



| ДОКЛАД ОТ ПРОУЧВАНЕ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                 |                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------|
| с вх.№ СпИС–142 от 26.01.2023г.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                 |                          |
| I. Уточнен класификационен индекс по МПК                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                 |                          |
| B64C29/00; B64C39/08; B64D27/02; B64C11/46; B64C3/14                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                 |                          |
| II. ОБЛАСТ НА ПРОУЧВАНЕ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                 |                          |
| Минимален обхват на проучване                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                 |                          |
| Вид класификация:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Класификационен индекс:                                                         |                          |
| МПК – 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | B64C29; B64C39; B64D27; B64C11; B64C3                                           |                          |
| Бази данни, в които е извършено проучването                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                 |                          |
| Espacenet, IPAS, Internet                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                 |                          |
| III. Релевантни документи                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                 |                          |
| Категория                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Цитиране на документите с посочване на релевантните части                       | Релевантни към претенции |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | WO2016164280A1, публикуван на 13-10-2016, SKYLIFT GLOBAL [US]                   | 1-10                     |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CN107207088A, публикуван на 26-09-2017, ELWHA LLC                               | 1-10                     |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CN209366469U, публикуван на 10-09-2019, INNER MONGOLIA HERWEN SCIENCE CO LTD    | 1-10                     |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CN209581872U, публикуван на 05-11-2019, UNIV NANJING POSTS & TELECOMMUNICATIONS | 1-10                     |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CN114423679A, публикуван на 29-04-2022, GEONBIAN FLIGHT CO LTD                  | 1-10                     |
| Категория на документа                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                 |                          |
| <p><b>X</b> – документът е от особено значение; претендираното изобретение няма новост или изобретателска стъпка, когато документът се разглежда самостоятелно</p> <p><b>Y</b> – 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</p> <p><b>A</b> – документ, отразяващ нивото на техниката, който не е от особено значение</p> <p><b>D</b> – документ, цитиран в описанието</p> <p><b>O</b> – неписмено разкриване, използване, прилагане, докладване или демонстриране</p> <p><b>P</b> - документ, публикуван преди датата на подаване в България, но след приоритетната дата</p> <p><b>E</b> – по-рано подадена българска заявка, но публикувана на или след датата на подаване</p> <p><b>L</b> – 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)</p> <p><b>&amp;</b> - документ от една патентна фамилия</p> |                                                                                 |                          |
| ДАТА: 02/02/2023г. ПОДПИС:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                 |                          |
| Пламен Гончев<br>Старши експерт ДЕЗИПМПД                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                 |                          |

## СТАНОВИЩЕ

ОТНОСНО: *Предварително проучване за новост на "Фотоволтаичен самолет с три фиксирани крила с едни и същи фиксирани електромоторни витла за вертикално излитане, кацане и хоризонтален полет", съгласно искане с вх. № : СПИС-142 от 26.01.2023г.*

*Проучването е направено въз основа на представеното описание, патентни претенции и приложенията към него фигури.*

Обектът на настоящото проучване е определен от една независима и девет зависими претенции, съгласно които, включва:

Фотоволтаичен самолет с три фиксирани овални крила с едни и същи фиксирани електромоторни витла за вертикално излитане, кацане и хоризонтален полет, включващ крила (1) с монтирани фотоволтаични панели върху горните им повърхности (2), аеродинамични кормила (3) и фюзелаж (4), характеризиращ с това, че аеродинамичните кормила (3) са вертикално монтирани, перпендикулярно долните крила (1), фюзелажът (4) е монтиран под горното крило (1), а самите крила (1) са овални и пръстеновидни, успоредни помежду си и са фиксирани към върховете на триъгълни рамки (5), при което поне на едно от крилата (3) са монтирани основите на поне четири Г-образни конзоли (6), като в перифериите на всяка от тях са монтирани по един електромотор (7), чиито работен вал е куплиран към входящ вал на вариаторна скоростна кутия (8), а към неин изходящ вал механично е свързан работният вал на витло (9).

Лопатките на всяко витло (9) са с радиално усукан аеродинамичен профил.

Овалните крила (1) са елипсовидни пръстени.

Всяко витло (9) е с четен брой еднакви лопати.

Всяко витло (9) е с нечетен брой еднакви лопати.

Триъгълните рамки (5) са еднакви и с равни страни.

Триъгълните рамки (5) имат симетрични аеродинамично обтекаеми профили.

Овалните крила (1) са с несиметрични профили на самолетно крило.

Овалните крила (1) са покрити с огънати фотоволтаични панели, плътно следващи кривините на овалните крила (1).

Поне две от овалните крила (1) лежат в една равнина.

Задача на настоящото изобретение е да се обезпечи фотоволтаичен самолет с три фиксирани овални крила с едни и същи фиксирани електромоторни витла за вертикално излитане, кацане и хоризонтален полет с ниска себестойност, със значително увеличена фотоволтаичната площ за повишена електрогенерация, да му осигури по-продължителна работа на електрическите му витла без наземно електрозареждане, а крилата да формират пространствено затворени контури, за да нулират индуцираните периферни крилни вихри.

При извършеното проучване са намерени документи, посочени в приложения доклад, релевантни на техническото решение на обекта от настоящото проучване, а именно:

Документът **WO2016164280A1**, публикуван на 13-10-2016, разкрива безпилотен летателен апарат за вертикално излитане и кацане, използвайки три главни ротора с вертикално повдигане без накланяне и променлива стъпка със система за завъртане на опашката. Трите основни ротора са разположени в равностранны триъгълна конфигурация.

В **CN107207088A**, публикуван на 26-09-2017. Настоящото изобретение се отнася до самолет който включва основа, първи ротор, свързан към първа стрела на основата, втори ротор, свързан към втора стрела на основата, и трети ротор, свързан към основата. Основата включва пространствена рамка.

Документът **CN209366469U**, публикуван на 10-09-2019. Полезният модел се отнася до техническата област на безпилотните летателни апарати, устройството се състои от фиксиращ вал, слънчев фотоволтаичен панел е разположен върху горната повърхност на фиксиращия вал, напречните греди са равномерно свързани към периферията на фиксиращия вал, роторите са разположени върху горните крайни повърхности на другите страни на напречните греди, опорите са равномерно разположени върху долната крайна повърхност на фиксиращия вал, акумулаторна батерия е разположена в средата на опорите.

Документът **CN209581872U**, публикуван на 05-11-2019, разкрива летателен апарат, който включва цилиндрично основно тяло, фиксирано основно крило, фиксирана опашка, люк, скоба, фотоволтаичен панел, платка на устройството, двигател, въртящ се вал, ротор и твърд фиксиращ прът. Твърдите фиксиращи пръти са четири.

Фиксирани на една и съща височина и четири от роторите са съответно свързани към съответните двигатели чрез въртящия се вал, четирите ротора са разположени на една и съща височина и точно над фюзелажа и главното крило.

**В CN114423679А**, публикуван на 29-04-22, разкрива самолет с вертикално излитане и кацане който включва фюзелаж, механизъм за накланяне, корпус на полезен товар и по избор може да включва атенюатор на удара, набор от наземни опорни елементи, набор от източници на енергия и набор от контролни елементи. Фюзелажът може да включва набор от ротори и набор от опорни елементи.

## НОВОСТ

След извършен сравнителен анализи между обекта, предмет на настоящото проучване и намерените при проучването документи, се установи, че не е разкрит фотоволтаичен самолет с три фиксирани крила с едни и същи фиксирани електромоторни витла за вертикално излитане, кацане и хоризонтален полет, който да включва всички технически признаци на обекта от проучването. Следователно, обектът на настоящото проучване, съгласно така формулираните претенции, е нов по смисъла на чл. 8, ал. 1 от Закона за патентите и регистрацията на полезните модели (ЗПРПМ).

Пламен Гончев

Старши експерт от ДЕЗИПМПД



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代理人 李献忠 张华

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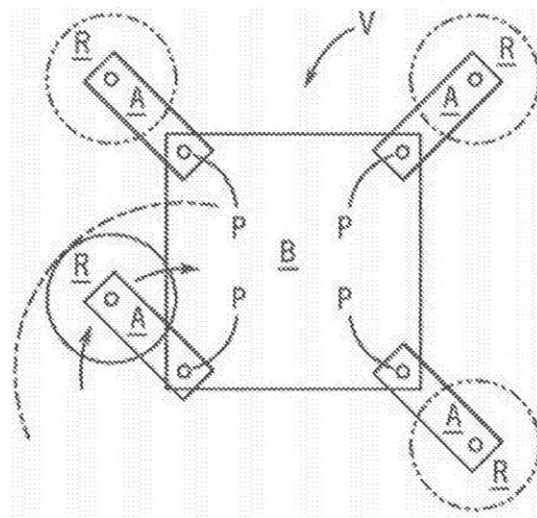
权利要求书4页 说明书26页 附图41页

(54)发明名称

可重新配置的无人飞行器系统

(57)摘要

公开了可重构无人飞行器系统。还公开了配置可重构无人飞行器的系统和方法,以及在空域中操作和管理可重构无人飞行器的系统和方法。飞行器选择性地可重构以修改飞行特性。飞行器包括转子组。至少一个转子相对于基座的位置可通过转子相对于吊杆的平移、吊杆相对于基座的枢转和吊杆相对于基座的平移中的至少一个来修改;使得可通过配置至少一个转子相对于基座的位置来修改飞行特性。配置在执行任务以载运有效载荷的具有转子组的飞行器的方法包括以下步骤:确定有效载荷的至少包括质量属性的属性,确定有效载荷将与飞行器联接的方式,至少部分地考虑有效载荷的属性来确定转子组中的每个转子的配置以及将转子组定位在用于飞行器执行任务的配置中。



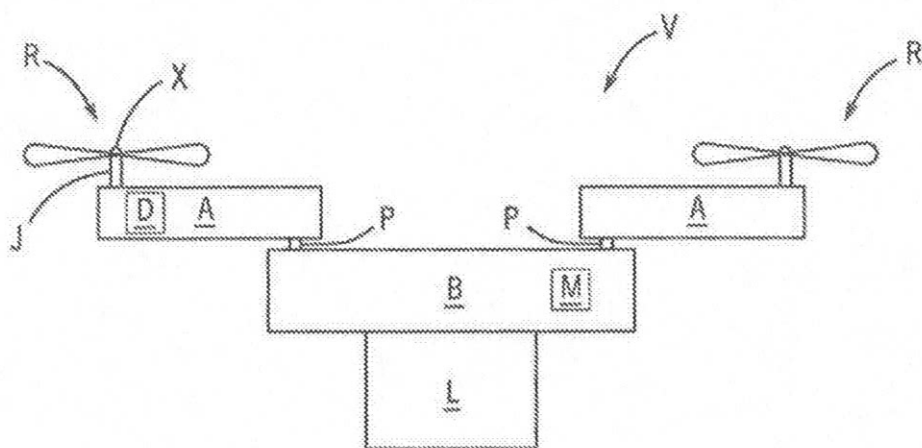


图1

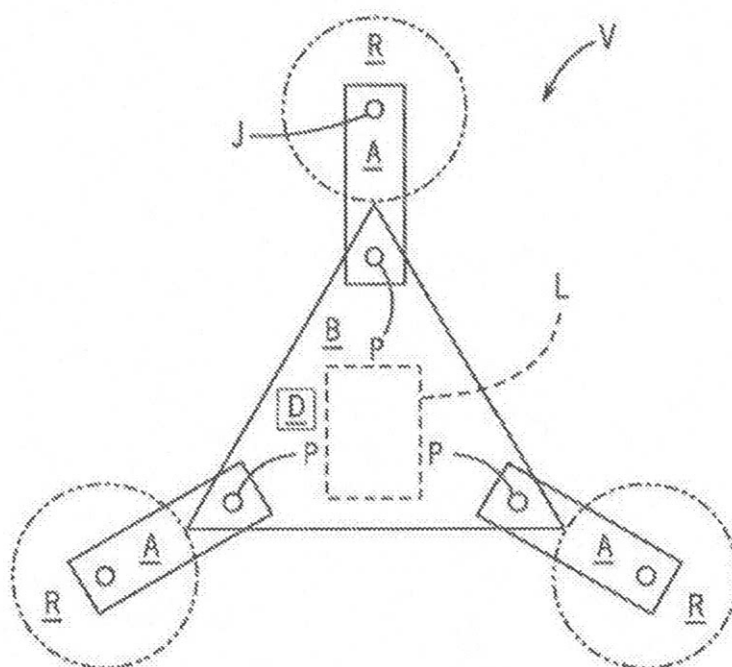


图2

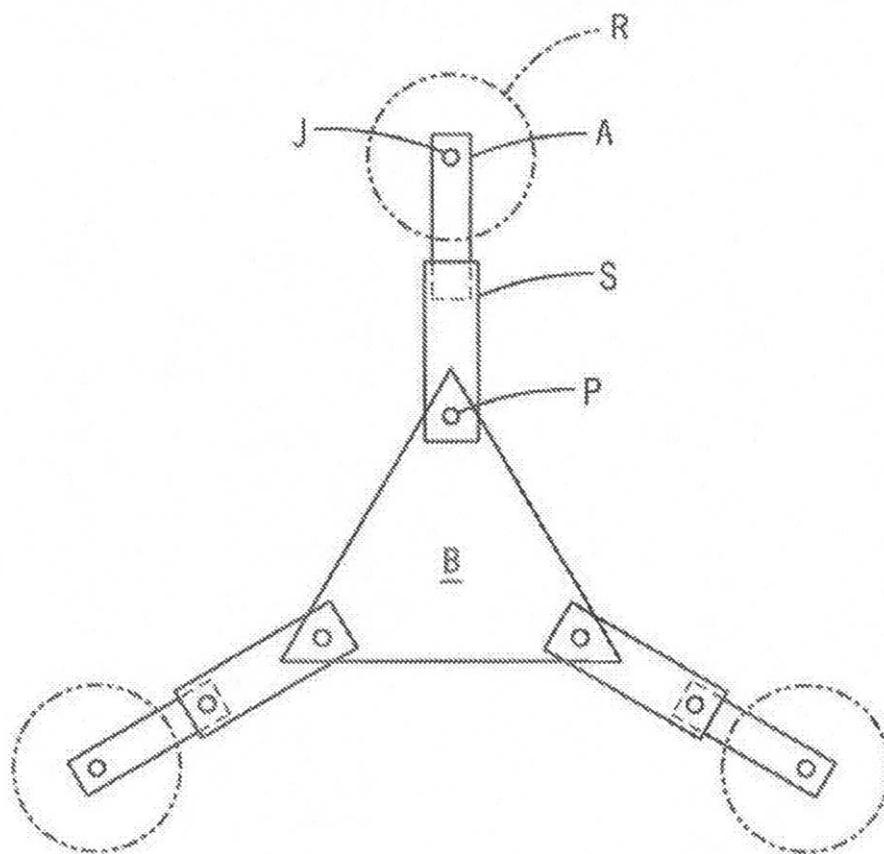


图10B

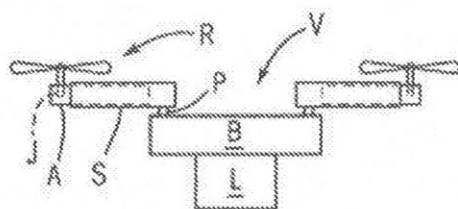


图11A

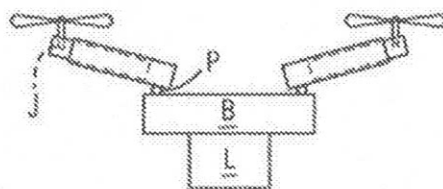


图11B

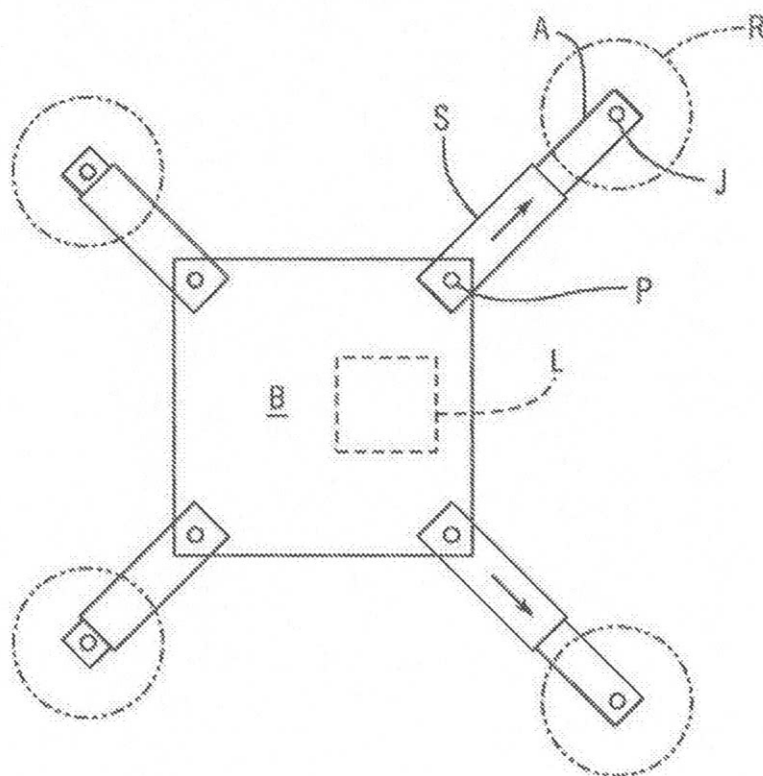


图20C



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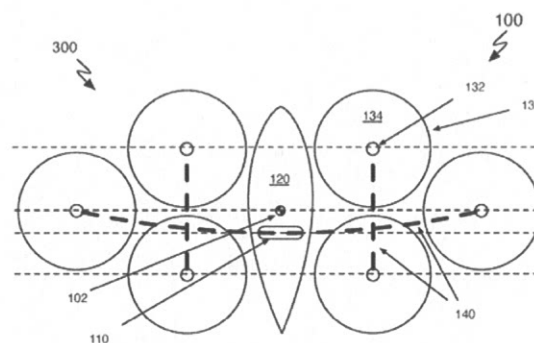
权利要求书3页 说明书20页 附图31页

(54) 发明名称

垂直起降飞行器

(57) 摘要

本飞行器可以包含：机身、倾斜机构、有效载荷壳体，并且可以任选地包含碰撞衰减器、一组地面支撑构件（例如，吊架）、一组动力源以及一组控制元件。所述机身可以包含：一组旋翼和一组支撑构件。



101  
(旋翼布置)

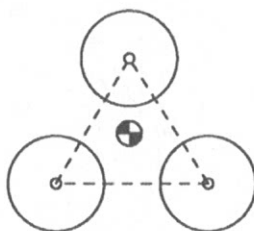


图5A

135 (顶部/底部)      135 (左/右)

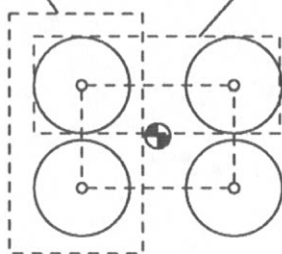


图5B

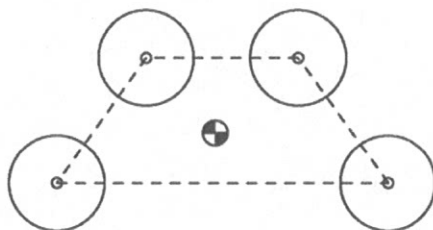


图5C

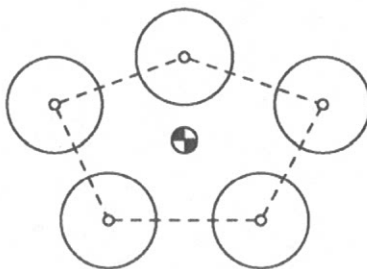


图5D

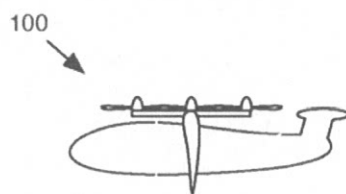


图16C

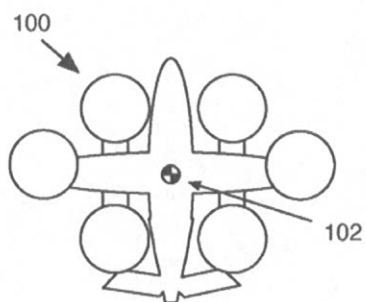


图17A

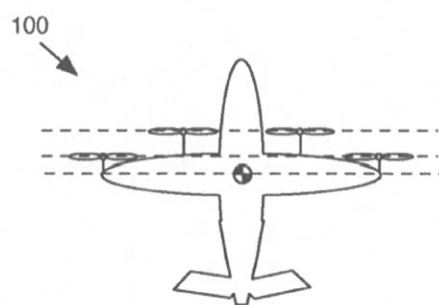


图17B

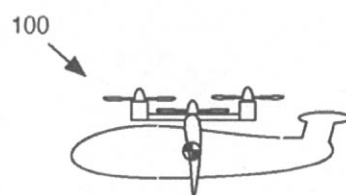


图17C

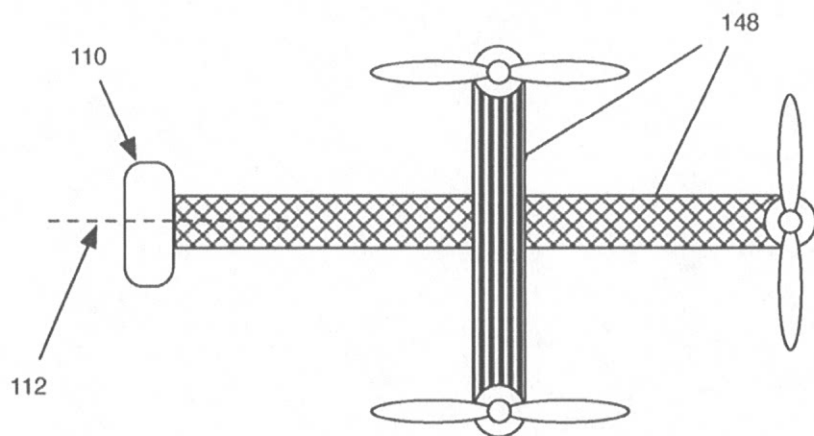


图22B

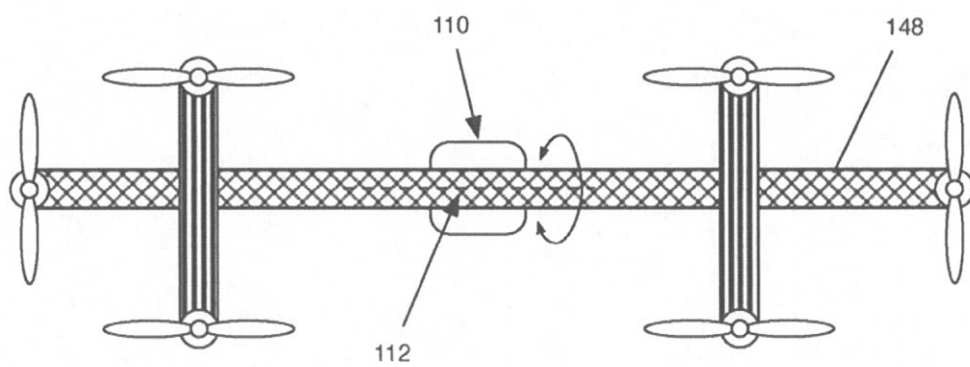


图22C

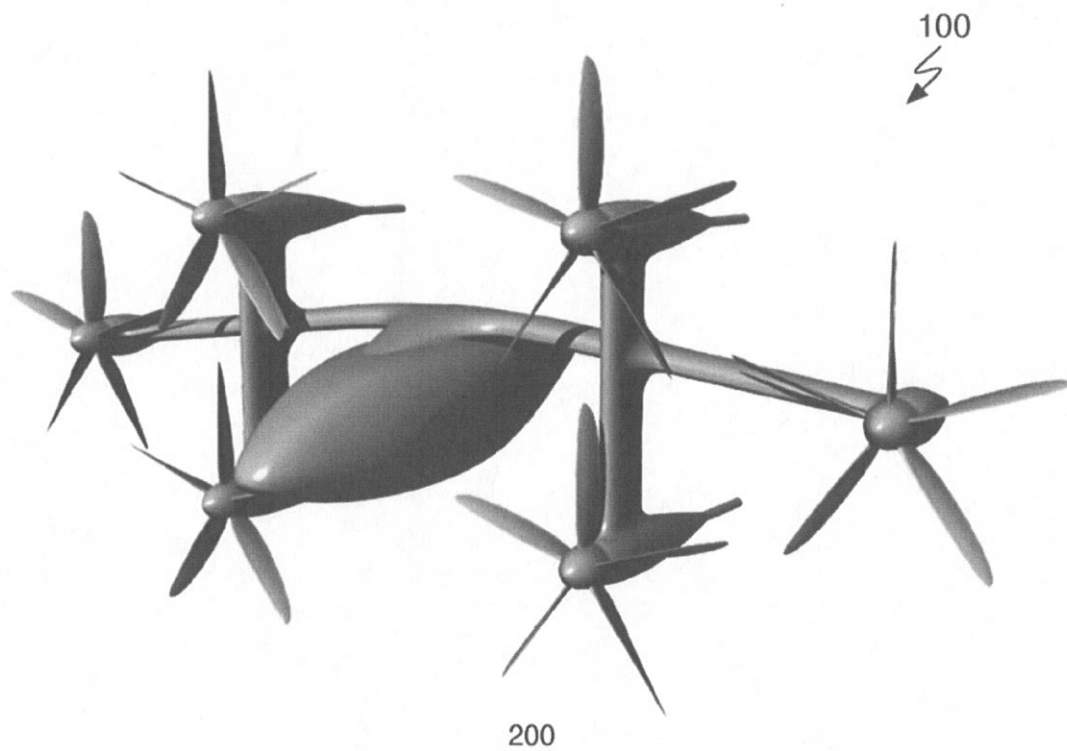


图23A

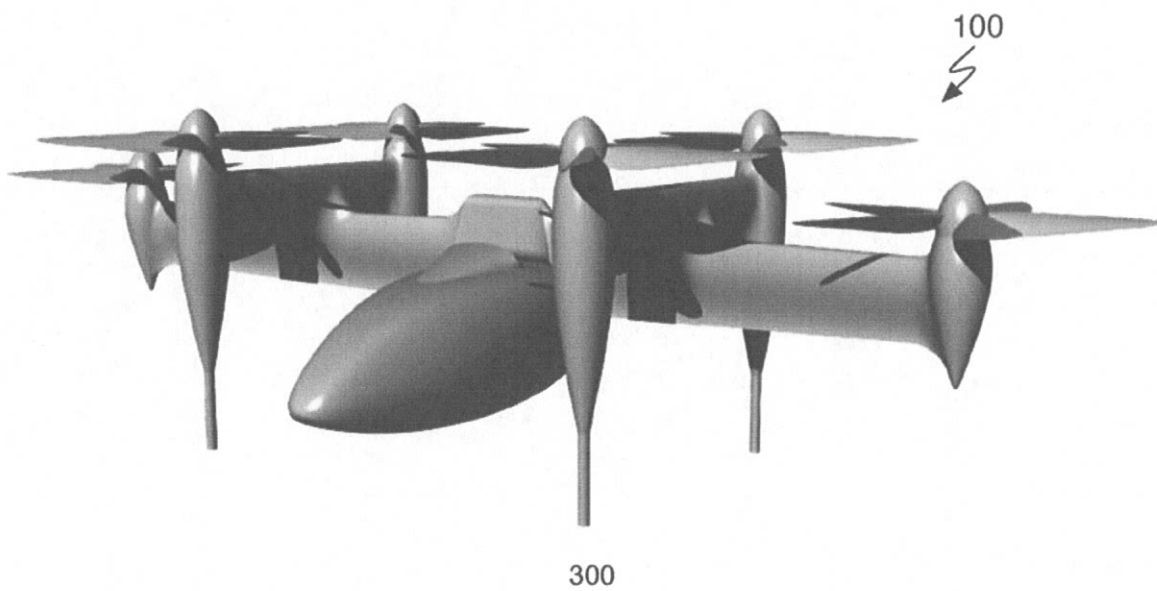


图23B



## (12)实用新型专利

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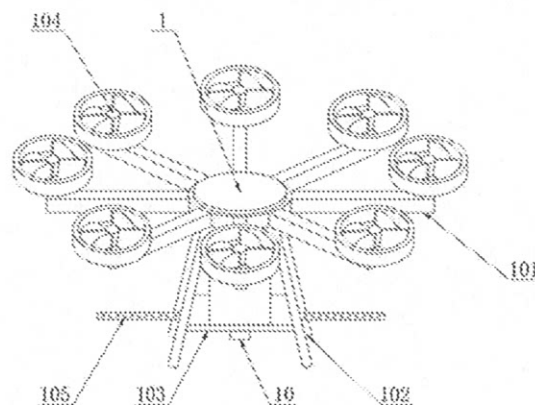
权利要求书1页 说明书4页 附图3页

### (54)实用新型名称

一种新型多旋翼植保无人机

### (57)摘要

本实用新型公开了一种新型多旋翼植保无人机,涉及无人机技术领域,包括固定轴,所述固定轴的上表面设置有太阳能光伏板,所述固定轴的四周均匀连接有横梁,所述横梁的另一侧上端表面设置有旋翼,所述固定轴的下端表面均匀设置有支架,所述支架的中间设置有蓄电池,所述置物板的上表面设置有水箱,设置了单向阀,能防止水箱内部的液体通过出水口流出,能有效的节约了作业成本,设置了搅拌叶,能使沉降在底部的溶质重新溶解入液体当中,能使水箱内部的液体各部分纯度相同,能避免因溶质沉降结晶而导致的管道堵塞的情况发生,设置了快插接头,能简化水管安装的技术性,能使农民不在专业人员的指导下,独立完成安装。





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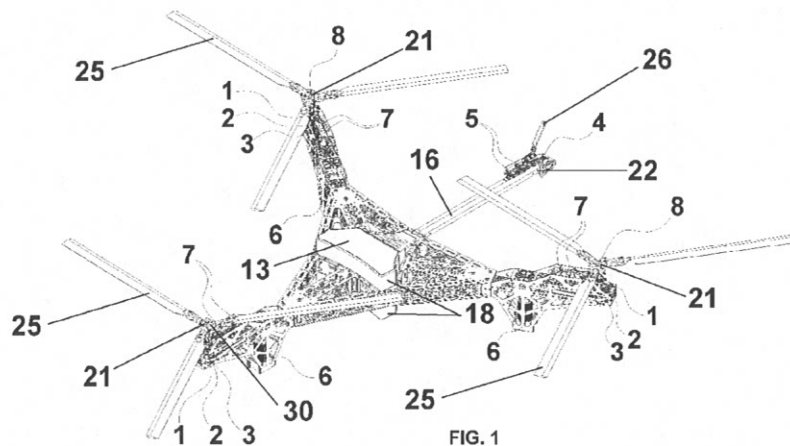
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(57) Abstract: An improved vehicle with superior performance and reliability. The vehicle, such as an unmanned aerial vehicle, is capable of vertical takeoff and landing, uses three swashless, variable-pitch vertical lift main rotors with a yaw tail rotor system. Two rear main rotors are optionally tiltrotors, which pivot to increase forward speed without the increased coefficient of drag inherent in tilting the entire vehicle. The three main rotors are positioned in an equilateral triangular configuration, improving balance, increasing load-bearing strength, and making it more compact in size. Movements are controlled through changes in pitch of the rotors, allowing the motors to maintain constant governed rotations per minute, maximizing drivetrain efficiency. Vehicle configurations disclosed herein allow for smaller vehicle size with greater performance than prior art vehicles.

