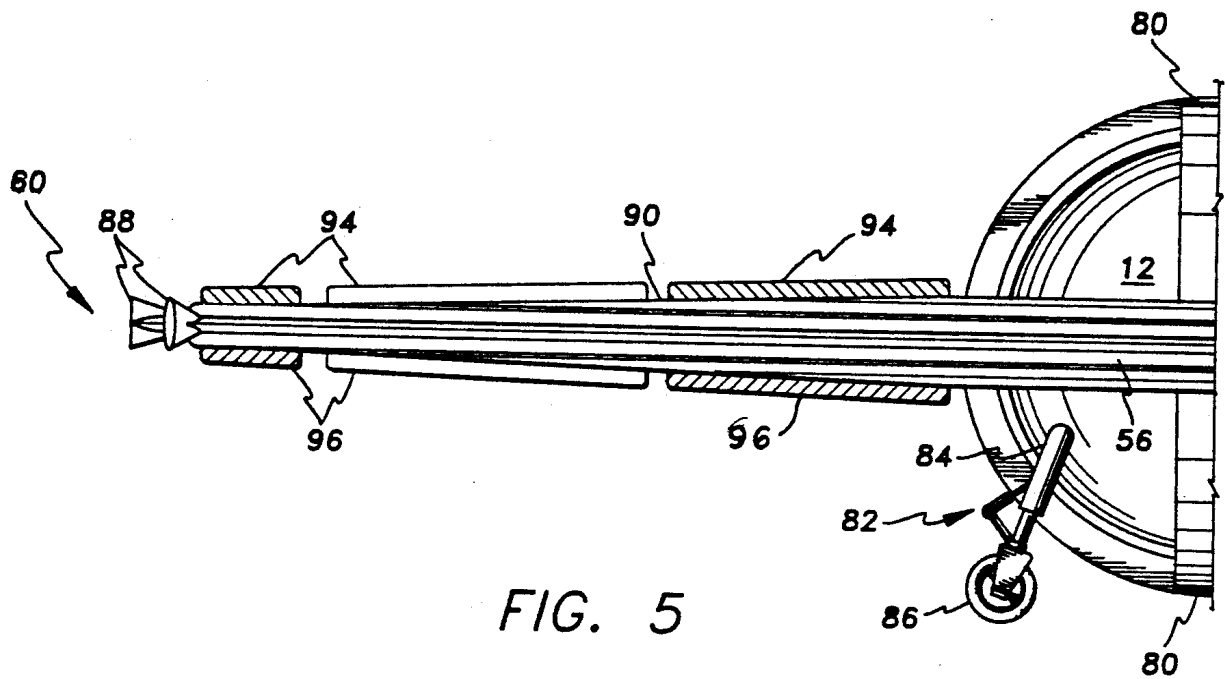


FIG. 4



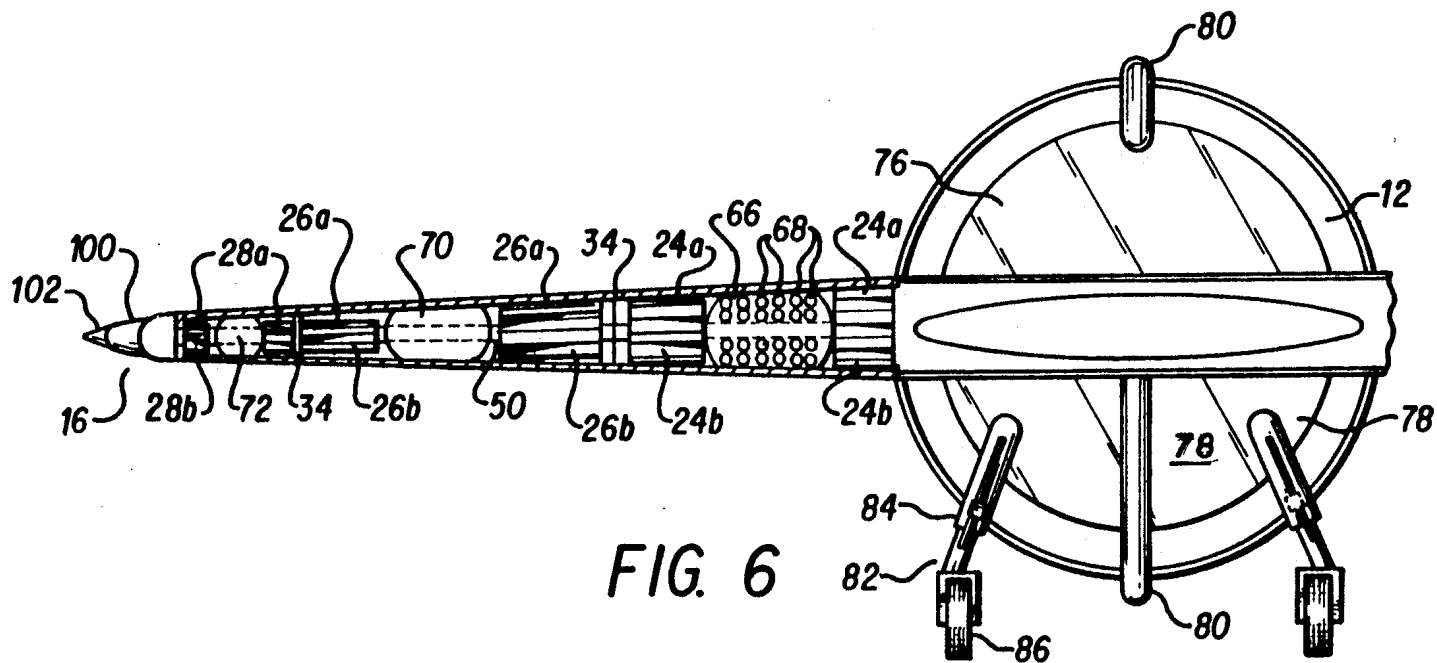


FIG. 6

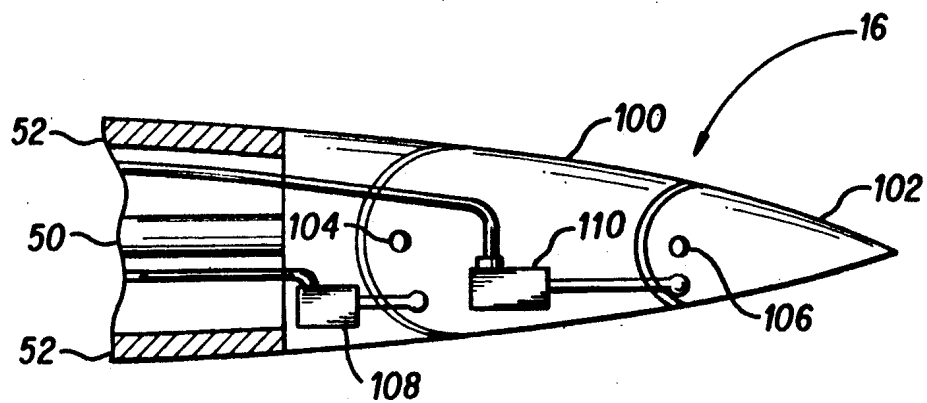


FIG. 8

DISC PLANFORM AIRCRAFT HAVING VERTICAL FLIGHT CAPABILITY

REFERENCE TO RELATED APPLICATION

This application is a continuation in part of utility patent application Ser. No. 07/395,358 filed on Aug. 17, 1989, now abandoned.

FIELD OF THE INVENTION

This invention relates generally to aircraft, and more specifically to an aircraft type having a plurality of concentric, counterrotating lifting fans or blades and the capability of vertical takeoff and landing, as well as other novel features.

BACKGROUND OF THE INVENTION

The development of heavier than air powered aircraft (i.e., airplanes, gyroplanes and helicopters) has led to a variety of different aircraft configurations, control systems, and powerplant, propeller and/or other systems and configurations. Most of these various configurations require some horizontal distance for takeoff and landing, thus restricting their use to specific airport or at least open areas not otherwise restricted. Even in the case of helicopters, where vertical takeoffs and landings are physically possible, the relative hazard due to the rapidly spinning, large diameter rotor blades generally precludes their use in any but specially designated areas, except for specialized emergency uses such as air ambulance service and the like. Moreover, the disastrous effects which would occur if a helicopter main or tail rotor blade were to strike a fixed object while taking off or landing in a confined area, result in most helicopter operations being restricted to airports just as are operations with fixed wing aircraft.

The need arises for an aircraft which is capable of vertical takeoffs and landings, while also being capable of relatively high speed flight. The aircraft lifting rotors, fans and/or blades must be completely contained within the fixed structure of the craft, in order to permit the safe operation of the craft within confined areas. In order that the craft operate efficiently at various airspeeds ranging from zero to maximum cruise or above, both aerodynamic and thrust control systems should be implemented. Torque may be eliminated by means of counterrotating lift devices, rather than anti torque tail rotors as in helicopters, thus further enhancing the safety of the craft. Finally, the craft should employ a relatively simple powerplant system which is capable of providing both thrust for horizontal flight and a lifting force for vertical flight, by means of appropriate lift fan technology.

DESCRIPTION OF THE RELATED ART

Grayson U.S. Pat. No. 2,935,275 discloses a disc shaped aircraft which contains a general powerplant and lifting fan configuration similar to a limited extent to that of the present invention. However, it does not appear that the patent to Grayson makes provision for yaw control in the craft. Other deficiencies will be noted in comparison to the disclosure of the present invention as described further below.

J. C. M. Frost et al. U.S. Pat. Nos. 3,022,963 and 3,051,417 each disclose a disc type aircraft including a peripheral control system. The control systems rely primarily on the well known Coanda effect, which may

have limited use in maneuvering a relatively large and heavy craft in all flight conditions.

P. B. Clover U.S. Pat. No. 3,243,146 discloses a vertical takeoff and landing aircraft with lifting power supplied by a single rotor or fan. Anti torque means are provided by a series of vanes within the craft which guide incoming air to the fan. The control system is completely aerodynamic (as opposed to reaction control means), but comprises generally horizontal control surfaces disposed completely within the entry air ducts of the craft. As the air mass must be contained within the respective ducts and cannot be deflected due to the duct walls, it is not seen how the control system of the Clover patent operates.

J. N. Modesti U.S. Pat. No. 3,503,573 discloses a disk shaped aircraft which is powered by rocket engines. Nearly the entire craft is spun by means of tangentially thrusting rockets, while means are provided for counterrotating the cockpit or cabin of the craft to produce a net rotational velocity which approaches zero for the cabin structure. However, no purpose for the rotation of the main portion of the craft appears to be disclosed in the Modesti patent.

J. A. Perseghetti U.S. Pat. No. 3,531,063 discloses a vertical takeoff aircraft and gyro guidance system therefor. Vertical thrust is provided by four jet engines, while the control system is by means of the gyroscopic precessional forces. Such a control system would by its nature require relatively heavy gyro assemblies, which in turn would necessitate relatively large and heavy engines to lift the weight of the craft.

U.S. Pat. Nos. 3,997,131 and 4,147,472 issued to A. Kling respectively disclose an electrically operated rotor system for aircraft and an annular shroud arrangement for rotating turbine blades.

DeSautel U.S. Pat. No. 4,214,720 discloses a disc shaped aircraft powered by sixteen jet engines arranged radially about the craft. The engines create a lifting force by directing their thrust around an annular airfoil shaped periphery. The annular periphery is also rotated, as in the patent to Modesti described above. Many of the same limitations of the Modesti patent are apparent here.

Finally, P. M. Panos U.S. Pat. No. 4,901,948 discloses a control system for a disc shaped aircraft comprising a plurality of rotatable nozzles, each of which may be rotated in its respective housing in order to direct thrust in a specific direction. This system is similar to reaction control systems known in other specialized aircraft applications, such as the Hawker Harrier aircraft series. The system bears no resemblance to the control system of the present invention.

None of the above noted patents, either singly or in combination, are seen to disclose the specific arrangement of concepts disclosed by the present invention.

SUMMARY OF THE INVENTION

By the present invention, an improved aircraft having concentric, counterrotating lifting fans and being capable of vertical flight is disclosed.

Accordingly, one of the objects of the present invention is to provide such an improved aircraft having a generally circular planform.

Another of the objects of the present invention is to provide an improved aircraft in which each of the counterrotating lifting fans or groups of counterrotating lifting fans are of equal areas.

Yet another of the objects of the present invention is to provide an improved aircraft in which the lifting fans are powered by means of turbine engines, which engines further provide thrust for horizontal flight.

Still another of the objects of the present invention is to provide an improved aircraft having an efficient and lightweight structure which combines cooperating elements which are arranged in tension and compression.

A further object of the present invention is to provide an improved aircraft having both a control system providing control at low airspeeds, and an aerodynamic control system for use at higher airspeeds.

An additional object of the present invention is to provide an improved aircraft of generally circular planform, which provides for passenger and/or cargo carriage both in a central area and further in a peripheral area of the craft.

With these and other objects in view which will more readily appear as the nature of the invention is better understood, the invention consists in the novel combination and arrangement of parts hereinafter more fully described, illustrated and claimed with reference being made to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front perspective view of the aircraft of the present invention, showing its general configuration.

FIG. 2 is a perspective view of an alternative configuration having a peripheral passenger and/or cargo compartment.

FIG. 3 is a top plan view of the craft showing the general arrangement of the lifting fans, engine intake and exhaust, central cabin area, and peripheral aerodynamic controls.

FIG. 4 is a top plan view in which the upper surface of the craft has been removed in order to more clearly show the internal structure and components.

FIG. 5 is a side view of a portion of the craft, showing additional details relating to the power system and other areas.

FIG. 6 is a front view of a portion of the craft, partially cut away, showing various internal components and systems of the lifting surface.

FIG. 7 is a view in section of the mechanism providing for the rotation of the lifting fans.

FIG. 8 is a view in section of the aerodynamic controls of the craft, showing the detail of the hinge arrangement.

Similar reference characters designate corresponding parts throughout the several figures of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, particularly FIG. 1 of the drawings, the present invention will be seen to relate to an aircraft 10 of generally circular or disc shaped planform. The embodiment of aircraft 10 shown in FIG. 1 may be seen to generally comprise a central, generally spherical compartment 12 which is surrounded by a generally circular area or lifting surface 14 which provides means for supporting the craft 10 in flight. Aerodynamic control surfaces, generally indicated as 16, are disposed around the periphery of surface 14.

FIG. 2 discloses an alternate embodiment 18 of the aircraft 10 of FIG. 1, in which the general configuration of aircraft 10 is constructed to a larger scale which enables an additional peripheral passenger or cargo

compartment 20 to replace the aerodynamic control surfaces 16 of aircraft 10. In lieu of peripheral aerodynamic control surfaces 16, separate trailing control surfaces 22 are used near the rear of craft 18 as shown in FIG. 2. Most of the remaining systems of the two embodiments 10 and 18 are common to the two aircraft, differing only in scale and various details as required by the structure of each aircraft 10 and 18. These remaining systems will be discussed in detail below in a discussion of the elements of the remaining figures.

FIG. 3 discloses a plan view of the aircraft 10 shown in FIG. 1. Before discussing in detail the arrangement shown in FIG. 3, it is important to note that the control of torque reactions in vertical flight aircraft is of critical importance. In this respect, the aircraft 10 and 18 of FIGS. 1 and 2 respectively have some common ground with helicopters. As the rotor of a helicopter rotates and develops a lifting force, a horizontal drag force will also be developed. Assuming that the helicopter is clear of the surface, and thus is free to move or rotate about any axis, the helicopter itself will tend to rotate in a direction opposite that of the direction of rotation of the main rotor.

Various solutions have been developed to overcome this torque reaction, the most common being an anti torque rotor installed on the tail of the helicopter. Multiple main rotor systems rotating in opposite directions are also seen in larger helicopters, the torque reaction of the two counterrotating main rotors thus canceling out. In any case, some provision must be made for the cancellation of torque reaction in aircraft capable of vertical flight, which obviously involves at least some flight at airspeeds too low for conventional aerodynamic controls to be effective.

The aircraft of embodiments 10 and 18, as shown in FIGS. 1 and 2 respectively, respond to this problem by means of a plurality of counterrotating lifting fan sets, designated as 24, 26 and 28 in FIG. 3. These fan sets 24, 26 and 28 each appear as a single fan in the top view shown in FIG. 3, but the cross sectional view of FIG. 6 discloses each fan set 24, 26 and 28 to comprise respectively an upper fan 24a, 26a, and 28a, and lower fan 24b, 26b and 28b. While three lifting fan sets, comprised of an inner lift fan set 24, central lift fan set 26, and outer lift fan set 28, are shown in FIG. 3, it will be understood that virtually any number of fans more than one could be constructed in this manner and caused to rotate in opposite directions in order to cancel any torque reaction. The critical point is that the mass and velocity of air moved by the fan or fans rotating in one direction must be very nearly the same as the mass and velocity of air moved by the fan or fans rotating in the opposite direction. If the air mass and velocity moved by each set of counterrotating fans is essentially equal, by definition the resulting lift force will be essentially equal and therefore the resulting drag force will also be essentially equal and any torque reaction will be all but canceled.

This is basically accomplished in the present invention by making the areas of each set of counterrotating fans equal. In other words, the areas of inner fan set 24 and outer fan set 28, which rotate in one direction, when added together are equal in area to that of central fan set 26 which rotates in a direction opposite to that of inner and outer fan sets 24 and 28. While other factors are of course involved in the amount of lift produced by a given lift fan set 24, 26, or 28, such as the blade pitch and therefore angle of attack, as well as rotational

speed, these factors may be adjusted accordingly in the construction of aircraft 10 or 18.

One means of accomplishing such adjustment is by means of the gearing used to drive lift fan sets 24 through 28, as shown more clearly in FIG. 7. By adjusting the gear ratio as desired, rotational speed of any one of the fan sets 24 through 28 may be adjusted accordingly, thus serving to equalize the lifting force and corresponding torque developed by any one of the fan sets 24 through 28. Alternatively, one set of fans 24, 26 or 28 may be equipped with variable pitch blades, not shown, and adjusted by means of controls in the cabin 12 of the aircraft 10 or 18 as is well known in the helicopter art. Only one set of fans 24, 26 or 28 need be so equipped, as when the pitch is adjusted on any one set of fan blades, the lift and therefore drag and torque may be made to be either greater than, equal to, or less than any other fan or set of fans.

The cross sectional view of FIG. 6 more clearly shows the vertical arrangement of the lifting fans 24a and b, 26a and b, and 28a and b, as well as other interior structural components described further below. In FIG. 6, the upper fans 24a, 26a, and 28a and lower fans 24b, 26b, and 28b may be seen. It will be noted that the blades of both upper and lower inner fans 24a and 24b are angled or pitched in the same relative direction, as they are both geared together and turn in the same direction. In a like manner, upper and lower central fans 26a and 26b are both geared together and revolve in the same direction relative to one another, although that direction of rotation is opposite that of inner fan set 24 and outer fan set 28. Similarly, upper and lower outer fans 28a and 28b are geared together in order to revolve in the same direction relative to one another and relative to inner fan set 24, while opposite the rotational direction of central fan set 26.

FIG. 7 discloses details of the drive mechanism 30 for fan sets 24, 26 and 28. It will be understood that FIG. 7 shows only the fan drive mechanism 30 for an upper set of lift fans 24a, 26a, or 28a, but that the drive mechanism for lower lift fans is essentially a mirror image in the vertical of the fan drive mechanism 30 shown in FIG. 7. Adjacent upper and lower drive mechanisms 30 each receive power input by means of a vertical shaft 64, which shafts 64 receive power from cooperating power output shafts 62 further described below.

It will also be seen that FIG. 7 discloses an essentially symmetrical arrangement, as would be required for the fan drive mechanism between adjacent lifting fan sets 24 and 26 or 26 and 28. Four fan drive mechanisms 30 are installed between upper inner lifting fan 24a and upper central lifting fan 26a, at locations 45 degrees from the longitudinal and lateral axes of aircraft 10 as shown in FIG. 4. In a like manner, an additional four fan drive mechanisms are positioned between upper central lift fan 26a and upper outer lift fan 28a, for a total of eight fan drive mechanisms 30 to drive the upper lift fans 24a, 26a and 28a. A symmetrical arrangement of eight more drive mechanisms 30 are located within the lower portion of lifting surface 14 immediately below mechanisms 30 which drive upper fans 24a, 26a, and 28a, to drive the lower lift fans 24b, 26b and 28b. Thus, there are a total of sixteen lift fan drive mechanisms 30 to drive lift fan sets 24, 26 and 28 in the aircraft configuration generally described in this specification.

Support webs 32 provide for the attachment and securing of each fan drive mechanism 30 within lifting surface 14; many of these structural components may

also be seen in FIG. 4. Support webs 32 extend radially outward from the central vertical axis of aircraft 10. For additional support, vertical circumferential walls 34 are located between inner and central fan sets 24 and 26 and between central and outer fan sets 26 and 28. The joint formed at the juncture of radial support webs 32 and circumferential walls 34 at the locations of drive mechanisms 30 provide the required structural strength for the installation of those drive mechanisms 30.

Each drive mechanism 30 is comprised of a pinion gear 36 which is secured to circumferential wall 34 by means of a bolt 38 or other suitable securing means. Pinion gear 36 in turn drives lift fan ring gears 40, which are secured to the adjacent peripheries of related lift fans 24a and b, 26a and b, and 28a and b.

Support bearings 42 are provided at the periphery of each lift fan 24a and b, 26a and b, and 28a and b. Bearings 42 may be formed in an angular rectangular or diamond pattern, as shown, or in some other suitable form. In any case, bearings 42 must contain and provide support for lift fans 24a and b, 26a and b, and 28a and b throughout any anticipated conditions which might induce a load upon bearings 42, hence the system of roller bearings 44 comprising each support bearing 42 which generally surround annular lift fan guides 46 in order to prevent the movement of such guides 46, and the fans 24a and b, 26a and b, and 28a and b to which guides 46 are attached by means of annular fan guide attachments 48, in any but a horizontal plane of rotation about the vertical axis of aircraft 10.

Further structural details of aircraft 10 may be seen in FIGS. 4 and 6. It is generally recognized that one of the strongest and lightest structural arrangements for a circular structure is a combination of support elements in tension and compression; this is the general arrangement used in the structure of aircraft 10. A plurality of radial compression ribs 50 in the central horizontal plane of aircraft 10 are positioned each 45 degrees around the vertical axis of aircraft 10. Each of these compression ribs 50 is of a generally tubular form with a hollow interior in order to provide for the containment of electrical wiring, hydraulic, fuel and other lines, etc. Additional rigidity of the structure is provided by upper and lower radial tension spokes 52, which lie in the same vertical planes as compression ribs 50. Each of these elements 50 and 52 is secured to the circumferential walls 34, support webs 32 and other structure as required to form a sturdy and rigid but relatively light-weight structure.

Power for aircraft 10 is supplied by one or more turbine or other suitable engines 54. In the preferred embodiment disclosed herein, three turboshaft engines 54 are located near the center of aircraft 10 as indicated in FIG. 4. A surrounding housing 56 within the center of aircraft 10 contains engines 54 and extends forward to an intake 58 and rearward to an exhaust outlet 60. While FIG. 4 discloses the general arrangement of the above power system, it is understood that structural and other components, such as central compartment 12 and some radial compression and tension ribs 50 and 52, will also be located in the immediate area occupied by engines 54 and housing 56. These components have generally been deleted from the engine housing 56 and intake and exhaust areas 58 and 60 in FIG. 4 for greater clarity.

At least one engine 54 is mechanically coupled to each of the drive mechanisms 30 by means of reduction gearing or a transmission, not shown, similar to that known in the art of helicopter turbine powerplants and

reduction gearing or transmissions for driving the rotor blades of such helicopters. A plurality of power output shafts 62 extend from such a turboshaft transmission to drive each of the lift fan drive mechanisms 30 discussed above. Output shafts 62 are each contained within a radial compression rib 50, and provide for transmission of power from engines 54 and other transmission means, to vertical shafts 64 and thence to each of the drive mechanisms 30.

Radial compression ribs 50 may also contain additional wiring, conduits, etc. for the transmission of electrical, hydraulic, and other energy or fluids, as noted above. For example, FIG. 6 discloses a coolant reservoir or system 66 comprising a plurality of coils or tubes 68, a fuel storage tank 70, and oil storage tank 72. It will be understood that each of these tanks or reservoirs 66, 70 and 72 are of generally concentric annular form, passing completely around the center of craft 10 to form a series of generally ring shaped reservoirs or tanks 66, 70 and 72. FIG. 6 discloses these tanks 66, 70 and 72 as a cross section through the interior of lifting surface 14. Tubular compression ribs 50 provide space for the passage of the various fluid lines from these tanks or reservoirs 66, 70 and 72 to the appropriate locations, such as oil line 74 to fan support bearings 42 as shown in FIG. 7.

Engine and flight controls for these various systems are conventionally located within central compartment 12, which provides space for a flight crew as well as some passengers and/or cargo. Central compartment 12 comprises an upper portion 76 and a lower portion 78 and is generally surrounded by a combination safety or rollover structure and aerodynamic surface 80. The lower portion 78 of central compartment 12 provides space for the retraction mechanism and retracted storage of landing gear 82, as well as space for additional components and/or payload. Landing gear 82 is comprised of a plurality of individual landing gear struts 84, each of which may be equipped with conventional tires 86 or other supportive means. It will be appreciated that due to the vertical takeoff and landing capability of aircraft 10, tires 86 or other means permitting aircraft 10 to move horizontally along a surface are not necessarily required. A simpler and lighter footpad or other suitable means, not shown, may also be installed at the lower end of each strut 84, as desired.

Aircraft 10 may be operated by an appropriately trained flight crew by starting the engines 54 and engaging and operating the appropriate engine and flight controls. One or more of the engines 54 will drive upper and lower lifting fans 24, 26 and 28 by means of drive mechanisms 30 and power output shafts 62, as described above. Due to the equal areas of the counterrotating lift fans, little or no torque reaction will occur. By increasing the speed of upper and lower lift fans 24, 26 and 28, sufficient vertical thrust may be achieved to overcome the weight of aircraft 10 and any additional load aboard, and vertical flight will occur.

It will be evident that at very low or zero airspeed, conventional aerodynamic flight controls will not be operable. Aircraft 10 provides for controllability at such very low airspeeds by means of a cyclic pitch control system in which the pitch of at least one set of lift fan blades 24, 26 or 28 may be varied over some portion of their rotational arc in order to increase or reduce the lifting force in some area of the lifting surface 14 and thus maintain control. It is envisioned that this cyclic pitch control be along similar lines to that

already well known and used for the cyclic control of helicopter rotor blades.

The present aircraft 10 provides for a plurality of engines 54, one or more of which may be used for the transmission of power to upper and lower lift fan blades 24, 26 and 28 as described above. The remaining engines are provided for the purpose of forward thrust for horizontal flight, as provided by engine housing 56 and exhaust outlet 60 as shown in FIG. 4 and 5. Exhaust outlet 60 may be equipped with thrust vectoring nozzles 88 for further control of aircraft 10.

It will be appreciated that as the appropriate flight controls are manipulated to translate aircraft 10 from vertical to horizontal flight, that airflow over lifting surface 14 may be utilized for the production of dynamic lift. This is advantageous, as less energy is thus required by the engine or engines 54 used to provide power for lift fans 24, 26 and 28. However, in order to provide for such dynamic lift over surface 14, the upper and lower surfaces 90 and 92 must be closed in order to prevent airflow from the relatively high pressure beneath lower surface 92 through lifting surface 14, to the relatively low pressure above upper surface 90 which will naturally occur as a result of the production of dynamic lift. This is accomplished by means of upper and lower vanes 94 and 96 as shown in FIG. 5, which may be actuated by means of pilot operable controls within the central compartment 12. Thus, as translation is made from vertical to horizontal flight, power to lift fans 24, 26 and 28 may be gradually reduced and upper and lower vanes 94 and 96 may be gradually closed to present a uniform, unbroken surface to such horizontal airflow as will occur in horizontal flight in order to produce dynamic lift over the airfoil shape of lifting surface 14.

It will be appreciated that the equal areas of counter-rotating lift fans 24, 26 and 28 may not provide for precisely balanced thrust levels, and that accordingly there may be some slight net torque reaction which will tend to cause aircraft 10 to yaw or rotate about its vertical axis while hovering or operating at very low airspeeds. Upper and lower vanes 94 and 96 may be further utilized during this portion of flight by partial deflection, thus causing some sideward reaction of the air exiting the lower lift surface 92 and thereby producing such antitorque thrust as may be required. As greater airspeed is gained, such torque reactions will be reduced as power is reduced to lift fans 24, 26 and 28 and the lift necessary to support aircraft 10 in flight is provided by aerodynamic means by lifting surface 14 as described above.

At airspeeds conducive to aerodynamic lift, it will be appreciated that aerodynamic control means will prove more desirable than the reaction control provided by the deflection of upper and lower vanes 94 and 96. Thus, aerodynamic control is provided by means of peripheral flaps 98. It is to be understood that as aircraft 10 is not by any means a conventional aircraft, some of the terms used in this specification do not necessarily directly relate to those used in conventional aircraft. In this instance, the term "flap" as used with conventional aircraft is generally accepted to mean an aerodynamic device located on the trailing edge of a wing, which device may be deflected downward for the purpose of increasing the lift coefficient of the wing. In the case of aircraft 10 of the present specification, the term "flap" is used to describe a peripheral aerodynamic control surface which may be deflected either upward or down-

ward to alter the lift coefficient of lifting surface 14. Flaps 98 may be deflected in unison, or deflected around only a portion of the periphery of lifting surface 14, to increase or decrease the lift coefficient of that portion of lifting surface 14 to which they are applied. 5

Peripheral flaps 98 are preferably comprised of an inner portion 100 and an outer portion 102, shown in greater detail in FIG. 8. By providing a double flap arrangement some greater efficiency is achieved, although it will be apparent to those skilled in the art that alternative arrangements may be acceptable. Inner flap 100 is secured to the periphery of lifting surface 14 at inner hinge 104, while outer flap 102 is attached to inner flap 100 by means of outer hinge 106. Inner and outer flaps 100 and 102 may be respectively actuated by hydraulic actuators 108 and 110, or by other suitable alternative means. 10

As forward speed is gained as described above, landing gear 82 may be retracted within the lower portion 78 of central compartment 12 and the aircraft 10 operated as described above and controlled and maneuvered by means of peripheral flaps 98. When slower forward speed is desired, as in approaching for a landing, the above described procedures may be essentially reversed in order to exchange the aerodynamic lift provided by lifting surface 12, for the lift provided by lifting fans 24, 26 and 28. Landing gear 82 may be extended, and aircraft 10 may be caused to descend essentially vertically and landed at any suitable location of sufficient size to contain the span of lifting surface 14. 15

The embodiment disclosed in FIG. 2, showing an aircraft 18 with an additional peripheral passenger or cargo compartment 20 may be operated in much the same manner as aircraft 10 described above, with the exception of the peripheral flight controls or flaps 98. In lieu of peripheral flaps 98, rearward flight controls 22 are provided when aircraft 18 has gained sufficient forward speed for their use. Flight controls 22 may be operated hydraulically as generally described above and known in the art, or by other suitable means. It will be apparent from the foregoing that aircraft 18 may be maneuvered and operated in flight in much the same manner as that described in detail for aircraft 10, including vertical maneuvering for achieving takeoffs and landings in a limited area. 20

It is to be understood that the present invention is not limited to the sole embodiment described above, but encompasses any and all embodiments within the scope of the following claims. 25

I claim:

1. A disc planform aircraft having vertical flight capability, said aircraft having a plurality of concentric lifting fan blade sets positioned around a central cabin area and an upper and a lower surface respectively containing upper and lower lifting fans, said fan blade sets comprising a first set and a second set, said first fan blade set comprises upper and lower inner lift fans and upper and lower outer lift fans and said second fan blade set comprises an upper and lower central lift fan, said first set and said second set having equal projected horizontal areas and rotating in opposite directions to one another, at least one engine providing power for said aircraft, 30

at least one of said at least one engine providing power for the operation of said fan blade sets, and means providing power transmission from said at least one of said at least one engine to said fan blade sets.

2. The aircraft of claim 1 wherein; each said first and said second lifting fan blade set includes a plurality of upper and lower lifting fan blades.
3. The aircraft of claim 1 wherein; said engine include one said engine providing power for said lifting fan blade sets.
4. The aircraft of claim 3 including; two additional engines providing power for horizontal flight.
5. The aircraft of claim 1 including; peripheral aerodynamic control means providing for control of said aircraft in flight.
6. The aircraft of claim 5 wherein; said peripheral aerodynamic control means comprise a plurality of first and second control surfaces, said first control surfaces each having an inner edge and an outer edge, each said first control surface inner edge hingedly attached to the periphery of said aircraft, said second control surfaces each having an inner and an outer edge, each said second control surface inner edge hingedly attached to a said first control surface outer edge.
7. The aircraft of claim 1 including; a structure comprised of a plurality of horizontal radial members in compression in combination with a plurality of upper and lower radial members in tension.
8. The aircraft of claim 7 wherein; said radial compression members are hollow.
9. The aircraft of claim 1 wherein; said power transmission means comprise a plurality of radial transmission shafts from said engine providing said fan blade power to a plurality of fan drive mechanisms, and said fan drive mechanisms providing power to said lift fan blades.
10. The aircraft of claim 9 wherein; said lift fan blades each have a peripheral annular fan guide extending vertically therefrom, each said fan drive mechanism including a plurality of bearing means, said bearing means providing for the containment of said annular fan guides and associated operative forces.
11. The aircraft of claim 9 wherein; said radial transmission shafts are contained within said radial compression members.
12. The aircraft of claim 1 including; a peripheral cabin area providing space for the carriage of payload.
13. The aircraft of claim 12 including; aerodynamic controls rearwardly located on said aircraft.
14. The aircraft of claim 1 wherein; said upper and lower surfaces each include a plurality of vane means, said vane means providing openings for the passage of air therethrough.
15. The aircraft of claim 14 wherein; said openings of said vane means are controllably variable. 35

* * * * *



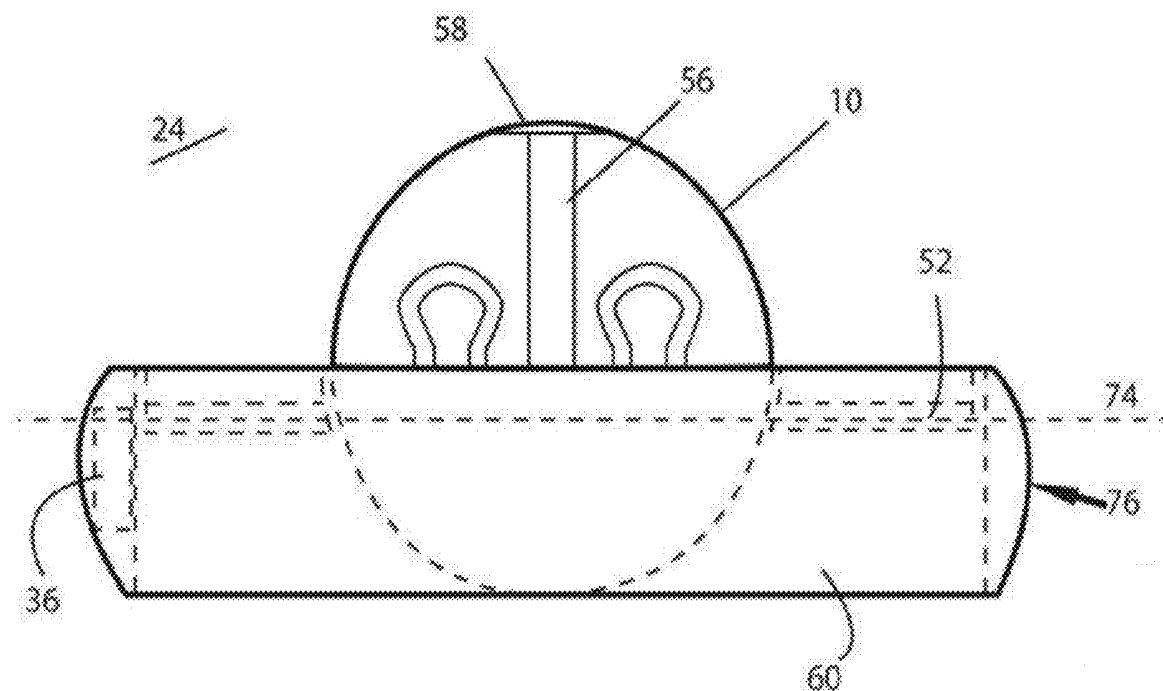
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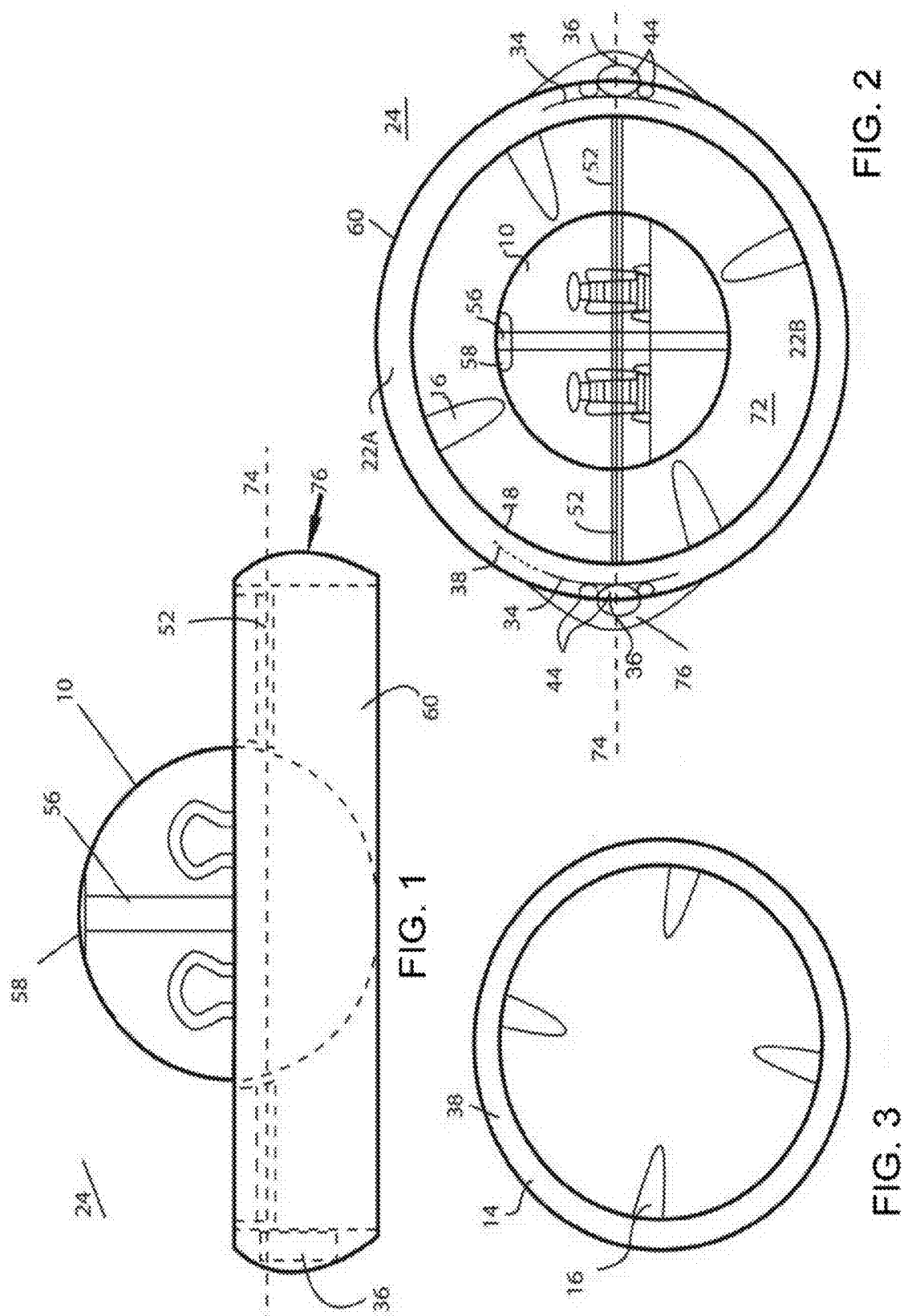
(19) **United States**(12) **Patent Application Publication**
RANDALL(10) **Pub. No.: US 2020/0062385 A1**(43) **Pub. Date: Feb. 27, 2020**(54) **AIRCRAFT HAVING VTOL,
TRANSLATIONAL AND TRAVERSE FLIGHT**

(60) Provisional application No. 60/941,965, filed on Jun. 5, 2007.

(71) Applicant: **AMERICAN AVIATION
TECHNOLOGIES, LLC**, Boynton
Beach, FL (US)**Publication Classification**(51) **Int. Cl.**
B64C 29/02 (2006.01)
B64C 39/06 (2006.01)(72) Inventor: **RUSSELL RANDALL**, LAND O
LAKES, FL (US)(52) **U.S. Cl.**
CPC **B64C 29/02** (2013.01); **B64C 39/062**
(2013.01)(21) Appl. No.: **16/659,265**(22) Filed: **Oct. 21, 2019****Related U.S. Application Data**(63) Continuation of application No. 16/185,119, filed on
Nov. 9, 2018, now Pat. No. 10,450,063, which is a
continuation-in-part of application No. 12/157,180,
filed on Jun. 5, 2008, now abandoned.(57) **ABSTRACT**

An aircraft capable of Vertical Take-Off and Landing (VTOL) and traverse flight. The aircraft generally includes a fixed outer structure including at least a generally cylindrical wing having an internal body situated within the fixed outer structure. A space is defined between the internal body and the fixed outer structure. Within this space are one or more rotatable ring impellers that create(s) thrust sufficient to achieve lift for the aircraft.





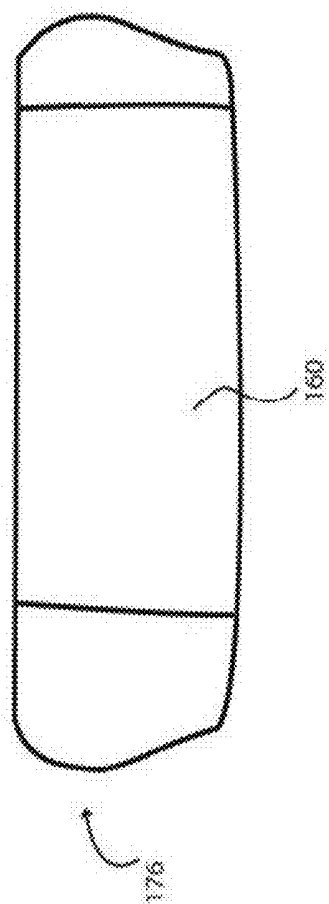


FIG. 4

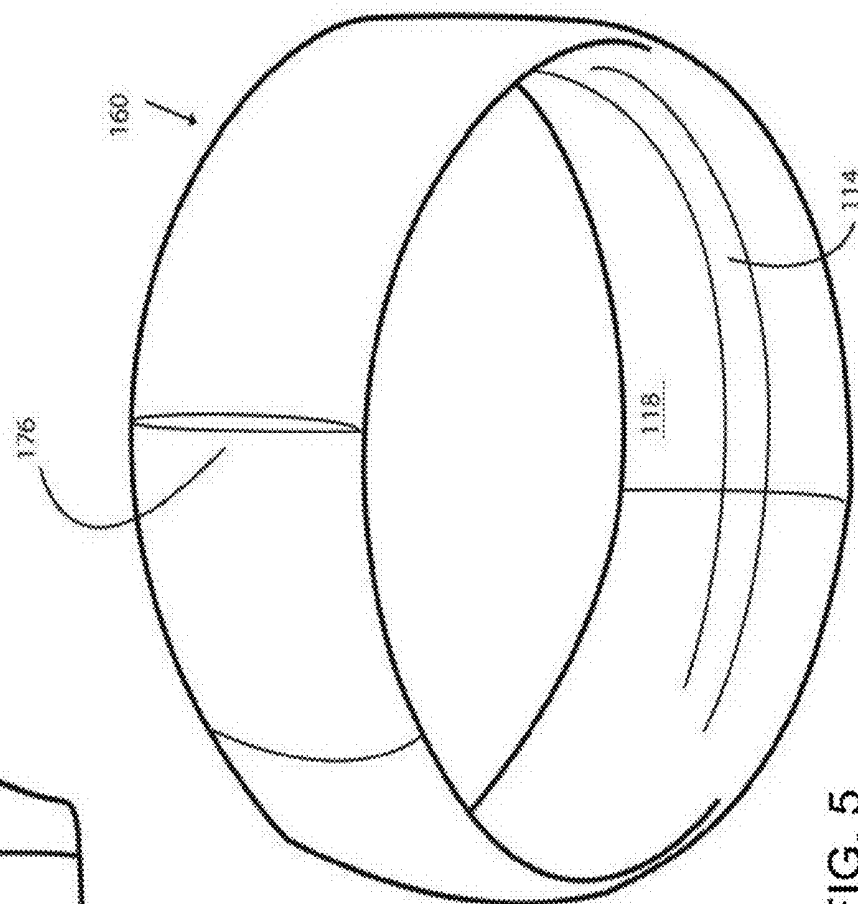


FIG. 5

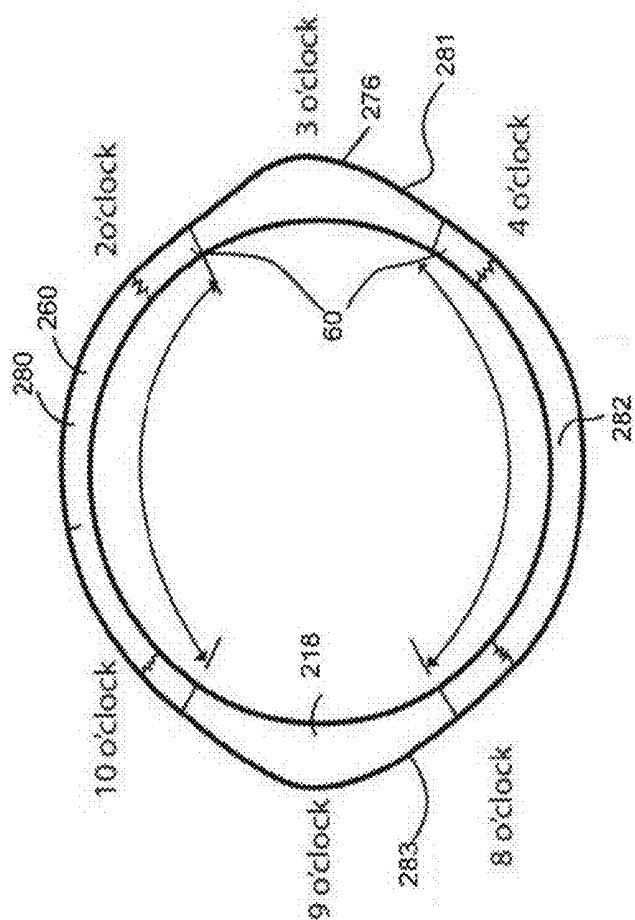


FIG. 6

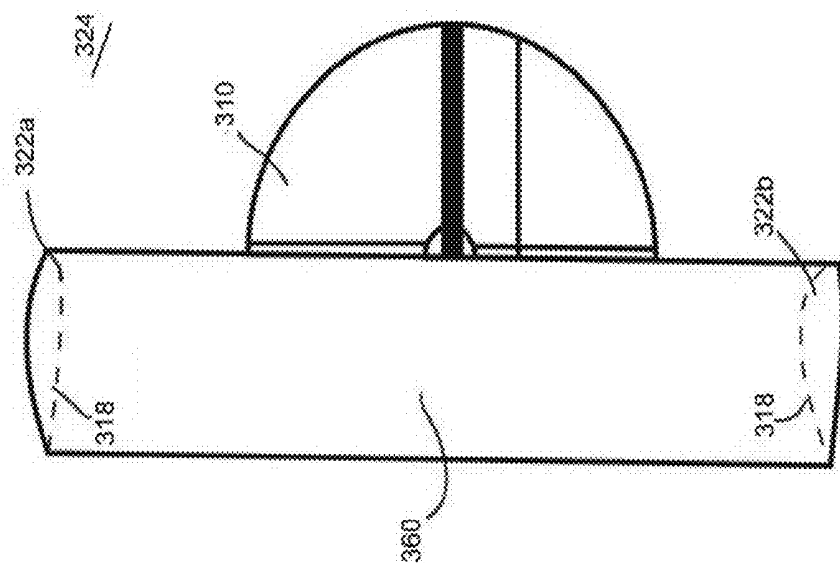


FIG. 7

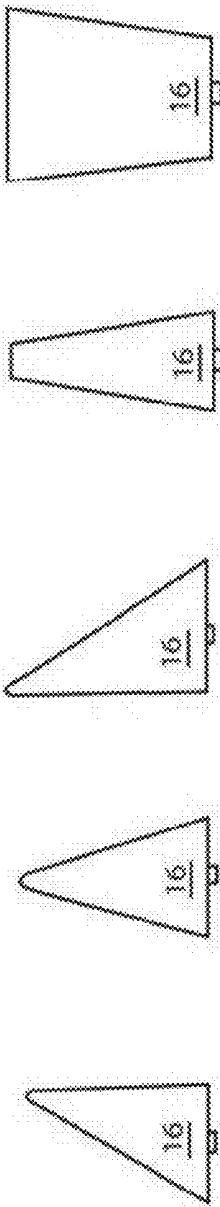


FIG. 8A

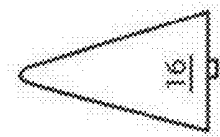


FIG. 8B

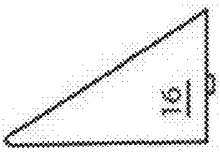


FIG. 8C



FIG. 8D

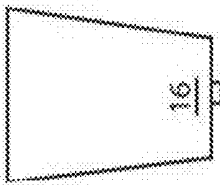


FIG. 8E



FIG. 8F



FIG. 8G

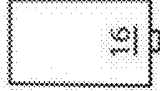


FIG. 8H



FIG. 8I



FIG. 8J



FIG. 8K

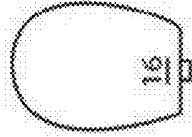


FIG. 8L



FIG. 8M

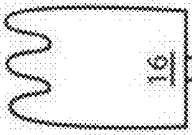


FIG. 8N

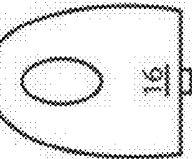


FIG. 8O

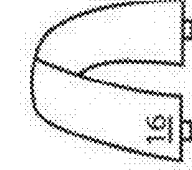


FIG. 8P

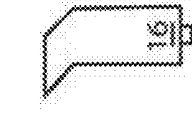
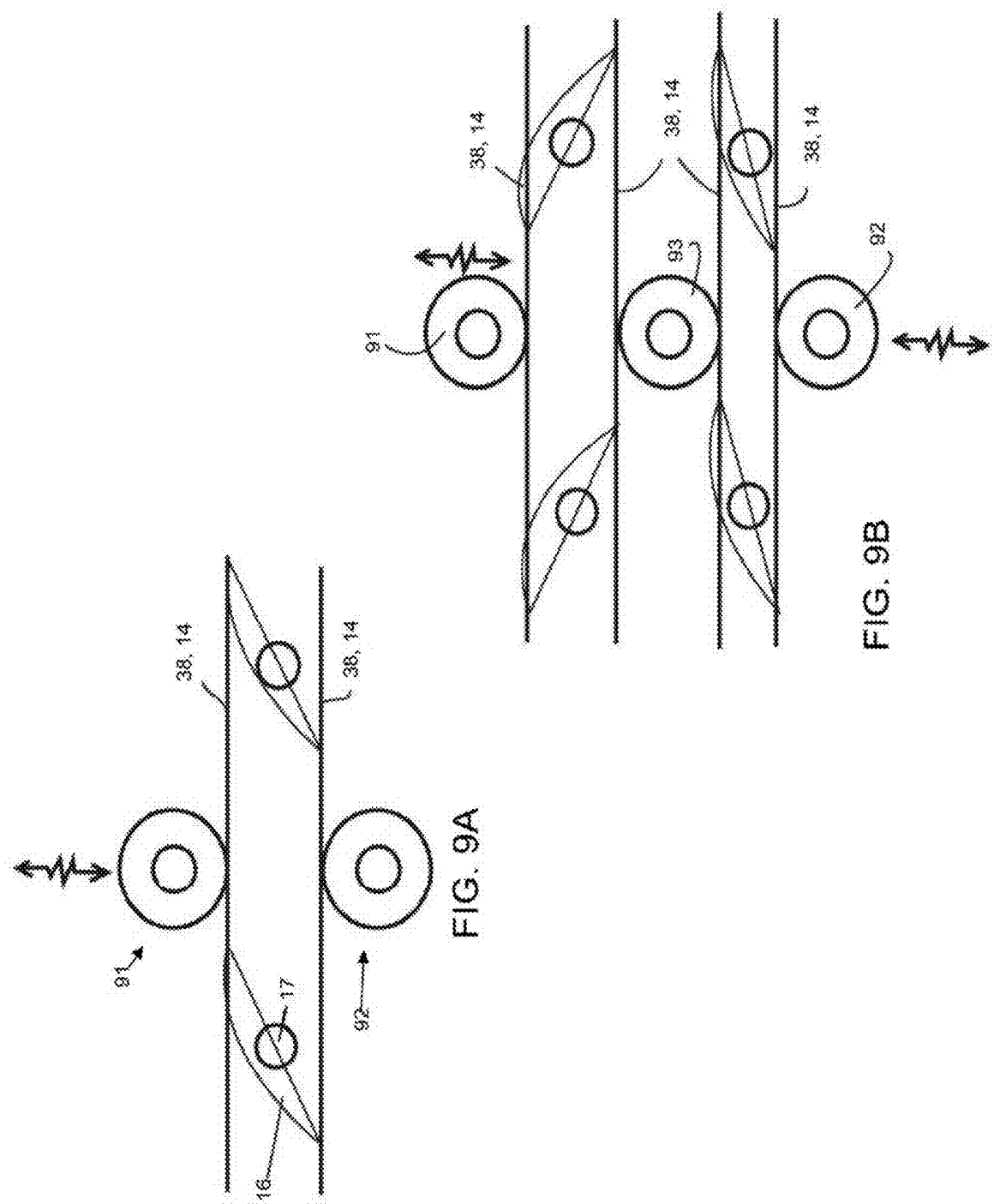
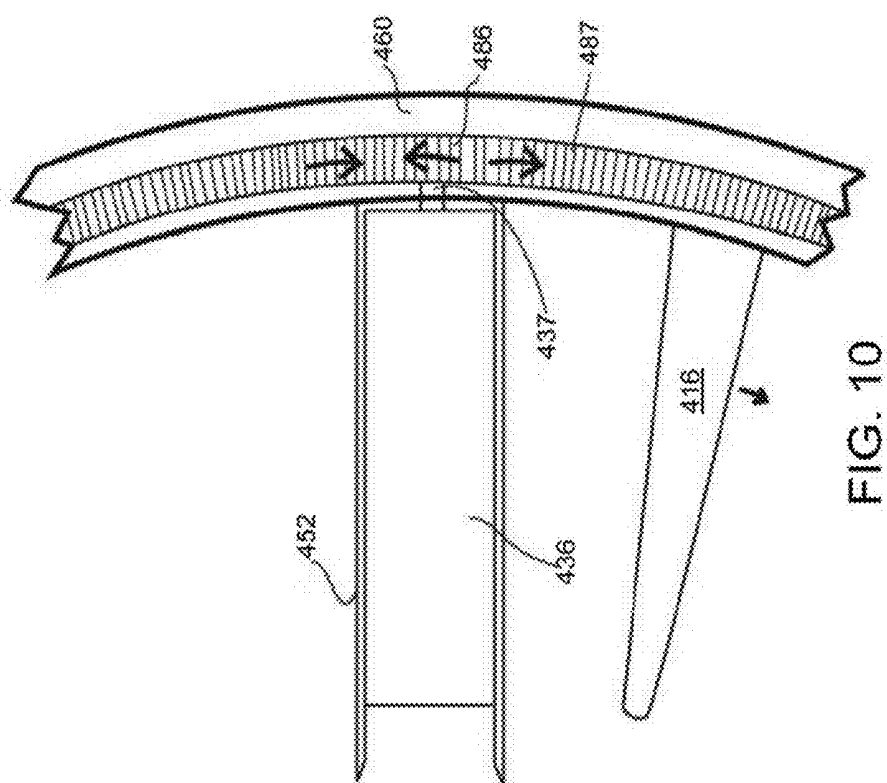
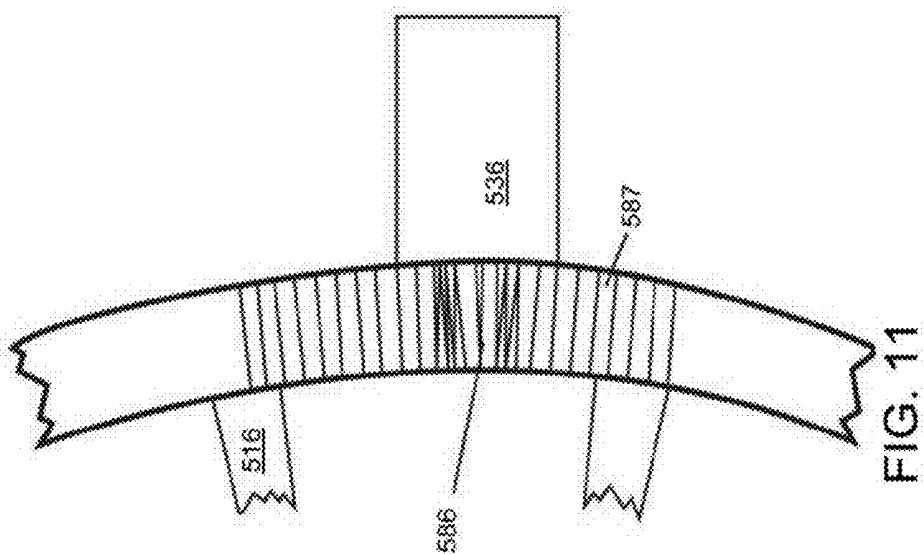
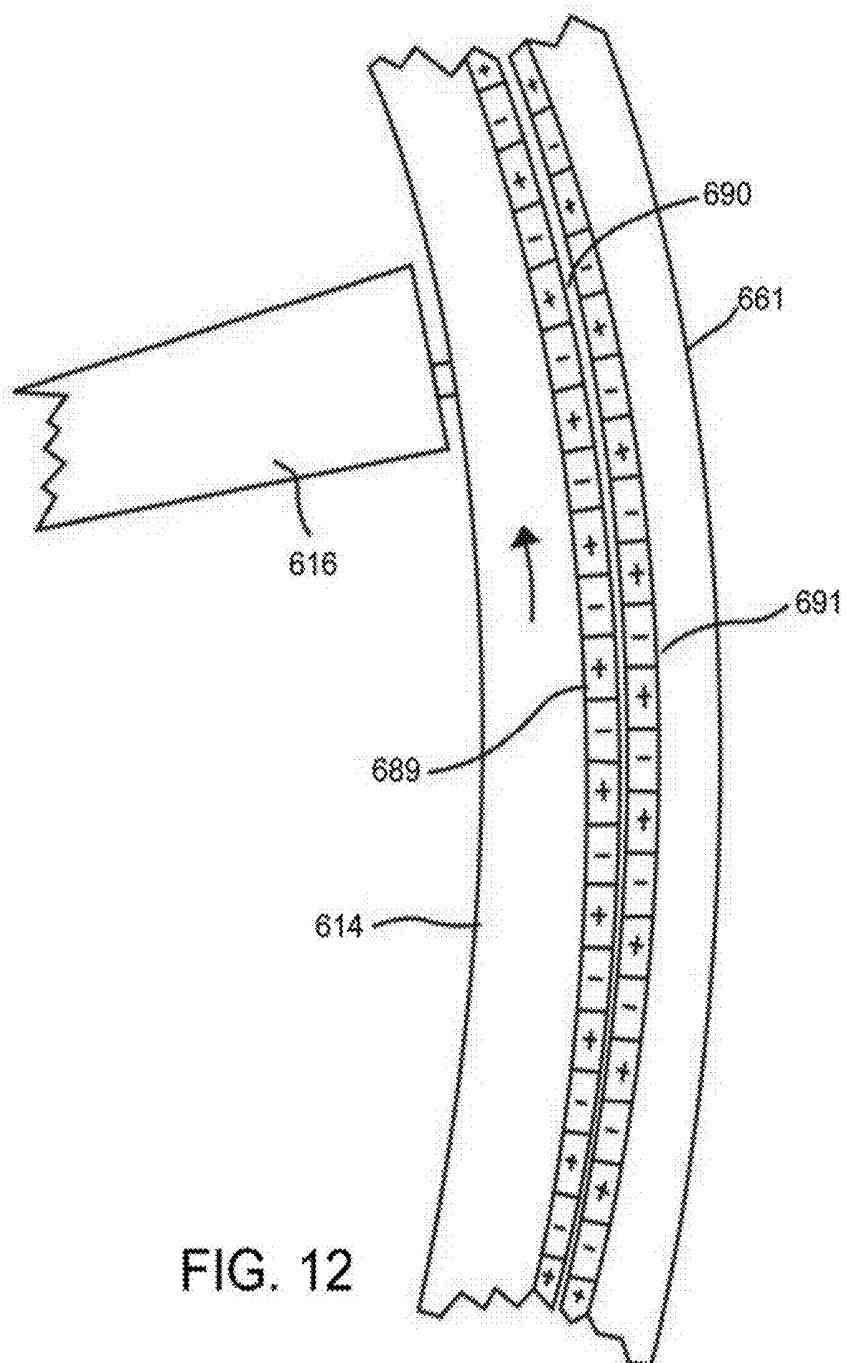


