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Vacuum Negative Pressure Starting Human Personal Flight Times

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Abstract

To adapt the material life demands of people, more rapid, convenient and efficient overhead three-dimensional transportation is concerned by people. This paper lays a theoretical foundation for that objective. First, the optimal force bearing mode in flight process is analyzed; Second, the butterfly-type aircraft as innovative assumption is proposed by observing the bird flying mode; Finally, the possibility to achieve the assumption is analyzed in combination with the existing flight technology, and the future development is proposed to achieve such assumption.

Keywords

Vacuum Negative Pressure; Butterfly-type Aircraft; The Bird Flying Mode.

1. Necessity to Start Human Personal Flight Times

In recent years, with the continuous development of social economy, urban population and motor vehicle have increased, and the congestion of urban road traffic has prevailed in the world's large and medium-sized cities. Then the corresponding traffic jam, traffic accident, energy waste, environmental pollution caused by exhaust emission of multiplied automobiles, etc. not only severely restrict the sustainable development of urban and social economy, but also seriously influence the life quality of urban residents. Now, the ground traffic can't meet the increasing material life demands of people, and the more rapid, convenient and efficient overhead three-dimensional transportation will be inevitably researched and concerned by people.

2. Technology and Historical Background Provide Necessary and Sufficient Condition of Starting Personal Aircraft

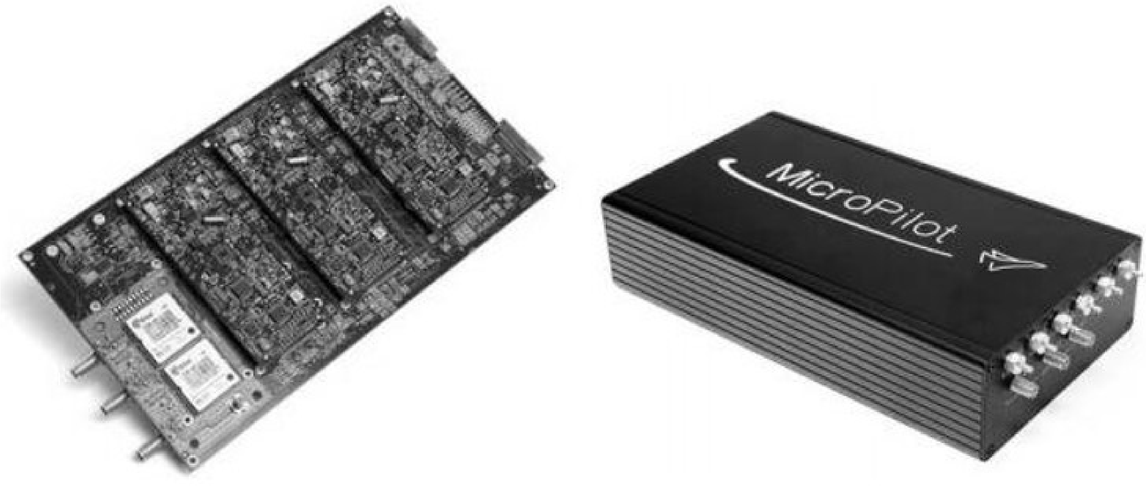

Figure 1. Commercial Flight Control of Canada Micropilot

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With the popularization of personal aircraft, the existing science and technology confront new challenge in the design and manufacturing of civil aircraft: for example, rapider computation speed of computer, more advanced computation method, higher sensitivity of sensor and feedback system, etc. are needed. Currently, the automatic driving and autonomous flight become the hotspots, the flight control system of unmanned aerial vehicle (UAV) occupies the absolute core position in the big system of UAV, and its connotation contains the comprehensive system of many subsystems such as navigation positioning system, environmental perception system, flight decision system, control system, etc. rather than the narrow "control". For example, the following figure 1 shows the commercial flight control of Canada Micropilot which combines both software and hardware.

1) Flight control hardware: It integrates and connects the computing unit, navigation sensor (inertial navigation, terrestrial magnetism, GPS, ultrasonic wave, laser, barometer, optical flow, navigation camera, etc.), wireless data transmission, etc., motor and steering gear control, etc.

2) Flight control software: With the abundance and expansion of flight control function, the embedded system often runs in the flight control of UAV and is equipped with the following functions: sensor data fusion, posture and position control, autonomous navigation, autonomous flight, waypoint management, remote control flight, fault protection, etc. Besides, the software function in the flight control system would show obvious differences with different application scenes.

3. Tension and Thrusting Force of Force Bearing Object

Understanding the specific principle of aircraft flight shall start from the most basic force bearing analysis. Generally speaking, the aircraft generally receives the aerodynamic force generated in flight movement, thrusting force of maintaining flight movement and the aircraft gravity. We here only discuss the power of aircraft in flight process, and such power can be summarized as tension or thrusting force in the aircraft field. Based on the following analysis, we can know two kinds of different acting forces generate different influence on the force bearing object.

