

A. F. ZAHM.
 HOVERING AIRPLANE.
 APPLICATION FILED JAN. 22, 1919.

1,401,934.

Patented Dec. 27, 1921.
 2 SHEETS—SHEET 1.

FIG. 1.

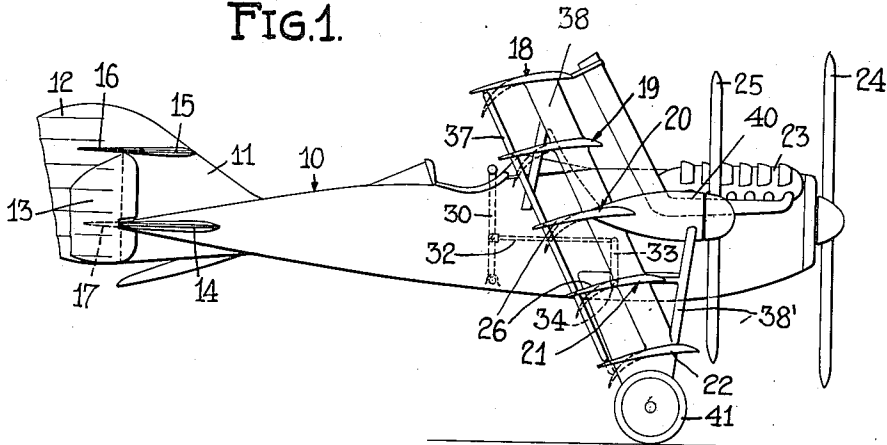


FIG. 2.

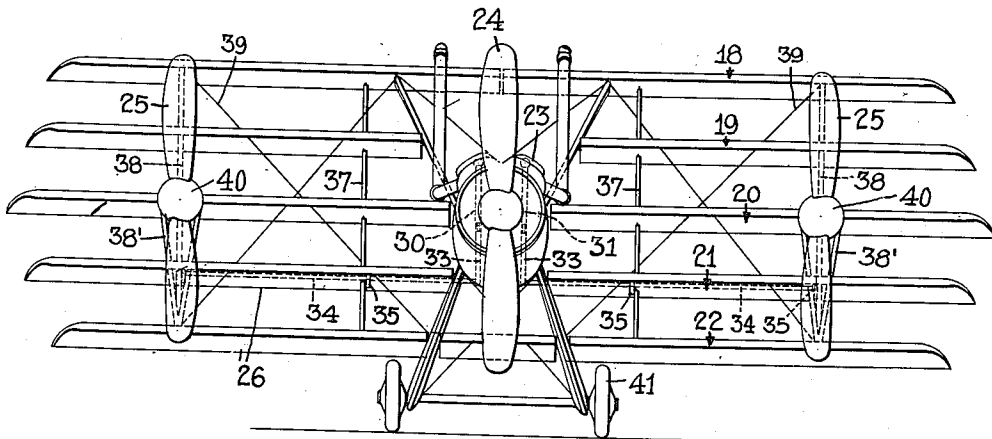


FIG. 5.

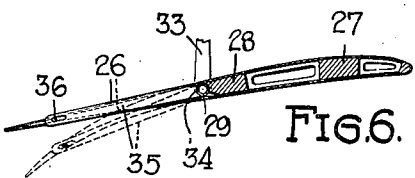
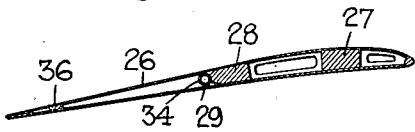
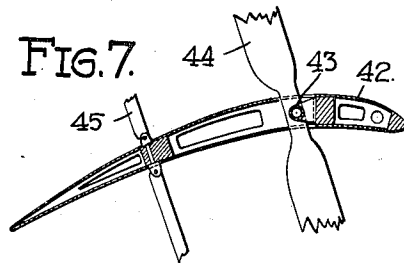


FIG. 6.

FIG. 7.



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2 SHEETS—SHEET 2.