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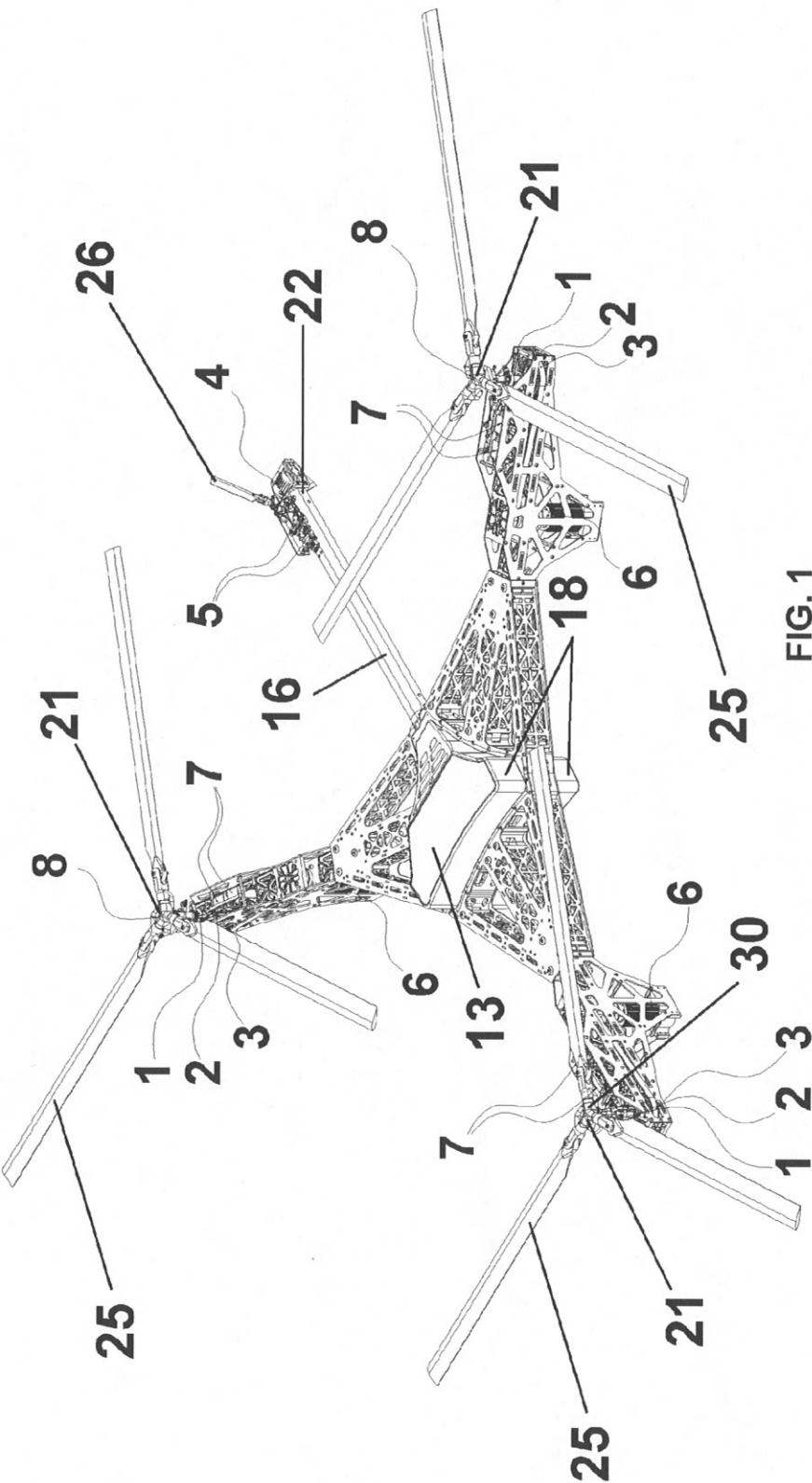
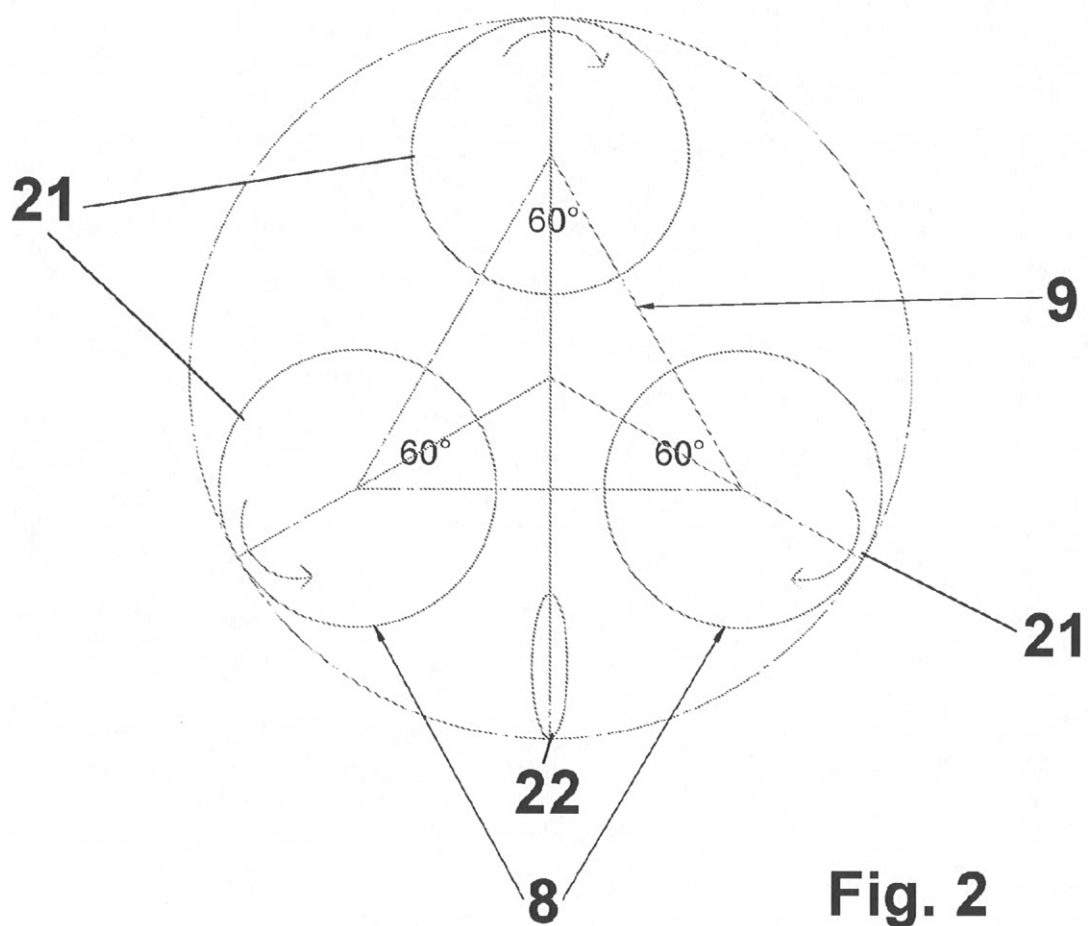


FIG. 1





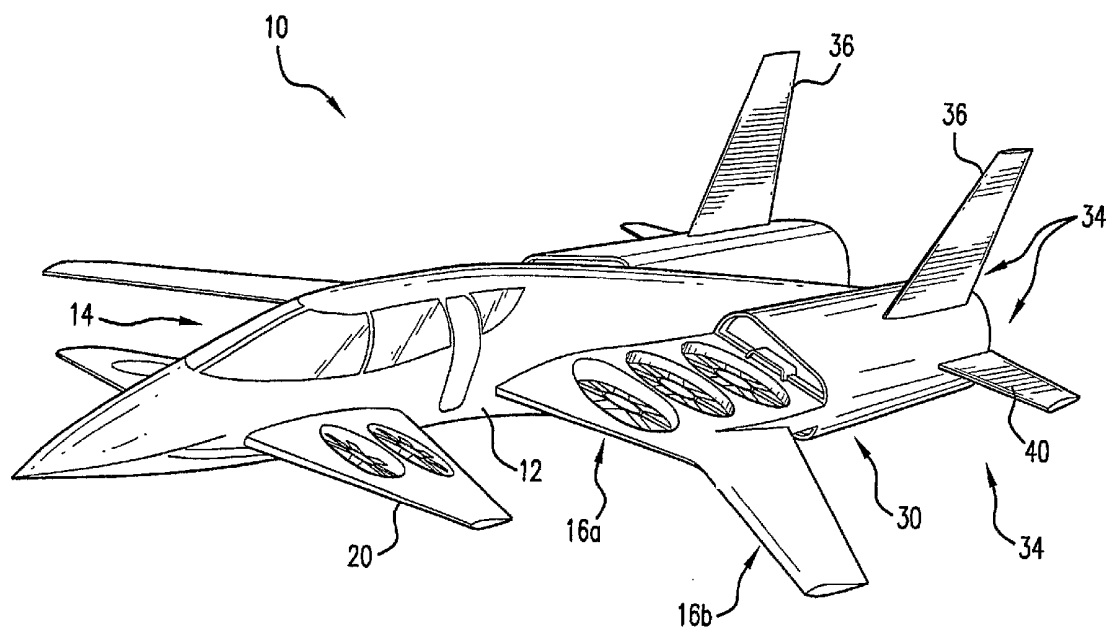
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(2), (4) Date: **Jan. 28, 2010**(57) **ABSTRACT**

A fixed-wing VTOL aircraft features an array of electric lift fans distributed over the surface of the aircraft. A generator is (selectively) coupled to the gas turbine engine of the aircraft. During VTOL operation of the aircraft, the engine drives the generator to generate electricity to power the lifting fans. Power to the lifting fans is reduced as the aircraft gains forward speed and is increasingly supported by the wings.