1) Influence of tension and thrusting force on the stability of force bearing object

One object with weight of G is put on one plane and receives the tension (traction force) and thrusting force of F, respectively, then we would find: the same tension (traction force) and thrusting force on one object would bring completely different stabilities to force bearing object. After receiving the tension F, the object would move along the tension direction, with clear and stable movement direction; while after receiving the thrusting force F, the object would easily have direction deviation, with the uncertain movement direction and easy instability (as shown in figure 2).

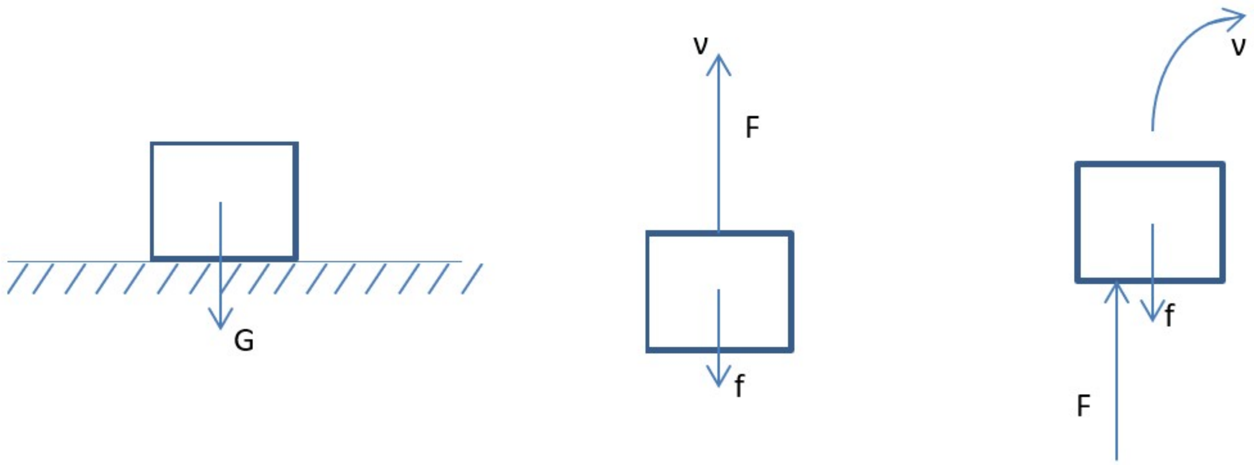

Figure 2. Influence of Tension and Thrusting Force on Stability of Force Bearing Object

2) Influence of Tension and Thrusting Force on Strength and Quality of Force Bearing Object

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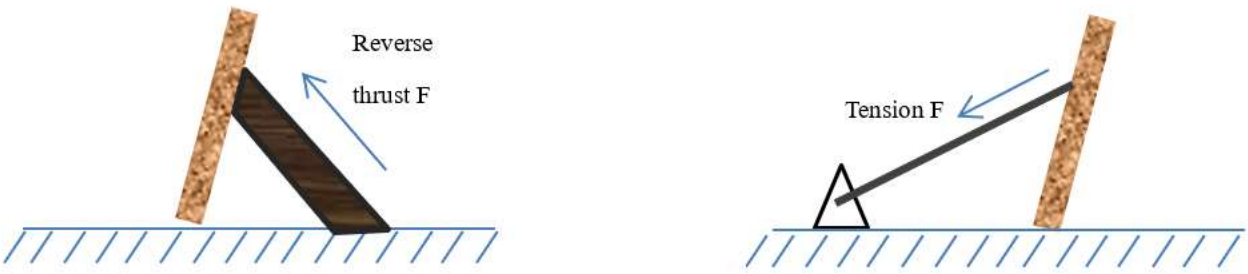

Figure 3. Influence of Tension and Thrusting Force on Strength and Quality of Force Bearing Object

Assuming one wall would collapse, we often adopt two kinds of practices: First, the collapse side can be supported; Second, the other side can be equipped with one traction device to pull the collapse side (as shown in figure 3). Obviously, such two methods can prevent wall from continuous collapse. We emphasize in researching the difference of support device and traction device. Then we find, for the traction method, only one wire rope is used as traction device to solve the problem perfectly; for the support method, the support shall have bigger size and higher strength, and may be ten times or hundred times larger than the wire rope section. Otherwise, the support may deform and then may be overwhelmed.