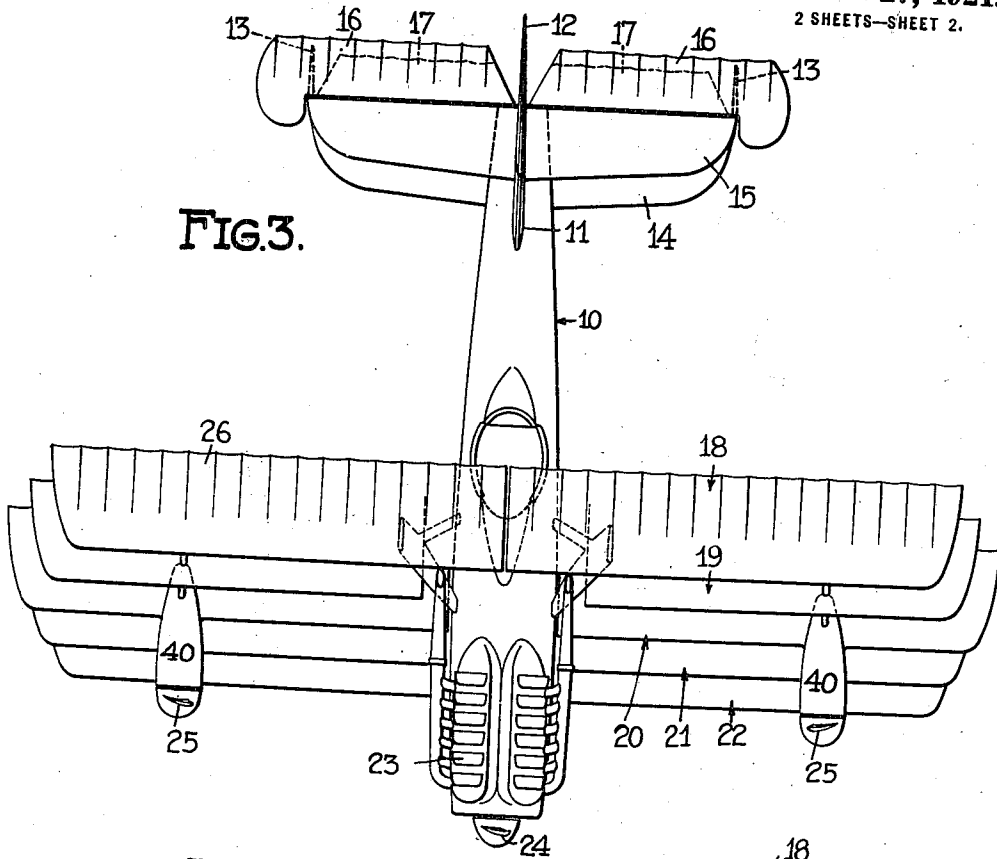


FIG. 3.

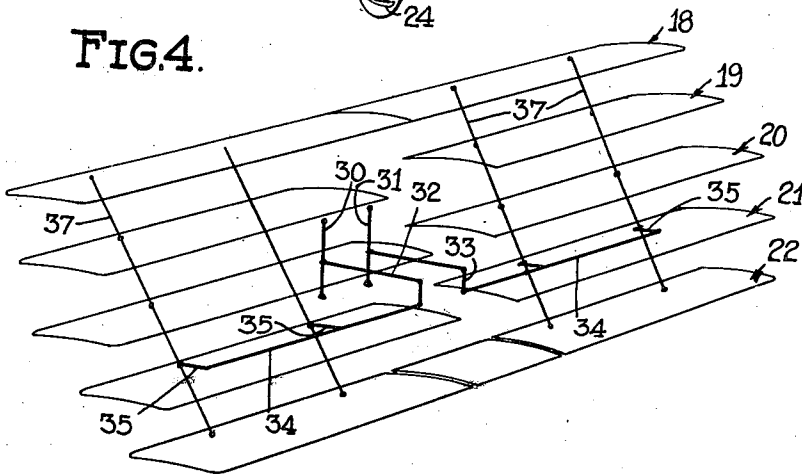


FIG. 4.

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UNITED STATES PATENT OFFICE.

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HOVERING AIRPLANE

1,401,934.

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Application filed January 22, 1919. Serial No. 272,558.

To all whom it may concern:

Be it known that I, ALBERT F. ZAHM, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Hovering Airplanes, of which the following is a specification.

My invention relates to airplanes of the "hovering" or "vertical lift" type and is an improvement upon the machine disclosed in application Serial No. 185,488 filed by me August 10, 1917.

Instead of deriving direct or nearly direct vertical lift from propellers operating in a true horizontal plane, as in a helicopter, such lift is derived through the reaction of the air (deflected from its course as defined by the propellers) upon a wing section especially adapted to that purpose—the propellers meanwhile rotating about substantially horizontal axes or in an approximate vertical plane. This downward reaction of the air may be secured in several ways. The leading edge of the airplane wings, for instance, may be pivoted and the wings in consequence given a very large angle of incidence, or, if desired, the wings may be given a flexible or pivotal trailing edge portion and heavily cambered. The result in each instance is identical, *i. e.*, the propelling force realized from the propeller or propellers is converted into vertical lift by the deflection of the propeller airblast in an approximate downward direction through its reaction on the biased or deeply cambered wings.