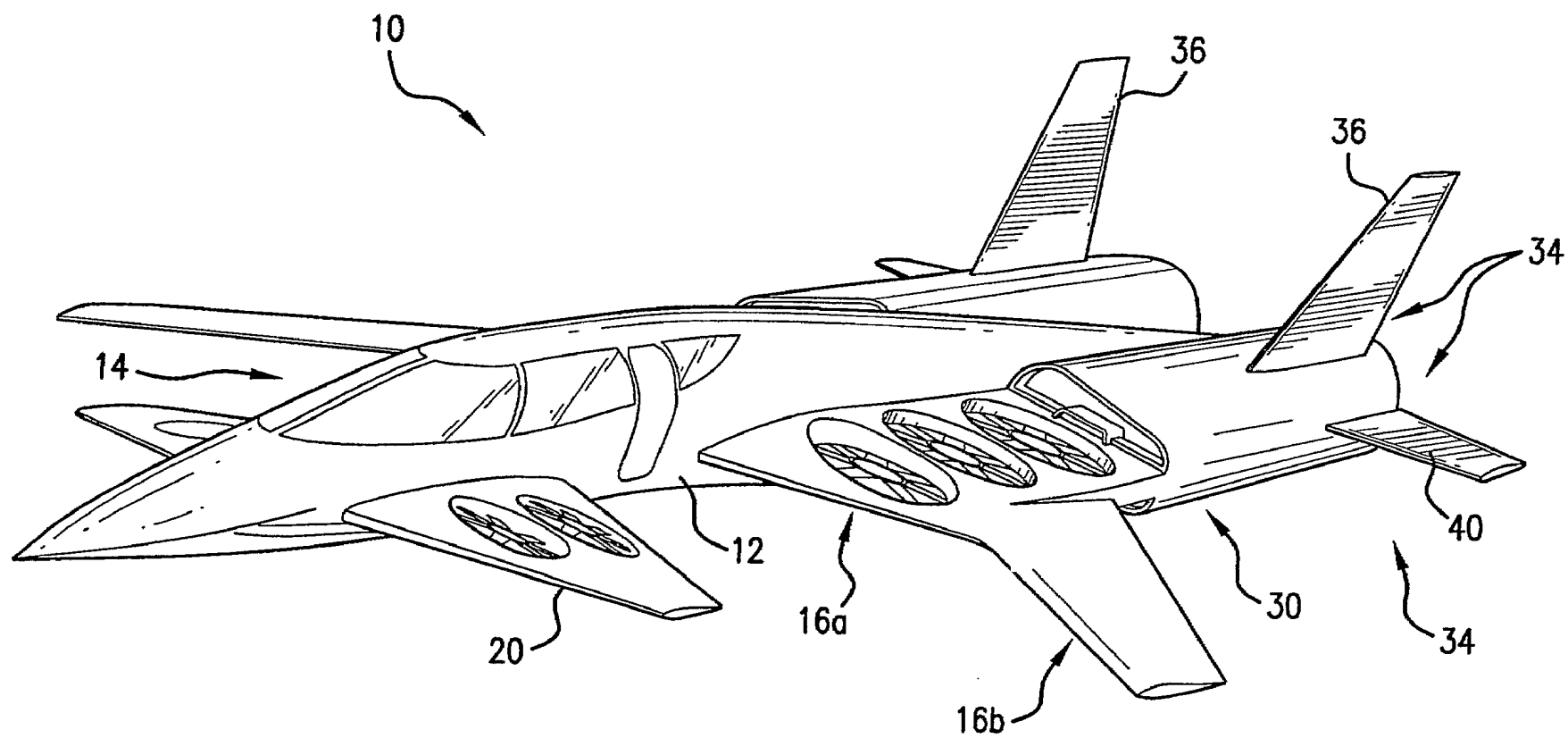


FIG. 1

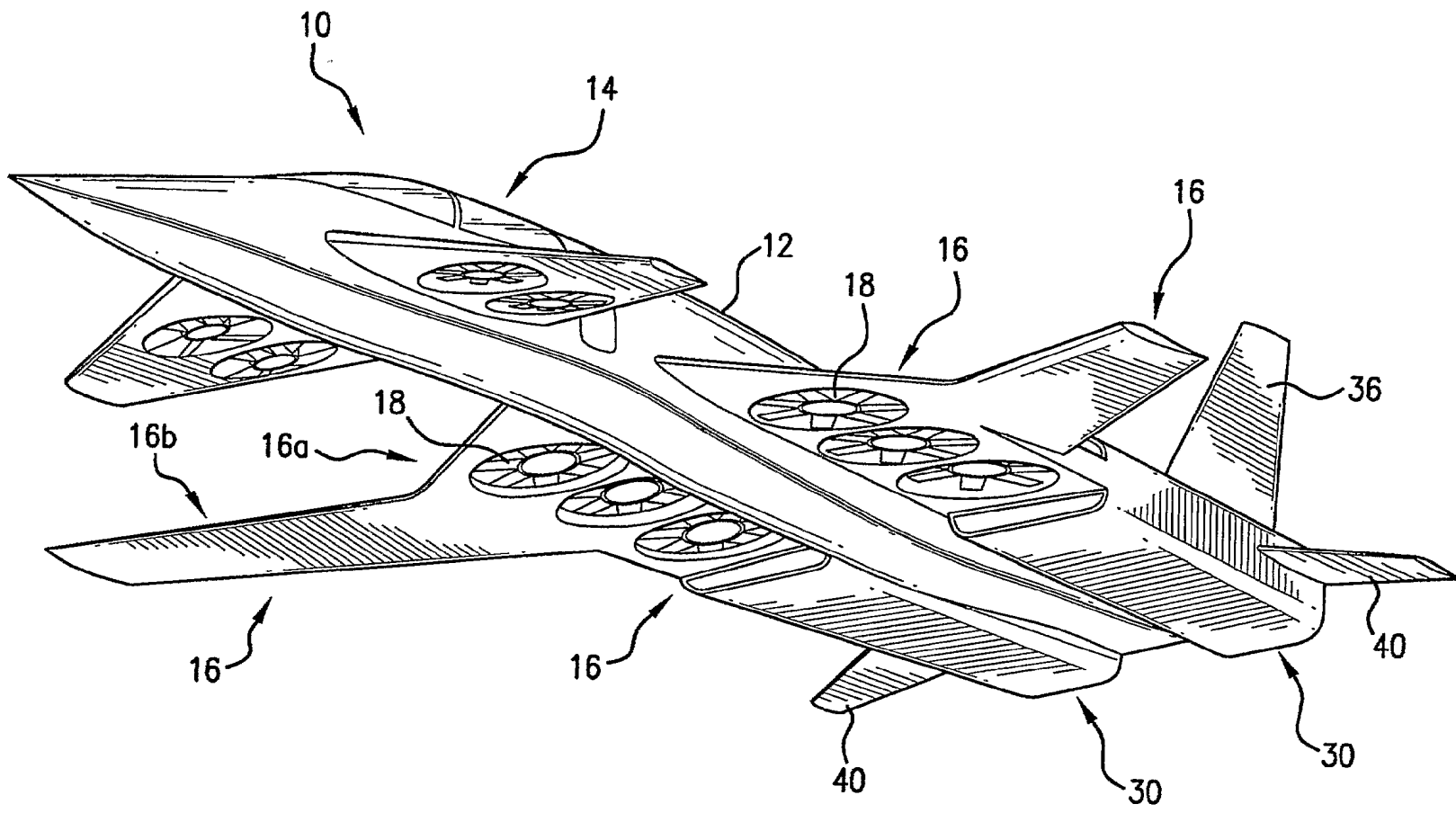


FIG. 2

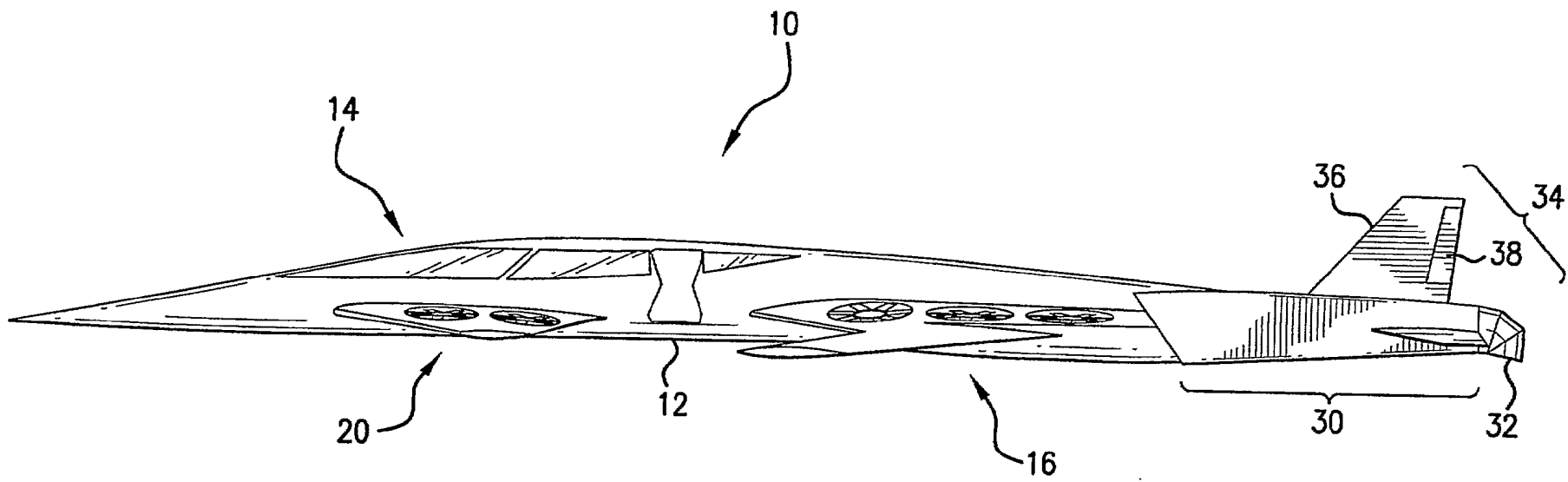


FIG. 3

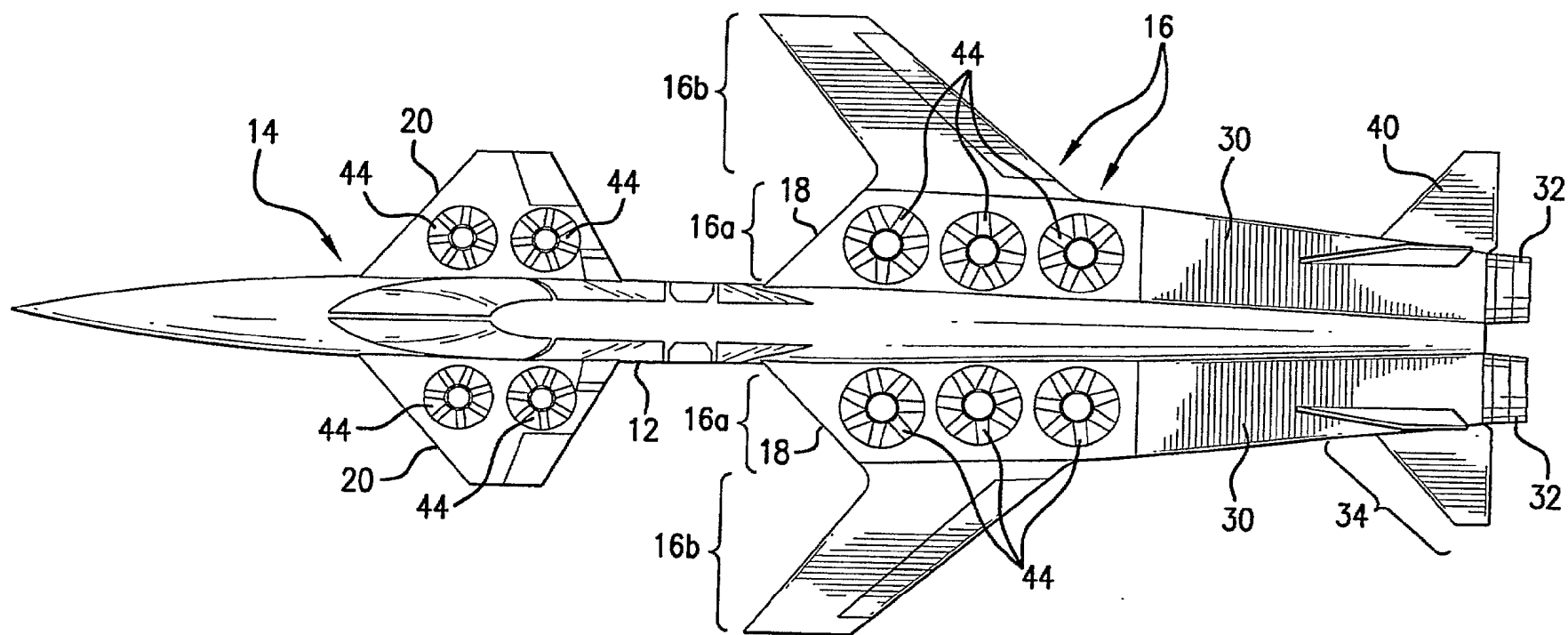


FIG. 4

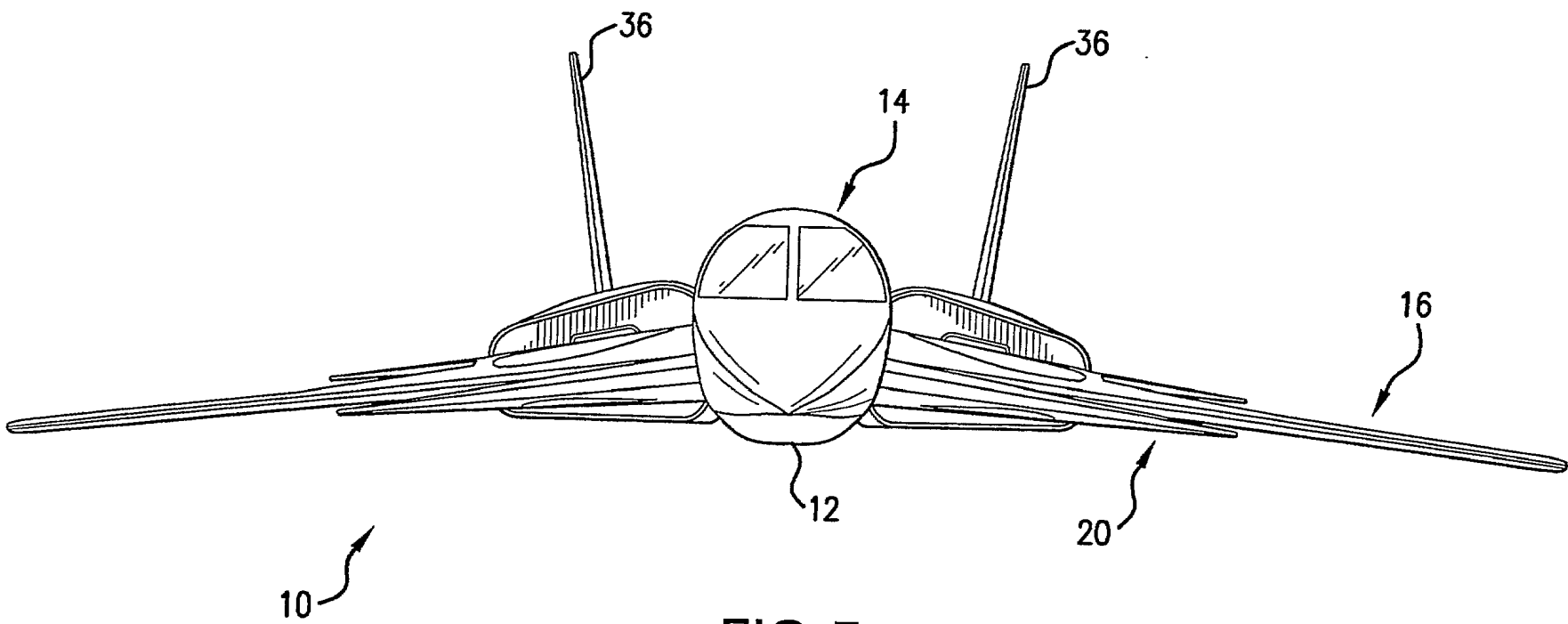


FIG. 5

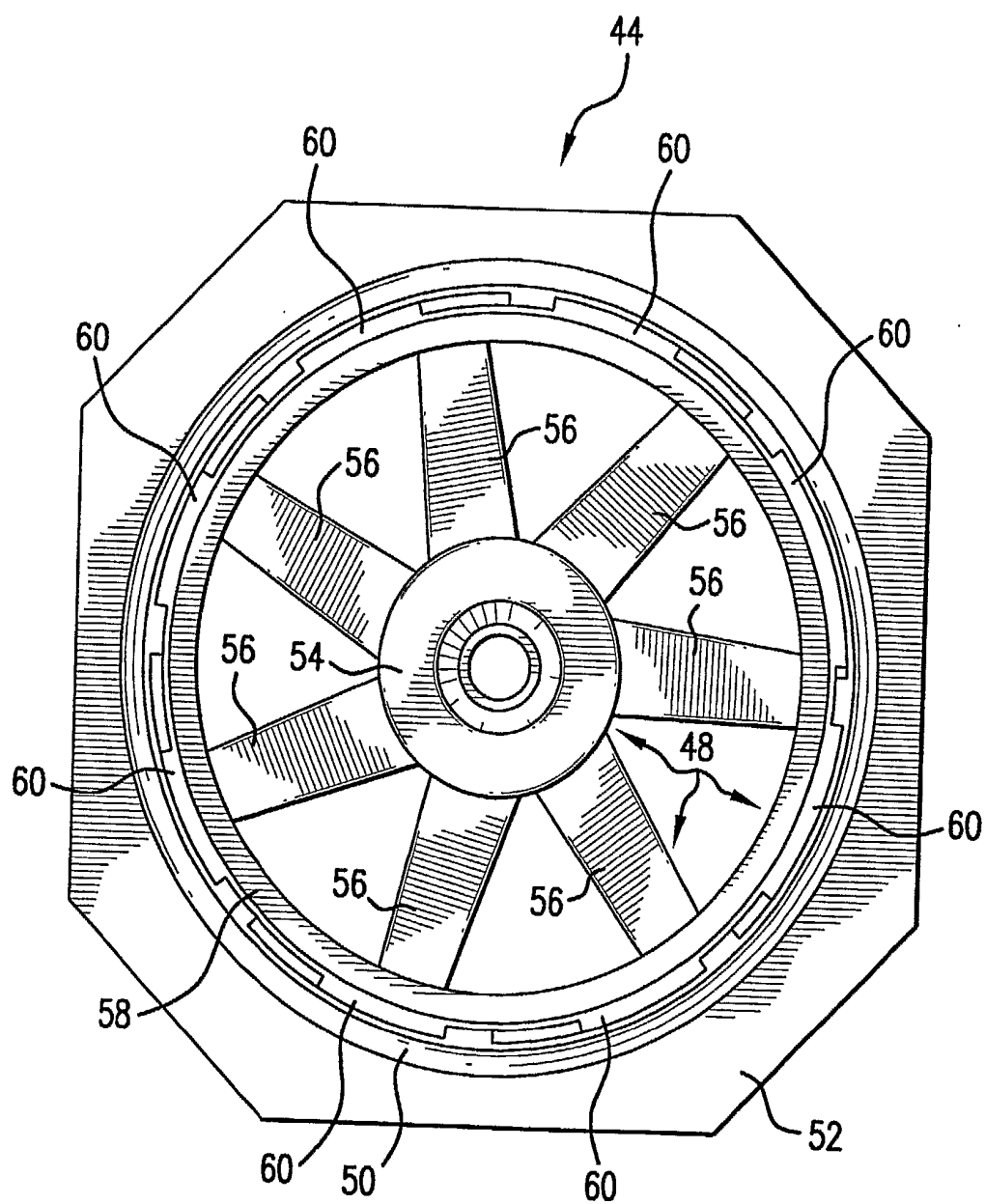


FIG. 6

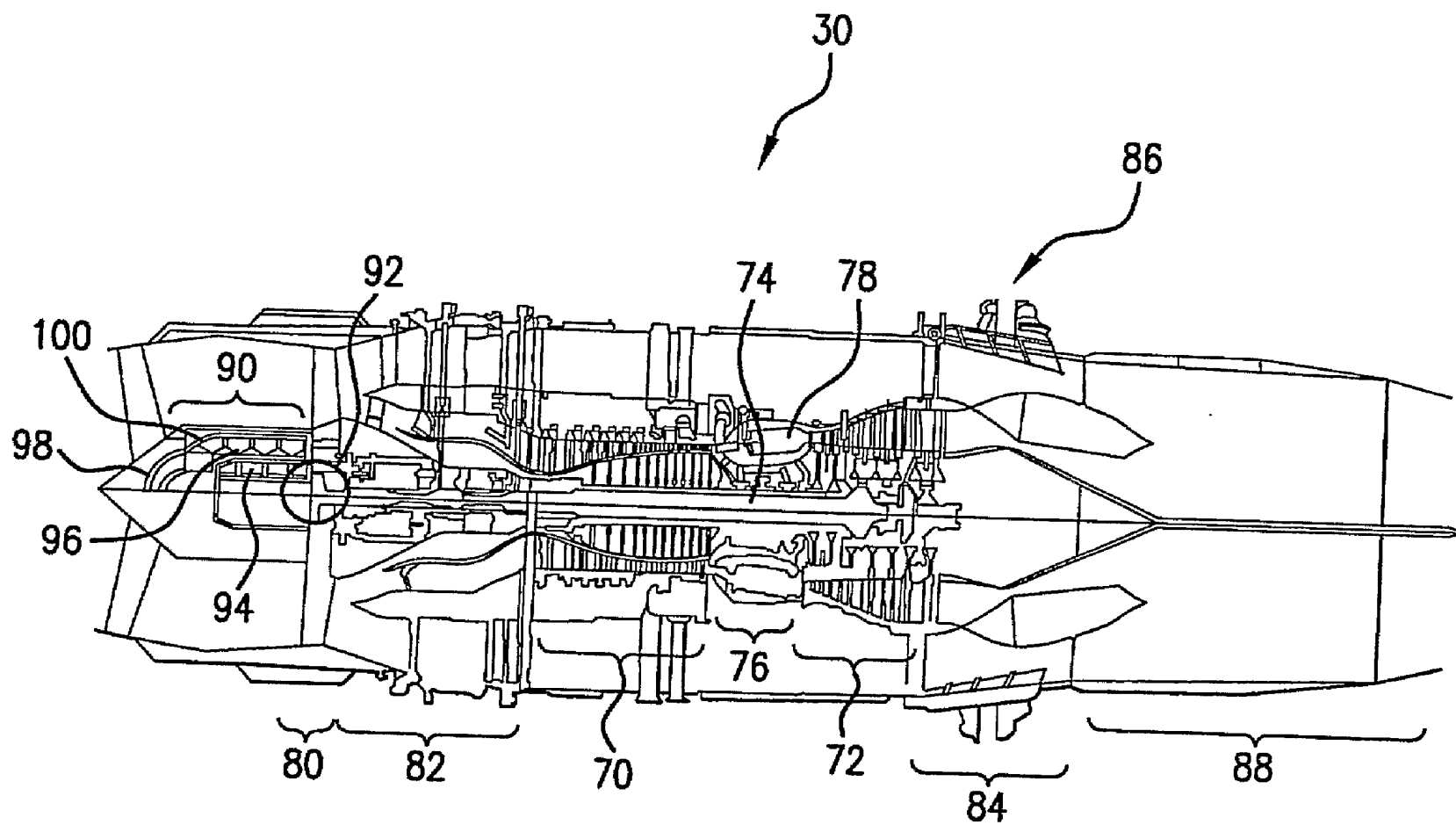


FIG. 7

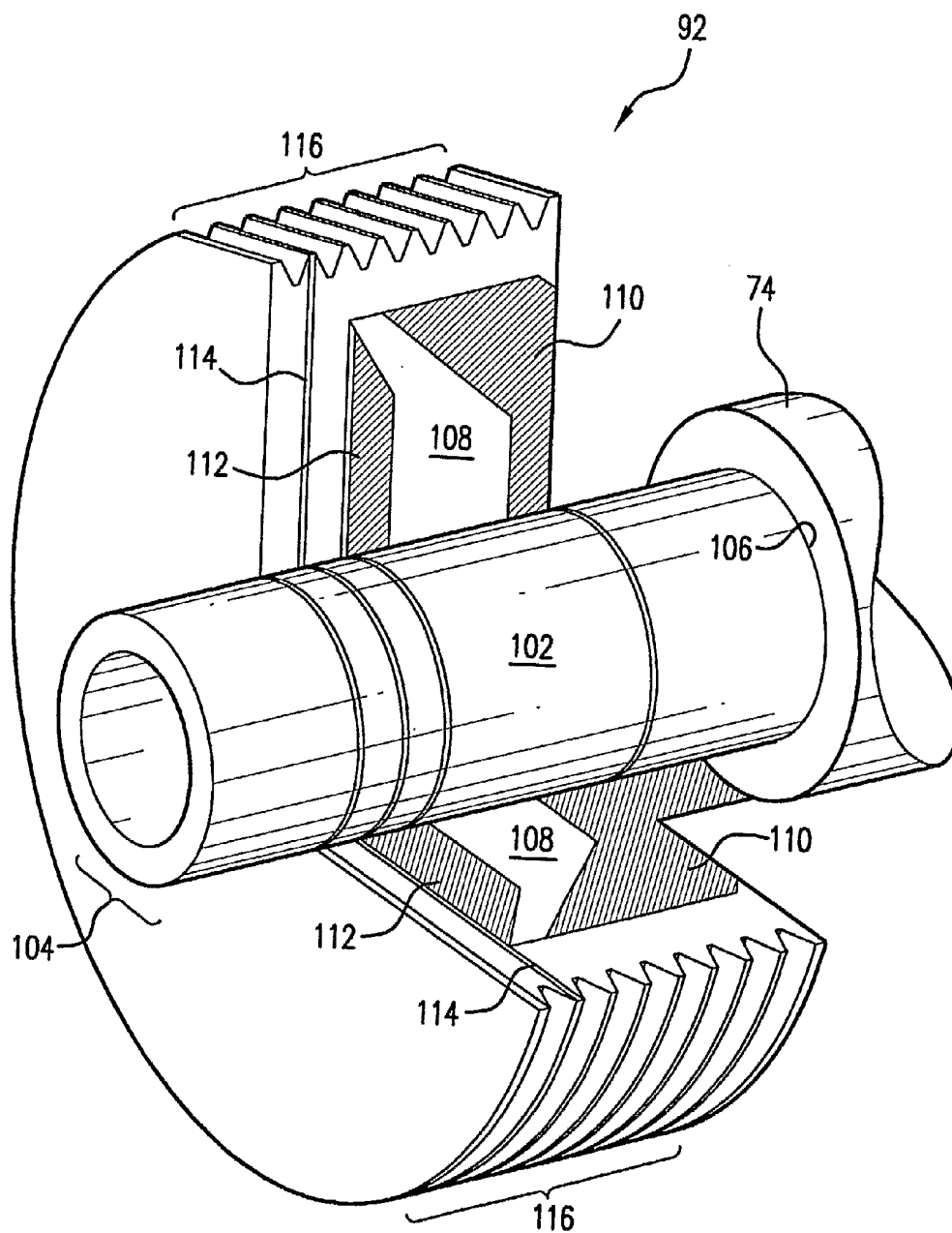


FIG. 8

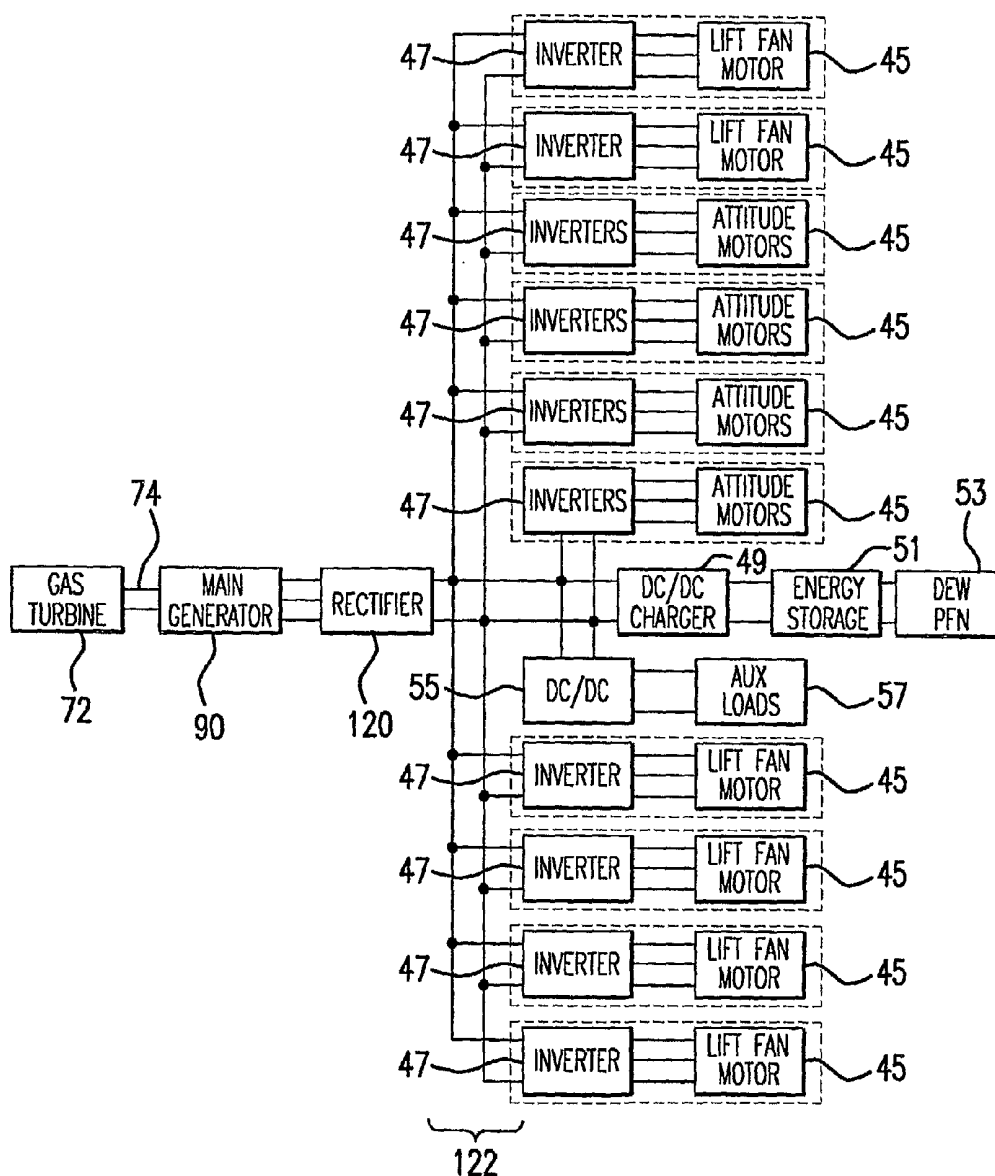
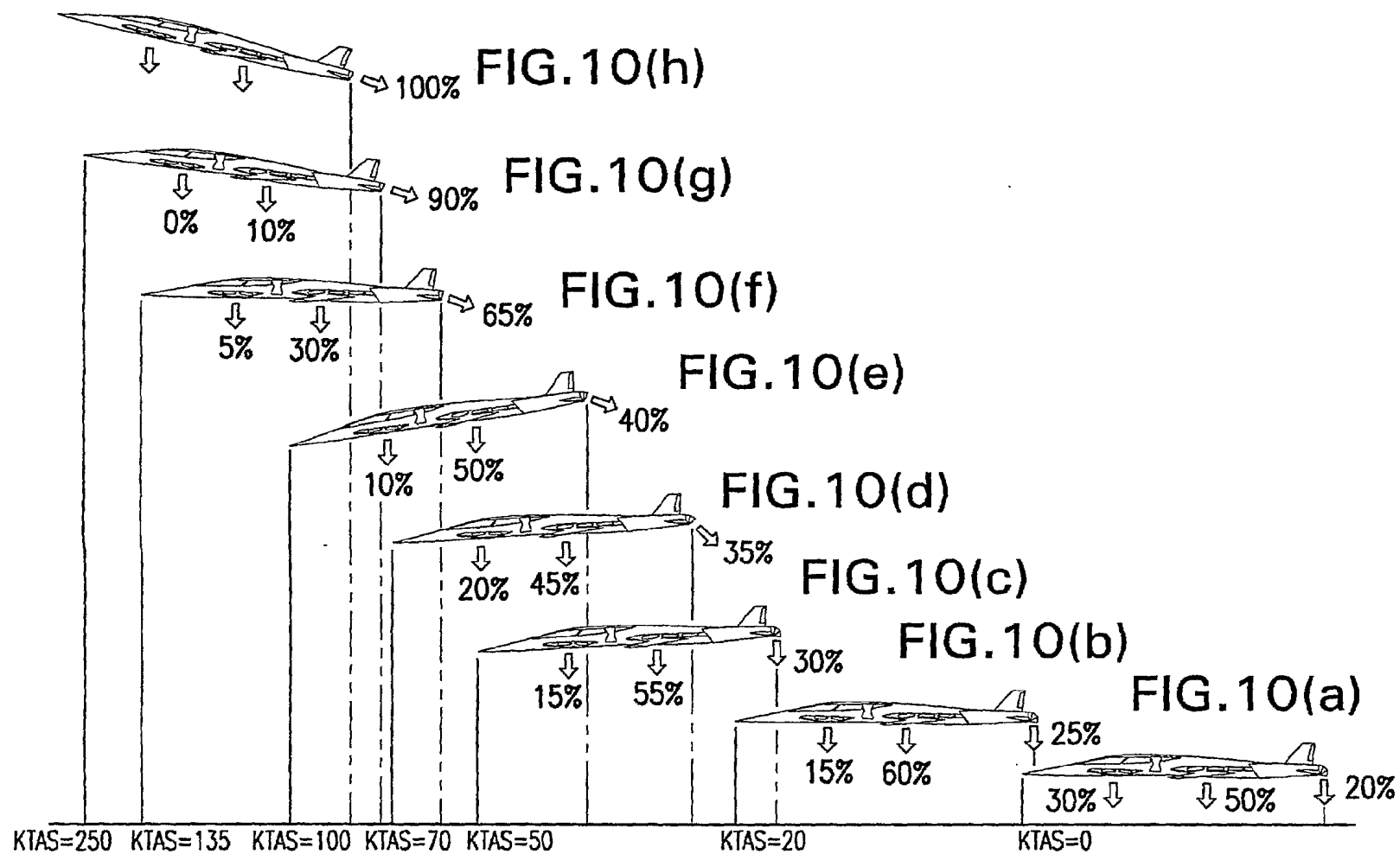


FIG.9



**HYBRID JET/ELECTRIC VTOL AIRCRAFT****CROSS-REFERENCE TO RELATED APPLICATIONS**

**[0001]** This application claims priority benefit of provisional U.S. applications 60/673,166 filed Apr. 20, 2005, and 60/695,690 filed Jun. 30, 2005, the contents of each of which is incorporated by reference in the entirety.

**FIELD OF THE INVENTION**

**[0002]** The invention relates to vertical take-off and landing (VTOL) or short take-off/vertical landing (STOVL) aircraft. (The term "VTOL" will be used hereafter to refer to VTOL or STOVL.) More particularly, the invention relates to fixed-wing VTOL aircraft.

**BACKGROUND OF THE INVENTION**

**[0003]** In general, two types of VTOL aircraft have been built and flown successfully: 1) rotary wing aircraft (helicopters) and 2) vectored-thrust, fixed-wing aircraft (e.g., the Harrier "Jump-Jet" and the JSF Joint Strike Fighter), in which the thrust generated by a turbojet engine is vectored downwardly for lift-off and then re-directed horizontally for wing-supported forward flight. Tilt-rotor vehicles such as the V-22 Osprey, in which vertically oriented rotors lift/lower the aircraft during takeoff/landings and rotate into horizontally oriented positions to propel the aircraft for wing-supported forward flight, are also known.

**[0004]** Although such aircraft serve their purposes with varying degrees of success, they are not without their limitations. For example, helicopters are limited in their forward speeds due to various aerodynamic considerations, including advancing/retreating blade aerodynamics. Additionally, the mechanical linkage systems by means of which power is transferred from the engines to the primary and tail rotors of helicopters are relatively complex and heavy. Similarly, the mechanical systems by means of which the engines of tilt-rotor aircraft pivot between their take-off/landing and forward flight orientations are extremely complex, and such tilt-rotor aircraft have not enjoyed widespread success.

**[0005]** Currently known fixed wing, vectored-thrust VTOL aircraft, on the other hand, are able to operate at much higher airspeeds than helicopters and tilt-rotor aircraft. Additionally, their thrust-vectoring systems are generally less complex and lighter than the pivoting systems found in tilt-rotor aircraft. Unfortunately, however, because current vectored-thrust VTOL aircraft lift and lower themselves by directing their engine exhaust directly downward, repeated operation of such aircraft in a given locale is limited to areas in which the ground surface has been specially prepared to withstand impingement of the hot gas exhaust. Furthermore, because such aircraft use the thrust of their engines directly and engine bleed-off air to respectively support and control the aircraft while in lifting/hover mode, which provides a relatively limited number of support posts or force points, control of such aircraft in hover mode can be relatively sensitive.

**[0006]** Further disadvantages of current VTOL systems may be summarized as follows. First, high power is required for VTOL in direct thrust systems. As a result, it is difficult to achieve sufficient margins for VTOL operation. Therefore, the engine is oversized, and significantly larger margins of engine thrust are required for VTOL than for efficient horizontal flight operation, and therefore range and efficiency of

operation are reduced. Second, systems using direct engine thrust have high effluent velocities from engine jet (approximately 2400 feet/second) and high exhaust temperatures (approximately 1250° F.). As a result, direct thrust systems have problems with hot gas ingestion of re-circulating exhaust flow as it mixes with ambient air underneath the aircraft while in ground effect. This can cause sudden loss of thrust and vertical control as the hot gas can stall or surge the turbine engine. Third, systems using highly loaded lift fans (e.g. JSF shaft-driven lift fan) still have very high downwash velocity from the lift fan (approximately 800 feet/second). Fourth, current systems exhibit relatively poor control of VTOL attitude, since they typically use high-pressure bleed air from the engine, which reduces the engine thrust margin and delays control—particularly in roll and yaw (as in the use of thrust roll posts in the JSF). Fifth, there is generally poor, slow control of altitude and vertical velocity due to turbine engine spool-up and spool-down time, hence throttle lags. Sixth, there is a high potential for catastrophic failure, since there is no lift fan or engine redundancy in current VTOL lift or control systems.

**[0007]** In addition to the preceding, the following information may also be helpful to appreciating the current invention and the benefits and advantages of the invention.

**[0008]** Currently, the principal approaches for practical VTOL flight vehicles, some of which are referenced above, can be grouped into three broad categories: low- to medium-speed vehicles with rotors (helicopters, tilt-rotors, and similar aircraft); low-speed lifting fan or ducted fan vehicles with more than one lifting fan (such as a flying platform like the Paisecki Flying Jeep); and high-speed vehicles using jet thrust or variations of jet thrust and highly loaded lifting fans (e.g., the Harrier and the JSF). These approaches are differentiated by many factors, but one of the most significant factors is the thrust loading for the propulsion system that provides lift for takeoff and transition to wing-borne low-speed forward flight. The thrust loading (pounds per square foot loading of the propulsor), or power loading (pounds of thrust per shaft horsepower) of the propulsor(s), determines the power required to lift the aircraft and the velocity of the corresponding momentum stream (downwash) below it.

**[0009]** In many designs, the propulsion system is used to provide both vertical forces for hover and horizontal forces for forward flight. This can be done by tilting the VTOL propulsion device (e.g., the rotor in a helicopter or tilt-rotor) or by providing a separate propulsion device. Some implementations of VTOL aircraft such as flying platforms (e.g., the Paisecki Flying Jeep) generate horizontal propulsion forces by tilting the entire vehicle. Other implementations of VTOL aircraft (e.g., the UrbanAero X-Hawk and the vehicle illustrated in U.S. Pat. No. 6,464,166) use sets of vanes in the exit flow of vertically mounted fans. Developmental programs such as the Defense Advance Research Projects Agency's Canard Rotor/Wing project (Dragonfly X-50) seek to combine rotor technology for VTOL flight with high-speed flight, by stopping the rotor and propelling the vehicle in forward flight—supported on the stopped rotor—using conventional jet thrust to do so.

**Helicopters And Tilt-Rotors**

**[0010]** Helicopters are very efficient for VTOL and low-speed flight because they operate at low thrust loadings (typically 20-30 lb/ft<sup>2</sup>), which greatly reduces both power requirements and downwash velocity. However, a generally large

rotor diameter is required to achieve the desirable low thrust loadings. The large diameter rotors operate at relatively low rotational speeds (to avoid problems with supersonic flow on the blades), so heavy, high-torque transmissions and shafting are needed to drive them. Moreover, the sheer size of the unprotected rotor disk leads to handling and safety issues with blade strike in obstacle-rich environments.

**[0011]** Furthermore, rotorcraft normally use articulated rotors for control by changing the collective and cyclic pitch of individual blades through a swashplate. The blades must be mounted in a hub that supports the blades and lets them rotate for pitch changes. As a result of this configuration, rotorcraft are mechanically complex and are subject to large vibratory loads as loading changes on the rotating blades. Torques generated by the rotor must be balanced, either by a tail rotor or another main rotor, further increasing complexity and weight.

**[0012]** Tilt-rotors combine helicopter VTOL efficiency with wing-borne flight at higher speeds by tilting the entire rotor system to act as propellers for forward flight. Tilt-rotors operate at higher thrust loading (typically 40-70 lb/ft<sup>2</sup>), with consequently higher power requirements and downwash velocity. Tilt-rotors also use the same mechanically complex collective and cyclic pitch control scheme for the rotors.

**[0013]** One of the great benefits of both helicopters and tilt-rotors is that they provide high levels of control in VTOL and low-speed flight. Their low downwash velocities permit operation over relatively unprepared surfaces and pose minimal danger to nearby ground personnel. However, a significant drawback of rotorcraft is their limited speed in forward flight. In particular, large differences in velocity between the advancing and retreating blades limit helicopter maximum speeds to less than 200 knots, and tilt-rotor aircraft have similar maximum speed limitations in VTOL and transitional flight (typically 350 knots). In forward flight with their rotors tilted forward, tilt-rotor aircraft are much faster than helicopters; nevertheless, the use of large rotors as propellers limits tilt-rotor aircraft's maximum speeds to less than 350 knots (e.g., 275 knots for the Boeing V-22 Osprey at cruise).

#### Hovering Platforms And Ducted Fans

**[0014]** Ducted fan aircraft and hovering platforms have even higher associated thrust loadings. These vehicles operate at intermediate propulsion system thrust loadings (on the order of 100-250 lb/ft<sup>2</sup>), with increased power requirements and associated downwash velocities as compared to helicopters but at a fraction of the downwash velocities associated with jet thrust-based VTOL systems. One advantage of these systems is that the rotors are contained within a shroud or duct that protects them from blade strike with other objects.

**[0015]** Examples of ducted fan vehicles include the Bell X-22A quad-rotor ducted fan aircraft. This vehicle was a "proof-of-concept" aircraft that demonstrated VTOL and forward flight capabilities, but it had the disadvantage of great mechanical complexity. In this aircraft, four turboshaft engines were used to power the vehicle, driving a complex transmission system and shafting to the four ducted fans. Fan lift control used variable pitch on the blades and another complex mechanism for the tilting ducts and rotors. Additionally, the X-22A was not a high-speed aircraft, with a maximum speed of only 255 knots. Although that is higher than a helicopter's maximum forward speed, it is less than the maximum speeds for tilt-rotor aircraft.

**[0016]** Flying platforms are another type of fan-driven vehicles in this category. These vehicles are typically built around two or three vertically oriented, fixed fans arranged in a flat body to provide lift. Power is applied to the fans by a mechanically complex transmission and shafting arrangement. Examples of this type of aircraft include the Paisecki Flying Jeep, which was built for the U.S. Army and Navy in the 1960's. The flying platforms were limited in control in VTOL and forward flight, depending on rotor blade pitch or throttle for vertical control and vanes in the fan flow for yaw and roll control. Flying platforms were primarily vehicles for hover and low-speed flight, using tilt of the overall vehicle lift vector to provide thrust for forward flight. These vehicles had relatively low maximum speeds (less than 100 knots) and became difficult to control at high speeds due to aerodynamic problems with the ducts in axial cross-flow.

**[0017]** More recent examples of flying platforms include the UrbanAero X-Hawk and the vehicle illustrated in U.S. Pat. No. 6,464,166. These aircraft use sets of vanes in the inflow and exit flow of the fans to generate moments and side forces, and variable pitch propellers for lift control. A separate set of fans is used to provide thrust for forward flight. A fly-by-wire control system is used to automate vehicle control. These aircraft are mechanically complex, with transmission and gearboxes to distribute engine power to the fans and rotors. Maximum speeds for these vehicle is very limited—only 80-100 knots.

**[0018]** Other examples of ducted fan aircraft include the Ryan XV-5A/B, which was built in the late 1950's and early 1960's. In VTOL, redirected engine exhaust gases were used to drive two wing-mounted lift fans and a forward fuselage-mounted fan. Louvered vanes were used in the fans for control and horizontal thrust in VTOL, and the engine exhaust was redirected to a conventional jet nozzle for forward flight. This vehicle demonstrated the fundamental feasibility of the fan-in-wing concept, but it had significant problems with transition between VTOL and forward flight. (Four aircraft were built; three crashed due to control-related problems in transition. The last prototype was turned over to NASA and now sits in an air museum)

#### Direct-Jet-Thrust VTOL Systems

**[0019]** VTOL jet fighters such as the JSF use either direct jet thrust to support the aircraft during takeoff and landing (as in the case of the Boeing X-32 JSF entry or the Harrier) or jet thrust combined with a highly loaded, mechanically driven fan (e.g., a turbofan or a shaft-driven lift fan as used in the Lockheed-Martin X-35). These vehicles operate at very high propulsor thrust loadings, e.g., on the order of 2500 lb/ft<sup>2</sup> or higher for the jet engines and 1500 lb/ft<sup>2</sup> for the direct-driven lift fans. As a result of such high thrust loadings, these aircraft must operate with far more power than helicopters and tilt-rotors in VTOL flight. These vehicles are inherently high-speed aircraft, with engines sized (as a result of their inefficiency for VTOL propulsion) for very high power levels.

**[0020]** The downwash velocities associated with direct-lift jet or lift fan systems is very high—between 800 feet/sec (lift fan) and 2000 feet/sec (jet thrust). This is dangerously high for ground personnel, and it makes it unlikely that these vehicles could be operated from any but carefully prepared reinforced surfaces. Additionally, the exhaust temperatures associated with direct-jet-thrust systems is very high—up to 1200° F.—thus posing an additional problem for near-ground operations. Furthermore, problems with hot gas ingestion of

downwash flow into the flight engine can cause catastrophic losses in lift. Careful management of the flows around these vehicles complicates their design and utilization, compromises their performance, and severely restricts the near-ground VTOL operation of these aircraft.

**[0021]** Despite the high power levels, these aircraft remain limited in terms of true VTOL capabilities under high-altitude, hot-day conditions, where engine thrust is reduced. This forces designers of direct-thrust systems to use sea-level thrust-to-weight ratios (T/W) as high as 1.5 to provide sufficient thrust margins for safe operation in challenging conditions. Such high T/W for the propulsion system leads to a gross mismatch of the engine thrust to the thrust required for efficient transonic cruise flight. This mismatch occurs because the typical cruise lift-to-drag ratio (L/D) for a fighter aircraft or unmanned combat air vehicle is between 6 and 10, which implies that a T/W of between 1/10 and 1/6 is needed at the cruise altitude. The reduction of thrust available with altitude will normally provide this match within the engine operating altitude range at throttle settings that provide good specific fuel consumption. If the engine thrust is too high at sea level (i.e. sized for VTOL), the engine must be operated at reduced throttle settings that are not efficient for long-range flight.

**[0022]** The current design of VTOL systems using direct-thrust also poses a problem in terms of balancing the lifting forces about the center of gravity (CG) of the aircraft. Placement of the engine nozzle at the aft end of the vehicle requires a so-called “magic finger” to provide balancing lift forces. In the case of the JSF, the lift fan provides this “magic finger,” but the layout of these vehicles is very sensitive to overall loading and thrust margins for the components.

**[0023]** Direct-thrust or lift-fan systems as currently implemented struggle with problems of control in VTOL and transitional flight. These systems provide vertical control through engine throttle manipulation. The throttle response of turbine engines is quite slow as a result of the high rotational inertia of the engine spools. These throttle lags greatly complicate control of the aircraft vertical state (altitude, vertical speed, and acceleration).

**[0024]** In direct-thrust or lift-fan systems, high-pressure bleed air from the engine is used in reaction nozzles on the wing and fuselage for roll and yaw control in VTOL, which reduces the thrust available from the engine to support the aircraft. Furthermore, the control forces from these systems are adequate but limited in terms of control authority. In addition, there is limited control power available from these bleed-air systems. When high levels of control response are commanded and the need for additional engine power is greatest, the ability of the engine to deliver that power is reduced by the use of bleed air. This is an inherent flaw in the bleed-air-based VTOL systems. These direct-jet-thrust systems also provide no redundancy for propulsion or control components.

**[0025]** In view of the foregoing, it is clear that there is a need for a high-speed VTOL aircraft that is mechanically less complex and faster than conventional rotorcraft (including tilt-rotor rotorcraft), that provides properly matched thrust loadings, and that can be launched from a greater variety of takeoff points than conventional high speed VTOL aircraft such as the Harrier and the JSF.

## SUMMARY OF THE INVENTION

**[0026]** The present invention provides a hybrid jet/electric VTOL aircraft that resolves or avoids the limitations of prior art VTOL aircraft addressed above. To that end, the present invention features a fixed-wing VTOL aircraft which takes off, lands, and hovers on a number of electrically powered lifting fans and that is powered for forward flight by one or more gas turbine engines. During vertical flight (i.e., takeoff, landing, and hover), electricity to drive the fans is generated using a generator that is driven off of one of the gas turbine engines. (A twin-engine configuration, with a generator driven off of each engine, is a preferred embodiment.) Residual thrust may be directed downward to augment or supplement the lift generated by the fans through a vectoring nozzle.

**[0027]** (As used herein, the term “fixed-wing” refers to aircraft in which the main lift-producing wings remain generally or relatively stationary relative to the vehicle during flight. The term is broad enough, however, to cover “swing-wing” aircraft such as the F-14 and the B1, in which the wings can be pivoted fore and aft during flight to assume different trim configurations depending on the vehicle’s operating point.)

**[0028]** A hybrid VTOL jet-electric air vehicle as per the invention allows the thrust capability of the engine to be more closely matched to the thrust required to achieve efficient horizontal flight for the airframe of the vehicle in which the engine is installed. Prior art vectored thrust VTOL aircraft have suffered thrust inefficiencies in forward flight because the engine thrust requirements have been set by the requirements to achieve VTOL using vectored thrust (whether vectored thrust alone or vectored thrust augmented by a mechanically shaft-driven lift fan).

**[0029]** The thrust required to achieve VTOL using vectored thrust has uniformly been substantially in excess of the thrust required to achieve efficient forward flight because the conversion of thrust from the gas turbine engine to lifting force has been relatively inefficient (because the lifting forces are concentrated in one or more jet thrust columns and in one column of lift fan discharge, and very high thrust forces are required to achieve VTOL—hence, inefficient high thrust loadings). With the current invention, in contrast, because the electrical system and the lift fans are able to achieve high efficiencies in converting the power from the gas turbine engine to lift thrust and because the lifting forces are widely spread at lower velocities and at greater fan thrust efficiencies (due to lower fan loadings), less thrust capacity is required from the gas turbine engine to achieve VTOL, and thus the gas turbine engine may be sized more appropriately to the requirements of the airframe to achieve efficient forward flight.

**[0030]** Also advantageously, the use of multiple electric lift fans distributed throughout the airframe of the vehicle enables the vehicle to achieve greater stability in VTOL operations than was previously possible. In the prior art, in-service VTOL aircraft have utilized only two “columns” of lift thrust—both columns being in the centerline of the aircraft (in the case of JSF) or immediately adjacent to the centerline (in the case of the Harrier). One experimental aircraft (the Ryan X-5A) utilized three columns—one on the centerline and one in each of the two wings. Aircraft in the prior art depended upon all columns of thrust for safe operation in VTOL. A VTOL aircraft per the invention, in contrast,

provides a level of redundancy that permits the loss of thrust from one or more fans without compromising the aircraft.

**[0031]** Further advantageously, now there is a fixed wing VTOL aircraft which does not have the constraints of high heat and high exhaust gas velocities in ground effect, as now the gas is ambient air temperature, traveling at low velocity and low temperature. Thus the air vehicle of the invention can take off and land from unprepared surfaces (tarmac, dirt, and grass), unlike certain VTOL aircraft in the prior art (e.g., Harrier, JSF, XV-5A/B, and Yakolev), which must use specially prepared reinforced surfaces. The vehicle of the invention shows distinct advantages over prior art VTOL vehicles offering low average downwash velocity from its distributed fan system for VTOL lift.

**[0032]** A vehicle according to the invention operates in VTOL with residual exhaust gas temperatures of 400-600 degrees Fahrenheit, and exhaust velocities of 300-600 feet per second, as compared to exhaust gas flow in prior art VTOL aircraft of 1200-1400 degrees Fahrenheit and exhaust gas velocities of over 2000 feet per second. Reduced exhaust temperatures due to engine power extraction are a decided advantage in the new concept, as the invention reduces airborne debris from lower exhaust flow and ambient VTOL lift from the electric fans, eases operation of personnel around the air vehicle providing a safer lift-off environment, and reduces fire hazards due to lower temperature exhaust and downward jet exhaust environment.

**[0033]** In a first aspect, the invention features a fixed-wing VTOL aircraft having a thrust-producing gas turbine engine, an array of electric lift fans distributed across the body of the aircraft, and a generator that is (selectively) driven by the gas turbine engine. The fans are powered by electricity generated by the gas turbine engine. In specific embodiments, the fans are, in total, able to support at least 25% of the weight of the aircraft, more preferably at least 50% of the weight of the aircraft, still more preferably at least 90% of the weight of the aircraft, and, most preferably, are able to support up to the entire weight of the aircraft.

**[0034]** In a second aspect, the invention features a method of operating a fixed-wing VTOL aircraft. According to this aspect of the invention, the aircraft lifts off from a resting surface using electrically powered lifting fans and then transitions to forward wing-borne flight, with thrust for forward flight being provided by one or more gas turbine engines. Electricity to drive the lifting fans is generated by the gas turbine engine(s). In preferred embodiments, the aircraft lifts off vertically and lands vertically; in other embodiments (STOVL), the aircraft takes off with a shortened take-off roll and lands vertically (when the weight of the aircraft is reduced due to fuel consumption, payload reduction, etc.).

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0035]** These and other features and advantages will become clearer in view of the detailed description below and the associated Figures, in which:

**[0036]** FIGS. 1-5 are a perspective view from above, a perspective view from below, a side elevation view, a plan view, and a front view, respectively, of an aircraft according to the invention;

**[0037]** FIG. 6 is a plan view of an electric lifting fan used in the aircraft illustrated in FIGS. 1-5;

**[0038]** FIG. 7 is a section view of an engine with a turbine-driven generator according to the invention;

**[0039]** FIG. 8 is a perspective view, partially cut away, of an electric clutch used in the engine shown in FIG. 7;

**[0040]** FIG. 9 is a schematic view of the electrical architecture of an aircraft according to the invention; and

**[0041]** FIGS. 10(a)-10(h) are a time sequence illustrating performance of an aircraft according to the invention, from vertical take-off through forward wing-borne flight.

#### DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

**[0042]** The overall configuration of a manned embodiment 10 of an aircraft incorporating a lift/propulsion system according to the invention is illustrated in FIGS. 1-5. The aircraft 10 has a fuselage 12 with a cockpit/cabin 14. The main wing portion 16 of the aircraft 10 extends from about the lengthwise mid-point of the fuselage 12 to the rear of the aircraft 10. Each main wing has a generally rectangular root portion 16a, with a rearward-swept leading edge 18, and a forward-swept, outboard wing extension portion 16b. (The root portion 16a is actually a strake that can be thought of as part of the fuselage.) This forward-sweep configuration of the main wings provides enhanced maneuverability and control, particularly during VTOL and transition to forward flight.

**[0043]** In addition to the main wing portion 16, the aircraft 10 includes canards 20 extending from the fuselage 12 and located lengthwise generally proximate the cockpit/cabin 14. The canards 20 provide additional lift and enhance maneuverability and controllability of the aircraft 10.

**[0044]** At its rear, the aircraft 10 is provided with a pair of gas turbine engines 30, e.g., turbofans, with one engine 30 located on either side of the aircraft 10's longitudinal centerline. (Single-engine configurations of aircraft according to the invention are also contemplated; operational principles of the invention are the same.) The engines 30 are integrated into the root portions 16a of the main wings of the aircraft, so part of each engine's intake is located above the root portion 16a and part of each engine's intake is located below the root portion 16a, as is shown most clearly in FIGS. 1, 2, and 5. Each engine 30 has a thrust-directing directional nozzle 32, which nozzle 32 pivots vertically from an uppermost position that is parallel to the centerline of the aircraft 10 to a lowermost position of 105° below horizontal (thrust is directed 105° downward relative to the centerline of the aircraft 10, i.e., downward and actually 15° forward). If desired, the nozzles 32 may also be configured to pivot laterally for enhanced maneuverability in yaw, although that is not necessary to practice the invention.

**[0045]** The empennage 34 of the aircraft 10 includes twin vertical fins 36, with rudders 38, and all-flying (all-moving) stabilizers 40. The vertical fins 36 and stabilizers 40 are supported by and extend from the respective housings of the engines 30.

**[0046]** A number of electrically powered lifting fans 44 are provided on the aircraft 10. The lifting fans 44 generate sufficient thrust to lift, support, and lower the aircraft 10 in VTOL and hovering operation. In particular, in the illustrated embodiment of the aircraft 10, three lifting fans are provided in the root portion 16a of each main wing, ahead of the engine inlet, and two lifting fans are provided in each canard 20, for a total of ten lifting fans 44. It will be understood, of course, that the number, size, and location of the lifting fans 44 will vary depending on the overall size and configuration of the

aircraft and that the inventive concept, explained more fully below, can be practiced with vastly differently configured aircraft.

[0047] The electric lifting fans **44** are illustrated in FIGS. **1-5** as completely open. However, a system of directional louvers and other door mechanism (not illustrated) covers each fan, in a manner known to those having skill in the art. The doors and louvers are opened during VTOL/hovering operation of the aircraft **10** and are closed during forward, wing-borne flight.

[0048] A preferred embodiment of an electric lifting fan **44** is shown in greater detail in FIG. **6** (again, without louvers being shown). The lifting fan **44** includes a multi-bladed fan member **48**, which is centered within a superconducting magnetic coil **50**. Superconducting magnetic coil **50** may be integrated into the preferably composite skin **52** of the aircraft wing/fuselage. Fan member **48** is fabricated from a central hub **54**, from which a number (e.g. seven, as shown) of fan blades **56** extend. The tips of the fan blades **56** are joined together by means of tip ring **58**. Preferably, the central hub **54**, fan blades **56**, and tip ring **58** are fabricated as a single integral unit. A series of permanent magnets **60** are attached (e.g., bonded or embedded) to the tip ring **58** around the circumference of the fan member **48**, and a small gap on the order of 1.0 mm is maintained between the radially outer surfaces of the permanent magnets **60** and the radially inner surface of the superconducting magnetic coil **50**. Although not specifically illustrated as such for clarity, the magnetic coil ring structure **50**, which is made from titanium, has a C-shaped cross section so as to form a channel. The tip ring **58** is a composite structure with a shape that is the male counterpart of the C-shaped channel and thus fits precisely in the 1.0 mm gap, magnetically suspended therein and restrained/guided against the out-of-plane loads the rotating fan will create under operation against the superconducting coil ring frame **50**. With this configuration, the fan member **48** is magnetically centered within the superconducting magnetic coil **50** and can be electromagnetically driven at an extremely high rate of revolution, on the order of 3600-8500 revolutions per minute (depending on the size of the fan and the power of the fan motor).

[0049] Electrical power to drive the lifting fans **44** is generated on board the aircraft **10**. In particular, it is generated by a generator (preferably a superconducting generator) that is driven by one of the engines **30**. Such a system is illustrated in FIGS. **7-9**. (The description that follows will be directed toward just one of the engines; it will be appreciated that, where there are multiple engines on the aircraft, one or more than one generator can be used, with generators on each of at least two of the engines.)

[0050] As illustrated in FIG. **7**, an engine **30** according to the invention includes, in large measure, generally known components. For instance, the engine—in this embodiment a low-bypass turbofan engine—include a compressor section **70** with multiple compressor stages (not individually numbered); a turbine section **72** with multiple turbine stages (not individually numbered); a main shaft **74** interconnecting the turbine section **72** with the compressor section **70** to drive the compressor section by expansion of hot gas through the turbine section **72**; and an annular burn ring or combustor section **76**, with fuel injector ring **78**, all of which are generally known in the art. Furthermore, the engine **30** includes a turbofan section **80** (driven by the turbine section **72** via the main shaft **74**); core and bypass inlet section **82**; afterburner section

**84** with fuel dump injectors **86** for the afterburners; and exhaust nozzle **88**, all of which are generally known in the art.

[0051] As is further illustrated in FIG. **7** and represented in FIG. **8**, an engine **30** according to the invention also includes a generator **90** that is selectively driven by the turbine **72** via the main shaft **74**. In particular, electric clutch **92**—electric clutches are generally known in the art—is used to engage and disengage the generator **90** to and from the main shaft **74**. Electric power is stored on board the aircraft in an energy storage system. Residual electric energy can be stored and used for ground start-up and operation of the electric clutch. The energy generation system is sized for engine start-up and to run the electric clutch. During start-up, usually a ground start cart is also utilized for electric power of environmental systems.

[0052] The generator **90** includes magnets **94**, which are centered within and rotates within coil casing **96**. Power cables **98** are used to take off electrical current generated by the generator **90** and distribute it to the lifting fan system, as explained in more detail below. The generator is oil-cooled, so oil cooling channels **100** pass throughout the superconducting coils of the generator outer structure coil casing **96**.

[0053] As indicated above, electric clutches are generally known in the art. An electric clutch assembly **92** for use in the present invention, however, is illustrated in greater detail in FIG. **8**. The electric clutch assembly includes a clutch spindle **102** around which or onto which various components of the clutch assembly are rotationally mounted. The forward end **104** of the clutch spindle **102** is spline-fit to the central shaft of the generator **90**, and the rearward end **106** of the clutch spindle **102** is spline-fit to the main turbine shaft **74**. The clutch assembly **92** further includes a permanent magnet armature **108** and magnetic excitation coils **110** and **112**. Coil charge lines **114** extend throughout the clutch assembly **92**, and the clutch assembly may be provided with magnetic air bearing guides **116**. The net effect of the construction of the electric clutch assembly **92** is that when the clutch assembly is not energized, the main shaft **74** is decoupled from the central shaft of the generator **90**, and the turbine does not drive the generator. When, on the other hand, the electric clutch assembly **92** is energized from the electric storage system or the ground start system, the main turbine shaft **74** is electromagnetically coupled to the central shaft of the generator **90** such that the turbine **72** drives the compressor **90**.

[0054] A schematic diagram of the overall electrical system by means of which the lifting fans **44** are driven is shown in FIG. **9**. As illustrated, gas turbine **72**—coupled to the generator via the electric clutch assembly **92** (not illustrated)—drives the main generator **90**. Rectifier **120** converts the alternating current produced by the main generator **90** into direct current, which is distributed along power bus **122** to the various lifting fans **44**. Each lifting fan **44** is driven by a fan motor **45**, and each fan motor **45** has an inverter **47** associated with it to smooth, condition, and regulate the amount of direct current from the power bus **122** before it is fed to the particular fan motor **45**. Thus, each electric fan has its own power or speed controller and may be governed independently or in a specific sequence for flight (take-off, landing, or transition). (As illustrated in FIG. **9**, four of the ten motors **45** are designated “Attitude Motors,” and the remaining six of the ten motors **45** are designated simply “Lift Fan Motors.” In the illustrated embodiment, the four Attitude Motors drive the lift fans **44** located in the canards **20**, while the other six Lift Fan Motors drive the lift fans **44** located in the main wings **16**.)

**[0055]** As further illustrated in FIG. 9, the electrical system may also include a DC/DC charger 49, which charges high-capacity energy storage member 51 (e.g., a DC-charged capacitor bank of 6000  $\mu$ F, with peak power to 1200 Kw, 0 to 10,000 volts, 300 Kj in 2.0 seconds). High-capacity energy storage member 51 provides electrical power to an energy-intensive load (i.e., a load that requires a large amount of energy) such as a directed energy weapon, e.g., laser or microwave (or, more specifically, to a pulse-forming network constituting a subsystem within the DEW which modifies the pulse to match the pulse coming off the generator, so as to run high-power electric weapons).

**[0056]** Furthermore, the electrical system may include a DC/DC charger 55 that charges the energy storage system at a low rate when the fans are in operation and a high rate when the fans are not needed, or when auxiliary power is at a minimum requirement. When there is excess power draw on the system, the DC/DC charger 55 maintains a minimum storage capacity in the storage system so that all critical electrical functions of the aircraft (central computer, flight controls) are maintained.

**[0057]** An example of flight operation of an aircraft 10 according to the invention with a generator on each of the engines, from vertical take-off through forward, wing-borne flight, is illustrated in FIGS. 10(a)—10(h). The sequence of figures illustrates the distribution of power generated by the gas turbine engines among the forward lifting fans 44 in the canards 20 (i.e., the attitude control fans), the main lifting fans 44 in the main wings 16, and out the rear of the engines in the form of exhaust-based thrust. For example, at lift-off, illustrated in FIG. 10(a), 30% of the power generated by the engines is used by the lifting fans 44 in the canards 20 in creating downward-acting thrust; 50% of the power generated by the engines is used by the lifting fans 44 in the main wings 16 in creating downward-acting thrust; and the remainder of the power generated by the gas turbine engines (20%), which exists in the form of exhaust-based thrust, is directed out the rear of the engines. As noted above, the nozzles 32 of aircraft 10 are thrust-vectoring; at takeoff, the nozzles are rotated downward so that the exhaust-based thrust produced by the engines is directed straight downward.

**[0058]** Forward flight is initiated by pivoting the nozzles 32 such that the exhaust-based thrust produced by the engines begins to be directed rearward. For example, FIG. 10(b) shows the aircraft with the nozzles 32 pivoted slightly rearward, which is sufficient to begin moving the aircraft forward (e.g., at a speed of 20 knots). At this point, an increasing percentage of the power produced by the engines (25%) is being used as exhaust-based thrust, and less is being used in the form of electric fan-based lifting thrust (15% canard fans/60% main wing fans). This trend continues as illustrated in FIGS. 10(c)—10(h), with more and more power generated by the engines being used in the form of exhaust-based thrust as the nozzles continue to pivot to bring the vector associated with that thrust to the final forward-flight orientation; with less and less power generated by the engines being used in the form of fan-based lifting thrust; and with forward speed of the aircraft increasing. Ultimately, the fans may shut down altogether and their louvers closed, at which point the entire weight of the aircraft is borne by the wings and any other lifting surfaces on the aircraft, or the fans may continue to be used to provide a nominal amount of lift and/or attitude control in pitch, roll, and/or yaw.

**[0059]** It may be observed that while the percentage of engine power utilized in the form of exhaust-based thrust increases monotonically from FIG. 10(a) to FIG. 10(h), the specific percentages of power utilized by the lifting fans in the canards and the lifting fans in the main wings do not decrease monotonically, but rather increase slightly then decrease again at certain points in the flight envelope. The overall trend, however, is for the amount of power utilized in driving the lifting fans to go to zero as forward speed of the aircraft increases and more and more of the weight of the aircraft is borne by the wings. The specific amount of thrust that needs to be generated by each of the various lifting fans will depend, in part, on the specific orientation of the aircraft and may be “hard-wired” into the flight takeoff software or result from adaptive avionics control/auto-pilot.

**[0060]** It will be appreciated that, depending on the weight of the aircraft and the lifting capability of the fans, it may be necessary to initiate a forward roll while the aircraft is still on the ground, to generate a certain amount of airspeed to help lift the aircraft off the ground. In other words, STOVL operation as opposed to VTOL operation may be required.

**[0061]** It will be further appreciated that the aircraft 10 can land vertically by largely reversing the vertical take-off procedure described above. In particular, the engine nozzle is rotated downward (if it is thrust-vectoring enabled) and the amount of thrust produced by the engine is reduced, while the lifting fans are opened and generate more and more lifting force as the aircraft slows and less weight is borne by the wings. To slow the aircraft, it may be necessary or desirable to provide reverse thrust, e.g., by using the airflow-directional control capability of the louvers covering the lifting fans and/or by rotating the engine nozzle down and slightly forward (e.g., 105° down from aft horizontal, i.e., 15° forward of straight down). The aircraft then settles to the ground, supported by the lift provided by the lifting fans and the residual thrust produced by the engine.

**[0062]** While the invention has been described with respect to a specific embodiment (e.g., a manned vehicle), it will be appreciated that the inventive concept can be incorporated into a wide variety of VTOL aircraft configurations, including unmanned as well as manned configurations. Furthermore, while operation of the aircraft is illustrated in FIG. 10 with pitching motion controlled by the relative amounts of power applied to the various groups of fans and being exhaust as exhaust-based thrust, it should be appreciated that differential application of power among the various fans—particularly as between the fans on the opposite lateral sides of the aircraft—can be used to effect roll, and yaw responses are produced by the torque moments caused by the operating fans in certain locations of the aircraft. Thus, the invention is defined by the following claims.

We claim:

1. A fixed-wing VTOL or STOVL aircraft, comprising: an airframe comprising a fuselage and wings; a thrust-producing gas turbine engine; an electrical generator that is driven by said gas turbine engine to generate electricity; a plurality of electric lift-producing fans distributed across said airframe; and an electrical system configured and arranged to provide electricity generated by said electrical generator to said electric fans to power said electric fans.
2. The aircraft of claim 1, wherein said fans, in total, are able to support at least 25% of the weight of said aircraft.

3. The aircraft of claim 2, wherein said fans, in total, are able to support at least 50% of the weight of said aircraft.

4. The aircraft of claim 3, wherein said fans, in total, are able to support at least 90% of the weight of said aircraft.

5. The aircraft of claim 4, wherein said fans, in total, are able to support the entire weight of said aircraft.

6. The aircraft of claim 1, further comprising a thrust-vectoring nozzle which is able to redirect thrust produced by said engine between a primarily aft-oriented direction and a primarily downward-oriented direction.

7. The aircraft of claim 1, wherein said electrical generator is selectively drivable by said gas turbine engine.

8. The aircraft of claim 7, further comprising an electric clutch by means of which said electrical generator is coupled to and decoupled from said gas turbine engine.

9. The aircraft of claim 1, wherein said fuselage comprises strakes and at least some of said fans are located in said strakes.

10. The aircraft of claim 1, further comprising canards.

11. The aircraft of claim 10, wherein at least some of said fans are located in said canards.

12. A method of operating an aircraft, the aircraft having wings, a thrust-producing gas turbine engine, an electrical generator driven by the engine, and a plurality of electrically driven lifting fans, said method comprising:

- a) lifting the aircraft off of a surface using the lifting fans to lift at least some of the weight of the aircraft, wherein the lifting fans are powered by electricity generated by the generator;
- b) decreasing the amount of lift generated by the lifting fans, whereby the lifting fans support a decreased amount of the weight of the aircraft;
- c) increasing thrust produced by the engine and directing at least a component of the thrust in a rearward direction so as to move the aircraft in a forward direction, whereby the wings support an increased amount of the weight of the aircraft;
- d) repeating steps b) and c).

13. The method of claim 12, wherein steps b) and c) are repeated until none of the weight of the aircraft is supported by the lifting fans and all of the weight of the aircraft is supported by the wings and any other lift-generating surfaces on the aircraft.

14. The method of claim 12, wherein the lifting fans initially support all of the weight of the aircraft.

15. The method of claim 12, wherein the lifting fans initially support less than all of the weight of the aircraft, said method further comprising initially directing at least a component of the thrust in a downward direction such that the downward-directed component of thrust supports a portion of the weight of the aircraft.

16. The method of claim 15, further comprising redirecting the thrust toward a rearward-acting direction as steps b) and c) are repeated.

17. The method of claim 12, wherein the aircraft initially lifts off of the surface vertically.

18. The method of claim 12, wherein the aircraft initially moves forward over the surface to generate wing-based lift before lifting off of the surface.

19. A method of operating a fixed-wing aircraft, the aircraft having a thrust-producing gas turbine engine, an electrical generator, and a plurality of electrically driven lifting fans, said method comprising:

- driving the generator with the gas turbine engine to generate electricity;
- driving the lifting fans with the electricity generated by the generator;
- hovering the aircraft supported at least in part on lift created by the lifting fans.

20. The method of claim 19, wherein the entire weight of the aircraft is supported by the lifting fans during said hovering.

21. The method of claim 19, wherein less than the entire weight of the aircraft is supported by the lifting fans during said hovering, said method further comprising directing thrust produced by the gas turbine engine downward to help support the weight of the aircraft.

22. A method of improving the lifting power loading efficiency of a fixed-wing, gas turbine engine-powered VTOL or STOVL aircraft, comprising distributing the lifting power produced by the gas turbine engine to a series of electric lifting fans distributed over the body of the aircraft by converting mechanical power produced by the gas turbine engines to electrical power and using the electrical power to drive the series of electric lifting fans.

\* \* \* \* \*



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(19) **United States**(12) **Patent Application Publication**  
**Tian**(10) **Pub. No.: US 2022/0411087 A1**(43) **Pub. Date: Dec. 29, 2022**(54) **VTOL FIXED-WING DRONE**(71) Applicant: **Shanghai Autoflight Co., Ltd.**,  
Shanghai (CN)(72) Inventor: **Yu Tian**, Hong Kong SAR (CN)(21) Appl. No.: **17/819,628**(22) Filed: **Aug. 14, 2022****Related U.S. Application Data**

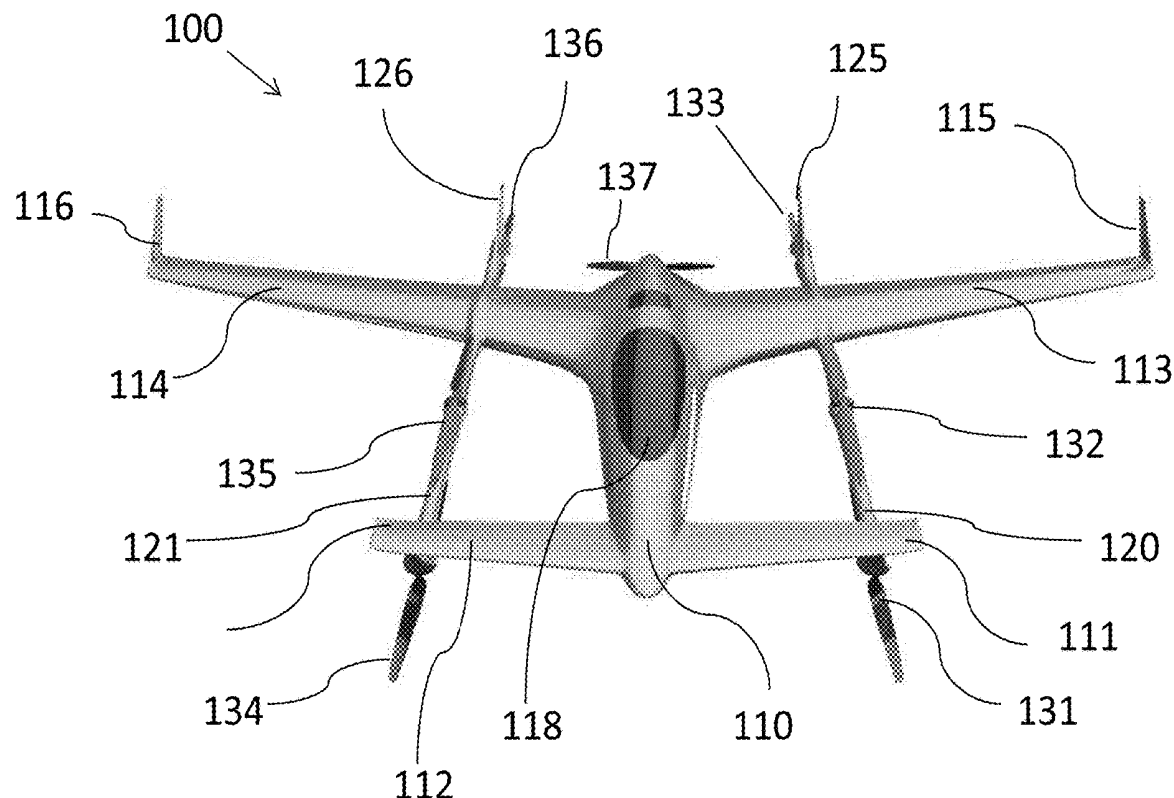
(62) Division of application No. 16/049,629, filed on Jul. 30, 2018, now Pat. No. 11,440,672, which is a division of application No. 15/643,452, filed on Jul. 6, 2017, now Pat. No. 10,081,436.

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**B64C 27/26** (2013.01); **B64C 2201/021**  
(2013.01); **B64C 2201/104** (2013.01); **B64C**  
**2201/165** (2013.01); **B64C 2201/024** (2013.01)

(57)

**ABSTRACT**

A long-distance drone having a main body, a left hind wing, a right hind wing, a left forewing, and a right forewing. There is a left linear support connecting the left forewing to the left hind wing, and a right linear support connecting the right forewing to the right hind wing. A plurality of propellers are disposed on the left and the right linear supports.