FIG. 8Q







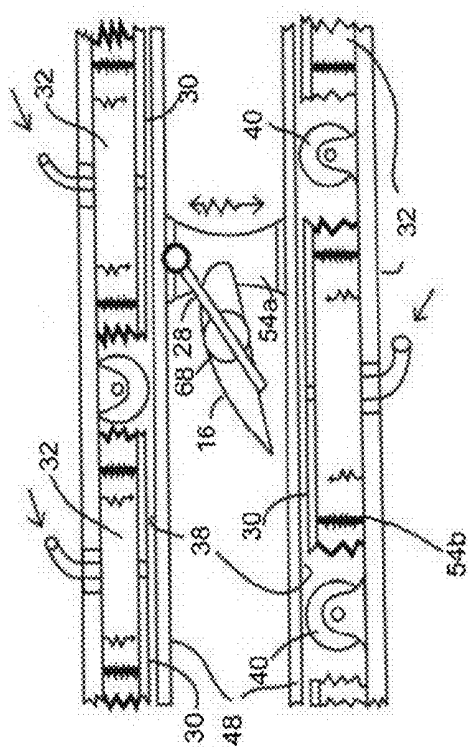


FIG. 13

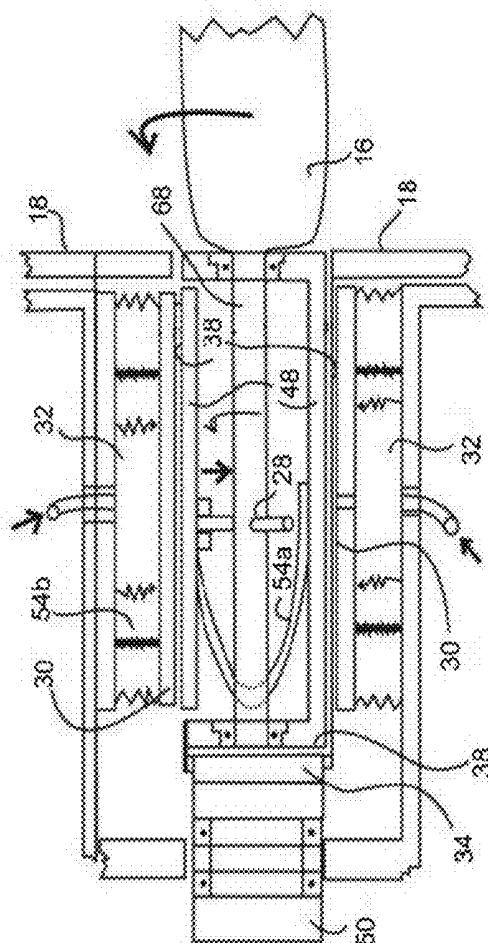


FIG. 14

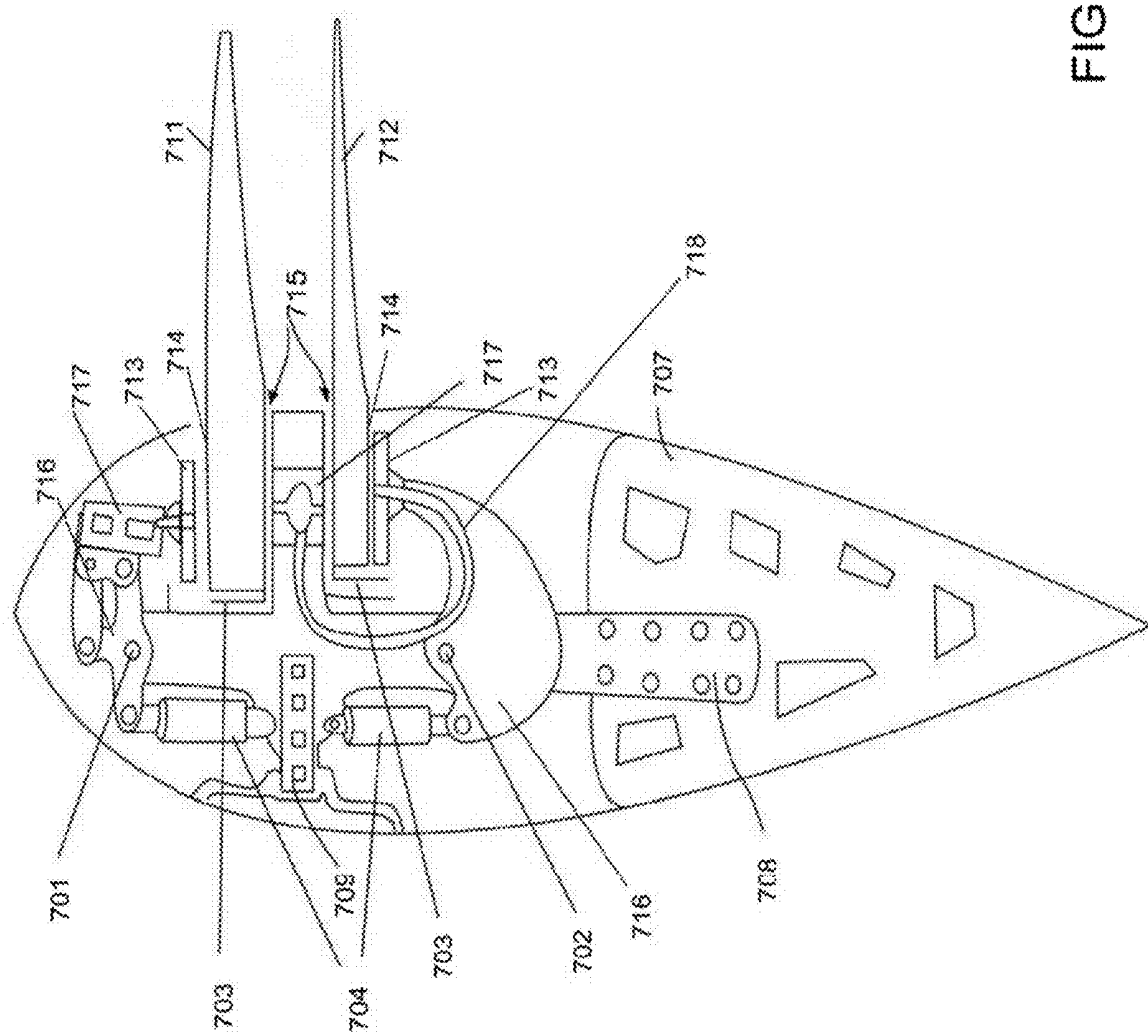


FIG. 15

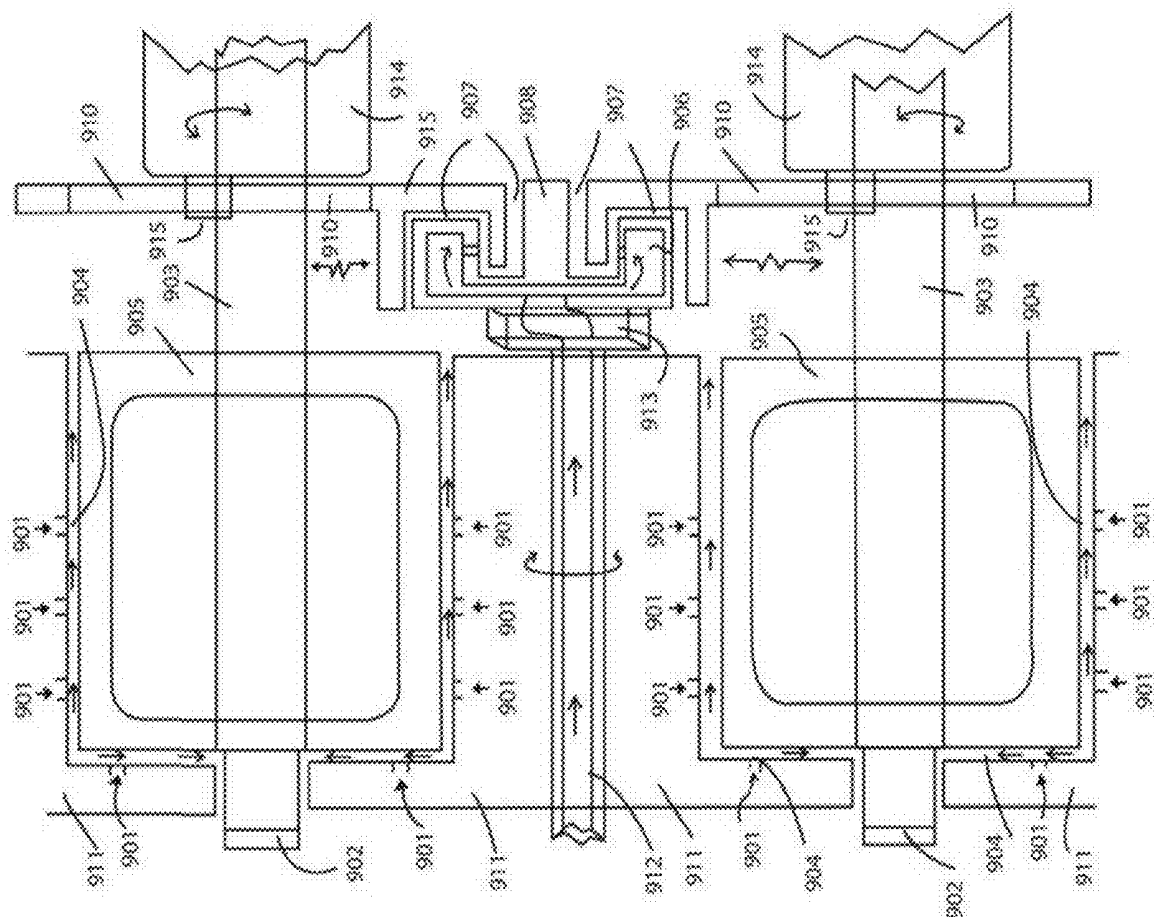


FIG. 17

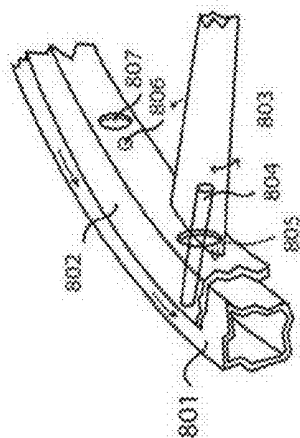


FIG. 16

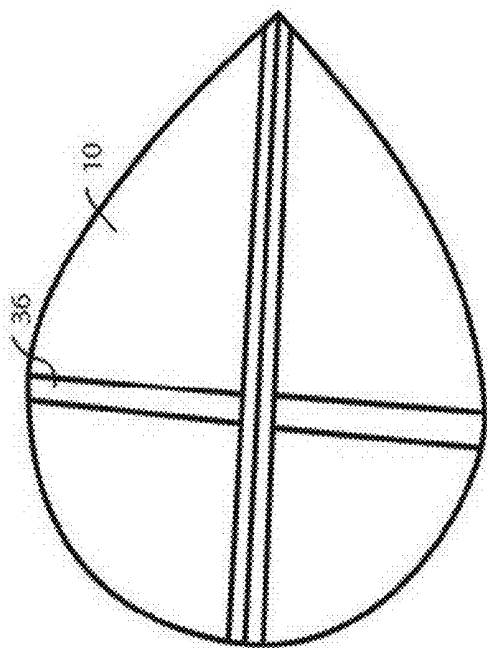


FIG. 19

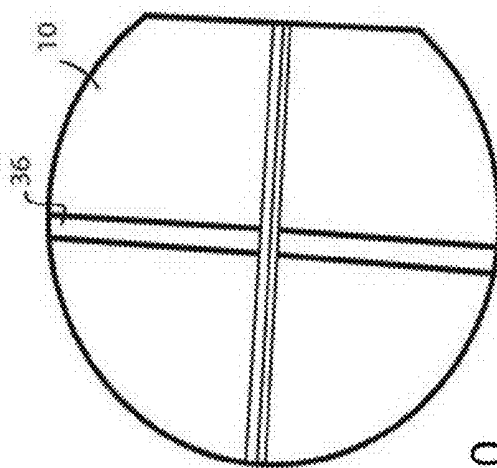


FIG. 20

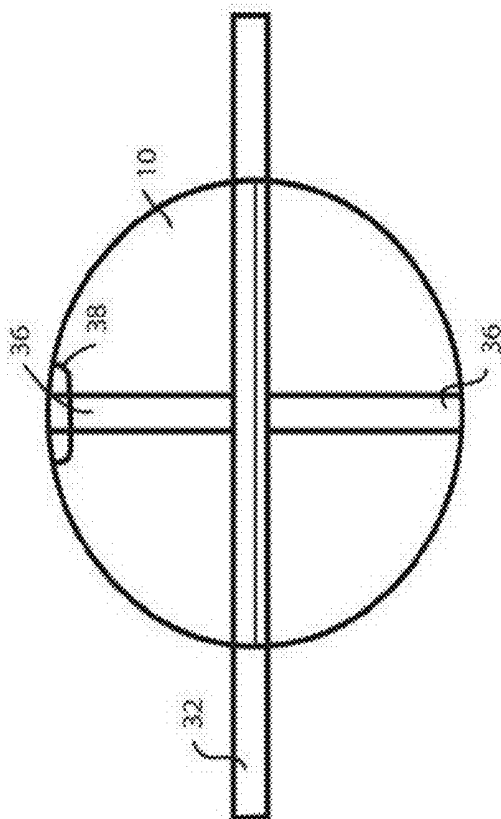


FIG. 18

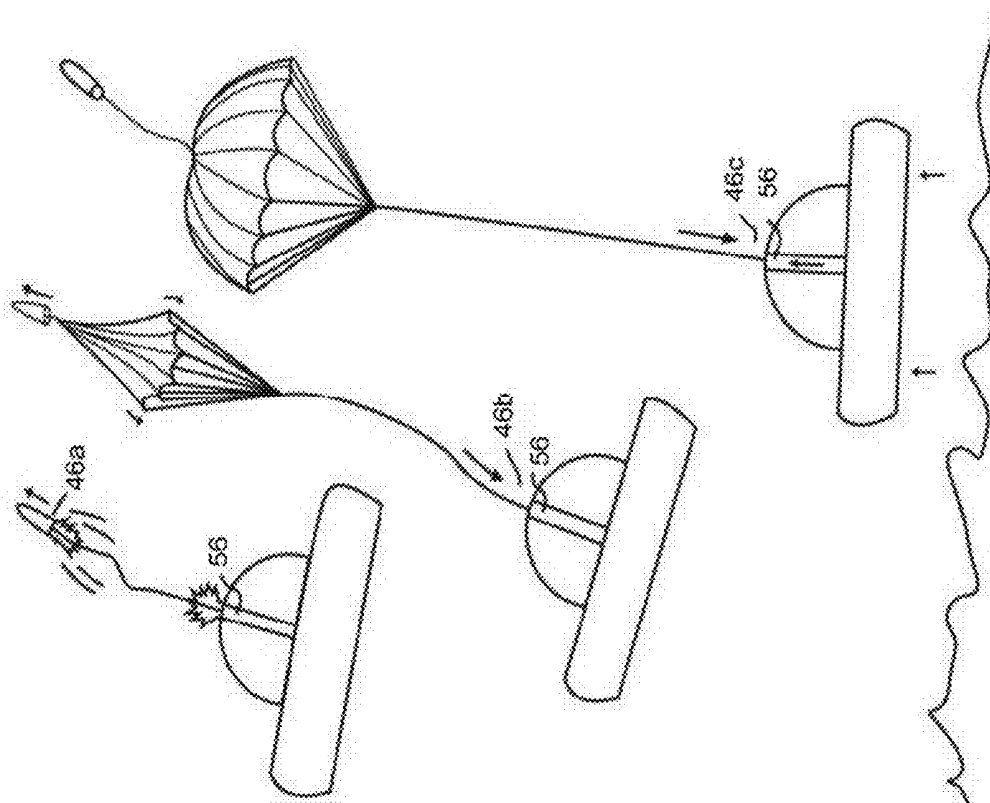


FIG. 21A

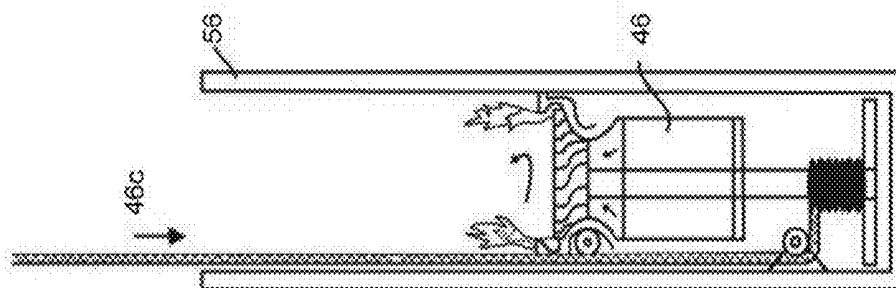


FIG. 21B

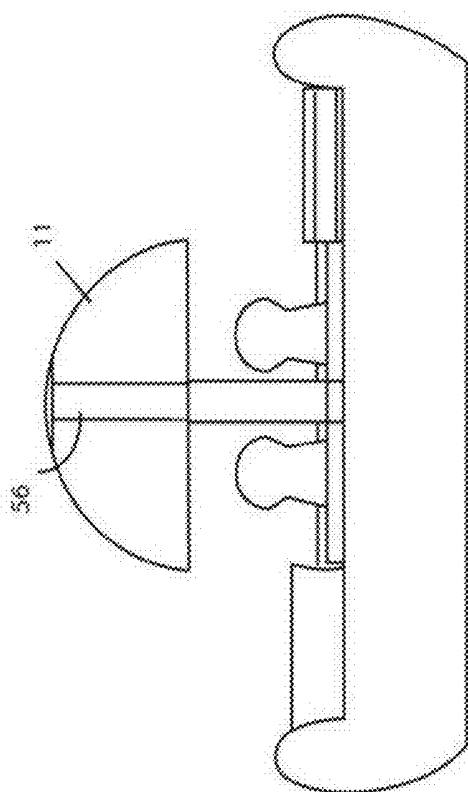


FIG. 22

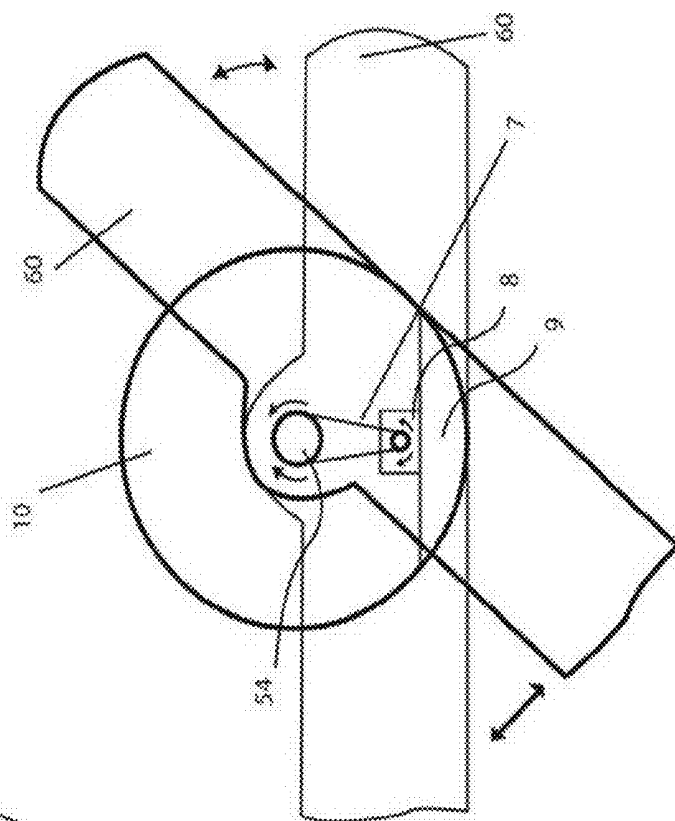


FIG. 23

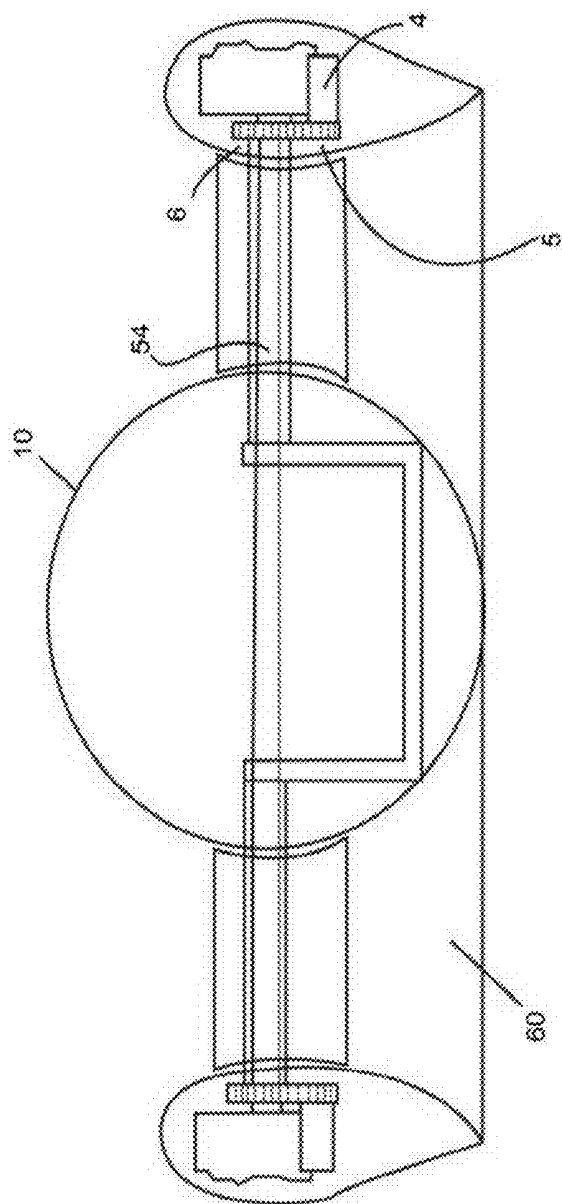


FIG. 24

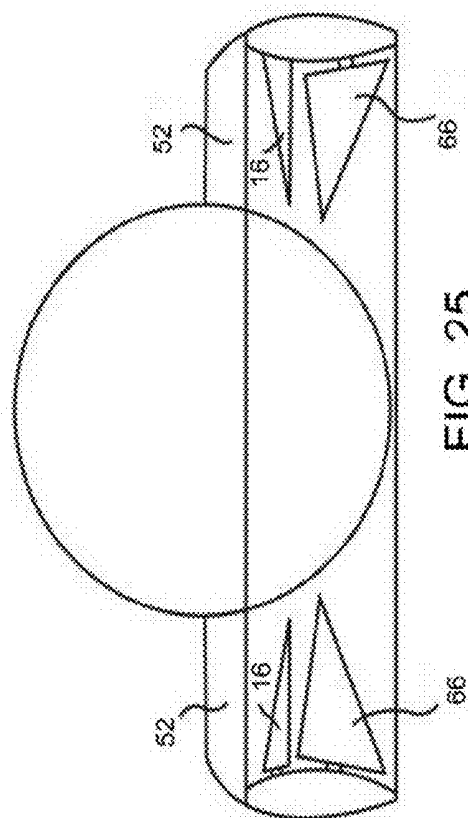


FIG. 25

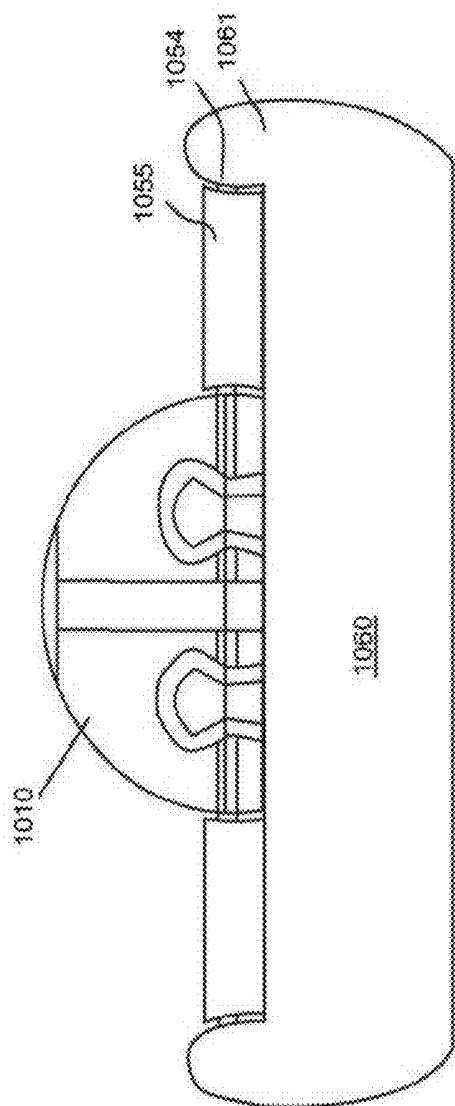


FIG. 26

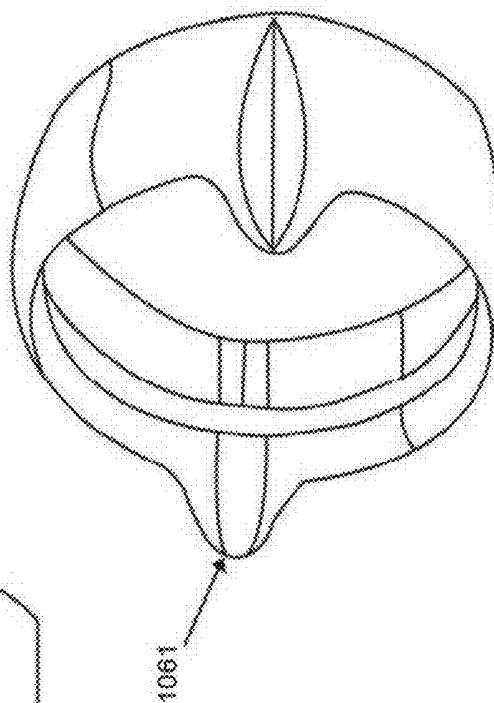
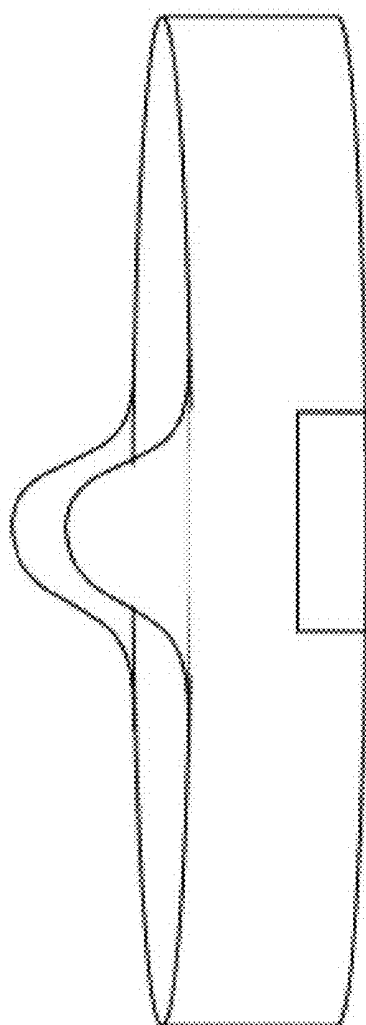


FIG. 27



Closed

FIG. 28

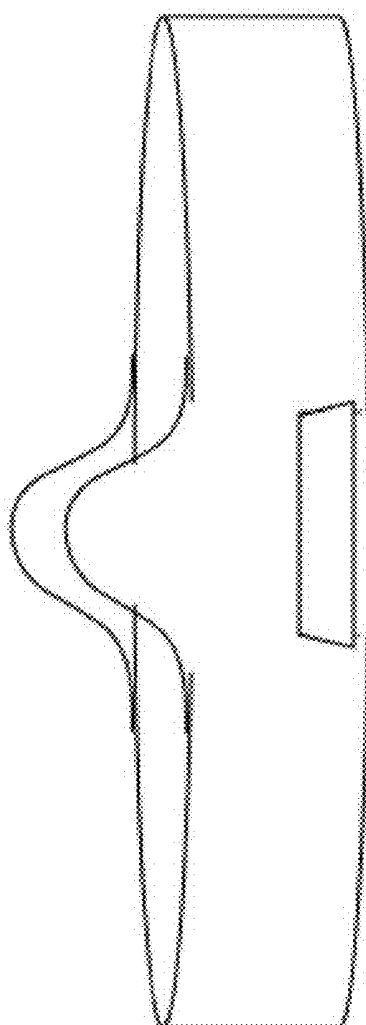
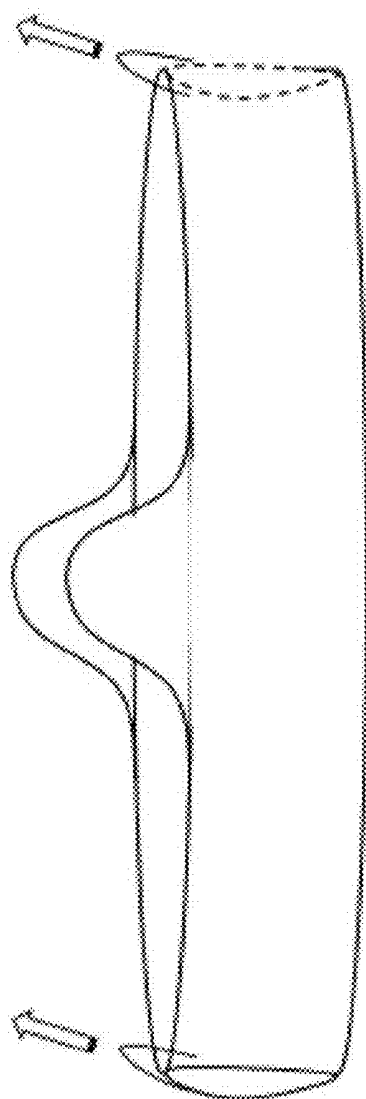
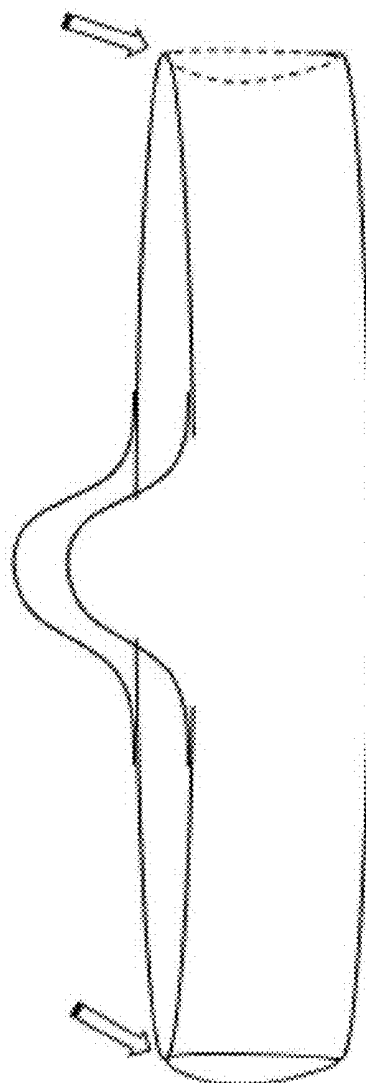


FIG. 29



Open

FIG. 30



Closed

FIG. 31

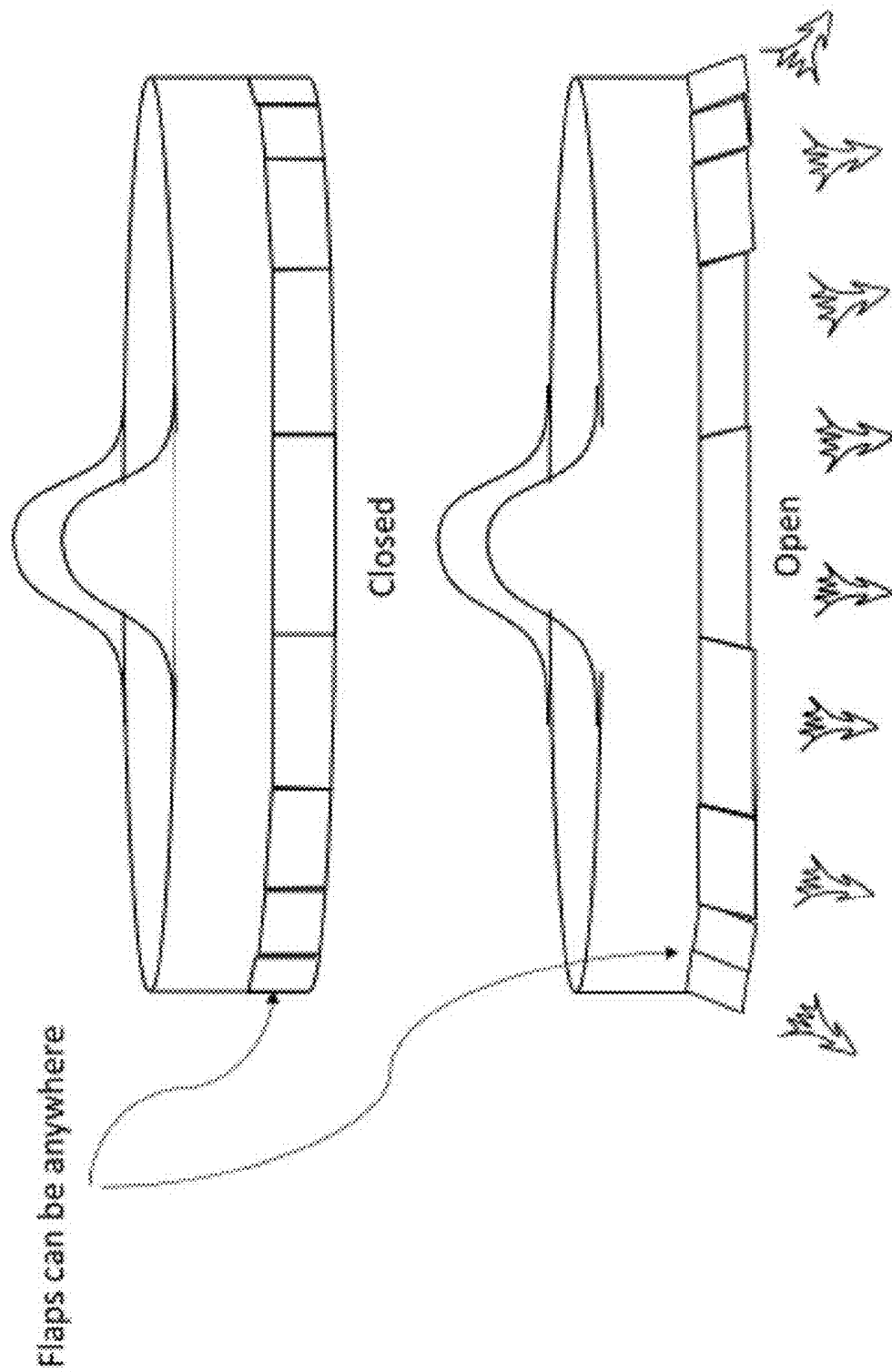
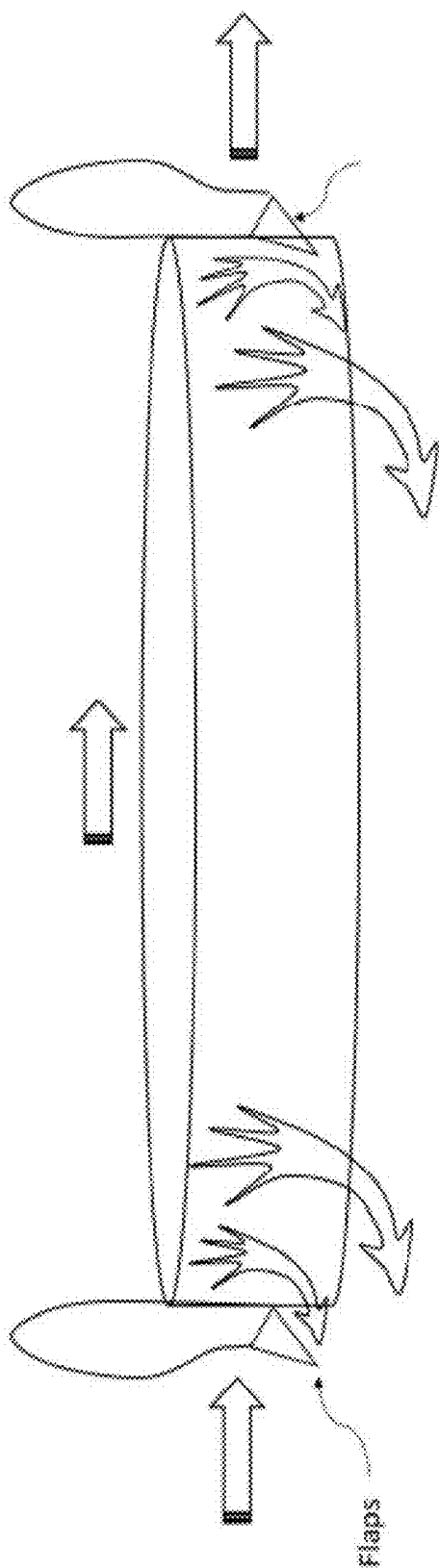


FIG. 32

FIG. 33



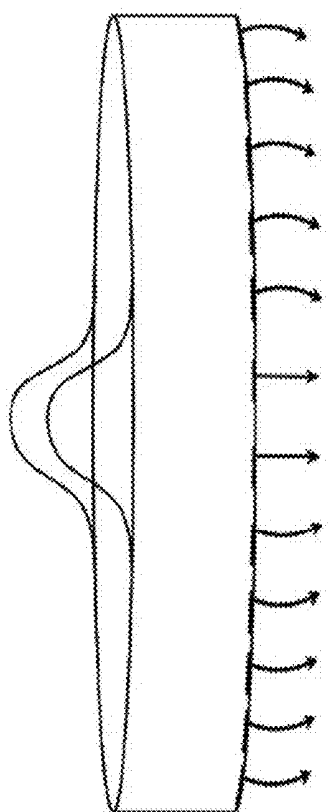


FIG. 35

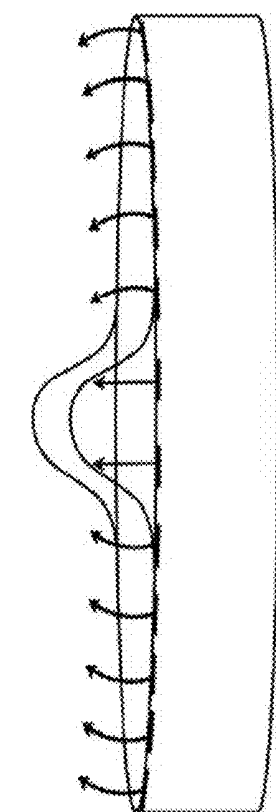


FIG. 36

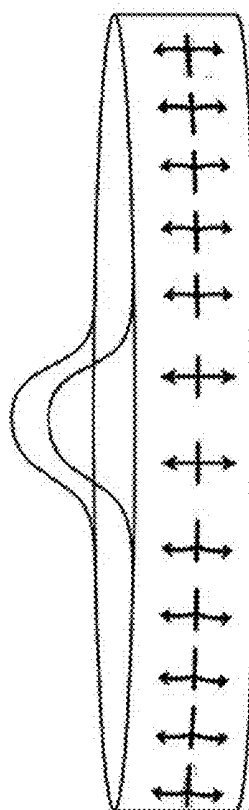


FIG. 37

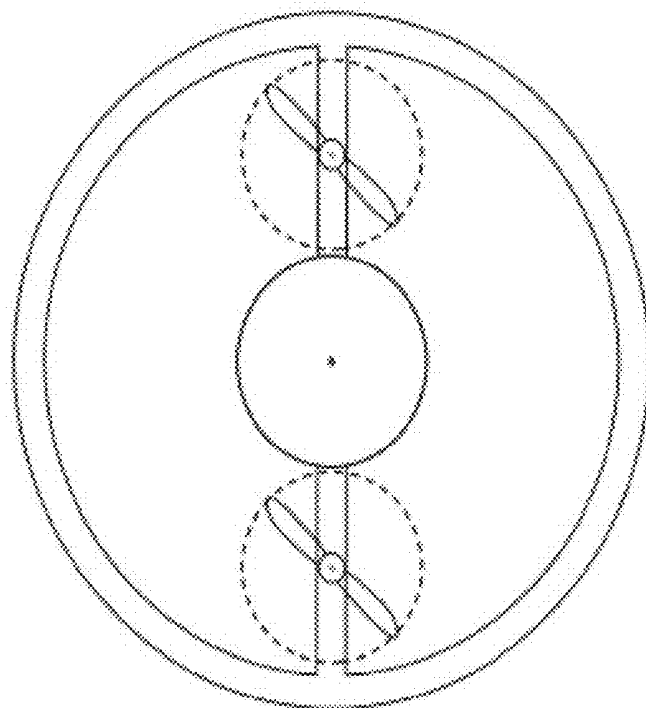


FIG. 38

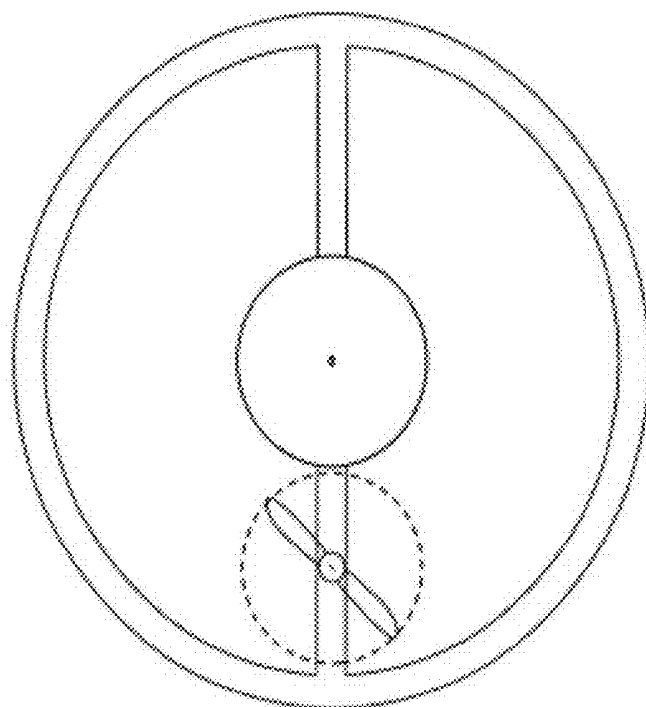


FIG. 39

One or more impellers within the ring-shaped wing

One or more impellers within the ring-shaped wing

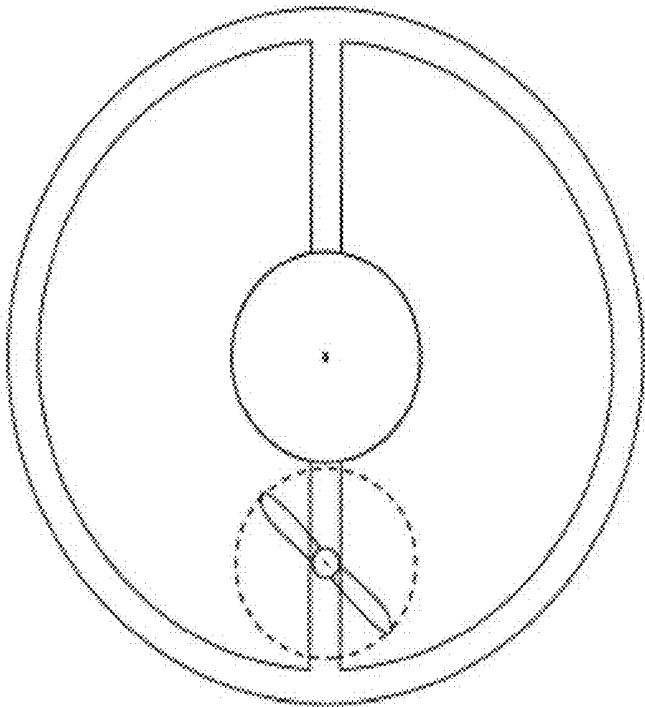


FIG. 40

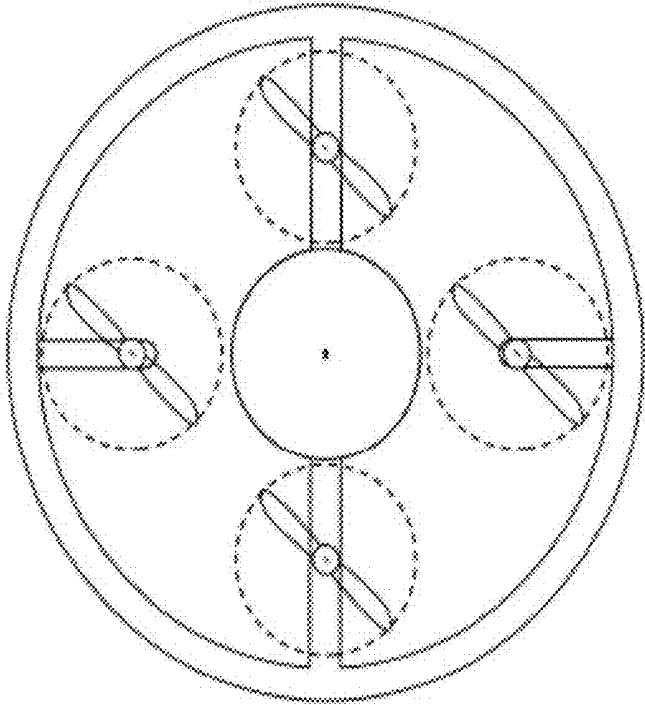


FIG. 41

Cockpit payload enclosure different shapes examples

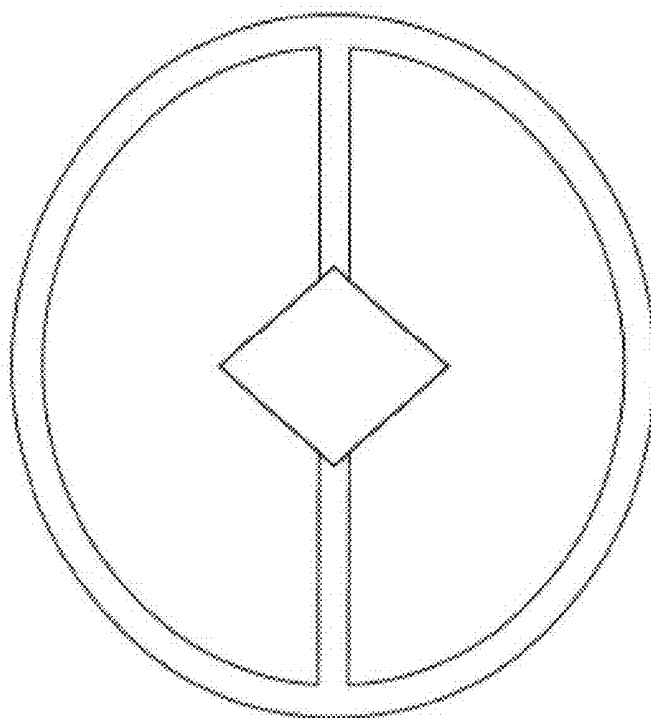


FIG. 42

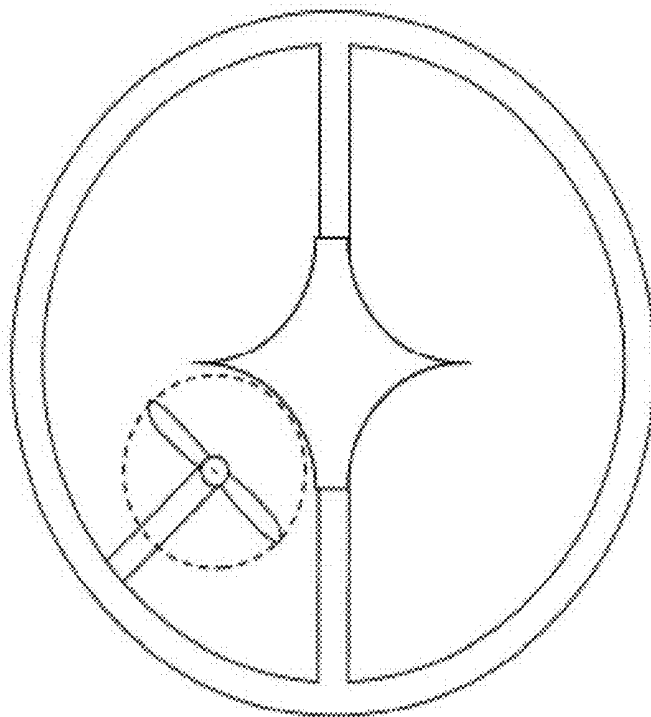


FIG. 43

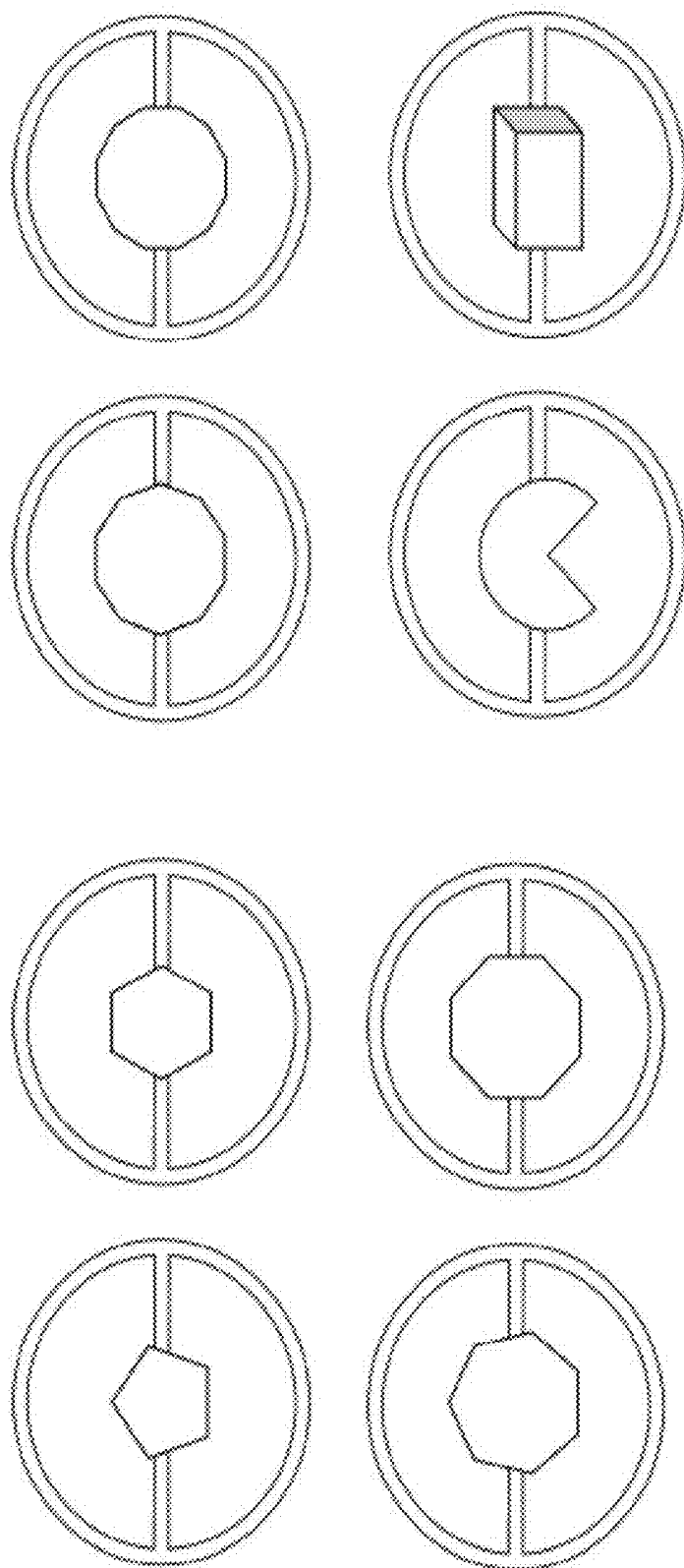


FIG. 44

Cockpit payload enclosure different shapes examples. These shapes may also be cross sections or combinations of plan views or cross sections

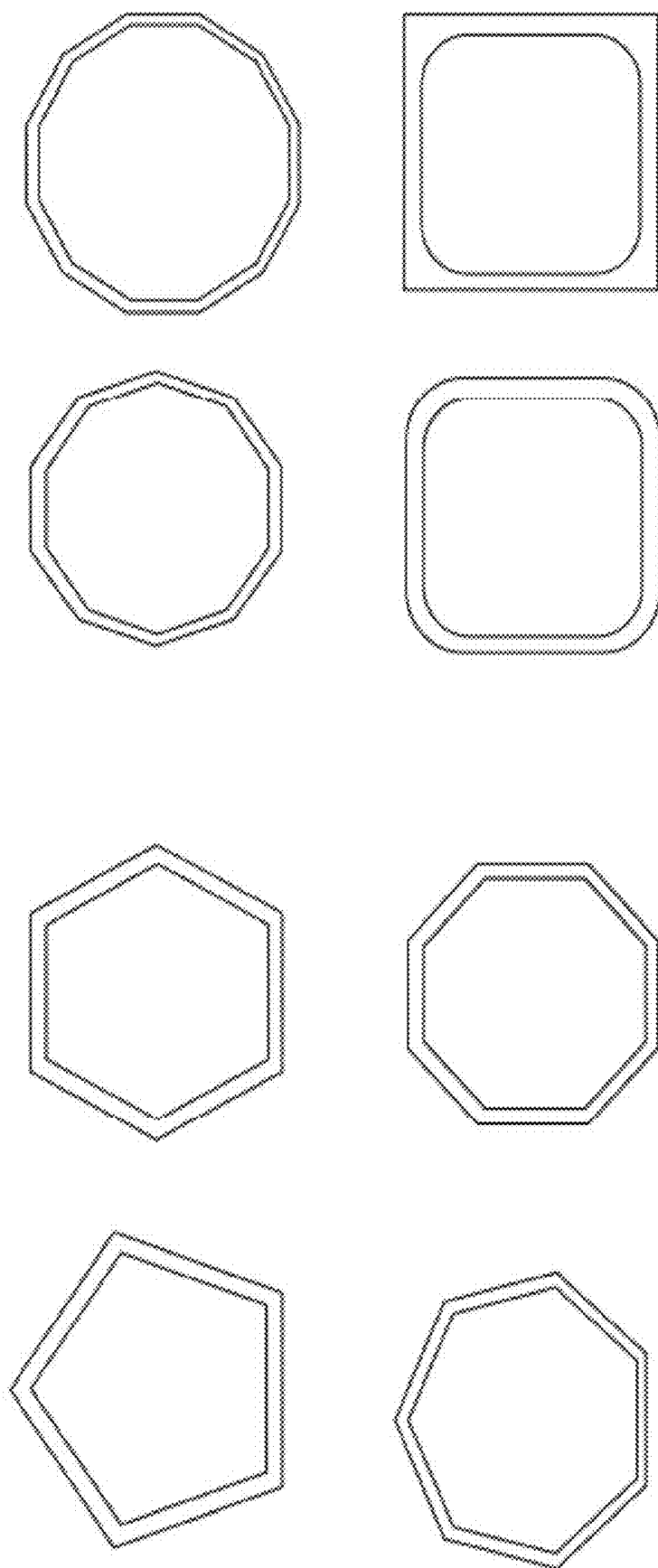


FIG. 45

Examples of possible shapes of continuous wing.

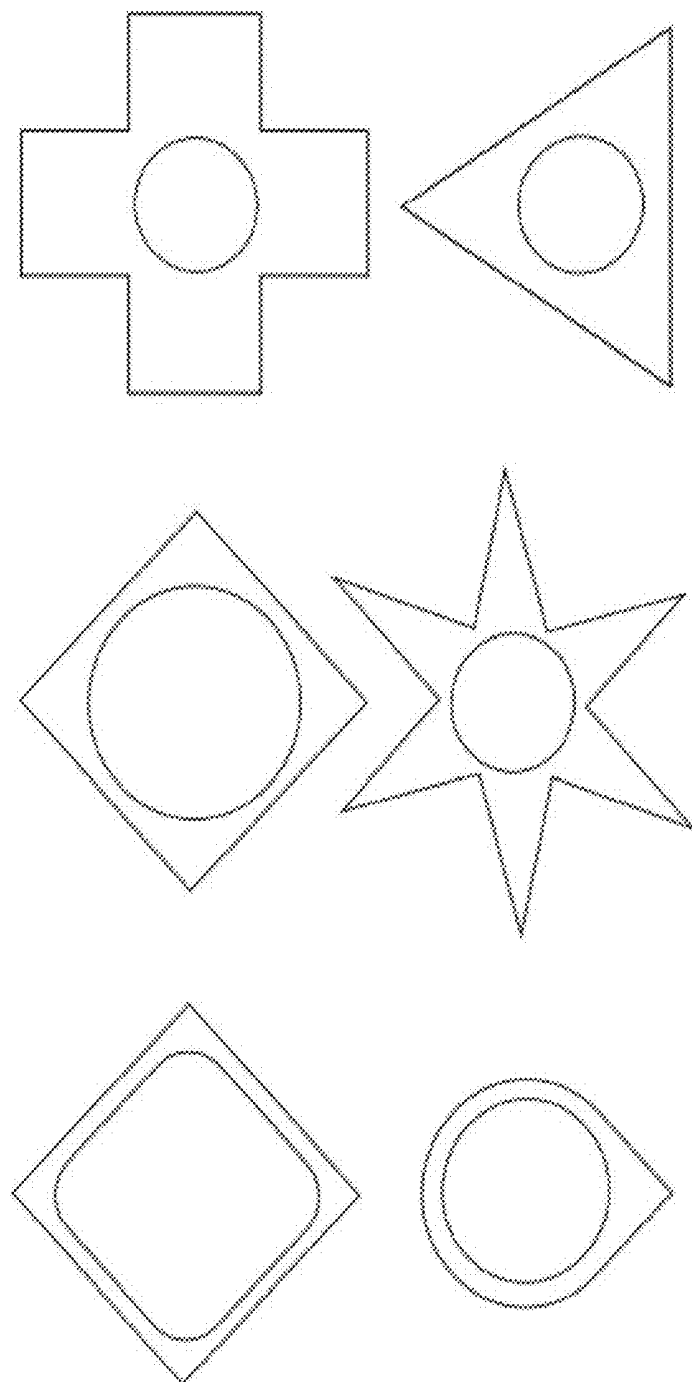


FIG. 46

Wing and cockpit payload enclosure different shapes examples. These shapes may also be cross sections or combinations of plan views or cross sections.