Another characteristic of the invention is the mounting of the airplane wings in superposed relation and one aft or slightly to the rear of the other as they progress rearwardly and upwardly from the lowermost wing. This arrangement increases or enhances the aero-dynamical efficiency of the wings by eliminating the blanketing tendency apparent when the wings are forwardly staggered or directly superposed with the result that there is no interference whatsoever between the superposed wings.

The wings (referring to the opposed groups rather than the individual wing) at opposite sides of the longitudinal axis of the craft are independently movable and may be shifted sufficiently to laterally balance the machine by increasing or decreasing the lift on either side. The use of ailerons is thus avoided. Moreover, as a result of

such adjustment the angle of incidence of the wings can be lessened to three degrees positive or even less and lift obtained by reaction of air thereon in the usual manner; the machine under such circumstances being operated as an airplane of the conventional type.

The advantages of a machine of the type disclosed are many. It may be launched into the air without even the slightest preliminary run and after reaching a safe altitude may be converted into a true airplane by flattening out or rather decreasing the angle of incidence of its wings. It can be flown, when once in the air, nose up, and made to climb vertically or nearly so, the thrust effort realized from the propellers being sufficient to secure the required lift. As a military craft it possesses both the advantages of a helicopter and the advantages of an airplane, although helicopters, up to this time have been impractical due to a lack of horse power per unit of weight. To hover or remain stationary while in mid-air it is but necessary that the motor be throttled down until the force of gravity and the lift force are equilibrated and the wings manipulated until the angle thereof satisfies the above conditions. Hovering action is possible in either of its positions of flight for the reason that the lift force is sufficient, whether flown as an airplane (keel horizontal) or as a helicopter, to counter-act the gravitational force. Longitudinal trim, while climbing vertically or at a steep angle, with the fore and aft axial line of the fuselage horizontal, is secured through manipulation of the rear controls, *i. e.*, the elevator flaps; as it is proposed to so position the rear control surfaces that the slip stream or air-blast from the propellers acts or rather reacts directly upon them regardless of the position or attitude of the machine. The structural advantages derived as a result of the relative arrangement of the airplane parts and in consequence of the specific arrangement of the several aero-foils will be hereinafter more particularly pointed out.

My invention consists in the novel features and combinations of parts herein described by way of example in their preferred embodiments, and the invention is more particularly pointed out in the appended claims. Further objects and advantages of the invention will more fully appear from the

following description taken in connection with the accompanying drawings.

Of the drawings, wherein like characters of reference designate like or corresponding parts;

Figure 1 is a side elevation of the improved machine illustrated diagrammatically.

Fig. 2 is a front end elevation.

Fig. 3 is a plan view.

Fig. 4 is a diagrammatic perspective view showing the wing control.

Fig. 5 is an enlarged cross sectional view of one of the wings (flattened out).

Fig. 6 is a similar view, the position of the trailing edge portion of the wing, when biased, being indicated in dotted lines, and

Fig. 7 is a further cross sectional view illustrating a modified form of wing.

The fuselage or body of the craft, designated as 10 is streamlined throughout and at its tail end is equipped with an empennage of more or less conventional form. The empennage consists of a vertical fin 11, main

rudder 12, auxiliary rudder 13, main horizontal stabilizer 14, auxiliary horizontal stabilizer 15, main elevator flap 16 and auxiliary elevator flap 17; the stabilizer surfaces 14 and 15 being negatively staggered and

superposed. The main rudder 12 is mounted in direct rearward continuation of the stabilizer fin 11 and the auxiliary stabilizers 15 respectively at opposite sides thereof.

The location of the auxiliary rudders is such that the rudders collectively (also elevator flaps) operate in the direct path of the propeller slip stream as defined by the central propeller.

Nearer the forward end of the fuselage than the rear end a number of superposed supporting surfaces or wings are mounted. These wings, designated respectively 18, 19, 20, 21 and 22 are superposed and located one slightly aft of the other as they progress upwardly from the lowermost wing.

Although of a given profile or cross sectional form (normally) the wings, collectively may be warped or biased to an extent deemed sufficient to deflect the air-blast from the

propellers vertically or nearly vertically downward whereby an upward force is exerted upon the wings. The propellers of which there are preferably three are arranged symmetrically at opposite sides of

the fore and aft axis of the machine and centrally thereof, the field of the several propellers being substantially equal (see Fig. 2) to the total area of the wing structure as measured from top to bottom and tip

to tip. In other words, the arrangement of the propellers is such that the total supporting surface area lies in the slip stream thereof.