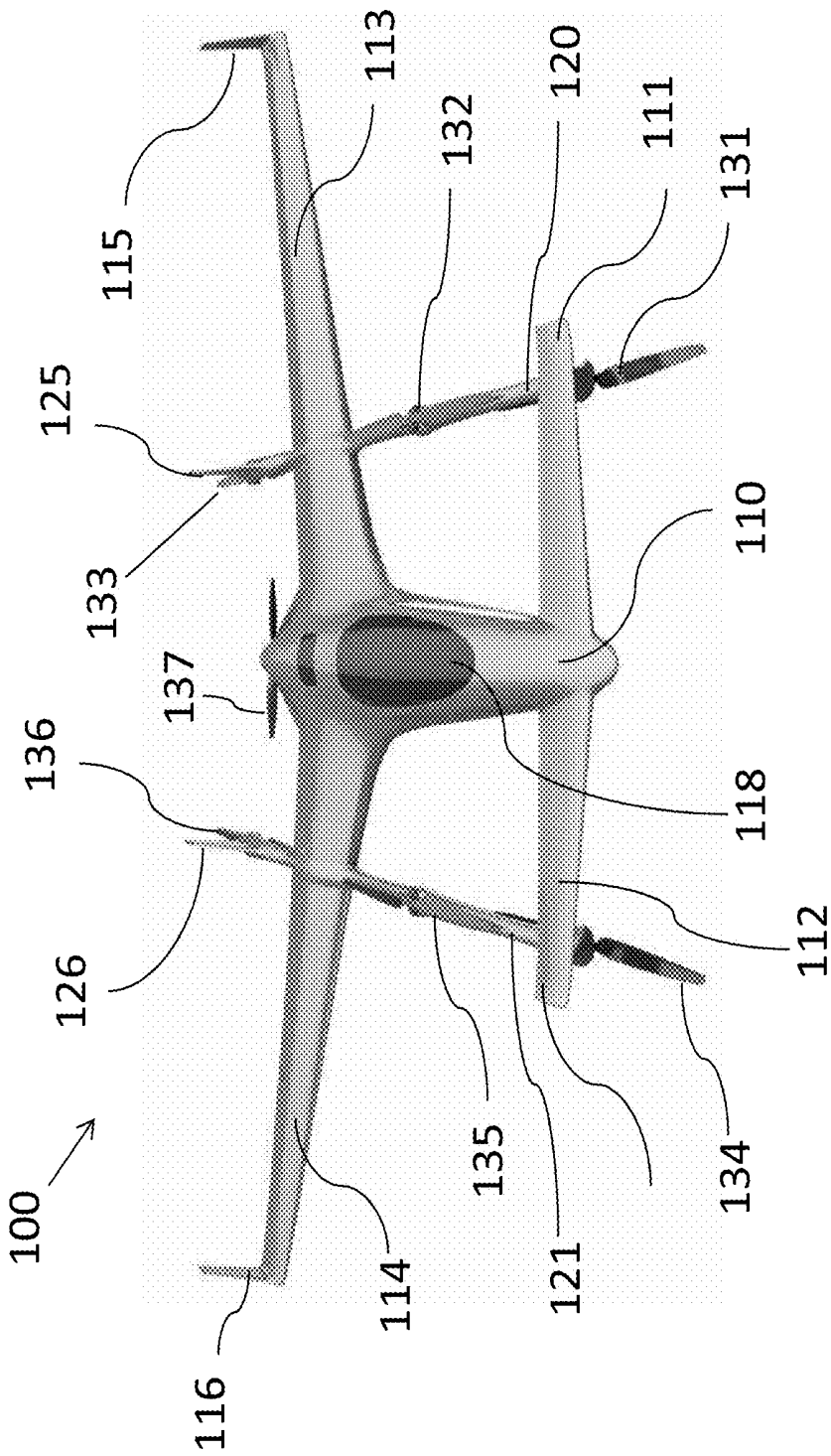


Fig. 1

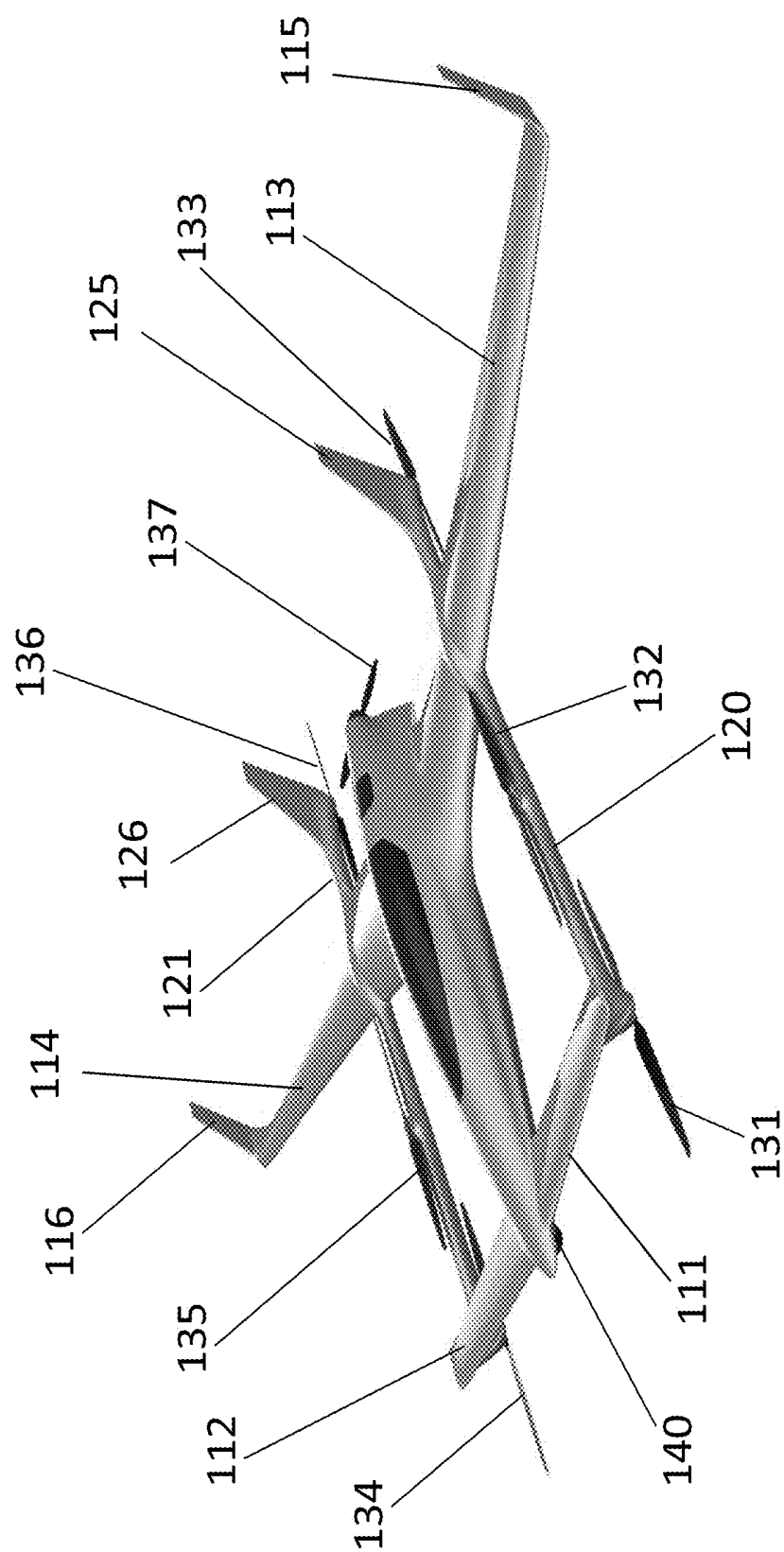


Fig. 2

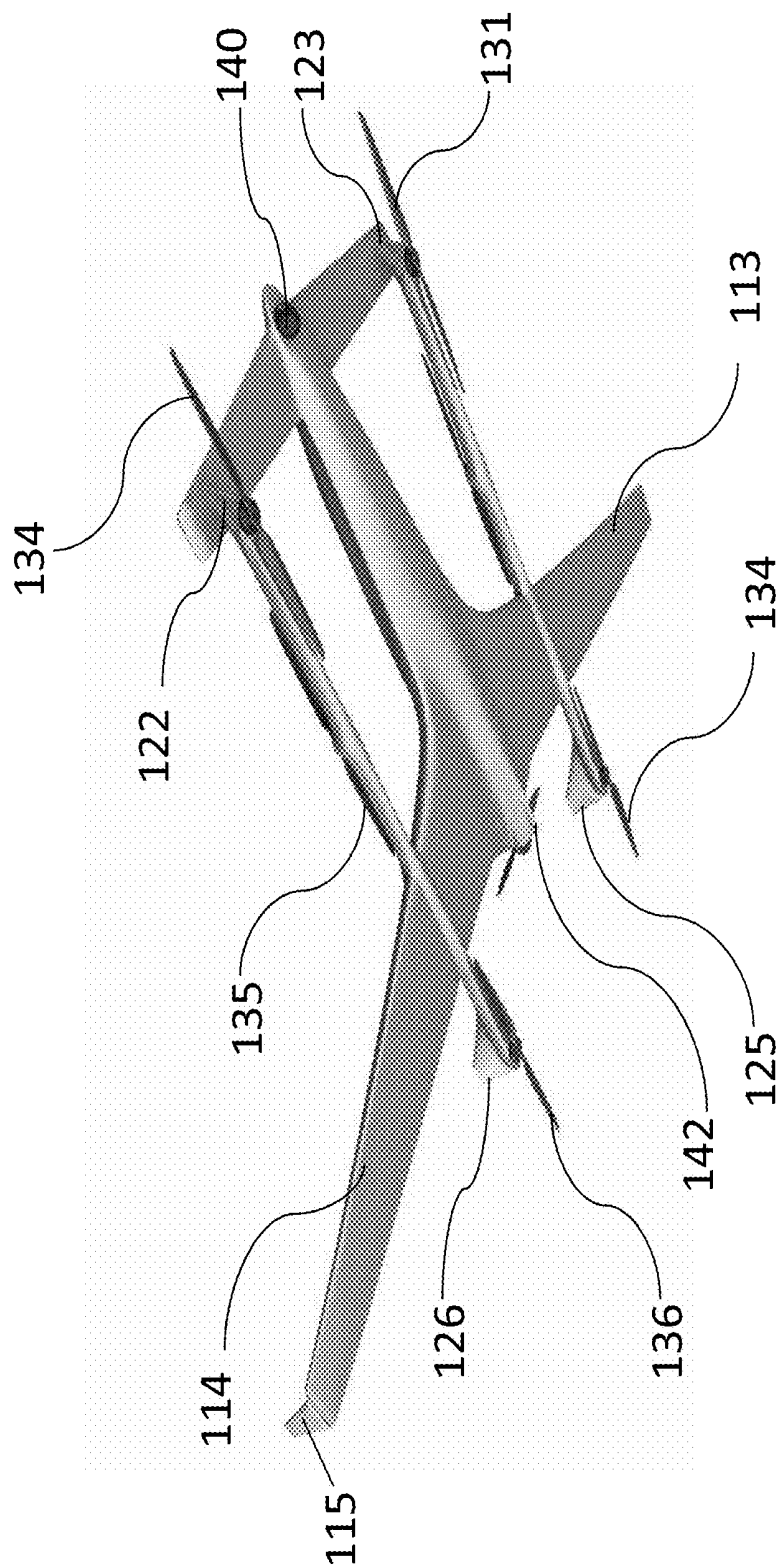


Fig. 3

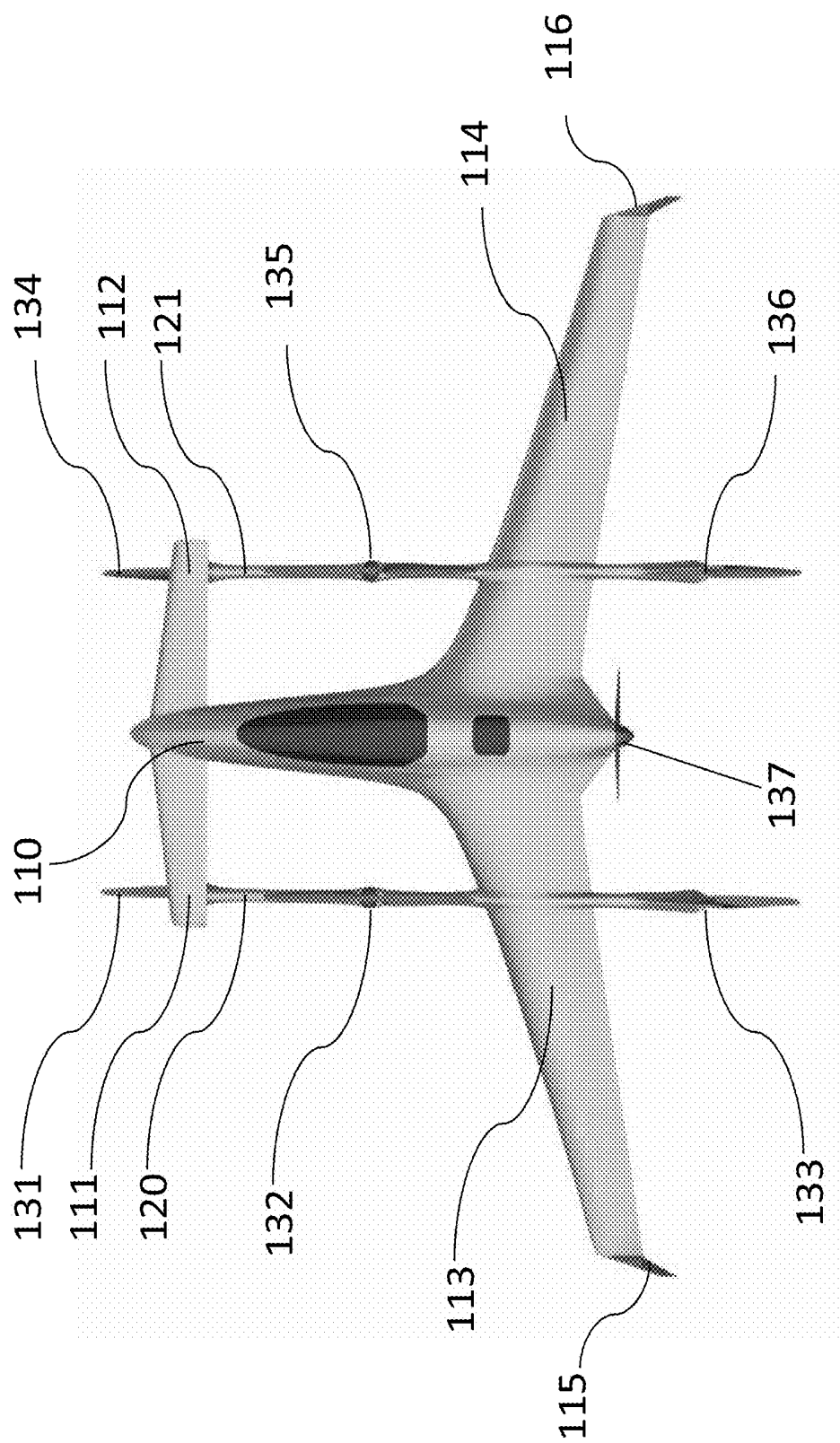


Fig. 4



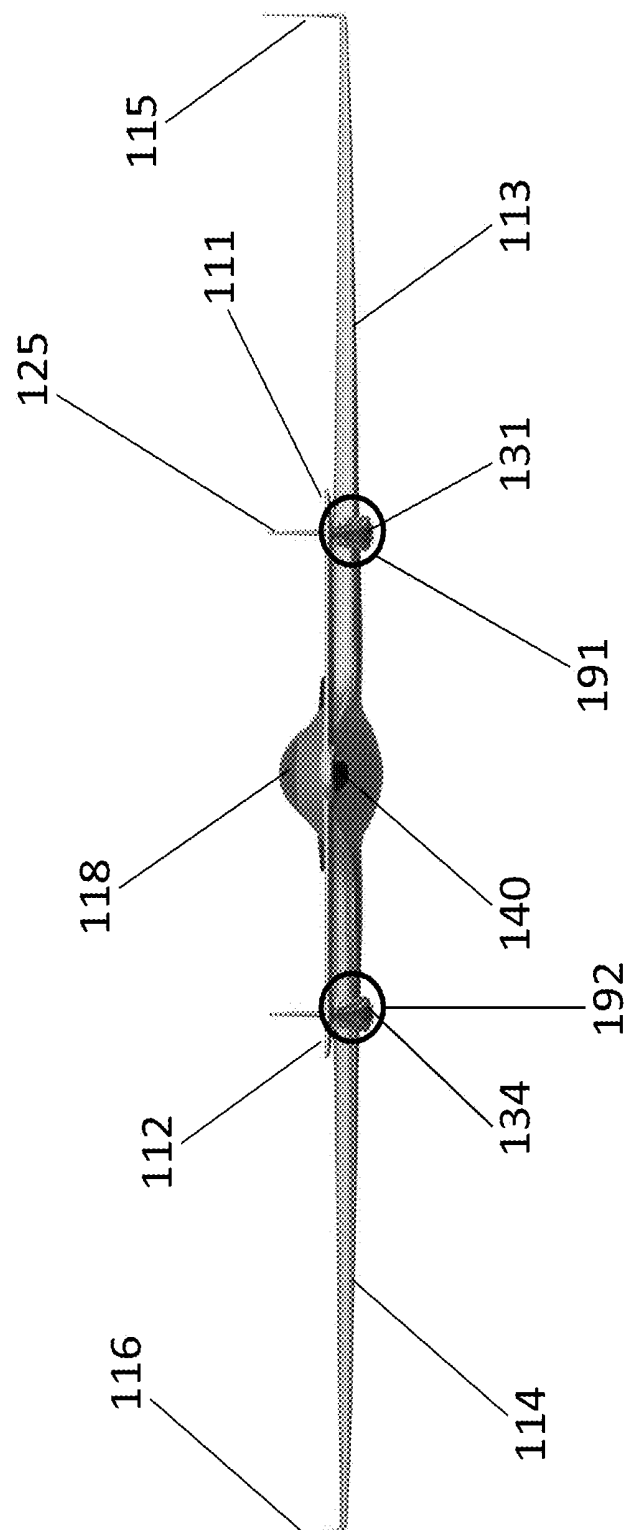


Fig. 6

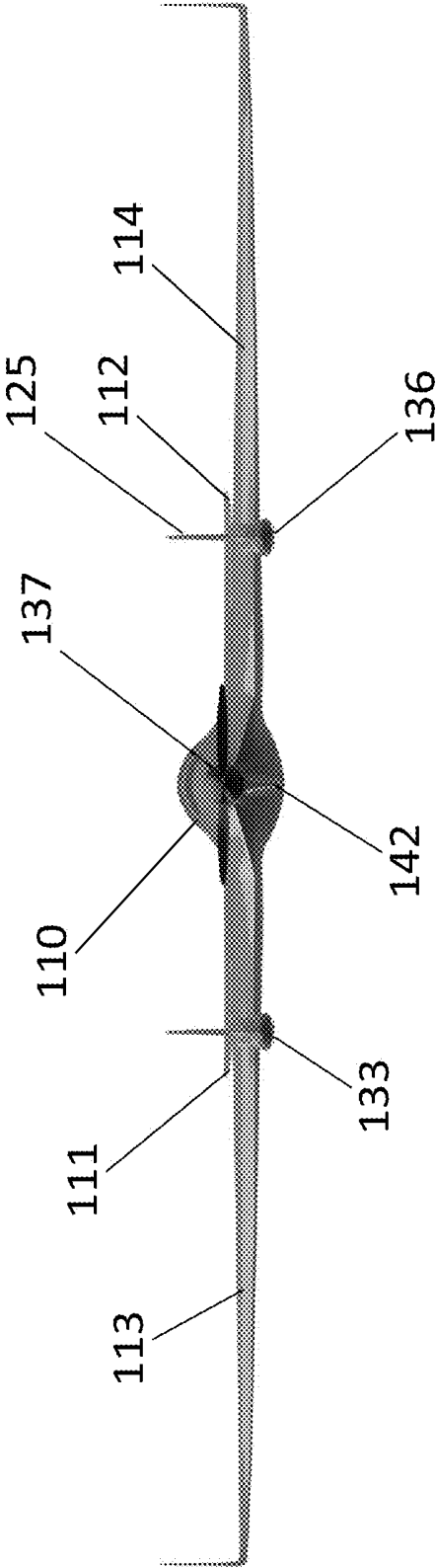


Fig. 7

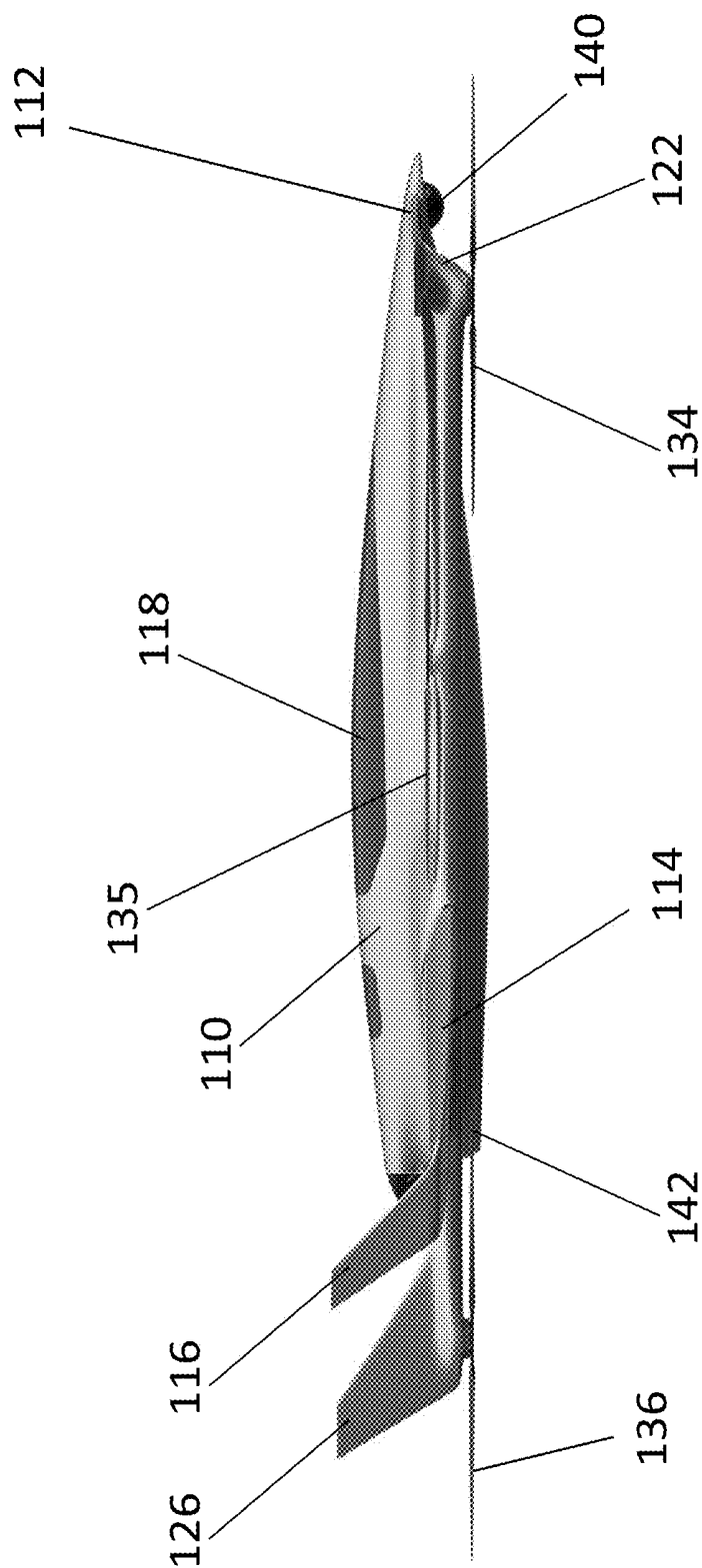


Fig. 8

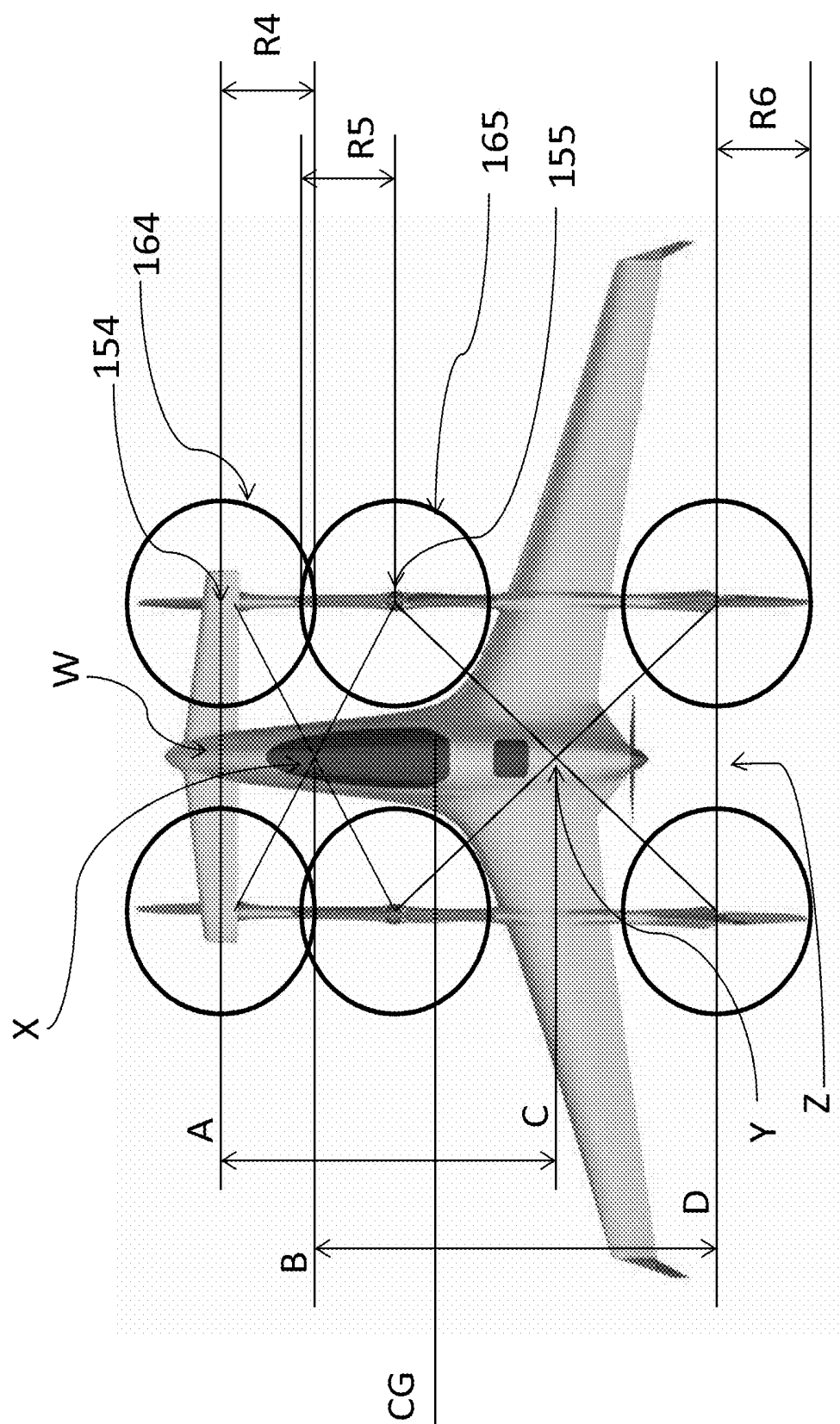


Fig. 9

**VTOL FIXED-WING DRONE****CROSS-REFERENCES**

[0001] This application claims priority to, and is a divisional application of, U.S. patent application Ser. No. 16/049,629, filed on Jul. 30, 2018, now allowed, which is a divisional application of U.S. patent application Ser. No. 15/643,452, filed on Jul. 6, 2017, now patented as U.S. patent Ser. No. 10/081,436, all of which are hereby incorporated by reference in their entireties.

[0002] Although incorporated by reference in its entirety, no arguments or disclaimers made in the parent application apply to this divisional application. Any disclaimer that may have occurred during the prosecution of the above-referenced application(s) is hereby expressly rescinded. Consequently, the Patent Office is asked to review the new set of claims in view of all of the prior art of record and any search that the Office deems appropriate.

**FIELD OF THE DISCLOSURE**

[0003] The present The field of the disclosure is aircrafts in general and hybrid VTOL fixed-wing drones specifically.

**BACKGROUND OF THE INVENTION**

[0004] Drones, whether manned or unmanned, have been proposed to conduct various missions and functions. Their missions and functions, however, are often limited by the traveling range and endurance of the drone. There is a continuing need for a drone that is sufficiently efficient to travel longer distances.

[0005] There is also a continuing need for new ways of creating redundancy in a drone so that when one propeller fails, the drone may still function and continue to stay in the air.

[0006] All referenced patents, applications and literatures are incorporated herein by reference in their entirety. Furthermore, where a definition or use of a term in a reference, which is incorporated by reference herein, is inconsistent or contrary to the definition of that term provided herein, the definition of that term provided herein applies and the definition of that term in the reference does not apply. The embodiment may seek to satisfy one or more of the above-mentioned desires. Although the present embodiment may obviate one or more of the above-mentioned desires, it should be understood that some aspects of the embodiment might not necessarily obviate them.

**SUMMARY OF THE INVENTION**

[0007] In one aspect of the disclosed long-distance drone, it can have a canard body style with a main body, a left main wing, a right main wing, a left forewing, and a right forewing. The left forewing can be attached to the main body forward of the left main wing, and the right forewing can be attached to the main body forward of the right main wing.

[0008] There can be a left linear support spaced apart from said main body connecting the left forewing to the left main wing.

[0009] There can also be a right linear support spaced apart from said main body connecting the right forewing to the right main wing.

[0010] In one aspect, there can be a first and a second propeller coupled to the left linear support. In another aspect, there can be a third and a fourth propeller coupled to the right linear support.

[0011] In further embodiments, there can be a fifth propeller coupled to the left linear support, and a sixth propeller coupled to the right linear support.

[0012] In yet another embodiment, the first propeller, the second propeller, and the third propeller can be linearly arranged to parallel the longitudinal axis of the main body, and the fourth propeller, the fifth propeller, and the sixth propeller can be linearly arranged to parallel the longitudinal axis of the main body.

[0013] The first propeller, the second propeller, and the third propeller can be directly disposed on the left linear support, and the fourth propeller, the fifth propeller, and the sixth propeller can be directly disposed on the right linear support.

[0014] Contemplated drone can optionally have a push propeller disposed at a back end of the main body.

[0015] In another embodiment, instead of a push propeller, there can be a seventh propeller coupled to the main body and the seventh propeller has a plane of motion that is perpendicular to a plane of motion of the first propeller.

[0016] Contemplated drone can further include a left vertical stabilizer disposed on a back end of the left linear support, and a right vertical stabilizer disposed on a back end of the right linear support.

[0017] In some embodiments, the first propeller and the third propeller can be disposed on a bottom side of the left linear support, while the second propeller can be disposed on a top side of the left linear support.

[0018] Likewise, the fourth propeller and the sixth propeller can be disposed on a bottom side of the right linear support, while the fifth propeller can be disposed on a top side of the right linear support.

[0019] In other embodiments, the first propeller and the second propeller are disposed on opposing sides of the left linear support, and the fourth propeller and the sixth propeller are disposed on opposing sides of the right linear support.

[0020] Further contemplated is for the first propeller to have a first range of motion with a first radius, and for the second propeller to have a second range of motion with a second radius. In some embodiments, the distance between the center of the first range of motion and the center of the second range of motion can be less than twice the first radius.

[0021] In yet other embodiments, wherein from a top view, a range of motion of the first propeller visually overlaps with a range of motion of the second propeller.

[0022] In yet another embodiment, the first radius can be substantially the same as the second radius.

[0023] Other embodiments of the disclosure include a fixed-wing drone having a left main wing and a right main wing; a left linear alignment of propellers having a first propeller, a second propeller, and a third propeller; a right linear alignment of propellers having a fourth propeller, a fifth propeller, and a sixth propeller. In some embodiments, the left linear alignment is parallel to the right linear alignment.

[0024] Contemplated first propeller, second propeller, and the third propeller can be directly disposed linearly in a

straight line on the left linear support, and the straight line can be parallel to a longitudinal axis of the main body.

**[0025]** There is also contemplated a method of improving stability, and/or durability, and or redundancy in a hybrid fixed-wing VTOL drone. In one embodiment, the method can include connecting a left main wing to a left canard forewing with a left linear support. Also, the method can include connecting a right main wing to a right canard forewing with a right linear support.

**[0026]** In some embodiments, the left and right linear supports can counteract against a twisting force applied to the main body of the drone during flight.

**[0027]** Contemplated method can include a step of arranging a spatial relationship between a center of gravity of the drone and said at least three propellers disposed on each of the left and right linear support, such that when any one of said propellers malfunctions, the drone may remain functioning by simply shutting down one other said propellers.

**[0028]** Various objects, features, aspects and advantages of the present embodiment will become more apparent from the following detailed description of embodiments of the embodiment, along with the accompanying drawings in which like numerals represent like components.

#### BRIEF DESCRIPTION OF DRAWINGS

**[0029]** It should be noted that the drawing figures may be in simplified form and might not be to precise scale. In reference to the disclosure herein, for purposes of convenience and clarity only, directional terms such as top, bottom, left, right, up, down, over, above, below, beneath, rear, front, distal, and proximal are used with respect to the accompanying drawings. Such directional terms should not be construed to limit the scope of the embodiment in any manner.

**[0030]** FIG. 1 is a top front perspective view of an embodiment of the contemplated drone utilizing a canard design having two parallel linear supports to connect the forewings with the main wings.

**[0031]** FIG. 2 is a top perspective view of an embodiment of the contemplated drone.

**[0032]** FIG. 3 is a bottom perspective view of an embodiment of the contemplated drone.

**[0033]** FIG. 4 is a top view of one embodiment of the contemplated drone.

**[0034]** FIG. 5 is a bottom view of one embodiment of the contemplated drone.

**[0035]** FIG. 6 is a direct frontal view of one embodiment of the contemplated drone.

**[0036]** FIG. 7 is direct rear view of one embodiment of the contemplated drone.

**[0037]** FIG. 8 is a right side view of one embodiment of the contemplated drone.

**[0038]** FIG. 9 is a top view of another aspect of the contemplated drone, illustrating spatial relationships of the propellers to each other, and explains the center of gravity of the drone.

#### DETAILED DESCRIPTION

**[0039]** The drone and its various aspects can now be better understood by turning to the following detailed description of the embodiments, which are presented as illustrated examples of the embodiment defined in the claims. It is

expressly understood that the embodiment as defined by the claims may be broader than the illustrated embodiments described below.

**[0040]** Many alterations and modifications may be made by those having ordinary skill in the art without departing from the spirit and scope of the embodiment. Therefore, it must be understood that the illustrated embodiment has been set forth only for the purposes of example and that it should not be taken as limiting the embodiment as defined by the following claims. For example, notwithstanding the fact that the elements of a claim are set forth below in a certain combination, it must be expressly understood that the embodiment includes other combinations of fewer, more or different elements, which are disclosed herein even when not initially claimed in such combinations.

**[0041]** The words used in this specification to describe the embodiment and its various embodiments are to be understood not only in the sense of their commonly defined meanings, but to include by special definition in this specification structure, material or acts beyond the scope of the commonly defined meanings. Thus if an element can be understood in the context of this specification as including more than one meaning, then its use in a claim must be understood as being generic to all possible meanings supported by the specification and by the word itself.

**[0042]** The definitions of the words or elements of the following claims therefore include not only the combination of elements which are literally set forth, but all equivalent structure, material or acts for performing substantially the same function in substantially the same way to obtain substantially the same result. In this sense it is therefore contemplated that an equivalent substitution of two or more elements may be made for any one of the elements in the claims below or that a single element may be substituted for two or more elements in a claim. Although elements may be described above as acting in certain combinations and even initially claimed as such, it is to be expressly understood that one or more elements from a claimed combination can in some cases be excised from the combination and that the claimed combination may be directed to a subcombination or variation of a subcombination.

**[0043]** As used herein, the terms “failure” and “malfunction” in conjunction with a propeller

**[0044]** refer to a condition where the propeller cease to function properly as intended by its manufacturer due to reasons outside of its control. For example, a propeller may fail or malfunction when it is damaged by an outside force. Propellers in a drone are known to be damaged when it collides with a bird, a tree, or a building. A propeller may also fail or malfunction when its mechanical or electrical a material component experience a break down. Also, a propeller may fail or malfunction when its power supply or fuel supply ceases to supply energy to the propeller when such supply of energy is expected.

**[0045]** As used herein, the term “center of gravity” in conjunction with the drone refers to a center of gravity in consideration of the total weight of the drone including all of its components, fuel (if any), and its payload. For example, if the drone is contemplate to carry cargo or human, the weight of the cargo and/or human would be part of the calculation in designing where the center of gravity should be.

**[0046]** As used herein, the term “range of motion” in conjunction with the propeller refers to a circular area

having a radius equal to the length of the propeller's blade. Since the blade of the propeller is designed to rotate either in a clockwise or counter-clockwise along a plane, the range of motion can also be described as a circular area along a plane.

**[0047]** As used herein, the term “overlap” in conjunction with the range of motions of propellers refers to a visual appearance that two circular areas have certain portions touching each other, but does not mean physical touching. That is, when two ranges of motions “overlap,” they do not mean physically overlapping each other. When two ranges of motions “overlap,” they merely appear to be in each other's space when looking from a particular angle. This overlaps may or may not necessarily create interference in fluid dynamics and aerodynamics of the two adjacent propellers.

**[0048]** As used herein, the term “hybrid” in conjunction with fixed-wing VTOL drone design refers to the classification of aircraft type, and does not refer to its power train. In the disclosure here, the term “hybrid” refers to the fact that the contemplated drone is a fixed-wing aircraft and at the same time has propellers so that the drone can vertically take-off and land (VTOL). In terms of power train, the contemplated embodiments can use entirely electric power train, a fuel-powered power train, a combination of both, or any other known or yet to be known power train technology.

**[0049]** As used herein, the term “drone” refers to any manned or unmanned aircraft, of various sizes. For example, contemplated drones as disclosed herein can have a wingspan of less than 0.5 meter, and can have a cabin space sufficiently large to seat passenger(s). The term “drone” as used herein can or cannot be limited to unmanned aerial vehicles (UAV).

**[0050]** As used herein, the term “vertical” in conjunction with a stabilizer refers to any angle. In one embodiment, it is at a 90 degree angle, perpendicular to the horizontal plane of the main wings. In other embodiments, it can be at a tilted angle.

**[0051]** The inventor has discovered a novel hybrid VTOL fixed-wing drone design that can drastically improve at least one of the following characteristics in a drone: efficiency, durability, travel distance, and redundancy.

**[0052]** Referring now to FIG. 1, FIG. 1 generally depicts the basic structure of a hybrid VTOL Fixed-wing drone 100 in accordance with one aspect of the disclosure.

**[0053]** Drone 100 is contemplated to have a main body 110, two forewings 111, 112 attached to the front end of the main body 110. There are two main wings 113, 114 attached to the main body towards the rear of the main body 110. This is a typical canard design where two smaller forewings are placed forward to two larger main wings.

**[0054]** Main body 110 can have an aerodynamic design and may optionally have a cabin sufficiently large to seat human passenger(s) or cargo. In the exemplar drone 100 as shown in the drawing figures, what appears to be a windshield 118 may or may not be an actual functional windshield 118, depending on whether the particular embodiment has a passenger cabin.

**[0055]** There can be two main wings 113 and 114 attached to the rear portion of the main body 110. In some embodiments, terminal ends of each of the main wings 113 and 114 may have a vertical stabilizer 115, 116.

**[0056]** Forewings 111 and 112 can be attached to the front end of the main body 110. Forewings 111, 112 are shorter than the main wings 113, 114.

**[0057]** There can be a left and a right linear supports 120, 121, each of which physically connects a forewing 111, 112 to the main wings 113, 114. In one aspect of the contemplated embodiment, the linear supports 120, 121 are fixed near the terminal ends of each perspective forewings 111, 112. In one embodiment, the linear supports 120, 121 can be fixedly attached a location on the forewings 111, 112 that is distal to the middle point between the tip of the forewings 111, 112 and the main body 110. In yet another embodiment, the linear supports 120, 121 can be fixedly attached to anywhere along the length of the forewings 111, 112. Although the exemplar linear supports 120, 121 shown in FIG. 1 are attached to the undersides of the forewings 111, 112, other embodiments may have the linear supports 120, 121 attached to the upper side of the forewings 111, 112.

**[0058]** The contemplated linear supports 120, 121 can be made of suitable materials to withstand the physical demands of flying, and can resist contortion. Such materials include natural and synthetic polymers, various metals and metal alloys, naturally occurring materials, textile fibers, glass and ceramic materials, and all reasonable combinations thereof.

**[0059]** The straight linear supports 120, 121 can provide structural integrity to the drone 100 by minimizing a contortion force applied to the main body 110 by the up and down movement of the main wings 113, 114 and the forewings 111, 112 during flight.

**[0060]** The linear supports 120, 121 can have a straight body and can be parallel to the longitudinal axis of the main body 110. As shown in the frontal view of FIG. 6, the straight body configuration allows minimum aerodynamic obstruction during flight. The linear supports 120, 121 can have a thickness that is no thicker than the thickest part of the main wings 113, 114. The linear supports 120, 121 can have a cross-sectional shape that is circular, oval, square, rectangular, or any other suitable shape.

**[0061]** In other contemplated embodiments (not shown), the linear supports 120, 121 can have a curvature or other angles besides being straight.

**[0062]** The left and right linear supports 120, 121 can have a suitable length to connect forewings 111, 112 to the main wings 113, 114. In the embodiment as shown in FIG. 3, the left and right linear supports 120, 121 are attached to the underside of the forewings 111, 112.

**[0063]** In the exemplar drone 100 shown in the drawing figures, the left and the right linear supports 120, 121 each can have a vertical stabilizer 125, 126 disposed on the top of its rear terminal end. In one embodiment, the vertical stabilizers 125, 126 are at a 90 degree angle, perpendicular to the horizontal plane of the main wings. In other embodiments, these vertical stabilizers 125, 126 can be at a tilted angle.

**[0064]** It should be understood that the above-described angles are exemplary and any other angles can be adopted in various embodiments of this disclosure.