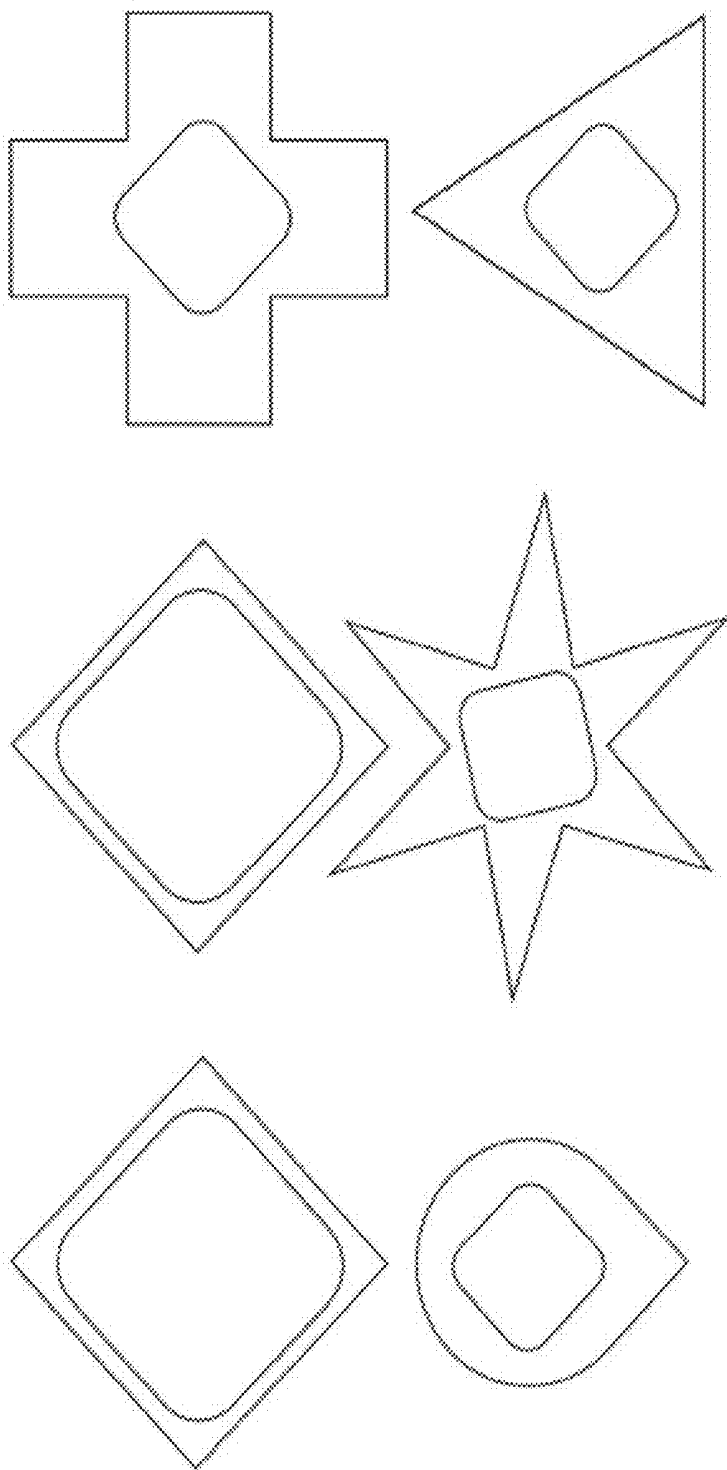


FIG. 47

Wing and cockpit payload enclosure different shapes examples. These shapes may also be cross sections or combinations of plan views or cross sections.

Main Impeller Drive Rim driven by external ducted fans impellers rims in opposite direction, negating torque and inducing control influence, angle of attack, roll, yaw, speed, altitude. By friction driving the main impeller rim via the external ducted fan impellers, the fans have more control leverage over the overall aircraft with a less complex drive system. The external drive impellers can also be individually steered or "valved off" by means of closing or constricting the air flow. This will cause the craft to have less lift in that duct section and will cause the overall aircraft to change its angle of attack.

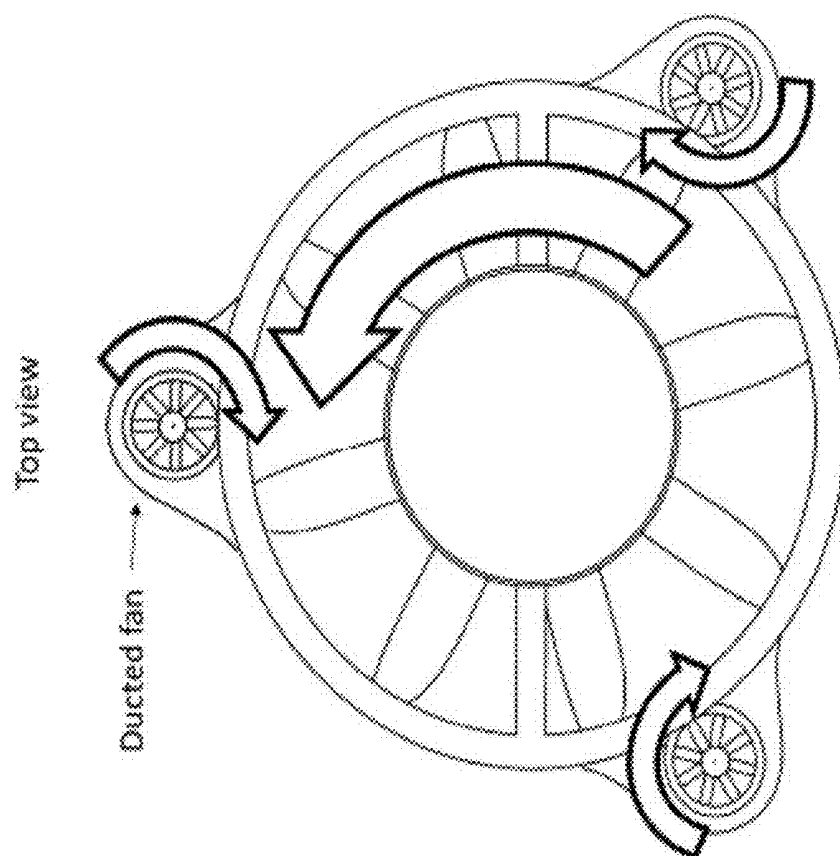


FIG. 48

Side View

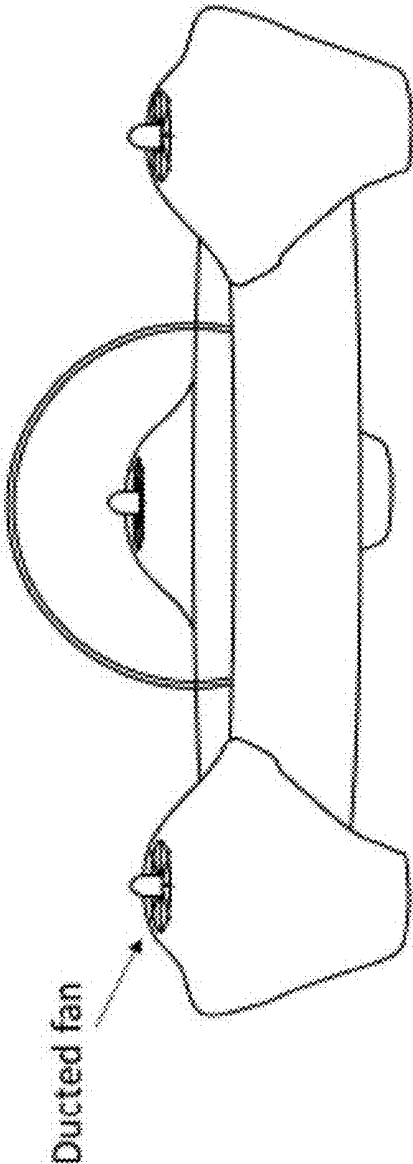


FIG. 49

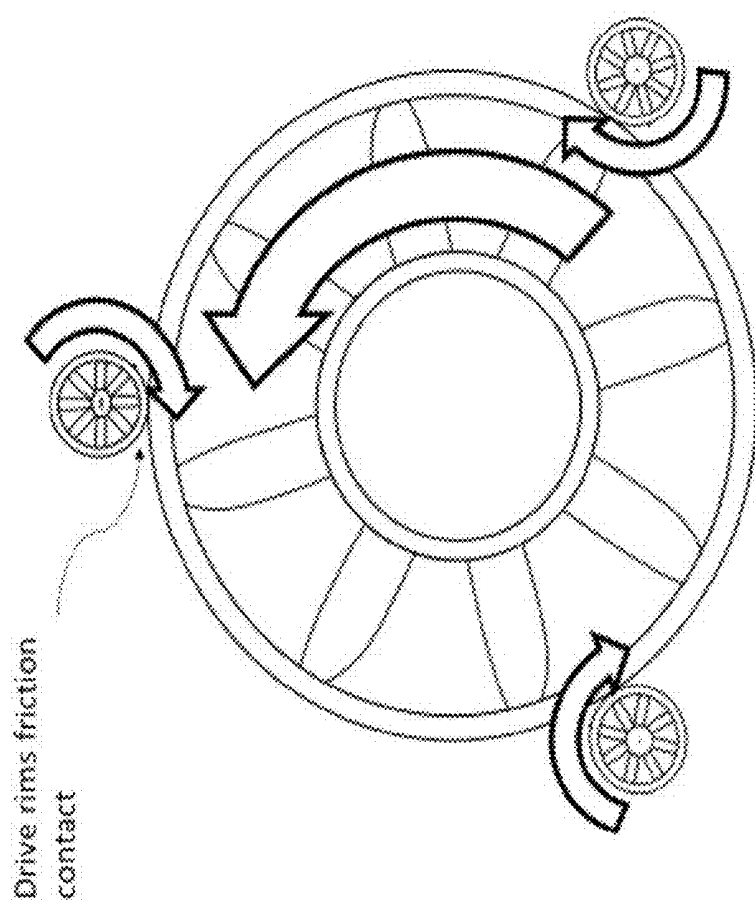


FIG. 50

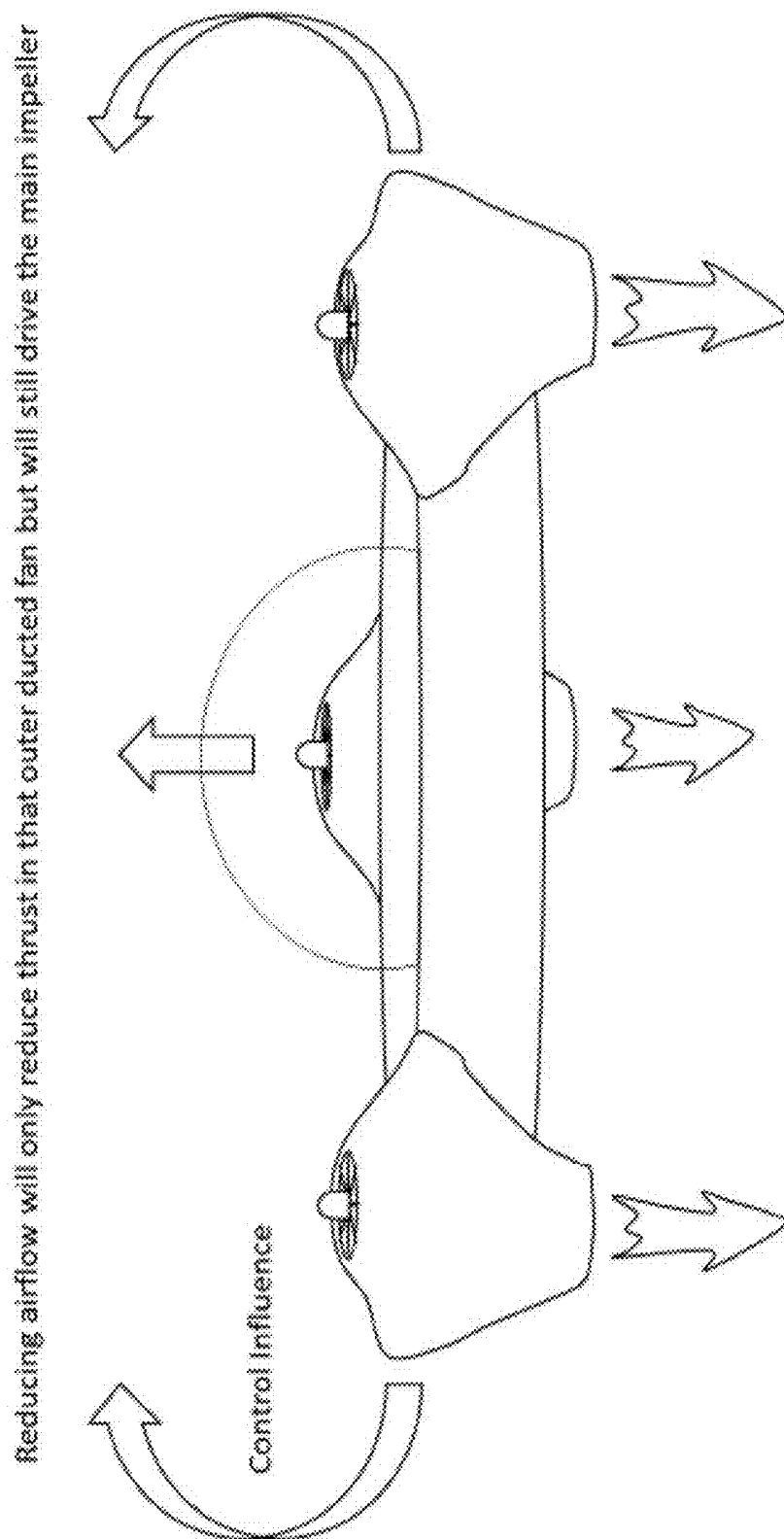
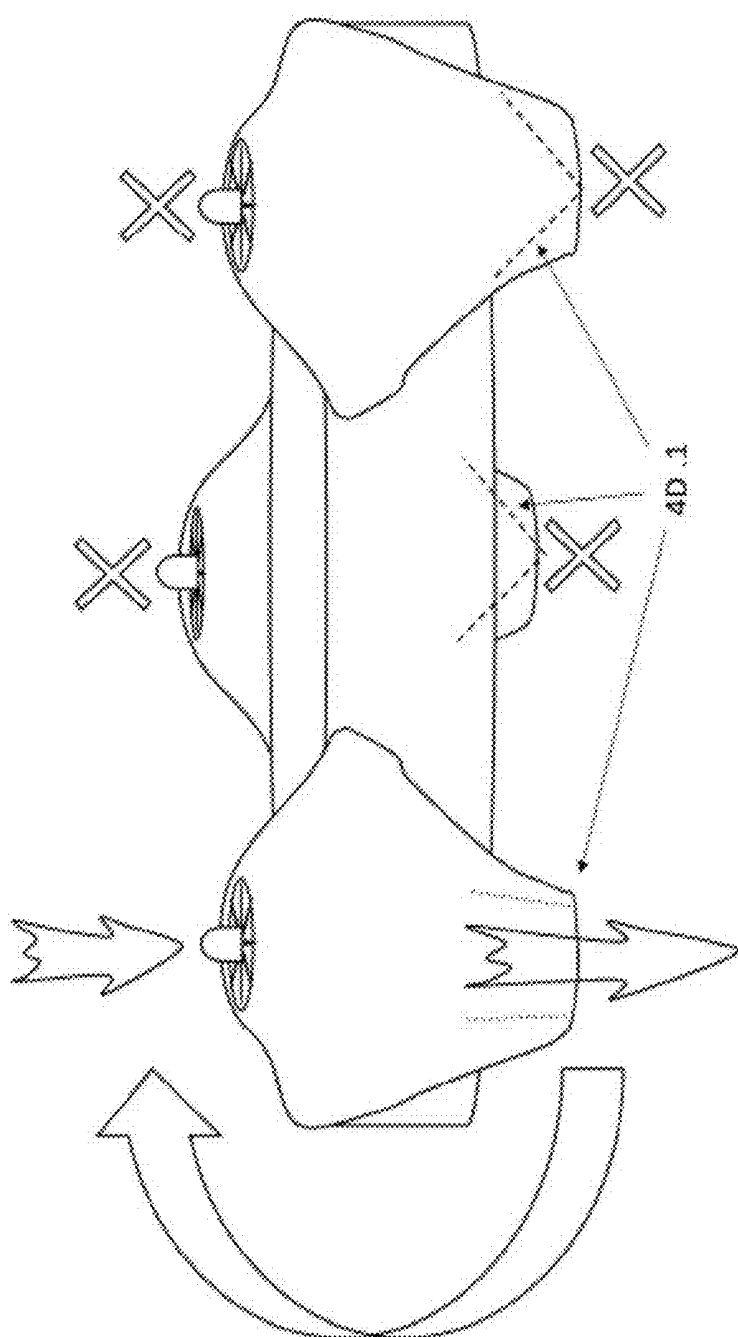


FIG. 51



Internal Vent gates or valves shown dotted lines

FIG. 52

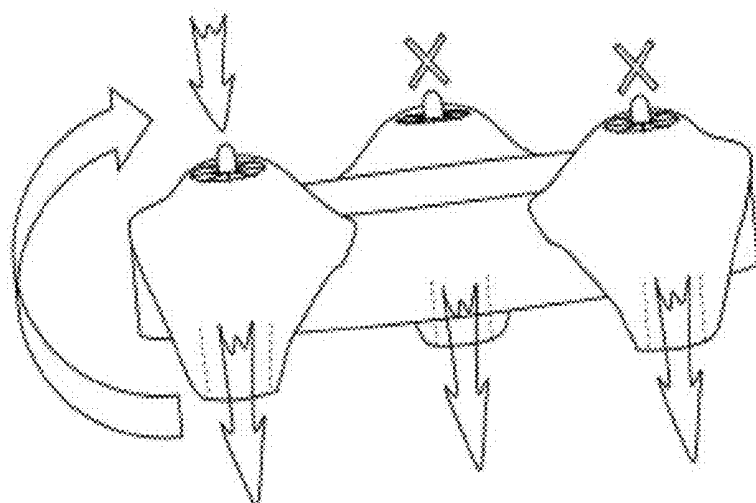


FIG. 54

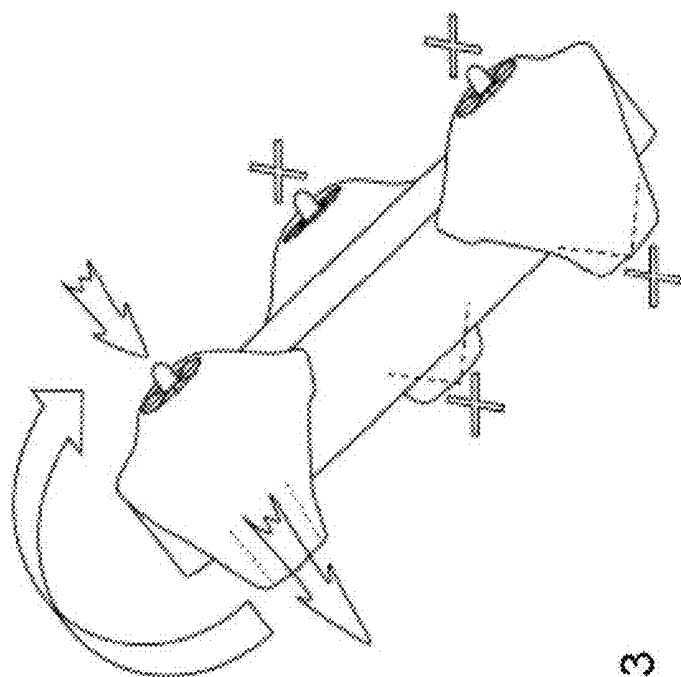


FIG. 53

Internal Vent gates or valves shown dotted lines

One or multiple propellers may be attached to the wing structure.

Top View

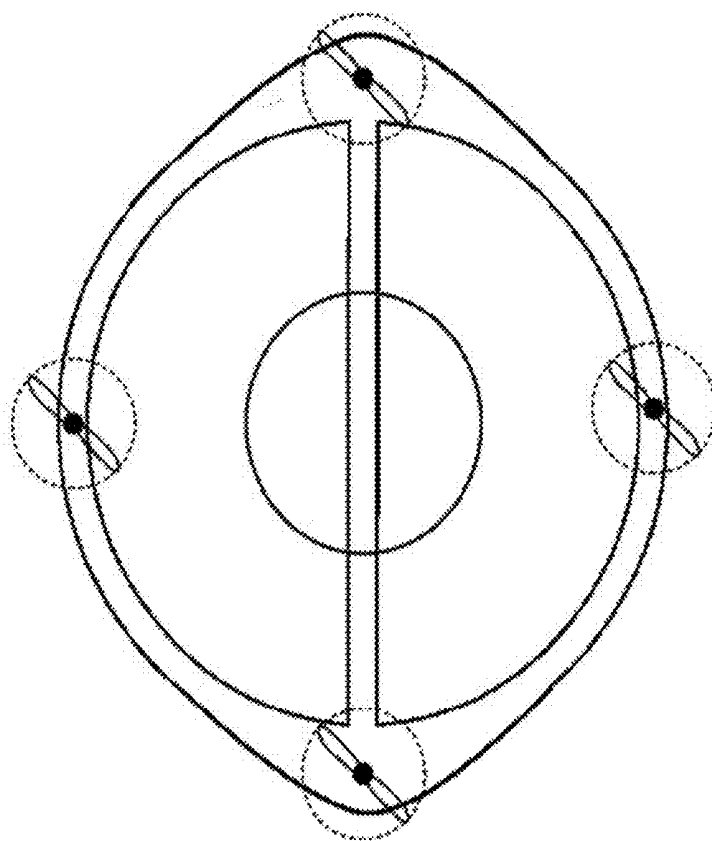


FIG. 55

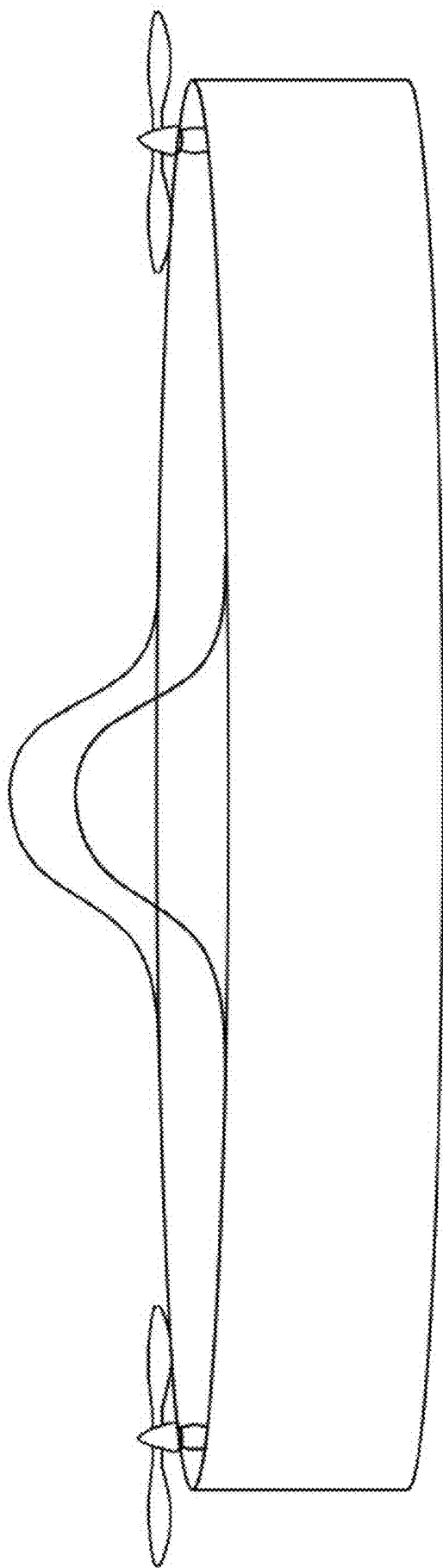


FIG. 56

Propellers may be attached to wing structure in various ways.

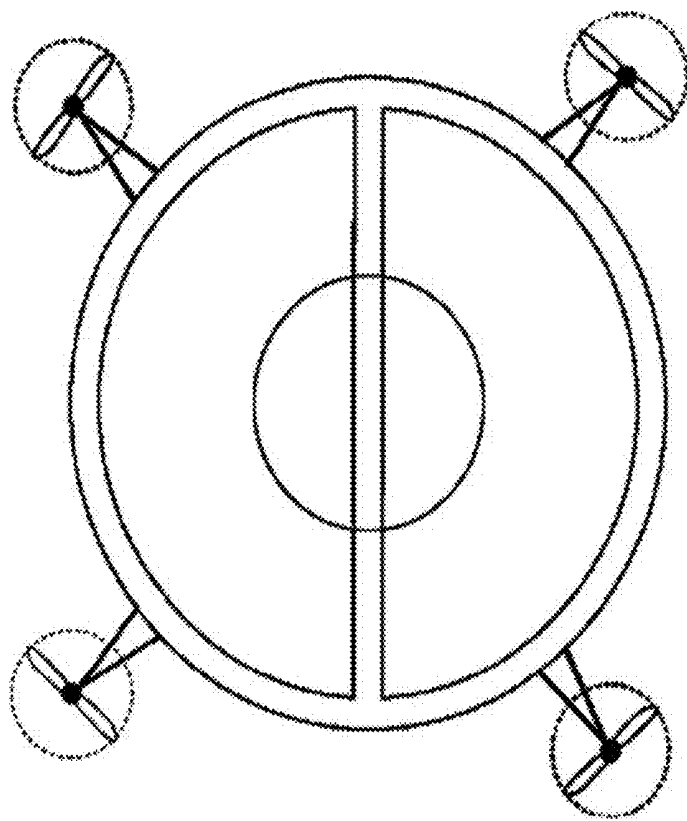


FIG. 57

AIRCRAFT HAVING VTOL, TRANSLATIONAL AND TRAVERSE FLIGHT

[0001] This application is a continuation-in-part of U.S. application Ser. No. 16/185,119, filed Nov. 9, 2018, which is a continuation-in-part of U.S. application Ser. No. 12/157,180, filed Jun. 5, 2008, which claims the benefit of and priority to U.S. Application Ser. No. 60/941,965, filed Jun. 5, 2007. All prior applications are fully incorporated by reference in their entireties for all purposes.

1. FIELD OF THE DISCLOSURE

[0002] The disclosure relates generally to aircrafts and more particularly to powered-lift Vertical Take Off and Landing (VTOL) aircraft.

2. BACKGROUND

[0003] Since powered flight began, the need to eliminate runways has compounded substantially. Airports are the overall bottlenecks in aeronautical transportation and they are taking an ever increasing amount of time to drive to and from, parking, wait in ever increasing lines, baggage portage and claims, etc.

[0004] Vertical takeoff and landing capability is also a most sought after capability in military missions having a variety of special benefits. Historically this has been handled almost entirely by the helicopter and while the helicopter has been an indispensable asset their drawbacks are many leaving yet again a need for a solution.

[0005] While there have been various forms of aircraft that do not need runways to operate, they usually have such major drawbacks that they are very limited in their applications.

[0006] Helicopters have the obvious open rotor threat and corresponding noise; require an expert to fly with both hands and feet; undesirable vibrations; require a tail rotor to counter the imparted torque to the hanging fuselage; and are complex, expensive to fly and maintain. Further, helicopters require the weight and expense of specialized landing gear. Additionally, helicopters usually only have one power source without back-up or parachute options.

[0007] Gyrocopters and gyroplanes, while not needing a tail rotor still have an open rotor and still yield most of the helicopter's drawbacks.

[0008] Tilt rotor is currently exceedingly expensive, also noisy, complex to control, operate and maintain. Very few tilt-rotor aircraft even exist at present time.

[0009] Thrust vectoring, the ability of an aircraft or other vehicle to direct the thrust from its main engine(s) or jets, can only be reasonably considered for military applications as they are deafening, profoundly expensive, and have huge heat signatures among others.

[0010] Another category is that of "powered lift". According to the Federal Aviation Authority (FAA) categorization, "Powered-lift means a heavier-than-air aircraft capable of vertical takeoff, vertical landing, and low speed flight that depends principally on engine-driven lift devices or engine thrust for lift during these flight regimes and on nonrotating airfoil(s) for lift during horizontal flight." 14 C.F.R. 1.1. However, since the FAA recognized this new category, few, if any, feasible aircrafts for this category have been developed, either for the military or civilian application.

[0011] Therefore, it is desirable to provide an aircraft capable of VTOL as well as effective forward flight (not

necessarily "low speed" flight as categorized in the FAA definition of powered-lift) that overcomes the above-described limitations and deficiencies with other aircraft.

SUMMARY OF THE DISCLOSURE

[0012] Generally, disclosed is a powered-lift Vertical Take Off and Landing (VTOL) aircraft capable of vertical takeoff, hover, aerodynamic flight (including, but not limited to level, horizontal flight), return to hover and vertical landing. Disclosed herein is an aircraft capable of Vertical Take-Off and Landing (VTOL) and traverse flight. This novel aircraft generally includes a fixed outer structure including at least a wing having an internal body situated within the fixed outer structure. A space can be defined between the internal body and the fixed outer structure. Within this space can be one or more rotatable ring impellers that create(s) thrust sufficient to achieve lift, or "powered-lift". As used herein, the term "powered-lift" is not intended to have the restraints imposed by the FAA. Rather, the term "powered-lift" as used herein refers to lift for vertical take-off, hovering, landing and/or maneuvering achieved by one or more rotatable ring impellers within a space formed by one or more wing structures.

[0013] According to the disclosure, a powered-lift aircraft is provided that can include one or more propulsion impeller rings that are carried by a generally cylindrical wing (60) and rotatably supported within a generally cylindrical cavity defined by the wing (60).

[0014] The one or more propulsion impeller rings (14) are disposed between an inner surface of the wing (60) and a cockpit payload enclosure (10) that's surrounded by and pivotally mounted to the wing, and the aircraft includes an attitude control system configured to maintain a longitudinal axis of the cockpit payload enclosure (10) in a generally constant level attitude relative to the earth's surface independent of the attitude of the wing (60).

[0015] Also according to the invention a generally cylindrical wing (60) is provided that has a non-constant cross sectional shape contoured to provide lift in at least one of an upper and a lower semi-cylindrical portion of the wing.

[0016] Also, a propulsion impeller ring drive system (14) can be provided that is supported within a generally cylindrical wing (60) or alternately, within the cockpit payload enclosure (10). The generally cylindrical wing (60) can house a mechanically driven propulsion impeller ring that derives power from at least one prime mover, and a mechanical drive operatively connected to the propulsion impeller ring and including one or more components selected from the list of components comprising a belt-drive, a friction roller drive, a magnetic drive, an electric motor, a gear drive, and an air bearing drive. The propulsion impeller ring drive system (14) can be provided and can be supported within a generally cylindrical wing (60) or alternately, within the cockpit payload enclosure (10).

[0017] The generally cylindrical wing (60) can house a mechanically driven propulsion impeller ring that derives power from at least one prime mover, and a mechanical drive operatively connected to the propulsion impeller ring and including one or more components selected from the list of components comprising a belt-drive, a friction roller drive, a magnetic drive, an electric motor, a gear drive, and an air bearing drive.

[0018] Also disclosed is a method for controlling the attitude of an airborne vehicle by asymmetrically controlling the pitch of impeller blades.

[0019] The propulsion impeller ring drive system (14) can be provided that includes a propulsion impeller ring comprising a plurality of impeller blades (16) pivotally supported on a ring for variable pitch control and including an asymmetric impeller blade pitch control system operatively connected to the impeller blades and actionable to cause the propulsion impeller ring to provide asymmetrical thrust by individually and differentially controlling the pitches of the impeller blades.

[0020] In one non-limiting embodiment, the asymmetric impeller blade pitch control system can comprise a pair of contra-rotating pitch control rings that sandwich impeller blades (16) of a propulsion impeller ring and are asymmetrically manipulable in such a way as to cause the propulsion impeller ring to provide asymmetrical thrust through individual differential control of the pitches of the impeller blades. Alternatively, the asymmetric impeller blade pitch control system can include billow-mounted air bearings (30) that are disposed between the pitch control rings and the impeller blades (16).

[0021] The propulsion impeller rings can be contra-rotatably supported within the generally cylindrical cavity defined by the generally cylindrical wing (60). A contra-rotatable propulsion impeller ring drive system can be provided that comprises contra-rotatable propulsion impeller ring supported by air bearings (30).

[0022] The asymmetric impeller blade pitch control system can comprise a pair of contra-rotating pitch control rings that sandwich the impeller blades (16) of a propulsion impeller ring and can be asymmetrically manipulable in such a way as to cause the propulsion impeller ring to provide asymmetrical thrust through individual differential control of the pitches of the impeller blades. Alternatively, the asymmetric impeller blade pitch control system can include billow-mounted air bearings (30) that are disposed between the pitch control rings and the impeller blades (16). An emergency ballistic recovery system can also be provided that can include an automatic riser retractor configured to partially retract risers and/or a cable suspending at least a portion of a powered-lift aircraft (24) from a parachute or parasail canopy immediately following chute deployment. In addition, a second retraction stage may be added to further soften the landing, activated by a ground proximity sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The foregoing summary as well as the following detailed description of preferred embodiments of the invention will be better understood when read in conjunction with the appended drawings. For the purposes of illustrating certain disclosed embodiments, there is shown in the drawings embodiments which are presently preferred. It should be understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown. In the drawings, where:

[0024] FIG. 1 is a schematic front view of a non-limiting aircraft embodiment constructed according to the disclosure and showing a wing of the aircraft oriented axially vertically for vertical flight, hovering or landing;

[0025] FIG. 2 is a schematic front view of the aircraft of FIG. 1 showing the wing of the aircraft oriented axially horizontally for generally level flight;

[0026] FIG. 3 is a schematic axial view an impeller ring having representative impeller blades extending radially inwardly from a propulsion impeller ring;

[0027] FIG. 4 is a radially-inward view of a non-limiting wing embodiment for an aircraft described herein;

[0028] FIG. 5 is a perspective view of the wing shown in FIG. 4;

[0029] FIG. 6 is a view of a wing showing four quadrant regions;

[0030] FIG. 7 depicts a side view of a powered lift aircraft in accordance with one non-limiting embodiment of the disclosure;

[0031] FIGS. 8A-8Q shows various embodiments of impeller blades FIG. 9A shows a roller having an integral driveshaft extending from a powerplant;

[0032] FIG. 9B shows a first impeller ring having blades thereon that are provided between a first set of plates, and a second impeller ring having blades thereon that are provided between a second set of plates;

[0033] FIG. 10 shows a driveshaft extending from an axle;

[0034] FIG. 11 shows a powerplant outside of the impeller ring;

[0035] FIG. 12 shows an electromagnetic drive mechanism;

[0036] FIGS. 13 and 14 show a radial view cross section and tangential cross section, respectively, of the propulsion impeller ring;

[0037] FIG. 15 is a cross sectional view of the wing of the powered-lift aircraft of FIGS. 1 and 2 showing contra-rotatable propulsion impeller rings of the powered-lift aircraft supported on a portion of a propulsion impeller ring drive system carried by and within the wing;

[0038] FIG. 16 shows a cross sectional view of another non-limiting embodiment of a pitch control mechanism in accordance with the present disclosure;

[0039] FIG. 17 shows a cross sectional view of a pitch control mechanism showing two impeller rings;

[0040] FIGS. 18, 19 and 20 show various configurations for a cockpit payload enclosure;

[0041] FIG. 21A is a parachute deployment and retraction system;

[0042] FIG. 21B is a parachute retraction mechanism;

[0043] FIG. 22 depicts access and egress to and from the cockpit enclosure;

[0044] FIG. 23 depicts a wing tilt control including one or more belts having one end associated with the axle and another end associated with a pulley;

[0045] FIG. 24 depicts an axle including gear structures at the ends, which cooperate with pinions that are driven by an actuator;

[0046] FIG. 25 shows rudders and blades extending radially inward from the propulsion impeller ring;

[0047] FIGS. 26 and 27 show a side view and a perspective view, respectively, of another wing configuration;

[0048] FIGS. 28 through 34 illustrate leading or trailing movable surfaces, such as flaps, that can be provided on the wing structure in accordance with the present disclosure;

[0049] FIGS. 35 through 37 illustrate an airflow attitude control system that can be provided in accordance with the present disclosure;

[0050] FIGS. 38 through 41 illustrate an embodiment where one or multiple propulsive units can be provided within the wing structure in accordance with the present disclosure;

[0051] FIGS. 42 and 44 illustrate non-limiting examples for the shape and mounting of the cockpit enclosure in accordance with the present disclosure;

[0052] FIGS. 45 through 47 illustrate non-limiting example for the shape of the wing in accordance with the present disclosure;

[0053] FIGS. 48 through 54 illustrate wing mounted ducted fans that can be used as a drive system and to control attitude in accordance with the present disclosure; and

[0054] FIGS. 55 through 57 illustrate wing mounted propellers to control attitude in accordance with the present disclosure.

DETAILED DESCRIPTION

[0055] FIG. 1 shows a schematic front view of an aircraft (24) capable of Vertical Take Off and Landing (VTOL), translational flight and generally level flight, and showing in one non-limiting embodiment a wing (60) of the powered-lift aircraft (24) oriented axially vertically for vertical flight, hovering or landing. FIG. 2 is a schematic front view of the powered-lift aircraft (24) of FIG. 1 showing the wing (60) of the powered-lift aircraft (24) oriented at some angle for translational flight, or axially horizontally for traverse or generally level flight. According to the disclosure, a powered-lift aircraft is provided that includes one or more propulsion impeller rings that are carried by a generally cylindrical wing or toroid-shaped wing (60) and rotatably supported within a generally cylindrical cavity (72) defined by the wing (60).

[0056] Referring to FIGS. 1 and 2, the aircraft (24) can include one or more propulsion impeller rings (14) that are carried by the wing (60). The one or more propulsion impeller rings (14) are disposed between an inner surface of the wing (60) and a cockpit payload enclosure (10) that can be surrounded by and pivotally mounted to the wing. The aircraft may include an attitude control system configured to maintain a longitudinal axis of the cockpit payload enclosure (10) in a generally constant level attitude relative to the earth's surface, independent of the attitude of the wing (60). FIG. 3 showing four representative impeller blades (16) extending radially inwardly from a propulsion impeller ring (14). The ring (14) may be carried within, for instance, the wing (60) of the powered-lift aircraft (24) of FIGS. 1 and 2.

[0057] The powered-lift VTOL aircraft (24), includes a cockpit payload enclosure (10) surrounded by and pivotally-mounted within a generally cylindrical wing (60) or duct. An axle structure (52) provides connection between a cockpit payload enclosure (10) is attached by to opposing sides of the wing (60). Thus, a load sharing axis (74) is created by the axle structure (52) that connects the wing (60) with the cockpit payload enclosure (10). The cockpit payload enclosure (10) may be fixed to the axle structure (52) and rotatably carried on or within the wing (60), for instance, on a suitable bearing. Alternatively, the axle structure (52) may be fixed at opposing sides of the wing (60) and pass through the cockpit payload enclosure (10) or a portion thereof (where the cockpit payload enclosure (10) is rotatable upon the axle structure (52)). In additional alternative embodi-

ments, the axle may be selectively coupled and decoupled from the wing (60) and/or the cockpit payload enclosure (10).

[0058] One rotatable or plural coaxially rotatable (contra-rotatable or co-rotatable), rim-driven propulsion impeller rings (14) with impeller blades (14) may be rotatably supported by the wing (60) between an inner surface of the wing (60) and the cockpit payload enclosure (10). Each propulsion impeller ring (14) may include one or a plurality of radially-disposed impeller blades (16). (As used in the present application the inventor intends the term "impeller" as the device that causes the propulsion of axial-flow air through the wing, rather than centrifugal-flow fluid propulsion).

[0059] In general, lift is provided when the impeller rings (14) rotate at rotational speeds sufficient to provide thrust force overcoming the weight of the aircraft (24). Furthermore, translational or generally level flight may be attained as described herein, whereby the thrust forces required may be minimized by suitable aerodynamic wing (60) configuration as described herein.

[0060] Thus, a method of powered-lift flight is provided that includes creating vectored thrust sufficient to achieve powered-lift. The thrust is generated by at least one impeller blade (16) attached to at least one propulsion impeller ring (14), the ring (14) being installed on or in a wing (60). The ring (14) including impeller blades (16) is generally rotatably carried or supported inside of the space (72) created by the wing (60). The cockpit payload enclosure (10) is also provided which is mounted generally within the axial rotation of the propulsion impeller ring (14). (Note that the wing (60) carrying the impeller ring (14) having blades (16) is capable of flight without the cockpit payload enclosure (10)).

[0061] In one embodiment, after a vertical take off, translational or generally level flight may be attained by rotation of the wing (60) relative the cockpit payload enclosure (10) in about the axle (52), with continued rotation of the impeller rings (14). In this embodiment, the cockpit payload enclosure (10) is attached by the axle structure (52) to opposing sides of the wing (60) with associated mechanisms to controllably pivot the wing (60) about the cockpit payload enclosure (10).

[0062] In another embodiment, after a vertical take off, translational or generally level flight may be attained by rotation of the impeller blades (16) pitch or angle of attack to relative airflow to change the angle of propulsion. In this embodiment, the cockpit payload enclosure (10) is attached by the axle structure (52) to opposing sides of the wing (60) in a manner to form gimbals. The center of gravity within the cockpit payload enclosure (10) may be varied, for instance, in flight, to cause the wing (60) to tilt forward (with respect to the plane of the so called 'great circle' (the circle on the surface of a sphere corresponding with a circumference of a sphere that divides a sphere into two hemispheres) of the spherical cockpit payload enclosure (10) as oriented in the upright position as shown in FIGS. 1 and 2) to translate from lift off or hovering to generally level flight, or from generally level flight to descent flight or backward to translate, for instance, from level flight or hovering to reverse flight.

[0063] The cockpit payload enclosure (10) may be pivotally mounted to maintain a generally constant level attitude relative to the earth's surface. This attitude may be maintained, or any other desired attitude, whether the wing (60)

and propulsion impeller ring (14) are oriented axially vertically for vertical, or near vertical flight or hovering (FIG. 1), whether the wing (20) and propulsion impeller ring (16) are oriented axially horizontally for translational or generally level flight (FIG. 2), or whether the wing (60) is between the axially vertical and horizontal attitudes.

[0064] Certain components of the powered-lift aircraft (24), as shown in the drawings, may be almost completely symmetrical, which allows for more cost-effective production methods to be used than would otherwise be possible. The symmetrical or nearly symmetrical shapes include the sphere, the ovoid, and the toroid, which can provide for structurally strong geometrical shapes.

[0065] The powered-lift aircraft (24) may be maneuvered by changing the attitude of the wing (60) and propulsion impeller ring (14), therefore, changing both the thrust vector of the powered-lift aircraft (24) and the angles of attack of the impeller blade(s) (16) and the upper and lower lifting surfaces of the wing (60).

[0066] The impeller (14) may be caused to rotate by a variety of sources. For instance, referring to the example of FIGS. 1 and 2, powerplants (36) generally within bulging powerplant nacelles (76) on opposing side of the wing (60). In general, one or more powerplants (e.g., engines or electric motors) may be carried in or upon the wing (60), or in or upon the cockpit payload enclosure (10), and operably coupled with the impeller ring (14) to cause rotational force. An engine may include prime movers such as combustion engines, turbine engines, air motors, turbine engines, jets, turbofans, electric motors, flywheels, rockets. Associated fuel sources may be provided in or upon the wing (60), in or upon the cockpit payload enclosure (10), or both. In further embodiments, one or more electric motors may be provided, wherein an associated electric power source may include batteries, supercapacitors (e.g., for propulsion surges), and/or fuel cells, which may be provided in or upon the wing (60), in or upon the cockpit payload enclosure (10), or both. Electrical collection, e.g., for recharging batteries or capacitors, may be accomplished by conventional recharging (e.g., docking to AC or DC power supply), one or more photovoltaic cells upon the aircraft (24), and/or wind turbines (e.g., suitably positioned to minimize air resistance).

[0067] Referring now to FIG. 4, a radially-inward view of a wing (160) is provided. Additionally, FIG. 5 shows a perspective view of the wing of FIG. 4. This wing (160), including impellers operably carried as described herein, may be used as an aircraft (e.g., with payload and/or cockpit space formed in or on the wing, not shown), may serve as the wing (60) shown with respect to aircraft (24) described above, or may be used as a component in another aircraft configuration. The wing (160) includes powerplant nacelles (176) and has a streamline aerodynamic shape in the direction of flight. In addition, FIG. 5 schematically depicts an impeller ring (114) on an inside surface (118), which is rotatably supported as described herein. The wing structures described herein are described as having a generally cylindrical shape. However, it should be understood that a “generally cylindrical wing” refers to any three dimension structure which may have non-parallel walls having a duct of constant or varying cross section in a circular, oval and/or ovoid shape (e.g., the dimensions and/or the shape may change along the length of the axis) through a central axis, and may encompass toroid-shaped structures. In addition, in certain embodiments, the cross section of the thickness of

the wing structure differs at different locations on the wing, and these configurations are also intended to be encompassed by the phrase “generally cylindrical wing”.

[0068] In certain non-limiting examples, and referring to FIG. 6, a wing (260) includes four quadrant regions (280) corresponding with the 10 o'clock to the 2 o'clock section of the wing (260); (281) corresponding with the 2 o'clock to the 4 o'clock section of the wing (260); (282) corresponding with the 4 o'clock to the 8 o'clock section of the wing (260); and (283) corresponding with the 8 o'clock to the 10 o'clock section. In certain configurations, sections (280) and (282) include suitable carrying structure (e.g., bearings, tracks) for an impeller ring, and have an exterior shape and dimension to act as an airfoil, for instance, in translational flight and generally level flight; and sections (281) and (283) include a powerplant (in one section only or in both section) and structures for mechanically cooperating a powerplant drive-shaft to the impeller ring, and has an exterior bulging shape to accommodate powerplant nacelles (276).

[0069] Thus, as shown in FIG. 6, a wing (360), from a horizontal axis in the circular view, includes four quadrants including an upper aerodynamic lifting quadrant (280) at the top of the wing, two side housing quadrants (281), (283) on either side of the wing, and a lower aerodynamic lifting quadrant (282) at the bottom of the wing. The side housing quadrants (281), (283) of a wing (360) houses one or more components selected from the group of components consisting of one or more powerplant components (e.g., at least one engine or motor), a power transfer unit, fuel or energy storage, cockpit and/or payload, flight-related components, or any combination including at least one of the foregoing components. In further embodiments, the side housing quadrants (281), (283) of a wing (360) may house one or more components including but not limited to jet turbines, rotary engines, motors, batteries, fuel cells, capacitors, compressed gas, photovoltaic cells, prime movers, belt drives, gear drives, electric drives, hydro drives, gas drives, traction/friction drives; nuclear fuel, liquid fuel, compressed gas fuel, solid fuel, electronics, avionics, landing gear, and a storage space.

[0070] FIG. 7 depicts a side view of a powered lift aircraft 324 similar to that shown with respect to FIG. 1 shown in forward flight (to the right as oriented in the page) and with hidden lines showing airfoil-shaped cross sections of upper (322a) and lower (322b) quadrants of the wing (e.g., corresponding to quadrants (280), (282) shown with respect to FIG. 6. The wing (360) is this asymmetrical in the sense that it may have a non-constant cross-sectional shape contoured to provide an asymmetric airfoil cross-section of wing (360) in upper (322a) and lower (322b) semi-cylindrical sectors or quadrants of the wing. The asymmetrical airfoil cross-section wings (360) will provide more lift than would a symmetric cross-section, particularly as the angle of attack of the airfoils approaches zero, assuming that the relative wind passing across the wing (360) structure is sufficient to generate lift, i.e., generally, when the aircraft (324) is in or near level flight relative to the earth's surface. In this configuration, the upper and lower quadrants or semi-cylindrical portions provide a bi-wing or bi-plane configuration in a flying duct. By adding features to the axle connecting the cockpit (310) to the wing (360) (e.g., described as axle (52) with respect to FIGS. 1 and 2) such as a shroud having an airfoil shape, as a middle wing, a tri-plane configuration can be attained. Further, by forming the cockpit in a shape

approximating an airfoil, or encasing the cockpit in such a shaped structure, as a middle wing, a tri-plane configuration can also be attained.

[0071] During forward flight, when the wing (360) is axially horizontally oriented and its axis is generally parallel to the relative wind, the upper (322a) and lower (322b) quadrants of the wing (60) act as lifting bodies. These upper and lower quadrants or semi-cylindrical portions may have airfoil cross sections that are either cambered or otherwise asymmetrically shaped. In other embodiments, the airfoil cross-sections may be symmetrical.

[0072] FIGS. 8A-8Q show various embodiments of impeller blades (16) in different configurations. In certain examples, such as shown in FIG. 8H, the impeller blade(s) (16) has a constant cross-sectional shape along its length. In certain examples, such as shown in FIGS. 8B and 8D, the impeller blade(s) (16) has a consistent but tapered cross sectional shape along its entire length. In certain examples, such as shown in FIGS. 8A, 8C, 8F, and 8G, the impeller blade(s) (16), the impeller blade(s) (16) has an asymmetrical shape along its length. In certain examples, such as shown in FIGS. 8F, 8G, 8J, 8K, 8L, 8M, and 8N, the impeller blade(s) (16) has a curved shape along its length. In certain examples, such as shown in FIGS. 8A, 8B, 8C, 8D and 8E, the impeller blade(s) (16) has a tapered shape along its length. In certain examples, such as shown in FIG. 8P, the impeller blade(s) (16) has a twisted shape along its length. In certain examples, such as shown in FIGS. 8A, 8B, 8C, 8D, 8E, 8P and 8Q, the impeller blade(s) (16) has a tapered and twisted shape along its length. In certain examples, such as shown in FIGS. 8I and 8K, the impeller blade(s) (16) has no tip. In certain examples, such as shown in FIGS. 8I and 8P, the impeller blade(s) (16) is connected in two places to the impeller ring (14) (where in FIG. 8I the impeller blade connects across diameter of the ring, and in FIG. 8P the two places of connection are across the height of the impeller ring).

[0073] Also according to the invention, a propulsion impeller ring drive system is provided that is supported within a generally cylindrical wing or alternately, within the cockpit payload enclosure. Also according to certain embodiments, a generally cylindrical wing is provided that houses a mechanically driven propulsion impeller ring that derives power from at least one prime mover, and a mechanical drive operatively connected to the propulsion impeller ring and including one or more components selected from the list of components consisting of a belt-drive, a friction roller drive, a magnetic drive, an electric motor, a gear drive, and an air bearing drive.

[0074] Referring back to FIGS. 1 and 2, a propulsion impeller ring drive system may include one or more drive belt (s) (34) providing, for instance, friction power from the prime mover(s) (36) (e.g., via one or more spur gears (44) as shown in FIG. 2) to the outer propulsion impeller ring surface(s). Alternatively, the propulsion impeller ring drive system may transfer power by friction from the prime mover(s) (36) through four parallel, generally co-planar pinch rollers, an inner pair of the pinch rollers being driven in counter-rotation by the prime mover(s) and an outer pair of the pinch rollers being idling pinch rollers positioned to maintain a requisite amount of friction between the driven rollers.

[0075] In certain non-limiting embodiments, and referring now to FIG. 9A, a roller (91) is provided, for instance,

having an integral driveshaft extending from a powerplant. Roller (91) an opposing roller (92) (which may be passive or also coupled to a driveshaft or powerplant) are in frictional engagement with surfaces (38) of an impeller ring (14). The rollers drive the ring (14) by frictional engagement with the surfaces (38) of the ring (34). In addition, the embodiment of FIG. 9A depicts an example of impeller blades (16) having adjustable pitch. For instance, top and bottom portions of the impeller blades are attached to top and bottom plates. The top and bottom plates may be compressed or expanded by pushing or pulling, respectively, the roller (91).

[0076] In a similar manner, and referring now to FIG. 9B, a first impeller ring (14) having blades (16) thereon are provided between a first set of plates, and a second impeller ring (14) having blades (16) thereon are provided between a second set of plates. A roller (93) is positioned between the first set of plates and the second set of plates. Rollers (91) and (92) are also provided, roller (91) being positioned on the outside of the first set of plates, and roller (92) being positioned on the outside of the first set of plates. By driving one or more of the rollers, the first impeller ring is rotated in one direction, and the second impeller ring is rotated in the opposite direction, referred to as coaxial contra-rotation. Furthermore, the plates may be squashed independently, for instance, where the blades of the first impeller ring are at a different angle than the blades of the second impeller ring.

[0077] In certain embodiments, and referring now to FIG. 10, a driveshaft (437) is provided extending from an axle (452) that carries the cockpit (not shown) and the wing (460). The powerplant (436), shown housed within the axle (452), may also be in the cockpit with the driveshaft (437) extending from the powerplant (436) through the axle (452). The driveshaft (437) is coupled to a pinion (486), which rotates in a first direction and is meshed with teeth of bevel or ring gear rack (487), causing bevel or ring gear (487) to rotate in a direction generally opposite the first direction. Rack (487) is integral with or coupled to the impeller ring having impeller blade(s) (416) extending therefrom.

[0078] In other non-limiting embodiments, and referring now to FIG. 11, a powerplant (536) is provided outside of the impeller ring, for example, within the body of the wing structure or extending outwardly therefrom. The powerplant (536) is coupled to a pinion 586, which rotates in a first direction and is meshed with teeth of bevel gear (587), causing bevel or ring gear (587) to rotate in a direction generally opposite the first direction. Bevel gear (587) is integral with or coupled to the impeller ring having impeller blade(s) 516 extending therefrom.

[0079] Referring now to FIG. 12, another embodiment of a drive mechanism for an impeller ring (614) is shown, generally in the configuration of an electromagnetic drive mechanism. This mechanism may be one or more phases, conventional rotor-stator type motor configuration, brushless motor configuration, or permanent magnet motor configuration. Impeller ring (614) (having blade(s) (616)) can include alternating polarity rotor magnets (689) or electromagnets (689) (depending on the motor configuration) fixed to the impeller ring (614) (as shown, on a surface of the impeller ring (614) facing outside of the ring). Correspondingly, the wing structure or a support structure (661) to the wing structure includes. In addition, the wing structure (660) includes alternating polarity rotor electro magnets (691) or magnets (691) (depending on the motor configuration, wherein the component (689) and (691) are opposite, i.e.,

when (689) is a magnet, (691) is an electromagnet, and vice versa). As is known in the field of electric motors, an air gap (690) is provided between the stator and rotor components (691), (689).

[0080] Also according to certain non-limiting embodiments disclosed herein, a method and system is provided for controlling the attitude of an airborne vehicle by asymmetrically controlling the pitch of impeller blades. Thus, a propulsion impeller ring drive system is provided that includes a propulsion impeller ring comprising a plurality of impeller blades pivotally supported on a ring for variable pitch control. In certain embodiments, the propulsion impeller ring drive system includes an asymmetric impeller blade pitch control system operatively connected to the impeller blades. The asymmetric impeller blade pitch control may be actuated to cause the propulsion impeller ring to provide asymmetrical thrust by individually and differentially controlling the pitches of the impeller blades. For instance, in a ring configuration with four blades, two of the blades may be actuated so that the degree of pitch is greater or less than the other two blades to provide asymmetrical thrust.

[0081] Also, in certain non-limiting embodiments described herein, according to the invention, an asymmetric impeller blade pitch control system is provided that comprises a pair of coaxial contra-rotating pitch control rings that sandwich impeller blades of a propulsion impeller ring and are asymmetrically actuatable in such a way as to cause the propulsion impeller ring to provide asymmetrical thrust through individual differential control of the pitches of the impeller blades. Alternatively, or in combination, the asymmetric impeller blade pitch control system includes billow-mounted air bearings that are disposed between the pitch control rings and the impeller blades, as described herein.

[0082] Referring to FIGS. 13 and 14, a radial view cross section and tangential cross section, respectively, of the propulsion impeller ring is shown. The propulsion impeller ring drive system is actionable to asymmetrically adjust the pitch of the impeller blades (16) in such a way as to change the attitude of the wing (60) and/or to control the flight path of the aircraft. To allow for asymmetrical impeller blade pitch control, propulsion impeller ring pitch control rings or squash plates (48) may be supported in such a way as to sandwich the impeller blades at a base (68) of each impeller blade (14) and be manipulated by hydraulic rams and/or mechanical linkages (28) in such a way as to control impeller blade pitch.

[0083] The propulsion impeller ring drive system may transfer power by friction from the powerplant through four parallel, generally co-planar pinch rollers, an inner pair (40) of the pinch rollers being driven in counter-rotation by the prime mover (s) and an outer pair (42) of the pinch rollers being idling pinch rollers positioned to maintain a requisite amount of friction between the driven rollers.

[0084] In other non-limiting embodiments, air bearings (30) mounted on air bellows (32) may be positioned above and/or below the drive ring squash plates (48) to change the pitch of the impeller blades (16), as well as to reduce friction between the rotating impeller blades (16) and the corresponding drive ring squash plates (48). This provides for very precise and responsive control of the powered-lift aircraft (24) at any speed or aspect of translation between hover and forward flight. A compression spring (54a) is provided to maintain compression on the impeller blade base (68), and extension springs (54b) are shown in the bellows

(32) to maintain the bellows in an extended state. The air bellows force, for instance, introduced by forcing air into the bellows, overcomes the springs (54a), (54b) to adjust the pitch.

[0085] A propulsion impeller ring drive system may be housed within the wing and operatively connected to the impeller blades (16) of each contra-rotatable propulsion impeller ring (14) and arranged to individually and incrementally pivot the impeller blades to provide variable pitch control (16). The propulsion impeller ring drive system may be arranged to impart counter-rotational force to counter-rotate the impeller blades (16).

[0086] The powered-lift aircraft (24) may be maneuvered by changing the attitude of the wing (60) and propulsion impeller ring (14), therefore, changing both the thrust vector of the powered-lift aircraft (24) and the angles of attack of the impeller blade(s) (16) and the upper and lower lifting surfaces of the wing (60). This may be accomplished by actuating squash plates that asymmetrically change the respective pitches of the impeller blade(s) (16).

[0087] In another non-limiting embodiment, and referring to FIG. 15, a variable pitch coaxial contra-rotating impeller control system is shown, which features very low friction. Impeller blades (711), (712) having the ability to vary the pitch or angle of attack compressing against an air bearing (713) the outer surfaces (714) against a film of pressurized air, e.g., an air bearing film (715). Blades (711), (712) may rotate the same direction or opposite directions on the air bearing film (715). A drive surface (703) may comprise a belt drive surface, a gear drive surface, or other suitable drive surface. Hydraulic pitch actuators (704) can also be provided but may alternatively be electromechanical or pneumatic actuators. Actuators (704) impart a force on lever arms (716) that pivots on fulcrums (701) and (702) that imparts a leverage force on the opposite side of the fulcrums to air bearing (713). Each of fulcrums (701) and (702) can operate independently of each other and impart an increase or reduction in pitch to each of the impeller's blades (711), (712). A structural ring (709) is shown and is outward of the structural manifold (717). Structural manifold (717) contains air pressure (e.g., 60 psi) and supply the air bearings via pressurized conduits or hoses (718). Member (707) is a structural member that supports directly or indirectly structures within the wing body and may be a rib or outer wing skin support.