The several propellers are preferably driven by a single power unit designated as

23 inclosed, for the major part, in the forward end of the fuselage 10. The central propeller 24 is directly driven by the power unit or motor 23 and side propellers 25 indirectly driven by suitable transmission of the gear and shaft type. The central propeller it will be noted, is mounted somewhat ahead of the side propellers for the reason that the air-blast of the side propellers is relied upon for the derivation of the vertical lift to a greater extent than the central propeller 24. Accordingly the side propellers are mounted in closer proximity to the leading edges of the several wings.

By negatively staggering the supporting surfaces or wings a blanketing of the air is eliminated and each wing made to exert a maximum of lift. The wings, or rather the supporting surfaces (see diagrammatic view, Fig. 4) preferably consist of separate panels, to wit; a central panel (only the center panel of the lower wing as herein illustrated) and opposed outer panels. The

outer panels of each wing or supporting surface are provided with flexible trailing edge portions 26 while the trailing edge portions of the central panel or panels are fixed. The wings throughout are founded upon wing beams 27 and 28 of suitable design. The rear wing beams of the several

wings carry the trailing edge portions 26 to which they are pivotally secured as at 29.

In the flight of the machine as an airplane the trailing edge portions of the several wings extend rearwardly in substantially streamline prolongation of the main body of the wings or in lateral continuation of the fixed trailing edge portions of the central panels. When it is desired that the thrust value of the outer propellers or rather the force derived from the rotation of the propellers in the vertical plane be converted into direct vertical lift, the flexible or movable trailing edge portions of the wings are biased or moved to the angular positions indicated by dotted lines in Fig. 1 with a result that the air stream reacting upon them is deflected downwardly. This deflection of the air-blast of the propellers converts the thrust or at least the greater portion of the thrust into direct or substantially vertical lift.

To maintain the equilibrium of the machine fore and aft while operating under the conditions above outlined the rear control surfaces are positioned as indicated, *i. e.*, directly to the rear of that portion of the wing structure characterized by an absence of adjustable or movable wings. The mid section of the wing structure being non-adjustable obviously the air-blast from the propellers is unaffected whereby the rear controls are rendered effective as controlling agents under all conditions of flight. In other words, by subjecting the rear controls

to the full air-blast of the center propeller at all times their operativeness is assured.

The mechanism for flexing or controlling the angularity of the adjustable wing sections comprises separate control levers 30 and 31 conveniently inclosed within the fuselage, in close proximity to the pilot's seat. Each lever is directly connected by a rod 32 and lever 33 with a shaft 34 inclosed in one of the wings of the particular group which the individual levers 30 and 31 control. The shafts 34 are preferably inclosed in the supporting surfaces 21, one in each wing thereof and extended throughout the greater portion of their length. At intervals throughout the length of each shaft rearwardly extending arms 35 are provided. These arms are rigid with the shafts and connect with trailing edge strips 36 inclosed in the wings 21 at or near their trailing edges. Accordingly in operation the levers 30 and 31 are moved, the shafts 31 turned, the arms 35 swung downwardly, and the wings proportionately biased (see Fig. 6) for simultaneously flexing all of the wings of the opposed groups. The several trailing edge sections of each group are interconnected as indicated at 37 in Fig. 4. The rigid connection between the superposed wings may be effected by wing posts 38 and wiring 39 in the ordinary manner.

In order that the vertical field of the propellers 25 may lie in a vertical plane slightly ahead of the wing structure a special form of engine bed mounting is provided. Inverted triangulated V-supports 38' are erected upon the lower supporting surface 22 at or near the ends of the wing structure. These supports constitute an adequate mounting for the transmission (not shown). To decrease the head resistance in flight as a true airplane the transmission mechanism is inclosed in streamline casings 40 at the forward ends of which the propellers 25 are disposed.

The landing gear 41 may be of any well known character although it is preferred that the struts be streamlined as a unit and arranged to diverge downwardly from the fuselage slightly ahead of the center of gravity of the machine. Preferably the center of gravity of the machine is located slightly to the rear of the resultant center of lift whereby in climbing vertically on an even keel the elevator flaps are given a positive angle to exert sufficient lift to properly elevate the tail.

In the modification illustrated in Fig. 7 the wing 42 is deeply cambered and made variable by pivoting it as at 43. The wing is supported by struts 44 and controlled by any suitable means. The interconnection between the wings indicated at 45 is for the same purpose as the intersection indicated at 37 in Fig. 4. By heavily cambering

the wing the same result is obtained as by displacing the trailing edge portion downward in the manner indicated as the preferred arrangement. The air-blast of the propeller is deflected from its course as defined by the propeller with the result that direct or nearly vertical lift is obtained rather than forward thrust, the thrust being neutralized by the drift.

