Jan. 9, 1940. **A. J. DEKKER** **2,186,064**

ROTARY PROPELLER AND THE LIKE DEVICE

Filed May 19, 1937 2 Sheets-Sheet 1

Fig. 1.

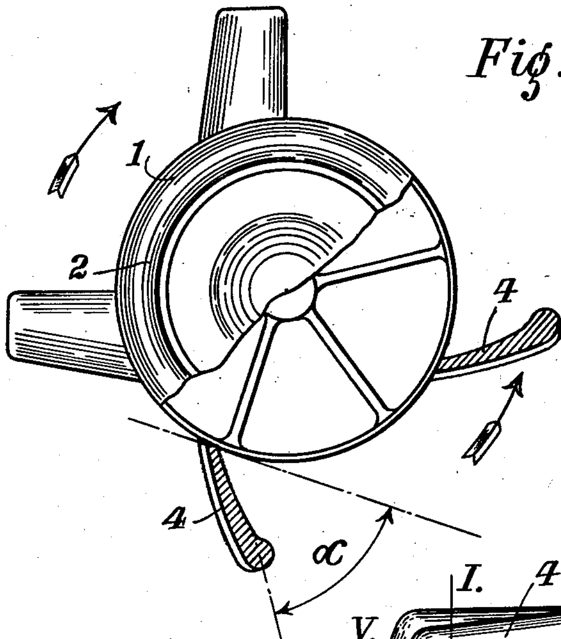


Fig. 2.

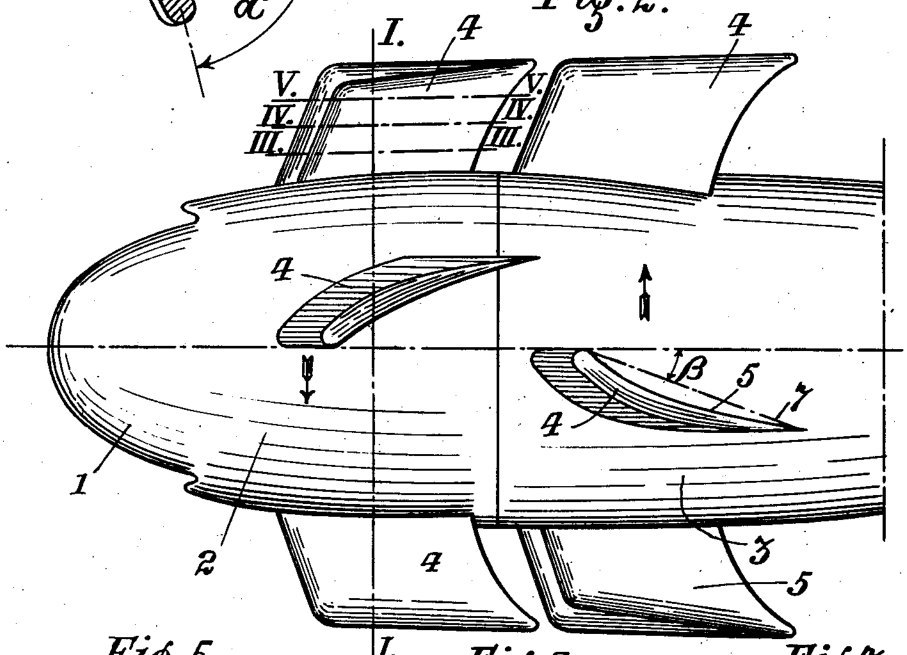
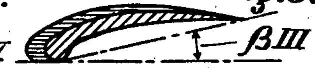


Fig. 5.

Fig. 4.

Fig. 3.



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ROTARY PROPELLER AND THE LIKE DEVICE

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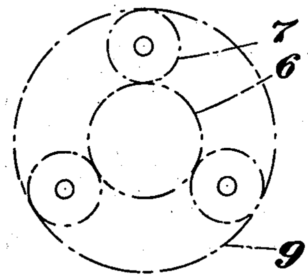


Fig. 7.

Fig. 6.