[0088] FIG. 16 shows a cross-sectional view of another non-limiting embodiment of a pitch control mechanism, showing an impeller drive ring (801), a squash-plate pitch control shield (802), impeller blade (803), an impeller support shaft (804), a pitch control shaft (805), a pitch control shaft hole (806) and an impeller shaft through slot (807). To change the pitch of impeller blade (803), a force is applied to a squash-plate pitch control shield (802) in a vertical axis in relation to impeller drive ring (801). This imparts a pivoting force on impeller blade (803) through the pitch control shaft (805) that is inserted into a hole (806). Impeller blade (803) is supported by impeller support shaft (804). Impeller support shaft (804) passes through the slot (807) and into the impeller drive ring (801).

[0089] FIG. 17 shows a cross-sectional view of a pitch control mechanism showing two impeller rings. The impeller rings (905) are supported by air bearings (904) and air is supplied through holes (901) in the support structure (911). A hollow shaft (912) connects to a control arm (913), which

supplies air pressure to an “E” shaped pitch control air bearing (908) with an internal air pressure manifold (906) that distributes air through holes into the air bearing (907). When a rotational force is applied to the shaft (912), the control arm (913) imparts a lifting force on (908) which through the air bearing imparts a force on both the upper and lower squash plate pitch control shields (915). Also shown in FIG. 17 are the impeller support shafts (903), impeller blades (914), impeller drive ring surfaces (902) that may be gear teeth, pulley teeth, electromagnetic or other suitable structures. Slots (910) allow the squash plate pitch control shields to slide around the impeller support shafts (903) parallel to the axis of the impeller drive rings axis of rotation and impart torque to the impeller blades through a shaft parallel to the impeller shaft extending outward from the base of the impeller blade into or through the squash plate control shields (915).

[0090] In certain non-limiting embodiments, the propulsion impeller rings can be coaxially contra-rotatably supported within the generally cylindrical cavity defined by the generally cylindrical wing. Also according to certain non-limiting embodiments, a contra-rotatable propulsion impeller ring drive system can be provided that comprises contra-rotatable propulsion impeller ring supported by air bearings, as described above. Furthermore, an asymmetric impeller blade pitch control system is provided that comprises a pair of contra-rotating pitch control rings that sandwich impeller blades of a propulsion impeller ring and are asymmetrically manipulable in such a way as to cause the propulsion impeller ring to provide asymmetrical thrust through individual differential control of the pitches of the impeller blades. Alternatively, the asymmetric impeller blade pitch control system includes billow-mounted air bearings that are disposed between the pitch control rings and the impeller blades. As non-limiting examples, FIGS. 15, 9B and 17 show various non-limiting embodiments of coaxial contra-rotating impellers with independent pitch control for each set of blades.

[0091] A propulsion impeller ring drive system may be housed within the wing and operatively connected to the impeller blades (16) of each contra-rotatable propulsion impeller ring (14) and arranged to individually and incrementally pivot the impeller blades to provide variable pitch control (16). The propulsion impeller ring drive system (14) may be arranged to impart counter-rotational force to counter-rotate the impeller blades (14).

[0092] In certain non-limiting embodiments, it may be desirable to have co-rotating coaxial impellers. For instance, one ring is provided having a first set of blades optimized for fuel efficiency, and another ring is provided having a second set of blades optimized for lifting force. During lift off, the second set of blades may be used, with the first set pitched to avoid interaction, or to compliment the second set of blades. Once leveled, the first set of blades may provide sufficient thrust in conjunction with the airfoil configuration, thereby realizing fuel efficiency benefits.

[0093] The multiple impeller rings herein may be driven by a single powerplant or each may be individually driven.

[0094] FIGS. 18, 19 and 20 show various configurations for a cockpit payload enclosure (10). The cockpit may contain conventional apparatus and systems as found in aircraft, including avionics, flight controls, weapons systems controls, “black box” apparatus. In addition, as discussed herein, the cockpit may also contain mechanisms and con-

trols for the cockpit sphere, e.g., to alter center of gravity. In addition, as discussed herein, a parachute and retraction system may be included. Furthermore, a radar and thermal imaging (e.g., FLIR) region 58 may be provided, schematically depicted in FIG. 1.

[0095] Furthermore, the cockpit may be formed of a suitable shape. For instance, FIG. 18 shows a cockpit payload enclosure (10) in a generally spherical configuration having an airfoil control surface enveloping pivot axle (52). FIG. 19 is a schematic side view of a cockpit payload enclosure (10) in a tear-drop configuration, for instance, suitable to serve as a middle wing of a tri-plane configuration in generally level flight as described herein. FIG. 20 is a schematic side view of alternative cockpit payload enclosure (10) configuration, having a truncated trailing end.

[0096] The cockpit payload enclosure (10) may include a spherical or hemispherical outer wall that is partially transparent and partially opaque. Alternatively, portions of the outer wall may be convertible from opaque to transparent through any one of a number of different means to include polarization or coatings. The outer wall of the cockpit payload enclosure (10) may be battle-hardened or armored. The outer wall may be completely or almost completely transparent to allow for unprecedented viewing above, to the sides, behind, and below during hover, transition, and/or aerodynamic flight.

[0097] As shown in certain non-limiting embodiments, the powered-lift aircraft (24) may in effect operate as a tri-plane, having upper and lower wings, and along the gimbal plane, exhaust gases vectored as thrust or lift, as well as middle wings provided by airfoil-enclosed cockpit/payload enclosure (10) Pivot axles (52), i.e., the axles that allow the gimbaling interaction and may optionally encompass the prime mover(s) (36).

[0098] Also, an emergency ballistic recovery system can be provided that includes an automatic riser retractor configured to partially retract risers and/or a cable suspending at least a portion of a powered-lift aircraft (24) from a parachute or parasail canopy immediately following chute deployment. In addition, a second retraction stage may be added to further soften the landing, activated by a ground proximity sensor.

[0099] FIG. 21A shows a parachute deployment and retraction system, and FIG. 21B shows a parachute retraction mechanism.

[0100] The cockpit/payload enclosure (10) may also include an emergency ballistic recovery system including a parachute or parasail housed within a ballistic package (FIG. 21A) along with an expulsion propellant (46) such as a pyrotechnic or compressed gas charge (FIG. 21B). The ballistic package may be housed within the cockpit support (56). The emergency ballistic recovery system may also include an automatic retractor configured to partially retract a cable connected to risers suspending the powered-lift aircraft (24), or some portion thereof, from a canopy of the parachute or parasail as required to obtain a “full chute” as rapidly as possible, ensuring rapid canopy inflation, increasing the margin of safety, especially in low altitude deployment. In addition, a second retraction stage may be added to further soften the landing, activated by a ground proximity sensor.

[0101] Referring now to FIG. 22, in certain embodiments, access and egress to and from the cockpit enclosure (10) may be accomplished by a stress bearing cockpit support 56,

for example, which telescopes from a closed position to an open position. The cockpit payload enclosure (10) may be pivotally mounted to maintain a generally constant level attitude relative to the earth's surface whether the wing (60) and propulsion impeller ring (14) are oriented axially vertically for vertical, or near vertical flight or hovering (e.g., FIG. 1). The wing (20) and propulsion impeller ring (16) are oriented axially horizontally for translational or generally level flight (e.g., FIG. 2, or the wing (60) is transitioning between the axially vertical and horizontal attitudes.

[0102] The powered-lift aircraft (24) may include a cockpit payload enclosure (10) attitude control system that includes a cockpit payload enclosure (10) attitude drive operatively connected between the cockpit payload enclosure (10) and the wing (60), a controller connected to the attitude drive, and an attitude sensor such as a mechanical or ring-laser gyroscope. The controller may be programmed to maintain a longitudinal axis of the cockpit payload enclosure (10) in a generally level attitude relative to the earth's surface in response to signals received from the attitude sensor.

[0103] Relying on aerodynamics alone for vertical stability of a powered-lift aircraft (24) is not as stable as when relying on the positioning of the center of gravity of the powered-lift aircraft (24). For this reason, the powered-lift aircraft (24) may be configured to rely on the positioning of its center of gravity as the default source of vertical stability or orientation of the cockpit payload enclosure (10). For instance, in the embodiments where the cockpit (10) is fixed with respect to the axle (54), a pilot may rotate a lever that is fixed to the axle, thereby altering the center of gravity. Rotating the cockpit payload enclosure's (10) center of gravity forward causes the wing (60) to transition from an axially vertical attitude to an axially horizontal attitude for forward horizontal flight. Rotating the cockpit payload enclosure's (10) center of gravity backward returns to the wing (60) to an axially vertical attitude for hovering, vertical flight, and/or landing. Asymmetrical thrust can be achieved radially through differential pitch control which is another way to control the wing (60)'s aspect relative to its horizontal to vertical axis. The cockpit payload enclosure (10) may be maintained in a vertical attitude unless the powered-lift aircraft (24) is banking in a turn. However, in other embodiments the cockpit payload enclosure (10) may be supported in such a way as to be driven to rotate in any orientation and may include an attitude control system that provides whatever attitude is commanded.

[0104] In certain embodiments, where the axle (54) rotates freely in a suitable bearing in the wing (60), as shown in side view in FIG. 23, the wing tilt control may include one or more belts (7) having one end associated with the axle (54) (which passes centrally through the cockpit payload enclosure (10)) and another end associated with a pulley (8), for instance, supported on a base 9 in the cockpit (10). The pulley (8) may be actuated, for example, to tilt the wing 60 to the position of wing (60').

[0105] In other embodiments, the axle 54 rotates freely through the cockpit, where it is controlled at the wing (60). For instance, as shown in FIG. 24, an axle (54) includes gear structures (6) at the ends, which cooperate with pinions (5) that are drive by an actuator (4). In this manner, the cockpit 10 may be rotated with respect to the wing (60).

[0106] Various alternatives are possible. FIG. 25 shows rudders (66) and blades (16) extending radially inward from

the propulsion impeller ring (14). Rudders (66) may be used generally as is conventionally known, to deflect air for steering, descent, ascent, and other various induced maneuvers. These may be used, for instance, in combination with the previously described control methodologies including impeller pitch control and/or wing tilt control.

[0107] Referring to FIGS. 26 and 27, another non-limiting wing configuration is shown. FIG. 26 shows a side view of the aircraft, and FIG. 27 shows a perspective view of a wing structure (1060) according to this embodiment. In general, the center of gravity of the cockpit (1010) is raised, for instance, by providing protrusions (1061) on the wing (1060). In this manner, the overall dimensions of the wing (1060) may be reduced. Also shown in FIG. 26 is a shroud (1055) surrounding the axle (1054), for instance, to provide an airfoil and serve as a middle wing in a tri-plane configuration discussed herein.

[0108] In other non-limiting embodiments, additional lift may be generated by redirecting the exhaust of the prime mover through a plenum in the gimbals axle and around the circumference of the cockpit payload enclosure, where the exhaust gases escape under pressure from actuated nozzles along the rear plenum of the cockpit payload enclosure, accelerated by incoming air scooped in along the leading plenum of the cockpit payload enclosure.

[0109] Using the disclosed powered-lift aircraft it is possible to experience powered-lift flight with a virtually seamless translation between vertical take off, hover, translation to aerodynamic, forward flight, with a return to hover and/or landing (VTOL). The load sharing axes of this powered-lift aircraft (24) share dynamic loads of weight, thrust, drag, and lift. The method of manufacture and the materials chosen may allow for low weight and high strength construction. A lower gross weight powered-lift aircraft (24) obviously requires less power, less fuel, and operates at lower cost. Also, unlike existing tilt-rotor VTOL aircraft that include axle-driven propellers and rotors that suffer from tip vortices thrust loss, a powered-lift aircraft (24) constructed according to the above-described embodiments will avoid such liabilities. The advantages and benefits of the disclose powered-lift aircraft can have significant military, commercial, and personal transportation implications.

[0110] Certain non-limiting benefits, features and/or advantages for one or more of the embodiments described herein can include, but are not limited to or required, the following:

[0111] 1. Provides a method of powered-lift flight that includes creating vectored thrust sufficient to achieve powered-lift, where the thrust is generated by at least one impeller blade attached to at least one propulsion impeller ring, installed in a wing.

[0112] 2. Provides at least one wing with asymmetrical aerodynamic lifting surfaces.

[0113] 3. Provides at least one impeller blade inside the wing.

[0114] 4. Provides at least one impeller blade mounted inside the propulsion impeller ring.

[0115] 5. Provides at least one cockpit payload enclosure mounted generally within the axial rotation of the propulsion impeller ring.

[0116] 6. Provides at least one load sharing axis, gimbals axle that connects the wing with the cockpit payload enclosure.

[0117] 7. Transition of the vehicle's lift can be seamlessly shifted between the impeller blade(s) and the lifting surfaces of the wing, successfully transitioning from hover, where lift can be substantially generated by the impeller blade(s) to forward flight, where impeller blade(s) lift also becomes thrust, and can be substantially augmented by the lifting surfaces of the wing;

[0118] 8. Flight control can be provided by a fly-by-wire system.

[0119] 9. Forward flight can be accomplished without asymmetric rotor lift penalties associated with "leading and lagging rotor" lift scenarios of rotorcraft, where the wing being gimbaled at some aspect horizontal axis to gain advantage of its lifting surfaces while allowing the impeller blade(s) to generate horizontal thrust.

[0120] 10. The cockpit payload enclosure can be provided in a position generally at the center of the propulsion impeller ring to provide controllability resulting from thrust being vectorable in all directions and to provide maneuverability due to the mass of the cockpit payload enclosure being in the center of the propulsion impeller ring and because the wing is free to gimbal around it.

[0121] 11. A wing with aerodynamic lifting surfaces, at least one impeller blade attached to at least one propulsion impeller ring, installed in the wing; at least one cockpit payload enclosure mounted generally within an axial rotation of the propulsion impeller ring; where the wing, in vertical orientation, provides structural support for control and a substantially vertical airfoils configured to enhance the aerodynamic efficiency of hover and load transmission from the propulsion impeller ring to the cockpit payload enclosure. The wing, from a horizontal axis in the circular view, can include four quadrants including an upper aerodynamic lifting quadrant at the top of the wing, two side housing quadrants on either side of the wing, and a lower aerodynamic lifting quadrant at the bottom of the wing.

[0122] 12. The side housing quadrants of the wing can house one or more components selected from the group of components comprising: at least one prime mover, a power transfer unit, fuel or energy storage, cockpit and/or payload, and flight-related components. Alternatively, the side housing quadrants of the wing can house one or more components selected from the group of components comprising: a jet turbine, a rotary engine, a motor, a battery, a fuel cell, a capacitor, compressed gas, a photovoltaic cell, a prime mover, a belt drive, a gear drive, an electric drive, a hydro drive, a gas drive, a traction/friction drive; nuclear fuel, liquid fuel, compressed gas fuel, solid fuel, a battery, electronics, avionics, landing gear, and a storage space.

[0123] 13. The upper and lower quadrants can be configured to generate lift by means of angle of attack and an aerodynamic shape such that this section of the wing creates lift in the manner normally associated with a fixed wing, and such that the upper and lower quadrants can provide a bi-wing configuration in a flying duct.

[0124] 14. The cockpit can be an airfoil-enclosed cockpit payload enclosure which can have pivot axles that may in effect operate as a tri-plane, having upper and lower wings as well as middle wings.

[0125] 15. Additional lift may be generated by redirecting the exhaust of the prime mover through a plenum in a gimbal axle and around the circumference of the cockpit payload enclosure, where the exhaust gases escape under pressure from actuated nozzles along the rear plenum of the cockpit

payload enclosure, accelerated by incoming air scooped in along the leading plenum of the cockpit payload enclosure. The additional lift can be created along the gimbal plane, as exhaust gases are vectored as thrust or lift, depending upon the orientation of the wing and the cockpit payload enclosure.

[0126] 14. In the propulsion impeller ring, at least one impeller blade(s) can extend generally inward from upper and lower attach points and can be connected to the propulsion impeller ring at these points and can extend from the ring itself toward a center of rotation, thereby reducing or eliminating "tip vortices losses" associated with traditional propeller and rotor designs.

[0127] 15. A moment of movement of the entire propulsion impeller ring is generally close to a center of lift of the impeller blade(s).

[0128] 16. More than one propulsion impeller ring can be included in a powered-lift aircraft.

[0129] 17. At least two of the propulsion impeller rings can be supported for counter-rotation.

[0130] 18. Squash plates controlled by either rollers and/or air bearing and/or mounted billows configured to control the angle of attack of the impeller blade(s) can be provided, thereby imparting variable lift, rotational resistance, and gyroscopic procession forces.

[0131] 19. One of the Rims may contain a different number of impeller blade(s) than another of the rims.

[0132] 20. One of the propulsion impeller rings may support impeller blade(s) of differing design than the impeller blade(s) supported on another of the propulsion impeller rings.

[0133] 21. The propulsion impeller ring can be rotated in a "E-shaped cross section" support cavity within the wing.

[0134] 22. The propulsion impeller ring can be supported by one or more of the structures included in the group comprising: wheels, rollers, pulleys, rails, magnetic separation, air Bearings, or some combination of air, gas, and/or fluid suspension.

[0135] 23. The propulsion impeller ring can be a component of an electric brushless motor.

[0136] 24. The impeller blade(s) can be attached to the propulsion impeller ring and is configured to generate lift in a vertical axis, and to generate thrust in a horizontal axis, and some combination of lift and thrust in transition.

[0137] 25. The impeller blade(s) can have a constant cross-sectional shape along its length,

[0138] 26. The impeller blade(s) can have a consistent but tapered cross sectional shape along its entire length.

[0139] 27. The impeller blade(s) can have an asymmetrical shape along its length.

[0140] 28. The impeller blade(s) can have a curved shape along its length.

[0141] 29. The impeller blade(s) can have a tapered shape along its length.

[0142] 30. The impeller blade(s) can have a twisted shape along its length.

[0143] 31. The impeller blade(s) can have a tapered and twisted shape along its length.

[0144] 32. The impeller blade(s) can have no tip.

[0145] 33. The impeller blade(s) can be connected in two places to the impeller blade.

[0146] 34. The tip of the impeller blade(s) can be unconnected.

- [0147] 35. The tips of the impeller blade(s) can be connected to an interior propulsion impeller ring.
- [0148] 36. The tips of the impeller blade(s) can connect to each other.
- [0149] 37. The propulsion impeller ring can include upper and lower pitch control rings joined angularly on the ring's inner wall by attachment points to the impeller blade(s).
- [0150] 38. The cockpit payload enclosure may include one or more items selected from the group of items comprising: pilot and/or passenger seating, a first responder gurney, cargo space, ordnance and munitions, telemetry equipment, avionics, electronic warfare equipment, reconnaissance and surveillance equipment, broadcast equipment, advertising, network operating center hardware, a prime mover, fuel, and cargo.
- [0151] 39. The cockpit payload enclosure can be coated.
- [0152] 40. The cockpit payload enclosure can be pressurized.
- [0153] 41. The cockpit payload enclosure can be armored.
- [0154] 42. The cockpit payload enclosure can be transparent.
- [0155] 43. The cockpit payload enclosure is protected by polarization filters.
- [0156] 44. The cockpit payload enclosure can have a shape including one or more shapes selected from the group of shapes comprising: a sphere, a teardrop, an ovoid, and an ellipsoid, or any other enclosure shape that would fit within the void created by the orbit and gimbaling of the impeller blade(s).
- [0157] 45. Load sharing axes that can be connection points and gimbals that can facilitate independent rotation of the wing.
- [0158] 46. Load sharing axes that can be connection points and gimbals that can facilitate independent rotation of the cockpit payload enclosure.
- [0159] 47. The load sharing axes can be configured to allow thrust created by the impeller blade(s) in the propulsion impeller ring to rotate around the cockpit payload enclosure.
- [0160] 48. A powered-lift aircraft that includes one or more propulsion impeller rings that are carried by a generally cylindrical wing and rotatably supported within a generally cylindrical cavity defined by the wing.
- [0161] 49. The propulsion impeller rings can be rotatably supported within the generally cylindrical cavity defined by the generally cylindrical wing.
- [0162] 50. The one or more propulsion impeller rings can be disposed between an inner surface of the wing and a cockpit payload enclosure that's surrounded by and pivotally mounted to the wing.
- [0163] 51. An attitude control system which can be configured to maintain a longitudinal axis of the cockpit payload enclosure in a generally constant level attitude relative to the earth's surface independent of the attitude of the wing.
- [0164] 52. An emergency ballistic recovery system that can include an automatic riser retractor configured to partially retract risers and/or a cable suspending at least a portion of a powered-lift aircraft from a parachute or parasail canopy immediately following chute deployment.
- [0165] 53. A generally cylindrical wing having a non-constant cross-sectional shape contoured to provide lift in at least one of an upper and a lower semi-cylindrical portion of the wing.
- [0166] 54. A propulsion impeller ring drive system supported within a generally cylindrical wing.
- [0167] 55. A propulsion impeller ring drive system that can include a propulsion impeller ring comprising a plurality of impeller blades pivotally supported on a ring for variable pitch control and can include an asymmetric impeller blade pitch control system operatively connected to the impeller blades and actionable to cause the propulsion impeller ring to provide asymmetrical thrust by individually and differentially controlling the pitches of the impeller blades.
- [0168] 56. An asymmetric impeller blade pitch control system comprising a pair of pitch control rings that sandwich impeller blades of a propulsion impeller ring and are asymmetrically manipulable in such a way as to cause the propulsion impeller ring to provide asymmetrical thrust through individual differential control of the pitches of the impeller blades.
- [0169] 57. Billow-mounted air bearings that can be disposed between the pitch control rings and the impeller blades.
- [0170] 58. A generally cylindrical wing housing a mechanically driven propulsion ring that derives power from at least one prime mover, and a mechanical drive operatively connected to the propulsion impeller ring and including one or more components selected from the list of components comprising of a belt-drive, a friction roller drive, a magnetic drive, an electric motor, a gear drive, and some combination of air, gas or liquid bearing drive.
- [0171] 59. A rotatable propulsion impeller ring drive system comprising contra-rotatable propulsion impeller rings supported by air bearings.
- [0172] 60. A method of controlling the attitude of an airborne vehicle by asymmetrically controlling the pitch of impeller blades.
- [0173] 61. An aircraft comprising: a toroid-shaped wing having an inner surface and with the wing defining a cylindrical cavity; one or more propulsion rings carried upon the inner surface of the wing; and at least one powerplant operably coupled to the one or more propulsion impeller rings to impart rotational force to the one or more propulsion impeller rings, wherein rotation of the propulsion rings causes thrust sufficient to achieve powered lift.
- [0174] 62. A cockpit payload enclosure surrounded by and pivotally-mounted to the wing with an axle structure that can be connected to opposing sides of the wing in gimballed relation, the axle structure can be rotatably supported on opposing sides of the wing and fixed on the cockpit payload enclosure or rotatably supported on the cockpit payload enclosure and fixed on opposing sides of the wing.
- [0175] 63. The axle structure can be rotatably supported on opposing sides of the wing and fixed on the cockpit payload enclosure.
- [0176] 64. The axle structure can be rotatably supported on the cockpit payload enclosure and fixed on opposing sides of the wing.
- [0177] 65. At least one of the one or more propulsion rings includes at least one impeller blade.
- [0178] 66. During powered lift operations, rotation of the wing relative to the cockpit payload enclosure can change the direction of thrust.
- [0179] 67. During powered lift operations and in a configuration where the wing is non-vertical, the wing can provide additional lift.
- [0180] 68. The wing can include airfoil shaped sections.

[0181] 69. A pair of propulsion rings can be provided that are supported for contra-rotation, each propulsion ring including at least one impeller blade.

[0182] 70. One or more squash plates controlled by rollers, air bearing, mounted billows, or a combination of one or more of rollers, air bearing, and mounted billows, wherein the squash plates configured to control the angle of attack of the impeller blades, thereby imparting forces selected from the group comprising variable lift, rotational resistance, gyroscopic procession forces, and a combination comprising at least one of variable lift, rotational resistance and gyroscopic procession forces.

[0183] 71. The cockpit payload enclosure can have a shape including one or more shapes selected from the group of shapes comprising: a sphere, a teardrop, an ovoid, an ellipsoid, and any other enclosure shape that would fit within the cylindrical cavity and not impaired by orbit and gimbaling of the propulsion ring.

[0184] 72. An attitude control system configured to maintain a longitudinal axis of the cockpit payload enclosure in a generally constant level attitude relative to the earth's surface independent of the attitude of the wing.

[0185] 73. The cockpit payload enclosure can have a shape including one or more shapes selected from the group of shapes consisting of a teardrop, an ovoid, and an ellipsoid, and further wherein during non-vertical flight, the cockpit payload enclosure can serve as a middle wing in a tri-plane configuration.

[0186] 74. An asymmetric impeller blade pitch control system including an apparatus for sandwiching impeller blades of the propulsion ring and for asymmetrically manipulating the impeller blades in such a way as to cause the propulsion ring to provide asymmetrical thrust through individual differential control of the pitches of the impeller blades.

[0187] 75. The propulsion ring can be supported by one or more of the structures included in the group comprising wheels, rollers, pulleys, rails, magnetic separation, air bearings, and a combination of air, gas, and/or fluid suspension.

[0188] As seen in FIGS. 28 through 34, leading and/or trailing edge flaps preferably provided on the wing Structure can be provided as another control method. Thus, one or more flaps may be engaged to influence or redirect air flow. Multiple flaps can be utilized as a control authority mechanism and may impart control forces such as torque, lift, breaking or shielding. This can direct thrust while grounded and hovering like a hovercraft just above a surface, in or out of ground effect or while flying forward. When hovering like a hovercraft, the flaps can act like a vent or gate and allow air to be expelled substantially in a direction opposite of desired drift. When hovering out of ground effect, the one or more flaps can aid in drifting sideways or "crabbing" while hovering or in transition to forward flight.

[0189] Though described above as flaps, the movable surfaces on the wings can be flaps, slats, ailerons, spoilers, etc. These movable surfaces can be located anywhere on the wing structure and may be activated using hydraulics, electromechanical motors, electrohydraulic combination systems, etc.

[0190] FIGS. 35 through 37 illustrate an airflow attitude control system that can be provided with one or more embodiments of the disclosed novel aircraft. As an alternative or in addition to movable surfaces on the wing structure (see FIGS. 28 through 34), the aircraft may use an attitude

control system which can preferably use air blown from openings or vents on the wing structure. The bursts of air impart forces or alter the pressure differential around or over the wing structure through one or multiple air vents or outlets circumferentially positioned along the leading edge, trailing edge or anywhere within the duct housing, which may be employed either independently or collectively to maintain stability or affect maneuvers throughout various flight modes. The velocity of the airflow through the vents may also be adjusted, either independently or collectively, through valves, vanes or other methods. This attitude control method may use air deflected from the main propulsion system impellers, engine discharge or air generated through an electrically powered distributive airflow system housed within the wing structure. The airflow vents may be activated manually or through an automated fly-by-wire (FBW) system, which can use sensors to detect changes in aircraft flight orientation. Actuation of components may be accomplished through magnetic forces, pneumatics, hydraulics, electric-mechanical motors or an electro-hydraulics combination.

[0191] FIGS. 38 through 41 illustrate an embodiment where one or multiple propulsive units can be provided within the wing structure. The number of propulsive units is not considered limited to any particular value. As seen, one or more prime movers or propulsive units can be mounted centrally within the gap of the outer wing structure that can be suspended or affixed within the air stream or disc loading area. Any number of impellers with any number of blades can be used and located within the wing structure, preferably in a balanced arrangement, which may be used as a prime mover for main propulsion. These propulsive units can be attached to the airframe structure and powered by an electric motor, hybrid electric motor or combustion engine. The drive systems may include gears, belts, bearings, friction rollers or magnets.

[0192] FIGS. 42 and 44 illustrate different non-limiting shapes and mounting for the cockpit enclosure. As seen, the cockpit payload may be composed of one or more shapes, structures or cavities that may also be composed of any shape, as viewed from a plan view (top down) or from the side that may be used to contain payload of software, hardware, fuel, batteries, energy storage, weapons, parachutes, passengers, cargo, etc. The shaped enclosure may or may not be pivotally mounted to the cross member suspending axle. The shaped enclosure can be mounted at a predetermined angle of attack or fixed to the outer ring wing structure as to be structurally and dimensionally unified.

[0193] FIGS. 45 through 47 illustrate different non-limiting shapes for the wing, in addition to the shapes shown in the earlier figures. Thus, the outer wing structure area shape can be any shape that is preferably endless/continuous. Certain non-limiting shapes shown, in addition to the earlier shown round or ring shaped, include without limitation, roundish, ellipse, oval, hexagon, octagon, polygon, pentagon, square, diamond, or any shape that may encompass via a radial plane inwardly the cockpit payload area."

[0194] FIGS. 48 through 54 illustrate wing-mounted ducted fans that can act as a drive system and/or to control attitude being provided. Thus, the primary central drive rim can also be driven via means of one or more drive motors, rollers, (wheels), drums, disks, gears or pulleys. The central area of the wheels may have spoke-like members, propellers or impeller blades designed to propel, force or thrust air and

may be used as another means of aerodynamic control. For example, if three are dispensed 120 degrees apart on the outer rim/outer surface and are driven one or more by a prime mover, since they are radially outward of the rim, the ducted fans may have increased mechanical advantage or torque influence on the total wing structure. The ducted fans may also be enclosed in nacelle covers that can be opened and closed or flow reduced independently for precision control. Accordingly, the main impeller drive rim can be driven by the external ducted fans impellers rims in opposite direction, negating torque and inducing control influence, angle of attack, roll, yaw, speed, altitude. By friction driving the main impeller rim via the external ducted fan impellers, the fans can have more control leverage over the overall aircraft with a less complex drive system. The external drive impellers can also be individually steered or "valved off" by means of closing or constricting the air flow. This can cause the craft to have less lift in that duct section and can cause the overall aircraft to change its angle of attack.

[0195] The one or multiple ducted fans can be integrated into the wing structure within nacelles or affixed to the outside of the wing, likely in a balanced arrangement. The ducted fans can be activated independently or collectively and rotated in different directions. The airflow or thrust discharged at the ducted fan exits can also be used in aerodynamic control. These ducted fans can be powered by an electric motor, hybrid electric motor, combustion engine, etc. The drive systems may include gears, belts, bearings, friction rollers or magnets.

[0196] As seen in FIGS. 55 through 57 wing-mounted propellers can be provided to control attitude. The wing mounted propellers can be provided as an alternative to the wing-mounted ducted fans in FIGS. 48 through 54, can comprise one or more open rotors or propellers that can be mounted on the wing structure, fixed or pivotally, likely in a balanced arrangement, for attitude control. The propellers may be independently or collectively activated, and can have tilting capability, which may be actuated using magnetic forces, pneumatics, hydraulics, electric-mechanical motors, electro-hydraulics combination, etc. Power can be supplied by electric motors, hybrid electric motors, combustion engines, etc. The drive systems can include gears, belts, bearings, friction rollers or magnets.

[0197] As described and shown, the novel device provides for a powered lift ducted fan system which can allow for a seamless transition from vertical to forward flight with operational flexibility. The device can be preferably provided with a rotatable ring-wing, dual shrouded contra-rotating impellers, a central axle-mounted payload compartment and the ability to take off or land on almost any surface, including water. As a scalable and multi-purpose platform, the novel aircraft's size and capabilities can be expanded depending on the mission requirements, from a small frame UAV (or drone) to potentially a heavy lift cargo and even passenger transport aircraft, either manned or unmanned.

[0198] In certain embodiments, the device can be a relatively small, high-performance UAV, which can primarily be used for consumer and commercial applications and can feature a globular, high visibility medial fuselage, designed for hemispherical viewing. Improved safety on the ground, low noise levels and the ability to operate in more confined environments can be provided. In other embodiments, a larger scale, optionally piloted version can be provided to address non-limiting markets such as urban air taxis, rapid

cargo delivery services and personal flying vehicles. In a further embodiment, a wedge-shaped aerodynamic fuselage can be provided for greater speed and stealth and can be for military applications though such use is not considered limiting.

[0199] The aircraft can be a powered-lift flying vehicle preferably incorporating a VTOL platform for relatively seamless transition from vertical to forward flight. As a preferably scalable system, the aircraft can be configured for different sizes depending on the application, such as, without limitation, from a small frame UAV to a large frame, piloted heavy lift or passenger transport aircraft.

[0200] The aircraft can include a ducted fan propulsion, an annular wing (ring-wing), a central cockpit/payload compartment or fuselage, and a load-sharing axle which can bridge the annular wing and fuselage. The payload compartment, can be either fixed or pivotally mounted on the axle, preferably maintains a generally upright orientation under normal operating parameters through an attitude control system using gyro-assisted stabilization technology, and through weight distribution, by positioning its center of gravity or balancing point generally in the lower half. This central payload section can take any number of shapes including, without limitation, spherical, oval or even teardrop, which approximates an airfoil with the characteristics of a lifting body. The annular wing can serve as the duct for the impellers, providing lift through its aerodynamic surfaces in the upper and lower quadrants, and directional control through its ability to partially rotate around the fuselage, along with the impeller rings, to change thrust vector and angle of attack. Lift produced by the airfoil wing structure can equal or exceed lift generated from the impellers in forward flight. To actuate the pivoting of the wing on the axle, a hydraulic or otherwise powered wing tilting gear mechanism can be used, the components of which can be housed in nacelles, the raised areas at opposing ends of the wing. The transverse axle can function as a structural support and can be fitted with movable aerodynamic surfaces to become a middle wing or an attitude control device by deflecting airflow. The leading edges of the wing, control surfaces and sections of the fuselage may be scalloped to improve efficiency. These protruding ridges, which can be referred to as tubercles, can reduce drag and increase lift. Other flight dynamics can be managed by adjusting the preferred independently operated impellers, using cyclic and collective pitch controls, similar to those on conventional helicopters. Small frame UAV models may use fixed pitch contra-rotating impellers. Another complex system for maintaining lateral stability can include the use of actuators to impart active differential thrust, called distributed electric propulsion, which generates moments by accelerating air around key points on the aircraft. Another embodiment can augment pitch and roll control through the addition of independently actuated thrust deflector vanes or control surfaces just beneath the impellers toward the duct exit. In addition to increased efficiency from shared disc loading, the dual contra-rotating impellers, rotating in opposite directions, has the advantage of balancing the effects of torque. Ducting or shrouding the impeller blades within the ring-wing structure can also be provided to provide the aircraft with the ability to operate in closer proximity to obstacles, such as buildings, which expands its applicability in urban environments. The ducted fan also can deliver significantly greater static thrust, and therefore higher efficiency, when

compared to open rotors of similar diameter. The duct prevents losses in thrust from the tips of the propeller (i.e. blade-tip losses) and allows for a higher operating rotational speed. Compared with open rotor aircraft, the disclosed aircraft can have greater operational flexibility and a smaller logistical footprint, with superior maneuverability, speed, safety, noise levels and efficiency. In its amphibious embodiment, the disclosed aircraft can have the ability to take off or land on almost any surface, including water, through flotation of the annular wing and fuselage.

[0201] Payload, range and speed requirements of the disclosed aircraft, as well as other operational considerations, can determine the type of propulsion system (prime mover) and energy source, that is chosen for a particular embodiment of the disclosed aircraft. The propulsion system may include combustion engines that can run on jet fuel, gasoline, natural gas, propane, hydrogen and biofuels, hybrid-electric motors, or electric motors that use hydrogen fuel cells or lithium-ion batteries, possibly in combination with supercapacitors. Supercapacitors can boost power during flight and quickly recharge by capturing and storing excess energy. As battery energy density continues to improve, hybrid-electric or fully electric power systems can become more feasible for short range and even extended range aircraft. Various configurations of gear, belt, friction or other drive systems may be used to turn the impeller rotor(s). In one embodiment, a scalable drive system with a ring-shaped architecture (i.e. “hubless motor,” “shaftless motor,” “rim-driven system,” etc.) can be used. In this type of electromagnetic drive system, the rotational force that drives the impeller can be generated through the interaction of circumferentially arranged permanent magnets attached to the outside of the impeller ring (rotor) and a stator integrated into the surrounding structure and not through a mechanical link such as a shaft or hub.

[0202] The disclosed aircraft platform can be designed to rebalance the center of thrust, lift forces and distribution of pressure in certain flight conditions, particularly during the shift from hover to forward flight, through coordinated incremental adjustments to engine thrust, impeller blade pitch, control vane defectors and wing orientation. The aircraft can maintain equilibrium through center of gravity and gyro-assisted stabilization of the payload compartment. Implementing active flow control actuators, air injection outlets circumferentially positioned within the interior of the duct, can also be provided to augment traditional trim control methods. Leading-edge flow control mechanisms can use either steady or synthetic jets of high-pressure air blowing outward toward the direction of the oncoming wind, separating the airflow over the duct lip. A side effect of this leading-edge flow separation can be a lowering of thrust, which may require additional propulsive power in proportion to increases in flight speed. Installing flow control actuators near the trailing edge of the duct, blowing air toward the duct exit, uses a Coandă surface to expand the airflow leaving the duct and does not negatively affect thrust. Each of these configurations has its advantages, with leading-edge flow control being preferred at higher angles of attack, and the two techniques may be used simultaneously or independently.

[0203] The disclosed aircraft can be designed for increased safety, reliability and efficiency while preferably matching or exceeding performance levels of existing VTOL aircraft in terms of range, maneuverability, logistical

footprint, payload, ceiling, operational flexibility and speed. The disclosed aircraft can incorporate some level of AI technology in its unmanned, optionally-manned and piloted aircraft through an intuitive or adaptive flight control system, including through the use of one or more sensors on the aircraft for collecting data.

[0204] As a failsafe, the disclosed aircraft may include dual engine systems, each of which can individually supply adequate thrust for normal lift and flight, and modular redundancy in all safety-critical systems, including electronic displays, electronic flight controls and certain mechanical components. For additional safety, a ballistic recovery parachute can be installed in manned versions of the aircraft, preferably located in the center compartment dome. In emergency situations, such as incapacitation of the pilot or if the aircraft is unable to fly, a rocket-powered parachute can be deployed, and the aircraft can slowly descend to the ground.

[0205] The disclosed aircraft can be capable of launching from or landing at almost any location and without runway infrastructure and can provide for direct point to point flights. Landing, eliminating this process can be a major safety advantage. The disclosed aircraft’s preferred relatively compact VTOL format with ducted fan blades has the advantage of greater safety on the ground and within more confined environments, with lower noise and vibration, compared to traditional helicopters.

[0206] There are numerous potential applications in military and commercial aviation for the disclosed aircraft platform, in unmanned or manned configurations. As one non-limiting example, in military aviation, the aircraft can be purposed for missions ranging from ISR to combat support, with mounted weapons systems and the ability to deliver ordnance, including missiles, bombs and rockets via the payload area or wing structure. The ISR aircraft may be mounted with radar, sensors and camera systems to transmit real-time data and imagery. The aircraft can also be used in explosives detection or to support secure wireless communications. In another embodiment/application, a personnel and heavy lift cargo transport aircraft can be designed to deliver troops, equipment and supplies or for insertion/extraction pararescue (PJ) operations. The ability to fly at low altitudes and in confined environments, close to buildings and terrain with elevations where radar is ineffective, makes the disclosed aircraft useful in many military missions. In addition, to further evade detection or interception, the aircraft can be optimized its stealth properties on its military aircraft. The device can inherently have low infrared (IR) emissions a low acoustic and vibration signature with internally housed propulsion systems and ducted impellers and can reduce its radar profile through the use of radar-absorbing materials and IR-suppression techniques. In an amphibious embodiment, with VTOL on water, adds another dimension to the military uses of the disclosed aircraft. In another embodiment preferably for the military (though not limited thereto) the aircraft can have a low-profile, wedge-shaped payload area or fuselage.

[0207] In the commercial sector, the disclosed platform can be used for aircraft ranging from small frame UAVs to large scale manned and unmanned passenger or cargo aircraft. In a small UAV format, the disclosed aircraft can carry a variety of payloads for a range of applications, including, without limitation, package delivery, security, surveillance, detection, exploration, inspection, mapping or aerial imag-

ery. As a larger aircraft, the disclosed aircraft can be designed for low-altitude, local transportation purposes as either an air taxi, personal flying vehicle or a short haul cargo aerial vehicle, an area of aviation called urban air mobility (UAM). The disclosed aircraft can also be used for recreational purposes and personal enjoyment. In one embodiment for commercial purposes the disclosed aircraft can have a spherical payload area or fuselage.

[0208] One or more of the following components or features can be provided in at least certain embodiments such as, without limitation, a payload compartment, central axle, ring wing and impeller powered with remotely controlled battery powered motors and a gear drive system. In certain embodiments, a spherical center compartment can be provided, such as, without limitation, in certain commercial applications as UAVs and short haul passenger transport. In other embodiments, a wedge-shaped aerodynamic center compartment which approximates an airfoil can be provided and can be intended for military operations, though such is not limiting. Each of the configurations can be scalable and may be used for unmanned or manned systems.

[0209] Though not limiting, as mentioned above, preferably for military applications, the aircraft can have an airfoil shaped fuselage or payload compartment to reduce drag and provide for a reduced radar profile. The aircraft may carry a range of payloads, including, without limitation, HD video cameras, electro-optic/infrared (EO/IR) sensors, communications relay equipment, Lynx multi-mode all weather radar, synthetic aperture radar (SAR), active electronically scanned array (AESA) radar, signal intelligence (SIGINT), thermal imagers, laser designators, range finders (LDRF), hyperspectral systems, electronic intelligence (COMINT and ELINT), electronic warfare (EW), communications jamming (COMJAMM), wideband Ku SATCOM and LOS, ground moving target indicating (GMTI), wide-area surveillance (WAAS) equipment and mapping systems. In a combat role, which may include, without limitation, air-to-surface, air-to-air and air-to-missile combat, the aircraft can be equipped with advanced weapons systems for carrying out precision airstrikes, including Viper Strike laser-guided glide weapons, laser-guided rockets, JAM guided bombs, GBU-12 Paveway II bombs, Hellfire missiles, Advanced Precision Kill Weapon System (APKWS), multi-spectral targeting system and laser range finder/designators. A large scale military VTOL aircraft embodiment may be used, without limitation, in missions currently performed by helicopters, such as troop transport, combat search and rescue, medical evacuation, as well as delivering supplies.

[0210] All measurements, dimensions, shapes, amounts, angles, values, percentages, materials, degrees, configurations, orientations, component layouts and configurations, mechanical/electrical supports, mechanical/electrical connection mechanisms, mechanical/electrical movement mechanisms, drive systems, product layout, components or parts; component or part locations, sizes, number of sections, number of components or parts, etc. discussed above or shown in the Figures are merely by way of example and are not considered limiting and other measurements, dimensions, shapes, amounts, angles, values, percentages, materials, degrees, configurations, orientations, component layouts and configurations, mechanical/electrical supports, mechanical/electrical connection mechanisms, mechanical/electrical movement mechanisms, drive systems, product layout, components or parts; component or part locations,

sizes, number of sections, number of components or parts, etc. can be chosen and used and all are considered within the scope of the invention.

[0211] It will be seen that the objects set forth above, and those made apparent from the foregoing description, are efficiently attained and since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matters contained in the foregoing description shall be interpreted as illustrative and not in a limiting sense. The aircraft has been shown and described herein in what is considered to be the most practical and preferred embodiment.

[0212] It should be understood that the exemplary embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments. While one or more embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from their spirit and scope.

[0213] Unless feature(s), part(s), component(s), characteristic(s) or function(s) described in the specification or shown in the drawings for a claim element, claim step or claim term specifically appear in the claim with the claim element, claim step or claim term, then the inventor does not consider such feature(s), part(s), component(s), characteristic(s) or function(s) to be included for the claim element, claim step or claim term in the claim when and if the claim element, claim step or claim term is examined, interpreted or construed. Similarly, with respect to any “means for” elements in the claims, the inventor considers such language to require only the minimal amount of features, components, steps, or parts from the specification to achieve the function of the “means for” language and not all of the features, components, steps or parts describe in the specification that are related to the function of the “means for” language.

[0214] Dimensions and/or proportions of certain parts in the figures may have been modified and/or exaggerated for the purpose of clarity of illustration and are not considered limiting.

[0215] While the aircraft and method of use have been described and disclosed in certain terms and has disclosed certain embodiments or modifications, persons skilled in the art who have acquainted themselves with the disclosure, will appreciate that it is not necessarily limited by such terms, nor to the specific embodiments and modifications disclosed herein. Thus, a wide variety of alternatives, suggested by the teachings herein, can be practiced without departing from the spirit of the disclosure, and rights to such alternatives are particularly reserved and considered within the scope of the disclosure.

[0216] While preferred embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the disclosure. Accordingly, it is to be understood that the novel aircraft and method of use have been described by way of illustrations and not limitation. This description and the accompanying drawings illustrate exemplary embodiments for the aircraft. Other embodiments are possible and modifications may be made to the exemplary embodiments without departing from the spirit and scope of the disclosure. It will be apparent to one of ordinary skill in the art that the

embodiments as described above may be implemented in many different embodiments of aircrafts, and in drive systems for other aircraft types as well. Therefore, the description and drawings are not meant to limit the invention. Instead, the appended claims define the scope of the disclosure.

What is claimed is:

1. A powered-lift aircraft capable of vertical take-off and vertical landing, hovering and translational and traverse flight, comprising:

a continuous wing having a cavity and an inner surface, the continuous wing defining a central open space area; one or more propulsion impeller rings rotatably supported within the cavity of the continuous wing;

a cockpit or payload enclosure disposed within a portion of the central open space area and pivotally mounted to and at least partially surrounded by the continuous wing; and

an attitude control system configured to maintain a longitudinal axis for the cockpit or payload enclosure in a generally constant level attitude relative to earth's surface and independent of an attitude of the continuous wing;

wherein during vertical takeoff of the aircraft the one or more propulsion impeller rings rotate at rotational speeds that are sufficient to provide enough thrust force to overcome a weight amount of the aircraft;

wherein the continuous wing axially horizontally oriented during level flight of the aircraft.

2. The powered-lift aircraft of claim 1 wherein portions of the continuous wing having a non-constant cross-sectional shape contoured for providing lift.

3. The powered-lift aircraft of claim 1 further comprising an impeller ring drive system that is supported within the continuous wing or the cockpit or payload enclosure.

4. The powered-lift aircraft of claim 1 further comprising a plurality of impeller blades that are pivotally or rotatably connected to at least one of the one or more propulsion impeller rings for variable pitch control, the plurality of impeller blades extending inward from the pivot connection to the impeller rings such that an outer portion of the plurality of impeller blades are positioned within the central open space area defined by the continuous wing and generally pointing toward the cockpit or payload enclosure.

5. The powered-lift aircraft of claim 4 further comprising an asymmetric impeller blade pitch control system operatively connected to the impeller blades to allow for individual and differential control of the impeller blades by the blade pitch control system to cause the one or more propulsion impeller rings to provide asymmetrical thrust.

6. The powered-lift aircraft of claim 2 wherein the one or more propulsion impeller rings are a pair of propulsion impeller rings housed within the cavity and such that a first of the pair of propulsion impeller rings rotates in a clockwise or counter-clockwise manner and the second of the pair of propulsion impeller rings rotates in an opposite manner as the rotation of the first propulsion impeller ring.

7. The powered-lift aircraft of claim 1 further comprising an emergency ballistic recovery system associated with the cockpit or payload enclosure.

8. The powered-lift aircraft of claim 1 wherein the continuous wing axially vertically oriented during vertical flight, hovering and vertical landing of the aircraft.

9. The powered-lift aircraft of claim 4 wherein the impeller blades extend radially inward from at least one of the one or more of the impeller rings.

10. The powered-lift aircraft of claim 1 further comprising an axle extending from a first area of the continuous wing to a second area of the continuous wing and across the central open space area and connected to the cockpit or payload enclosure for providing pivotal communication between the cockpit or payload enclosure and the continuous wing.

11. The powered-lift aircraft of claim 1 further comprising one or more powerplants secured to the continuous wing and operatively associated with the one or more propulsion impeller rings for causing the one or more propulsion impeller rings to rotate.

12. The powered-lift aircraft of claim 4 further comprising a drive system housed within the continuous wing for individually and incrementally pivoting the plurality of impeller blades to provide variable pitch control.

13. The power-lift aircraft of claim 4 wherein each of the plurality of impeller blades can be individually manipulated to pivot or rotate in a particular direction independent of the other impeller blades of the plurality of impeller blades.

14. The power-lift aircraft of claim 1 further comprising one or more air bearings for supporting the one or more propulsion impeller rings within the cavity of the continuous wing.

15. The power-lift aircraft of claim 1 wherein the cockpit or payload enclosure having a teardrop or airfoil configuration which serves as a middle wing of a tri-fold configuration during generally level flight of the aircraft.

16. A powered-lift aircraft capable of vertical take-off and vertical landing, hovering and translational and traverse flight, comprising:

a continuous wing having a cavity and an inner surface, the continuous wing defining a central open space area; one or more propulsion impeller rings rotatably supported within the cavity of the continuous wing;

a cockpit or payload enclosure disposed within a portion of the central open space area and pivotally mounted to and at least partially surrounded by the continuous wing; and

an attitude control system configured to maintain a longitudinal axis for the cockpit or payload enclosure in a generally constant level attitude relative to earth's surface and independent of an attitude of the continuous wing;

wherein during vertical takeoff of the aircraft the one or more propulsion impeller rings rotate at rotational speeds that are sufficient to provide enough thrust force to overcome a weight amount of the aircraft;

17. The powered-lift aircraft of claim 16 further comprising movable surfaces provided on a leading or trailing edge of the continuous wing and movable from an open position to a closed position; wherein in the open position the movable surface influence or redirect air flow.

18. The powered-lift aircraft of claim 16 wherein the continuous wing defining one or more air vents or outlets circumferentially positioned along a leading edge or trailing edge of the continuous wing and further comprising one or more move valves or vanes to control airflow through the vents.

19. The powered-lift aircraft of claim 16 further comprising one or more ducted fan assemblies mounted to the continuous wing.

20. The powered-lift aircraft of claim **16** further comprising one or more propeller assemblies mounted to the continuous wing.

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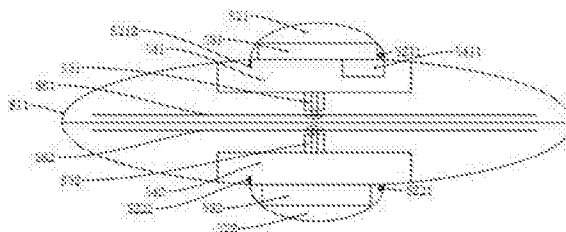
权利要求书1页 说明书2页 附图1页

(54)发明名称

一种碟形无人机

(57)摘要

本发明公开了一种碟形无人机,包括碟形外壳,电池,螺旋桨,重心控制单元,所述碟形外壳内上部连接上控制仓,所述上控制仓下部固定上电机,所述上电机下部连接上机翼,所述碟形外壳内部下侧连接下控制仓,所述下控制仓上部连接下电机,所述下电机上部连接下机翼,所述控制仓下部连接云台。本发明的碟形飞行器气动性好,结构简单,震动小,可广泛便于消费者使用。



1. 一种碟形无人机, 包括碟形外壳, 电池, 螺旋桨, 重心控制单元, 其特征在于, 所述碟形外壳内上部连接上控制仓, 所述上控制仓下部固定上电机, 所述上电机下部连接上机翼, 所述碟形外壳内部下侧连接下控制仓, 所述下控制仓上部连接下电机, 所述下电机上部连接下机翼, 所述控制仓下部连接云台。

2. 根据权利要求1所述的一种碟形无人机, 其特征在于, 所述重心控制单元为所述碟形无人机可移动可拆卸电池, 控制所述可拆卸电池重心水平左右移动, 前后移动的重心控制仓组成。

3. 根据权利要求1所述的一种碟形无人机, 其特征在于, 所述碟形外壳为镂空结构。

4. 根据权利要求1所述的一种碟形无人机, 其特征在于, 所述上下电机在同一竖直轴线上。

5. 根据权利要求4所述的一种碟形无人机, 其特征在于, 所述同一竖直轴线为碟形无人机中轴线。

6. 根据权利要求4所述的一种碟形无人机, 其特征在于, 所述上下机翼以碟形无人机中心水平面对称。

7. 根据权利要求4所述的一种碟形无人机, 其特征在于, 所述上下机翼尺寸相同。

8. 根据权利要求1所述的一种碟形无人机, 其特征在于, 所述上控制仓与下控制仓通过固定在外壳上的导线连接。

一种碟形无人机

技术领域

[0001] 本发明涉及一种飞行器,尤其是一种碟形无人机。

背景技术

[0002] 近年来无人机发展迅速,大多数无人机采用的是都是多旋翼型无人机,多旋翼无人机所需旋翼多为四翼或者八翼,机翼过多导致飞机重量较大,造成飞机飞行时间较短,同时由于机翼裸露在外面得不到保护容易被撞毁,同时由于多旋翼无人机的机壁结构导致无人机体积较大,结构较为复杂,同时多旋翼无人机气动性能效率不高。

发明内容

[0003] 为了克服上述现有技术的不足,本发明的目的是提供一种碟形无人机。

[0004] 为解决上述技术问题,本发明的技术方案是:一种碟形无人机,包括碟形外壳,电池,螺旋桨,重心控制单元,其特征在于,所述碟形外壳内上部连接上控制仓,所述上控制仓下部固定上电机,所述上电机下部连接上机翼,所述碟形外壳内部下侧连接下控制仓,所述下控制仓上部连接下电机,所述下电机上部连接下机翼,所述控制仓下部连接云台。

[0005] 所述重心控制单元为所述碟形无人机可移动可拆卸电池,控制所述可拆卸电池重心水平左右移动,前后移动的重心控制仓组成,所述碟形外壳为镂空结构,其特征在于,所述上下电机在同一竖直轴线上,所述同一竖直轴线为碟形无人机中轴线,所述上下机翼以碟形无人机中心水平面对称,所述上下机翼尺寸相同,所述上控制仓与下控制仓通过固定在外壳上的导线连接。

[0006] 本发明有益效果:本发明碟形无人机采用同轴双桨结构,提高无人机机翼气动性,提高无人机飞行效率,同时结构简单,保护无人机机翼,同时防碰撞,结构轻便,便于控制,同时节省了空间。

[0007] 附图说明:

本发明可以通过附图给出的非限定性实例进一步说明。

[0008] 图1是碟形无人机的正面结构示意图。

[0009] 图2是碟形外壳的俯视结构示意图。

[0010] 图中:碟形外壳S11,可翻盖外壳S21,电池S31,旋柱S211,卡槽S212,上控制仓S41,重心控制仓S411,上电机S51,上机翼S61,可翻盖外壳S22,旋柱S221,云台S32,下控制仓S42,下电机S52,下机翼S62

具体实施方式:

下面结合附图和实施例对本发明作进一步说明

如图1:一种碟形无人机,包括碟形外壳S11,碟形外壳是内外连通结构,优选地由网状结构构成的,从图2中它的俯视示意图可以看到,网状结构内外连通,从而使机翼S61,S62转动时内外气体流动,碟形外壳上部连接半椭圆形可翻盖外壳S21,翻盖外壳保护电池S31,电池S31可以左右前后水平移动,电池保护壳通过旋柱S211可以打开和关闭,同时卡槽S212可

以在可翻盖外壳时固定可翻盖外壳S21,可翻盖外壳S21可以起到保护电池和碟形无人机的作用,碟形外壳内部上部连接上控制仓S41,上控制仓内部有控制系统,控制无人机的飞行模块,拍照模块,图像传输模块,电机控制舱内部有重心控制仓S411,重心控制仓S411与电池S41共同构成了重心控制单元。上控制仓下部固定上电机S51,上电机S51可以进行转动方向调制,上电机下部安装上机翼S61,碟形无人机下部连接着可翻盖外壳S22,可翻盖外壳S22通过旋柱S221进行打开和关闭,同时有卡槽S222可以在椭圆形外壳关闭时进行固定,椭圆形外壳S22内部包裹着云台S32,云台连接在底部控制仓S42底座上,底座上面连接着下控制仓S42,下控制仓内部有电调模块,云台控制模块,控制仓上部连接着下电机S52,电机上部连接着下机翼S62,上控制仓和下控制仓连接时,将导线固定在碟形飞行器的外壳上面,避免了导线对机翼的影响。优选地使上下机翼S61,S62沿着碟形无人机中心面对称,同时上下机翼S61,S62尺寸相同,同时上下电机S51,S52都在碟形无人机的中轴线上,可以使无人机的气动性达到最大。无人机起飞时,通过飞行控制模块控制机翼S61和机翼S62沿着同一个方向旋转控制无人机起飞,在空中停留时,通过飞行控制模块降低机翼S61与S62转速来控制飞机在空中静止,需要下降时通过飞行控制模块控制飞机机翼S61与机翼S62旋转方向来控制飞机的下降。当需要前进或者后退时,通过控制模块,控制重心控制重心控制单元,移动电池S31方向,控制碟形无人机的重心,同时通过飞行模块控制机翼S61与S62旋转方向控制飞机前进与后退;需要左右移动时,通过控制模块控制重心控制单元控制电池S31左右移动控制无人机的中心,同时通过控制电机的速度与旋转方向控制电机的左右移动。

[0011] 如图2:从图中可以看到碟形外壳呈网状结构。

[0012] 以上所述的本发明实施方式,并不构成对本发明保护范围的限定。任何在本发明的精神和原则之内所作的修改、等同替换和改进等,均应包含在本发明的权利要求保护范围之内。

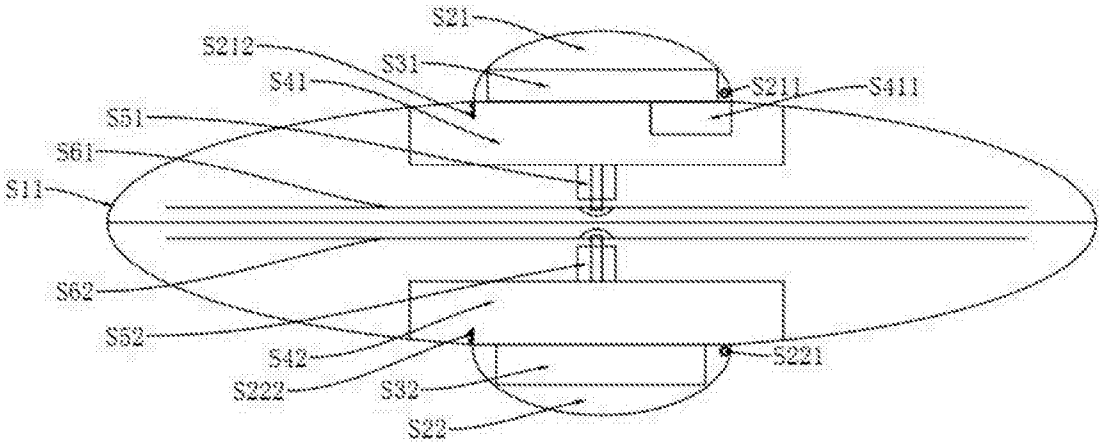


图1

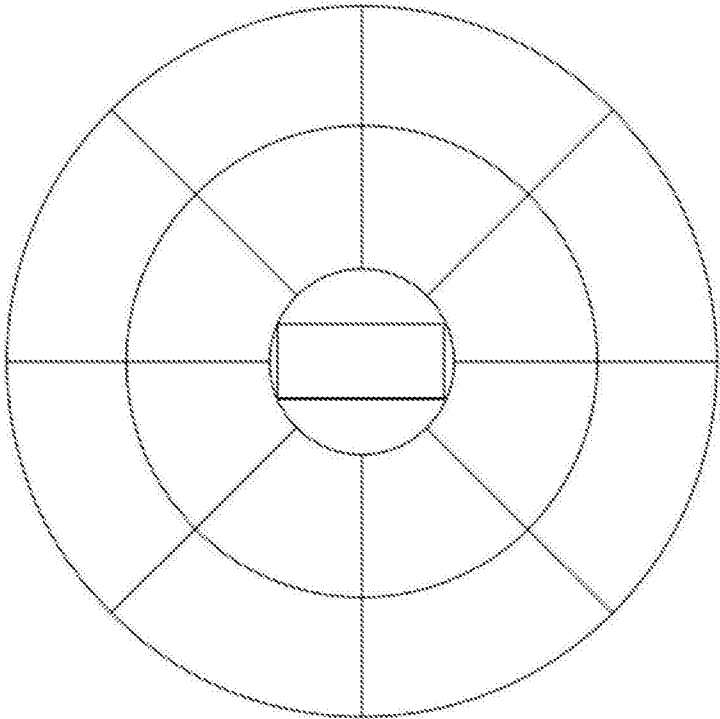


图2


 ФЕДЕРАЛЬНАЯ СЛУЖБА
 ПО ИНТЕЛЛЕКТУАЛЬНОЙ СОБСТВЕННОСТИ

(12) ОПИСАНИЕ ИЗОБРЕТЕНИЯ К ПАТЕНТУ

На основании пункта 1 статьи 1366 части четвертой Гражданского кодекса Российской Федерации патентообладатель обязуется заключить договор об отчуждении патента на условиях, соответствующих установившейся практике, с любым гражданином Российской Федерации или российским юридическим лицом, кто первым изъявил такое желание и уведомил об этом патентообладателя и федеральный орган исполнительной власти по интеллектуальной собственности.

