Dec. 31, 1946. D. W. MAIN 2,413,460

AIRPLANE

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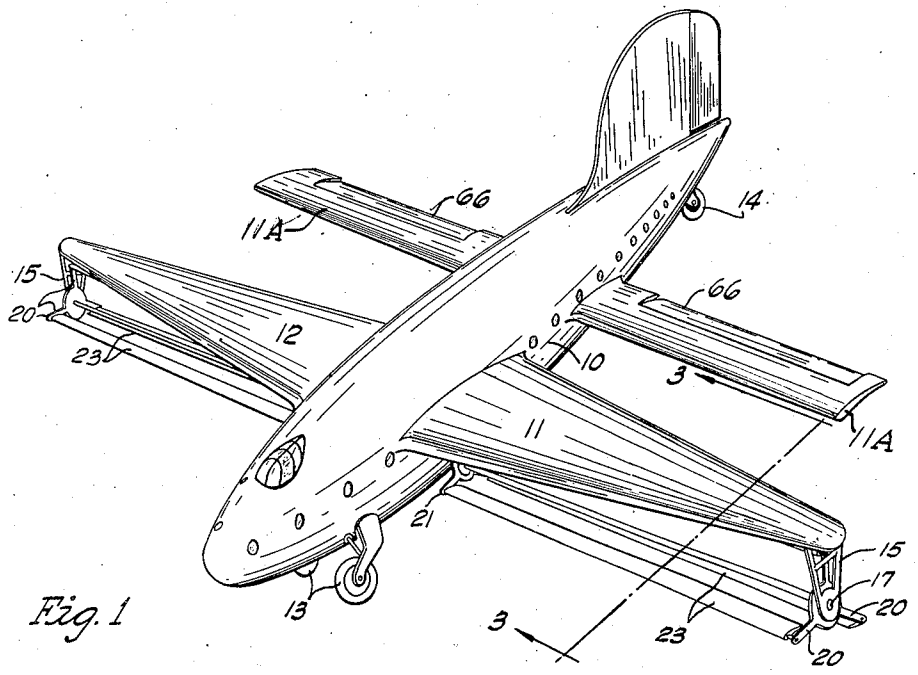