**[0065]** Referring now to FIG. 3, there can optionally be rotors and propellers disposed on each of the linear supports 120 and 121 to provide vertical take-off and landing capabilities to the drone 100. Various numbers of propellers are contemplated. In the embodiments shown in the figures, each linear support 120, 121 has three propellers. Left linear

support 120 can have a propeller 131 disposed at the front terminal end of the linear support 120, on the underside of the left forewing 111, facing downwards. Left linear support 120 can have another propeller 132 disposed on top of the linear support 120 at a location in between the forewing 111 and the main wing 113, facing upwards. Left linear support 120 can have yet another propeller 133 disposed at the bottom of the linear support 120 near a rear terminal end, facing downwards.

[0066] Similarly on the right side of the drone 100, right linear support 121 can have a propeller 134 disposed at the front terminal end of the right linear support 121, on the underside of the right forewing 112, facing downwards. Right linear support 121 can have another propeller 135 disposed on top of the right linear support 121 at a location in between the forewing 112 and the main wing 114, facing upwards. Right linear support 121 can have yet another propeller 136 disposed at the bottom of the right linear support 121 near a rear terminal end, facing downwards.

[0067] Each of the propellers 131, 132, 133, 134, 135, 136 shown in the drawing figures has two blades. In some embodiments, propellers 131, 132, 133, 134, 135, 136 can lock into a longitudinal position (as shown in FIGS. 1-4) during high speed flying when these propellers 131, 132, 133, 134, 135, 136 are not necessary to keep the drone 100 in air. By locking these propellers into a longitudinal position parallel to the direction of the flight, aerodynamic is improved, as opposed to not locking them or keeping them spinning.

[0068] As those of ordinary skill in the art will recognize, the propellers 131, 132, 133, 134, 135, 136 may readily be modified as dictated by the aesthetic or functional needs of particular applications. For example, each of all or some of the propellers 131, 132, 133, 134, 135, 136 can have 2-blades, 3-blades, 4-blades, or any other known types of blades.

[0069] As to the rotors that drive the propellers 131, 132, 133, 134, 135, 136, to maintain an aerodynamic profile, rotors should have as low a profile as possible. It is important to appreciate that although the present embodiment is particularly well suited for use by implementing a low-profile rotor, it should be understood that other types of rotor or combinations of different types of rotors can be used to perform that same function as the low-profile rotors.

[0070] As shown in FIG. 6, the contemplated rotors can be disposed within the linear supports 120, 121 and do not bulge out or extend beyond the aerodynamic contour of the linear supports 120, 121. Even the propellers 131, 132, 133, 134, 135, 136 can have a low-profile and can be disposed closely to the linear supports 120, 121 so that when the propellers 131, 132, 133, 134, 135, 136 are locked in a longitudinal position (as shown in FIG. 6) during high speed flying, an improved aerodynamic profile is present.

[0071] In one embodiment, the lowest portion of the propellers 131, 132, 133, 134, 135, 136 do not extend beyond the lowest part of the main body 110. In another embodiment, the highest portion of the propellers 131, 132, 133, 134, 135, 136 do not extend beyond the highest part of the main body 110. As shown in FIG. 6, from a frontal view, the distance between the highest points of the propellers 131, 132, 133, 134, 135, 136 to the lowest point of the propellers 131, 132, 133, 134, 135, 136 is substantially equal to the thickest part of the main wings 113, 114.

[0072] In yet another contemplated embodiment, a novel feature includes arranging multiple rotors/propellers in only two parallel columns such that from a frontal view, these multiple rotor/propellers create only two points 191, 192 of air disturbance (see FIG. 6). This is important because this design drastically improve the aerodynamic profile of a multicopter drone, or a VTOL drone.

[0073] FIG. 8 illustrates one embodiment of how the six propellers 131, 132, 133, 134, 135, 136 can be arranged. In this embodiment, the six propellers 131, 132, 133, 134, 135, 136 are arranged in two columns parallel to each other. Each column can be parallel to the longitudinal axis of the main body 110. Known multi-copter drones arrange their propellers in an evenly spaced array to encircle around the center of gravity, because evenly spaced array in a circle provides the best stability and redundancy. When one propeller in such prior art multi-copter drone fails, the prior art multi-copter simply turns off another propeller on the opposite end of the circular array so the rest of the working propellers are balanced to keep the drone in the air. In the embodiment shown in FIGS. 1-5, the six propellers 131, 132, 133, 134, 135, 136 are not evenly spaced apart from an adjacent propeller. By having the six propellers 131, 132, 133, 134, 135, 136 arranged in two parallel columns, drag is minimized because the frontal profiles of all six propellers 131, 132, 133, 134, 135, 136 would only equal to the frontal profile of about two such propellers (see FIGS. 6 and 7).

[0074] It should be particularly appreciated that although the drawing figures only show six propellers 131, 132, 133, 134, 135, 136, any even numbers of propellers can be arranged in two parallel columns. In one embodiment, the drone 100 can have two parallel columns of propellers, each column having two propellers. In another embodiment, the drone 100 can have two parallel columns of propellers, each column having four propellers. In yet another embodiment, the drone 100 can have two parallel columns of propellers, each column having five propellers.

[0075] This plurality of propellers 131, 132, 133, 134, 135, 136 may be disposed on various locations along the length of the linear supports 120, 121.

[0076] In one embodiment as shown in FIGS. 4 and 5, linear supports 120, 121 each has a rear terminal end that extends rearward beyond the rear edge of the main wings 113, 114. By extending its rear terminal end beyond the rear edge of the main wings 113, 114, the linear supports 120, 121 in the exemplar embodiment can have propellers 133, 136 disposed on the their terminal end without having the main wings 113, 114 in the way of airflow during vertical takeoff and landing. As shown in FIG. 9, the two circles surrounding propellers 133, 136 represent the range of motion for their respective blades. Both circles do not overlap with the main wings 113, 114.

[0077] In the embodiments shown in the drawing figures, contemplated linear supports 120, 121 do not extend forward beyond the frontal edge of the forewings 111, 112. The embodiment shown in FIG. 3 has both linear supports 120, 121 terminate right underneath the forewings 111, 112. The terminal ends of the linear supports 120, 121 can each form a vertical ledge 122, 123.

[0078] In another embodiment (not shown), contemplated linear supports 120, 121 may each extend beyond the frontal edge of the forewings 111, 112. In that way, the two

front-most propellers **131**, **134** can operate without being interfered by the forewings **111**, **112** being in the way of airflow.

[0079] In the embodiment shown in FIG. 9, high efficiency can be achieved by keeping the main body **110** and the linear supports **120**, **121** reasonably short, thereby keeping the total weight of the drone relatively low. Instead of using smaller propellers **131**, **132**, **134**, **135** in the first two rows of propeller arrangement so these two rows of propellers do not interfere with each other by overlapping their range of motion, this embodiment can have the first rows' range of motion **164** overlap the second row's range of motion **165**. In the embodiment of FIG. 9, each propeller in the first row can have a radius **R4**. Each propeller in the second row can have a radius **R5**. Each propeller in the last row can have a radius **R6**.

[0080] Although the propellers with different length of blades (thereby a different range of motion radius) can be utilized, the embodiment in FIG. 9 has all six propellers **131**, **132**, **133**, **134**, **135**, **136** having the same radius. In this embodiment, the distance between the center rotating axle **154** of propeller **134** to the center rotating axle **155** of propeller **135** is less than twice the radius **R4**.

[0081] From a top view, the ranges of motions **164**, **165** appear to overlap each other partially. Their respective propeller blade, however, do not physically make contact with each other because these two propellers **134**, **135** are disposed on opposite sides of the same linear support **121**. All six propellers **131**, **132**, **133**, **134**, **135**, **136** blow air in a downward fashion.

[0082] In one aspect of the disclosure, the contemplated drone **100** can have a push propeller **137** disposed on the rear end of the main body **110**. The push propeller **137** has a spinning axle that is perpendicular to the spinning axles of propellers **131**, **132**, **133**, **134**, **135**, **136**. During high speed flight, the push propellers **137** is instrumental moving the drone **100**, whereas all six propellers **131**, **132**, **133**, **134**, **135**, **136** are locked and not rotating as described above.

[0083] Drone **100** can be equipped with other accessories, such as a camera **140** to conduct aerial surveillance and other data collection. Camera **140** can be disposed at any other position on the drone **100**.

[0084] Contemplated drone **100** can optionally have one or more air diffusers disposed on the underside of the drone. As shown in FIG. 3, one air diffuser **142** can be disposed on the rear bottom end of the main body **110**. The diffuser **142** can be a shaped section of the main body's underbody. In other embodiments, the air diffuser **142** may act as a deturbulator.

[0085] One aspect of the instant disclosure includes a contemplated method to arrange a spatial relationship between a center of gravity of a drone and at least three propellers disposed on each of the left and right side of the drone, whether or not these propellers are disposed on the linear supports. In some embodiments, these propellers are arranged in pairs, each pair being equal-distant to each other forming two parallel arrays. The intended objective is to keep the drone **100** reasonably light weight, to keep the drone aerodynamically enhanced, to have sufficient power to vertically takeoff without resorting to the biggest and strongest rotors, and to have a build-in redundancy such that when any one of the six or more propellers malfunctions, the drone may remain functioning by simply shutting down one other said propellers.

[0086] For example, when propeller **131** fails, the drone can turn off propeller **136** to still keep the drone balanced; when propeller **132** fails, the drone can turn off propeller **135** to still keep the drone balanced; when propeller **133** fails, the drone can turn off propeller **134** to still keep the drone balanced; and vise versa.

[0087] As illustrated in FIG. 6, the spatial arrangement of the propellers **131**, **132**, **133**, **134**, **135**, **136** between each other and to the center of gravity of the drone can be done by the following method. In one example, consider that each of the six propellers **131**, **132**, **133**, **134**, **135**, **136** have the same output of 1 kg. Propellers **131** and **134** would have a center of lift force (2 kg) at point W (line A), which is a point equal-distant to the center of propeller **131** and propeller **134**. Propellers **131**, **132**, **134** and **135** would have a center of lift force (4 kg) at point X (line B), which is a point equal-distant to the center of propellers **131**, **132**, **134** and **135**. Propellers **132**, **133**, **135** and **136** would have a center of lift force (4 kg) at point Y (line C), which is a point equal-distant to the center of propellers **132**, **133**, **135** and **136**. Propellers **133** and **136** would have a center of lift force (2 kg) at point Z (line D), which is a point equal-distant to the center of propellers **133** and **136**. The contemplated center of gravity for the entire drone **100** can be line CG which is two third the distance from line A to line C, which is also one third the distance from line B to line D.

[0088] Another aspect of the instant disclosure is a method of making hybrid VTOL fixed-wing drones lighter while providing it with sufficient structure and powertrain needs to maintain long-distance flying and/or high speed flying. Longer main body would mean heavier body that causes the flight time to decrease unless larger powertrain and power source is provided, which in turn also cause the drone to be heavier and less aerodynamic.

[0089] In yet another aspect of the disclosure, a novel way of arranging multiple propellers in a hybrid VTOL fixed-wing drone includes that propellers to not stack on top of another propeller. In the illustrated embodiments, six propellers **131**, **132**, **133**, **134**, **135**, **136** are horizontally spaced part from each other, and there can be no stacking of propellers.

[0090] In one contemplated method, the first row of propellers are caused to overlap in their range of motion with the second row of propellers when looking from a top view. In another contemplated method, the first row of propellers **131**, **134** are disposed near or at the bottom side of the canard forewings **111**, **112**.

[0091] Contemplated fixed-wing drones having the disclosed features or designed by the disclosed methods can expect to have a continuous flight time of at least eight hours when using an electric powertrain, and 24-hours when using a hybrid (fuel-electric) powertrain.

[0092] The above disclosed embodiments can be made of all known suitable natural or synthetic materials or a mixture of materials. Additionally, it should be appreciated that the materials contemplated herein may be derivatized in numerous manners.

[0093] Although all of the above inventive features discussed are discussed in conjunction with a canard body style in an aircraft, all of the features discussed are also contemplated to be implemented on any other fixed-wing aircraft body styles. These features specifically includes, but are not limited to: arrangement of multiple rotors/propellers in only two parallel columns; arrangement of multiple rotors/pro-

pellers that occupy only two points of disturbance from a frontal view; having two parallel linear supports to physically connect wings in the front to wings in the back; overlapping propellers' ranges of motion to decrease the length of the main body of the aircraft; disposing adjacent propellers on opposite sides of the drone (e.g., one disposed on top, the other disposed on the bottom of the drone); utilizing low-profile rotors that are no thicker than the thickest part of a main wing; utilizing low-profile propeller blades that does not extend substantially beyond the highest part of the main wing; and utilizing low-profile propeller blades that does not extend substantially beyond the lowest part of the main wing.

**[0094]** Another way of describing this novel method of improving an aerodynamic profile of a drone is to entirely enclose low-profile rotors for each of the at least three propellers disposed on each linear support **120**, **121**. In this way, the linear array of these three propellers can have a combined frontal projection that substantially equals to a cross sectional area of each linear support **120**, **121**.

**[0095]** Additionally, although flaps, ailerons, rudders, and elevators are not specifically discussed in this disclosure, each of them can be used in any of the disclosed embodiments.

**[0096]** Thus, specific embodiments and applications of a hybrid VTOL Fixed-Wing Drone have been disclosed. It should be apparent, however, to those skilled in the art that many more modifications besides those already described are possible without departing from the disclosed concepts herein. The embodiment, therefore, is not to be restricted except in the spirit of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced. Insubstantial changes from the claimed subject matter as viewed by a person with ordinary skill in the art, now known or later devised, are expressly contemplated as being equivalent within the scope of the claims. Therefore, obvious substitutions now or later known to one with ordinary skill in the art are defined to be within the scope of the defined elements. The claims are thus to be understood to include what is specifically illustrated and described above, what is conceptually equivalent, what can be obviously substituted and also what essentially incorporates the essential idea of the embodiment. In addition, where the specification and claims refer to at least one of something selected from the group consisting of A, B, C . . . and N, the text should be interpreted as requiring only one element from the group, not A plus N, or B plus N, etc.

**1.** A VTOL (vertical takeoff and landing) fixed-wing drone, said VTOL drone comprising:

a left hind wing, a right hind wing, a left forewing, and a right forewing, all of which being attached to a fuselage of the VTOL drone;

no more than two linear supports to minimize drag, said two linear supports consist of a left linear support and a right linear support;

the left hind wing is connected to the left forewing by the left linear support to minimize a contortion force applied to the fuselage during flight;

the right hind wing is connected to the right forewing by the right linear support to minimize the contortion force applied to the fuselage during flight;

a first plurality of lifting propellers entirely disposed on an outside of the left linear support;

a second plurality of lifting propellers entirely disposed on an outside of the right linear support;

the first plurality and second plurality of lifting propellers can be locked in a fixed position during flight while the first plurality and second plurality of lifting propellers remain entirely disposed on the outside of the left and right linear supports, respectively;

wherein the left and right linear supports are spaced apart from the fuselage; and

wherein one of said first plurality of lifting propellers disposed entirely on the outside of the left linear support is disposed on a top side of the left linear support, and another one of said first plurality of lifting propellers disposed entirely on the outside of the left linear support is disposed on a bottom side of the left linear support.

**2.** The VTOL drone as recited in claim **1** wherein the first plurality of lifting propellers has at least three propellers disposed in a linear array and the second plurality of lifting propellers has at least three propellers disposed in a linear array.

**3.** The VTOL drone as recited in claim **2**, wherein the linear array on the left linear support parallels with the linear array on the right linear support.

**4.** The VTOL drone as recited in claim **3**, wherein the left and right forewings and the left and right hind wings have no movable flight control surfaces.

**5.** The VTOL drone as recited in claim **3**, wherein at least two of the first plurality of lifting propellers partially overlap in their range of movement from a top view.

**6.** The VTOL drone as recited in claim **3**, wherein the left hind wing and the right hind wing are the rear most horizontal wings in the drone.

**7.** The VTOL drone as recited in claim **3**, wherein the left forewing is shorter than the left hind wing.

**8.** The VTOL drone as recited in claim **3**, placing a center of gravity of the drone on a center longitudinal location of the fuselage, wherein the center of gravity is located at two third of a distance from

a point A which is defined as a center of lift force between a foremost lift propeller on the left linear support and a foremost propeller on the right linear support to

a point C which is defined as a center of lift force between a rearmost two lift propellers on the left linear support and a rearmost two lift propellers on the right linear support.

**9.** The VTOL drone as recited in claim **3**, wherein said center of gravity is located at one third of a distance from

a point B which is defined as a center of lift force between a foremost two lift propellers on the left linear support and a foremost two lift propellers on the right linear support

to  
 a point D which is defined as a center of lift force between  
 a rear most lift propeller on the left linear support and  
 a rearmost propeller on the right linear support.

**10.** A VTOL fixed-wing drone, said VTOL drone comprising:

a fuselage;  
 a left hind wing, a right hind wing, a left forewing, and a  
 right forewing, all of which being attached to the  
 fuselage;  
 no more than two linear supports, said two linear supports  
 consist of a left linear support and a right linear support;  
 the left hind wing is connected to the left forewing by the  
 left linear support to minimize a contortion force  
 applied to the fuselage during flight;  
 the right hind wing is connected to the right forewing by  
 the right linear support to minimize the contortion force  
 applied to the fuselage during flight;  
 at least three lifting propellers entirely disposed on the  
 outside of the left linear support;  
 at least three lifting propellers entirely disposed on the  
 outside of the right linear support;  
 wherein the at least three lifting propellers of the left  
 linear support and the at least three lifting propellers of  
 the right linear support can be locked in a fixed position  
 during flight while the at least three lifting propellers of  
 the left linear support and the at least three lifting  
 propellers of the right linear support remain entirely  
 disposed on the outside of the left and right linear  
 supports, respectively;  
 wherein the left and right linear supports are spaced apart  
 from the fuselage and are parallel to each other;  
 a center of gravity of the drone is located on a center  
 longitudinal location of the fuselage; and  
 wherein one of the at least three lifting propellers dis-  
 posed entirely on the outside of the left linear support

is disposed on a top side of the left linear support, and  
 another one of the at least three lifting propellers  
 disposed entirely on the outside of the left linear  
 support is disposed on a bottom side of the left linear  
 support.

**11.** The VTOL drone as recited in claim **10**, wherein said  
 center of gravity is located at one third of a distance from  
 a point B which is defined as a center of lift force between  
 a foremost two lift propellers on the left linear support  
 and a foremost two lift propellers on the right linear  
 support  
 to

a point D which is defined as a center of lift force between  
 a rear most lift propeller on the left linear support and  
 a rearmost propeller on the right linear support.

**12.** The VTOL drone as recited in claim **11**, wherein the  
 left and right forewings and the left and right hind wings  
 have no movable flight control surfaces.

**13.** The VTOL drone as recited in claim **12** further  
 comprising providing a push propeller on the drone to  
 provide a force of propulsion.

**14.** The VTOL drone as recited in claim **12**, wherein the  
 foremost two lift propellers disposed on the left linear  
 support partially overlap in their ranges of movement from  
 a top view.

**15.** The VTOL drone as recited in claim **10**, wherein the  
 center of gravity is located at two third of a distance from  
 a point A which is defined as a center of lift force between  
 a foremost lift propeller on the left linear support and  
 a foremost propeller on the right linear support  
 to  
 a point C which is defined as a center of lift force between  
 a rearmost two lift propellers on the left linear support  
 and a rearmost two lift propellers on the right linear  
 support.

\* \* \* \* \*



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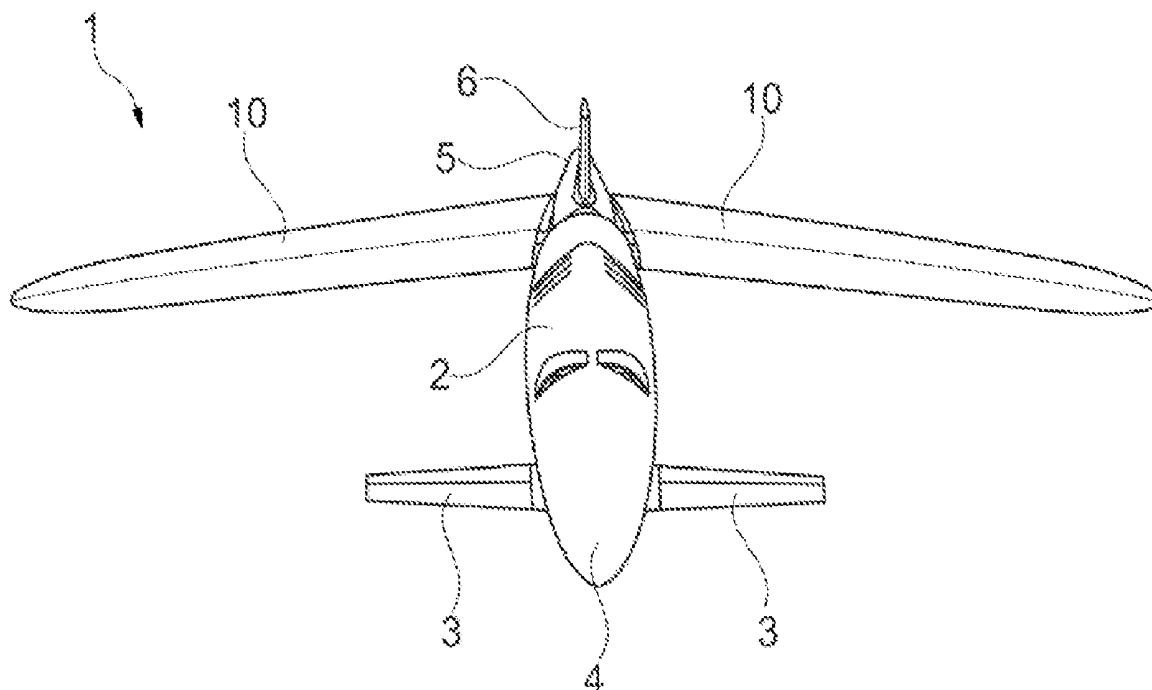
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(2013.01); **B64C 2201/08** (2013.01); **B64C**  
**2201/162** (2013.01)(57) **ABSTRACT**

A drone including a front section, a wing structure supported by a rotor located behind the front section, and a propeller at the rear. The wing structure including two wings rotating the rotor, the wing structure being able to move between a flight configuration, in which the rotor is immobile relative to the front section and the propulsion provided by the propeller, and a flight configuration with the wing structure rotating, in which the rotor is rotated relative to the front section, the rotor being connected to the front section with a possibility of orienting its axis of rotation relative thereto in order able to direct the drone in the rotary wing structure configuration by acting on said orientation.