4. Flight Characteristics of Existing Aircraft

1) Fixed wing aircraft, such as civil aviation passenger plane: flight height of 5000-10000m, and speed of 500-800km/hour. The civil aviation passenger plane usually adopts fixed wing jet-propelled engine, with large load capacity, rapid flight speed and high maneuverability. Aircraft isn't hindered by high mountain, river, desert and ocean ship. It is safe and comfortable, with relatively smaller influence by weather and high safety factors. But the fixed wing aircraft must adopt the sliding acceleration or deceleration to take off and land, which is deemed as its chief drawback. Therefore, it is severely restricted by take-off and landing site and can't be popularized like automobile.

2) Spiral wing aircraft, such as helicopter: flight height of below 10,000m and the speed of about 0-300km /hour. One or many large-scale horizontal rotation power engines provides the lift force for helicopter which has the following strengths: vertical ascending and descending, hovering in the air, low-altitude, low-speed or backward flight. But the helicopter is driven by unconstrained free space screw powered engine, its flight is severely restricted and influenced by the air side flow and turbulent flow, with difficult driving, and the security can't be guaranteed. It can't be promoted as civil aircraft.

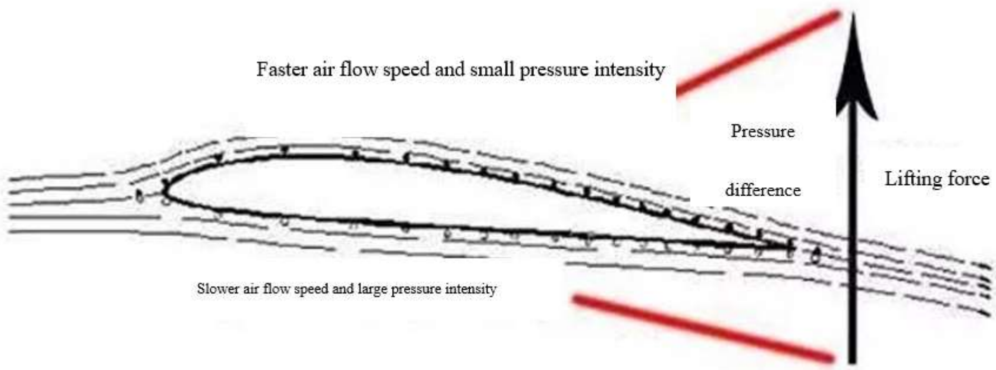

Figure 4. Explanation of plane flight principle with Bernoulli's Principle

3) Limitation in explanation of plane flight principle with Bernoulli's Principle

From the perspective of modern aeronutics, the aircraft rises as per the Bernoulli's Principle, namely the larger the fluid's flow velocity is, the smaller its pressure intentity is; The smaller the flow velocity is, the stronger the pressure intensity is (as shown in figure 4). The aircraft's wing, like the shape in figure 7, can make the flow velocity below wing lower than that above wing, and their pressure intensity difference (namely the pressure strength below wing is higher than that above wing) can improve the flight lift force of aircraft. The pressure intensity difference (or lift force) is related to the advance rate of aircraft. The larger the advance speed of aircraft is, the larger the pressure intensity difference and lift force is. So aircraft must move ahead at high speed upon take-off in order to rise to sky. When aircraft needs to fall, it only needs to reduce the advance speed, then its lift force would naturally decrease and is less than the weight of aircraft, then it would land.

The lift force in Bernoulli's Principle can't sufficiently explain the flight principle of aircraft, which isn't narrated in addition in this paper. But we all recognize that the aircraft flight must be based on certain speed, and the thrusting force is necessary. The air is pushed and air's counter-acting force drives the aircraft to obtain the flight power so that the aircraft can obtain speed.

5. About Bird Flying

Birds' body structure gets the amazing flying ability after the long evolution for one hundred million years, and their flapping-wing flying capability has surpassed the existing fixed wing and rotor wing aircraft in many aspects. In recent decades, various countries have also researched the bird wings' motion trajectory, flapping frequency, change of flow field around wings, wing change rules, etc. Opinions vary in terms of the bird flying principle. The bird flying experience is summarized comprehensively and systematically the first time after research for many years, and the bird flying mechanism is mastered clearly, which would inevitably bring the revolutionary change to the bionics development of flapping flying.