Fig. 1

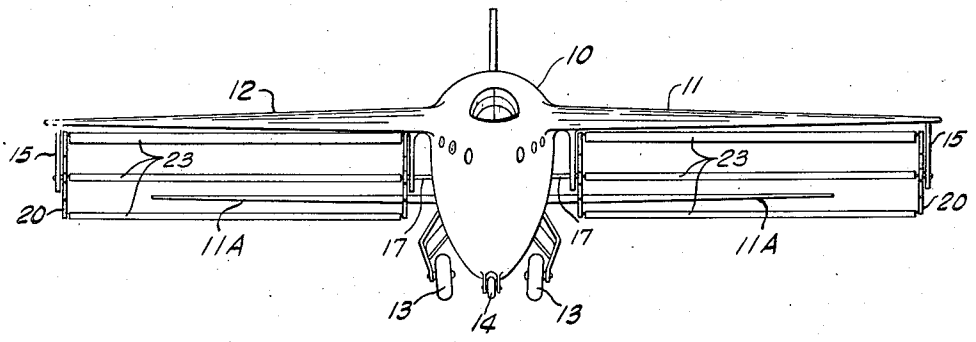


Fig. 2

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AIRPLANE

Filed May 16, 1944 4 Sheets-Sheet 2

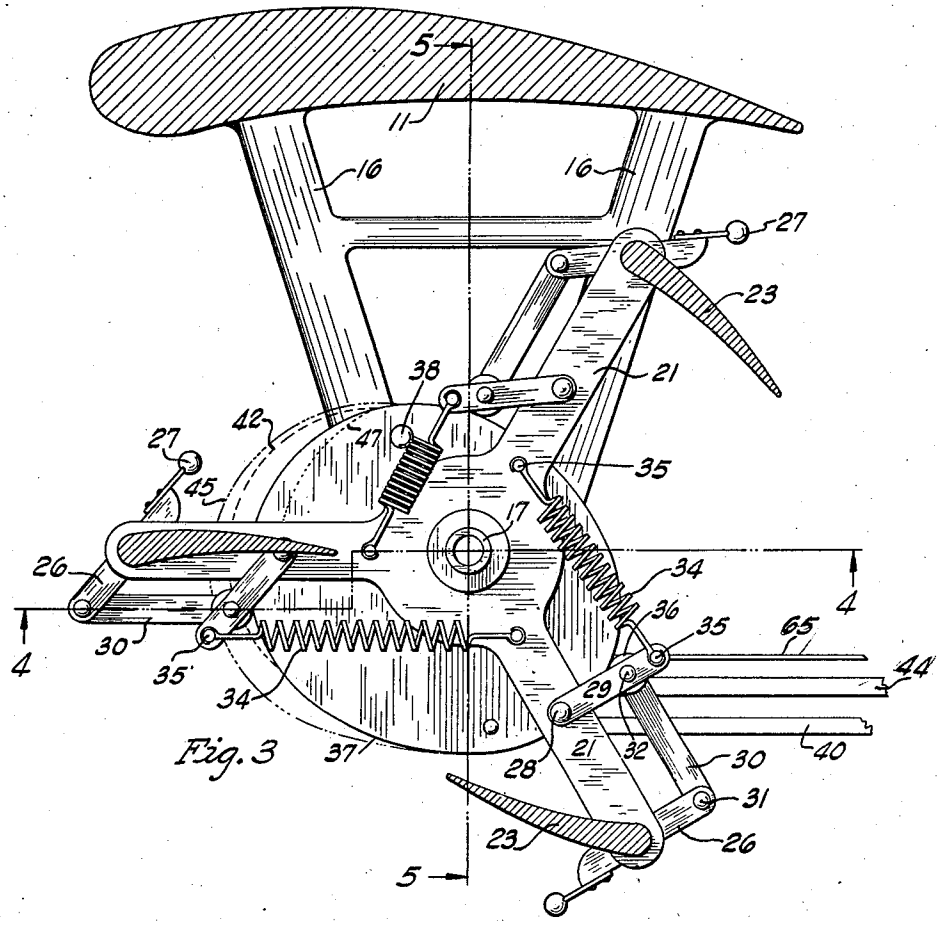


Fig. 3

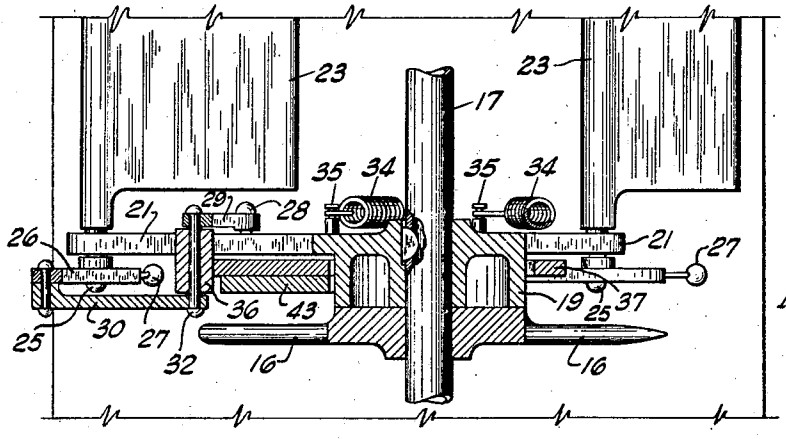


Fig. 4

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AIRPLANE

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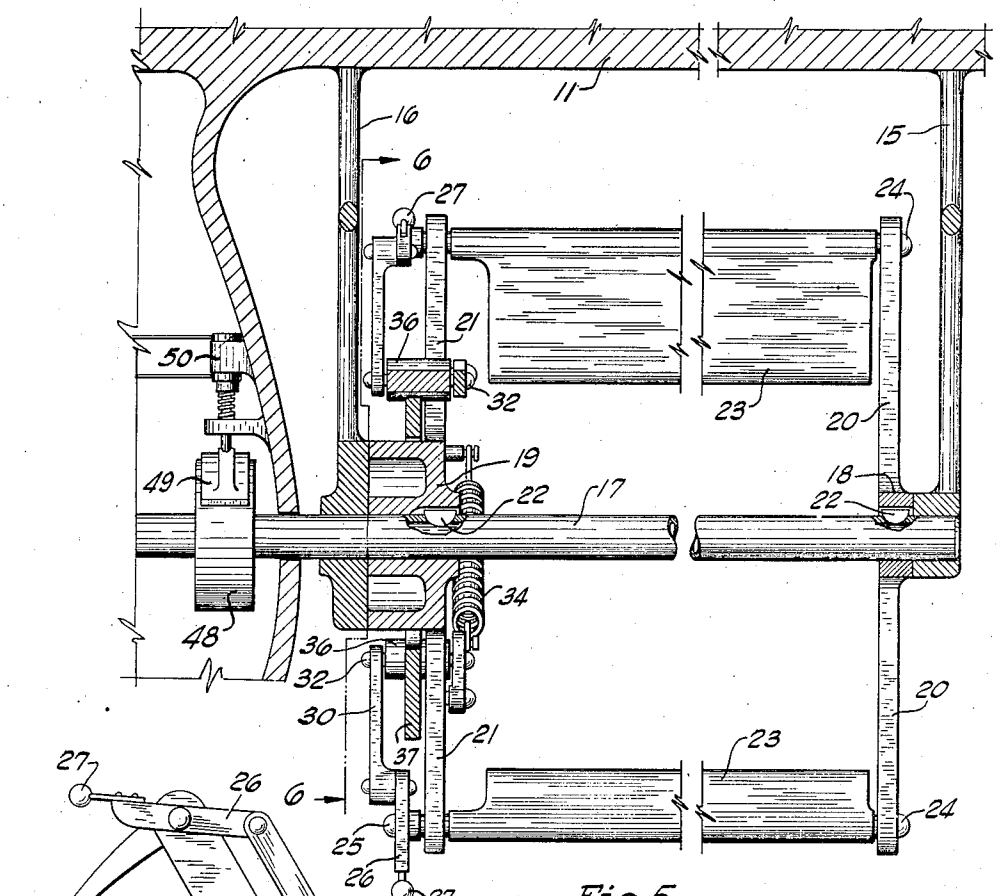