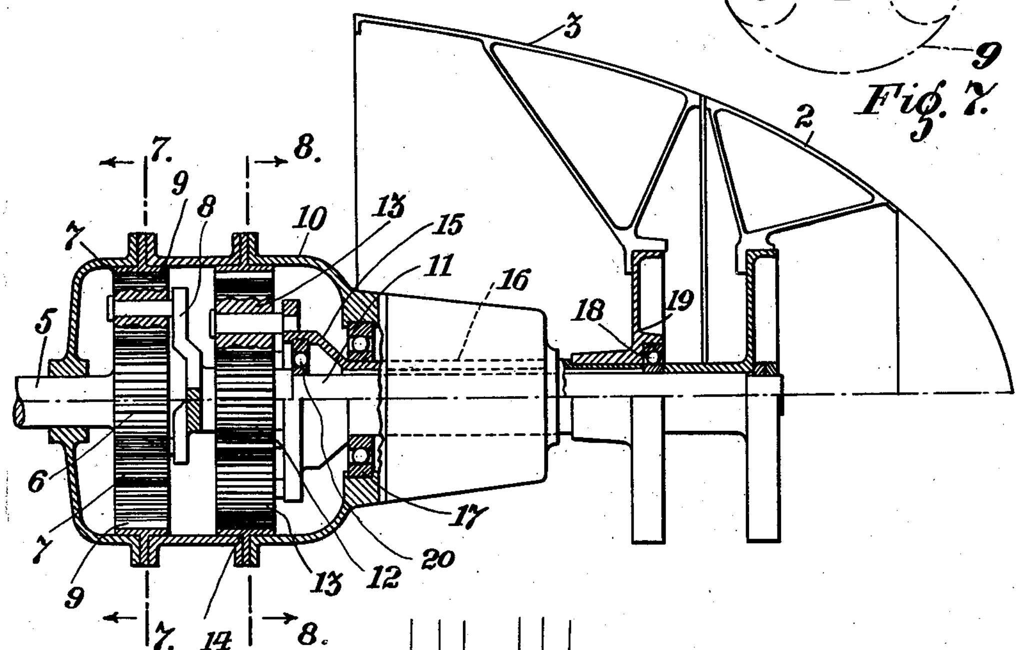
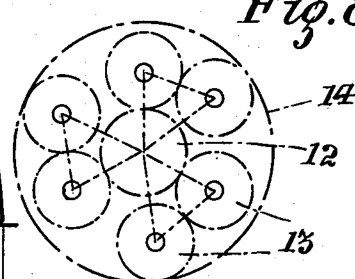


Fig. 8.



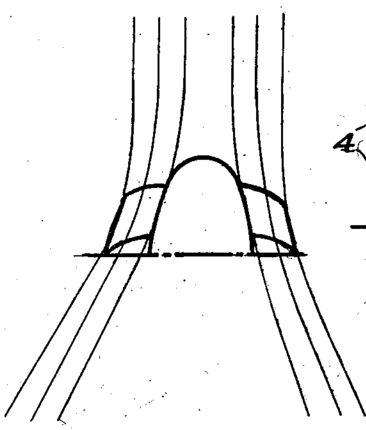


Fig. 9.

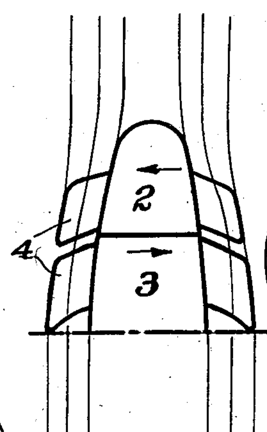


Fig. 10.

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UNITED STATES PATENT OFFICE

2,186,064

ROTARY PROPELLER AND THE LIKE DEVICE

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Application May 19, 1937, Serial No. 143,549
In Great Britain June 3, 1936

8 Claims. (Cl. 170—165)

The present invention relates to rotary propeller devices having blades or the like by means of which energy is given to a medium or obtained from a medium.

Propeller devices can be divided into two distinctive principal groups:

I. *Screw propellers.*—In these one or more blades move, causing or obtaining pressure on or from the medium in an axial direction forming a rather small angle of incidence with the direction of the plane or planes in which the blades lie.

II. *Cycloidal propellers.*—In these one or more blades or paddles move, causing or obtaining pressure on or from the medium, in a direction forming an angle of incidence of 90° with the plane or planes in which the blades or paddles lie.

In these two kinds of constructions the following unfavourable characteristics are shown with increasing axial velocity;

(*a*) as transmitters of energy to the medium they possess less reaction pressure;

(*b*) as receivers of energy from the medium they exert less pressure on the medium.