1) Structure of bird feathers

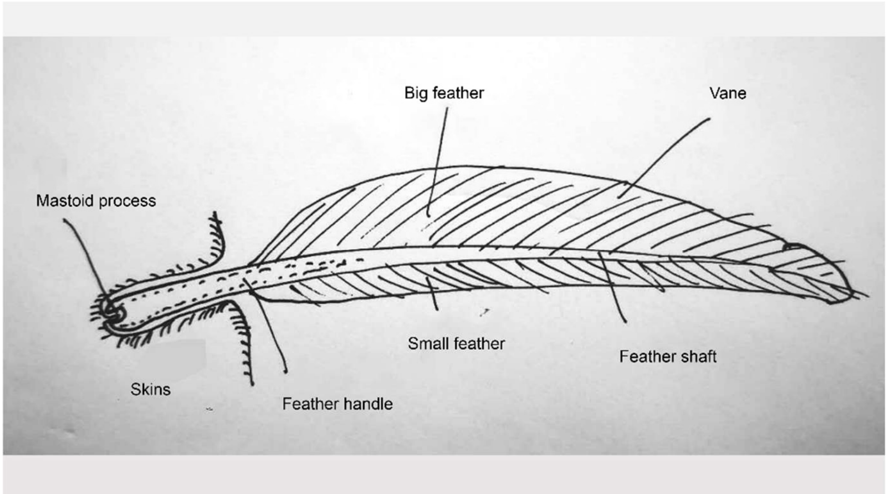

Figure 5. Structure of Bird Feathers

For the birds flying in the air, their flying efficiency shall be guaranteed, which is deemed as one of the most important problems. So birds shall perceive the airflow, even shall accurately perceive the airflow speed and direction as well as the current location's air pressure, altitude, etc. Their feathers just can accurately perceive the air. As everyone knows, bird body is covered with soft and compact feathers to keep the body temperature in flying on the one hand and to reduce the air friction in flying due to special structure of feathers on the other hand. The feather handle is hollow (as shown in figure 5), the air in hollow part and the feather handle are a standard barometer in fact. Due to the change

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of external pressure intensity or the bending of feather, the feather handle tube is flattened and the internal air pressure changes, thus measuring and perceiving the change of external air pressure.

In the bird flying process, the air in hallow part of feather handle would expand or be squeezed with the change of flying height, thus causing the change of internal air pressure; Besides, in the wing flapping, the bending of feathers causes the feather handle tube is flattened and internal air pressure changes. Birds can pass the signal about air pressure change to neurons sensory cells of mastoid process head of feather root, and calculate and judge the environment air's flow direction, flow velocity, air pressure, altitude, etc., thus judging the air lifting condition. Birds don't collide with each other in flying just because their feathers can accurately perceive and judge the air flow field. The eagles and seagulls just judge the ascending air current and downdraght through the feathers to achieve rotation and climbing in ascending air current without flapping wings; While the common birds accurately calculate the wing flapping frequency by judging air pressure to achieve the steady and quick flying.

2) Wing structure of birds

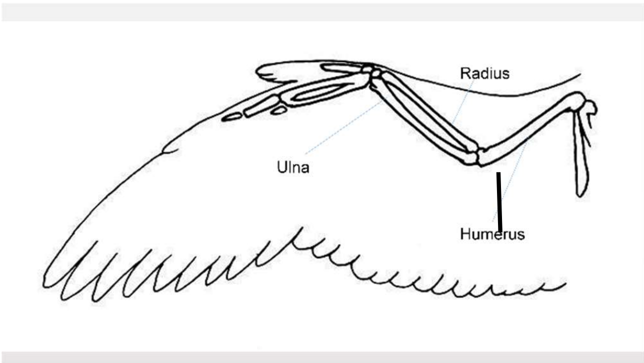

Figure 6. Wing Structure of Birds

a) Wing structure of birds A depression is formed at the humerus, radius, ulna (as shown in figure 6) and wing end of the wing, would form the air column on the side away from the body when finishing the pressing action in flying and jointly form a high-pressure air pavilion on the side close to body and the body. The air column generates the lifting and forward pushing action to the wings, while the high-pressure air pavilion can directly push body upwards and forwards.