Fig. 5

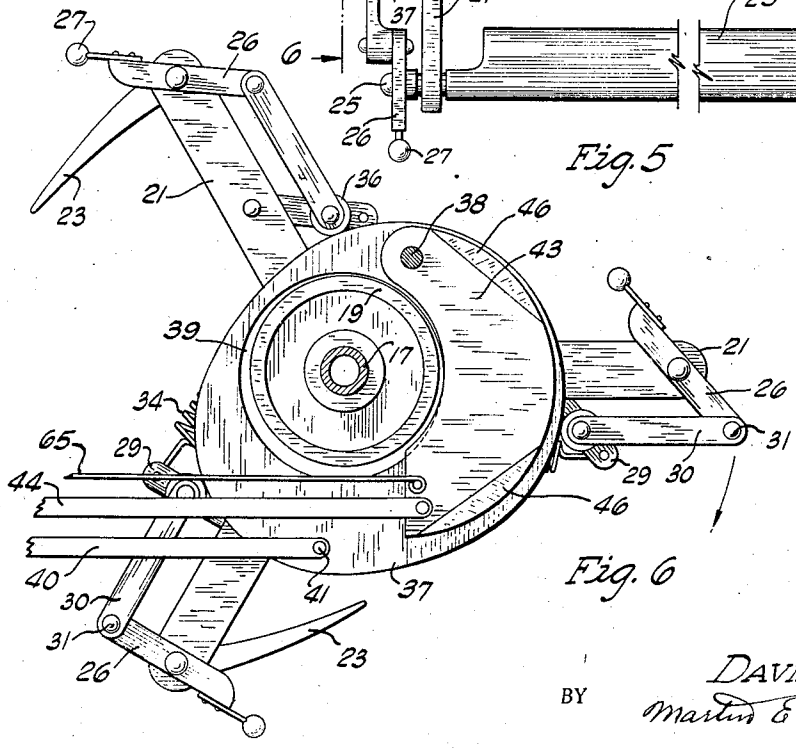


Fig. 6

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AIRPLANE

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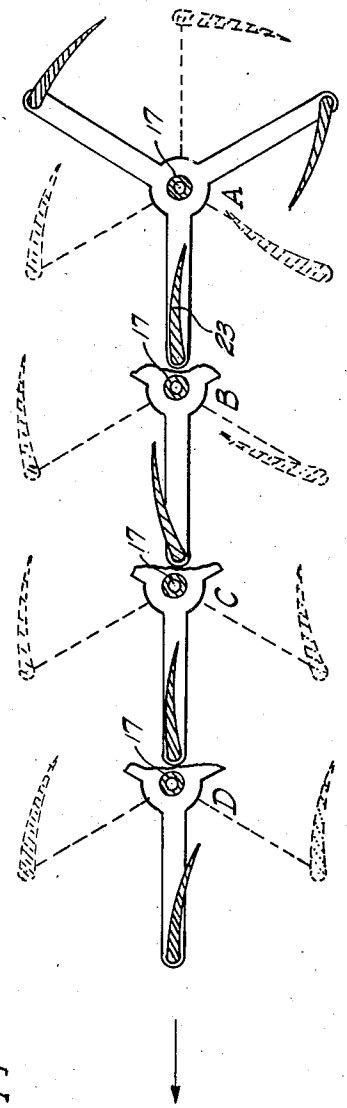


Fig. 7

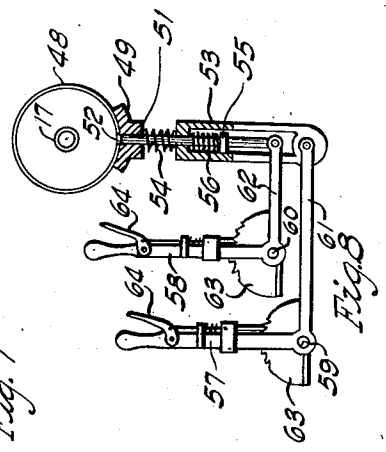


Fig. 8

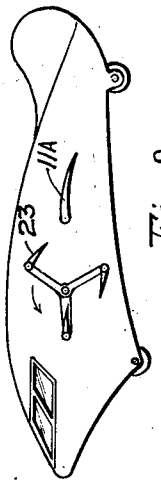


Fig. 9

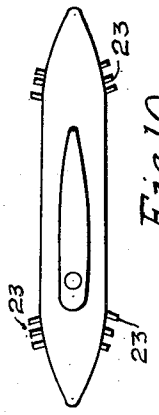


Fig. 10

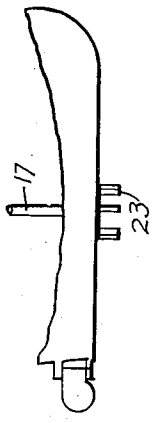


Fig. 11

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UNITED STATES PATENT OFFICE

2,413,460

AIRPLANE

David W. Main, Detroit, Mich.

Application May 16, 1944, Serial No. 535,891

8 Claims. (Cl. 244—9)

1

This application refers generally to improvements in the cycloidal type of airplane and marine propulsion, and is an improvement on applicant's co-pending application Serial No. 460,759, filed October 5, 1942.

While the principle of the cycloidal type of craft is old, nevertheless, the attainment of flight has been impossible of fulfillment in the prior art due partly to mechanical complications, vibration and shock, and the inability of such structures to combine the correct movements, angles of blade incidence, and blade contour in sequence at all times in order to produce the necessary resultants for successful performance. Heretofore the positive effects have been almost entirely canceled out by the negative forces generated thereby rendering the device inoperative to any useful extent or for the purpose intended.

It has long been known that the blade cord curvature is very important and that in very few cases, if any, would the aerodynamically correct blade contour be similarly shaped on opposite sides of the airfoil which condition is also true of an efficient cycloidal type blade with further modifications. But not until the disclosure made in applicant's co-pending application, previously referred to, has it been possible to successfully and efficiently adapt a blade for cycloidal propulsion having a cambered or concave under surface or one having a different upper and lower surface contour.

