July 28, 1942. E. SCHNEIDER 2,291,062

BLADE WHEEL PROPELLER, PARTICULARLY FOR WATERCRAFT

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Fig. 1.

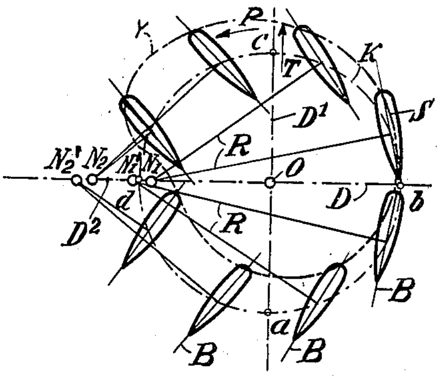


Fig. 2.

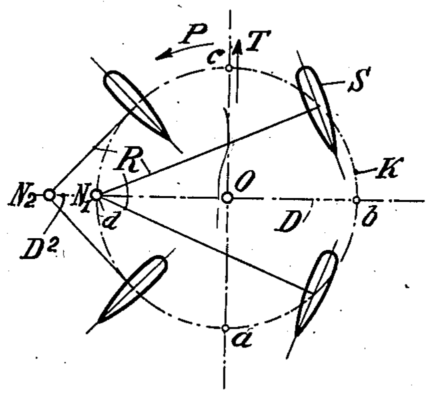


Fig. 3.

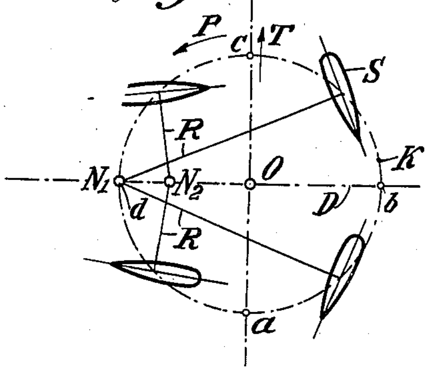


Fig. 4.

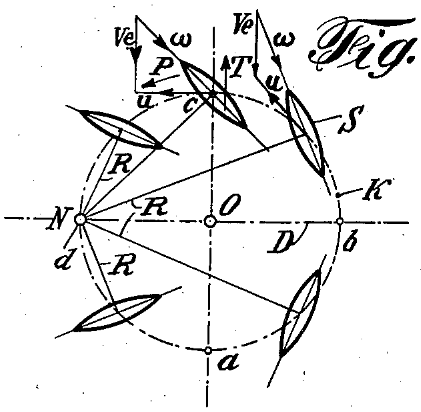


Fig. 5.

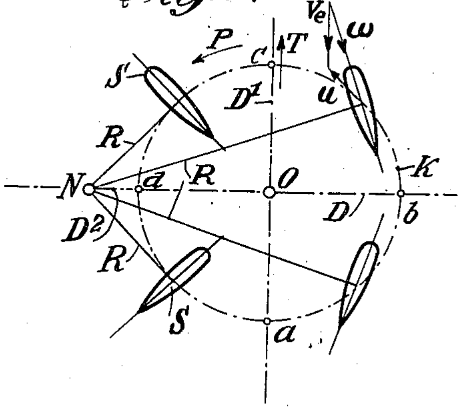
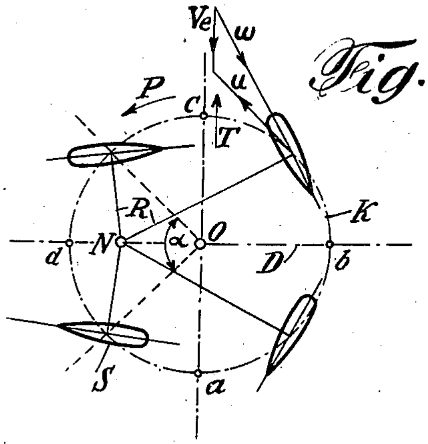


Fig. 6.