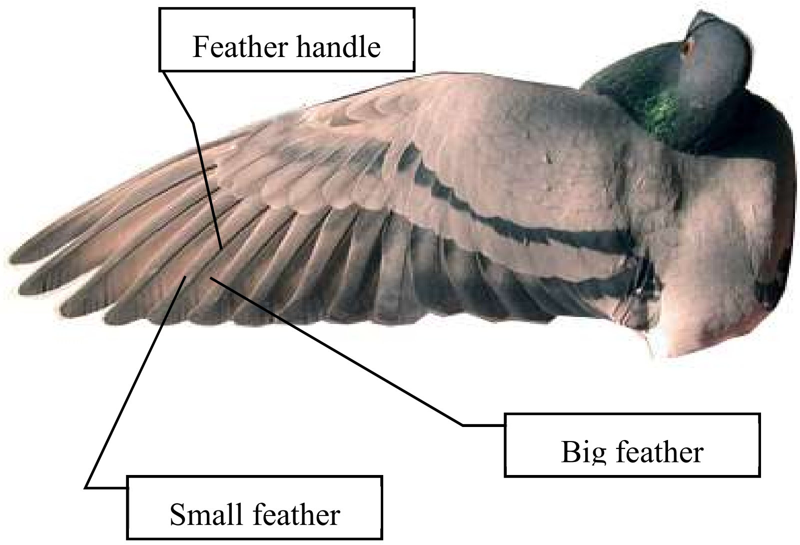

Figure 7a. Position of Birds' Big

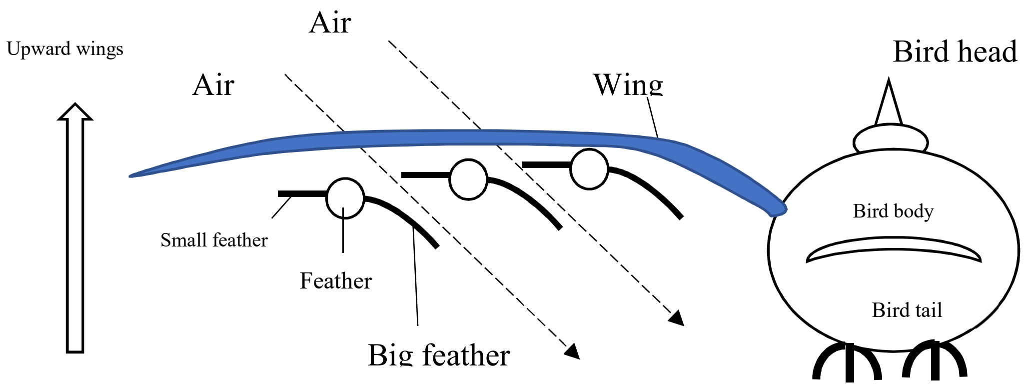

Figure 7b. Big Feather and Small Feather Form Air Gap When Birds Rise Wings To Import Air To Downside of Body

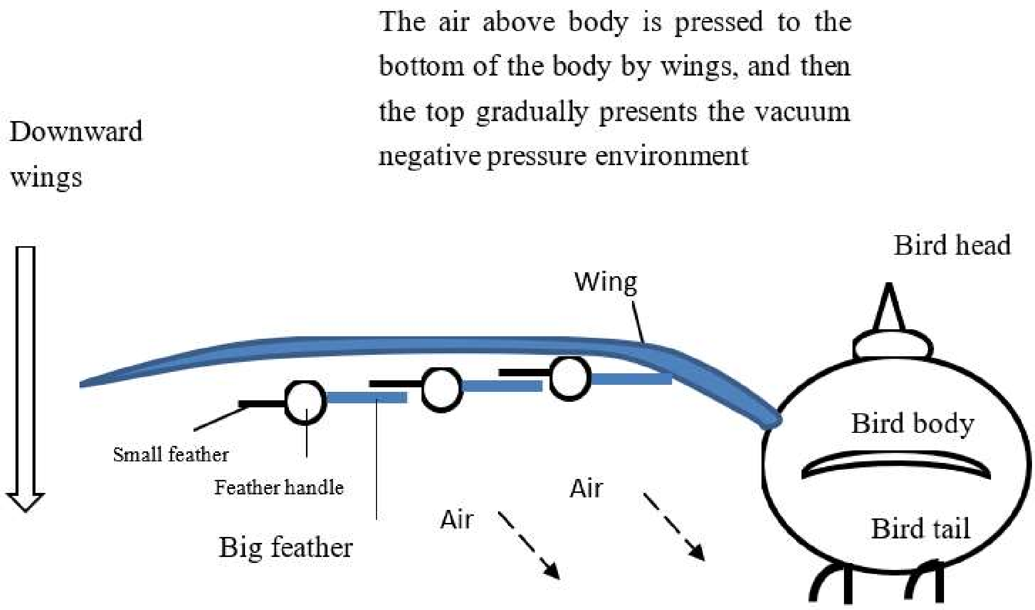

Figure 7c. Big Feather and Small Feather Form Closed Form in Case of Downlink Wings To Squeeze Air toward the Bottom of Body

b) Upward wings: When birds lift wings upwards, the big feather on the side close to body bends downwards under the role of same air thrusting force, and forms an airway with the adjacent small feather. The channel leads air to flow toward the lower body side of bird (as shown in figure 7-1 and 7-2) to form a high-pressure air column below body. When the high-pressure air column is formed below body, its counter-acting force makes wings naturally expand and lift; Besides, the vacuum negative pressure section flapped by wings above back causes the wings naturally lift upwards. Wings lift very easily through coordination of such two strengths, and in the lifting process, feathers form many diversion channels. As a result, birds need to overcome small resistance force. Based on conventional thinking, the lifting needs to overcome gravity and air resistance, so it is deemed as the action with the most energy consumption. But for birds, such process is very labor-saving and most time-saving. Besides, from the perspective of birds' body structure, the lifting muscle group is relatively small and simple.