Because, if used in combination with or less extreme angles of blade incidence through the lower circle of revolution for the purpose of generating optimum propulsive and/or other forces, they would subsequently prove impractical, without the employment at this stage of means similar to that disclosed by applicant for the first time, as will be later explained in detail. It being understood that in order to attain flight, among other requirements, it is necessary to provide a type of blade of such construction as to enable the blade to rapidly grasp, compress, and release the medium acted upon in the order named, and furthermore, the cycloidal type craft requires extreme cyclical variations in the angle of blade incidences around the orbit of revolution, and a different combination of blade angles for each type of flight desired. Heretofore, due to limitations in the mechanical structure, it has been necessary to either feather the blades prematurely through the lower circle of revolution with a consequent loss in propulsive force, or to oscillate the blades to a modified angle of incidence which has resulted in but a degree of limited effectiveness

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followed by a negative reaction, or to attain a more or less severe degree of blade incidence at substantially right angles to the direction of travel. While this latter angle of blade incidence is momentarily correct for best results and during such time as the air is being forced rearwardly or downwardly or a combination of both, it becomes abruptly incorrect in cases where the blade is required to travel or rise broadside through the advanced rear section, with either the upper or lower face against the medium, because this results in a cancellation of the positive effects previously attained.

Even if the camber were reversible at this stage, it would prove only partly efficient because of the requisite differences in contour between the leading and trailing edges, and the difficulty of feathering the blades. However, no such mechanism is known or described in the prior art.

It is in the top, forward, and the front rear section of the circle of revolution where most of the desired forces must be generated, however, there are some forces generated in the rapid reversion of the blades in the lower rear section followed by a sculling effect in the upper rear section. Whatever action that takes place in the rear section must necessarily have a minimum negative effect. Returning to the front forward section again, the blade as it travels through this important section must be capable at times of sustaining fixed angles of blade incidence for an interval and at other times the blade angle must be in wide divergence from the path of revolution of the rotor itself. At this point applicant desires to point out that the angle of incidence of the blade during most operations while traversing the upward forward circle of revolution should be maintained as nearly horizontal for the most part as permissible to prevent a breakdown of the airflow passing through the wing section, also to develop optimum lifting forces momentarily and subsequently, and to eliminate drag.

Objects

One of the principal objectives of this application is to show a construction whereby the aerodynamic forces may be harnessed to insure the reversal of the blade travel on its axis in the rearward section by causing the medium acted upon to exert a pressure upon the blade which pressure in turn is automatically transferred to the cam follower for holding it against the cam to insure positive action at all times.

A supplementary objective to the first mentioned objective is to show several constructions

whereby the cam follower may be held against the cam surface either independently or in connection with the above mentioned aerodynamic means.

Another objective is to show a cam structure whereby any desired combinations of blade incidence may be secured at the will of the operator.

An important objective is to combine a stationary wing structure and a revolving cycloidal wing system so that each may be useful to the other and mutually cooperate. The cycloidal wing structure among other things assists the stationary wing structure in providing greater lift by augmenting the high and low pressures areas adjacent thereto.

Another objective is to instantly convert a revolvable cycloidal wing system to a multiple stationary wing series and vice versa at the will of the operator whereby all the wings may be used for gliding on account of engine failure or otherwise.

Another objective is to provide an anti-torque and control mechanism in the form of an auxiliary wing mounted near the bottom rear section of the rotor in the slip stream.

Another objective is to provide a fluid balancing means whereby the desired equilibrium and center of gravity may be obtained.

An important objective is to show a construction whereby the cycloidal principle may be more successfully adapted to marine propulsion for high speed operation, and for elevating and depressing a submarine.

The combined objective is to produce an airplane construction whereby the aspect ratio of the wings may be held to reasonable limits for better maneuverability, the landing field held to a nominal size, and the cost of construction reduced to a minimum. It is thought that applicant's structure will reduce the aspect ratio to about one-half or effect a corresponding increase in the useful load carried, and will be relatively quiet, able to take off and land slowly from small airfields, and can be autorotated or sailed to a safe landing.

The purpose of this application is to show and describe a simple and practical structure of light weight construction whereby all the necessary movements for the various operations may be obtained in a smooth rotative manner. The necessary blade movements required for successful operation are so diverse and complex that it is very doubtful, in my estimation, that any device as described in the prior art, is adaptable to operate in a medium as light as air and requiring the use of eccentrics, variable eccentrics, multiplicity of gearing, quadrant levers, etc., capable of producing the requisite motions; could be constructed and operated successfully on account of the opposing motions of its component parts, necessary speed of its moving parts, and the problem of various controls. Such a structure, it seems to me would be subject to prohibitive shock and vibration. It is thought that some of the more simple constructions of the pure cycloidal principle may be more or less successful when applied to marine propulsion because of the fewer requisites and the slower speed requirements while operating in a fluid medium such as water. However, for this purpose I also provide a smooth circular and adjustable cam whereby almost any result may be obtained in a smooth rotative manner.

As described and shown in my copending application, a modified form of the conventional wing structure may be retained although it would be practical on the smaller type cycloidal plane to eliminate the supporting rotor structure in the slip stream. However, a skeletonized wing structure may be also utilized to form an outward support for the propeller shaft axis.