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 (54) **ДИСКОЛЕТ**

(57) Реферат:

Изобретение относится к авиационной технике, в частности к конструкциям комбинированных летательных аппаратов. Дисколет включает корпус, соединенный свободно без трансмиссии с несущим тонким диском, снабженным складными радиальными лопастями центробежного вентилятора, закрепленными шарнирно к верхней плоскости диска. По периферии диска расположены регулируемые лопасти осевого вентилятора, преобразующегося в несущий винт в вертикальном полете и в кольцевое крыло в

горизонтальном полете. Под диском установлены складывающиеся заподлицо с нижней поверхностью диска лопасти привода вращения диска реактивными газами двигателей. Двигатели закреплены к корпусу при помощи стабилизаторов управления полетом. Достигается возможность объединить свойства дискового крыла самолета, которое создает подъемную силу при обтекании воздушного потока в горизонтальном полете, с несущим винтом в вертикальном полете. 2 ил.



FEDERAL SERVICE
FOR INTELLECTUAL PROPERTY

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(12) ABSTRACT OF INVENTION

According to Art. 1366, par. 1 of the Part IV of the Civil Code of the Russian Federation, the patent holder shall be committed to conclude a contract on alienation of the patent under the terms, corresponding to common practice, with any citizen of the Russian Federation or Russian legal entity who first declared such a willingness and notified this to the patent holder and the Federal Executive Authority for Intellectual Property.

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Mikhajlov Sergej Vladimirovich (RU)

(54) **DISC CRAFT**

(57) Abstract:

FIELD: aircraft engineering.

SUBSTANCE: proposed craft comprises the frame coupled without transmission with bearing thin disc equipped with folding radial blades of centrifugal fan articulated with the disc top surface. Axial fan adjustable blades are arranged the disc edges converting into rotor in vertical flight and into circular wing in

horizontal flight. Disc drive blades folding flush with the disc bottom surface are arranged under the disc, disc being spinned by engine jet gas. Engines are secured to aforesaid frame by flight control fins.

EFFECT: combined design.

2 dwg

RU 2 515 823 C1

RU 2 515 823 C1

Изобретение относится к авиационной технике, в частности к самолетам, автожирам, вертолетам, и может быть использовано для создания преобразуемого летательного аппарата.

Известен дисколёт по патенту РФ №2101215 С1, состоящий из корпуса, соединенного
 5 свободно, без трансмиссии, с несущим диском, снабженным лопастным центробежным вентилятором с окнами по периметру диска и осевым вентилятором, установленным по периферии диска с регулируемыми и втягиваемыми в диск лопастями, двигателями. Диск разделен на воздушную и лопастную части диаметральной перегородкой, первая часть снабжена окнами соплами вытеснения сжатого воздуха для привода вращения
 10 диска, а во второй расположены лопасти с барабаном и тросом намотки. Однако такая конструкция сложна и имеет большое поперечное сечение диска, что ухудшает аэродинамику горизонтального полета.

Изобретение направлено на устранение указанных недостатков.

Достигается это тем, что в дисколёте, состоящем из корпуса, соединенного свободно,
 15 без трансмиссии, с несущим диском, снабженным лопастным центробежным вентилятором с окнами по периметру диска, и осевым вентилятором, установленным по периметру диска с регулируемыми лопастями, двигателей, лопасти центробежного вентилятора выполнены складными, при этом лопасти осевого вентилятора преобразуются в кольцевое крыло.

На фиг.1 показан дисколёт, вид сверху, где на верхней половине чертежа показан дисколёт со сложенными в горизонтальной плоскости лопастями для горизонтального полета, на нижней половине чертежа лопасти дисколёта повернуты вертикально для вертикального полета; на фиг.2 - дисколёт, вид сбоку и спереди.

Конструкция включает корпус 1, соединенный свободно, без трансмиссии, с несущим
 25 тонким диском 2, являющимся маховиком и обтекателем, снабженный регулируемыми радиальными лопастями 3, закрепленными шарнирно на верхней плоскости диска 2, образующими центробежный вентилятор с возможностью их складывания заподлицо диска. По периферии диска 2 установлены регулируемые лопасти 7, образующие в горизонтальном положении кольцевое крыло. Под диском 2 установлены
 30 складывающиеся заподлицо нижней поверхности диска лопасти 4 привода вращения диска реактивными газами одного из, как минимум, двух двигателей 5, закрепленных к корпусу 1 при помощи стабилизаторов управления полетом 6. Двигатели 5 оборудованы тормозными интерцепторами, способными отклонять реактивные газы на лопасти 4.

Как вариант (на чертеже не показано), лопасти 3 центробежного вентилятора могут
 35 быть закреплены под диском 2, при этом ступица диска будет иметь спицы, образующие входное окно вентилятора.

Предлагаемая конструкция дисколёта объединяет возможности дискового крыла самолета, которое создает подъемную силу при обтекании воздушного потока в
 40 горизонтальном полете с несущим винтом в вертикальном полете вертолетов и автожиров.

В вертикальном полете лопасти 3 раскладываются перпендикулярно плоскости диска, образуя центробежный вентилятор, подающий воздух на лопасти 7 осевого вентилятора, создавая разрежение над диском, при этом лопасти 7 переводятся на угол
 45 атаки и превращаются в несущий винт, создавая вертикальную тягу и повышенное давление под диском, что обеспечивает подъемную силу дисколёта. Вихревые потоки, образующиеся в результате перепада давления по периметру диска, улавливаются лопастями 7, что дает дополнительную подъемную силу. Лопасти 4, расположенные

под диском 2, устанавливаются в вертикальное положение для взаимодействия с отклоненным интерцепторами реактивным потоком одного из двигателей 5. Поворот диска и компенсация реактивного момента от его вращения осуществляется изменением тяги противоположного двигателя.

5 В горизонтальном полете лопасти 7 устанавливаются на небольшой угол атаки для вращения диска 2, увеличивая аэродинамические качества диска в 2...3 раза по сравнению с неподвижным, а лопасти 4 складываются заподлицо нижней поверхности диска. Управление горизонтальным полетом осуществляется при помощи стабилизаторов 6, а также изменением тяги двигателей 5.

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Формула изобретения

Дисколет, состоящий из корпуса, соединенного свободно без трансмиссии с несущим диском, снабженным лопастным центробежным вентилятором с окнами по периметру диска и осевым вентилятором, установленным по периметру диска с регулируемыми
15 лопастями, двигателей, отличающийся тем, что лопасти центробежного вентилятора выполнены складными, при этом лопасти осевого вентилятора преобразуются в кольцевое крыло.

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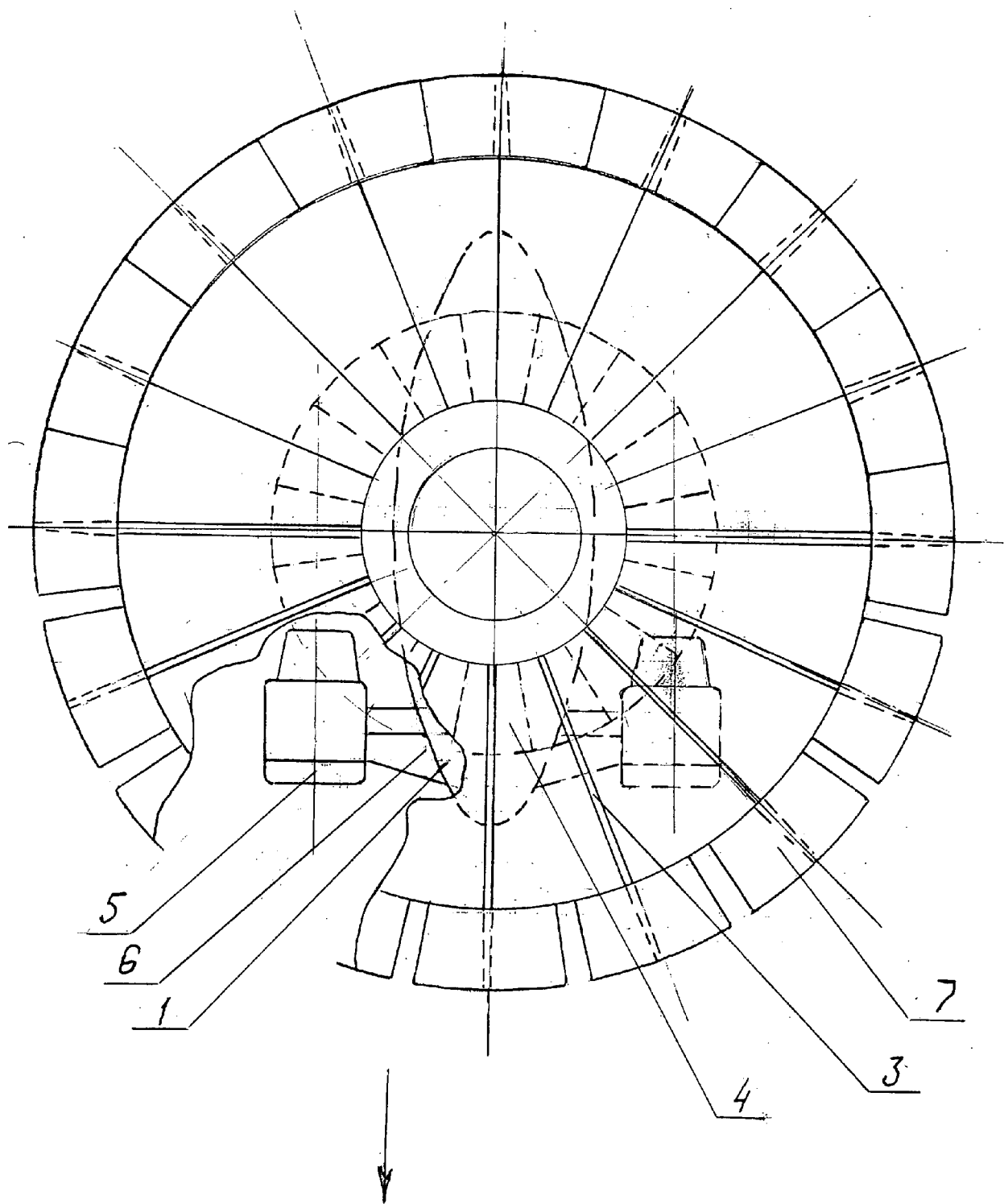
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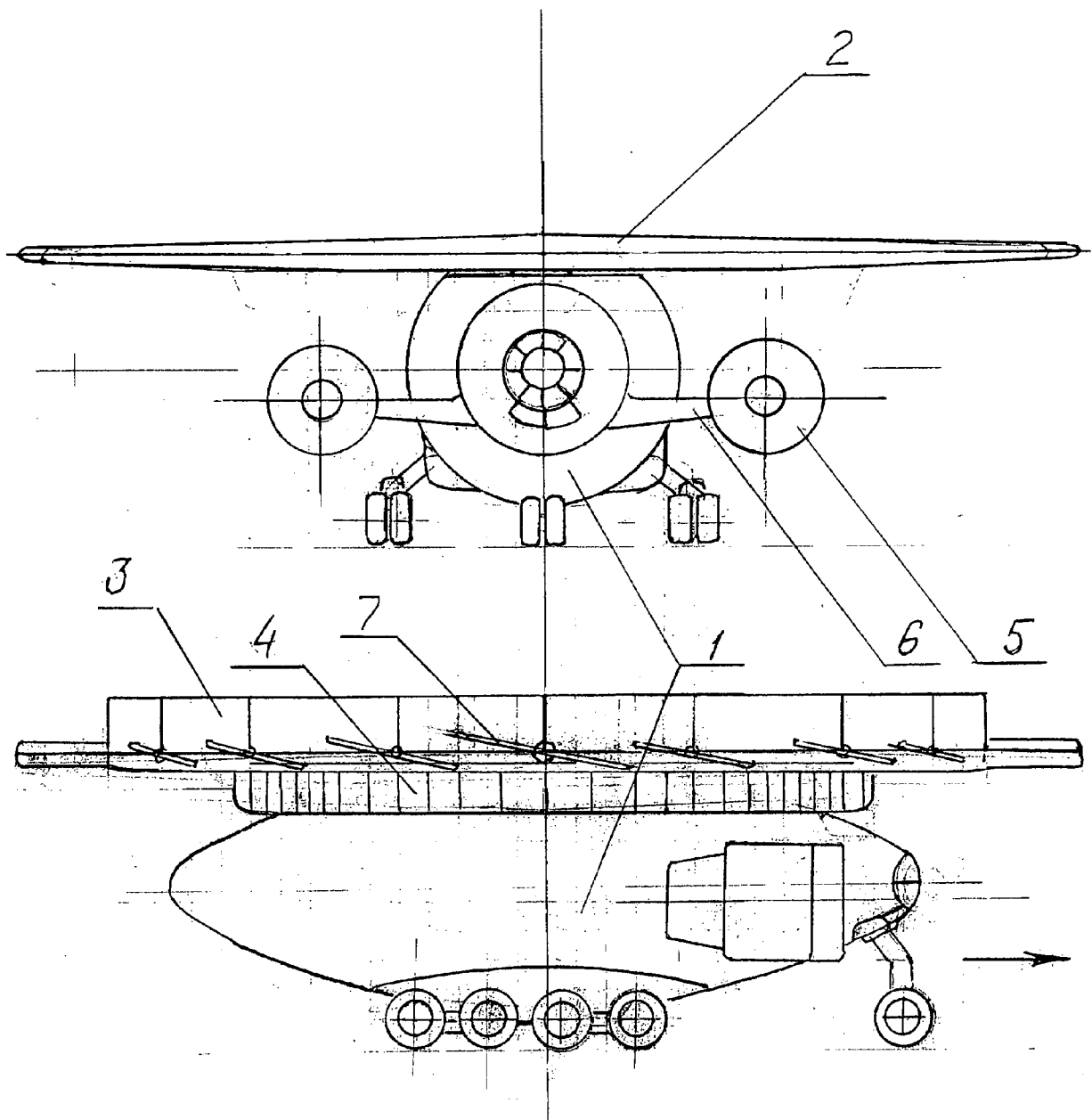
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Фиг. 1



Фиг. 2

(19) 日本国特許庁 (JP)

(12) 公 開 特 許 公 報 (A)

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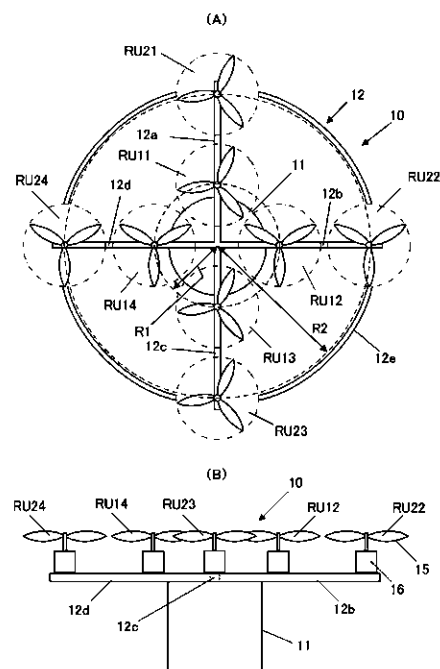
(54) 【発明の名称】 垂直離着陸飛行体

(57) 【要約】 (修正有)

【課題】 複数個のマルチブレードロータ（プロペラ）を備えた飛行体（マルチコプター）において、容易かつ迅速に姿勢制御を行えるようにする。

【解決手段】 機体の中心から所定距離だけ離れた第1円周上に配設された複数の内側ロータユニット（RU11～RU14）と、機体の中心から前記所定距離よりも大きな所定距離だけ離れた第2円周上に配設された複数の外側ロータユニット（RU21～RU24）と、前記内側ロータユニットおよび外側ロータユニットを駆動制御する制御手段とを備えた垂直離着陸飛行体において、機体の浮上は主として内側ロータユニット（RU11～RU14）を動作させて行い、機体の姿勢制御は主として外側ロータユニット（RU21～RU24）を動作させて行うようにした。

【選択図】 図1



【特許請求の範囲】**【請求項 1】**

機体の重心を通る中心軸から所定距離だけ離れた第 1 円周上に配設された複数の第 1 ロータユニットと、前記中心軸から前記所定距離よりも大きな所定距離だけ離れた第 2 円周上に配設された複数の第 2 ロータユニットと、前記第 1 ロータユニットおよび第 2 ロータユニットを駆動制御する制御手段とを備えた垂直離着陸飛行体であって、

前記機体の浮上は、少なくとも前記第 1 ロータユニットを動作させて行い、

前記機体の姿勢制御は、少なくとも前記第 2 ロータユニットを動作させて行うことを特徴とする垂直離着陸飛行体。

【請求項 2】

前記制御手段は、機体をホバリングさせる際には、効率が最大とみなせる回転数領域で前記第 1 ロータユニットの駆動源が回転するように制御することを特徴とする請求項 1 に記載の垂直離着陸飛行体。

【請求項 3】

前記第 1 ロータユニットおよび第 2 ロータユニットをそれぞれ偶数個ずつ備え、前記制御手段は、前記第 1 ロータユニットの半数および前記第 2 ロータユニットの半数を時計回り方向へ回転させ、残りの半数を反時計回り方向へ回転させることを特徴とする請求項 1 または 2 に記載の垂直離着陸飛行体。

【請求項 4】

前記第 1 ロータユニットおよび第 2 ロータユニットをそれぞれ 4 個であることを特徴とする請求項 3 に記載の垂直離着陸飛行体。

【請求項 5】

前記 4 個の第 1 ロータユニットおよび 4 個の第 2 ロータユニットはそれぞれ円周方向に 90 度の間隔で配設されるとともに、前記 4 個の第 2 ロータユニットは前記 4 個の第 1 ロータユニットと円周方向に 45 度ずれた位置に配設されていることを特徴とする請求項 4 に記載の垂直離着陸飛行体。

【請求項 6】

前記第 2 ロータユニットの駆動源は、該駆動源の最大トルクが前記第 1 ロータユニットの駆動源の最大トルクよりも小さな値に設定されていることを特徴とする請求項 1～5 のいずれかに記載の垂直離着陸飛行体。

【発明の詳細な説明】**【技術分野】****【0001】**

本発明は、垂直軸回りに回転駆動されるマルチブレードロータもしくはプロペラを複数個備えた垂直離着陸飛行体（マルチコプター）に関する。

【背景技術】**【0002】**

従来より、垂直離着陸可能な飛行体として、垂直軸回りに回転駆動されるロータもしくはプロペラを複数個備えたマルチコプターが知られている。マルチコプターは、例えばカメラを搭載し遠隔操縦可能に構成することで、人が立ち入れないエリアを空撮して情報を得るのに利用される。かかる遠隔操縦可能なマルチコプターにおいては、姿勢の安定性と操縦性が良好であることが重要であり、安定性と操縦性の向上のために種々の発明が提案されている。

【0003】

例えば、特許文献 1 には、8 個のプロペラユニットを同一円周上あるいは 4 個ずつ 2 段に配置するとともに、周方向へ移動可能に構成する。そして、いずれか 1 個のプロペラユニットが故障し停止した場合には、故障したプロペラユニットの位置へ他のプロペラユニットに近付けることで安定性を高め、安全な飛行、着陸を可能にする飛行体に関する発明が記載されている。

【0004】

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また、特許文献2には、機体の中心に副回転翼（ロータ）を配置するとともに、該副回転翼を中心にして同一円周上に3つの主回転翼（ロータ）を配置した飛行体に関する発明が記載されている。

さらに、特許文献3には、同一円周上に8個のロータを配置するとともに、ほぼ放射状に配設された複数のアームとこれらのアームを連結する円形フレームを設け、各アームの途中にロータを取り付けた飛行体に関する発明が記載されている。

【先行技術文献】

【特許文献】

【0005】

【特許文献1】特開2002-370696号公報

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【特許文献2】特開2003-212191号公報

【特許文献3】特開2011-046355号公報

【発明の概要】

【発明が解決しようとする課題】

【0006】

特許文献1に記載されている発明は、一部のプロペラが停止した場合に安全な飛行を可能にすることを課題とするもので、プロペラユニットを移動可能に構成しているため、構造が複雑になる。また、特許文献1に記載されている飛行体にあつては、水平移動用のプロペラを揚力発生用の8個のプロペラとは別個に胴体部の側部（4箇所）に設けているため、部品点数が多くなり、重量も重くなるという不都合がある。

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【0007】

特許文献2に記載されている飛行体は、ロータの数が4個であるため浮上構造は簡単であるが、燃料タンクをキャビンの外周3カ所または機体内部に配置し、燃料タンク内の航空燃料を相互に移動させることで機体の水平維持を行なうようにしている。そのため、水平維持機構が複雑になる。また、特許文献2には、飛行中に機体が傾斜した場合における瞬時的変位の微調整には、エンジン排出ガスの吐出で行うようにしてもことが記載されている。しかし、そのような姿勢制御を可能にするには、排気ガス吐出口の配置や向き等が制約され、設計上の自由度が減少することとなるとともに、モータを動力源とするマルチコプターにはそのような技術を適用することができないという課題がある。

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【0008】

特許文献3に記載されている飛行体は、複数（8個）のロータを同一円周上に配置するようにしたもので、このような構成にあつては、推力発生部の外形（8個のロータの外接円）ひいては機体全体が大きくなってしまふ。また、全てのロータが対等の関係にあるため、機体を上昇または下降させる場合も姿勢を制御する場合も、全てのロータの回転数（揚力）を考慮して制御する必要がある、制御が複雑になるとともに効率を優先した制御が困難であるという課題がある。

本発明は、上記のような課題に鑑みてなされたもので、複数個のマルチブレードロータ（プロペラ）を備えた垂直離着陸飛行体（マルチコプター）において、容易かつ迅速に姿勢制御を行えるようにすることを目的とする。

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【課題を解決するための手段】

【0009】

上記目的を達成するため、本発明は、

機体の重心を通る中心軸から所定距離だけ離れた第1円周上に配設された複数の第1ロータユニットと、前記中心軸から前記所定距離よりも大きな所定距離だけ離れた第2円周上に配設された複数の第2ロータユニットと、前記第1ロータユニットおよび第2ロータユニットを駆動制御する制御手段とを備えた垂直離着陸飛行体であつて、

前記機体の浮上は、少なくとも前記第1ロータユニットを動作させて行い、

前記機体の姿勢制御は、少なくとも前記第2ロータユニットを動作させて行うように構成した。

【0010】

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上記構成によれば、機体の中心から離れるほど小さな揚力で機体を傾ける大きなモーメントを発生することができるため、第2ロータユニットを動作させて機体の姿勢制御を行うことで姿勢制御に伴うロータの回転数の変化を小さくすることができる。その結果、所望の姿勢に変化させるのに要する姿勢制御の応答時間を短くすることができる。さらに、少ない力で姿勢制御を行なえるので、外側に配置されるロータユニットとしてサイズの小さなものを使用することができ、飛行体の小型、軽量化が可能になる。また、機体の浮上は、主として内側位置する第1ロータユニットを動作させて行うので、ロータユニットの性能に差があって揚力変化が多少ばらついたとしてもそれによるモーメントが小さいため、姿勢の安定性が損なわれにくい。

【0011】

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また、望ましくは、前記制御手段は、機体をホバリングさせる際には、効率が最大とみなせる回転数領域で前記第1ロータユニットの駆動源が回転するように制御するように構成する。

かかる構成によれば、ロータユニットの駆動効率を向上させることができ、より長時間、長距離の飛行が可能となる。

【0012】

また、望ましくは、前記第1ロータユニットおよび第2ロータユニットをそれぞれ偶数個ずつ備え、前記制御手段は、前記第1ロータユニットの半数および前記第2ロータユニットの半数を時計回り方向へ回転させ、残りの半数を反時計回り方向へ回転させるように構成する。

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かかる構成によれば、ロータユニットの回転駆動で生じる反トルクを容易に相殺させて、機体が回転するのを防止することができる。

【0013】

さらに、望ましくは、前記第1ロータユニットおよび第2ロータユニットをそれぞれ4個であるように構成する。

かかる構成によれば、姿勢制御が容易であると共に、4個の第1ロータユニットまたは4個の第2ロータユニットのうちいずれか一つが故障して回転が停止したとしても、残りのロータユニットを使用して安全かつ容易に機体を着陸させることができる。

【0014】

また、望ましくは、前記4個の第1ロータユニットおよび4個の第2ロータユニットはそれぞれ円周方向に90度の間隔で配設されるとともに、前記4個の第2ロータユニットは前記4個の第1ロータユニットと円周方向に45度ずれた位置に配設されているようにする。

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かかる配置としては、例えば図3(A)、(B)や図4(A)に示すような配置が考えられる。このような配置にすることで、機体に8個のロータユニットを搭載する場合に、ロータユニットの集積度を高めることができ、飛行体の小型化が可能になる。

【0015】

さらに、望ましくは、前記第2ロータユニットの駆動源は、該駆動源の最大トルクが前記第1ロータユニットの駆動源の最大トルクよりも小さな値に設定されているように構成する。

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かかる構成によれば、揚力発生用のロータユニットの駆動源を大きくする一方、姿勢制御用のロータユニットの駆動源は小さくできるため、姿勢の制御性を良好にしつつ機体の安定性を高めることができる。

【発明の効果】

【0016】

本発明によれば、複数のマルチブレードロータ（プロペラ）を備えた垂直離着陸飛行体（マルチコプター）において、容易かつ迅速に姿勢制御を行うことができる。言い換えると、本発明によれば、姿勢の安定性を保持しつつ機体を昇降させる際のロータの制御が比較的容易なマルチコプターを実現することができるという効果がある。

【図面の簡単な説明】

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【0017】

【図1】図1は本発明の実施形態に係る垂直離着陸飛行体としてのマルチコプターの概略を示すもので、(A)は平面図、(B)は正面図である。

【図2】図2は実施形態に係るマルチコプターの制御システムの構成例を示すブロック図である。

【図3】図3(A)～(C)は実施形態に係るマルチコプターの変形例を示すロータ配置図である。

【図4】図4(A)～(C)は実施形態に係るマルチコプターの他の変形例を示すロータ配置図である。

【図5】図5はロータユニットに使用するモータの特性の一例を示す特性図である。

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【発明を実施するための形態】

【0018】

以下、図面を参照しながら、この発明の一実施形態について詳しく説明する。

図1は、本発明の実施形態に係る垂直離着陸飛行体（以下、マルチコプターと称する）の概略を示すもので、(A)は平面図、(B)は正面図である。

図1(B)に示すように、本実施形態のマルチコプター10は、演算制御装置やバッテリー、ジャイロスコープのような姿勢センサ、カメラなどを収納した筒状の胴体部11と、該胴体部11の上部に固定されたフレーム12とを有する。

【0019】

フレーム12は、図1(A)に示すように、機体の中心から放射状に伸び互いに直角をなすように配設された4本のアーム12a、12b、12c、12dと、該アーム12a～12dの先端を結合する円環状の機枠12eとから構成されている。機枠12eは、円環状に限定されず、楕円形や多角形などであってもよい。

なお、機体は、その重心が上記アーム12a～12dの中心を通る鉛直線上に来るように、各構成部品の形状、配置等が設計される。フレーム12は、航空機分野では一般的な、例えば炭素繊維強化プラスチック(CFRP)やチタン合金、アルミ合金のような軽量で強度の高い材料で構成するのが望ましい。

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【0020】

また、マルチコプター10は、アーム12a～12dの中間位置にそれぞれ装着された4個のロータユニットRU11～RU14と、アーム12a～12dの先端部にそれぞれ装着された4個のロータユニットRU21～RU24とを備える。言い換えると、ロータユニットRU11～RU14は機体の中心から半径R1の円周上に90度間隔で配設され、ロータユニットRU21～RU24は機体の中心から半径R2(≒2×R1)の円周上に90度間隔で配設されている。

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ロータユニットの数は8個に限定されず、6個あるいは10個以上であってもよいが、反トルクによる機体の回転を防止する観点から、偶数個とするのが望ましい。

【0021】

上記ロータユニットRU11～RU14とRU21～RU24は、図1(B)に示すように、それぞれ、ロータ15、該ロータ15を回転駆動するモータのような駆動源16、該駆動源16を制御するコントローラ(図示省略)などから構成されている。

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1本のアーム上に2個のロータユニットを取り付けている本実施例では、ロータ15の直径をDとすると、半径R1とR2の関係は、 $R1 < R2$ 、 $R2 - R1 > D$ であればよく、例えばR1はR2の $1/2$ とすることが考えられる。ただし、ロータユニットRU11(RU13)およびこれと隣接する他のアーム上のロータユニットRU12、RU14のロータ同士の干渉を防止するため、 $R1 > D \div \sqrt{2}$ を満足するようにR1、R2、Dの値を決定する。

【0022】

さらに、本実施例では、演算制御装置は、内側に位置する4個のロータユニットRU11～RU14は、揚力発生用のロータとして動作するように制御する。また、外側に位置する4個のロータユニットRU21～RU24は、主として姿勢制御用のロータとして動

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作するように制御する。さらに、移動のための推力は、左右または前後のロータの回転数をアンバランスにして機体を傾けるように制御することにより得る。

また、特に限定されるものではないが、反トルクによる機体の回転を防止するため、8個のロータユニットのうち4個は時計回り方向へ回転させ、残りの4個は反時計回り方向へ回転させる。具体的には、例えば、機体の中心を挟んで対向する位置に配置されているロータユニットのロータ同士は、互いに逆方向に回転させるように制御することが考えられる。

【0023】

上記のように、8個のロータユニットを設けることにより、いずれかのユニットが故障してロータが停止しても、残りのユニットの推力（回転数）を適宜制御することによって、安全に着地させることができる。

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また、外側に位置する4個のロータユニットRU21～RU24を姿勢制御用のロータとして動作させることによって、てこの原理から、内側のロータユニットよりも少ない回転数の変化で発生するモーメントを大きくすることができることが分かる。つまり、姿勢制御に伴うロータの回転数の変化を小さくすることができ、これにより、所望の姿勢に変化するのに要する姿勢制御の応答時間を短くすることができる。さらに、少ない力で姿勢制御を行なえるので、ロータユニットRU21～RU24のモータやロータとして、RU11～RU14よりも小さなものを使用した軽量のユニットとすることができる。

【0024】

また、上記のように、内側に位置する4個のロータユニットRU11～RU14を揚力発生用のロータとして動作させ、一定の回転数で回転させることにより、浮上に必要な消費電流を一定にすることができる。その結果、バッテリーの容量を最適化することが容易となり、高効率化を達成することができる。

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より具体的には、モータの特性を図示すると、図5に示すようになる。図5において、符号Aで示す直線は電流－トルク特性、符号Bで示す直線は回転数－トルク特性、符号Cで示す曲線は効率－トルク特性を示す。図5より、トルクが小さ過ぎても大き過ぎても効率は低下し、使用するモータにより最大効率となる時のトルクの大きさおよび回転数が決まっていることが分かる。

【0025】

一方、1個のロータユニットの推力は、モータのトルクと使用するロータの特性（形状、大きさ等）で決まる。従って、機体全体の重量Wが決まったら、モータの最大効率時のトルクで決定されるロータユニットの推力をTとすると、 $T = W / 4$ なる性能のモータを選択する。

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そして、そのようなモータをロータユニットRU11～RU14の駆動源として機体に搭載し、最大効率となる時の回転数で回転させれば、浮上（ホバリング）時に最大効率となるようにモータを駆動制御することができる。また、バッテリーの容量は、上記のようにして決定したモータの消費電流と、目標とする飛行時間および移動距離等から決めることができる。

【0026】

図2は、上記のような構成のマルチコプター10の制御システムの構成例を示す。

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図2に示すように、制御システムは、マルチコプター10の制御系30と、マルチコプター10の制御系30に対して上昇や降下、前進、後退、左進、右進、旋回等の操縦指令を送って遠隔制御するための操縦装置（リモコン）40とから構成される。操縦装置40からの操縦指令は、無線信号でも良いし、有線による信号でも良い。

マルチコプター10の制御系30は、姿勢を検出する姿勢センサ31と、操縦装置40からの操縦指令を受けて全体を制御する演算制御装置32と、ロータユニットRU11～RU14、RU21～RU24を制御するモータコントローラなどからなる。

【0027】

特に限定されるものではないが、この実施例では、揚力発生用のロータユニットRU11～RU14の各モータ16a～16dは共通のモータコントローラ33により制御され

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る。また、姿勢制御用のロータユニットRU21～RU24には、各ユニットのモータ16e～16hを制御するモータコントローラ34e～34hが設けられている。

演算制御装置32は、操縦装置40からの操縦指令信号および姿勢センサ31からの信号（加速度、角速度）に基づいて、機体の上昇や降下に必要なモータのトルクすなわち回転数と、姿勢制御や移動に必要なモータのトルクすなわち回転数を算出する。そして、演算制御装置32からモータコントローラ33および34e～34hに対しては、回転数指令信号が送られる。

【0028】

ここで、モータ16a～16dを共通のモータコントローラ33により制御するようにしているのは、揚力のみを発生させるにはこれらのモータをほぼ同一の回転数で回転させればよいためである。モータコントローラ33は、自己の制御下のロータ特にモータ16a～16dの性能にバラツキがある場合、そのバラツキを考慮して駆動信号を補正し各モータへ送るように構成することができる。

一方、前進、後退、左進、右進、旋回を行なう場合、姿勢制御用のロータユニットRU21～RU24のモータ16e～16hは異なる回転数で回転させる必要がある。そこで、演算制御装置32は、進行方向や進行速度等に応じて各ロータユニットに配分するトルクを演算し、対応する回転数指令信号をモータコントローラ34e～34hへ送って、モータ16e～16hを個別に制御するようにしている。

【0029】

次に、上記実施形態に係るマルチコプターの変形例を、図3を用いて説明する。

第1の変形例は、図3（A）に示すように、外側の姿勢制御用のロータユニットRU21～RU24の配置を変え、内側の揚力発生用ロータユニットRU11～RU14とは45度周方向へずれた位置に配置したものである。かかる配置とすることによって、外側の姿勢制御用のロータユニットRU21～RU24が配置される円の半径R2の値を、図1のものに比べて小さくすることができ、全体を小型化することができる。ただし、各ロータユニットをアームで支持する場合には、アームの本数は図1のものよりも多くなる。4本のアームの中間点を結合する環状のフレームを設けて、該フレーム上に内側の揚力発生用ロータユニットRU11～RU14を搭載するように構成しても良い。

【0030】

第2の変形例は、図3（B）に示すように、8個のロータユニットRU11～RU14、RU21～RU24の配置は図3（A）と同じにし、ロータの大きさを、外側のものは小さく、内側のものは大きくしたものである。

第3の変形例は、図3（C）に示すように、8個のロータユニットRU11～RU14、RU21～RU24の配置は図1のものと同じにし、ロータの大きさを、外側のものは小さく、内側のものは大きくしたものである。

前述したように、外側のロータユニットRU21～RU24で姿勢を制御するようにした場合には、姿勢の変化に大きな力を必要としないので、図3（B）や（C）の変形例のように構成しても、制御上特に不都合はない。

【0031】

図4（A）は、図3（A）に示す第1変形例をさらに変形したもので、図3（A）のものに比べて、内側のロータユニットRU11～RU14が配置される円の半径R1の値を、図3（A）のものに比べて大きくしたものである。この場合、外側のロータユニットRU21～RU24が配置される円の半径R2の値も少し大きくなるため、全体の大きさが図3（A）のものに比べて若干大きくなるものの、図1のものよりは全体の大きさを小さくすることができる。

図4（B）は、ロータユニットの数を8個ではなく6個としたものである。ただし、この変形例においても、外側の4個のロータユニットRU21～RU24を姿勢制御用として駆動し、内側の2個のロータユニットRU11、RU12を姿勢制御用として駆動するものとする。なお、ロータユニットの数が6個の場合には、図4（C）に示すように、外側の4個のロータユニットRU21～RU24を互いに離して配置する構成も考えられる

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【0032】

なお、上記実施形態では、複数のロータユニットを支持する枠体として、放射状のアーム12a～12dとこれらのアームの先端を結合する円環状機枠12eとから構成したものを示したが、これに限定されず格子状のフレームなどであってもよい。

また、実施形態では、ロータを回転させる動力源としてモータを使用したものを示したが、動力源としてガソリンエンジン等を使用したものであってもよい。さらに、ロータとして3枚のブレードを有するものを図示したが、2枚のブレードあるいは4枚以上のブレードを有するものであってもよい。

【0033】

さらに、特に外側の姿勢制御用ロータユニットRU21～RU24に関しては、アームの軸方向へ移動可能な構成とし、回転数を一定に保持したまま、ロータの位置を径方向へずらすことで姿勢制御を行なえるように構成してもよい。

また、実施形態においては、内側のロータユニットRU11～RU14と外側のロータユニットRU21～RU24を同一平面上に配設したが、内側のロータユニットと外側のロータユニットの取付け高さは異なってもよい。

また、実施形態においては、本発明を、撮影機能を備えたマルチコプターに適用した場合について説明したが、本発明は、農薬や肥料の散布、交通インフラが破壊された被災地への物資運搬等、他の用途のマルチコプターにも利用することができる。

【符号の説明】

【0034】

10 マルチコプター（垂直離着陸飛行体）

11 胴体部

12 フレーム

12a, 12b, 12c, 12d アーム

12e 円環状機枠

15 ロータ

16 駆動源（モータ）

30 制御系

31 姿勢センサ

32 演算制御装置（制御手段）

40 操縦装置（リモコン）

RU11～RU14 内側のロータユニット

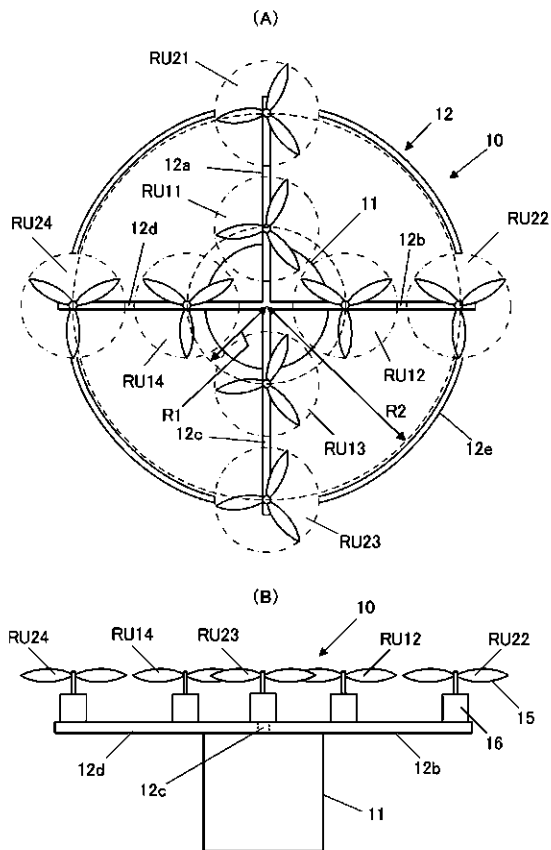
RU21～RU24 外側のロータユニット

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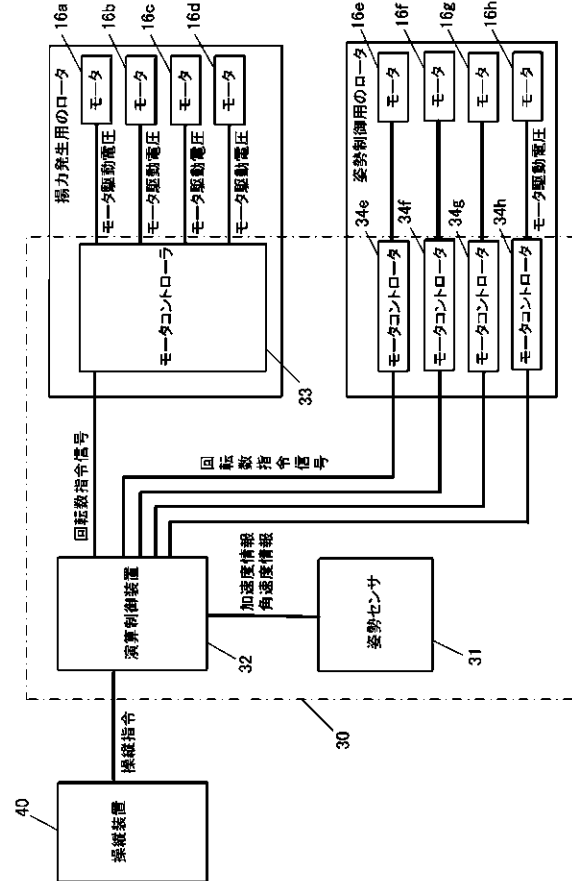
20

30

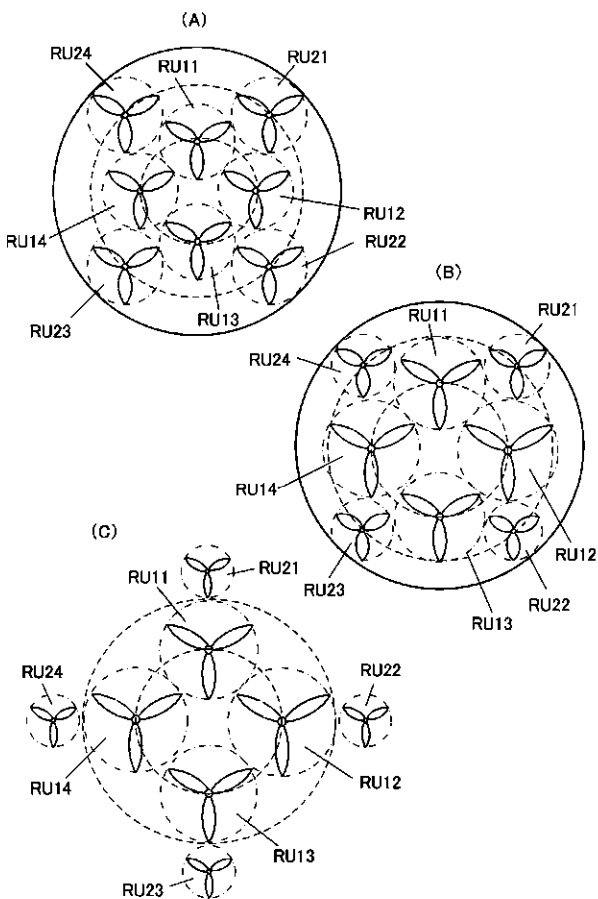
【図 1】



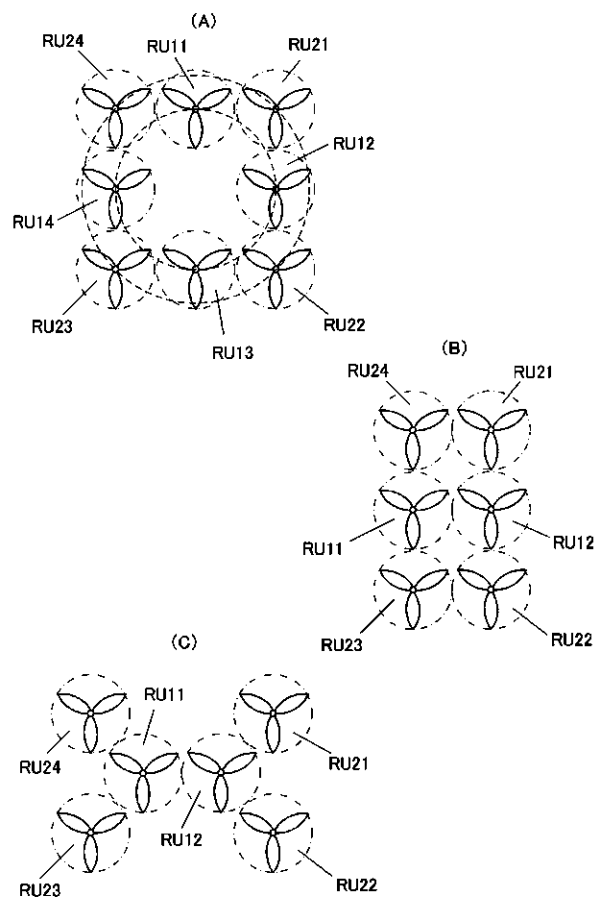
【図 2】



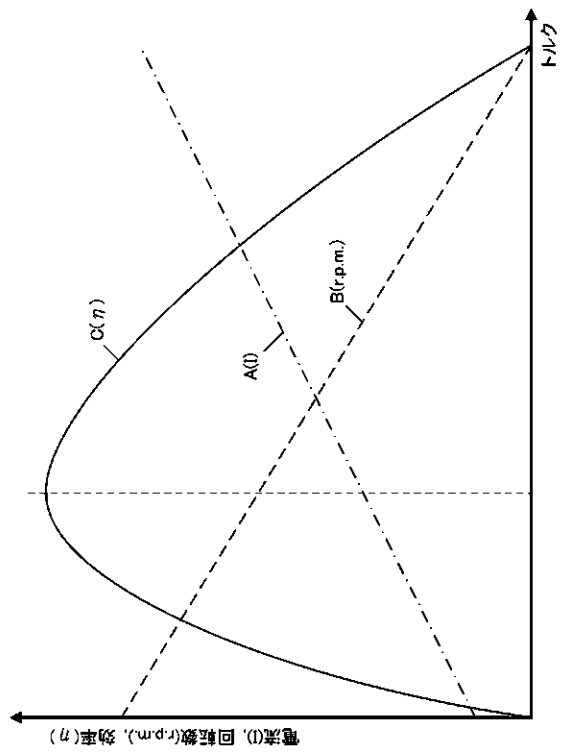
【図 3】



【図 4】



【図 5】



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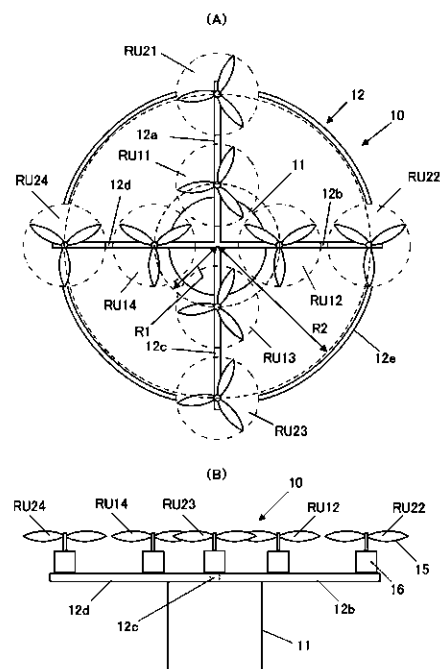
(54) 【発明の名称】 垂直離着陸飛行体

(57) 【要約】 (修正有)

【課題】 複数個のマルチブレードロータ（プロペラ）を備えた飛行体（マルチコプター）において、容易かつ迅速に姿勢制御を行えるようにする。

【解決手段】 機体の中心から所定距離だけ離れた第1円周上に配設された複数の内側ロータユニット（RU11～RU14）と、機体の中心から前記所定距離よりも大きな所定距離だけ離れた第2円周上に配設された複数の外側ロータユニット（RU21～RU24）と、前記内側ロータユニットおよび外側ロータユニットを駆動制御する制御手段とを備えた垂直離着陸飛行体において、機体の浮上は主として内側ロータユニット（RU11～RU14）を動作させて行い、機体の姿勢制御は主として外側ロータユニット（RU21～RU24）を動作させて行うようにした。

【選択図】 図1



【特許請求の範囲】**【請求項 1】**

機体の重心を通る中心軸から所定距離だけ離れた第 1 円周上に配設された複数の第 1 ロータユニットと、前記中心軸から前記所定距離よりも大きな所定距離だけ離れた第 2 円周上に配設された複数の第 2 ロータユニットと、前記第 1 ロータユニットおよび第 2 ロータユニットを駆動制御する制御手段とを備えた垂直離着陸飛行体であって、

前記機体の浮上は、少なくとも前記第 1 ロータユニットを動作させて行い、

前記機体の姿勢制御は、少なくとも前記第 2 ロータユニットを動作させて行うことを特徴とする垂直離着陸飛行体。

【請求項 2】

前記制御手段は、機体をホバリングさせる際には、効率が最大とみなせる回転数領域で前記第 1 ロータユニットの駆動源が回転するように制御することを特徴とする請求項 1 に記載の垂直離着陸飛行体。

【請求項 3】

前記第 1 ロータユニットおよび第 2 ロータユニットをそれぞれ偶数個ずつ備え、前記制御手段は、前記第 1 ロータユニットの半数および前記第 2 ロータユニットの半数を時計回り方向へ回転させ、残りの半数を反時計回り方向へ回転させることを特徴とする請求項 1 または 2 に記載の垂直離着陸飛行体。

【請求項 4】

前記第 1 ロータユニットおよび第 2 ロータユニットをそれぞれ 4 個であることを特徴とする請求項 3 に記載の垂直離着陸飛行体。

【請求項 5】

前記 4 個の第 1 ロータユニットおよび 4 個の第 2 ロータユニットはそれぞれ円周方向に 90 度の間隔で配設されるとともに、前記 4 個の第 2 ロータユニットは前記 4 個の第 1 ロータユニットと円周方向に 45 度ずれた位置に配設されていることを特徴とする請求項 4 に記載の垂直離着陸飛行体。

【請求項 6】

前記第 2 ロータユニットの駆動源は、該駆動源の最大トルクが前記第 1 ロータユニットの駆動源の最大トルクよりも小さな値に設定されていることを特徴とする請求項 1～5 のいずれかに記載の垂直離着陸飛行体。

【発明の詳細な説明】**【技術分野】****【0001】**

本発明は、垂直軸回りに回転駆動されるマルチブレードロータもしくはプロペラを複数個備えた垂直離着陸飛行体（マルチコプター）に関する。

【背景技術】**【0002】**

従来より、垂直離着陸可能な飛行体として、垂直軸回りに回転駆動されるロータもしくはプロペラを複数個備えたマルチコプターが知られている。マルチコプターは、例えばカメラを搭載し遠隔操縦可能に構成することで、人が立ち入れないエリアを空撮して情報を得るのに利用される。かかる遠隔操縦可能なマルチコプターにおいては、姿勢の安定性と操縦性が良好であることが重要であり、安定性と操縦性の向上のために種々の発明が提案されている。

【0003】

例えば、特許文献 1 には、8 個のプロペラユニットを同一円周上あるいは 4 個ずつ 2 段に配置するとともに、周方向へ移動可能に構成する。そして、いずれか 1 個のプロペラユニットが故障し停止した場合には、故障したプロペラユニットの位置へ他のプロペラユニットに近付けることで安定性を高め、安全な飛行、着陸を可能にする飛行体に関する発明が記載されている。

【0004】

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また、特許文献2には、機体の中心に副回転翼（ロータ）を配置するとともに、該副回転翼を中心にして同一円周上に3つの主回転翼（ロータ）を配置した飛行体に関する発明が記載されている。

さらに、特許文献3には、同一円周上に8個のロータを配置するとともに、ほぼ放射状に配設された複数のアームとこれらのアームを連結する円形フレームを設け、各アームの途中にロータを取り付けた飛行体に関する発明が記載されている。

【先行技術文献】

【特許文献】

【0005】

【特許文献1】特開2002-370696号公報

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【特許文献2】特開2003-212191号公報

【特許文献3】特開2011-046355号公報

【発明の概要】

【発明が解決しようとする課題】

【0006】

特許文献1に記載されている発明は、一部のプロペラが停止した場合に安全な飛行を可能にすることを課題とするもので、プロペラユニットを移動可能に構成しているため、構造が複雑になる。また、特許文献1に記載されている飛行体にあつては、水平移動用のプロペラを揚力発生用の8個のプロペラとは別個に胴体部の側部（4箇所）に設けているため、部品点数が多くなり、重量も重くなるという不都合がある。

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【0007】

特許文献2に記載されている飛行体は、ロータの数が4個であるため浮上構造は簡単であるが、燃料タンクをキャビンの外周3カ所または機体内部に配置し、燃料タンク内の航空燃料を相互に移動させることで機体の水平維持を行なうようにしている。そのため、水平維持機構が複雑になる。また、特許文献2には、飛行中に機体が傾斜した場合における瞬時的変位の微調整には、エンジン排出ガスの吐出で行うようにしてもことが記載されている。しかし、そのような姿勢制御を可能にするには、排気ガス吐出口の配置や向き等が制約され、設計上の自由度が減少することとなるとともに、モータを動力源とするマルチコプターにはそのような技術を適用することができないという課題がある。

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【0008】

特許文献3に記載されている飛行体は、複数（8個）のロータを同一円周上に配置するようにしたもので、このような構成にあつては、推力発生部の外形（8個のロータの外接円）ひいては機体全体が大きくなってしまふ。また、全てのロータが対等の関係にあるため、機体を上昇または下降させる場合も姿勢を制御する場合も、全てのロータの回転数（揚力）を考慮して制御する必要がある、制御が複雑になるとともに効率を優先した制御が困難であるという課題がある。

本発明は、上記のような課題に鑑みてなされたもので、複数個のマルチブレードロータ（プロペラ）を備えた垂直離着陸飛行体（マルチコプター）において、容易かつ迅速に姿勢制御を行えるようにすることを目的とする。

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【課題を解決するための手段】

【0009】

上記目的を達成するため、本発明は、

機体の重心を通る中心軸から所定距離だけ離れた第1円周上に配設された複数の第1ロータユニットと、前記中心軸から前記所定距離よりも大きな所定距離だけ離れた第2円周上に配設された複数の第2ロータユニットと、前記第1ロータユニットおよび第2ロータユニットを駆動制御する制御手段とを備えた垂直離着陸飛行体であつて、

前記機体の浮上は、少なくとも前記第1ロータユニットを動作させて行い、

前記機体の姿勢制御は、少なくとも前記第2ロータユニットを動作させて行うように構成した。

【0010】

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上記構成によれば、機体の中心から離れるほど小さな揚力で機体を傾ける大きなモーメントを発生することができるため、第2ロータユニットを動作させて機体の姿勢制御を行うことで姿勢制御に伴うロータの回転数の変化を小さくすることができる。その結果、所望の姿勢に変化させるのに要する姿勢制御の応答時間を短くすることができる。さらに、少ない力で姿勢制御を行なえるので、外側に配置されるロータユニットとしてサイズの小さなものを使用することができ、飛行体の小型、軽量化が可能になる。また、機体の浮上は、主として内側位置する第1ロータユニットを動作させて行うので、ロータユニットの性能に差があって揚力変化が多少ばらついたとしてもそれによるモーメントが小さいため、姿勢の安定性が損なわれにくい。

【0011】

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また、望ましくは、前記制御手段は、機体をホバリングさせる際には、効率が最大とみなせる回転数領域で前記第1ロータユニットの駆動源が回転するように制御するように構成する。

かかる構成によれば、ロータユニットの駆動効率を向上させることができ、より長時間、長距離の飛行が可能となる。

【0012】

また、望ましくは、前記第1ロータユニットおよび第2ロータユニットをそれぞれ偶数個ずつ備え、前記制御手段は、前記第1ロータユニットの半数および前記第2ロータユニットの半数を時計回り方向へ回転させ、残りの半数を反時計回り方向へ回転させるように構成する。

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かかる構成によれば、ロータユニットの回転駆動で生じる反トルクを容易に相殺させて、機体が回転するのを防止することができる。

【0013】

さらに、望ましくは、前記第1ロータユニットおよび第2ロータユニットをそれぞれ4個であるように構成する。

かかる構成によれば、姿勢制御が容易であると共に、4個の第1ロータユニットまたは4個の第2ロータユニットのうちいずれか一つが故障して回転が停止したとしても、残りのロータユニットを使用して安全かつ容易に機体を着陸させることができる。

【0014】

また、望ましくは、前記4個の第1ロータユニットおよび4個の第2ロータユニットはそれぞれ円周方向に90度の間隔で配設されるとともに、前記4個の第2ロータユニットは前記4個の第1ロータユニットと円周方向に45度ずれた位置に配設されているようにする。

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かかる配置としては、例えば図3(A)、(B)や図4(A)に示すような配置が考えられる。このような配置にすることで、機体に8個のロータユニットを搭載する場合に、ロータユニットの集積度を高めることができ、飛行体の小型化が可能になる。

【0015】

さらに、望ましくは、前記第2ロータユニットの駆動源は、該駆動源の最大トルクが前記第1ロータユニットの駆動源の最大トルクよりも小さな値に設定されているように構成する。

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かかる構成によれば、揚力発生用のロータユニットの駆動源を大きくする一方、姿勢制御用のロータユニットの駆動源は小さくできるため、姿勢の制御性を良好にしつつ機体の安定性を高めることができる。

【発明の効果】

【0016】

本発明によれば、複数のマルチブレードロータ（プロペラ）を備えた垂直離着陸飛行体（マルチコプター）において、容易かつ迅速に姿勢制御を行うことができる。言い換えると、本発明によれば、姿勢の安定性を保持しつつ機体を昇降させる際のロータの制御が比較的容易なマルチコプターを実現することができるという効果がある。

【図面の簡単な説明】

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【0017】

【図1】図1は本発明の実施形態に係る垂直離着陸飛行体としてのマルチコプターの概略を示すもので、(A)は平面図、(B)は正面図である。

【図2】図2は実施形態に係るマルチコプターの制御システムの構成例を示すブロック図である。

【図3】図3(A)～(C)は実施形態に係るマルチコプターの変形例を示すロータ配置図である。

【図4】図4(A)～(C)は実施形態に係るマルチコプターの他の変形例を示すロータ配置図である。

【図5】図5はロータユニットに使用するモータの特性の一例を示す特性図である。

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【発明を実施するための形態】

【0018】

以下、図面を参照しながら、この発明の一実施形態について詳しく説明する。

図1は、本発明の実施形態に係る垂直離着陸飛行体（以下、マルチコプターと称する）の概略を示すもので、(A)は平面図、(B)は正面図である。

図1(B)に示すように、本実施形態のマルチコプター10は、演算制御装置やバッテリー、ジャイロスコープのような姿勢センサ、カメラなどを収納した筒状の胴体部11と、該胴体部11の上部に固定されたフレーム12とを有する。