c) Downward wings: Karman Vortex Street theory is time-tested in fluid motion, and is also suitable for the bird flying: When the two wings lift to the top position, they also fit together and start pushing (as shown in figure 7-3). At this time, big feather closes all air channels, and two closed concave wings press at the same time. As mentioned above, in the lifting process of wings, they have formed high-pressure section closing to the below part of body, and have formed the vacuum negative pressure section above the back. The air pressure below the wings grows due to wings pressing, in this way, the increasing air pressure reaches a kind of dynamic balance with the gravity and the lifting force needed for flying speed. In the meanwhile, we observe and find the pressing action duration of bird wings is longer than the lifting action duration in the whole flying process and is more homogeneous. The lifting action and pressing action of wings are just like the stroke of engine cylinder, in which the pressing action means the work of compressed air of cylinder end, and the lifting action means the air combustion and expansion. The expanded air conducts work of the cylinder head, and the process is strikingly similar to the air pressure condition. The pressing needs greater force to form high-pressure air column. The negative pressure of air is formed on the back, based on which the wings lift, with very small resistance. So the birds' chest muscle is developed, while the back muscle isn't developed. That's why we never see birds fly with the back downward.

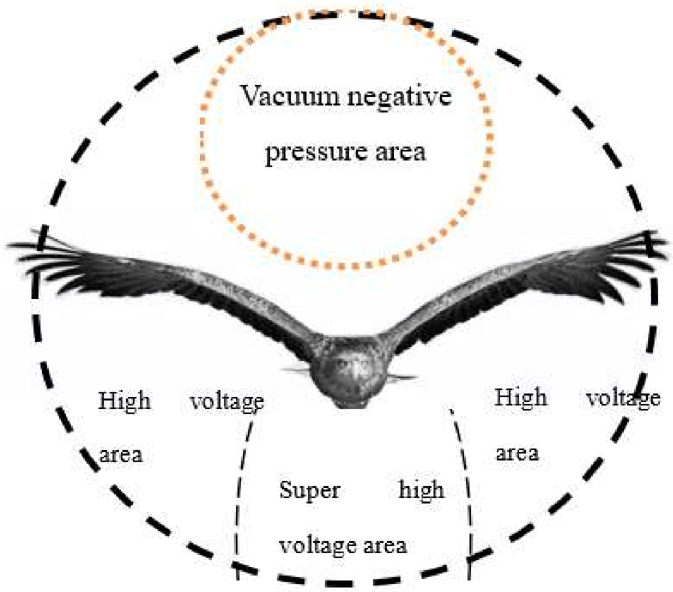

Figure 8. Air Tunnel of Bird Flying

3) Premise for continuous and steady flying of birds

Continuous flying requires the steady flight channel, just as ground traffic needs smooth and flat road surface, because the bumpy ground surface would inevitably result in the bump in driving process. In flying process, birds form flying wind tunnel (as shown in figure 8) with negative-pressure tension on back side and high-pressure backstepping on veutro around their bodies through frequent up and down reciprocating motion of wings. This wind tunnel generates a continuous upward pull-up on the back of birds, and generates a continuous upward thrusting force on the lower abdomen of birds so that the bird body can keep forward smoothly all the time. Due to the air pressure change of their feather handle, birds can perceive whether such wind tunnel is steady or not. In this flying wind tunnel, birds can fly freely.

However, there is a mysterious phenomenon in flying process for many experts and scholars, namely the faster the flying speed is, the slower the wings flap. In common sense, the faster the flying speed is, the faster the wings flap. In fact, we neglect the "speed". As mentioned above, the humerus, radius, ulna and wing end of the wing would form a depression. In the air flow field, for the objects at faster speed, the air field is closed to the rigid body. Therefore. For a flying bird at extremely fast speed, it flaps wings and presses the air approximate to rigid body with wing depression, such powerful effect is equal to the counter-acting force obtained by use after pushing the wall on roadside with hands.

6. Vacuum Negative Pressure Tension as Driving Force is Deemed as the Effective Method to Reduce Aircraft Size and Improve Aircraft Safety

1) Enlightenment of birds flying

Due to the special structure of birds' wings and feathers, the air tunnel is formed where vacuum negative pressure on the back pulls up and the abdomen is lifted by high pressure upon wing flapping so that birds can fly easily in air. The high pressure of abdomen and the pull-up of back efficiently overcome the gravity, and provides sufficient power for the bird flying. We also find that just due to the special structure of wings and feathers, birds can't fly with abdomen upwards, otherwise, the lifting force and gravity would be overlaid in the same direction. In the meanwhile, just because birds skillfully apply the pull-up strength of vacuum negative pressure, the flying conforms to the tension requirements in stability and structure of objects; The flying is more stable and the link structure is more compact.