Having thus described the objects of the invention, the means by which these objects are attained will now be described, and for this purpose reference will be had to the accompanying drawings in which:

Figure 1 is a perspective view of an airplane constructed in accordance with my invention;

Figure 2 is a front elevation thereof;

Figure 3 is a section taken on line 3—3, Figure 1;

Figure 4 is a section taken on line 4—4, Figure 3;

Figure 5 is a section taken on line 5—5, Figure 3;

Figure 6 is a section taken on line 6—6, Figure 5;

Figure 7 is a composite view showing several adjustments of the propeller blades to effect different operations;

Figure 8 is a diagrammatic view showing one form of brake mechanism;

Figure 9 is a side view of an airplane showing a modified construction;

Figure 10 is a top plane view of the submarine showing my improved cycloidal propeller employed thereby for effecting quick control; and

Figure 11 shows, in a diagrammatic manner, a cycloidal propeller positioned on the under surface of the ship.

In the drawings reference numeral 10 designates the fuselage of an airplane. Extending laterally from the fuselage are two cantilever beams 11 and 12 which are in the form of the usual airplane wings, but of much smaller dimensions. The fuselage is provided with landing wheels, two of which have been shown in Figure 1 and designated by reference numeral 13. There is also a wheel 14 at the rear end of the fuselage. Positioned beneath the wings 11 and 12 are cycloidal propellers which provide the lifting and propelling force and which will now be described. Extending downwardly from the wings are brackets 15 and 16, the former being near the outer ends of the wings and the latter adjacent the fuselage. Since the two propellers are identical in construction with the exception that the parts are rights and lefts as may be required to adapt them to use on opposite sides of the fuselage, only one of the propellers will be described in detail. A shaft 17 is journalled in bearings in the lower ends of the brackets in a manner shown most clearly in Figure 5. The shaft extends into the interior of the fuselage and is connected by suitable means to an internal combustion engine which produces the power necessary for rotating the shaft. Secured to the shaft adjacent the inner surfaces of the brackets are hubs 18 and 19, from the former spokes 20 extend radially as shown in Figure 1 and from the latter hub spokes 21 extend radially as shown more particularly in Figure 3. The hubs are held against rotation by means of keys 22, or some similar means. Extending between the outer ends of the spokes 20 and 21 are propeller blades that have been designated by reference numerals 23. The blades have faired cross sections as shown in Figure 3. The outer ends of the blades are rotatably connected with the spokes 20 by means of pivots 24 and the inner

ends are provided with trunnions or pivots 25 that extend through bearings in the outer ends of the spokes 21. Secured to the trunnions 25 are levers 26 that are non-rotatably connected with the trunnions. These levers extend to both sides of the trunnions, as shown in the drawings. Weights 27 are secured to one end of the levers for a purpose which will hereinafter appear. Pivotally connected to the spokes 21 at points 28 are levers 29. A connecting bar 30 extends from the pivots 31 at the outer end of levers 26 to the pivot 32 in lever 29. Levers 26 and 29, together with the arms 21 and connecting bars 30 form a distortable parallelogram. Tension springs 34 connect the points 35 at the outer ends of levers 29 with anchors 35' positioned approximately at the inner ends of the next adjacent spoke 21 as shown very clearly in Figure 3. The springs exert a force tending to rotate the link assembly in a counterclockwise direction, when viewed as in Figure 3, for a purpose which will hereinafter appear. It will be noted that the pivot pins 32 carry rollers 36 as shown most clearly in Figure 4.

From Figures 4 and 5 it will be seen that hub 19 is of much greater thickness than the arms 21 and that the arms are spaced away from bracket 16. Surrounding hub 19 is a cam 37 which is pivotally connected with a portion of the bracket 16 by means of a pivot 38. Cam 37 has an opening 39 that encircles the hub in the manner shown in Figure 6. Opening 39 is larger than the hub and this makes it possible for the cam to be shifted through a considerable angular distance about its pivot 38. A connecting rod 40 is pivotally connected with the cam at 41 and extends to a suitable control lever position within the fuselage at a point adjacent the pilot seat so that he may, at will, shift cam 37 about its pivot. Springs 34 serve to press the rollers 36 against the periphery of cam 37 and when the propeller rotates in a counterclockwise direction, when viewed as in Figure 3, the angular relation between the blades 23 and the axes of the spokes is controlled by the radial distance from the center of shaft 17 to the periphery of the cam positioned on a line connecting the center of shaft with the center of pivot 32 and since this distance is different for different angular positions of the cam, it follows that the incidence angles of the blades will be altered in a predetermined sequence, which depends on the contour of the cam. In Figure 3, the angular position of the blades for three positions has been indicated and it is assumed that the propellers rotate in a counterclockwise direction when viewed as in Figure 3. From the position of the blades, it will be apparent that the blade fartherest to the left, when moving downwardly exerts a lifting force and that the angular relation of the blades changes from that shown at the left in Figure 3 to the one shown at the bottom while passing through an angle of 120°. It therefore follows that as the blade moves downwardly, the lifting force becomes a component of a resultant, the other component of which exerts a propelling force and that the propelling force increases with the downward movement of the blade. From the lowermost position shown in Figure 3 to the uppermost blade position, the blade turns through an angle of almost 180 degrees with the result that it feathers the air current so as to exert practically no force either in depressing or retarding the movement of the plane. By shifting the cam 37 about its pivot 38 so that it approaches