A machine of this character may be launched from and landed upon the deck of a ship as well as from the roof of a building. It may be launched straight into the air in a confined space so that the value of the machine from a military point of view as well as from a commercial aspect is increased. If desired, when once in the air the nose end of the machine may be tilted up by manipulation of the rear controls and the machine flown as a helicopter, sufficient lift being derived from the separate propellers to obtain this end. The power plant should of course be sufficiently light per unit of horse power to make the machine a practical success and as the development of such aeronautical motors possessing the above characteristics has already taken place the machine is entirely practical in every respect. In lieu of ailerons for maintaining lateral equilibrium of the machine the opposed groups of wings are operated to increase the lift value on that side of the machine tilted down. Other mechanism may of course be installed. The arrangement of the supporting surfaces one above and to the rear of the other prevents the deflected air from the upper from coming down upon the top surface of the next wing beneath and accordingly eliminates all tendency to blanket the air. The degree of negative stagger however is immaterial since it is only necessary to remove the superposed wings longitudinally to a slight extent.

While I have described my invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art after understanding my invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. I aim in the appended claims to cover all such modifications and changes.

What is claimed is:

1. In an airplane, the combination, of a plural number of propellers, the axes of the propellers being horizontal, curved supporting surfaces including adjustable and fixed wing panels, the adjustable wing panels being movable into positions whereby the propeller air-blast is deflected downwardly with the result that sufficient vertical lift is obtained to bodily lift the machine into the air without altering its flying attitude and without altering the angular relation of the propeller axis to the horizontal, together with a control surface for maintaining the

machine in longitudinal trim, the location of the control surface relatively to the fixed wing panel being such that the propeller air-blast successively impinges the fixed wing panel and the control surface under all flight conditions.

2. In an airplane, the combination, of a propeller, a curved wing designed to deflect downwardly the propeller air-blast, the degree of deflection being such that the thrust value of the propeller operating in a substantially vertical plane is converted into approximate vertical lift, a second propeller, a comparatively flat wing section arranged directly behind said second propeller, and a control surface so arranged relatively to the flat wing section and to the second propeller that the air-blast from the propeller acts successively upon the flat wing section and the control surface under all conditions of flight.

3. An airplane including in combination, a superposed tier of negative staggered supporting surfaces, at least one of the supporting surfaces comprising a rigid wing section and a non-rigid wing section, the non-rigid wing section of each wing being sufficiently elongated transversely of the machine to extend substantially throughout the full length of the supporting surface, a plural number of vertically rotating propellers so arranged relatively to the supporting surfaces that the major portion of the area of the total number of the surfaces lie in the propeller slip stream, means for rotating the propellers, and means for adjusting the angular relation of the non-rigid wing section to deflect the air blast of the propeller in a substantially vertically downward direction.

4. In an airplane, a supporting surface comprising a relatively small rigid and relatively large non-rigid wing sections, a propeller arranged to direct its air-blast over the rigid section of the wing, a plurality of propellers arranged to direct their air-blast over the non-rigid section of the wing, and means for biasing the non-rigid wing section to deflect the air-blast of the second

mentioned propellers in a substantially vertically downward direction.

5. In an airplane, a fuselage, a motor enclosed in the fuselage, a propeller, a wing structure including a comparatively small rigid and comparatively large non-rigid wing sections, the rigid wing section being so related to the propeller that the air-blast thereof bathes its surface, directional control surfaces located to the rear of the rigid wing section, said surfaces being also bathed by the air-blast of the propeller under all conditions of flight and additional propellers arranged out laterally from the fuselage at opposite sides thereof, the arrangement of said last mentioned propellers being such that the non-rigid wing sections follow in the slip stream thereof.

6. In an airplane, the combination, of a plurality of negatively staggered superposed supporting surfaces, one of said supporting surfaces comprising a relatively small fixed center panel and comparatively large divided outer panels, the line of division between the sections constituting said outer panels being extended longitudinally of the wing structure, means for deflecting the trailing sections of the outer panels downwardly, a central propeller, a directional control surface, the relative arrangement of the central propeller and the directional control surface being such that the slip stream of the propeller impinges successively the center panel and the directional control surface under all flight conditions, side propellers, the relative arrangement of the side propellers to the outer wing panels being such that the propeller slip stream impinges successively the forward section and the adjustable trailing section of said outer panel, means to bias the trailing sections of said outer panels downwardly to such an extent as to direct the propeller slip stream substantially vertically downward, and means to drive the propellers.

In testimony whereof I hereunto affix my signature.

ALBERT F. ZAHM.