2) Stable and reliable aircraft shall cleverly utilize vacuum negative pressure for pull-up

The existing flight adopts positive pressure startup and pushing as kinetic propulsion mode, which proposes very high requirements to the strength and stiffness of flying body. Therefore, it is very common that most aircrafts weigh dozens tons, even several hundred tons. As mentioned above, such structure and propulsion mode easily result in instability, so the control technology and automation level are highly required. If the aviation thrusting force is changed into tension or air traction force, just as birds' body structure and flying skills, the aircraft's stability would become higher and the aircraft has smaller requirements in structure and strength due to more definite and stable traction force direction.

7. Product Suitable for Human Personal Flight Times

The spiral wing aircraft helicopter is favored by aircraft researchers due to its superior characteristics such as the take-off and landing on the spot, hovering in the air, etc. In recent years, due to the rapid development of flight control technology, the multi-axis spiral wing aircraft evolving from helicopter has obtained unprecedented development and has also tended to be bloomy. But it is most regrettable that such form of aircraft can't avoid a fetal limitation regardless of evolution: that is, its flight severely restricts the influence of air side flow and turbulent flow around aircraft, with difficult driving, and the flight stability and security can't be guaranteed.

We can imagine a kind of aircraft which can take off and land at will without special runway at 800km/hour and 0-3,000m altitude, can hover in the air and shuttle back and forth among urban buildings at random, without worrying the influence of air side flow and turbulent flow. Based on that imagination, we conduct the reverse research on the existing aircraft's outline and power source. But regrettably, no aircraft can meet these requirements. One shape outline occurs time and time again: dish-shaped aircraft. The top of dish structure can create the vacuum negative pressure pull-up, the bottom can achieve the airblast backstepping, and the surrounding streamline machine body can effectively cope with the influence of side flow or turbulent flow. So it is almost the unique selection. A kind of design scheme of annular wing dish-shaped aircraft with vertical take-off and landing and hovering which is more suitable for civil personal popularization and promotion can be designed. Such aircraft is composed of the oval frame, cab, passenger cabin, power cabin, annular wing, flight control system, etc. (figure 9 and figure 10). It owns the upward vacuum negative pressure tension and the thrusting force of air backstepping. The aircraft as mentioned can show the completely different flight ability by matching the existing aircraft power unit with different specifications and models.

The aviation shall solve the following primary issues: how to obtain the lift force needed by the aircraft, reduce the resisting force of aircraft and improve its flight security performance. The aircraft

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appearance adopts the oval dish structure which is the optimal outline structure for flight in air flow field and can solve the above three problems perfectly. First, the lift force needed for flight has been expounded in details, so it isn't repeated excessively; Second, the structure generates the minimum disturbance of the air flow field and the minimum air resistance in flight process; Finally, such structure owns relatively reliable flight security performance. It can achieve the vertical take-off and landing of multiaxial spiral wing power aircraft, hovering at a fixed height, etc., and the multiaxial spiral wing power aircraft's flight attitude is almost not influenced by the air side flow and is more stable and reliable; The aircraft in this paper also owns the flight speed which can be achieved by the aircraft with fixed wing duct, its flight energy consumption is far less than the existing aircraft with fixed wing duct, and its take-off and landing doesn't need the runway. All of them are the necessary characteristics of universal aircraft.

For the annular wing dish-shaped aircraft with vertical take-off and landing and hovering, its longitudinal section is an ellipsoidal structure (as shown in figure 10), and the outer surfaces of upper and lower body of oval structure are two dished disks. The cab is set in the center of upper dished disk and stands out in the upper dished disks so that the driver can observe the surrounding environment. Below the cab is the engine room set, which can offer large space to take passengers or cargos. The annular region around the cab and engine room can be used to set up the aircraft power unit. In the annular region, several smooth channels are evenly distributed in the central axis of the aircraft. In the channel, the corresponding quantity of motors can be set as per the aircraft's load and own weight as well as users' requirements in aircraft performance. In general, 3 or above power mechanisms can be set and evenly distributed in the aircraft power device area. For the patent in this paper, the aircraft's structural characteristics and flight principle are expounded based on 4 power mechanisms as examples. The power mechanisms provide flight power for the aircraft in the method of inhaling air inwards through upper mouth and injecting air downwards through lower mouth. The annular wing of aircraft is outside the area of the aircraft power unit. The annular wing changes the lift force or inverse lifting of air by downwards extruding, upwarping or hiding flange, thus achieving the lift-off, landing or horizontal flight in the flight process (figure 11).