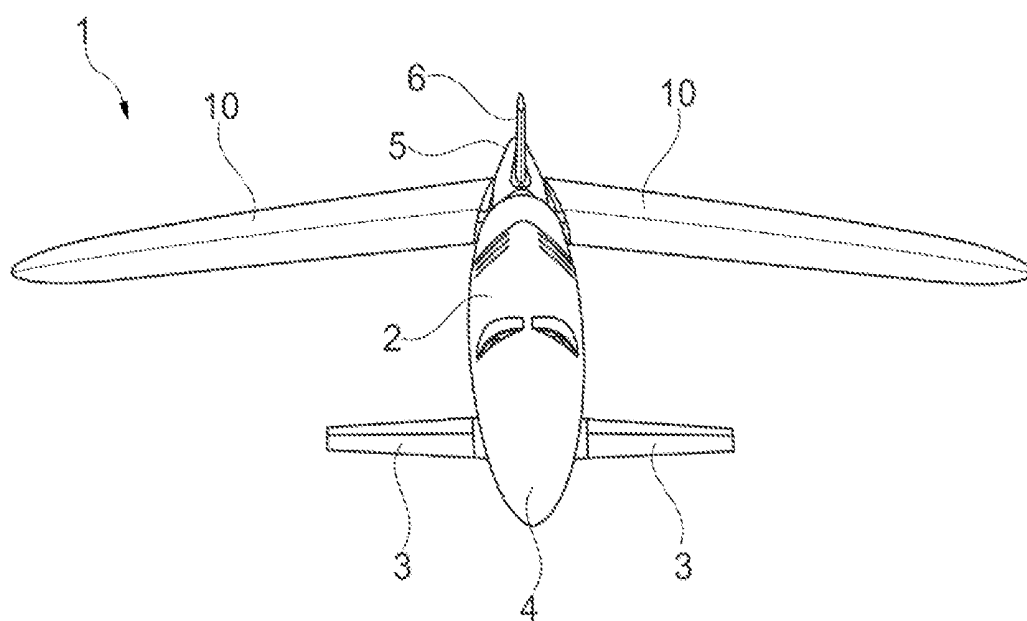


Fig. 1

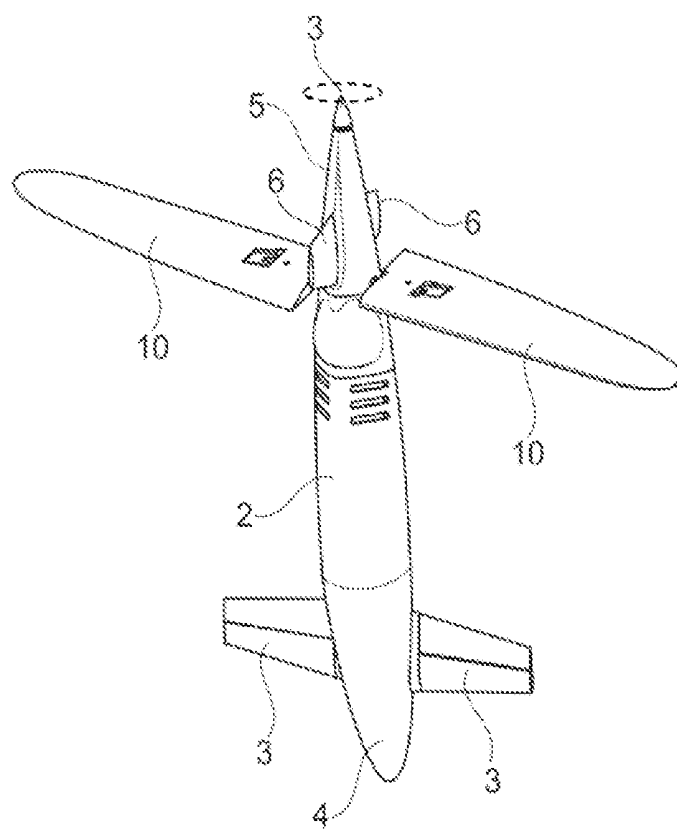


Fig. 2

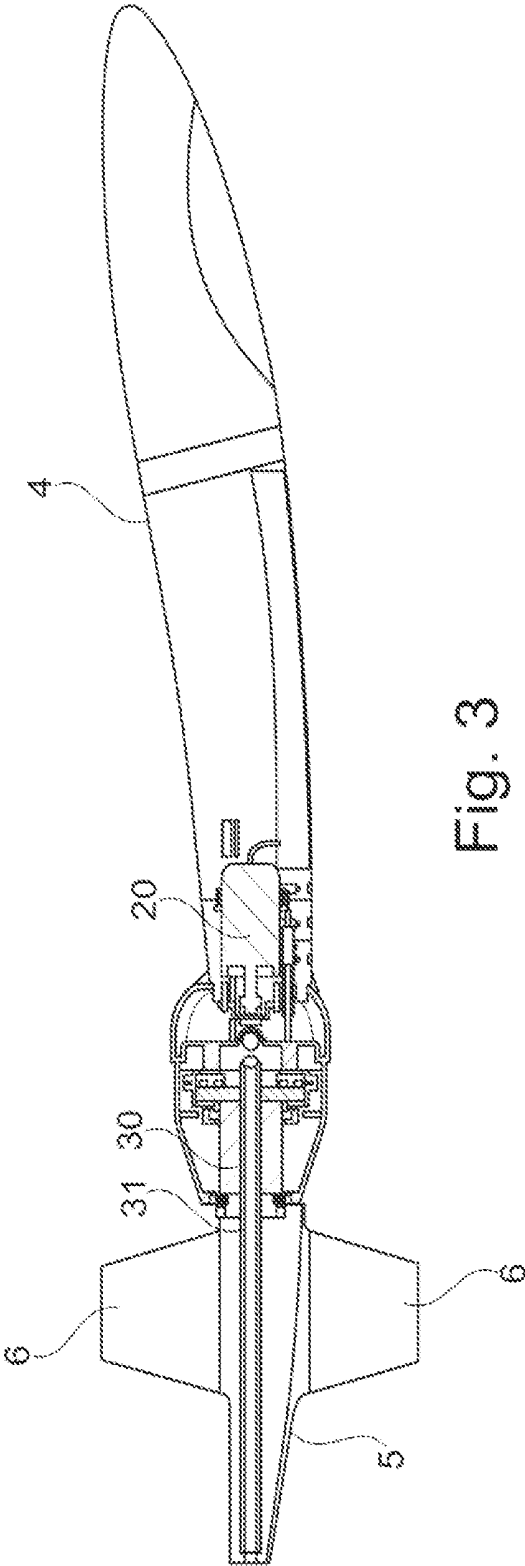


Fig. 3

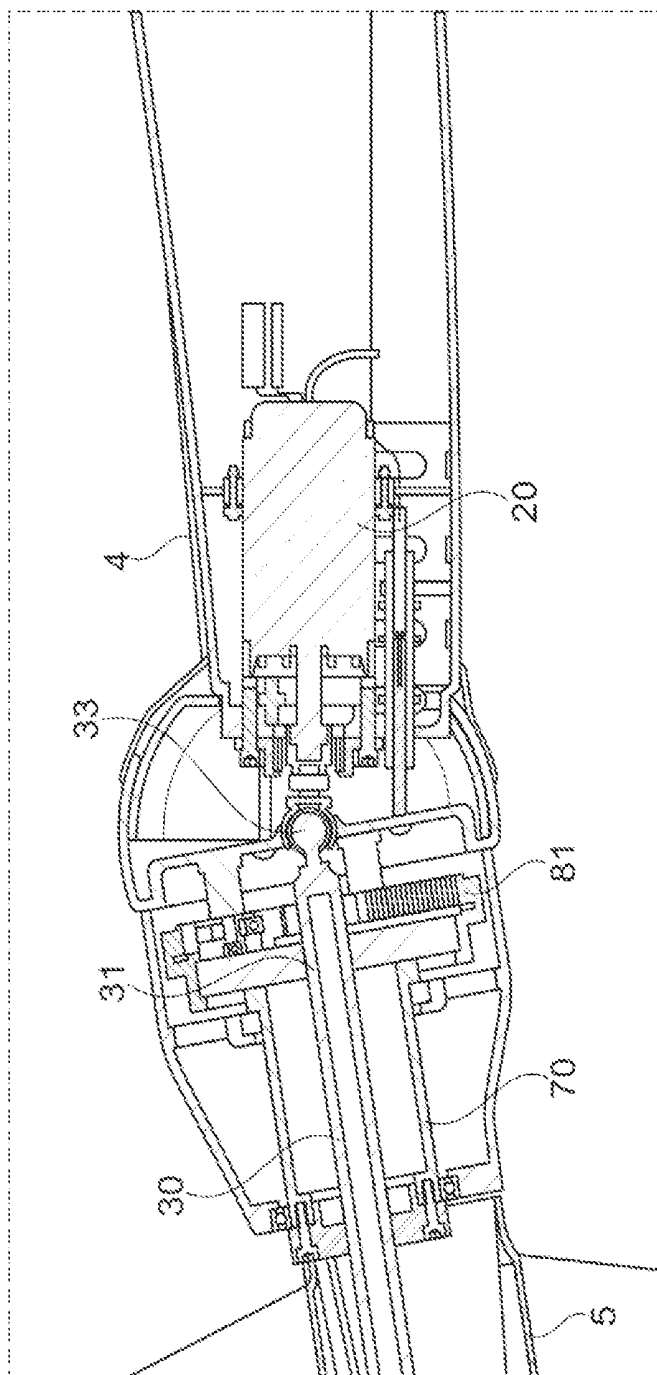


Fig. 4

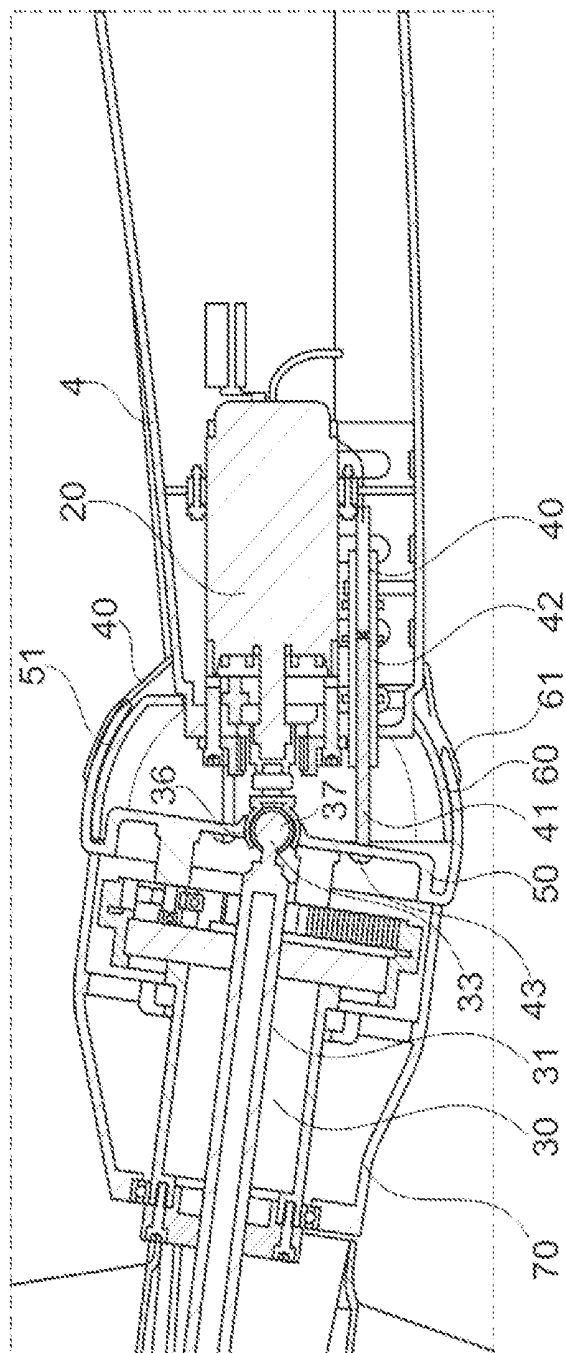


Fig. 5

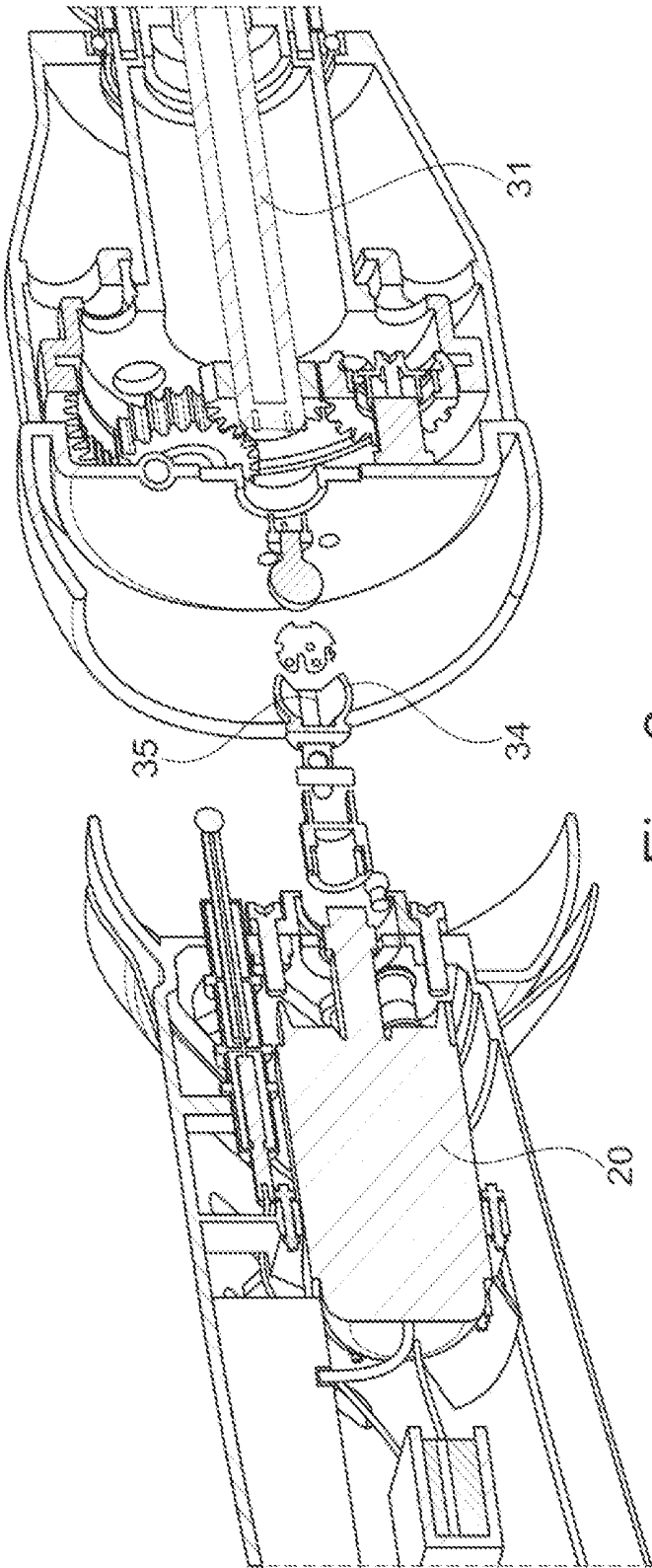


Fig. 6

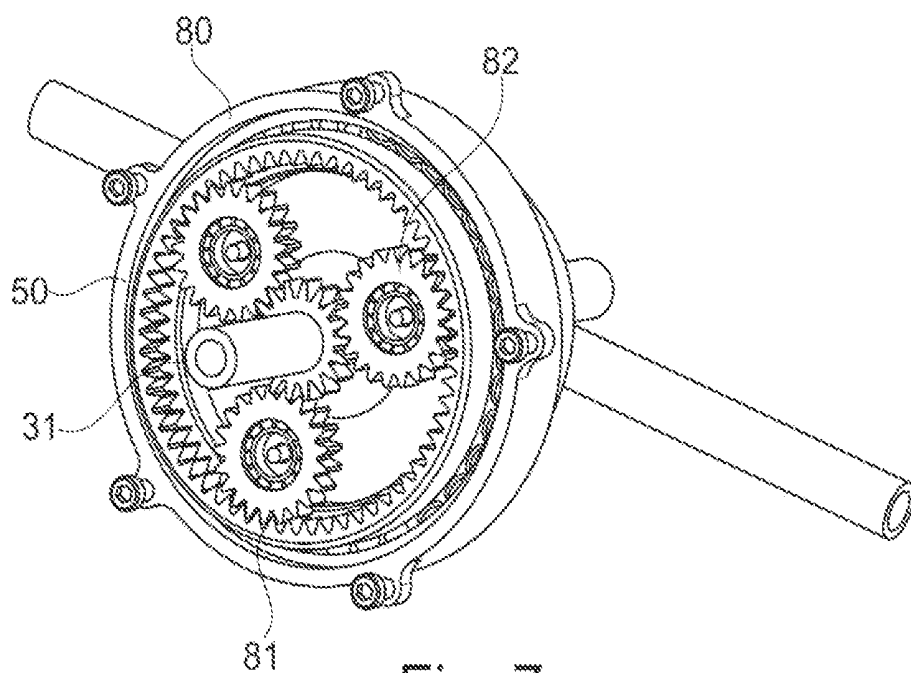


Fig. 7

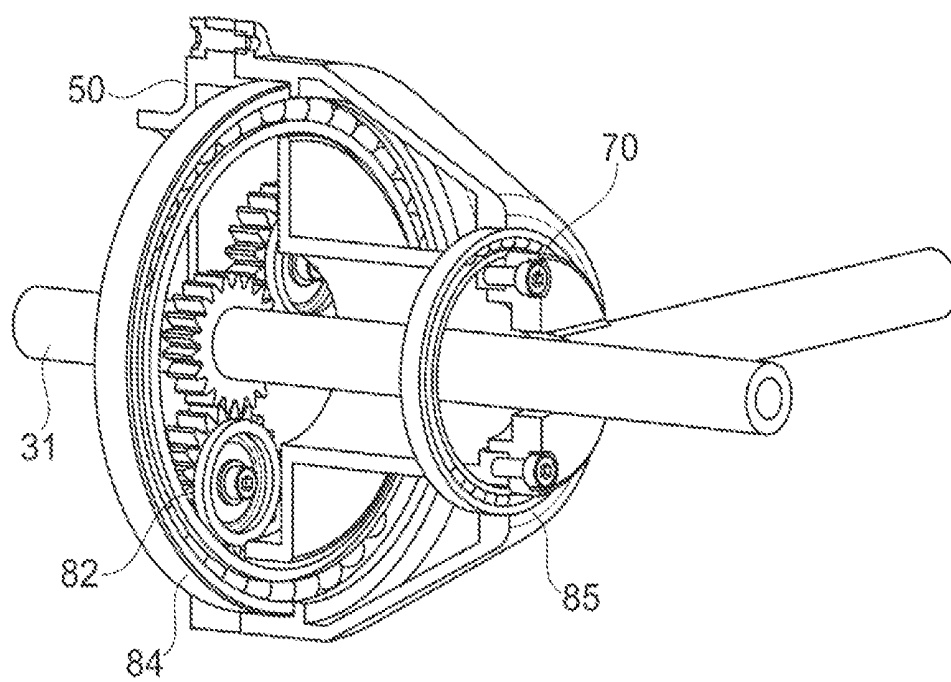


Fig. 8

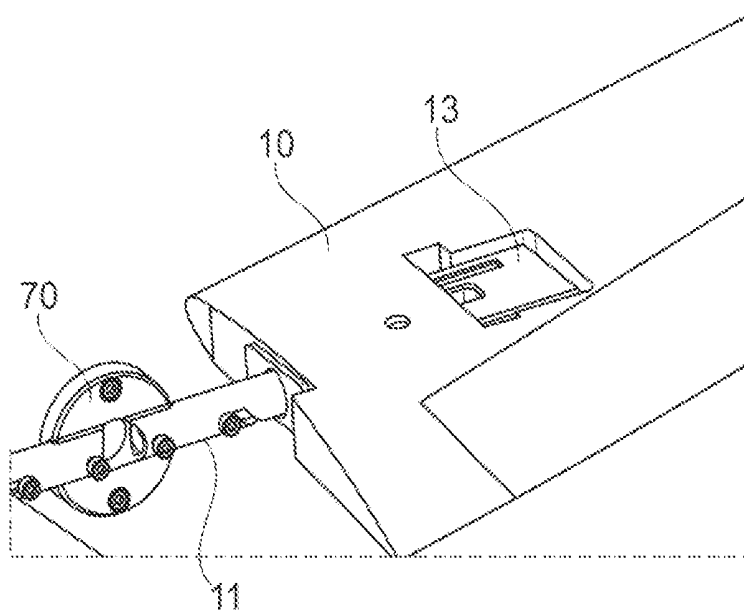


Fig. 9

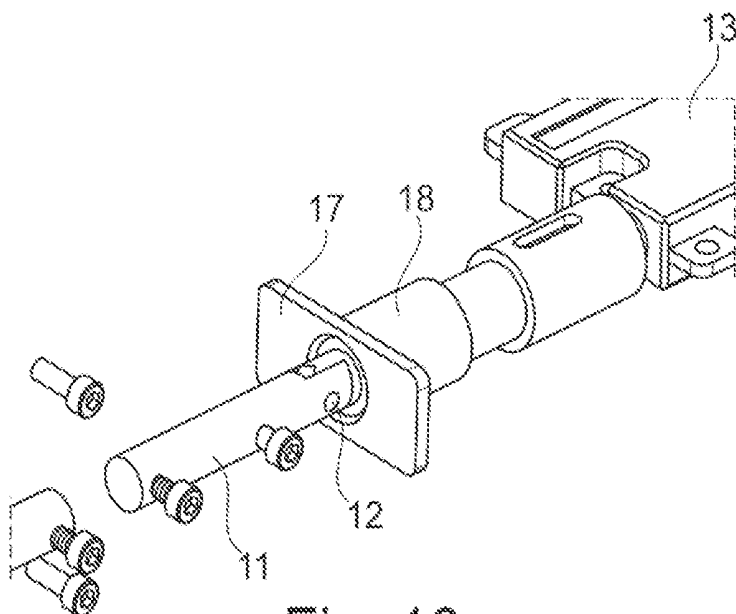
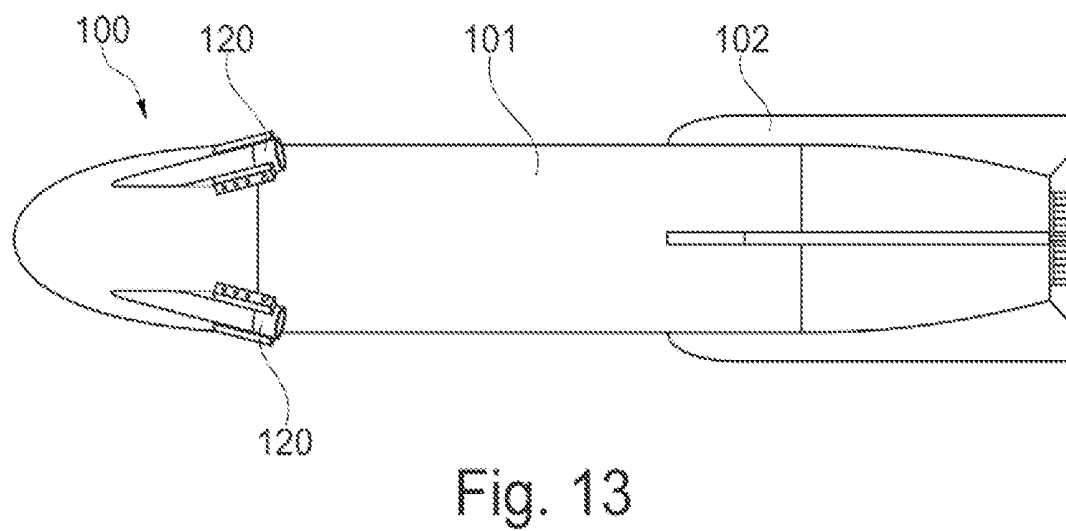
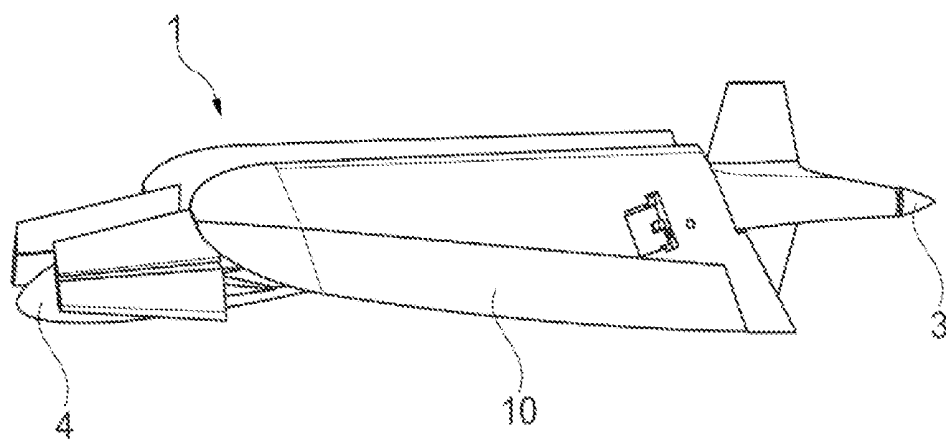
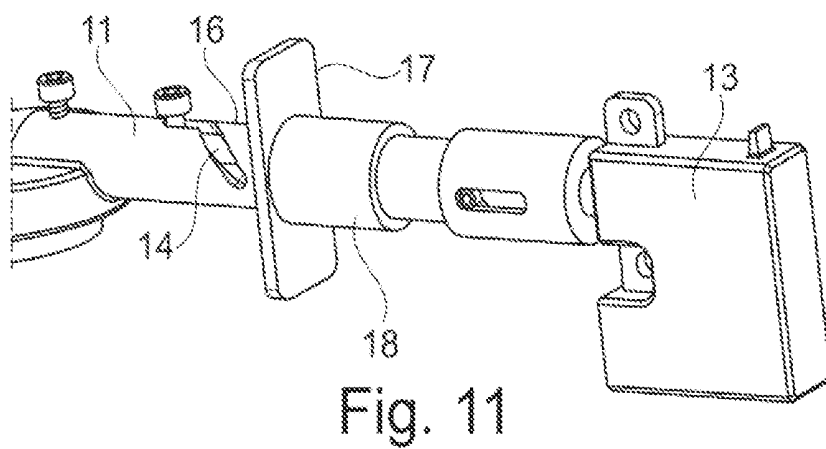