This can be explained for both cases by the fact that the transmitted or received energy depends on the so-called slip of the two kinds of propellers, and this slip decreases with increasing axial velocity.

An aim of this invention is to improve the relation between the reaction pressure (or action pressure) of the device and the kinetic velocity in the direction of this pressure, or in other words to make this reaction pressure (or action pressure) not to decrease but to remain constant or increase with increasing axial velocity, and a further aim is to reduce or obviate the reaction moment torque on the device.

In accordance with an object of the invention sail-shaped blades are used in a device provided with a boss or hub of streamline form of large diameter, consisting of two or more hub parts one behind the other, on each of which a number of the sail-shaped blades are fitted. Each succeeding hub part revolves in the opposite direction to the preceding one, preferably at a different rotational speed and in this manner the resulting reaction moment torque can be made zero and in addition, the slip stream is directed substantially straight backwards and is relatively "firm" and undisturbed, it having been found that the slip stream of a single hub part with sail shape blades is directed outwardly so that in aircraft there is a lack of air pressure on the rudder and elevator with consequent lack of control over the aircraft. The best result is obtained when the second hub part revolves more slowly than the first, and when the mutual distance between the blades of two successive hub parts of one group (measured from the rear edge of a front blade to the leading edge of a rear blade) is from the minimum practical working clearance up to 20% of the total diameter of the propeller, when measured from the tip of the blades.

The invention will now be described by way of example with reference to the accompanying drawings which show, by way of example, one constructional form of the invention.

Fig. 1 is a front view partly in section according to the line I—I of Fig. 2;

Fig. 2 is a side view and

Figs. 3, 4 and 5 are respectively sections of a blade according to the lines III—III, IV—IV and V—V in Fig. 2.

Fig. 6 is cross section elevation showing the drive and Figs. 7 and 8 are diagrammatic views on the lines 7—7, and 8—8 of Fig. 6.

Figs. 9 and 10 are diagrammatic plan views showing slip streams for respective single and double propeller units.

The rather thick streamline form boss **1** is in two sections **2** and **3** adapted to be rotated in opposite directions, each section being provided with a set of, for instance, four comparatively short blades **4**. These blades, in cross sections taken in planes at right angles to the axis of rotation, such as in Fig. 1, show substantially the form of lifting aerofoils with a concave pressure side and also show such form in sections taken in any cylindrical surface concentric with the axis of rotation as in Figs. 3, 4 and 5. Further it will be seen from Figs. 3, 4 and 5 that the angle β between the chord of a blade section and the axis of rotation preferably decreases from the root to the tip of the blade. This angle may vary between 5° and 40°. The length of the chord increases proceeding from the root to the tip of the blade.

With respect to a plane tangent to the surface of the hub the blades are a little inclined in the direction of rotation so that in this case the angle α with this plane amounts to less than 90°.

In order to obtain a desired greater curvature at the fore and outer edges the blades are provided at these edges with thickenings or beadings as shown.

In order to reduce or obviate reaction moment the sections **2** and **3** are driven in opposite directions. In the example shown the rear section **3** is driven with a rotational speed which is 66% of the rotational speed of the front section 2.

It is thought that the reason why the reaction moment is obviated when the rear blades are rotated slower than the front blades is that the front blades direct the air reawardly and in their direction, that is, the air stream is directed to some extent helically and this adds to the resistance which the rear blades encounter and thus increases the reaction moment to an amount opposite and equal or substantially equal to the reaction moment of the more rapidly rotating front blades.

The driving mechanism is shown in Figs. 6 to 8 and consists of the engine shaft 5 driving an epicyclic gear consisting of the toothed sun wheel 6, three planets 7 on a carrier 8, and an internally toothed annulus 9 fixed on the casing 10. The carrier 8 is fixed on, or formed on, a shaft 11 which carries the front hub part 2. The shaft 11 also carries a sun wheel 12 of a second epicyclic gear including the three pairs of planet wheels 13 (see especially Fig. 8). The inner wheel of each pair meshes with the sun wheel 12 and its fellow while the latter meshes with an internally toothed annulus 14 fixed in the casing 10. The planets 13 are mounted on a carrier 15 fixed or formed on a hollow sleeve or shaft 16 which carries the rear hub part 3 and surrounds the shaft 11 and is mounted to rotate on ball bearing 17, a further ball bearing 18 being located between the shaft 11 and the member 19 of the rear hub part 3, and a further ball bearing 20 being located between shaft 11 and carrier 15. It will be seen that with this arrangement the front hub part 2 will be rotated in the same direction as the engine shaft 5 while, owing to the planet pairs 13, the sleeve 16 which carries the rear hub part 3 will be rotated in the opposite direction. The gearing may, for example, be such that the rear hub part 3 makes 66 revolutions for every 100 revolutions of the front section, the opposite directions of rotation being indicated by the arrows shown in Fig. 2.