the dotted line position designated by reference numeral 42, the incidence angles of the blades will be correspondingly modified and the blade that moves downwardly will have its rear edge slightly lower than it will with the cam in full line position. If the cam 37 is turned so as to move it toward the dotted line position, indicated by reference numeral 47 in Figure 3, the angular relationship of the blades to the direction of movement of the plane will be changed in an opposite direction so as to increase the propelling force while decreasing the lifting force. By means of the adjustment of cam 37 about its pivot, the relationship between the propelling and lifting forces at different parts of the propeller blade rotation can be altered. By shifting cam 37 all points in its periphery are moved in a corresponding manner and since it is sometimes desirable to alter the incidence angles of the blades at one position without effecting corresponding changes in other positions, an auxiliary cam member 43 has been provided and mounted for angular movement about the pivot 38. The position of this auxiliary cam is controlled by means of a connecting rod 44 that is connected by suitable link mechanisms to a control lever adjacent the pilot seat. Cam 43 can be moved forwardly into a position indicated by dotted line 45 in Figure 3 without changing the position of cam 37. It is apparent that when the propeller rotates and the cam 43 is in its maximum forward position, the incidence angles of the blades will be such as to produce a retarding component instead of a propelling one and by this means it is possible to effect a reversing action and also to effect a quick turn or shift in the direction of movement. The counterweights 27 are provided for the purpose of producing a force that counteracts the centrifugal forces developed by the rotation of links 30 and such portions of levers 26 and 29 as project to the leading side of the spokes. By making the counterweight of sufficient mass it can also be used to supplement the action of the spring and may conceivably replace the spring as a means for keeping rollers 36 in contact with the cam periphery. In order to cushion the shocks that might otherwise result as the rollers 36 pass over the projecting peripheral portions of cam 43, the end portions of the periphery of this cam may be constructed from some pneumatic or resilient material such as rubber and these resilient portions have been designated by reference numeral 46 in Figure 6. Other equivalent means may be substituted for the resilient cam portions if found desirable.

By positioning the cam 37 approximately as shown in Figure 3, the maximum lifting force is obtained and this position is therefore the most desirable for take-off. As the plane leaves the ground, cam 37 is rotated in a counterclockwise direction with the result that the force exerted by the blades in their downward movement will be resolved into two components, the propeller force component increasing in proportion as the cam is shifted from the full line to the dotted line designated by reference numeral 47. A brake drum 48 is connected with shaft 17 and is preferably positioned within the fuselage, as shown in Figure 5. Suitable brake mechanisms comprising a brake shoe 49 is associated with the brake drum and provided with a control mechanism so that the pilot can apply this brake or release it at will. The brake serves to control the rotation of the propellers while volplaning

and under special conditions which need not be described in detail.

Since there are many well known mechanisms for controlling brakes, some of which are hydraulic, others pneumatic and others mechanical, and since whichever is found to be the most suitable can be selected for this purpose, the brake control mechanism has not been shown in detail, but has merely been indicated in a general way in Figure 5 by a pneumatic device comprising cylinder **50**.

In Figure 8, however, another braking operating mechanism has been illustrated, and in this the brake shoe **49** has been shown as provided with an opening for the reception of a plunger **51**, which is intended to be inserted in the opening **52** of the brake drum **48**. A member **53** is provided with an opening through which the plunger **51** extends and a compression spring **54** is positioned between the brake shoe and the member **53**. It will be observed that the plunger has a collar **55** that forms one abutment for the compression spring **56** whose other end rests against the shoulder in member **53**. The brake shoe and the plunger can be operated independently by means of levers **57** and **58** that are pivoted respectively at **59** and **60**. In the drawings, levers **57** and **58** are shown as formed integral with the arms **61** and **62**, respectively, so as to form bell crank levers. A quadrant **63** is provided for each lever and also detent means operated by handles **64**. When the brake is to be applied, lever **57** is rotated in a counterclockwise direction, thereby compressing spring **54** and applying the brake. For the purpose of locking the propeller in a predetermined rotatable position, plunger **51** is urged against the brake drum and when it enters the opening **52**, it positively latches the propeller against further rotation.

Attention is also called at this point to the cable **65** that is connected with the auxiliary cam **43**. This cable extends to and controls the ailerons for a purpose and in a manner which will be hereinafter explained.

In Figure 7, a composite view has been shown for the purpose of illustrating, in a clearer manner, the operation of the propeller. The view has been divided into four parts which have been designated by A, B, C and D. In part A the position of the blades has been shown as in Figure 3. The positions indicated by dotted lines are intermediate positions which serve to show an extra step in the movement and helps to give a clearer idea of the position of the blades at various parts of the cycle.

In positions B, C and D, the forward blade only has been shown in full lines and three positions of the blade during the downward and rearward movement have been illustrated. In the arrangement shown in Figure B, the cam has been adjusted so as to obtain a maximum forward propelling component and corresponds to high speed. The position shown in Figure C corresponds to hovering speed and that shown in Figure D corresponds to the position of the blades for reversing. In Figure C there is no perceptible propelling force, whereas the lifting force has a maximum. Since the two propellers can be independently adjusted, it is possible to obtain a relationship in which the change of direction of a plane thus equipped can be very quickly effected because if one propeller is positioned to exert a maximum propelling force and the other practically no propelling force, it is evident that a quick turn will result.

The diagrams in Figure 7 are, of course, illustrative only and are intended for illustrative purposes.