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Ernst Schneider

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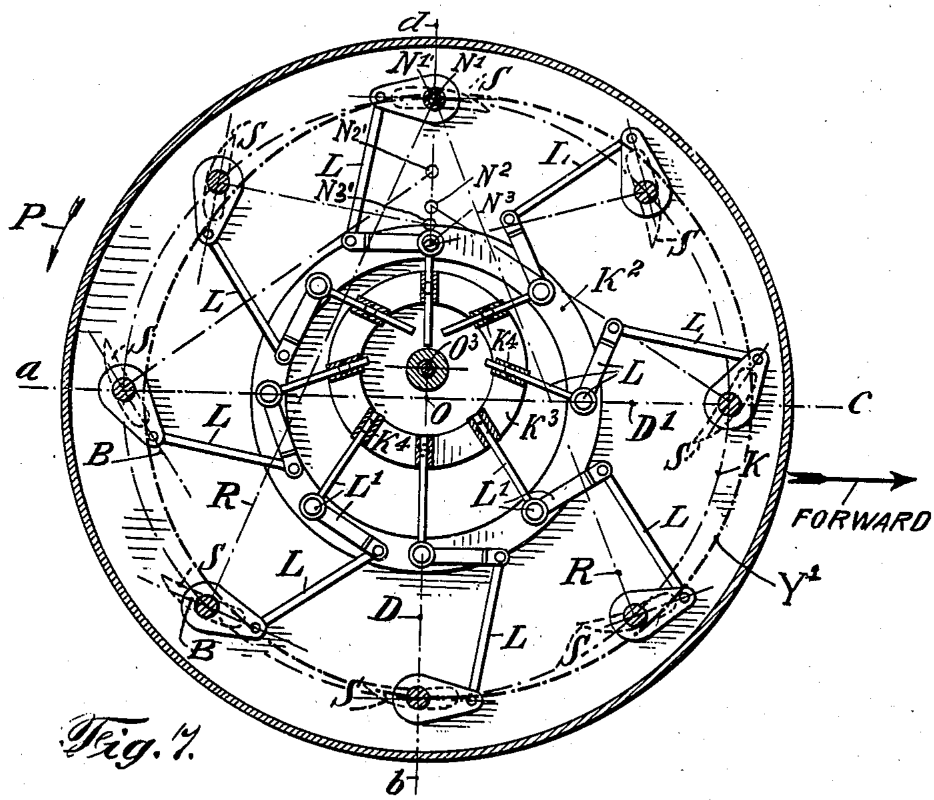

Fig. 7.

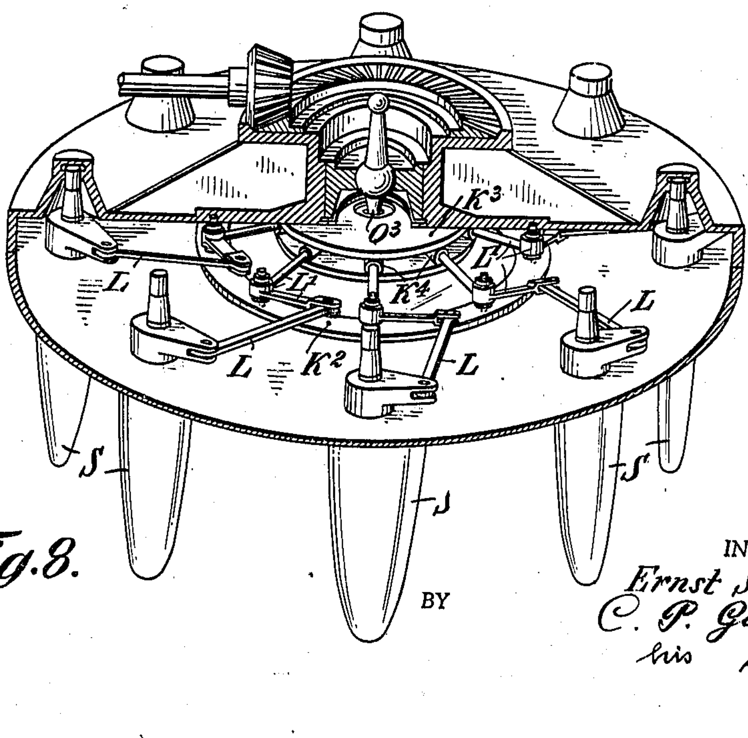

Fig. 8.