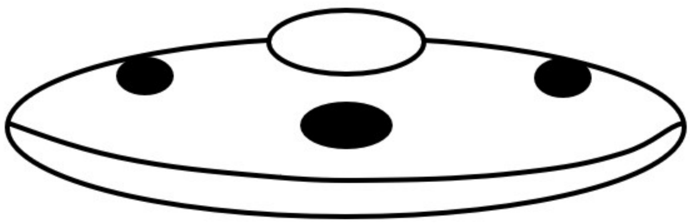

Figure 9. Appearance of Four-power Annular Wing Dish-shaped Aircraft with Vertical Take-off and Landing and Hovering

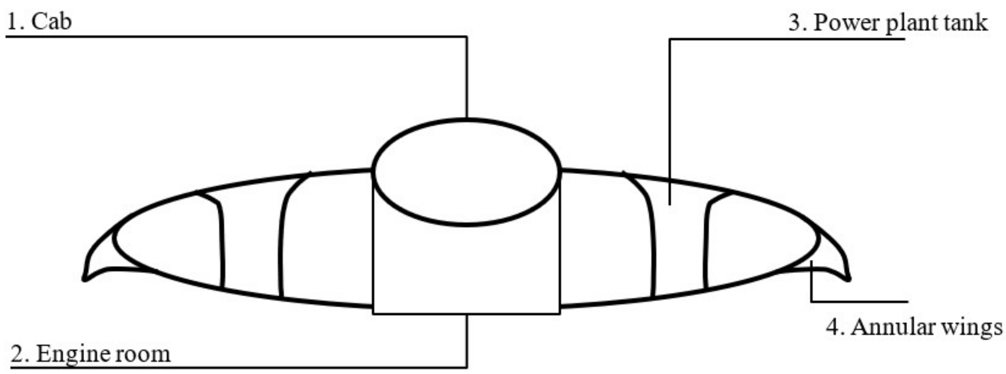

Figure 10. Each Function Structure of Aircraft

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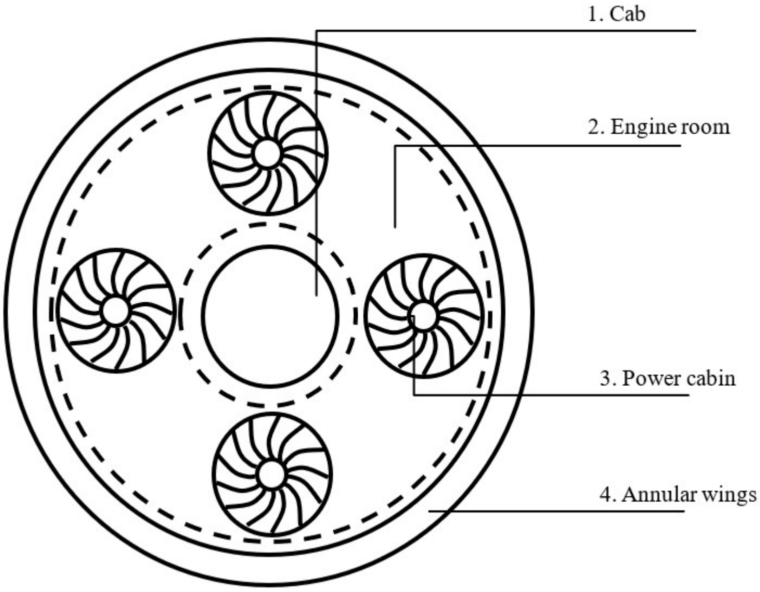

Figure 11. Division of Each Functional Zone of Aircraft

8. Technical Requirements of Butterfly-type Aircraft

The development of flight control system of butterfly-type aircraft implicates many disciplines and many subjects. Engineers from many departments shall coordinate work, and research and development team shall master the professional knowledge in many fields such as control theory, aerodynamics, flight mechanics, structural mechanics, simulation and modeling, embedded development, hardware design, etc. Besides, different from traditional UAV, personal butterfly-type aircraft pays more attention to the management of power battery, management of real-time flight speed (including the speed of aircraft in flight direction, and the rising speed and decline speed in vertical direction, etc.), management of acceleration set to ensure the driving comfort, management of parameters such as air pressure, temperature, oxygen contents, etc. of cab and passenger cab, management of escape in critical situation, etc. The accurate management of those parameters must be based on the precise calculation of computer, big data system of internet, more advanced algorithmic logic, etc. Currently, there are few enterprises which own solution of UAV flight control technology and are worth learning, such as DJI WooKong series, Naza series flight control system, ZERO TECH's dual-redundancy safety flight control system, XAG's SUPERX and MINIX flight control system, etc.

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