Referring now more particularly to Figure 7, it is pointed out that at no point through the circle of revolution is the airplane detrimentally interfered with or impeded, with the possible exception of a small area at the rear. In the upper part of the orbit the blades are substantially horizontal for the greater part and therefore do not interfere appreciably with the air flow through the rotors. In the bottom half of the circle of revolution, the inflowing air is given additional rearward velocity and acceleration and in addition a small downward velocity. It is mostly through the downward and rearward motion that the blades quickly grasp and compress the air. This compressed air is then quickly liberated, but not until the blades have progressed rearwardly at a comparatively steep pitch to the farthermost point of effectiveness. At this point the blades move approximately 90 degrees on their own axes in the same general direction as the rotor axes and preferably through as small an area and space of time as practical, which area may be less than 90 degrees in extent. In this connection it should be noted in particular that the blades never complete a full revolution on their own axes while revolving in their orbit around the rotor axes, as the rotation of the blade is counteracted by the rotation of the propeller. Due to the backward sweep of the blades, an impetus is given to the usual trailing wake and the drag at this point is believed to be completely neutralized. Coincident with this action, the blades are being feathered for minimum negative effect on the upstroke followed by a change to sculling incidence.

From Figure 1 it will be seen that some laterally projecting wings that have been designated by **11***a*, are provided with ailerons **66**. The position of the ailerons is controlled by means of a cable **65** that is connected with the auxiliary cam **43** as shown in Figure 6. The adjustment of this cam controls the position of the aileron so as to produce a proper operative relationship between the forces resulting from the propeller operation, thereby stabilizing the position of the airplane in its travel for every position of the cams. The operation of cable **65** may be modified or nullified by an overriding connection within reach of the pilot.

In Figure 9 a slightly modified form of airplane or airship has been shown in which the wing-like supporting members **11** and **12** have been omitted and the cycloidal propeller projects laterally, being supported merely by the shaft **17**. With this arrangement, there is less resistance to forward motion and greater maneuverability than with the other constructions.

Attention is called in particular to the position of the aileron **11***a* of the auxiliary wing which is located in the slip stream from the rotating propeller and serves the function usually performed by the stabilizers or elevators and vertical rudders at the rear of an ordinary airplane. Since the operation of the propellers can be readily changed as has heretofore been explained, no horizontal rudders are required. Such a ship is especially well adapted for use where quick maneuverability is an item of importance.

In Figure 10 a submarine has been shown provided with four cycloidal propellers having short blades that project outwardly in the manner illustrated. These blades can readily be changed

so as to effect a quick submergence of the submarine and to enable it to make quick turns when eluding an airplane or another warship. Various types of surface ships may also be equipped in a like manner and in some cases the propeller axis may be vertical instead of horizontal.

Attention is also again called to Figure 8 and to the fact that when the propellers are so positioned that plunger 51 can enter the opening 52, the various blades will be in substantially horizontal position for volplaning, which position is best illustrated in part C of Figure 7 and in Figure 9.

In Figure 11, a diagrammatic representation has been shown in which a cycloidal propeller like that described and claimed in this application, is positioned underneath the ship and mounted for rotation about a vertical axis. Of course there may be more than one such propeller secured to each ship and each is provided with control mechanism like that described thereby providing means for propelling and for obtaining sudden changes of direction of movement.

Having described the invention what is claimed as new is:

1. A propeller of the cycloidal type having a plurality of blades mounted to move in a cylindrical orbit about a common axis, a propeller shaft, a support for the shaft and propeller, means for turning the blades on their own axes in a predetermined sequence while moving in their orbit, said last named means comprising a cam encircling the common axis, means for shifting the cam relative to the common axis, means for translating variations in the cam surface into rotary movement of the blades about their own axis, to effect a predetermined cyclic change in the incidence angles during each orbital movement, an auxiliary cam associated with the first cam and forming means for changing the effective cam contour, means for shifting the auxiliary cam relative to the first cam.

2. An aircraft, comprising, a fuselage, a motor, and propeller comprising a plurality of elongated, transversely streamlined blades mounted for revolution in a cylindrical orbit about a central axis which extends substantially perpendicular to the axis of the fuselage, means for oscillating the blades about their own axes as they revolve about their orbit comprising a cam positioned in a plane perpendicular to the axis of rotation, a cam pivot spaced from the common axis and stationary with respect to the fuselage, the cam being mounted for limited oscillation about the pivot, means comprising a cam follower operatively connected with the blades for imparting to the latter a cyclic angular movement determined by the cam surface contour, means for shifting the cam rotarially about its pivot to effect a variation in blade oscillation, means for urging the cam followers against the cam surface as the propeller operates, and a second cam pivotally connected with the first cam for movement into a position to modify the effective cam contour, whereby a variation in the cyclic blade oscillation can be obtained at a predetermined part of the blade orbit independently of the main cam.

3. An aircraft, comprising a fuselage, a motor and a plurality of elongated, transversely streamlined blades mounted for revolution in a cylindrical orbital path about a central axis which extends substantially perpendicular to the axis of the fuselage, means for oscillating the blades about their own axes as they revolve about their common axis, comprising a cam positioned in a plane perpendicular to the axis of rotation, a cam pivot stationary with respect to the fuselage and eccentric with respect to the common axis, the cam being mounted for limited oscillation about its pivot, means comprising a cam follower operatively connected with the blades for imparting to the latter a cyclic angular movement determined by the cam surface contour, means for shifting the cam rotatably about its pivot to effect a variation in blade oscillation, means for urging the cam followers against the cam surface as the blades revolve in their orbit, a second cam pivotally connected with the first cam for movement into a position to modify the effective cam contour, whereby a variation in blade oscillation can be obtained at a predetermined part of the blade orbit independently of the main cam, and a brake mechanism operatively connected with the propeller for effecting a frictional resistance to its rotation.