It will be seen that the blades 4 have substantially the shape of a fore-and-aft sail if the front edge of the blade is considered as the mast, the end as the gig and the tangent plane at the hub as the gaff to which the sail is attached, the blade being curved in the manner of a sail in two directions at right angles to each other, that is, parallel to the mast and parallel to the gig with the greatest curvature near the mast and gig. Just as in the case of sailing where the gig makes a smaller angle with the axis of the ship than the gaff, the chord of the end or tip of the blade makes a smaller angle with the axis of the propeller device than the chord of the root of the blade (see Figs. 3 to 5).

The blade is fixed to the hub part in such manner that during rotation without axial motion the particles of the medium impinge on the blade at an angle of about 70°, which can be compared to sailing with half wind or close to the wind.

With increasing axial velocity and with constant rotational velocity the angle at which the particles of the medium impinge on the blade decreases. This can be compared to sailing close to the wind, when, as is well known, the tractive power or propelling force of the sail increases as the angle between the incoming wind and the sail decreases until the maximum effect is reached at an angle of about 6°. The equivalent maximum effect will only be attained by the propeller device in accordance with the present invention when the axial velocity amounts to fully twice the rotational linear velocity, the latter being measured at the blade end or tip. Hence the tractive power of propelling force of the propeller device in accordance with the invention will increase till this velocity is attained.

Moreover, increasing the axial velocity, while the rotation velocity remains constant, causes the force with which the particles of the medium impinge upon the blade to increase, and thus the tractive power or propelling force also increases, just as in the case of sailing close to the wind the tractive power or propelling force of the sail increases in proportion to the velocity of the wind.

This increase in the tractive power or propelling force due to the increase of the axial velocity and the consequent pressure increase of the particles of the medium will only stop when the particles of the medium impinge upon the blade at an angle considerably less than 6°. Only when, by a further increase of the axial velocity, these particles travel in the same direction with respect to the blade as the chord of the blade, will the tractive power not show any further increase.

In order to obtain a proper sail effect the blades have been given a large surface. Because of this large surface the rotational velocity can be considerably less than that of other existing propellers. In this way an almost noiseless working is obtained, but at the same time the reaction torque is increased, which is a disadvantage.

This disadvantage is avoided or mitigated by rotating the hub parts 2 and 3 in opposite directions as above described. A further disadvantage which is obviated by having a rear hub part 3 rotating in the opposite direction, is that of a diffused or outwardly directed slip stream with reference to the axis of rotation. It has been found that such a divergent slip stream, as illustrated in Fig. 9, was given by a propeller device having only one hub part such as 2 with sail shaped blades thereon as above described. Such a divergent slip stream resulted in lack of air pressure on the elevators and rudder of an aircraft and caused an extreme difficulty in the control of the aircraft. Contrary to normal expectation, the rear contra-rotating part 3 corrects the slip stream, as illustrated in Fig. 10, and thus gives a slip stream which is "firm" and undisturbed and which is directed substantially straight back, generally in parallel directions on different sides of the hub part, instead of substantially divergently as with a single propeller having the sail shaped blades.

What I claim is:

1. A rotary propeller device comprising a plurality of hub parts placed one behind each other, a plurality of blades on each hub part, the blades on each hub part being curved in two directions like sails, the cross-sections of the blades taken on any cylindrical surface coaxial with the axis of rotation of the hub part as well as the cross-sections of the blades taken on any surface normal to the axis of rotation of the hub part being similar to those of lifting aerofoils, and means for rotating alternate hub parts in opposite directions, whereby a substantially undisturbed slip stream is produced extending generally in parallel directions on different sides of the hub parts.