【0019】

フレーム12は、図1(A)に示すように、機体の中心から放射状に伸び互いに直角をなすように配設された4本のアーム12a、12b、12c、12dと、該アーム12a～12dの先端を結合する円環状の機枠12eとから構成されている。機枠12eは、円環状に限定されず、楕円形や多角形などであってもよい。

なお、機体は、その重心が上記アーム12a～12dの中心を通る鉛直線上に来るように、各構成部品の形状、配置等が設計される。フレーム12は、航空機分野では一般的な、例えば炭素繊維強化プラスチック(CFRP)やチタン合金、アルミ合金のような軽量で強度の高い材料で構成するのが望ましい。

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【0020】

また、マルチコプター10は、アーム12a～12dの中間位置にそれぞれ装着された4個のロータユニットRU11～RU14と、アーム12a～12dの先端部にそれぞれ装着された4個のロータユニットRU21～RU24とを備える。言い換えると、ロータユニットRU11～RU14は機体の中心から半径R1の円周上に90度間隔で配設され、ロータユニットRU21～RU24は機体の中心から半径R2(≒2×R1)の円周上に90度間隔で配設されている。

ロータユニットの数は8個に限定されず、6個あるいは10個以上であってもよいが、反トルクによる機体の回転を防止する観点から、偶数個とするのが望ましい。

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【0021】

上記ロータユニットRU11～RU14とRU21～RU24は、図1(B)に示すように、それぞれ、ロータ15、該ロータ15を回転駆動するモータのような駆動源16、該駆動源16を制御するコントローラ(図示省略)などから構成されている。

1本のアーム上に2個のロータユニットを取り付けている本実施例では、ロータ15の直径をDとすると、半径R1とR2の関係は、 $R1 < R2$ 、 $R2 - R1 > D$ であればよく、例えばR1はR2の $1/2$ とすることが考えられる。ただし、ロータユニットRU11(RU13)およびこれと隣接する他のアーム上のロータユニットRU12、RU14のロータ同士の干渉を防止するため、 $R1 > D \div \sqrt{2}$ を満足するようにR1、R2、Dの値を決定する。

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【0022】

さらに、本実施例では、演算制御装置は、内側に位置する4個のロータユニットRU11～RU14は、揚力発生用のロータとして動作するように制御する。また、外側に位置する4個のロータユニットRU21～RU24は、主として姿勢制御用のロータとして動

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作するように制御する。さらに、移動のための推力は、左右または前後のロータの回転数をアンバランスにして機体を傾けるように制御することにより得る。

また、特に限定されるものではないが、反トルクによる機体の回転を防止するため、8個のロータユニットのうち4個は時計回り方向へ回転させ、残りの4個は反時計回り方向へ回転させる。具体的には、例えば、機体の中心を挟んで対向する位置に配置されているロータユニットのロータ同士は、互いに逆方向に回転させるように制御することが考えられる。

【0023】

上記のように、8個のロータユニットを設けることにより、いずれかのユニットが故障してロータが停止しても、残りのユニットの推力（回転数）を適宜制御することによって、安全に着地させることができる。

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また、外側に位置する4個のロータユニットRU21～RU24を姿勢制御用のロータとして動作させることによって、てこの原理から、内側のロータユニットよりも少ない回転数の変化で発生するモーメントを大きくすることができ、これにより、所望の姿勢に変化するのに要する姿勢制御の応答時間を短くすることができる。さらに、少ない力で姿勢制御を行なえるので、ロータユニットRU21～RU24のモータやロータとして、RU11～RU14よりも小さなものを使用した軽量のユニットとすることができる。

【0024】

また、上記のように、内側に位置する4個のロータユニットRU11～RU14を揚力発生用のロータとして動作させ、一定の回転数で回転させることにより、浮上に必要な消費電流を一定にすることができる。その結果、バッテリーの容量を最適化することが容易となり、高効率化を達成することができる。

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より具体的には、モータの特性を図示すると、図5に示すようになる。図5において、符号Aで示す直線は電流－トルク特性、符号Bで示す直線は回転数－トルク特性、符号Cで示す曲線は効率－トルク特性を示す。図5より、トルクが小さ過ぎても大き過ぎても効率は低下し、使用するモータにより最大効率となる時のトルクの大きさおよび回転数が決まっていることが分かる。

【0025】

一方、1個のロータユニットの推力は、モータのトルクと使用するロータの特性（形状、大きさ等）で決まる。従って、機体全体の重量Wが決まったら、モータの最大効率時のトルクで決定されるロータユニットの推力をTとすると、 $T = W / 4$ なる性能のモータを選択する。

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そして、そのようなモータをロータユニットRU11～RU14の駆動源として機体に搭載し、最大効率となる時の回転数で回転させれば、浮上（ホバリング）時に最大効率となるようにモータを駆動制御することができる。また、バッテリーの容量は、上記のようにして決定したモータの消費電流と、目標とする飛行時間および移動距離等から決めることができる。

【0026】

図2は、上記のような構成のマルチコプター10の制御システムの構成例を示す。

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図2に示すように、制御システムは、マルチコプター10の制御系30と、マルチコプター10の制御系30に対して上昇や降下、前進、後退、左進、右進、旋回等の操縦指令を送って遠隔制御するための操縦装置（リモコン）40とから構成される。操縦装置40からの操縦指令は、無線信号でも良いし、有線による信号でも良い。

マルチコプター10の制御系30は、姿勢を検出する姿勢センサ31と、操縦装置40からの操縦指令を受けて全体を制御する演算制御装置32と、ロータユニットRU11～RU14、RU21～RU24を制御するモータコントローラなどからなる。

【0027】

特に限定されるものではないが、この実施例では、揚力発生用のロータユニットRU11～RU14の各モータ16a～16dは共通のモータコントローラ33により制御され

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る。また、姿勢制御用のロータユニットRU21～RU24には、各ユニットのモータ16e～16hを制御するモータコントローラ34e～34hが設けられている。

演算制御装置32は、操縦装置40からの操縦指令信号および姿勢センサ31からの信号（加速度、角速度）に基づいて、機体の上昇や降下に必要なモータのトルクすなわち回転数と、姿勢制御や移動に必要なモータのトルクすなわち回転数を算出する。そして、演算制御装置32からモータコントローラ33および34e～34hに対しては、回転数指令信号が送られる。

【0028】

ここで、モータ16a～16dを共通のモータコントローラ33により制御するようにしているのは、揚力のみを発生させるにはこれらのモータをほぼ同一の回転数で回転させればよいためである。モータコントローラ33は、自己の制御下のロータ特にモータ16a～16dの性能にバラツキがある場合、そのバラツキを考慮して駆動信号を補正し各モータへ送るように構成することができる。

一方、前進、後退、左進、右進、旋回を行なう場合、姿勢制御用のロータユニットRU21～RU24のモータ16e～16hは異なる回転数で回転させる必要がある。そこで、演算制御装置32は、進行方向や進行速度等に応じて各ロータユニットに配分するトルクを演算し、対応する回転数指令信号をモータコントローラ34e～34hへ送って、モータ16e～16hを個別に制御するようにしている。

【0029】

次に、上記実施形態に係るマルチコプターの変形例を、図3を用いて説明する。

第1の変形例は、図3（A）に示すように、外側の姿勢制御用のロータユニットRU21～RU24の配置を変え、内側の揚力発生用ロータユニットRU11～RU14とは45度周方向へずれた位置に配置したものである。かかる配置とすることによって、外側の姿勢制御用のロータユニットRU21～RU24が配置される円の半径R2の値を、図1のものに比べて小さくすることができ、全体を小型化することができる。ただし、各ロータユニットをアームで支持する場合には、アームの本数は図1のものよりも多くなる。4本のアームの中間点を結合する環状のフレームを設けて、該フレーム上に内側の揚力発生用ロータユニットRU11～RU14を搭載するように構成しても良い。

【0030】

第2の変形例は、図3（B）に示すように、8個のロータユニットRU11～RU14、RU21～RU24の配置は図3（A）と同じにし、ロータの大きさを、外側のものは小さく、内側のものは大きくしたものである。

第3の変形例は、図3（C）に示すように、8個のロータユニットRU11～RU14、RU21～RU24の配置は図1のものと同じにし、ロータの大きさを、外側のものは小さく、内側のものは大きくしたものである。

前述したように、外側のロータユニットRU21～RU24で姿勢を制御するようにした場合には、姿勢の変化に大きな力を必要としないので、図3（B）や（C）の変形例のように構成しても、制御上特に不都合はない。

【0031】

図4（A）は、図3（A）に示す第1変形例をさらに変形したもので、図3（A）のものに比べて、内側のロータユニットRU11～RU14が配置される円の半径R1の値を、図3（A）のものに比べて大きくしたものである。この場合、外側のロータユニットRU21～RU24が配置される円の半径R2の値も少し大きくなるため、全体の大きさが図3（A）のものに比べて若干大きくなるものの、図1のものよりは全体の大きさを小さくすることができる。

図4（B）は、ロータユニットの数を8個ではなく6個としたものである。ただし、この変形例においても、外側の4個のロータユニットRU21～RU24を姿勢制御用として駆動し、内側の2個のロータユニットRU11、RU12を姿勢制御用として駆動するものとする。なお、ロータユニットの数が6個の場合には、図4（C）に示すように、外側の4個のロータユニットRU21～RU24を互いに離して配置する構成も考えられる

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【0032】

なお、上記実施形態では、複数のロータユニットを支持する枠体として、放射状のアーム12a～12dとこれらのアームの先端を結合する円環状機枠12eとから構成したものを示したが、これに限定されず格子状のフレームなどであってもよい。

また、実施形態では、ロータを回転させる動力源としてモータを使用したものを示したが、動力源としてガソリンエンジン等を使用したものであってもよい。さらに、ロータとして3枚のブレードを有するものを図示したが、2枚のブレードあるいは4枚以上のブレードを有するものであってもよい。

【0033】

さらに、特に外側の姿勢制御用ロータユニットRU21～RU24に関しては、アームの軸方向へ移動可能な構成とし、回転数を一定に保持したまま、ロータの位置を径方向へずらすことで姿勢制御を行なえるように構成してもよい。

また、実施形態においては、内側のロータユニットRU11～RU14と外側のロータユニットRU21～RU24を同一平面上に配設したが、内側のロータユニットと外側のロータユニットの取付け高さは異なってもよい。

また、実施形態においては、本発明を、撮影機能を備えたマルチコプターに適用した場合について説明したが、本発明は、農薬や肥料の散布、交通インフラが破壊された被災地への物資運搬等、他の用途のマルチコプターにも利用することができる。

【符号の説明】

【0034】

10 マルチコプター（垂直離着陸飛行体）

11 胴体部

12 フレーム

12a, 12b, 12c, 12d アーム

12e 円環状機枠

15 ロータ

16 駆動源（モータ）

30 制御系

31 姿勢センサ

32 演算制御装置（制御手段）

40 操縦装置（リモコン）

RU11～RU14 内側のロータユニット

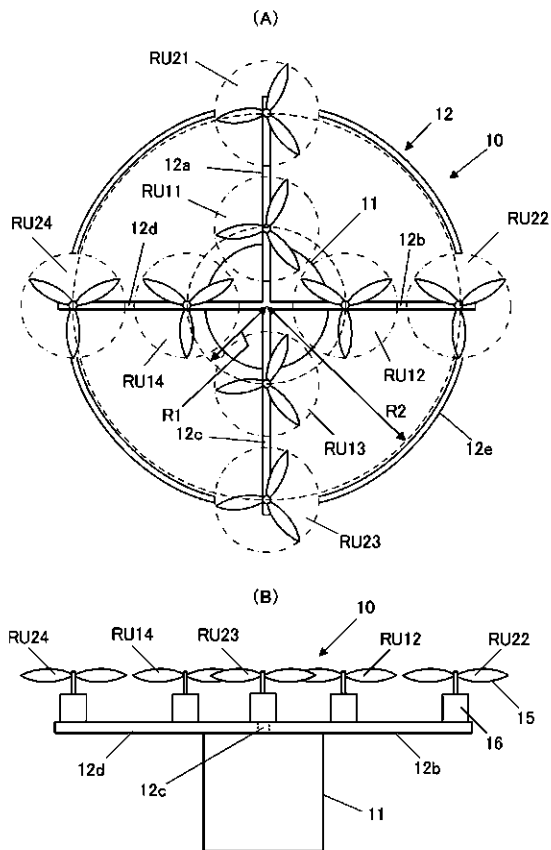
RU21～RU24 外側のロータユニット

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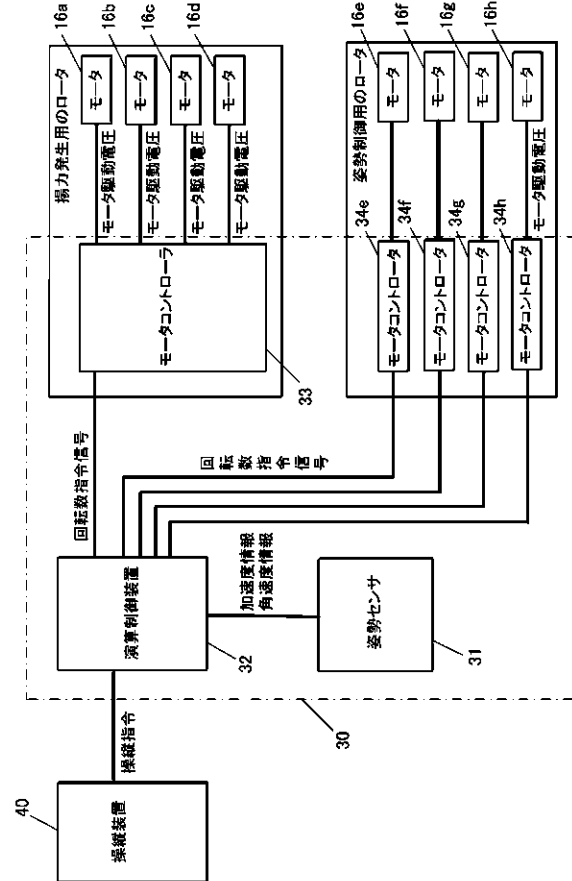
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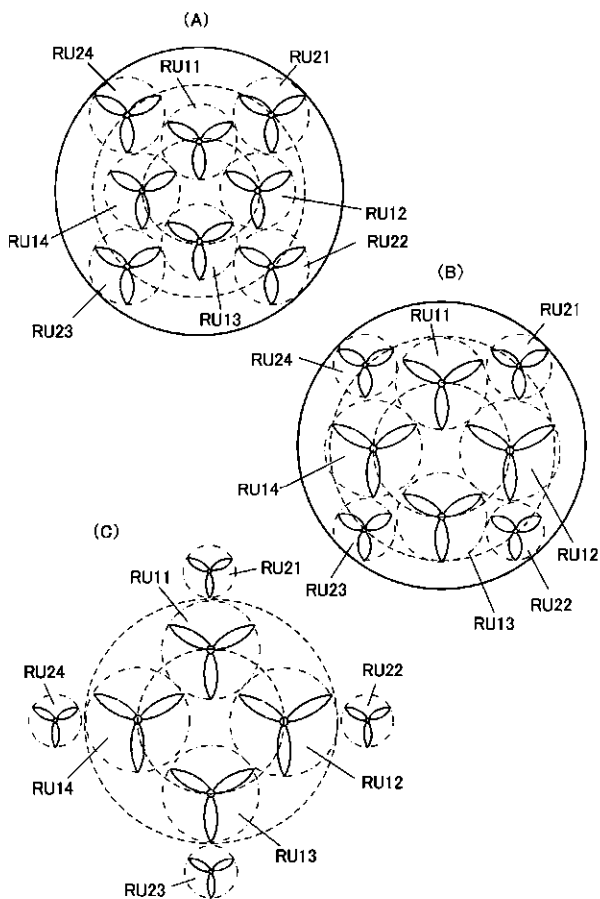
【図 1】



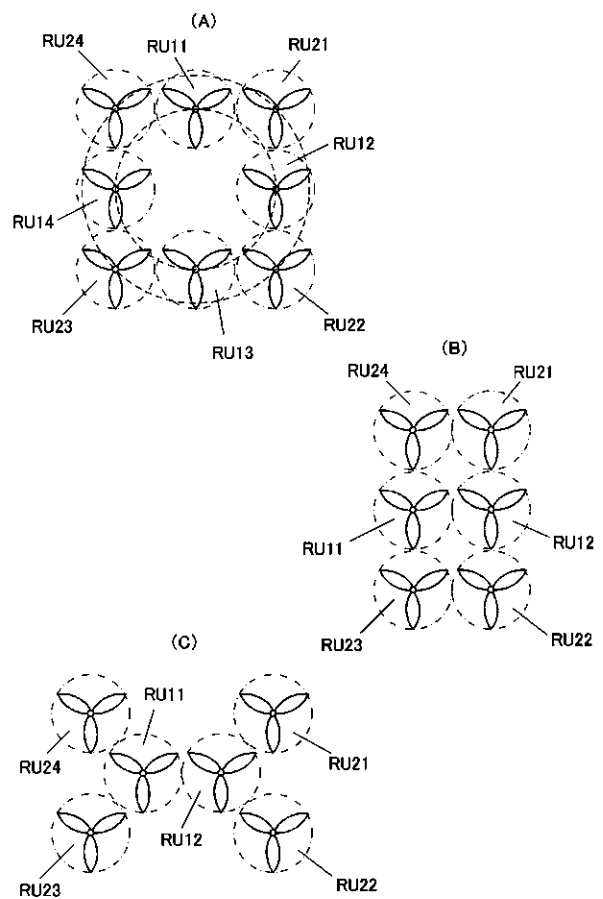
【図 2】



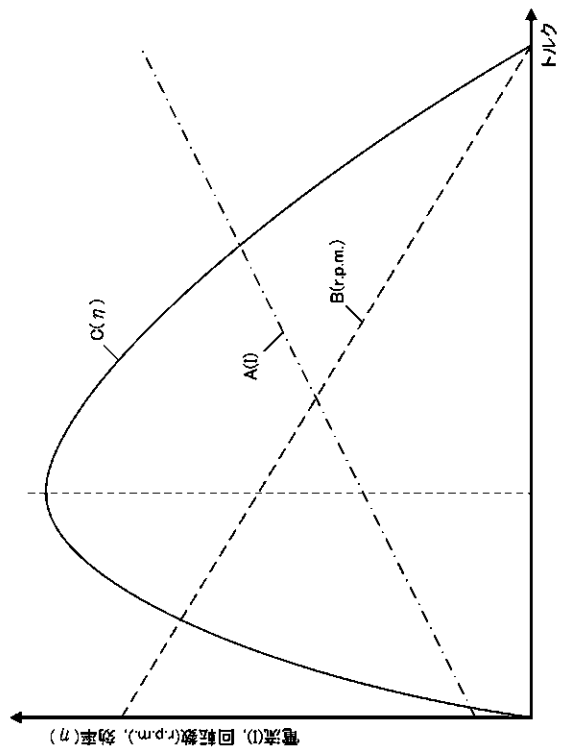
【図 3】



【図 4】



【図 5】

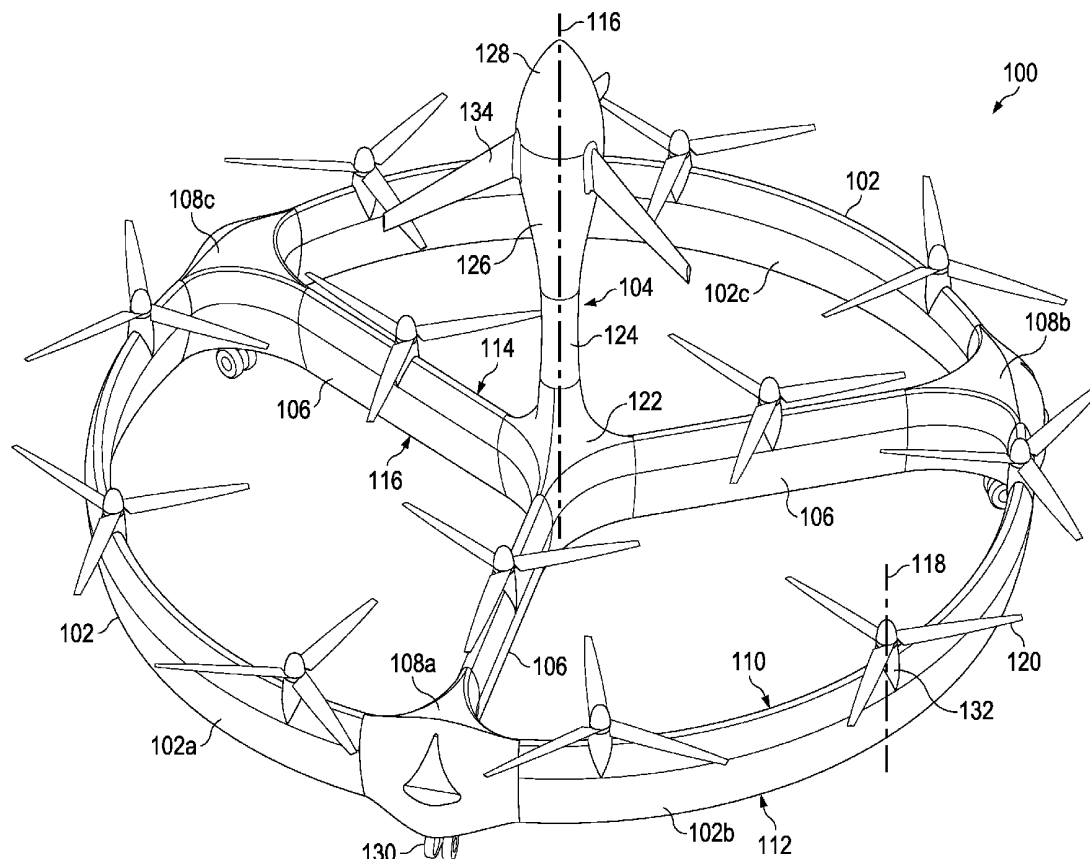




US 20180244381A1

(19) **United States**(12) **Patent Application Publication****Fenny et al.**(10) **Pub. No.: US 2018/0244381 A1**(43) **Pub. Date: Aug. 30, 2018**(54) **VERTICAL TAKE OFF AND LANDING
CLOSED WING AIRCRAFT****Publication Classification**(51) **Int. Cl.****B64C 29/02** (2006.01)**B64C 39/06** (2006.01)(52) **U.S. Cl.**CPC **B64C 29/02** (2013.01); **B64C 39/06**
(2013.01)(71) Applicant: **Bell Helicopter Textron Inc.**, Fort
Worth, TX (US)(72) Inventors: **Carlos Alexander Fenny**, Fort Worth,
TX (US); **Rohn Lee Olson**, Hurst, TX
(US); **Andrew James Zahasky**, North
Richland Hills, TX (US)(21) Appl. No.: **15/593,554**(22) Filed: **May 12, 2017****Related U.S. Application Data**(60) Provisional application No. 62/336,290, filed on May
13, 2016, provisional application No. 62/336,432,
filed on May 13, 2016, provisional application No.
62/336,363, filed on May 13, 2016, provisional ap-
plication No. 62/336,420, filed on May 13, 2016,
provisional application No. 62/336,465, filed on May
13, 2016.**ABSTRACT**

An aircraft capable of vertical takeoff and landing, stationary flight and forward flight includes a closed wing that provides lift whenever the aircraft is in forward flight, a fuselage at least partially disposed within a perimeter of the closed wing, and one or more spokes coupling the closed wing to the fuselage. One or more engines or motors are disposed within or attached to the closed wing, fuselage or spokes. Three or more propellers are proximate to a leading edge of the closed wing or the one or more spokes, distributed along the closed wing or the one or more spokes, and operably connected to the one or more engines or motors. The propellers provide lift whenever the aircraft is in vertical takeoff and landing and stationary flight, and provide thrust whenever the aircraft is in forward flight.



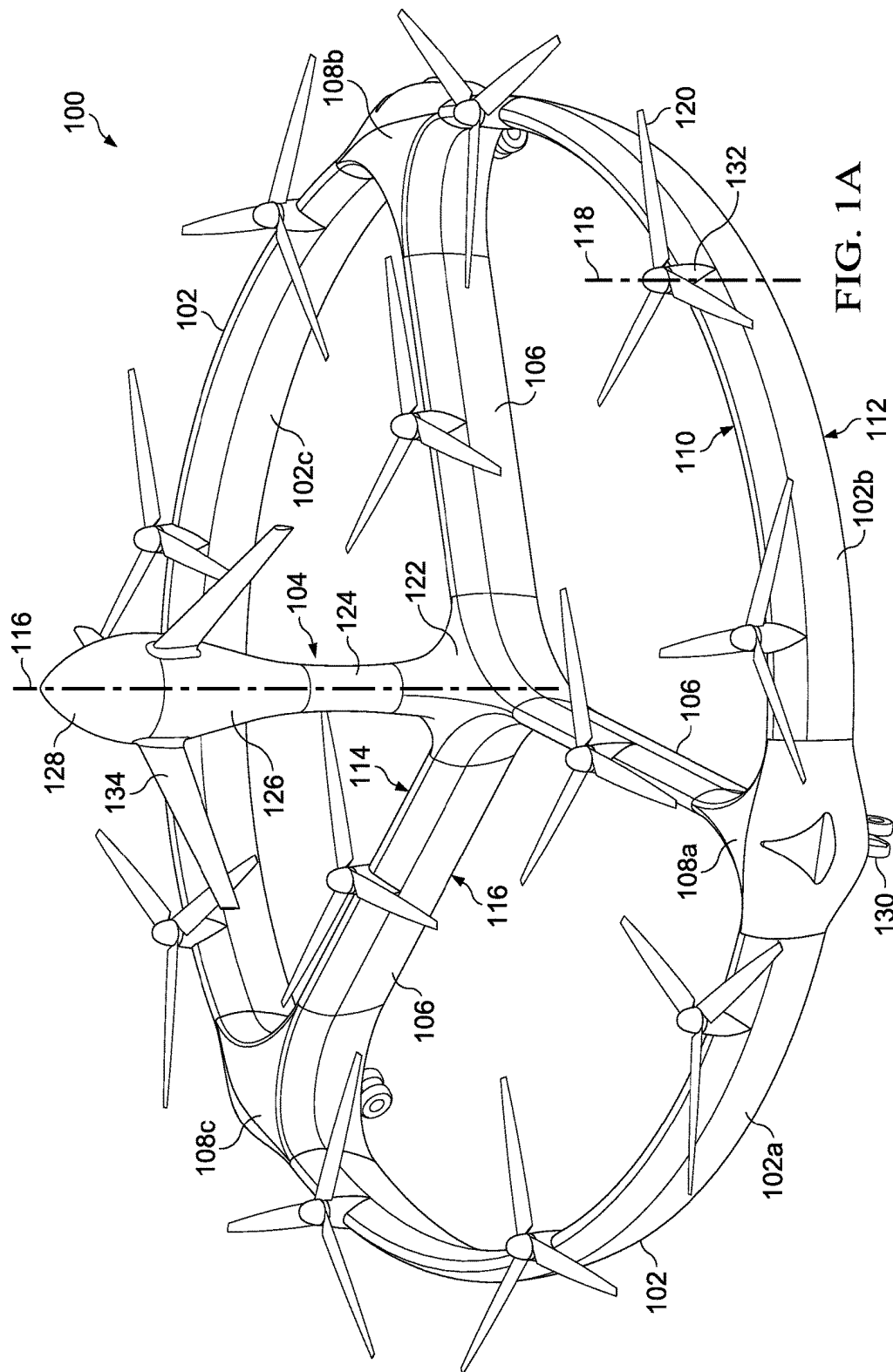
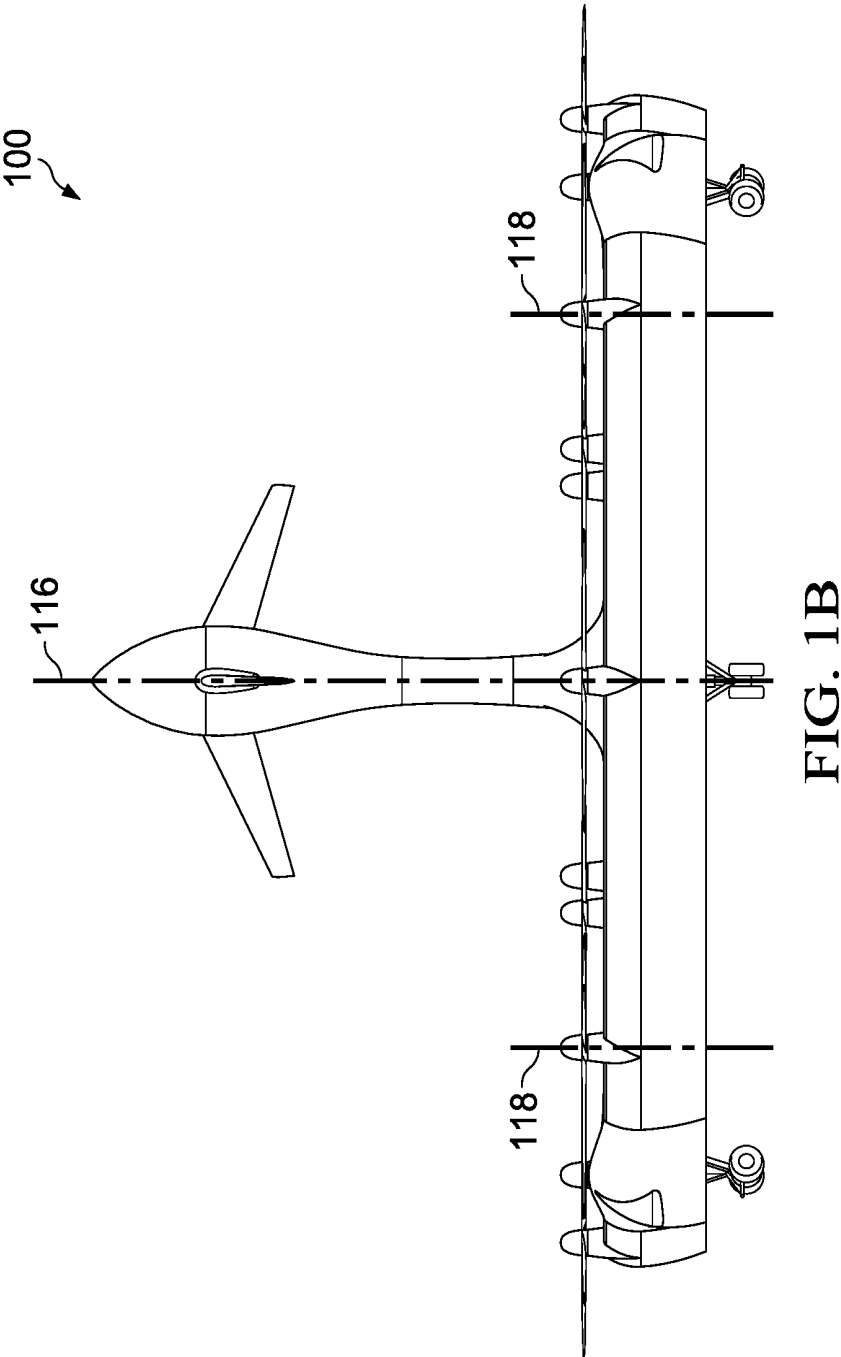


FIG. 1A



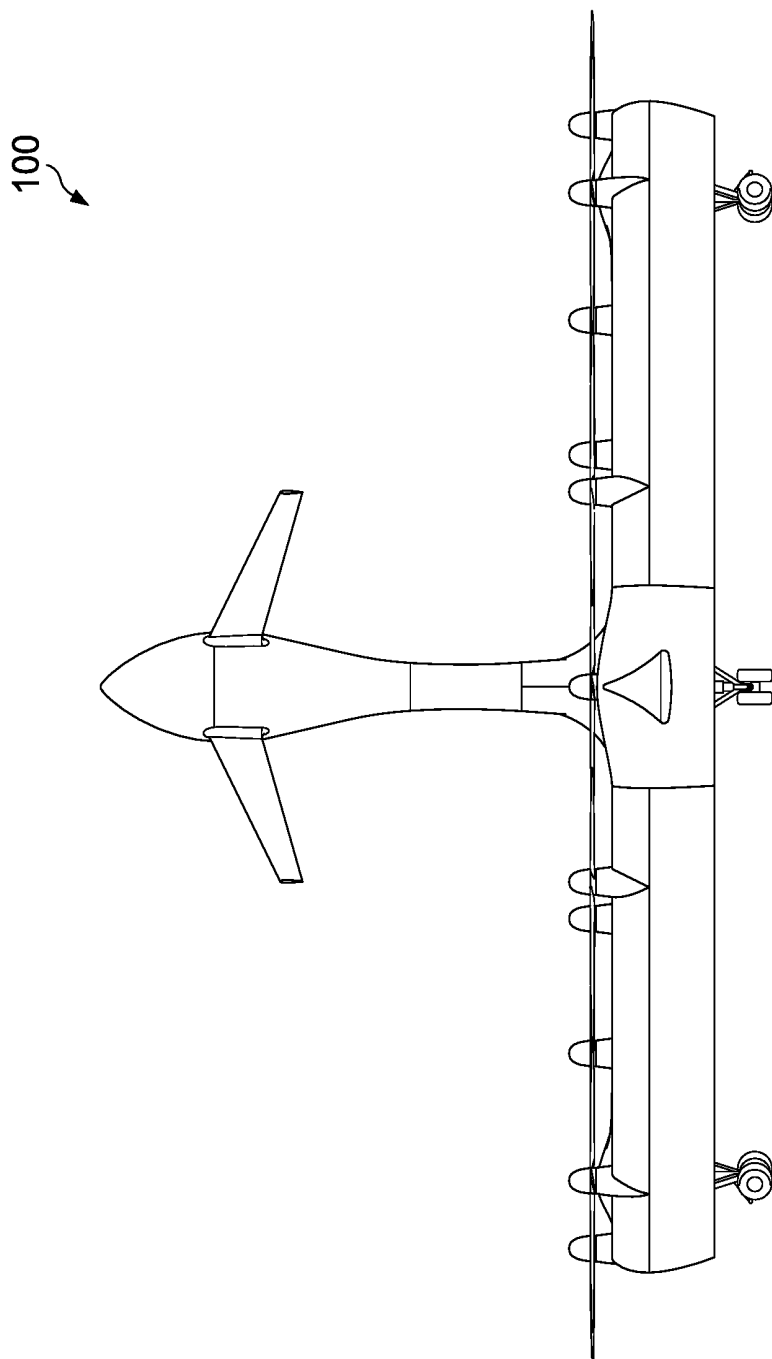


FIG. 1C

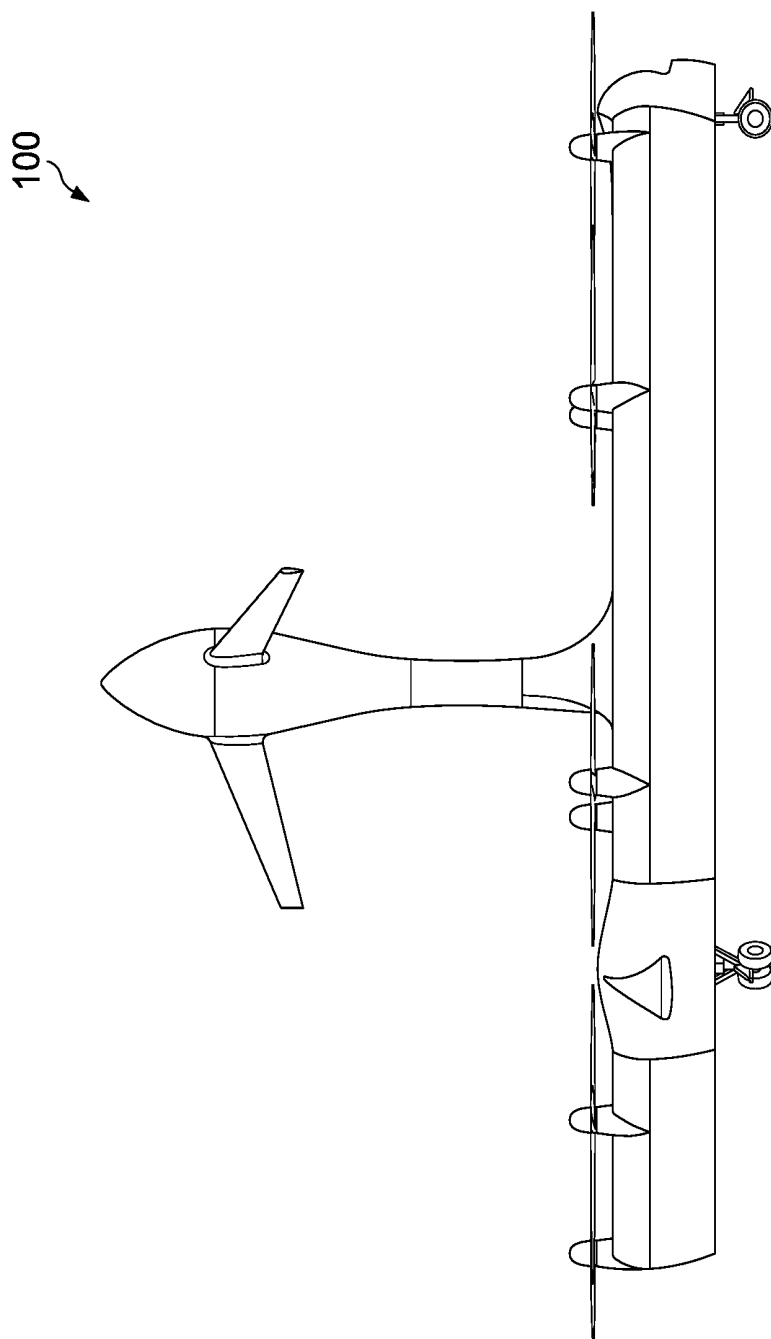


FIG. 1D

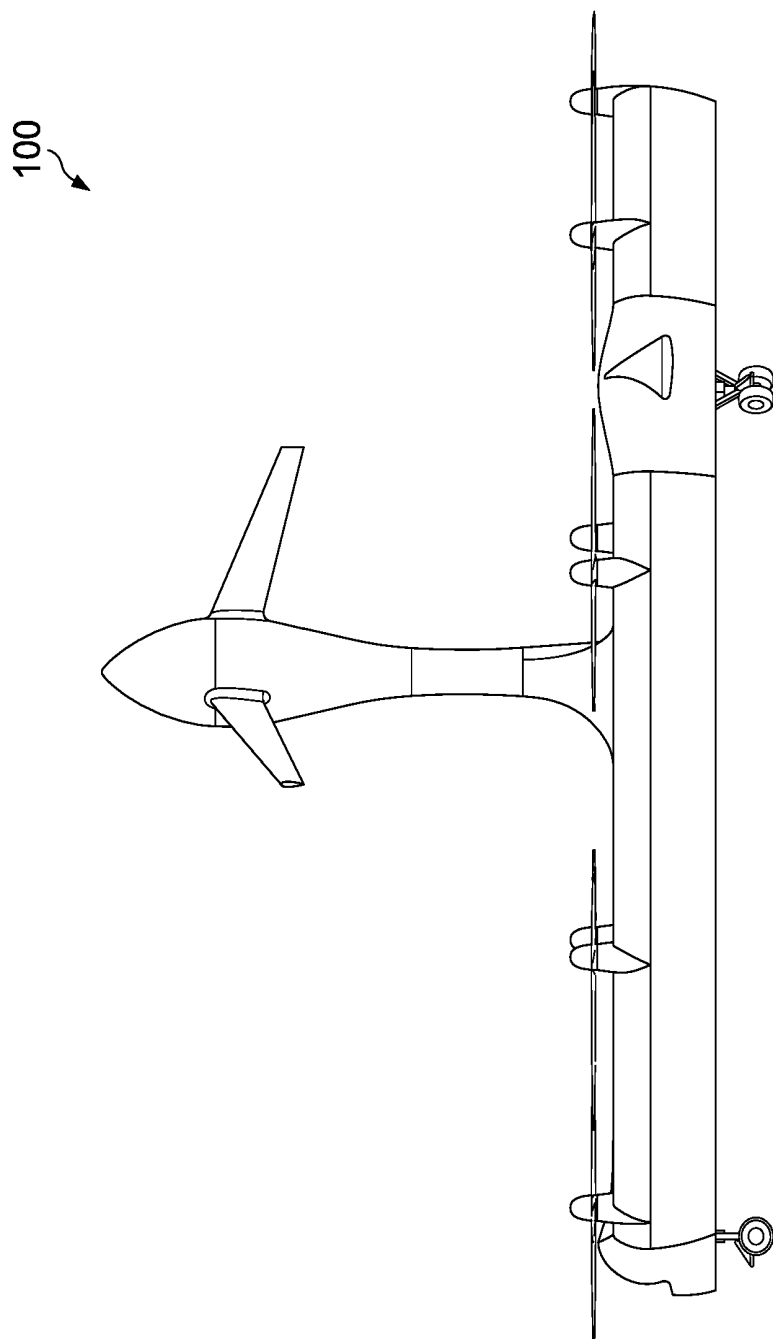


FIG. 1E

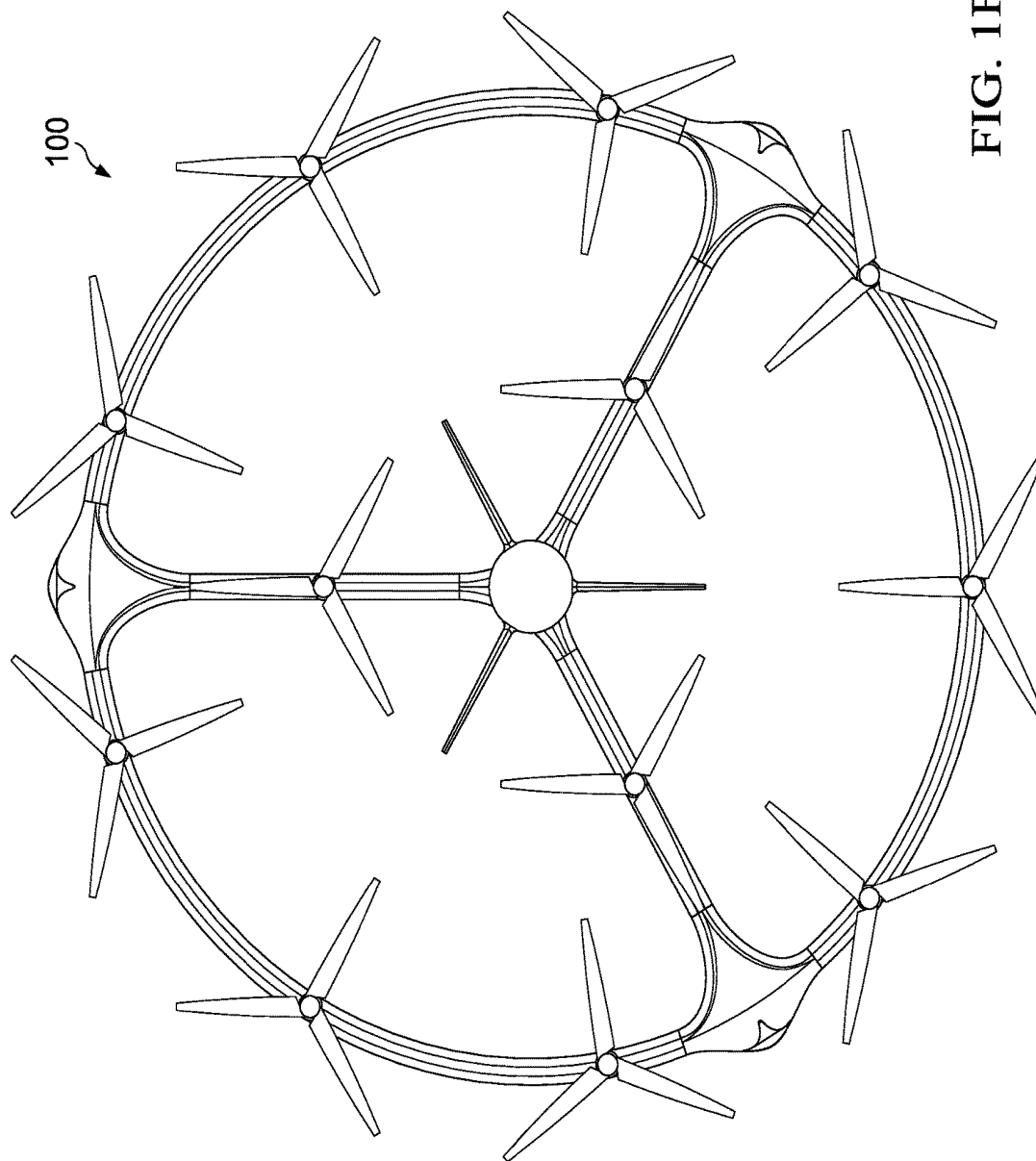
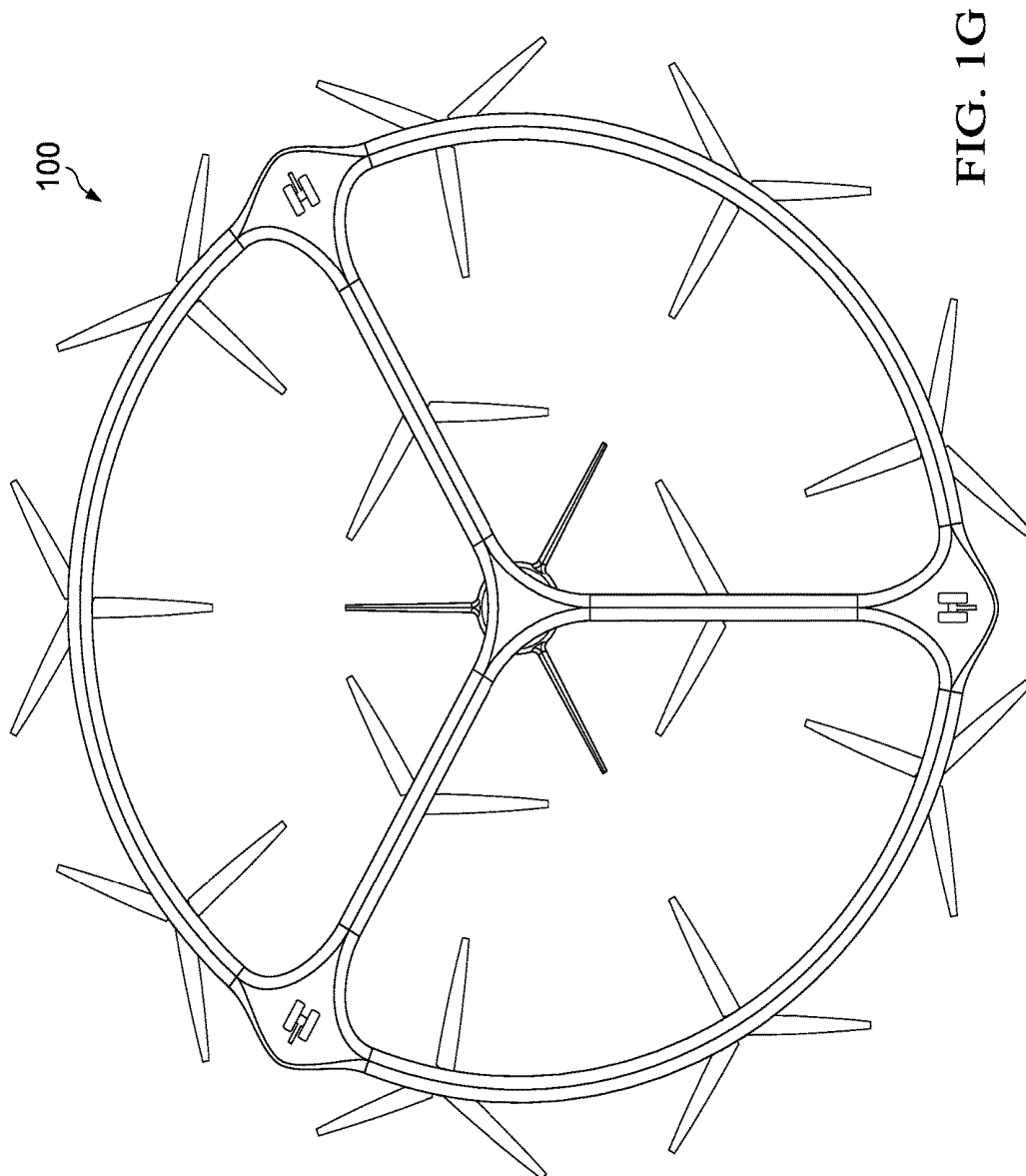
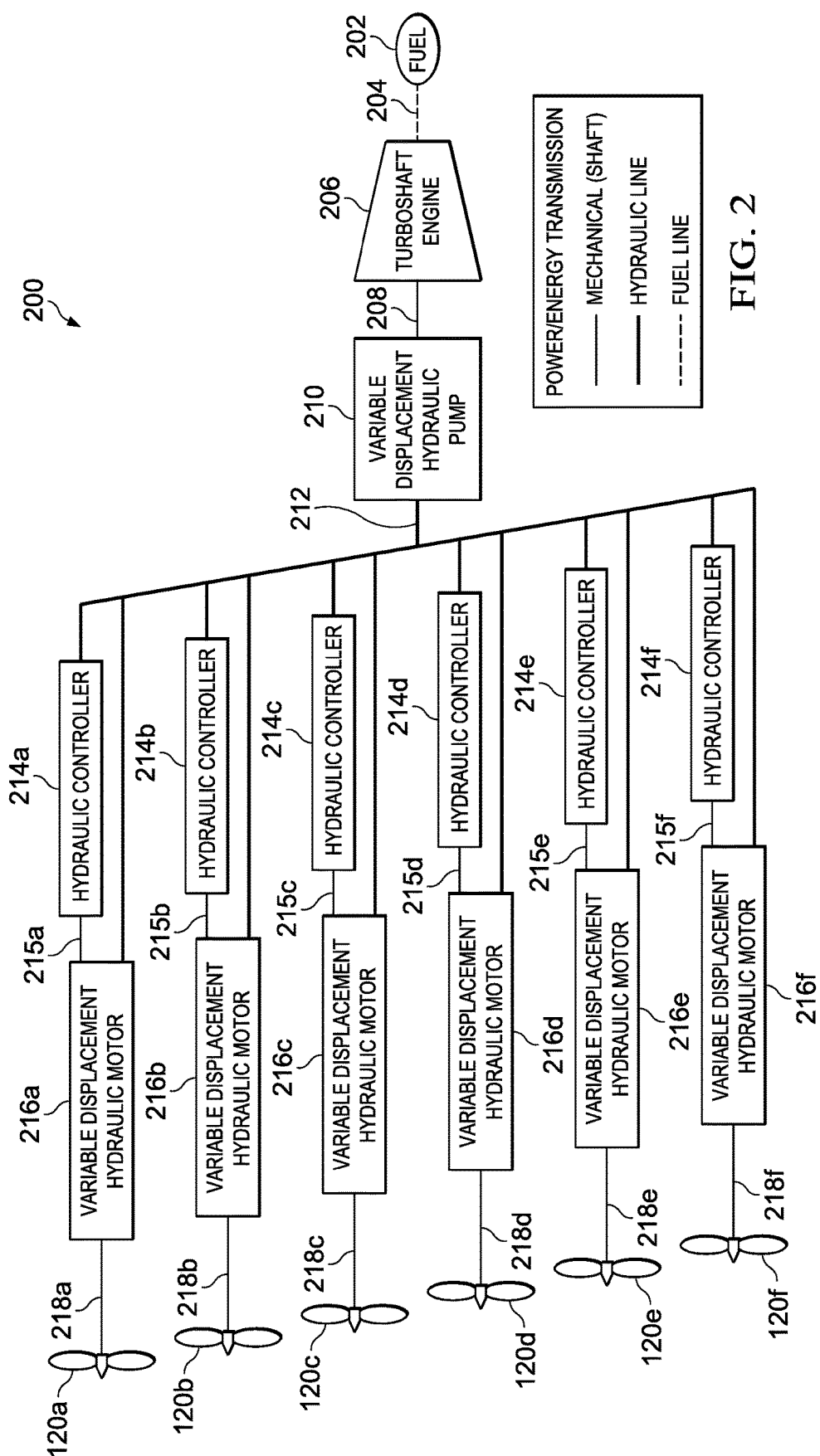


FIG. 1F





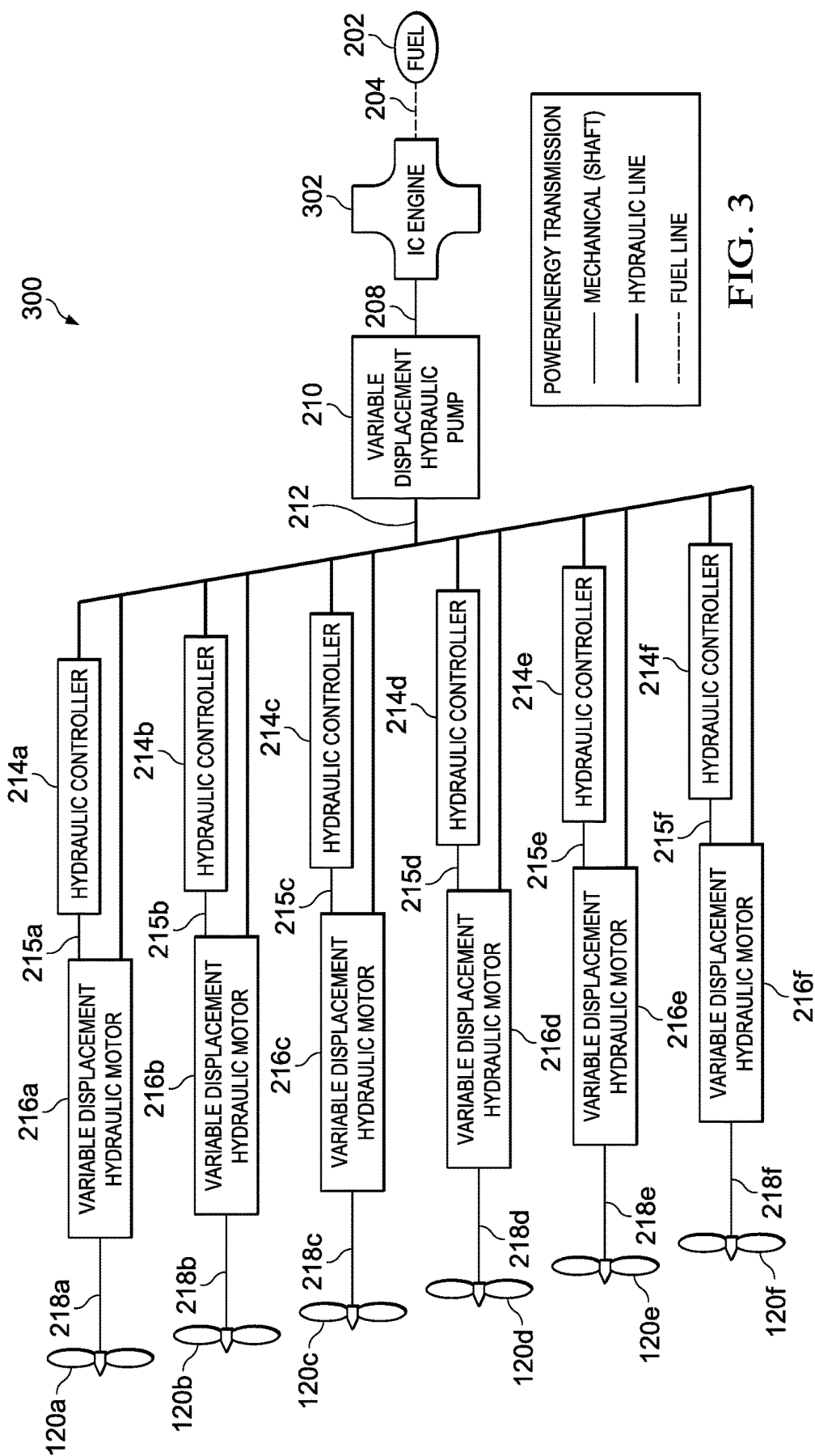
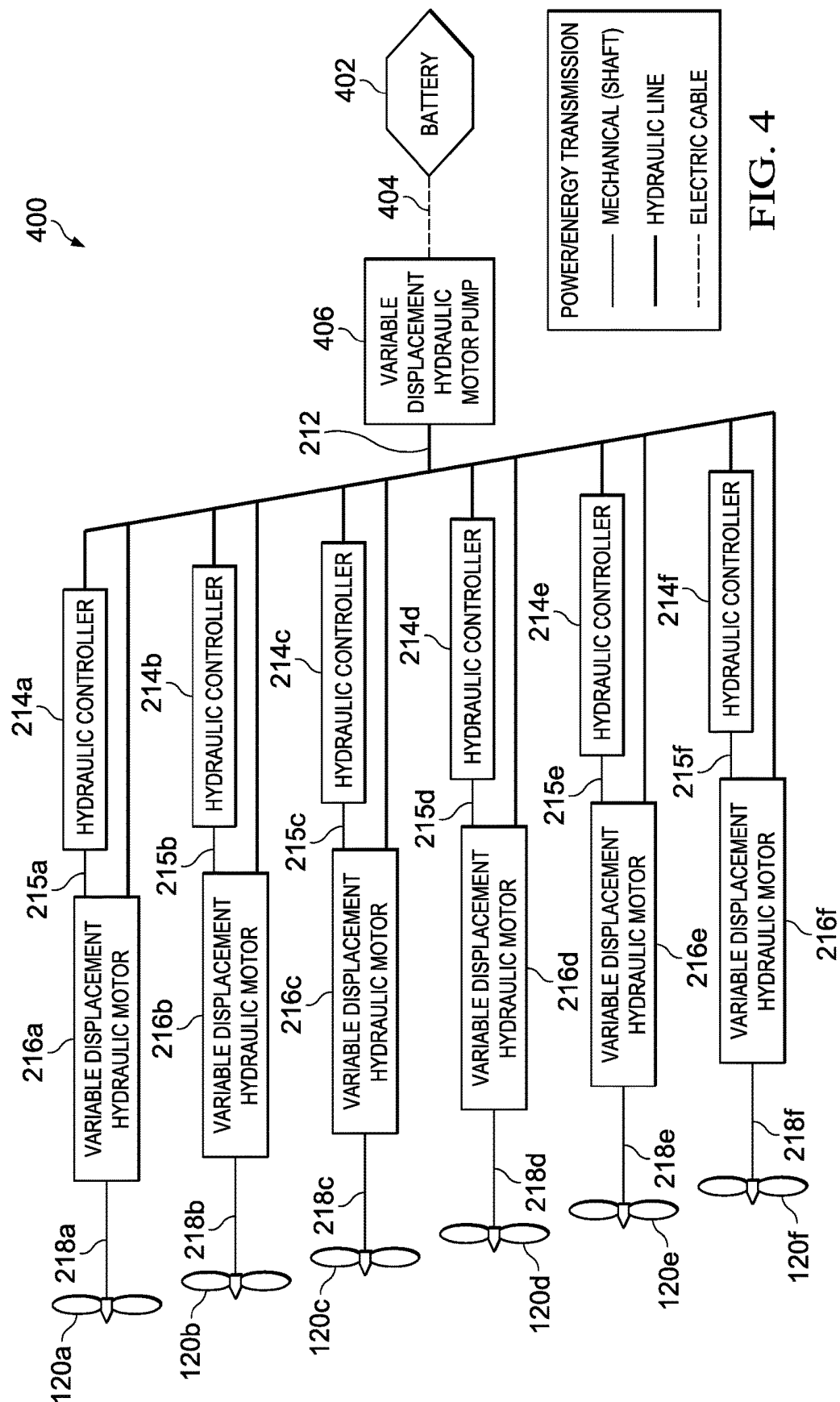
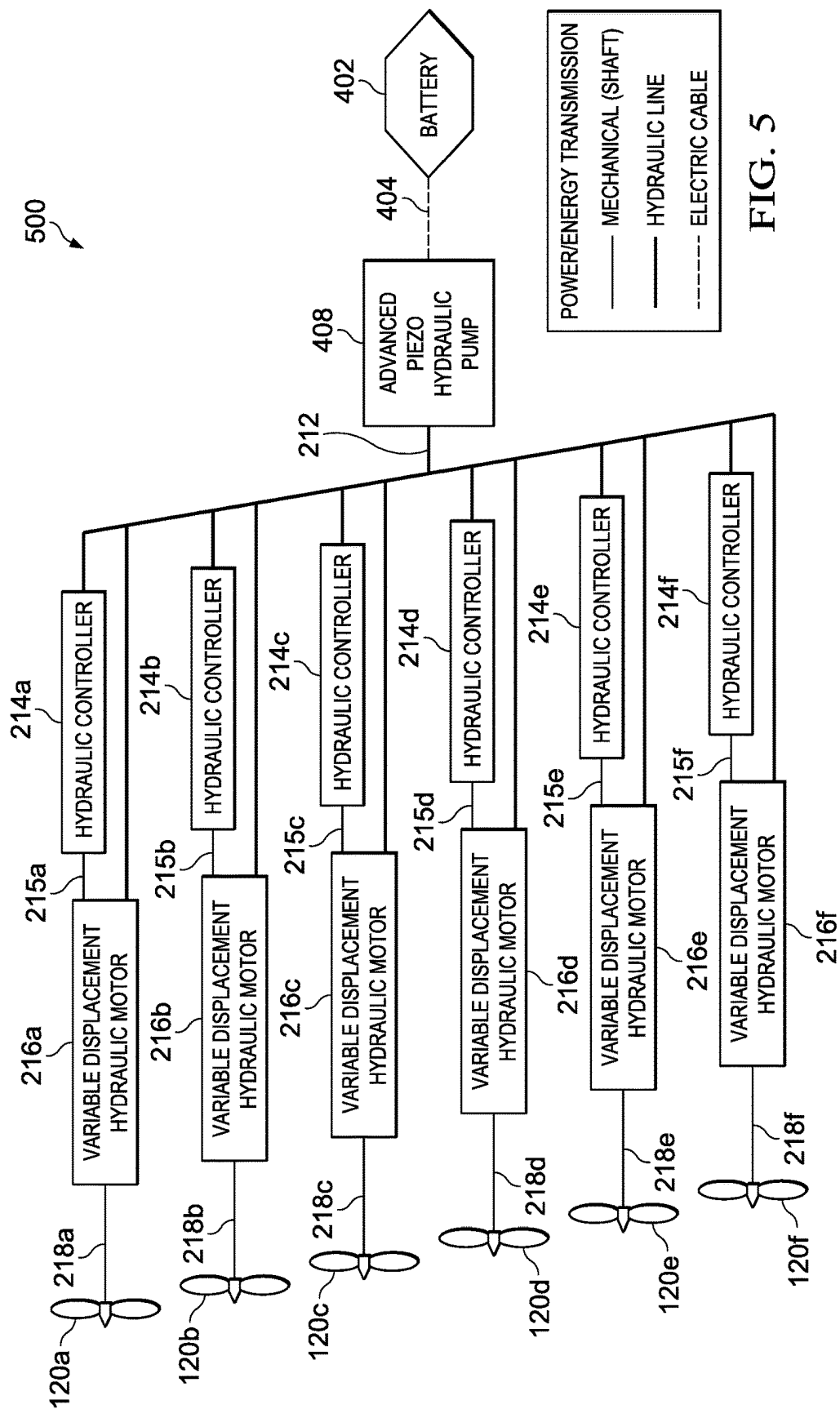
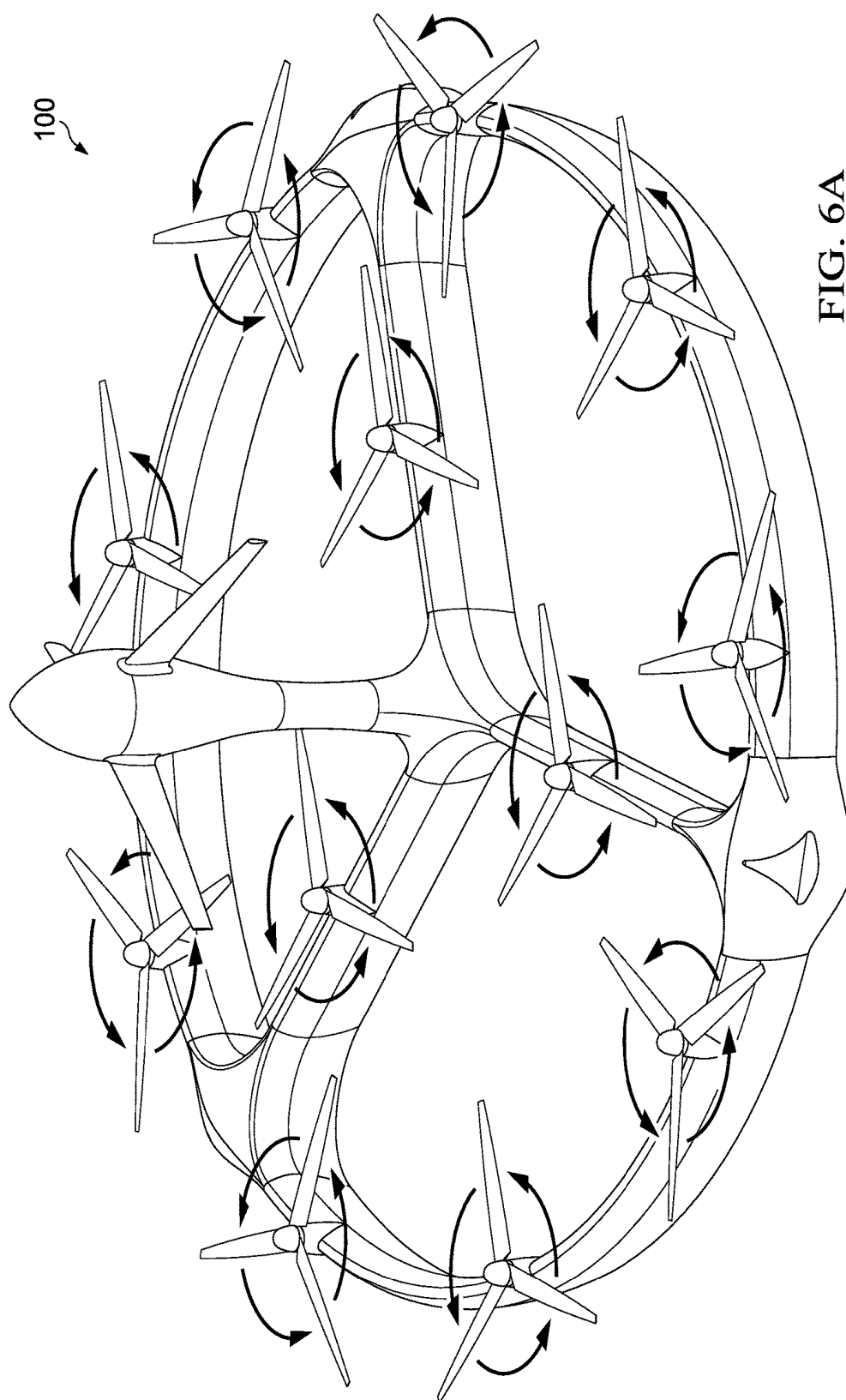