4. An aircraft, comprising a fuselage, a motor and a plurality of elongated, transversely streamlined blades mounted for revolution in a cylindrical orbital path about a central axis which extends substantially perpendicular to the axis of the fuselage, means for oscillating the blades about their own axes as they revolve about their common axis, comprising a cam positioned in a plane perpendicular to the axis of rotation, a cam pivot stationary with respect to the fuselage, and eccentric with respect to the common axis, the cam being mounted for limited oscillation about its pivot, means comprising cam followers operatively connected with the blades for imparting to the latter a cyclic angular movement determined by the cam surface contour, means for shifting the cam rotatably about the pivot to effect a variation in the cyclic blade oscillation, means for urging the cam followers against the cam surface as the blades revolve in their orbit, a second cam pivotally connected with the first cam for movement into a position to modify the effective cam contour, whereby a variation in cyclic blade oscillation can be obtained at a predetermined part of the blade orbit independently of the main cam, a brake mechanism operatively connected with the propeller for effecting a frictional resistance to its rotation, and a detent operable independently of the brake mechanism for latching the propeller in a predetermined rotarial position.

5. A propeller embodying an axle mounted for rotation, a bearing for each end of the axle, a hub nonrotatably connected with the axle adjacent each bearing, a plurality of radial arms projecting from each hub, a propeller blade positioned between correspondingly positioned arms and mounted for cyclic pivotal movement about their own axes, a cam plate pivotally connected with one of the bearings, between the bearing and the adjacent hub, said cam enclosing the axle, means for shifting the position of the cam relative to the axle, a cam follower mechanism operatively associated with each blade for translating cam surface variations into cyclic blade oscillation, means for urging the cam followers into engagement with the cam surface as the propeller rotates on its axle, whereby the incidence angles of the blades will be varied in a predetermined manner during their orbital movement, means comprising an auxiliary cam member pivotally connected with the first cam for movement into a position in which its surface extends beyond the peripheral cam surface of the first cam, and means for moving the auxiliary cam relative to the main cam.

6. A propeller embodying an axle mounted for rotation, a bearing for each end of the axle, a hub nonrotatably connected with the axle adjacent each bearing, a plurality of radial arms projecting from each hub, a propeller blade positioned between correspondingly positioned arms and mounted for pivotal movement about their own axes, a cam plate pivotally connected with one of the bearings, between the bearing and the adjacent hub, said cam enclosing the axle, means for shifting the position of the cam relative to the axle, a cam follower mechanism operatively associated with each blade for translating cam surface variations into cyclic blade rotation about its axis, means for urging the cam followers into engagement with the cam surface as the propeller rotates on its axle, whereby the incidence angles of the blades will be varied in a predetermined cyclic manner during their orbital movement, means comprising an auxiliary cam member pivotally connected with the first cam for movement into a position in which its surface extends beyond the peripheral cam surface of the first cam to alter the effective cam contour, means for moving the auxiliary cam relative to the main cam, and a friction brake mechanism operatively associated with the propeller to exert thereon a frictional resistance against rotation.

7. A propeller embodying an axle mounted for rotation, a bearing for each end of the axle, a hub nonrotatably connected with the axle adjacent each bearing, a plurality of radial arms projecting from each hub, propeller blades positioned between correspondingly positioned arms and mounted for pivotal movement about their own axes, a cam plate pivotally connected with one of the bearings, positioned between the bearing and the adjacent hub, said cam enclosing the axle, means for shifting the position of the cam relative to the axle, a cam follower mechanism operatively associated with each blade for translating cam surface variations into cyclic blade oscillation about its axis, means for urging the cam followers into engagement with the cam surface as the propeller rotates on its axle whereby the incidence angles of the blades will be varied in a predetermined cyclic manner during their orbital movement, means comprising an auxiliary cam member pivotally connected with the first cam for movement into a position in which its surface extends beyond the peripheral cam surface of the first cam to alter the effective cam contour, means for moving the auxiliary cam relative to the main cam, a friction brake mechanism operatively associated with the propeller to exert thereon a frictional resistance against rotation, and a manually operable detent for latching the propeller in a predetermined rotary position.

8. An aircraft, comprising, a fuselage, a motor and a plurality of elongated blades mounted for revolution in a cylindrical orbit about a central axis which extends substantially perpendicular to the axis of the fuselage, means for oscillating the blades about their own axes as they revolve about their orbit comprising a cam positioned in a plane perpendicular to the axis of rotation, a cam pivot spaced from the common axis and stationary with respect to the fuselage, the cam being mounted for limited oscillation about the pivot, means comprising a cam follower operatively connected with the blades for imparting to the latter a cyclic angular movement determined by the cam surface contour, means for shifting the cam rotarially about its pivot to effect a variation in blade oscillation, means for urging the cam followers against the cam surface as the blades revolve in their orbits, a second cam pivotally connected with the first cam for movement into a position to modify the effective cam contour, whereby a variation in the cyclic blade oscillation can be obtained at a predetermined part of the blade orbit independently of the main cam, an auxiliary wing positioned adjacent and to the rear of each propeller in the path of the air therefrom, an aileron attached to each wing and means interconnecting the ailerons and the second cam to effect a conjoint adjustment of the two.

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