2. A rotary propeller device comprising a plurality of hub parts placed one behind the other, a plurality of blades on said hub parts, the blades

having a concave pressure or medium-engaging side curved in a direction substantially parallel to the leading edge of the blade and also in a direction at right angles to said first direction, the chords of the blade sections making angles of about between 5° to 40° with a plane containing the axis of rotation of said hub parts, and means for rotating alternate hub parts in opposite directions with the rear part, rotating slower than the front part so that the resulting reaction torque is substantially zero and the slip stream is directed substantially straight to the rear without substantial spreading, the average distance between the rear edges of the blades on the leading hub part being from the minimum working clearance to 20% of the wing tip diameter.

3. A rotary propeller device comprising a plurality of hub parts placed one behind the other, a plurality of blades on said hub parts, the blades having a concave pressure or medium-engaging side curved both radially and axially with reference to the axis of rotation of the hub parts and the curvatures being respectively greatest in the region of the outer edge and the leading edge of the blade and the chords of the blade sections being inclined at right angles between 5° and 40° with reference to the planes containing the axis of revolution of the hub parts and the blades being inclined radially with reference to the axis of rotation so that said medium-engaging side makes an angle less than 90° with a plane tangent to the hub part, and means for rotating alternate hub parts in opposite directions with the rear part rotating slower than the front part so that the resultant reaction torque is substantially zero and the slip stream is directed substantially straight to the rear without substantial spreading, the average distance between the rear edges of the blades on the leading hub part being from the minimum working clearance to 20% of the wing tip diameter.

4. A rotary propeller device comprising a plurality of hub parts placed one behind each other, a plurality of blades on each hub part, the blades being curved in two directions like sails and the chords of the blade sections making angles between 5° and 40° with a plane containing the axis of rotation of said hub parts, and means for rotating alternate hub parts in opposite directions with the rear hub part rotating slower than the front hub part so that the reaction moment of the different parts amounts practically to zero, and whereby the slip stream is relatively undisturbed and is directed substantially straight to the rear.

5. A rotary propeller device comprising a front hub part and a rear co-axial hub part which constitute a relatively thick hub of streamline form, each hub part having a plurality of blades thereon, the blades having a concave pressure or medium-engaging side curved in a direction substantially parallel to the leading edge of the blade and also in a direction at right angles to the said first direction and the chords of the blade sections being inclined at angles between 5° to 40° to planes containing the axis of rotation and the blades of the front section being inclined oppositely to those of the rear part, epicyclic gear means for rotating the front hub part, and further epicyclic gear means for rotating said rear hub part in the opposite direction at about ⅔ the number of revolutions of the front part, so that the reaction moment of the device is about zero and whereby a relatively undisturbed slip stream directed substantially to the rear is produced, the axial distance between the rear edge of the front blades and the leading edge of the rear blades measured at the roots of the blades being from 5% to 10% of the wing tip diameter.

6. A rotary propeller device comprising a plurality of hub parts placed one behind each other, a plurality of blades on each hub part, the blades on each hub part being curved like sails in two directions mutually at right angles and the chord of any blade section making an angle which is not more than 40° and is not less than 5° with a plane containing the axis of rotation of said hub parts, and means for rotating alternate hub parts in opposite directions, so that the reaction moment of the different parts amounts practically to zero, and the slip stream is directed substantially to the rear generally in parallel directions on different sides of the hub parts.

7. A rotary propeller device comprising a plurality of hub parts placed one behind the other, a plurality of blades on each said hub parts, the blades on each hub part showing in cross-sections on any cylindrical surface co-axial with the axis of rotation as well as in cross-sections on any surface normal to the axis of rotation a shape similar to that of a lifting aerofoil, the chords of the first said blade-cross-sections making angles of between 5° and 40° with a plane containing the axis of rotation of said hub parts, and the distance between the leading and rear edges of the blades of successive hub parts being from the minimum working clearance up to about 20% of the total diameter of the propeller, and means for rotating alternate hub parts in opposite directions.

8. An air-craft propeller comprising two co-axial hub parts constituting a substantially continuous streamline hub, a plurality of blades on each hub part, and means for rotating the hub parts in opposite directions, the blades on both hub parts showing on cylindrical cutting-surfaces coaxial with the axis of the hub parts cross sections similar to those of lifting airfoils and showing also on cutting-planes normal to said axis cross sections having each a concave pressure side, the chords of any of the first said blade cross-sections making an angle of less than 40° but not less than 5° to said axis of rotation, the inclination of the blades on the respective hub parts being in mutually opposite senses, and the axial distance between the adjacent edges of the respective hub-part blades being from the minimum working clearance to 20% of the blade-tip diameter.

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