FIG. 3







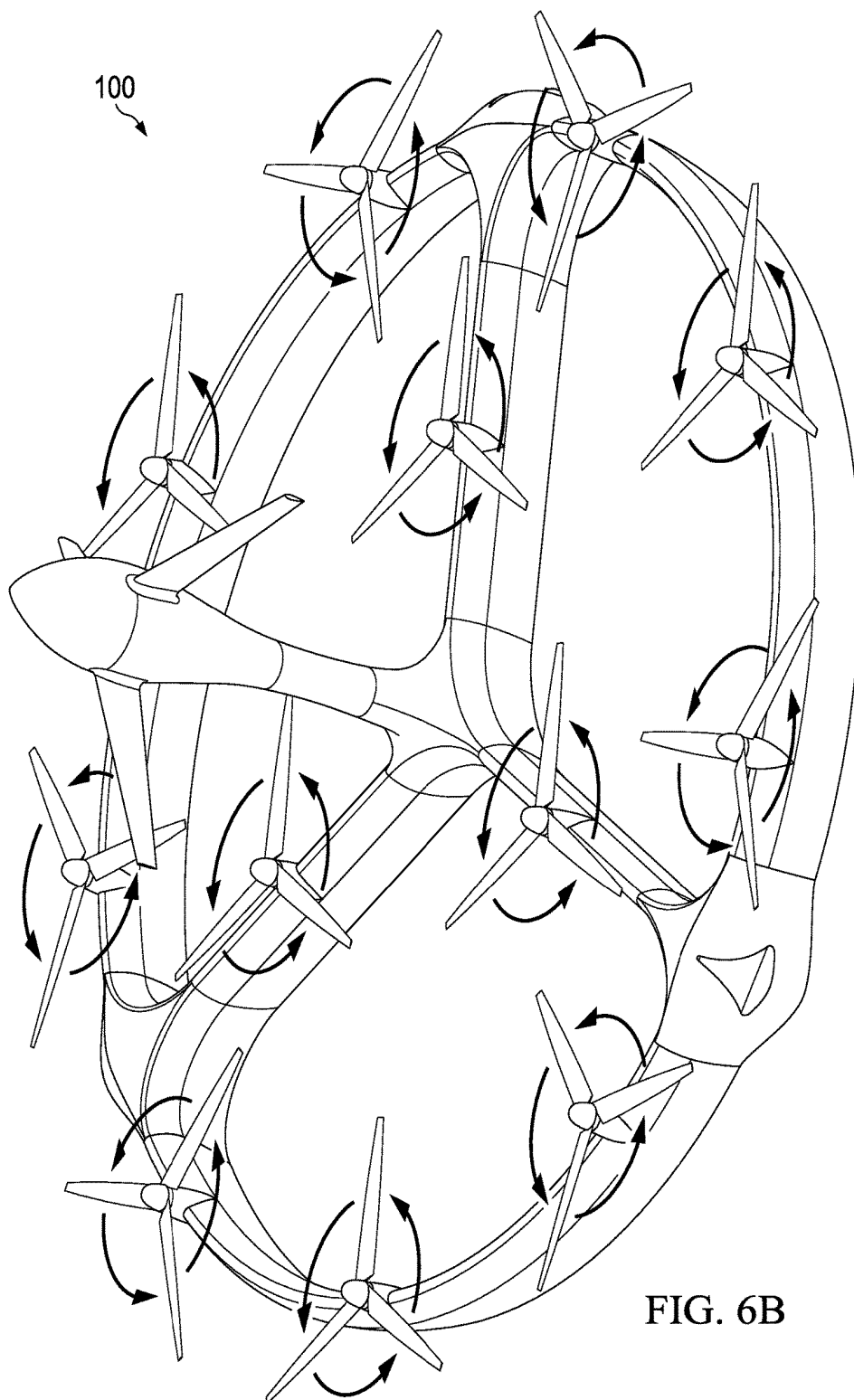


FIG. 6B

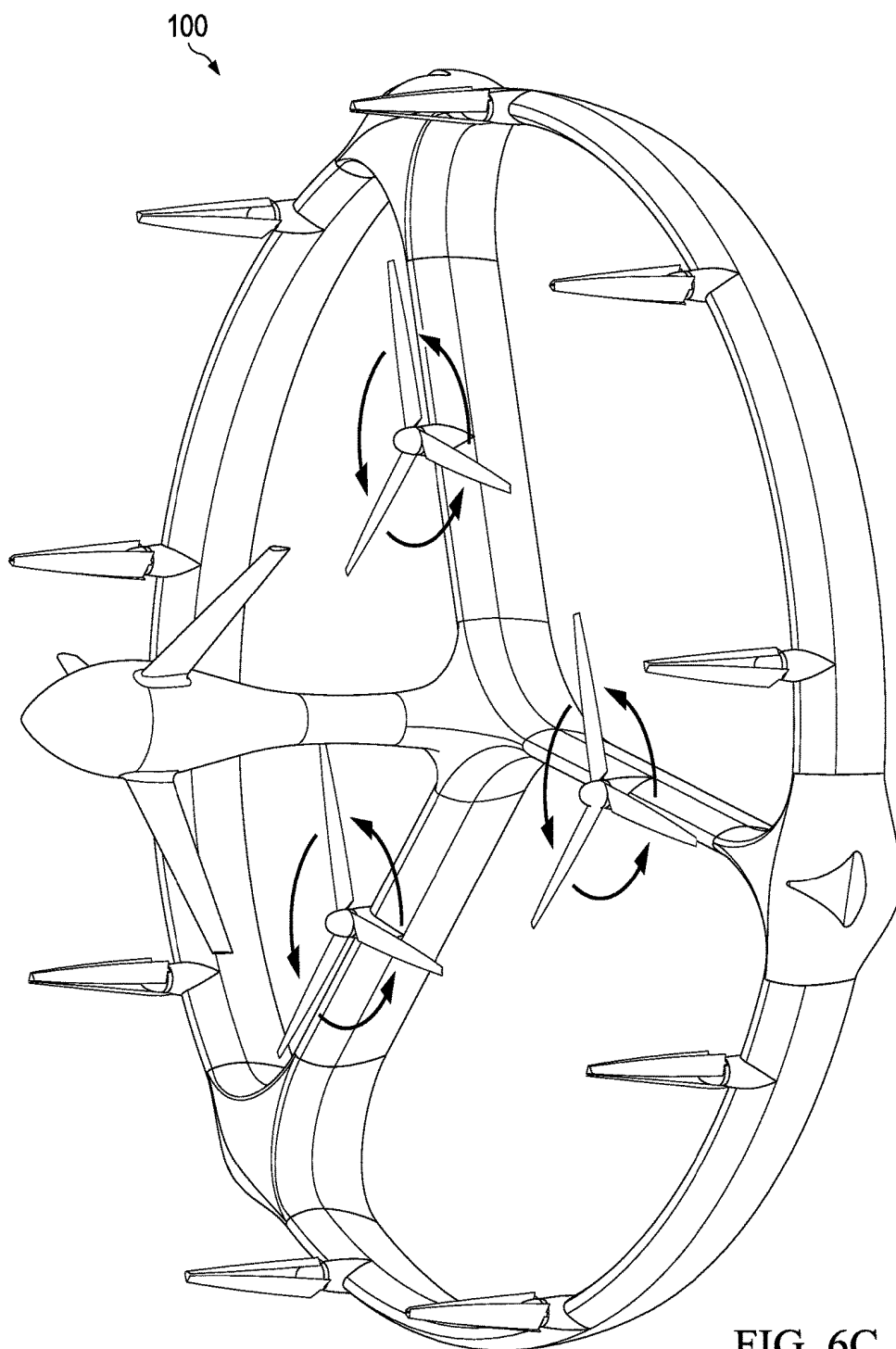


FIG. 6C

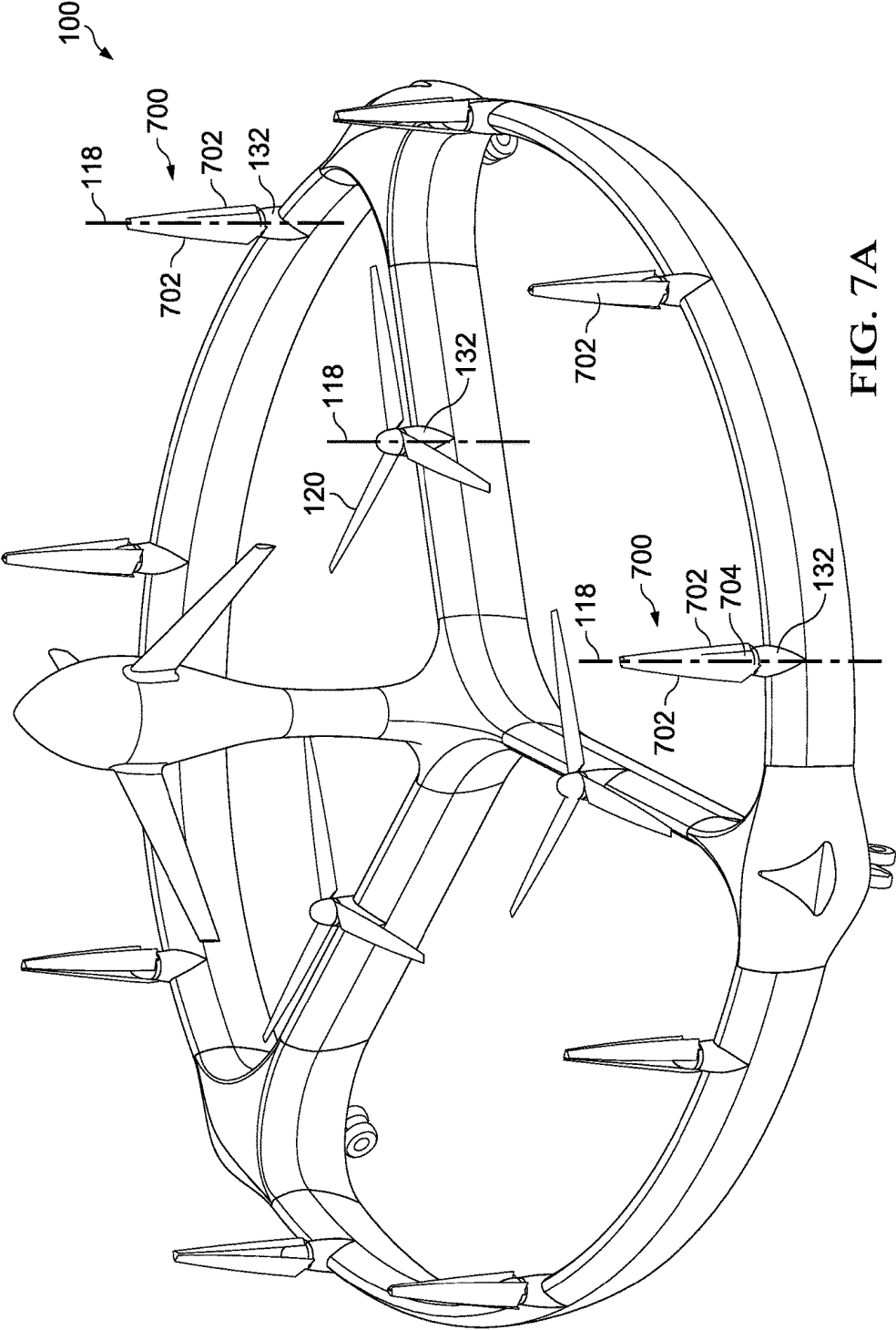


FIG. 7A

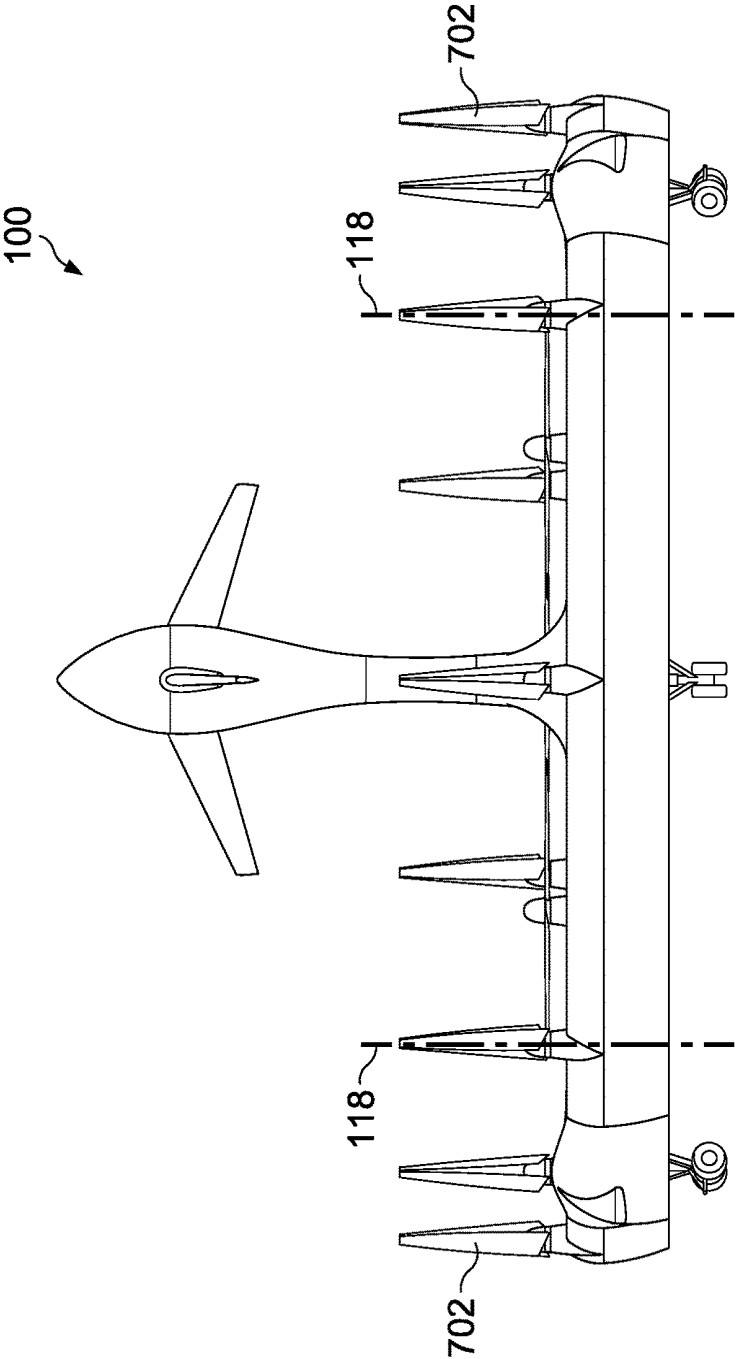


FIG. 7B

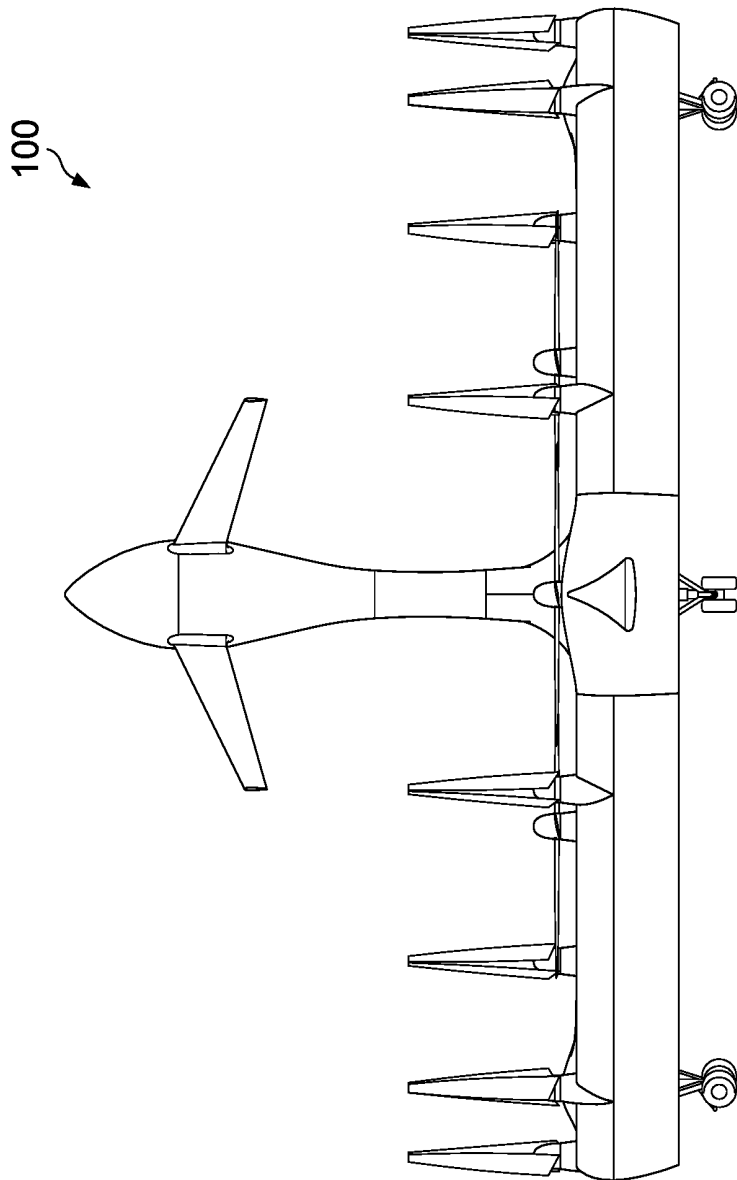


FIG. 7C

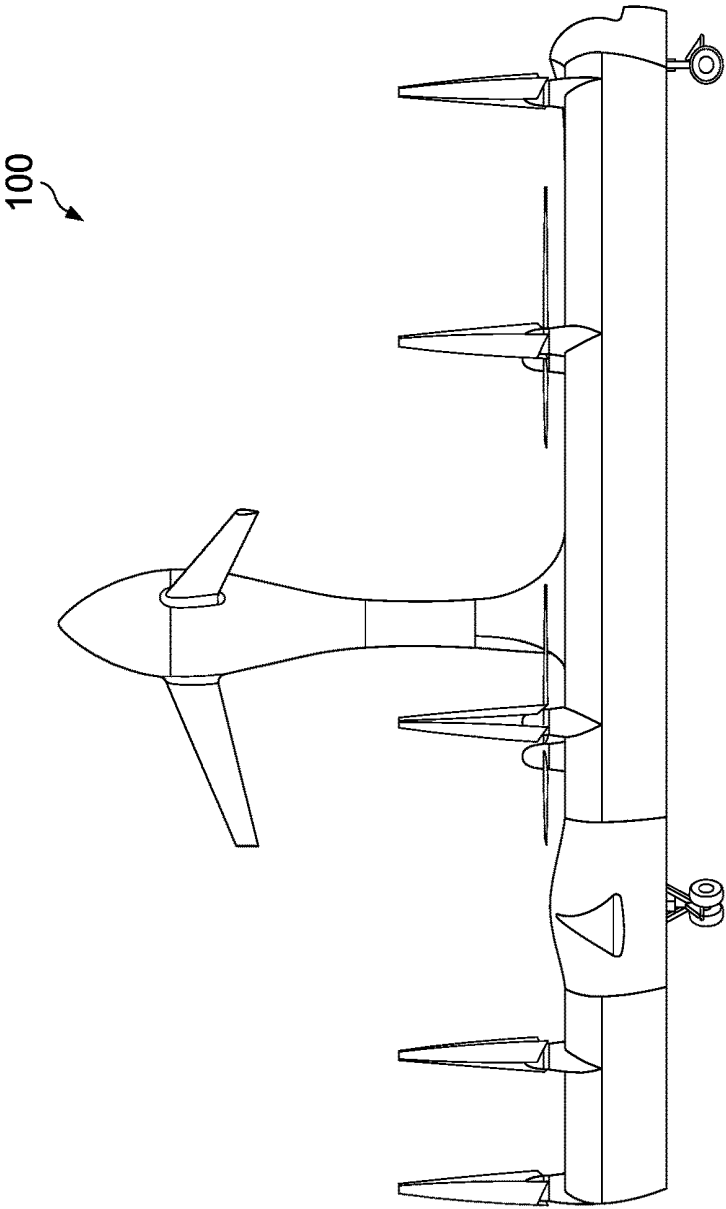
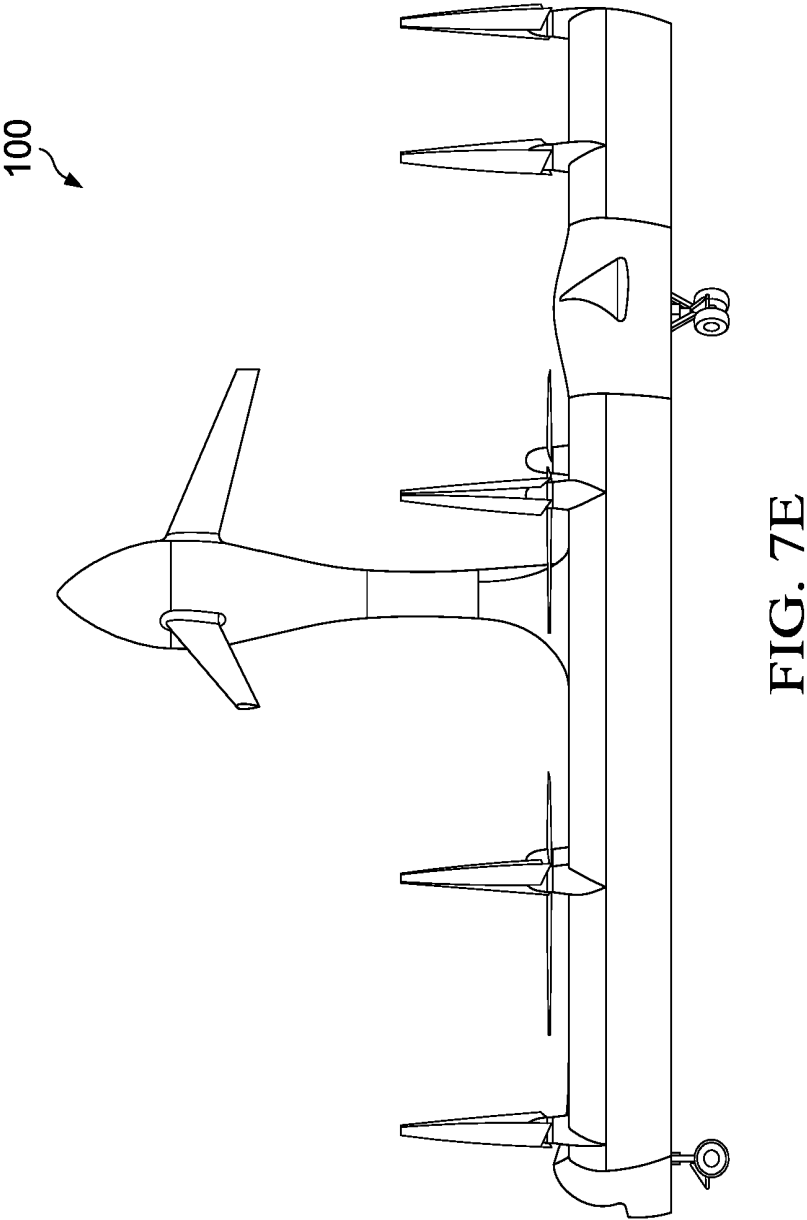
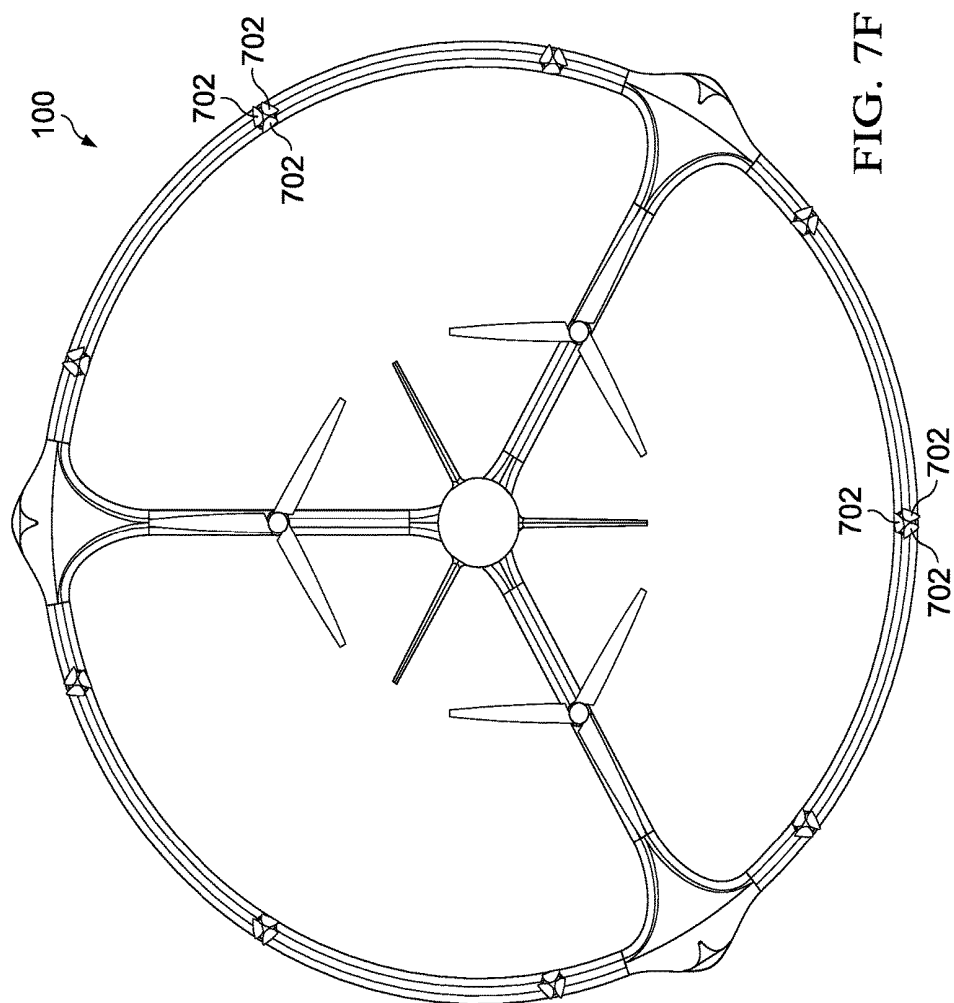
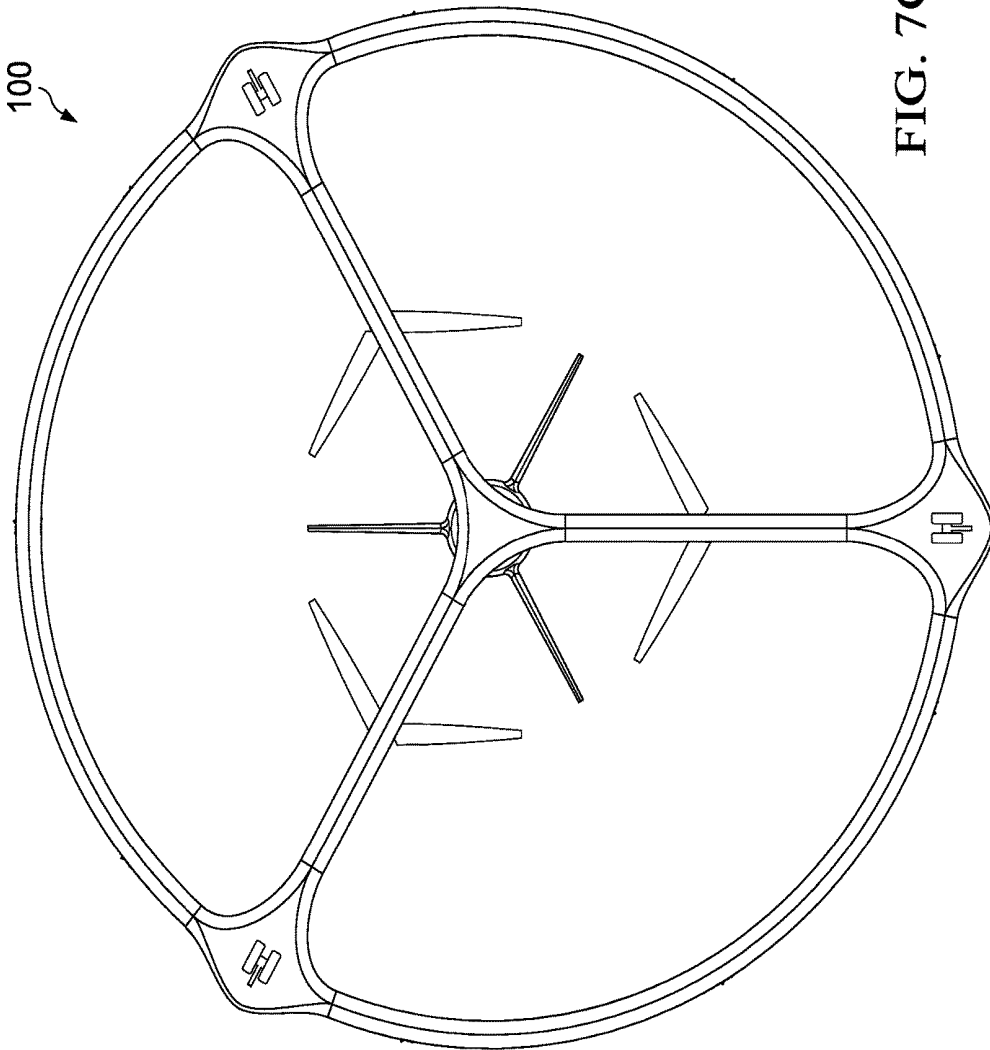
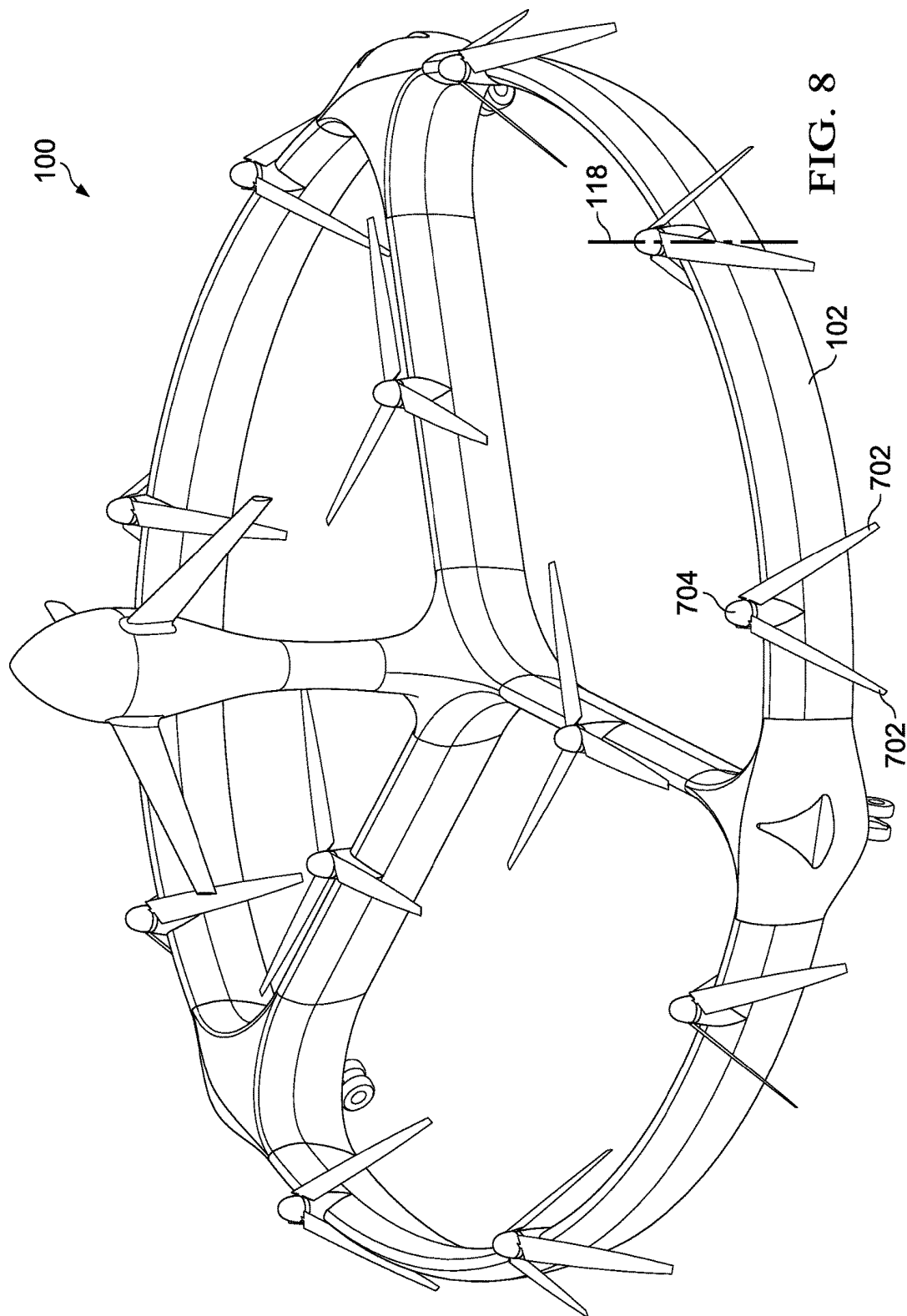


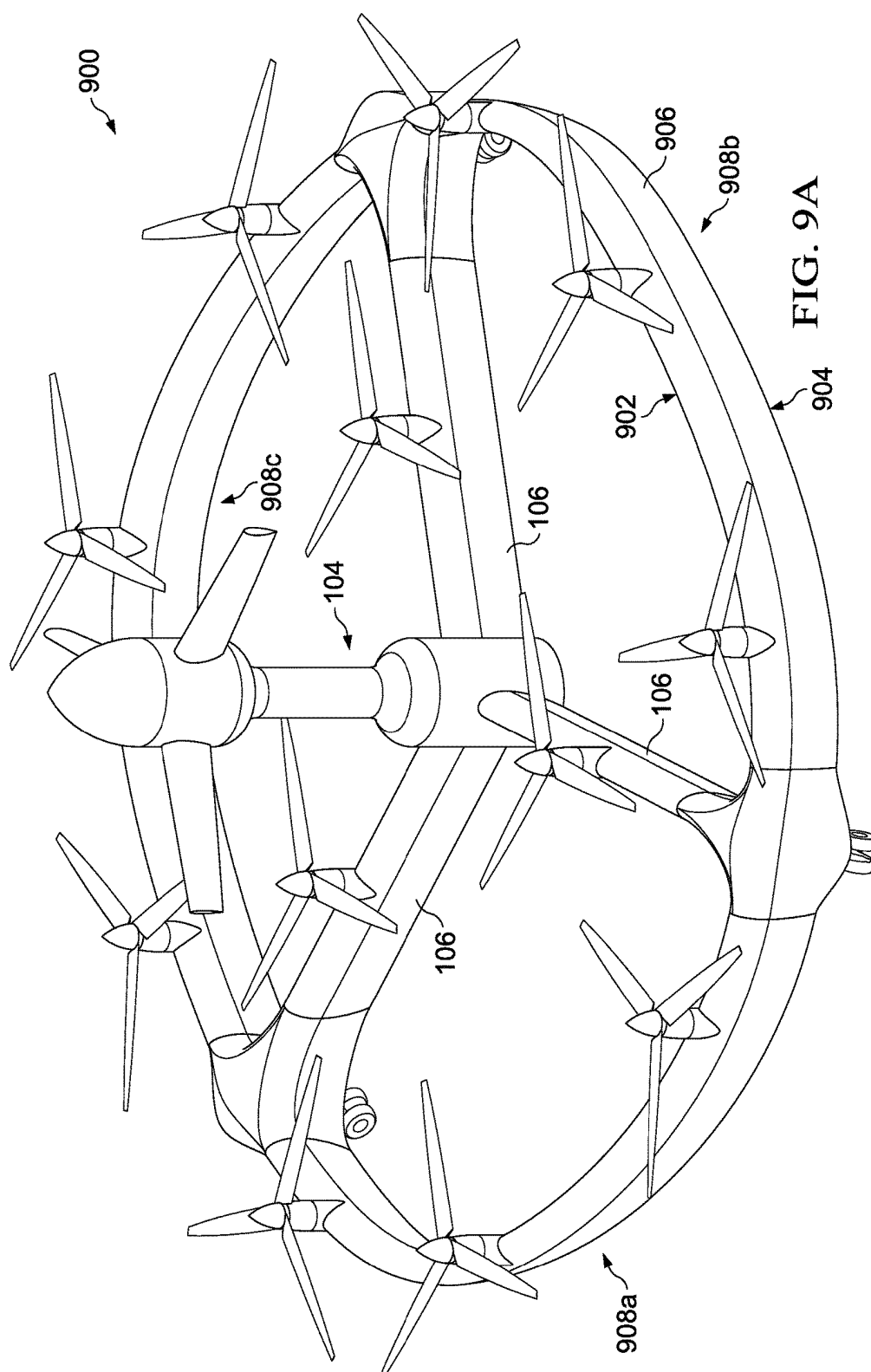
FIG. 7D











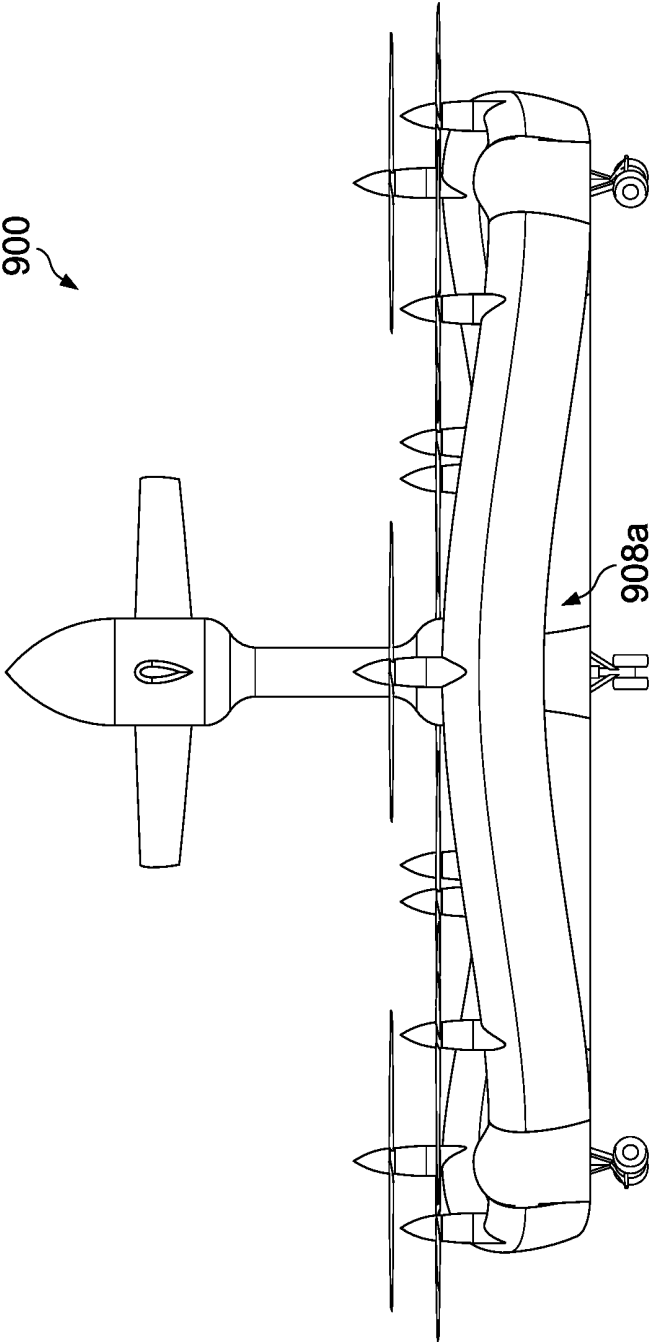


FIG. 9B

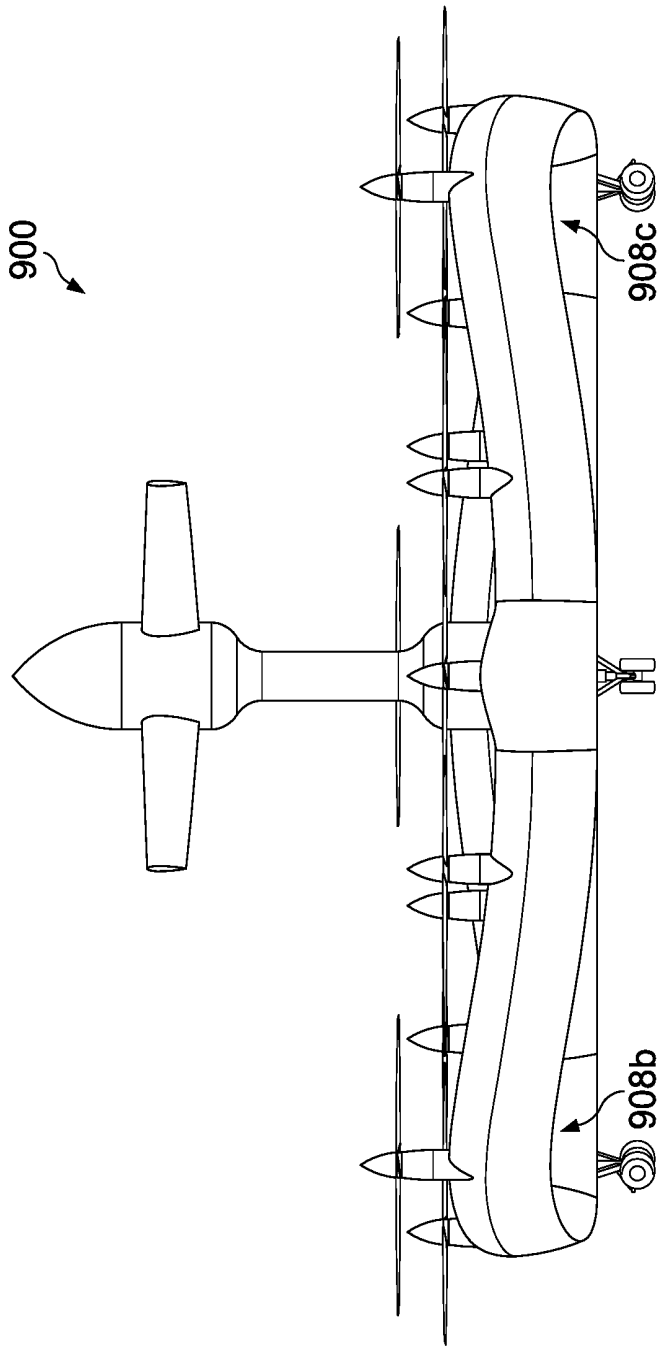


FIG. 9C

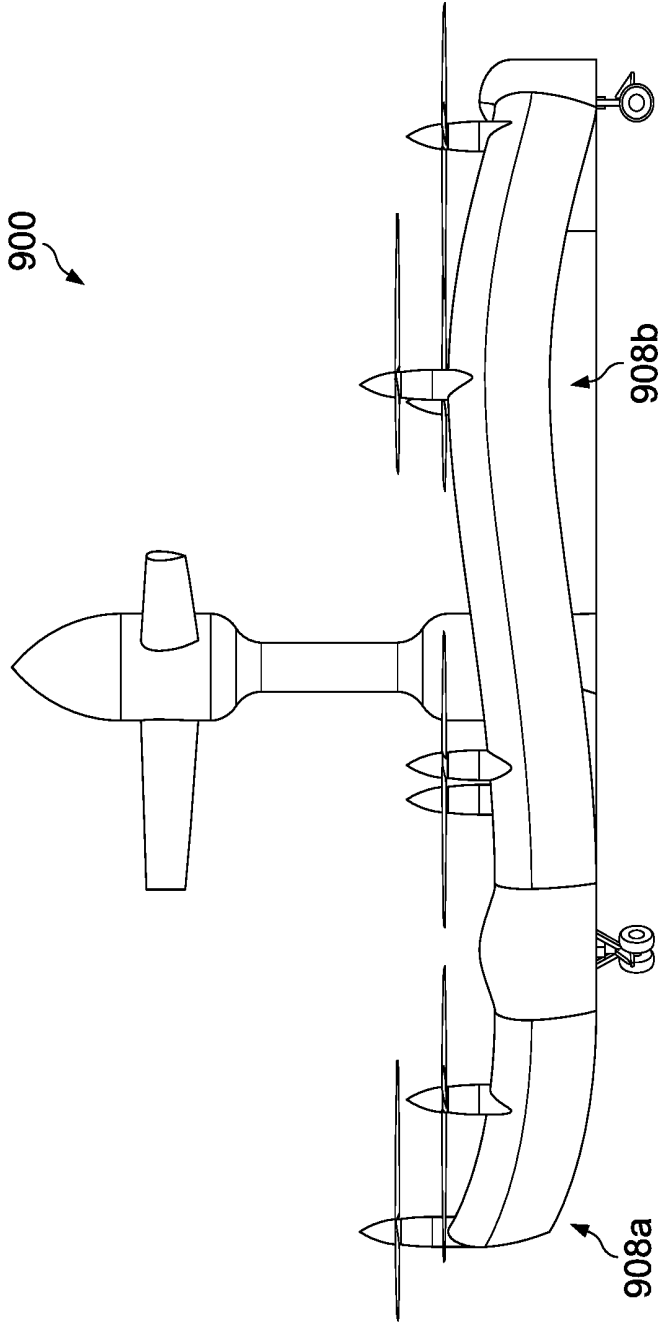


FIG. 9D

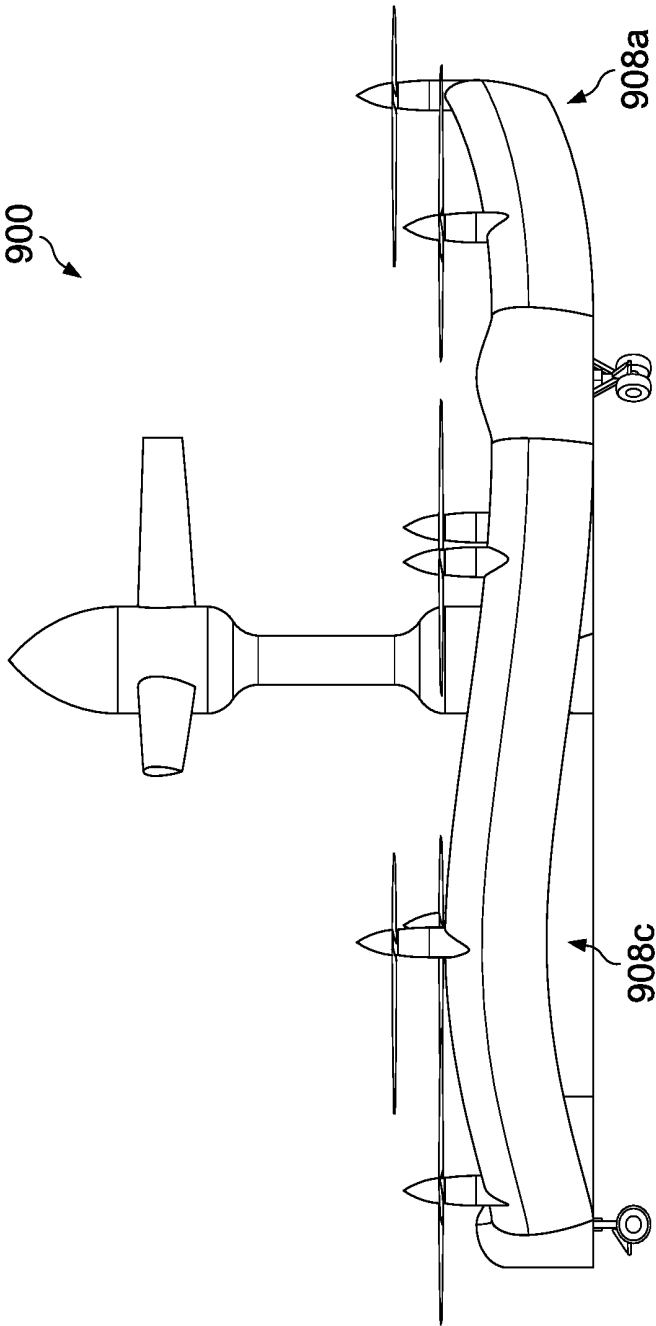


FIG. 9E

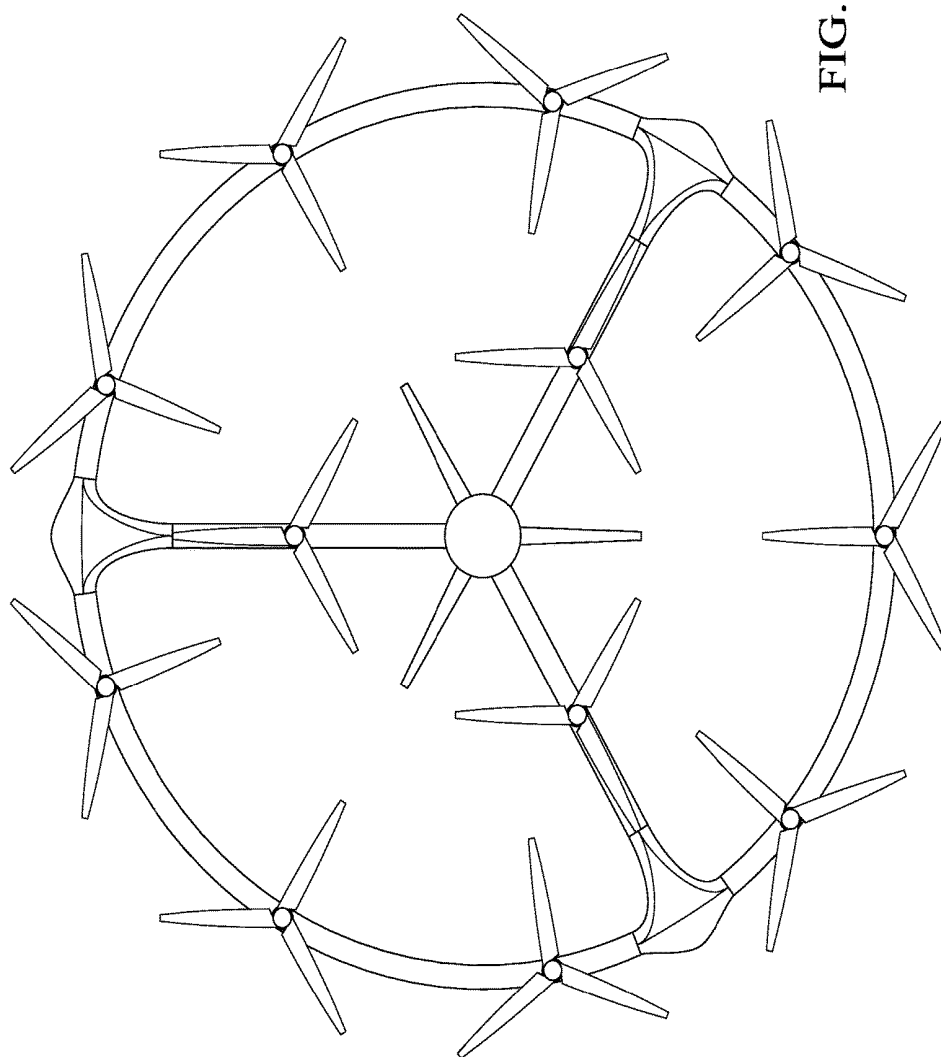


FIG. 9F

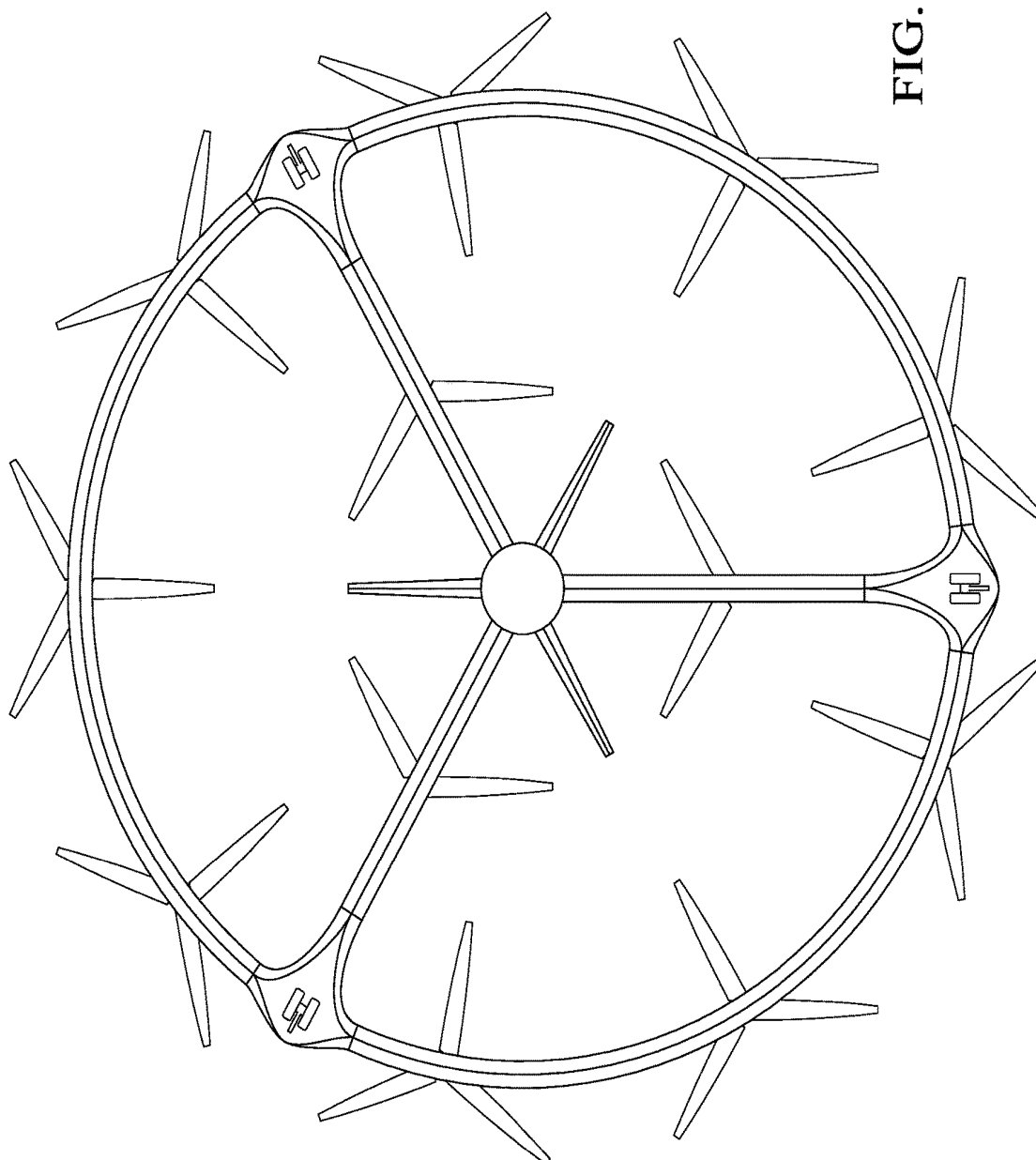


FIG. 9G

VERTICAL TAKE OFF AND LANDING CLOSED WING AIRCRAFT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Ser. No. 62/336,290, filed May 13, 2016 entitled “Distributed Propulsion”, U.S. Provisional Application Ser. No. 62/336,432, filed May 13, 2016 entitled “Forward Folding Rotor Blades”, U.S. Provisional Application Ser. No. 62/336,363, filed May 13, 2016 entitled “Vertical Take Off and Landing Closed Wing Aircraft”, U.S. Provisional Application Ser. No. 62/336,420, filed May 13, 2016 entitled “Distributed Propulsion System for Vertical Take Off and Landing Closed Wing Aircraft”, and U.S. Provisional Application Ser. No. 62/336,465, filed May 13, 2016 entitled “Modular Fuselage Sections for Vertical Take Off and Landing Distributed Airframe Aircraft”, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD OF THE INVENTION

[0002] The present invention relates in general to the field of aircraft design, and more particularly, to vertical take off and landing closed wing aircraft.