Fig. 10



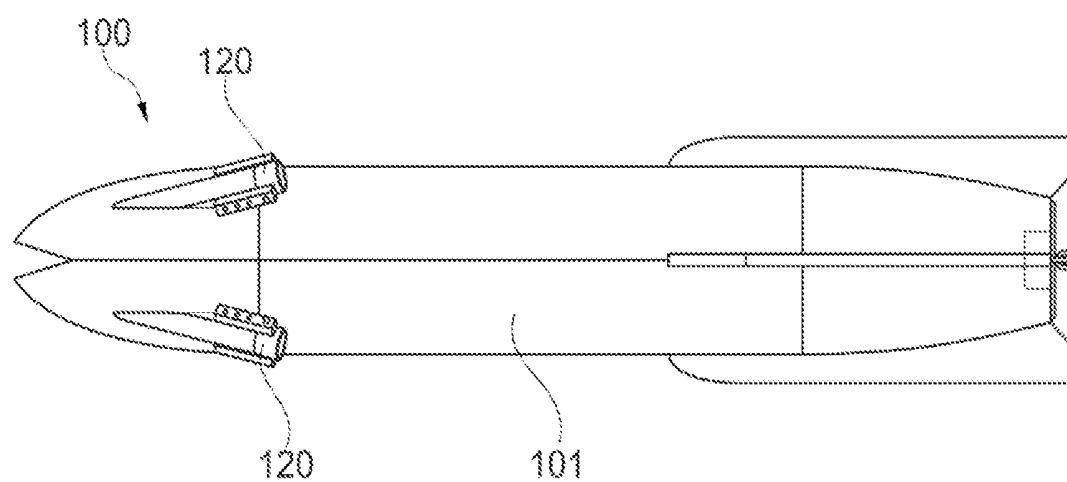


Fig. 14

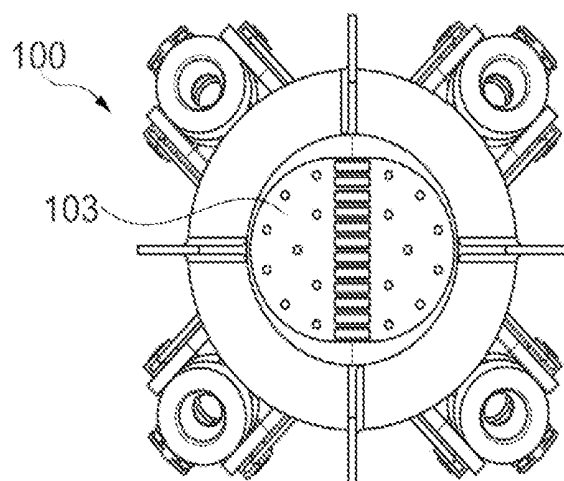


Fig. 15

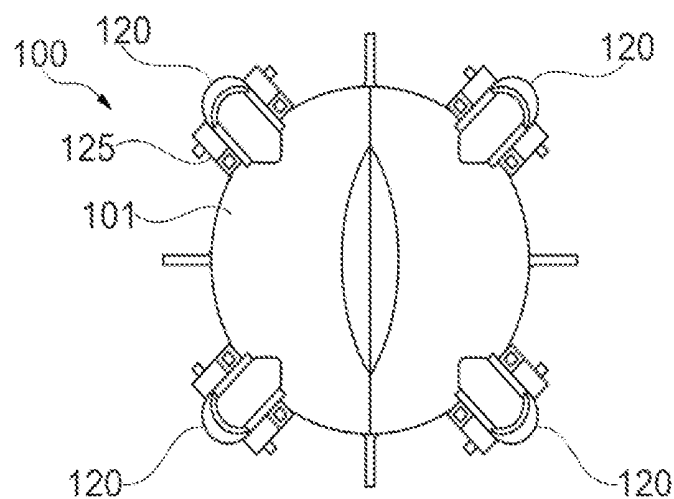


Fig. 16

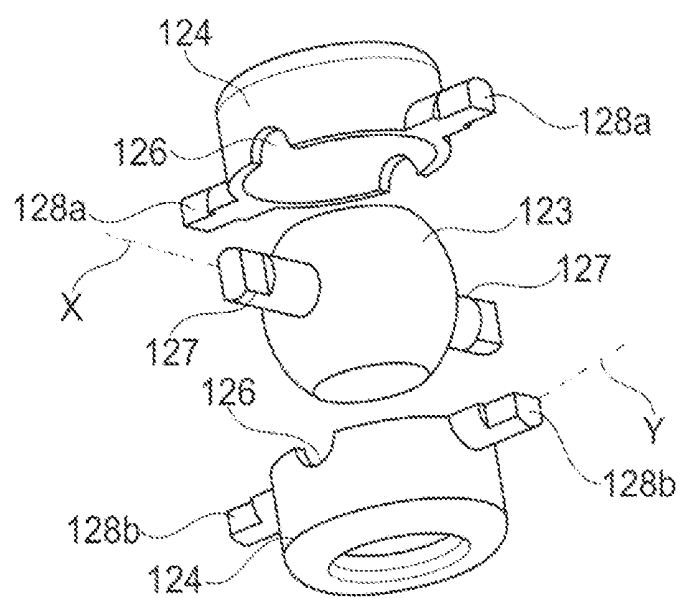


Fig. 17

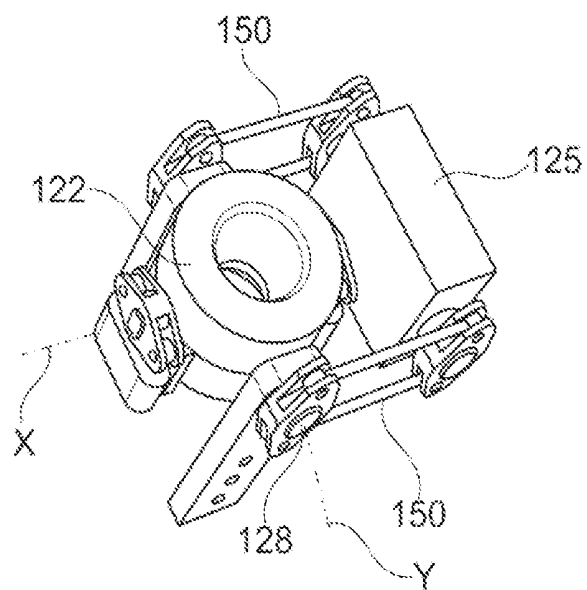


Fig. 18

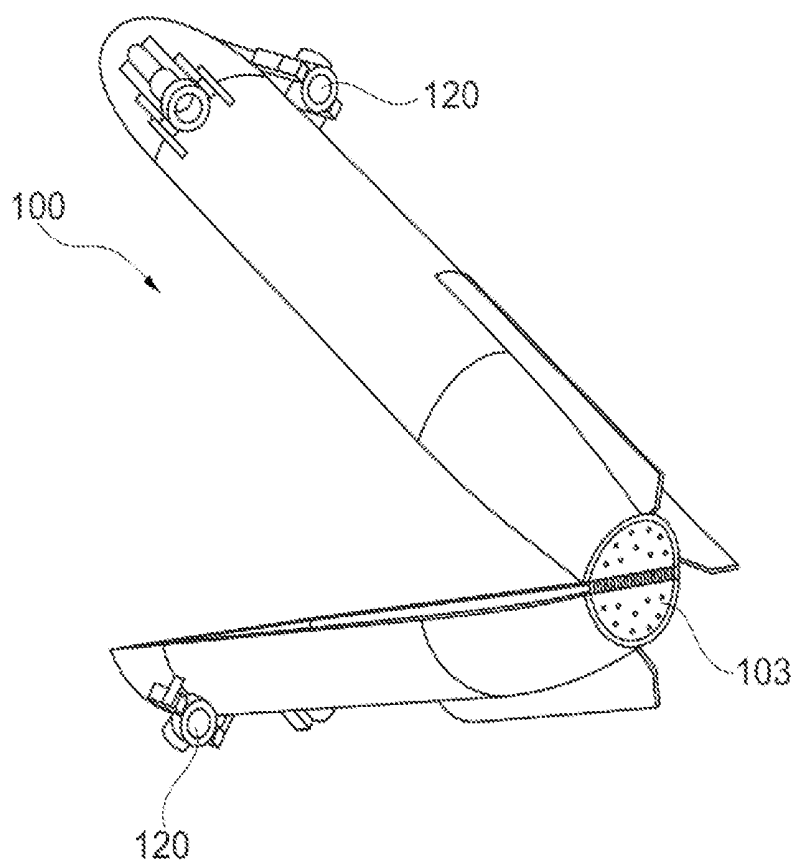


Fig. 19

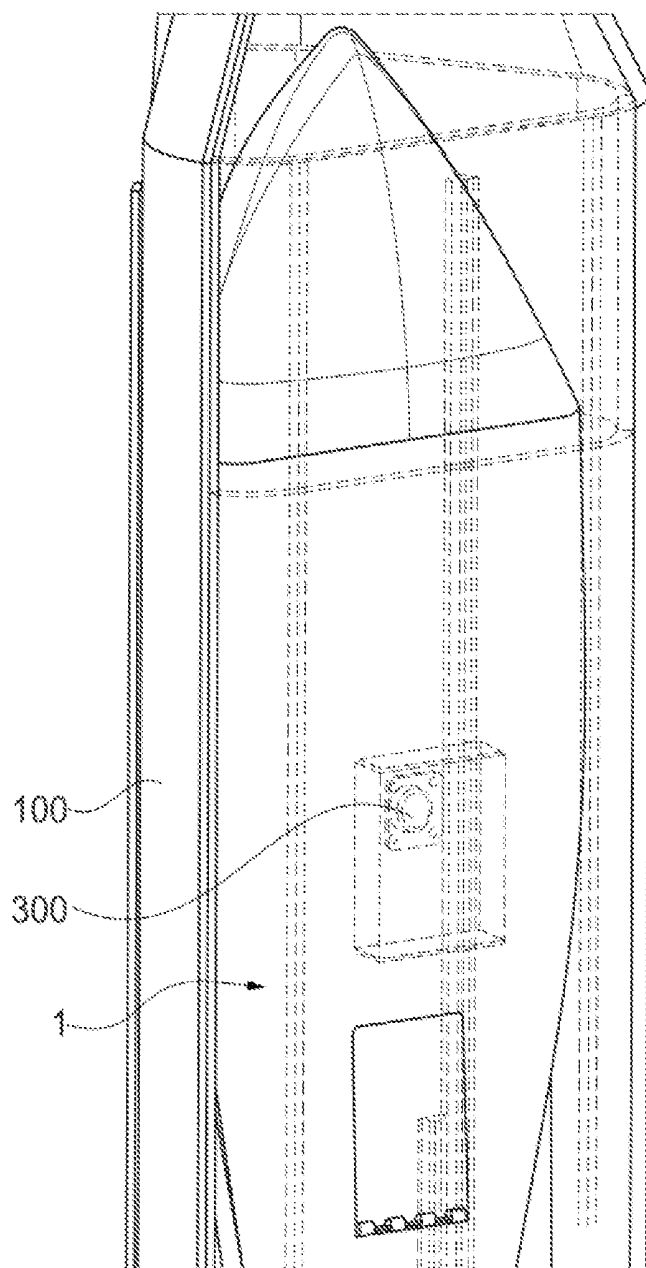


Fig. 20

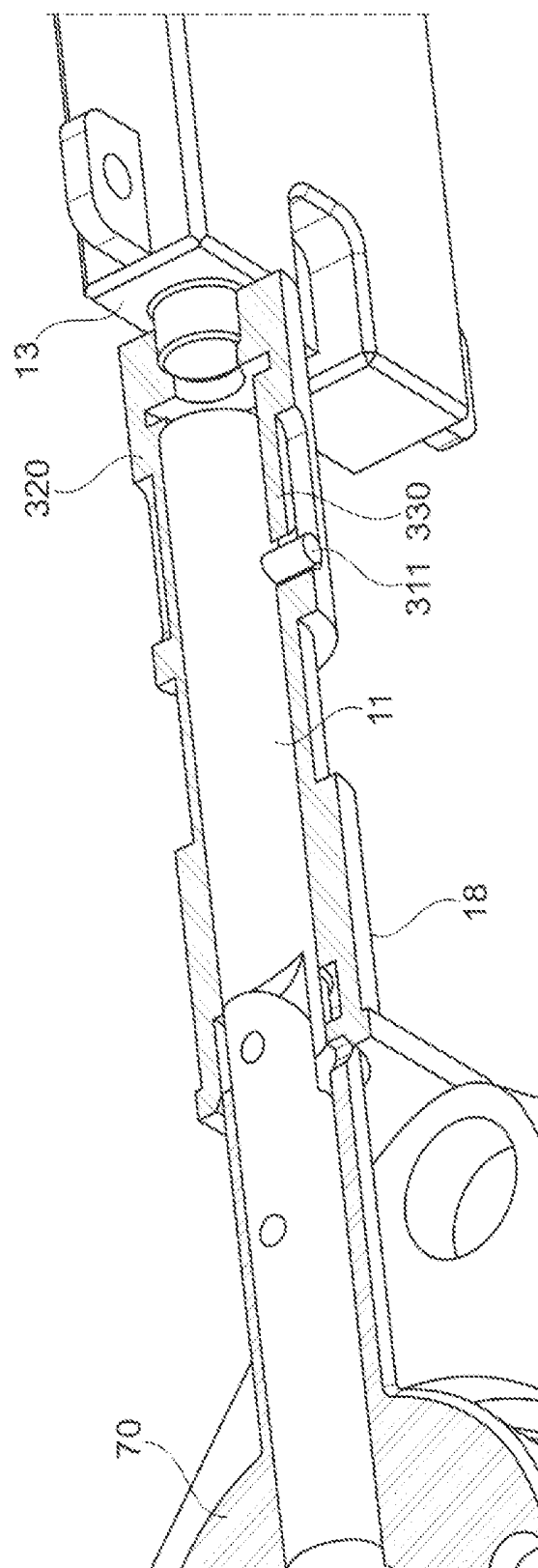


Fig. 21

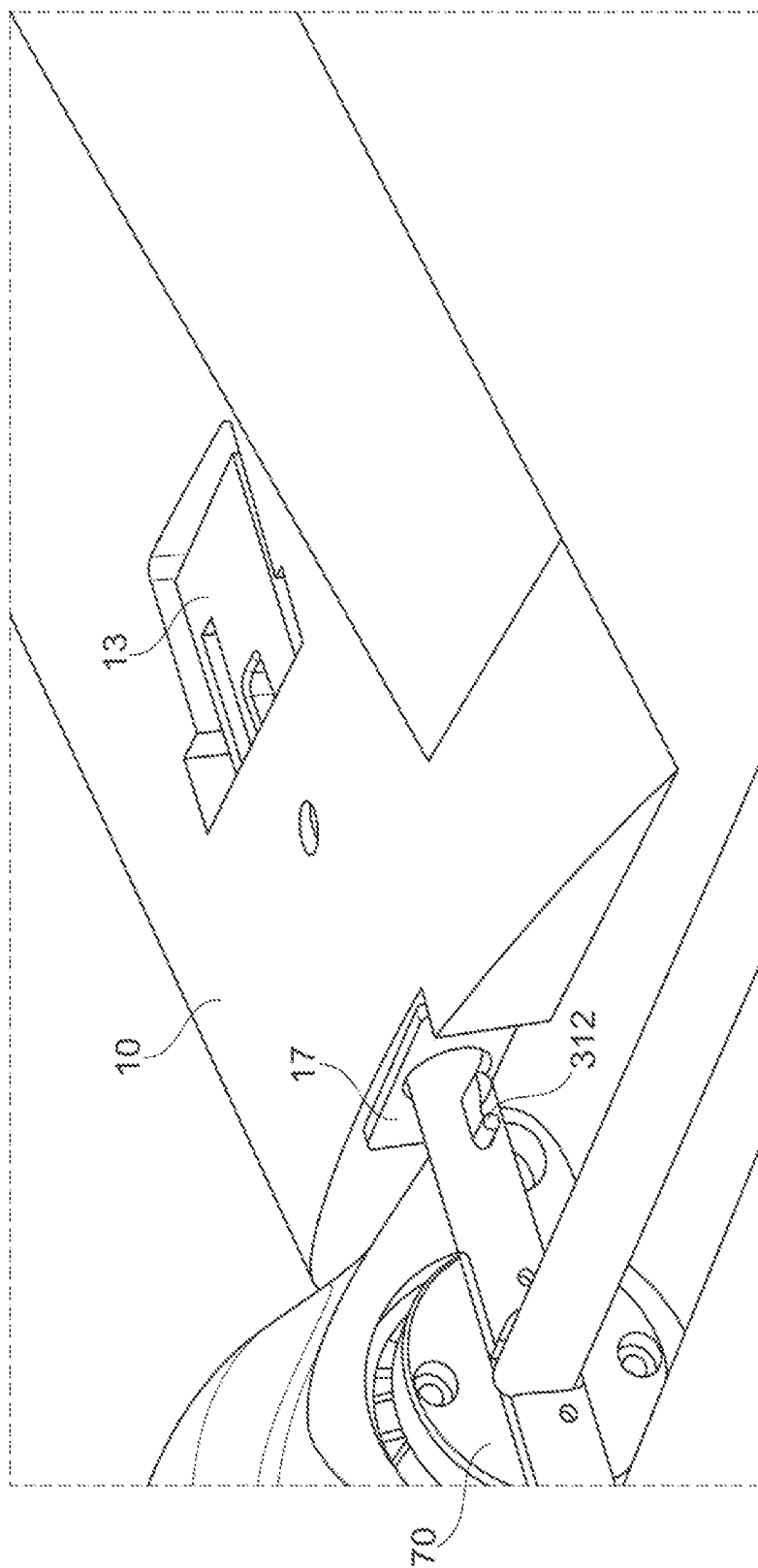


Fig. 22

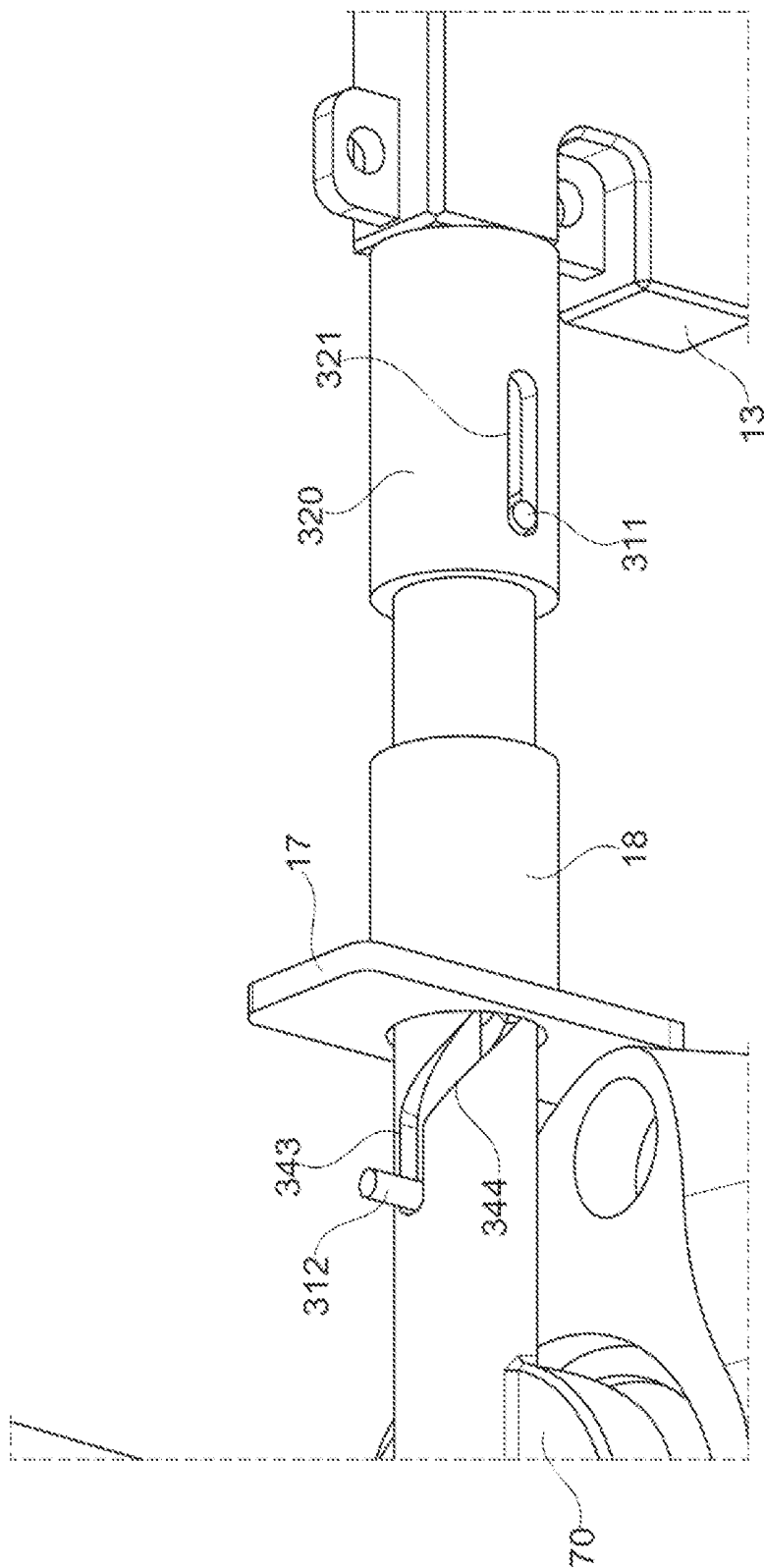


Fig. 23



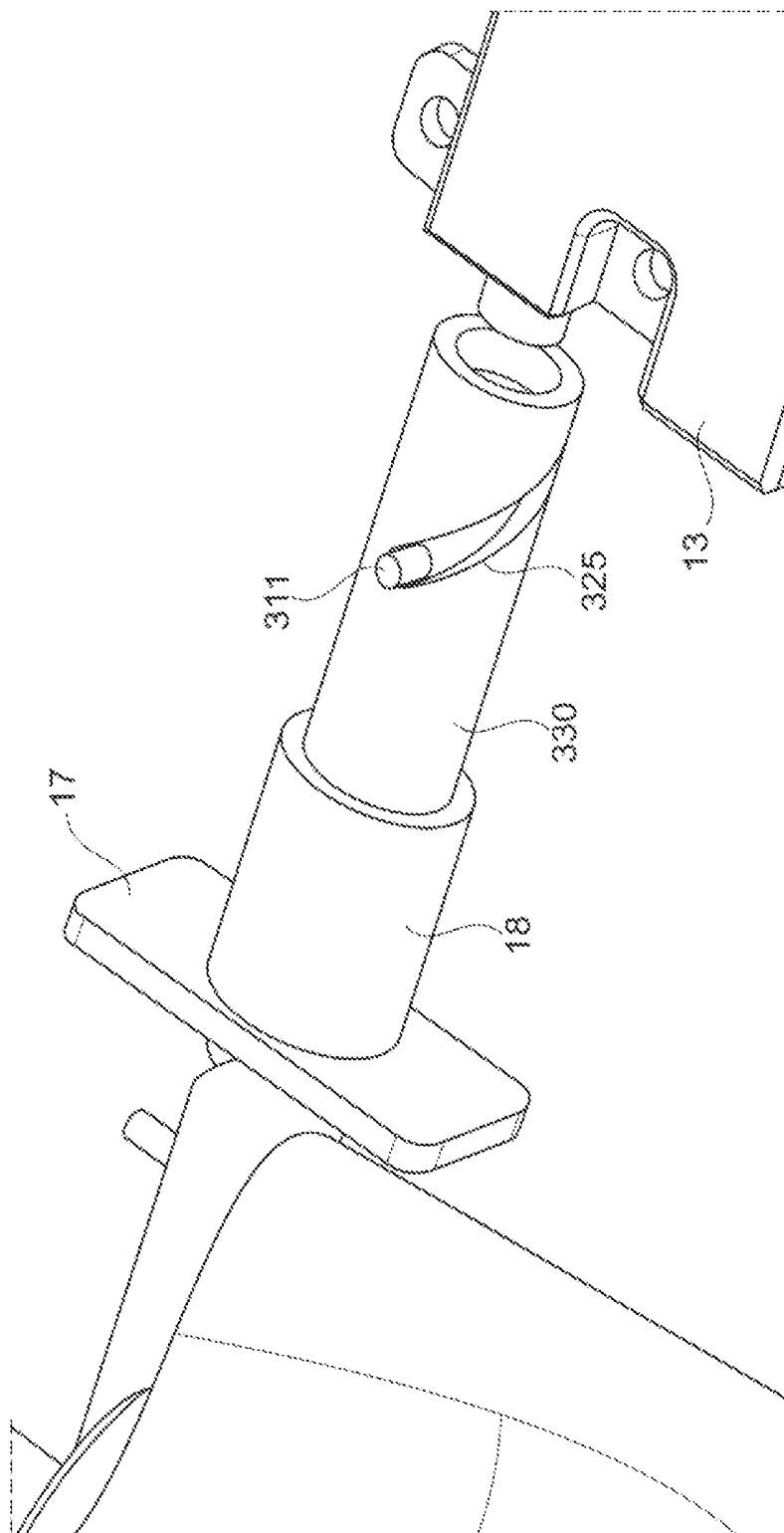


Fig. 25

**DRONE****TECHNICAL FIELD**

[0001] The present invention relates to a drone with adaptable wing structure and to a corresponding launcher.

**PRIOR ART**

[0002] Application WO 2018/024567 discloses a drone with adaptable wing structure, comprising two wings connected to a rotor, the wing structure being able to be adapted between a rapid-flight configuration in which the rotor is immobile relative to the fuselage and a rotary-wing flight configuration in which the rotor is rotationally driven relative to the fuselage.

[0003] There is a need to improve this type of drone still further, and notably to improve the maneuverability thereof when flying in the rotary-wing flight configuration.

**DESCRIPTION OF THE INVENTION**

[0004] The invention seeks to meet this need, according to a first of its aspects.

**SUMMARY OF THE INVENTION**

[0005] Thus, one subject matter of the invention is a drone comprising a front section, a wing structure borne by a rotor situated behind the front section, and a propeller at the rear, the wing structure comprising two wings rotating with the rotor, the wing structure being able to adapt between a flight configuration in which the rotor is stationary relative to the front section and the propulsion is provided by the propeller, and a rotary-wing flight configuration in which the rotor is rotationally driven relative to the front section, the rotor being connected to the front section with the possibility of orienting its axis of rotation relative to said front section so as to be able to steer the drone in the rotary-wing configuration by altering said orientation.

[0006] Thanks to the possibility of orienting the rotor in advancing flight in the rotary-wing configuration, the drone can be steered horizontally without the need to provide a complex cyclic-pitch control at the connection between the wings and the rotor.

[0007] With the drone comprising a stator bearing the rotor, the stator may be connected by at least one actuator to the front section, the actuator being designed to modify the orientation of the stator relative to the front section when actuated. As a preference, the drone comprises several actuators connecting the front section to the stator and, when actuated, making it possible to modify the orientation of the stator relative to the front section about at least two axes. As a greater preference, the drone comprises three actuators connecting the front section to the stator, these being positioned 120° apart about the longitudinal axis of the stator. These actuators are preferably linear actuators and are preferably each connected to the stator by a swivel joint.

[0008] Like a helicopter, the drone according to the invention may have a collective pitch control and a cyclic pitch control. The collective pitch control can be provided by actuators situated in the wings. The cyclic pitch control is achieved by inclining the stator. Thus, as a preference, the wings can pivot relative to the rotor in order to change incidence, thereby making it possible to change the collective pitch in the rotary-wing configuration.

[0009] As a preference, the drone comprises a swivel-joint connection between the front section and the stator. Such a connection advantageously is able to react some of the mechanical load between the front section and the stator. A deflector advantageously covers this joint, so as to maintain continuity of the fuselage at the transition between the front section and the stator, in spite of the changes in orientation of the latter.

[0010] The drone comprises a motor for driving the rotation of the propeller. This motor is preferably housed in the front section, a drivetrain connecting the motor to the propeller, this drivetrain comprising a universal joint allowing drive to be transmitted from the motor to the propeller despite the changes in orientation of the axis of rotation of the rotor relative to the front section. As a preference, the drone is arranged in such a way that the movements orienting the axis of rotation of the rotor are effected about a center of rotation on which the universal joint is centered.

[0011] As a preference, the propeller and the rotor are moved by one and the same motor. The rotor may be driven via an epicyclic reduction gearbox.

[0012] The drone may comprise a rear section bearing the propeller, the rotor rotating between the front and rear sections.

[0013] As a preference, each wing is connected to the rotor by a mast comprising a joint allowing the wing to be folded against the fuselage during a phase of launch of the drone, when the latter is contained inside a launcher.

[0014] As a further preference, the drone comprises a mechanism allowing the hinge to be immobilized once the wing has deployed. This blocking mechanism may comprise a locking ring which in the locked position covers the hinge and thus immobilizes the mast in a configuration in which it is coaxial with the ring. An actuator housed in the wing may generate a relative movement between the mast and the locking ring to bring the latter into its blocking configuration.

[0015] The variation in incidence of the wing relative to the rotor can be obtained by a mechanism which converts a rotational movement of an actuator into an axial movement of the mast. The latter may comprise a first stud near to the actuator and a second stud near to the rotor. The two studs move together under the action of the actuator. The latter drives the rotation of a drive ring that has an axial slot in which the first stud is engaged. The first stud is also engaged in a helical slot of a tubular part fixed with the wing, secured to the locking ring. Thus, a rotation of the drive ring is accompanied by an axial movement of the mast relative to the locking ring and to the fixed tubular part. The second stud is engaged in a slot formed on a tubular part which is fixed on the rotor and which rotates therewith. This slot comprises a first portion which is linear and extends radially, and a second portion which is helical. When the mast moves axially, under the effect of the rotation of the actuator, the second stud moves along the linear first portion and then along the second portion. The first portion serves to lock the wing in the fixed-wing forward-flight configuration. The second portion allows modification of the incidence of the wing in the rotary-wing configuration, so as to vary the collective pitch.

[0016] Another aspect of the invention, independently of or in combination with the foregoing, has as its subject matter a launcher that can be used to launch a drone as

defined above, comprising a cap able to house the drone, and four vectored-thrust boosters for orienting the launcher.

[0017] As a preference, the drone has folding wings that can be folded against the fuselage when the drone is contained inside the launcher.

[0018] As a preference, the cap comprises two articulated sections which are kept closed by the aerodynamic thrust when the launcher is moving at high speed.

[0019] As a preference, the drone comprises folding wings which can be folded against the fuselage when the drone is contained inside the cap.

[0020] As a preference, each booster comprises a deflector comprising a body able to pivot about a first axis of rotation, this body enclosing an element that is able to pivot about a second axis perpendicular to the first. The body may notably be formed of two units which are assembled around a toric section constituting said element.

[0021] As a preference, a system of redundant actuators provides control of the pivoting of the deflector about these two axes of rotation.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The invention may be better understood from reading the detailed description which follows of one non-limiting exemplary embodiment thereof, and from studying the attached drawing, in which:

[0023] FIG. 1 depicts one example of a drone in a fixed-wing rapid-flight configuration,

[0024] FIG. 2 depicts the drone of FIG. 1 in a rotary-wing configuration,

[0025] FIG. 3 is a partial and schematic longitudinal section through the drone of FIGS. 1 and 2,

[0026] FIG. 4 depicts a detail of the connection between the stator and the front section of the drone, for a given orientation of the axis of rotation of the rotor,

[0027] FIG. 5 is a view similar to FIG. 4 for a different orientation of the axis of rotation of the rotor,

[0028] FIG. 6 is an exploded schematic perspective view of the connection between the stator and the front section,

[0029] FIG. 7 is a schematic partial view of the rotor drive mechanism,

[0030] FIG. 8 is a partial and schematic view in longitudinal section of the mechanism of FIG. 7,

[0031] FIG. 9 partially and schematically depicts the connection between the wings and the rotor,

[0032] FIG. 10 depicts an embodiment detail of the connection between a wing and the rotor,

[0033] FIG. 11 is a view similar to FIG. 10 of another embodiment detail,

[0034] FIG. 12 illustrates the folding of the wings along the fuselage for launch,

[0035] FIG. 13 depicts an example of a launcher viewed face-on,

[0036] FIG. 14 depicts the launcher of FIG. 13, viewed from the side,

[0037] FIG. 15 depicts the launcher of FIG. 13, viewed from beneath,

[0038] FIG. 16 depicts the launcher of FIG. 13 viewed from above,

[0039] FIG. 17 depicts a detail of the fitting of a deflector,

[0040] FIG. 18 partially and schematically illustrates the deflector orientation mechanism,

[0041] FIG. 19 illustrates the opening of the launcher,

[0042] FIG. 20 depicts a connector that allows the drone to exchange data with the launcher, when present within same,

[0043] FIG. 21 is a schematic and partial longitudinal section of the mechanism integrated into the root of a blade,

[0044] FIG. 22 depicts the blade at its root,

[0045] FIG. 23 depicts the mechanism of FIG. 21, from a different angle,

[0046] FIG. 24 is a view analogous to FIG. 23, from a different angle and

[0047] FIG. 25 depicts the mechanism of FIGS. 23 and 24, with the drive ring removed.

#### DETAILED DESCRIPTION

[0048] The drone 1 according to the invention and depicted in FIGS. 1 and 2 comprises two wings 10 which are able to move relative to the fuselage 2 between a fixed-wing configuration corresponding to FIG. 1, and a rotary-wing configuration illustrated in FIG. 2.

[0049] The drone 1 comprises, at the rear, a propeller 3 depicted schematically in FIG. 2 and, at the front, canard foreplanes 3. The rear section 5 of the drone 1 may bear ailerons and/or rudders 6.

[0050] In the fixed-wing configuration, the wings 10 are fixed relative to the fuselage, with a forward-swept configuration, allowing the drone to move like an airplane, in rapid flight. The forward-swept configuration offers a combination of advantages including energy efficiency associated with its low drag, optimized lift and payload, better maneuverability and greater tolerance to stalling at very low speed.

[0051] In the example illustrated, the fuselage of the drone has a central bay, of prismatic cross section, which contributes to its lift.

[0052] In the rotary-wing configuration, the wings 10 rotate with a rotor relative to the front section 4 of the drone, with opposite incidences. In this configuration, the wings 10 act like helicopter blades. The propeller 3 can then rotate in the opposite direction from the wings 10, in order to provide counter torque.

[0053] When the drone is moving in advancing flight in the rotary-wing configuration, the dorsal ridge of the prismatic cross section of the central bay is preferably positioned to face into the relative airflow.

[0054] According to a first aspect of the invention, the axis of rotation of the rotor can be oriented relative to the front section 4 making it possible to control the advance of the drone in the rotary-wing configuration.

[0055] If reference is now made more particularly to FIGS. 3 to 8, it may be seen that the drone 1 comprises a main electric motor 20, preferably of the brushless type, housed in the front section 4 and connected to the propeller 3 by a drivetrain 30 comprising a shaft 31.

[0056] The front section 4 houses three actuators 40 arranged 120° apart about the axis of rotation of the motor 20. These actuators 40 are linear actuators in the example considered and each comprise a rod 41 able to move axially relative to the body 42 of the actuator. The rods 41 are connected at their end by a swivel joint 43 to a stator 50 and are able to control the orientation of the latter relative to the front section 4.

[0057] The stator 50 comprises a peripheral skirt 51 in the form of a portion of a sphere, which forms a swivel joint with an internal skirt 60 of corresponding shape belonging to the front section 4.

[0058] A deflector **61** mounted on the fuselage of the front section **4** partially covers the peripheral skirt **51** and provides a certain continuity of the exterior surface of the drone **1**, for better aerodynamic performance.

[0059] The wings **10** are borne by a rotor **70** which can rotate relative to the stator **50**.

[0060] The motor **20** preferably incorporates an eddy current electromagnetic brake and a rotor positioning sensor such as an optical encoder.

[0061] The electromagnetic brake allows the rotor **70** running at full power to be immobilized quickly. Its position is continually determined by the optical encoder allowing the motor controller to reposition the rotor if necessary.

[0062] A transmission mechanism **80** allows the rotor **70** to be driven by the motor **20**.

[0063] In the example illustrated, this mechanism **80** is of the epicyclic reduction gearbox type and comprises, as is more particularly visible in FIG. 7, an inner sun gear **32** consisting of a gearwheel mounted on the shaft **31**, a large ring gear **81** that forms an integral part of the rotor **70**, and a planet carrier **82**.

[0064] The rotor **70** is guided by rolling bearings **84** and **85** borne by the stator **50**.

[0065] When this is blocked, rotation of the shaft **31** drives that of the rotor **70**, with a reduction ratio. In that case, the propeller **3** rotates in the opposite direction to the rotor **70**.

[0066] When the planet carrier **82** is free to rotate, the rotor **70** can have its rotation blocked.

[0067] When the large ring gear **81** is blocked, only the propeller **3** is driven in rotation. When the large ring gear **81** is unblocked, the epicyclic gearbox acts like a reduction gearbox and drives the wings **10**. This sequence is reversible.

[0068] Actuators which have not been shown allow the selective blocking of the rotation of the planet carrier **82** or of the rotor **70**.

[0069] The drivetrain **30** comprises a universal joint **33** between the shaft **31** and the motor **20** to allow the rotational torque of the motor **20** to be transmitted to the shaft **31** while at the same time allowing freedom in the orientation of the shaft **31** relative to the motor **20**.

[0070] This universal joint **33** may be of the constant-velocity joint type and comprise, as illustrated in FIG. 6, a cage **34** provided on its interior surface with grooves **35** which house balls **36** transmitting torque with an internal ball **37**. The cage **34** of the constant-velocity joint **33** and the swivel joint formed between the skirts **51** and **60** are substantially concentric.

[0071] If reference is made to FIGS. 9 to 11 it may be seen that the roots of the wings **10** comprise masts **11** connected to the rotor **70** and each comprising a joint **12**, visible in FIG. 10, that allow the wings to be folded against the fuselage as illustrated in FIG. 12.

[0072] A rotary actuator **13** is housed in each wing to modify their incidence in the rotary-wing configuration or to block their incidence in the fixed-wing configuration.

[0073] The two working axes of the roots allow the wings **10** to be folded along the fuselage and their angle of attack to be adjusted. The wings **10** are automatically deployed by the relative airflow and locked by a locking ring **18** which fits over the articulation **12** when the mast **11** is moved axially relative to this ring **18** by the actuator **13**. As can be seen in FIGS. 21 to 25 in particular, each ring **18** takes the form of a cylindrical segment secured to its respective wing

and provided with a pull reinforcement **17** perpendicular to its end. The reinforcement **17** hugs the chord of the roots and is embedded in the profile of the wing, behind the leading edge. A mechanism converts a rotational movement of the actuator **13** into an axial movement of the mast **11**. The latter may have a first stud **311** near to the actuator and a second stud **312** near to the rotor. The two studs **311** and **312** move together under the action of the actuator **13**. The latter drives the rotation of a drive ring **320** which has an axial slot **321** in which the first stud **311** is engaged. The first stud **311** is also engaged in a helical slot **325** of a tubular part **330** fixed with the wing, secured to the locking ring **18**. Thus, a rotation of the drive ring **320** is accompanied by an axial movement of the mast **11** relative to the locking ring **18** and to the fixed tubular part **330**. The second stud **312** is engaged in a slot **340** formed on the tubular part **341** which is fixed to the rotor **70** and which rotates therewith. This slot **340** has a first portion **343**, which is linear and extends radially, and a second portion **344** which is helical. When the mast **11** moves axially under the effect of the rotation of the actuator **13**, the second stud **312** moves along the linear first portion **343** and then into the helical second portion **344**. The first portion **343** serves to lock the wing **10** when advancing in fixed-wing configuration. The second portion **344** allows the modification of the incidence of the wing **10** in the rotary-wing configuration, in order to vary the collective pitch.

[0074] The actuators **13** may be powered from the rotor via rotary slip rings. The actuators may be controlled using carrier currents for example.

[0075] In the rotary-wing configuration, the asymmetry between the propeller **3** and the rotor **70** is compensated for mechanically by the epicyclic gearbox which adjusts the number of revolutions per minute between the two. Thus, the volume of air swept by the propeller **30** is preferably substantially equal to the volume of air swept by the wings **10** rotating with the rotor.

[0076] The drone **1** can be launched by being contained, with all the wings folded, as illustrated in FIG. 12, in a launcher **100** like the one depicted in FIGS. 13 to 19.

[0077] As a preference, this launcher is capable of maneuvering at high speed and, during the launch phase, adopts the flight characteristics of a surface-to-air missile.

[0078] The launcher comprises a cap **101** of circular cross section and a cruciform empennage **102**. The maneuverability and controllability of the launcher are provided by four boosters **120** arranged symmetrically around the cap.

[0079] The cap **101** comprises two shells connected at the bottom by an articulation **103** visible in FIG. 15.

[0080] The symmetrical thrust from the four boosters **120** acts together to keep the cap **101** closed until they enter their deceleration phase.

[0081] Vectored thrust optimizes the positioning times with a very tight turn between vertical launch and horizontal flight. Independent of its maneuverability, the use of vectored thrust means that control of the launcher can be maintained with just three boosters should one of the boosters fail.

[0082] The four boosters **120**, mounted symmetrically on each side of the cap, each have two degrees of freedom (vertical and horizontal) the resultant being vectored thrust. Each booster is directly connected to a deflector **122** which forces the gases to follow a toric section **123** with inbuilt nozzle, visible in FIG. 17, providing horizontal corrections. Vertical corrections are achieved by the body of the deflec-

tor, which is made up of two units **124** encapsulating the toric section **123**. The latter is able to pivot about an axis of rotation X relative to the body of the deflector formed by the units **124**. The section **123** is produced with diametrically opposed stub axles **127** which are housed in corresponding openings in the body of the deflector, these openings being formed by the mating of cutouts **126** present on each of the units **124**.

[0083] Each unit **124** comprises diametrically opposed half stub axles which when the units **124** are brought together form the stub axles **128** as illustrated in FIG. **18**, allowing the deflector to be oriented about an axis of rotation X perpendicular to the axis Y.

[0084] Each system of actuators **125** of a booster deflector **120** is preferably provided with symmetrical redundancy regarding commands for rotation both about the axis X and about the axis Y, giving the system reliability.

[0085] In particular, as illustrated, the body of the deflector may bear two actuators each one connected to a respective stub axle **127**, to control the tilting of the toric section **123** relative to the body of the deflector, and this can pivot about the axis Y under the action of two actuators each connected to a stub axle **128** by a respective linkage mechanism **150**.

[0086] The reliability of release is critical to mission success and the load factors exerted on the cap **101** may compromise opening. In order to remove this risk, the cap is kept closed at high speed during the tight turns that the launcher is liable to make and during the deceleration phase thereof.

[0087] Throughout the duration of the flight, the airflow applies pressure to the convex deflection surface of the cap and separation occurs at a controlled velocity during deceleration. The launcher opening velocity is controlled by the joint effects of the air pressure, for example by way of a Pitot tube, and the mechanical pressure applied to the fuselage, for example by means of a piezoelectric pressure sensor.

[0088] Once it reaches the programmed position, the cap **101** opens, as illustrated in FIG. **19**, and ejects the drone **1** which can then continue its flight in fixed-wing or rotary-wing configuration. Once the mission is over, the drone **1** can be recovered by an autonomous land system with which it communicates.

[0089] The drone may, as illustrated in FIG. **20**, comprise a connector **300** connected to a corresponding connector present on the launcher (not visible) for the exchange of data between the two, and notably allowing control of the boosters and deflectors by the electronics of the drone during the launch phase. During the release of the drone, the connectors separate. The connector **300** may be present on the ventral face of the fuselage.

[0090] In an alternative, the drone is gyrostabilized by motors equipped with small bladed rotors housed in the fuselage. These motors play no part in the lift of the drone, and their capability is strictly limited to producing counter torque thrust and creating a moment that allows an approach path to be maintained with a given angle during landing. In order to avoid stability problems associated with the differences in pressure between the exterior surface of the cell and the inside, the openers may be closed off by a circular slide mechanism incorporated into the nose of the cell. The mechanism may be passive and the slide may reach its position under the effect of gravity. In the event of reversal of the configuration of the wing structures (rotary-wing/fixed wing) the extension generated by the slide shifts the

center of gravity towards the rear of the platform, thus contributing to increasing its stability at low speed. At high speed, the slide retracts under the pressure of the relative airflow.

1. A drone comprising a front section, a wing structure borne by a rotor situated behind the front section, and a propeller at the rear, the wing structure comprising two wings rotating with the rotor, the wing structure being able to adapt between a flight configuration in which the rotor is stationary relative to the front section and the propulsion is provided by the propeller, and a rotary-wing flight configuration in which the rotor is rotationally driven relative to the front section, the rotor being connected to the front section with the possibility of orienting its axis of rotation relative to said front section so as to be able to steer the drone in the rotary-wing configuration by altering said orientation.

2. The drone as claimed in claim 1, further comprising a stator bearing the rotor, the stator being connected by at least one actuator to the front section, the actuator being designed to modify the orientation of the stator relative to the front section when actuated.

3. The drone as claimed in claim 2, further comprising several actuators connecting the front section to the stator and, when actuated, making it possible to modify the orientation of the stator relative to the front section about at least two axes.

4. The drone as claimed in claim 3, further comprising three actuators connecting the front section to the stator, these being positioned 120° apart about the longitudinal axis of the stator.

5. The drone as claimed in claim 2, further comprising a swivel joint connection between the front section and the stator.

6. The drone as claimed in claim 1, further comprising a motor for driving the rotation of the propeller, this motor being housed in the front section, a drivetrain connecting the motor to the propeller, this drivetrain comprising a universal allowing drive to be transmitted from the motor to the propeller despite the changes in orientation of the axis of rotation of the rotor relative to the front section.

7. The drone as claimed in claim 6, wherein the movements orienting the axis of rotation of the rotor are effected about a center of rotation on which the universal joint is centered.

8. The drone as claimed in claim 1, wherein the wings are configured to pivot relative to the rotor in order to change their incidence.

9. The drone as claimed in claim 1, wherein the propeller and the rotor are moved by one and the same motor.

10. The drone as claimed in claim 1, further comprising a rear section bearing the propeller, the rotor rotating between the front and rear sections.

11. The drone as claimed in claim 1, wherein each wing is connected to the rotor by a mast comprising a joint allowing the wing to be folded against the fuselage during a phase of launch of the drone, when the latter is contained inside a launcher, the drone comprising a mechanism allowing the hinge to be immobilized once the wing has deployed.

12. The drone as claimed in claim 8, wherein the variation in incidence of the wing relative to the rotor being obtained by a mechanism which converts a rotational movement of an actuator into an axial movement of the mast.

**13.** A launcher in which there is placed a drone as claimed in claim **1**, the drone comprising folding wings which can be folded against the fuselage when the drone is contained inside the launcher.

**14.** The launcher as claimed in claim **13**, wherein the launcher comprising a cap housing the drone, and four vectored-thrust boosters for orienting the launcher.

**15.** The launcher as claimed in claim **14**, the cap comprising two articulated sections which are kept closed by the aerodynamic thrust when the launcher is moving at high speed.

**16.** The launcher as claimed in claim **14**, wherein each booster comprising a deflector comprising a body able to pivot about a first axis of rotation.

**17.** The launcher as claimed in claim **16**, the body being made up of two units which are assembled around a toric section constituting said element and/or a system of redundant actuators being providing control of the pivoting of the deflector about these two axes of rotation.

**18.** The drone as claimed in claim **11**, wherein the blocking mechanism comprises a locking ring which in the

locked position covers the hinge and thus immobilizes the mast in a configuration in which it is coaxial with the ring and/or an actuator housed in the wing making it possible to generate a relative movement between the mast and the locking ring to bring the latter into its blocking configuration.

**19.** The drone as claimed in claim **12**, wherein the mast comprises a first stud near to the actuator and a second stud near to the rotor, the two studs moving together under the action of the actuator, the latter driving the rotation of a drive ring that has an axial slot in which the first stud is engaged, the first stud also being engaged in a helical slot of a tubular part fixed with the wing, secured to the locking ring, a rotation of the drive ring being accompanied by an axial movement of the mast relative to the locking ring and to the fixed tubular part, the second stud being engaged in a slot formed on a tubular part which is fixed on the rotor and which rotates therewith, this slot comprising a first portion which is linear and extends radially, and a second portion which is helical.

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