STATEMENT OF FEDERALLY FUNDED RESEARCH

[0003] None.

BACKGROUND OF THE INVENTION

[0004] Without limiting the scope of the invention, its background is described in connection with aircraft. With the popularity of unmanned drones, there has been resurgence in the use of “tail sitter” or “pogo” configurations. These configurations are generally very stable, but lack the long range and high speed of traditional aircraft. As a result, there is a need for an aircraft that can transition between vertical hover and horizontal airplane mode flight.

SUMMARY OF THE INVENTION

[0005] An aircraft capable of vertical takeoff and landing, stationary flight and forward flight includes a closed wing that provides lift whenever the aircraft is in forward flight, a fuselage at least partially disposed within a perimeter of the closed wing, and one or more spokes coupling the closed wing to the fuselage. One or more engines or motors are disposed within or attached to the closed wing, fuselage or spokes. Three or more propellers are proximate to a leading edge of the closed wing or the one or more spokes, distributed along the closed wing or the one or more spokes, and operably connected to the one or more engines or motors. The propellers provide lift whenever the aircraft is in vertical takeoff and landing and stationary flight, and provide thrust whenever the aircraft is in forward flight.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The novel features believed characteristic of the present application are set forth in the appended claims. However, the system itself, as well as a preferred mode of use, and further objectives and advantages thereof, will best be understood by reference to the following detailed description when read in conjunction with the accompanying draw-

ings, in which the leftmost significant digit(s) in the reference numerals denote(s) the first figure in which the respective reference numerals appear, wherein:

[0007] FIG. 1A is a perspective view of a closed wing aircraft in accordance with one embodiment of the present invention;

[0008] FIG. 1B is a front elevation view of the closed wing aircraft of FIG. 1A;

[0009] FIG. 1C is a rear elevation view of the closed wing aircraft of FIG. 1A;

[0010] FIG. 1D is a right side elevation view of the closed wing aircraft of FIG. 1A;

[0011] FIG. 1E is a left side elevation view of the closed wing aircraft of FIG. 1A;

[0012] FIG. 1F is a top plan view of the closed wing aircraft of FIG. 1A;

[0013] FIG. 1G is a bottom plan view of the closed wing aircraft of FIG. 1A;

[0014] FIG. 2 shows a schematic of a hybrid turboshaft engine hydraulic distributed propulsion system in accordance with one embodiment of the present invention;

[0015] FIG. 3 shows a schematic of a hybrid internal combustion engine-engine hydraulic distributed propulsion system in accordance with one embodiment of the present invention;

[0016] FIG. 4 shows a schematic of a hybrid electric hydraulic distributed propulsion system in accordance with one embodiment of the present invention;

[0017] FIG. 5 shows a schematic of a hybrid electric hydraulic with a piezo-electric pump distributed propulsion system in accordance with one embodiment of the present invention;

[0018] FIG. 6A depicts the closed wing aircraft of FIG. 1A in stationary flight (hover mode including vertical take off and landing) in accordance with one embodiment of the present invention;

[0019] FIG. 6B depicts the closed wing aircraft of FIG. 1A in transition from stationary flight to forward flight and vice versa in accordance with one embodiment of the present invention;

[0020] FIG. 6C depicts the closed wing aircraft of FIG. 1A in forward flight in accordance with one embodiment of the present invention

[0021] FIG. 7A is a perspective view of a closed wing aircraft in accordance with one embodiment of the present invention in which the rotors on the spokes are deployed and the rotors on the closed wing are folded forward;

[0022] FIG. 7B is a front elevation view of the closed wing aircraft of FIG. 7A;

[0023] FIG. 7C is a rear elevation view of the closed wing aircraft of FIG. 7A;

[0024] FIG. 7D is a right side elevation view of the closed wing aircraft of FIG. 7A;

[0025] FIG. 7E is a left side elevation view of the closed wing aircraft of FIG. 7A;

[0026] FIG. 7F is a top plan view of the closed wing aircraft of FIG. 7A;

[0027] FIG. 7G is a bottom plan view of the closed wing aircraft of FIG. 7A;

[0028] FIG. 8 is a perspective view of a closed wing aircraft in accordance with one embodiment of the present invention in which the rotors on the spokes are deployed and the rotors on the closed wing are folded backward;

[0029] FIG. 9A is a perspective view of a closed wing aircraft having a sinusoidal-shaped circular wing in accordance with one embodiment of the present invention;

[0030] FIG. 9B is a front elevation view of the closed wing aircraft of FIG. 9A;

[0031] FIG. 9C is a rear elevation view of the closed wing aircraft of FIG. 9A;

[0032] FIG. 9D is a right side elevation view of the closed wing aircraft of FIG. 9A;

[0033] FIG. 9E is a left side elevation view of the closed wing aircraft of FIG. 9A;

[0034] FIG. 9F is a top plan view of the closed wing aircraft of FIG. 9A; and

[0035] FIG. 9G is a bottom plan view of the closed wing aircraft of FIG. 9A.

DETAILED DESCRIPTION OF THE INVENTION

[0036] While the system of the present application is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the present application to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present application as defined by the appended claims.

[0037] To facilitate the understanding of this invention, a number of terms are defined below. Terms defined herein have meanings as commonly understood by a person of ordinary skill in the areas relevant to the present invention. Terms such as “a”, “an” and “the” are not intended to refer to only a singular entity, but include the general class of which a specific example may be used for illustration. The terminology herein is used to describe specific embodiments of the invention, but their usage does not delimit the invention, except as outlined in the claims.

[0038] Illustrative embodiments of the present application are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developer's specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0039] As used herein, reference may be made to the spatial relationships between various components and to the spatial orientation of various aspects of components as the devices are depicted in the attached drawings. However, as will be recognized by those skilled in the art after a complete reading of the present application, the devices, members, apparatuses, etc. described herein may be positioned in any desired orientation. Thus, the use of terms such as “above,” “below,” “upper,” “lower,” or other like terms to describe a spatial relationship between various components or to describe the spatial orientation of aspects of such components should be understood to describe a relative relationship between the components or a spatial orientation of

aspects of such components, respectively, as the device described herein may be oriented in any desired direction.

[0040] As will be described in more detail below, various embodiments of the present invention integrate a circular wing or ring wing configuration with a distributed propulsion system to create a vertical takeoff and landing (VTOL) aircraft configuration with long range and high speed. These performance capabilities are achieved without increased aircraft complexity and cost normally incurred with this level of capability in a VTOL aircraft. No reconfiguration of the aircraft is required to transition between vertical hover and horizontal airplane mode flight. The “tail sitter” or “pogo” configuration allows transition without any physical configurations. However, in some embodiments, structural, aerodynamic or power plant adjustments and/or reconfigurations may be desirable. In some embodiments, the rotor blades of the closed wing mounted propellers can be folded either forward or back to further reduce drag and provide increased speed and duration.

[0041] Now referring to FIGS. 1A-1G, various views of a closed wing aircraft **100** in accordance with one embodiment of the present invention are shown. More specifically, FIG. 1A is a perspective view, FIG. 1B is a front elevation view, FIG. 1C is a rear elevation view, FIG. 1D is right side elevation view, FIG. 1E is a left side elevation view, FIG. 1F is a top plan view, and FIG. 1G is a bottom plan view. This closed wing aircraft **100** features the following: 1) Tail sitter configuration provides for conversion to airplane mode without reconfiguration; 2) Circular wing optimizes propulsion, structural, aerodynamic, and center of gravity (CG) requirements; 3) Gearboxes and drive train are completely eliminated; 4) Rotor cyclic and collective controls are replaced by variable speed constant pitch propellers; and 5) Yaw in vertical flight and roll in hover mode are provided by trailing edge surfaces on the spokes connecting the closed wing to the fuselage.

[0042] The closed wing aircraft **100** utilizes the ring wing configuration to provide a symmetric matrix distribution of hydraulic or electric motor driven propellers to maximize controllability and provide safety in the event of a hydraulic or electric motor failure. The ring wing also reduces the effects of cross winds during takeoff and landing by minimizing the affected wing area and eliminating induced yaw. In airplane mode flight the ring wing allows the aircraft maintain any roll position in order to position sensors as required. For noise reduction the propellers within the ring provide an acoustic barrier. Structurally, the combination of distributed propulsion and the ring wing minimizes bending moments allowing for lighter and stiffer structure compared with distributed propulsion on straight wings. Engines or fuel/batteries can be housed in the base of the fuselage or at the intersection of the spokes to the ring wing for strength and minimization of weight. Landing gear is positioned at these points for similar reasons.

[0043] More specifically, the aircraft **100** can be manned or unmanned and is capable of vertical takeoff and landing, stationary flight and forward flight. The aircraft **100** includes a closed wing **102**, a fuselage **104** at least partially disposed within a perimeter of the closed wing **102**, and one or more spokes **106** coupling the closed wing **102** to the fuselage **104**. The closed wing **102** can be circular-shaped, oval-shaped, triangular-shaped, polygonal-shaped or any other shape suitable for the desired operational and aerodynamic requirements of the aircraft **100**. In addition, the closed wing

can be made up of a plurality of wing segments **102a**, **102b**, **102c** and wing-spoke intersections or junctions **108a**, **108b**, **108c** connected together. The cross-sectional profile of the closed wing **102** between the leading edge **110** and trailing edge **112** can be a symmetrical airfoil or any desirable aerodynamic shape. The number of spokes **106** can be determined, in part, by the shape and size of the closed wing **102**, and the shape, size and payload of the fuselage **104**. The cross-sectional profile of the spokes **106** between the leading edge **114** and the trailing edge **116** can be a symmetrical airfoil or any desirable aerodynamic shape. The closed wing **102**, the fuselage **104** and the one or more spokes **106** are preferably symmetrically shaped to provide transition between vertical takeoff and landing, stationary flight and forward flight in any direction. However, non-symmetrical shapes can be used. As a result, the shape of the closed wing **102** and number of spokes **106** shown in the figures is only one example and is not intended to limit the scope of the invention. The closed wing **102** may also include one or more doors or removable sections that provide access to the fuselage **104** when the aircraft **100** is in a landed position.

[0044] The fuselage **104** may include one or more sections or modules that have a longitudinal axis **116** substantially parallel to a rotational axis **118** of the propellers **120**. The shape and length of the fuselage **104** will vary depending on the desired mission and flight characteristics. As a result, the shape and length of the fuselage **104** shown in the figures is only one example and is not intended to limit the scope of the invention. For example, the fuselage **104** may include a rear section or module **122** substantially disposed at a center of the closed wing **102** that provides a fuselage-spoke intersection or junction, a middle section or module **124** connected to the rear section or module **122**, a front section or module **126** connected to the middle module **124**, and a nose section or module **128** connected to the front section or module **126**. Sections or modules **122**, **124**, **126**, **128** can be removably connected to one another, which makes the aircraft **100** configurable for any desired mission or function. In other words, the closed wing **102** and one or more spokes **106** provide a stable flight platform any desired payload. Moreover, the middle **124**, front **126** and nose **128** sections or modules can detach, pivot, or retract at least partially into one or more of the other sections or modules for storage or transport of the aircraft **100**. The rear **122**, middle **124**, front **126** and nose **128** sections or modules can be individually configured to be a cockpit module, a cabin module, an escape module, a payload module, a sensor module, a surveillance module, a power source module, a fuel module, or any combination thereof. Note that the nose section or module **128** may contain one or more parachutes.

[0045] The aircraft **100** also includes three or more landing gear, pads or skids **130** operably attached to the closed wing **102**. Typically, the landing gear, pads or skids **130** will be disposed proximate to the wing-spoke intersections or junctions **108a**, **108b**, **108c** where there is more structural support. The landing gear, pads or skids **130** can be retractable.

[0046] One or more engines or motors **132** are disposed within or attached to the closed wing **102**, fuselage **104** or spokes **106** in a distributed configuration. Three or more propellers **120** are proximate to the leading edge **110** of the closed wing **102** or the leading edge **114** of the one or more spokes **106**, distributed along the closed wing **102** or the one or more spokes **106**, and operably connected to the one or

more engines or motors **132**. In the embodiment shown, nine propellers **120** are disposed proximate to the closed wing **102**, and one propeller **120** is disposed proximate to each spoke **106**. The propellers **120** can be variable speed constant pitch propellers or other type of propeller. The distribution and number of propellers **120** are designed to provide stability during the failure of one or more propellers **120**, or engines or motors **132**.

[0047] In one embodiment, a source of hydraulic or electric power is disposed within or attached to the closed wing **102**, fuselage **104** or spokes **106** and coupled to each of the of hydraulic or electric motors **132** disposed within or attached to the closed wing **102**, fuselage **104** or spokes **106**. The source of hydraulic or electric power provides sufficient energy density for the aircraft to attain and maintain operations of the aircraft **100**. The source of hydraulic or electric power can be one or more batteries, a piston engine, or a turboshaft engine. A controller is coupled to each of the hydraulic or electric motors **132**, and one or more processors are communicably coupled to each controller that control an operation and speed of the plurality of hydraulic or electric motors **132**. Note that a single source of hydraulic or electric power can drive multiple hydraulic or electric motors **132**. For example, a source of hydraulic or electric power can be located in the wing-spoke intersections or junctions **108a**, **108b**, **108c** or the rear fuselage **122** where there is more structural support. Hydraulic or electric power distribution systems can be used to transmit the power to the hydraulic or electric motors **132**, which in turn drive the propellers **120**. The hydraulic or electric motors **132** are selected based on at least one of aerodynamics, propulsive efficiency, structural efficiency, aeroelasticity, or weight of the aircraft. Moreover, the propellers **120**, or the engines or motors **132** can be mounted to pivot to provide directional thrust. Similarly, additional thrusters can be disposed on the closed wing **102**, fuselage **104** or spokes **106**. Various examples of distributed power systems are shown in FIGS. 2-5.

[0048] Referring now to FIG. 2, a schematic of a hybrid turboshaft engine hydraulic distributed propulsion system **200** in accordance with one embodiment of the present invention is shown. In the hybrid turboshaft engine hydraulic distributed propulsion system **200**, a source of fuel **202** is connected to a fuel line **204** that feeds a turboshaft engine **206** that generates a mechanical force that is transmitted by a mechanical shaft **208** that is connected to a variable displacement hydraulic pump **210**. The variable displacement hydraulic pump **210** is connected to, and provides hydraulic power to, hydraulic lines **212**. The hydraulic fluid in hydraulic lines **212** is connected to hydraulic controllers **214a-214f**, which are connected mechanically by mechanical shafts **215a-215f** to the variable displacement hydraulic motors **216a-216f**, respectively, each of which is depicted being connected by mechanical shafts **218a-218f** to propellers **120a-120f**, respectively. Changing the displacement of the variable displacement hydraulic motors **216a-216f** can control the speed and torque of the variable displacement hydraulic motors **216a-216f**. The variable displacement hydraulic motors **216a-216f** can be self-cooling. This schematic shows the Hybrid Turboshaft Engine Hydraulic distributed propulsion system **200** as having six (6) hydraulic controllers **214a-214f**, and six (6) variable displacement hydraulic motors **216a-216f**. However, the skilled artisan will recognize that the present invention can include a smaller or larger number of variable displacement hydraulic

motors and propellers, for example 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 or more. In this embodiment, the fuel is converted into mechanical power/energy via the turboshaft engine **206**, which provides the hydraulic power that drives the variable displacement hydraulic motors **216a-216f** and therefore the propellers **120a-120f**.

[0049] Now referring to FIG. 3, a schematic of a hybrid internal combustion engine-engine hydraulic distributed propulsion system **300** in accordance with one embodiment of the present invention is shown. In this embodiment, the hybrid internal combustion engine-engine hydraulic distributed propulsion system **300** uses a source of fuel **202** that is connected to fuel line **204** that feeds an internal combustion engine **302** that generates a mechanical force that is transmitted by a mechanical shaft **208** that is connected to a variable displacement hydraulic pump **210**. The variable displacement hydraulic pump **210** is connected to, and provides hydraulic power to, hydraulic lines **212**. The hydraulic fluid in hydraulic lines **212** is connected to hydraulic controllers **214a-214f**, which are connected mechanically by mechanical shafts **215a-215f** to the variable displacement hydraulic motors **216a-216f**, respectively, each of which is depicted being connected by mechanical shafts **218a-218f** to propellers **120a-120f**, respectively. Changing the displacement of the variable displacement hydraulic motors **216a-216f** can control the speed and torque of the variable displacement hydraulic motors **216a-216f**. The variable displacement hydraulic motors **216a-216f** can be self-cooling. This schematic shows the Hybrid Internal Combustion Engine-Engine Hydraulic distributed propulsion system **300** as having six (6) hydraulic controllers **214a-214f**, and six (6) variable displacement hydraulic motors **216a-216f**. However, the skilled artisan will recognize that the present invention can include a smaller or larger number of variable displacement hydraulic motors and propellers, for example 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 or more. In this embodiment, the fuel is converted into mechanical power/energy via the internal combustion engine **302**, which provides the hydraulic power that drives the variable displacement hydraulic motors **216a-216f** and therefore the propellers **218a-218f**.

[0050] Referring now to FIG. 4, a schematic of a hybrid electric hydraulic distributed propulsion system **400** in accordance with one embodiment of the present invention is shown. In this embodiment, the hybrid electric hydraulic distributed propulsion system **400** uses one or more batteries **402** that are connected to electrical cable **404** that directly powers a variable displacement hydraulic motor pump **406**. The variable displacement hydraulic motor pump **406** is connected to, and provides hydraulic power to, hydraulic lines **212**. The hydraulic fluid in hydraulic lines **212** is connected to hydraulic controllers **214a-214f**, which are connected mechanically by mechanical shafts **215a-215f** to the variable displacement hydraulic motors **216a-216f**, respectively, each of which is depicted being connected by mechanical shafts **218a-218f** to propellers **120a-120f**, respectively. Changing the displacement of the variable displacement hydraulic motors **216a-216f** can control the speed and torque of the variable displacement hydraulic motors **216a-216f**. The variable displacement hydraulic motors **216a-216f** can be self-cooling. This schematic shows the Hybrid Internal Combustion Engine-Engine Hydraulic distributed propulsion system **400** as having six (6) hydraulic

controllers **214a-214f**, and six (6) variable displacement hydraulic motors **216a-216f**. However, the skilled artisan will recognize that the present invention can include a smaller or larger number of variable displacement hydraulic motors and propellers, for example 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 or more. In this embodiment, the electrical power is converted into mechanical power/energy via the variable displacement hydraulic motor pump **406**, which provides the hydraulic power that drives the variable displacement hydraulic motors **216a-216f** and therefore the propellers **218a-218f**.

[0051] Now referring to FIG. 5, a schematic of a hybrid electric hydraulic with a piezo-electric pump distributed propulsion system **500** in accordance with one embodiment of the present invention is shown. In this embodiment, the hybrid electric hydraulic with a piezo-electric pump distributed propulsion system **500** uses one or more batteries **402** that are connected to electrical cable **404** that directly powers a piezo-hydraulic pump **408**. The piezo-hydraulic pump **408** is connected to, and provides hydraulic power to, hydraulic lines **212**. The hydraulic fluid in hydraulic lines **212** is connected to hydraulic controllers **214a-214f**, which are connected mechanically by mechanical shafts **215a-215f** to the variable displacement hydraulic motors **216a-216f**, respectively, each of which is depicted being connected by mechanical shafts **218a-218f** to propellers **120a-120f**, respectively. Changing the displacement of the variable displacement hydraulic motors **216a-216f** can control the speed and torque of the variable displacement hydraulic motors **216a-216f**. The variable displacement hydraulic motors **216a-216f** can be self-cooling. This schematic shows the Hybrid Internal Combustion Engine-Engine Hydraulic distributed propulsion system **500** as having six (6) hydraulic controllers **214a-214f**, and six (6) variable displacement hydraulic motors **216a-216f**. However, the skilled artisan will recognize that the present invention can include a smaller or larger number of variable displacement hydraulic motors and propellers, for example 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 or more. In this embodiment, the electrical power is converted into mechanical power/energy via the piezo-hydraulic pump **408**, which provides the hydraulic power that drives the variable displacement hydraulic motors **216a-216f** and therefore the propellers **218a-218f**.

[0052] Some of the benefits of the distributed hydraulic system of the present invention, in conjunction with electric propulsion, can be attained by the present invention, for aircraft of all sizes. For example, for use with Vertical Take-Off and Landing (VTOL) aircraft the advantages of the present invention include: (1) a reduction in aircraft propulsion installation weight through greater structural integration; (2) the elimination of (rotor cyclic) control through differential and vectoring thrust for pitch, roll, and yaw moments; (3) high production rates and easy replacement of motors or propulsors that are small and light; (4) in the case of turbine/IC engine electric power generation, reduced fuel consumption and emissions through independent control of engine and rotor speeds; and (5) using electric batteries provided for more efficient energy usage, reduced emissions, and lower noise.

[0053] Further advantages of the present invention include addressing certain road blocks to distributed electric propulsion for larger VTOL aircraft. The present invention provides one or more of the following benefits: (1) the

elimination of electric motor and required controller power densities are low at required power levels (excessive weight); (2) eliminate electric motor torque capacity that is inadequate for speed changes required for thrust vectoring of larger rotors; (3) with increased power, electric motors require large diameters with ducted air or liquid cooling to prevent over heating (increased weight/envelope/complexity); (4) with increased power electric motor bearings require active lubrication (increased weight/complexity); and (5) current battery technology energy density insufficient for practical applications due to excessive weight.

[0054] Referring now to FIGS. 6A-6C, the aircraft 100 is shown in stationary flight (hover mode including vertical take off and landing) (FIG. 6A), transition from stationary flight to forward flight and vice versa (FIG. 6B), and forward flight (FIG. 6C). The closed wing 102 provides lift whenever the aircraft 100 is in forward flight. The three or more propellers 120 provide lift whenever the aircraft 100 is in vertical takeoff and landing and stationary flight, and provide thrust whenever the aircraft 100 is in forward flight. During forward flight, the propellers 120 can be selectively feathered or operated in a low power mode because the closed wing 102 and spokes 106 provide lift. One or more flight control surfaces are disposed on or extending from the closed wing 102, spokes 106 or the fuselage 104 to provide improved control and flight characteristics. The one or more control surfaces may include one or more air foils, winglets, elevators or ailerons. For example and as shown in FIGS. 1A-1G, winglets 134 mounted on the forward section or module 126 of the fuselage 104. Note that the one or more airfoils or winglets can be retractable, removable, stowable or variable swept.

[0055] As shown, the closed wing 102, fuselage 104 and spokes 106 are not substantially reconfigured for transition between vertical takeoff and landing, stationary flight and forward flight. However, in some embodiments it may be desirable to have the one or more spokes 106 operable to change a position of the closed wing 102 with respect to the fuselage 104 or vice versa. In other words, the spokes 106 would selectively pivot the closed wing 102 to act like a giant flap in horizontal mode and/or assist in transition to/from vertical mode.

[0056] The aircraft 100 provides a stable platform for one or more sensors or surveillance packages disposed on, disposed within or attached to the closed wing 102, spokes 106 or fuselage 104. In fact, the configuration of the aircraft 100 allows the placement of the one or more sensors or surveillance packages to provide a 360 degree view. Moreover, the extension of the fuselage 104 from the engines or motors 132 provides a wide unobstructed view for the one or more sensors or surveillance packages.

[0057] As shown in FIG. 6C and FIGS. 7A-7G, the propellers 120 can be selectively folded in a forward direction. The propellers 120 could also be folded in a backward direction. In the embodiment having the forward folding propellers 120, each propeller 700 includes two or more rotor blades 702, each rotor blade 702 in mechanical communication with a hub 704 and pivotable about an axis of rotation 118. A fold linkage mechanically couples a rotating portion of a bearing plate to the rotor blade 702. An actuator is coupled to a non-rotating portion of the bearing plate and is operable to reposition the bearing plate from a first position to a second position such that the folding links pivot the rotor blades 702 from a deployed position to a folded

position. The folded position can be a forward direction, which extends past the hub 704 with the first position of the bearing plate is closer to the hub 704 than the second position of the bearing plate. A tip of all the rotors 702 can be preloaded together in the forward folded position such that a vibration of the rotors 702 is minimized.

[0058] Alternatively and as shown in FIG. 8, the folded position can be a backward direction, which extends away from the hub 704, and the first position of the bearing plate is closer to the hub 304 than the second position of the bearing plate. The angle or distance that the rotors 702 can fold will depend on the relative size and shape of the closed wing with respect to the pivot point and size of the rotors. For example, FIG. 8 shows the rotors 702 folded in a backward position, but not against the surface of the closed wing 102 or substantially parallel to the rotational axis 118 of the rotors 702. Some embodiments of the present invention will have the rotors 702 resting against or close to the surface of the closed wing 102 and/or substantially parallel to the rotational axis 118 of the rotors. An example of backward folding rotor blades is disclosed in U.S. Pat. No. 9,156,545 which is hereby incorporated by reference in its entirety.

[0059] Now referring to FIGS. 9A-9G, various views of a closed wing aircraft 900 having a sinusoidal-shaped circular wing in accordance with one embodiment of the present invention are shown. More specifically, FIG. 9A is a perspective view, FIG. 9B is a front elevation view, FIG. 9C is a rear elevation view, FIG. 9D is right side elevation view, FIG. 9E is a left side elevation view, FIG. 9F is a top plan view, and FIG. 9G is a bottom plan view. As shown, the leading edge 902 and trailing edge 904 of the closed wing 906 are sinusoidal-shaped. Instead of the circular wing being a constant height around the center fuselage 104 as previously shown, the wing rises and falls to create three sinusoidal humps 908a, 908b, 908c. The humps 908a, 908b, 908c are at their highest between the three spokes 106 and lowest where the wing 906 attaches to the spokes 106. The advantages of this configuration are as follows: 1) Additional wing ground clearance to the circular wing when landing. With the flat circular wing landing must be close to perpendicular to avoid damaging the wing or the landing gear must be made much longer. 2) Improved access to center fuselage. With the flat circular wing access to the center fuselage is restricted by the height of the wing. 3) Improved stability by moving the wing center of pressure closer to the aircraft's center of gravity. The same benefits are achieved but to a lesser degree with four sinusoidal humps and four spokes and two sinusoidal humps with two spokes. With more than four sinusoidal humps the benefits are negligible. Alternatively, only one of the leading edge 902 or the trailing edge 904 of the closed wing 906 is sinusoidal-shaped. Moreover, other wing shapes can be used.

[0060] It will be understood that particular embodiments described herein are shown by way of illustration and not as limitations of the invention. The principal features of this invention can be employed in various embodiments without departing from the scope of the invention. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, numerous equivalents to the specific procedures described herein. Such equivalents are considered to be within the scope of this invention and are covered by the claims.

[0061] All publications and patent applications mentioned in the specification are indicative of the level of skill of those skilled in the art to which this invention pertains. All publications and patent applications are herein incorporated by reference to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

[0062] The use of the word “a” or “an” when used in conjunction with the term “comprising” in the claims and/or the specification may mean “one,” but it is also consistent with the meaning of “one or more,” “at least one,” and “one or more than one.” The use of the term “or” in the claims is used to mean “and/or” unless explicitly indicated to refer to alternatives only or the alternatives are mutually exclusive, although the disclosure supports a definition that refers to only alternatives and “and/or.” Throughout this application, the term “about” is used to indicate that a value includes the inherent variation of error for the device, the method being employed to determine the value, or the variation that exists among the study subjects.

[0063] As used in this specification and claim(s), the words “comprising” (and any form of comprising, such as “comprise” and “comprises”), “having” (and any form of having, such as “have” and “has”), “including” (and any form of including, such as “includes” and “include”) or “containing” (and any form of containing, such as “contains” and “contain”) are inclusive or open-ended and do not exclude additional, unrecited elements or method steps. In embodiments of any of the compositions and methods provided herein, “comprising” may be replaced with “consisting essentially of” or “consisting of”. As used herein, the phrase “consisting essentially of” requires the specified integer(s) or steps as well as those that do not materially affect the character or function of the claimed invention. As used herein, the term “consisting” is used to indicate the presence of the recited integer (e.g., a feature, an element, a characteristic, a property, a method/process step or a limitation) or group of integers (e.g., feature(s), element(s), characteristic(s), property(ies), method/process steps or limitation(s)) only.

[0064] The term “or combinations thereof” as used herein refers to all permutations and combinations of the listed items preceding the term. For example, “A, B, C, or combinations thereof” is intended to include at least one of: A, B, C, AB, AC, BC, or ABC, and if order is important in a particular context, also BA, CA, CB, CBA, BCA, ACB, BAC, or CAB. Continuing with this example, expressly included are combinations that contain repeats of one or more item or term, such as BB, AAA, AB, BBC, AAABC-CCC, CBBA, CABABB, and so forth. The skilled artisan will understand that typically there is no limit on the number of items or terms in any combination, unless otherwise apparent from the context.

[0065] As used herein, words of approximation such as, without limitation, “about”, “substantial” or “substantially” refers to a condition that when so modified is understood to not necessarily be absolute or perfect but would be considered close enough to those of ordinary skill in the art to warrant designating the condition as being present. The extent to which the description may vary will depend on how great a change can be instituted and still have one of ordinary skill in the art recognize the modified feature as still having the required characteristics and capabilities of the unmodified feature. In general, but subject to the pre-

ceding discussion, a numerical value herein that is modified by a word of approximation such as “about” may vary from the stated value by at least $\pm 1, 2, 3, 4, 5, 6, 7, 10, 12$ or 15% from the stated value.

[0066] All of the methods disclosed and claimed herein can be made and executed without undue experimentation in light of the present disclosure. While the methods of this invention have been described in terms of preferred embodiments, it will be apparent to those of skill in the art that variations may be applied to the methods and in the steps or in the sequence of steps of the method described herein without departing from the concept, spirit and scope of the invention. All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the spirit, scope and concept of the invention as defined by the appended claims.

What is claimed is:

1. An aircraft capable of vertical takeoff and landing, stationary flight and forward flight, comprising:

a closed wing that provides lift whenever the aircraft is in forward flight;

a fuselage at least partially disposed within a perimeter of the closed wing;

one or more spokes coupling the closed wing to the fuselage;

one or more engines or motors disposed within or attached to the closed wing, fuselage or spokes; and

three or more propellers proximate to a leading edge of the closed wing or the one or more spokes, distributed along the closed wing or the one or more spokes, and operably connected to the one or more engines or motors to provide lift whenever the aircraft is in vertical takeoff and landing and stationary flight and provide thrust whenever the aircraft is in forward flight.

2. The aircraft of claim 1, wherein the closed wing is circular-shaped, oval-shaped, triangular-shaped, or polygonal-shaped.

3. The aircraft of claim 1, wherein a leading edge or trailing edge or a combination thereof of the closed wing are sinusoidal-shaped.

4. The aircraft of claim 1, wherein the closed wing comprises a plurality of wing segments connected together.

5. The aircraft of claim 1, wherein the closed wing, the fuselage and the one or more spokes are not substantially reconfigured for transition between vertical takeoff and landing, stationary flight and forward flight.

6. The aircraft of claim 1, wherein the closed wing, the fuselage and the one or more spokes are symmetrically shaped to provide transition between vertical takeoff and landing, stationary flight and forward flight in any direction.

7. The aircraft of claim 1, further comprising one or more parachutes operably disposed within a nose of the fuselage.

8. The aircraft of claim 1, wherein the fuselage comprises:

a rear module substantially disposed at a center of the closed wing and having a longitudinal axis substantially parallel to a rotational axis of the three or more propellers;

a front module removably connected to the rear module and substantially aligned with the longitudinal axis.

9. The aircraft of claim 7, wherein:

the front module comprises a cockpit module, a cabin module, an escape module, a payload module, a sensor module or a surveillance module; and

the rear module comprises a cabin module, a payload module, a sensor module, a surveillance module, a power source module or a fuel module.

10. The aircraft of claim 7, further comprising one or more middle modules removably connected between the front module and the rear module.

11. The aircraft of claim 7, wherein the front module detaches, pivots, or retracts at least partially into the rear module for storage or transport of the aircraft.

12. The aircraft of claim 1, wherein the aircraft is manned or unmanned.

13. The aircraft of claim 1, further comprising one or more flight control surfaces disposed on or extending from the closed wing, the one or more spokes or the fuselage.

14. The aircraft of claim 13, wherein the one or more control surfaces comprise one or more air foils, winglets, elevators or ailerons.

15. The aircraft of claim 14, wherein the one or more airfoils or winglets are retractable, removable, stowable or variable swept.

16. The aircraft of claim 1, wherein the closed wing further comprises one or more doors or removable sections that provide access to the fuselage when the aircraft is in a landed position.

17. The aircraft of claim 1, wherein the one or more engines or motors comprise:

a plurality of hydraulic or electric motors disposed within or attached to the closed wing, fuselage or spokes in a distributed configuration;

a source of hydraulic or electric power disposed within or attached to the closed wing, fuselage or spokes and coupled to each of the of hydraulic or electric motors disposed within or attached to the closed wing, fuselage or spokes, wherein the source of hydraulic or electric power provides sufficient energy density for the aircraft to attain and maintain operations of the aircraft;

a controller coupled to each of the hydraulic or electric motors; and

one or more processors communicably coupled to each controller that control an operation and speed of the plurality of hydraulic or electric motors.

18. The aircraft of claim 17, wherein the hydraulic or electric motors are selected based on at least one of aerodynamics, propulsive efficiency, structural efficiency, aeroelasticity, or weight of the aircraft.

19. The aircraft of claim 17, wherein the source of hydraulic or electric power is one or more batteries, a piston engine, or a turboshaft engine.

20. The aircraft of claim 17, wherein the plurality of hydraulic or electric motors comprise 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, or 25 hydraulic or electric motors.

21. The aircraft of claim 17, wherein the hydraulic motors are defined further as a variable displacement hydraulic motor, wherein a speed and a torque are controlled by changing a displacement of the variable displacement hydraulic motor.

22. The aircraft of claim 17, wherein the hydraulic or electric motors are self-cooling.

23. The aircraft of claim 17, wherein the source of hydraulic or electric power comprises a turboshaft engine or

an internal combustion engine, and a variable displacement hydraulic pump connected between the turboshaft engine or the internal combustion engine and the plurality of hydraulic or electric motors.

24. The aircraft of claim 17, wherein the source of hydraulic or electric power comprises one or more batteries, and a variable displacement hydraulic motor pump or a piezo-hydraulic pump connected between the one or more batteries and the plurality of hydraulic or electric motors.

25. The aircraft of claim 1, wherein the each of the four or more propellers comprise a variable speed constant pitch propeller.

26. The aircraft of claim 1, wherein each propeller comprises:

two or more rotor blades, each rotor blade in mechanical communication with a hub and pivotable about an axis of rotation;

a bearing plate comprising a rotating portion and a non-rotating portion;

a fold linkage coupled to the rotating portion of the bearing plate and in mechanical communication with the rotor blade; and

an actuator coupled to the non-rotating portion of the bearing plate and operable to reposition the bearing plate from a first position to a second position such that the folding links pivot the rotor blades from a deployed position to a folded position.

27. The aircraft of claim 26, wherein the folded position comprises a forward direction extending past the hub, and the first position of the bearing plate is closer to the hub than the second position of the bearing plate.

28. The aircraft of claim 26, wherein the folded position comprises a backward direction extending away from the hub, and the first position of the bearing plate is closer to the hub than the second position of the bearing plate.

29. The aircraft of claim 26, wherein a tip of all the rotors are preloaded together in the forward folded position such that a vibration of the rotors is minimized.

30. The aircraft of claim 1, wherein the three or more propellers are selectively feathered or operated in a low power mode.

31. The aircraft of claim 1, further comprising three or more landing gear, pads or skids operably attached to the closed wing.

32. The aircraft of claim 31, wherein the three or more landing gear, pads or skids are retractable.

33. The aircraft of claim 1, further comprising one or more sensors or surveillance packages disposed on, disposed within or attached to the closed wing, the one or more spokes or the fuselage.

34. The aircraft of claim 1, wherein the one or more spokes comprise three spokes.

35. The aircraft of claim 34, wherein the propellers comprise nine propellers disposed proximate to the closed wing, and one propeller disposed proximate to each spokes.

36. The aircraft of claim 1, wherein the one or more spokes are operable to change a position of the closed wing with respect to the fuselage or vice versa.

* * * * *

[54] **VERTICAL TAKEOFF AND LANDING
AIRCRAFT**

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[52] U.S. Cl.244/23 C

[51] Int. Cl.B64c 29/00

[58] Field of Search244/12, 23, 3.24; 239/265.35

[56] **References Cited**

UNITED STATES PATENTS

3,238,875	3/1966	Stadler et al.....	244/3.24
3,390,899	7/1968	Herbert et al.....	239/265.35
3,416,754	12/1968	Pinaire et al.....	239/265.35

2,947,496	8/1960	Leggett.....	244/12
2,990,137	6/1961	Willis.....	244/12
3,082,977	3/1963	Arlin.....	244/12
3,162,011	12/1964	Mullins et al.	244/23
3,465,989	9/1969	Bowshier	244/23

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[57]

ABSTRACT

A vertical takeoff and landing (VTOL) aircraft has a discus-shaped fuselage with a plurality of angularly equispaced lift-generating assemblies. Each assembly comprises a rotor above or flush with the fuselage, a compressor in the fuselage drawing air in from above, and a nozzle below the fuselage for expelling the air from the compressor in a jet. The nozzles can be rotated to point in any direction. Thus, according to the settings of the nozzles, the aircraft can rise or sink vertically and move in any horizontal direction.

7 Claims, 4 Drawing Figures

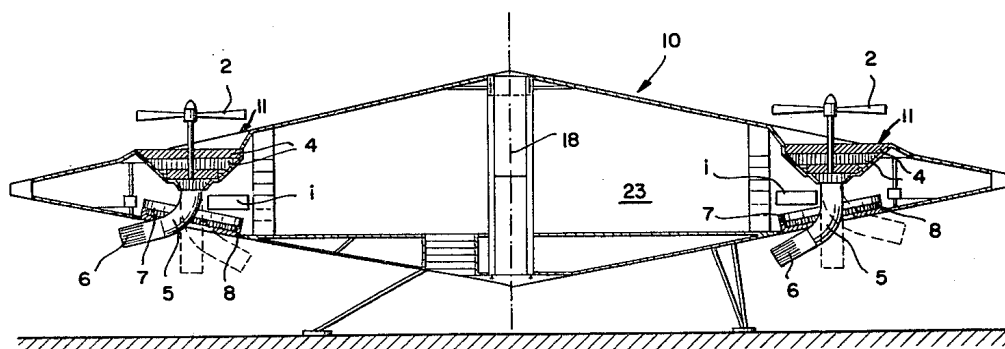


FIG. 4

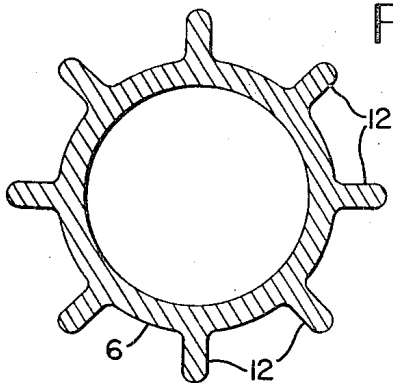
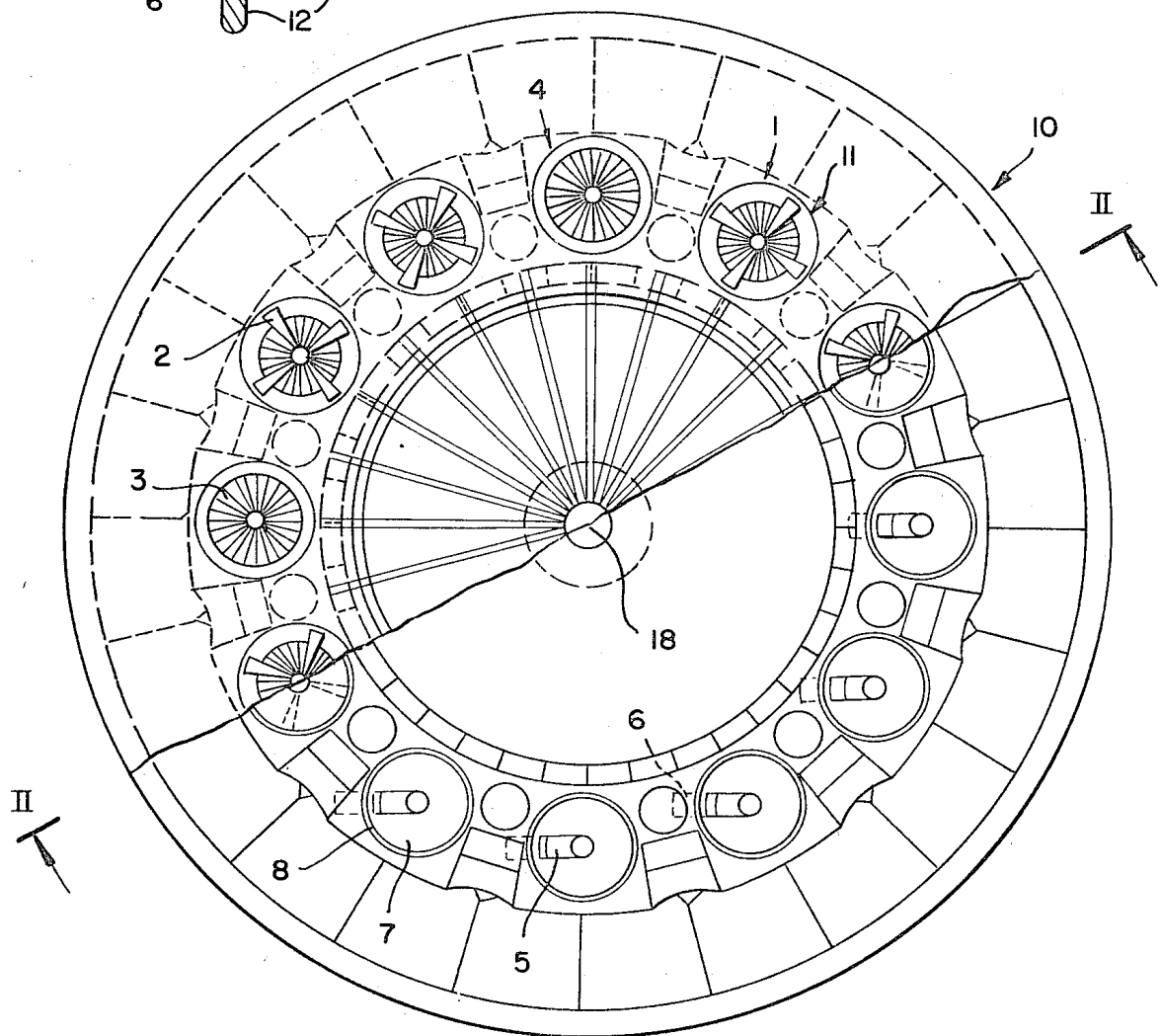


FIG. 1



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FIG. 2

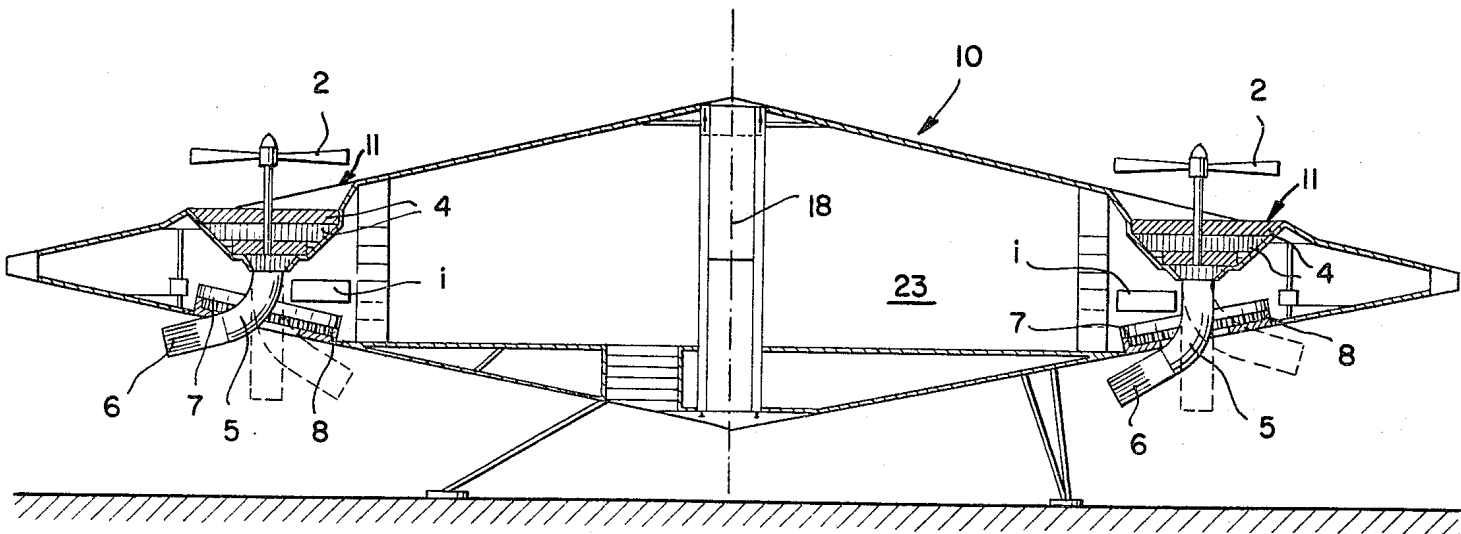
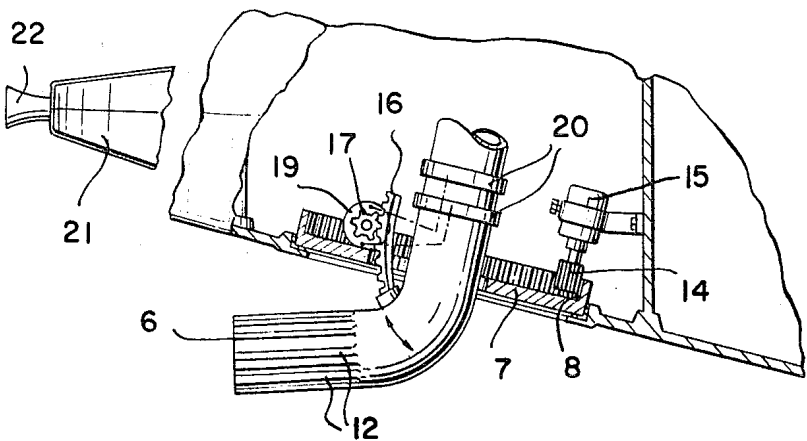


FIG. 3



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VERTICAL TAKEOFF AND LANDING AIRCRAFT

FIELD OF THE INVENTION

The present invention relates to an aircraft and, more particularly, to an aircraft of the vertical takeoff and landing (VTOL) type.

BACKGROUND OF THE INVENTION

There are two general types of aircraft: those which use air currents passing over relatively fixed airfoils for lift, and those using substantially horizontal fans or screws to mount in the air. Both types offer particular advantages and disadvantages. The conventional airplane is relatively inexpensive and can attain great speeds with large payloads; however, it requires extensive takeoff and landing facilities and is adversely affected by many wind conditions. Those aircraft of the helicopter type can take off and land vertically on any more or less flat and solid surface; but they are very expensive, can only attain relatively low cruising speeds, and cannot carry large payloads.

Solutions to the above-mentioned difficulties have been attempted in the form of hybrid aircraft supposedly combining the advantages of the two types while obviating their disadvantages. One such essay is an aircraft equipped with horizontally oriented screw propellers that are used only on takeoff and landing and are folded back during normal flight wherein conventional wings and vertically oriented fans are used. Sometimes the entire wing-and-propeller assembly is rotatable through 90° to make this possible. Such an aircraft has certain advantages, yet it still uses the principle of lift generated by airflow over an airfoil for conventional flight and has, therefore, several disadvantages. Namely, such a vehicle must attain a certain horizontal velocity before it can be converted from one mode to the other, a speed often very difficult to obtain with the means at hand. Furthermore such aircraft are complicated and expensive in the extreme and, thus, troublesome and often dangerous.

OBJECTS OF THE INVENTION

It is, therefore, the general object of the present invention to provide an improved aircraft.

A more specific object is to provide an aircraft of the VTOL type which overcomes the disadvantages of the above-described aircraft.

SUMMARY OF THE INVENTION

The above objects are attained, in accordance with some of the features of the present invention, by an aircraft having a discus-shaped fuselage mounting a plurality of circumferentially spaced lift-generating assemblies and thereby being a sort of flying saucer. Each assembly comprises a rotor above or flush with the fuselage and oriented in a generally horizontal plane, means for rotationally driving the rotor, preferably in the form of a radial-piston engine, and a compressor below each rotor sucking air in from above and expelling it below through a nozzle. Control means is provided to turn the nozzles individually or jointly in any substantially horizontal direction and to turn them through substantially 90° so that they can point straight down, or off to any side.

Such an aircraft can take off or land vertically, the lift being generated substantially by the rotors and by the air being expelled in high-pressure jets from the bottom of the aircraft. Once airborne, the craft can be displaced horizontally by pointing the nozzles back, in the direction of travel. Simple alteration of motor speed and orientation of the nozzles thus controls the craft fully. The rotors above the fuselage virtually eliminate drag during takeoff, and permit such takeoff regardless of wind direction.

According to an important feature of this invention, the fuselage is defined between an upper and a lower conical surface (of the upper and lower halves of the airframe) centered on the vertical axis of the aircraft so that the fuselage tapers

radially outward, the structure having its center of gravity located along the vertical axis and preferably at the lower third of the latter so that disturbances of the aircraft in flight, e.g., as a result of air turbulence will immediately result in a compensating movement of the aircraft to restore its horizontal position with the center of gravity located in the same vertical line with the top of the aircraft. It is important also to note that the lift-generating means act along the upper surface of the fuselage and thereby provides a lever type of action to restore aircraft stability.

An important aspect of this invention resides in the provision, in addition to airscrews (propellers), lift-generating fans with air increase formed by openings in the upper conical surface of the fuselage while the nozzles discharge high-velocity jets of air along the lower conical surface. The advantages of an arrangement of this type are that it may make use in a novel manner, of principles which have already been recognized in fixed-wing aircraft. Thus it is known to reduce the viscous drag or air resistance along the leading edge and upper skin of a fixed airfoil by providing openings in the latter through which the boundary layer is drawn and discharged below the airfoil or at its trailing edge, thereby eliminating the turbulence along the airfoil surfaces and increasing both propulsion and lift efficiency. In accordance with this principle, the fans draw air from along the upper surface and feed the air to the nozzles directly or through a compressor which may be driven on the same shafts as the fans, turbulence along the upper surface of the fuselage is minimized and air resistance reduced. The fans, moreover, may alternate with individual airscrew arrangements and/or pairs or triplets of such airscrews and may be driven by any convenient prime movement. The airscrews or propellers are advantageously spaced above the surface so that immediately below that there may be provided the open mouth or inlets of the compressors which are coupled with the propellers.

I have found, most surprisingly, that high stability can be assured and simple steering or rudder control accomplished by providing the discharge nozzles as flexible ducts whose upper portions extend axially and thus are aligned with the shafts of the respective compressors, propellers and fans, while the lower portion of each duct is bent in a form of an elbow to provide a discharge and extending generally radially with respect to the axis of the upper portion of the duct. The elbow is lodged in a control disk which is generally planar and lies along the upwardly and outwardly inclined frustoconical underside of the fuselage so as to be rotatable about an axis intersecting the axis of the respective propeller, fan, or compressor and extending perpendicular to the underside of the fuselage. An especially important characteristic of this invention is that the depending portion of the elbow, which extends more or less radially as noted above, is formed with longitudinally extending fins performing a rudder function.

DESCRIPTION OF THE DRAWING

The above and other objects, features, and advantages will become more fully apparent in the following description, reference being made to the accompanying drawing, in which:

FIG. 1 is a diagrammatic top view partly broken away and partly in section of an aircraft according to the present invention;

FIG. 2 is a section along the line II—II of FIG. 1; and
FIG. 3 is a vertical section showing details of FIG. 1 in enlarged scale;

FIG. 4 is a cross section view of the aircraft's rotatable nozzles disclosing the stabilizing fins in enlarged scale.

SPECIFIC DESCRIPTION

As shown in FIGS. 1-3 the aircraft has a fuselage 10 shaped like a discus with upper and lower conical faces, thereby making the craft into a sort of flying saucer. Spaced around this fuselage 10, equidistant from a center axis 18 and angularly equidistant from one another are a plurality, here 12, of lift-

generating assemblies 11. Each assembly has a rotor in the form of an airscrew propeller 2 or a lift fan 3, the distribution depending on the size and weight of the craft. The airscrews 2 are substantially above the fuselage 10, while the fans 3 are virtually flush therewith.

Below each rotor, mounted in the fuselage 10, is a compressor 4 which draws air in from below the rotor and expels it through a flexible tube 5. This compressor 4 is mounted on the same shaft with the rotor which is itself driven by a radial-piston engine 1.

FIG. 3 shows more details of the craft. Mounted on the end of the tube 5 is a nozzle 6 provided with longitudinal laterally projecting fins 12 acting as rudders or stabilizers. The tube 5 is fitted through a disk 7 formed with an internal gear 8 which meshes with a pinion 14 on an electric motor 15. This arrangement, with motor 15, allows the nozzles 6 to be pointed in any horizontal direction. The nozzle 6 further mounts an arcuate rack 16 which meshes with a pinion 17 of a motor 19 connected through sliprings 20 to a source of power. This motor 19 adjusts the inclination to the vertical of the nozzle, thereby allowing it to point straight down or, as shown in FIG. 2, to the side.

The fuselage has an extreme edge 21, as shown in FIG. 3, which may carry a ramjet 22 used during flight for extra speed.

In order to take off, the nozzles 6 are either pointed straight downward, or directed somewhat inwardly toward one another. Once the vehicle is airborne, the nozzles 6 are directed to a side, all in the same direction, to displace the craft in the opposite direction. The jets 22 along one portion of the edge 21 assist the flight in the horizontal.

The center of gravity of the loaded craft is advantageously held in the lower third of a center region 23. In this manner, the lift caused by the assemblies 11 is distributed all around the load and mostly above it, thereby giving the craft great stability. Indeed, the craft's normal center of gravity is exactly in the center, due mainly to the symmetrical construction, so that this stability is built in. Furthermore, change in speed of any of the motors 1 can be effected to raise or lower an edge of the craft, if desired.

I claim:

1. An aircraft comprising:

a closed-skin discus-shaped fuselage of circular outline having conical upper and lower halves centered on an axis and defining all of the airfoil surface of the aircraft within said outline, the center of gravity of the aircraft being located along said axis in said lower half;

a plurality of lift-generating assemblies spaced around said fuselage, each of said assemblies including a respective rotor rotatable along the top of said fuselage, means for rotationally driving said rotor, a respective compressor in said fuselage below said rotor drawing in and compressing air from below said rotor, and a respective nozzle connected to said compressor to expel from below said fuselage the air compressed thereby, said nozzles projecting downwardly below said fuselage and exclusively forming rudder controls for said aircraft; and

control means for selectively directionally orienting each of said nozzles, each of said control means including a rotatable disk mounted on and substantially flush with the lower surface of said fuselage, said nozzle being formed at the lower end of a fixed-elbow tube rising through the disk to the compressor, and drive means connected to said disk for rotating same and thereby rotating said nozzle.

2. The aircraft defined in claim 1 wherein each of said control means further includes means for orienting the respective tube and nozzle in a vertical plane.

3. The aircraft defined in claim 1 wherein said rotor is an airscrew spaced above said fuselage.

4. The aircraft defined in claim 1 wherein said rotor is a fan substantially flush with the upper surface of the fuselage.

5. The aircraft defined in claim 1 wherein said nozzles are formed with longitudinal fins below said fuselage.

6. The aircraft defined in claim 1 further comprising a shaft, said rotor and said compressor being mounted on said common shaft and said means for rotationally driving said rotor thereby also driving said compressor.

7. The aircraft defined in claim 1 wherein said assemblies are angularly equispaced around said fuselage.

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