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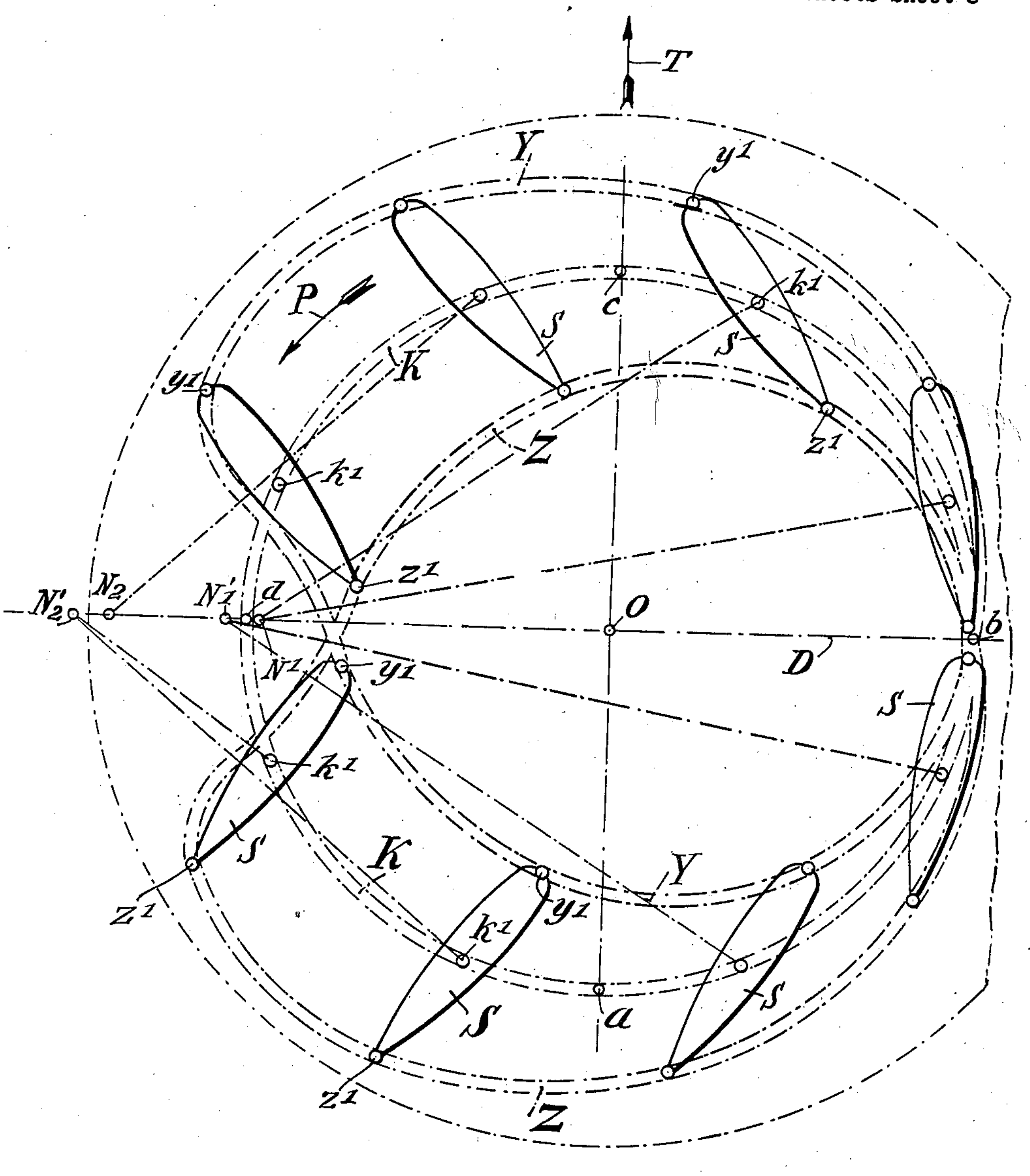

Fig. 9.

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UNITED STATES PATENT OFFICE

2,291,062

BLADE WHEEL PROPELLER, PARTICULARLY FOR WATERCRAFT

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Application March 7, 1940, Serial No. 322,815
In Germany February 6, 1939

2 Claims. (Cl. 170—148)

This invention relates to blade wheel propellers for water or air crafts. In these propellers the blades are arranged upon a rotor, and the blades can feather about their axes while moving through their circular orbit. The blades are either at substantially right angles to the plane of rotation of the rotor, in which case they form a cylindrical blade propeller, or the blades are inclined at a small angle to the plane of rotation of the rotor, in which case they form a conical blade propeller. In either case, problems in regard to efficiency of operation arise, and it is one of the objects of this invention to so co-relate the blades of the rotor as to obtain the highest efficiency of propelling action of the propeller, at the normal speed of rotation, the normal speed being usually the highest speed for which the propeller is designed.

For the proper understanding of the actions of blade wheel propellers, the circular orbit is divided into quadrants, formed by two diameters perpendicular to each other, one of these diameters being in line with the longitudinal axis of the boat or ship to which the propeller is applied, and the other being at right angles thereto and athwartship. Assuming the boat or ship to move forward, and provided the propeller rotates counter clockwise when looking down at it, the semicircle at the right hand of the longitudinal axis diameter and in which blades move in forward direction, is known as the forward running blade semicircle and the semicircle at the left hand of said axis diameter in which the blades move in the rearward direction, is known as the rearward running blade semicircle. The semicircle forward of the athwartship diameter is known as the forward semicircle, and the semicircle aft of that diameter is known as the rearward semicircle. In earlier disclosures, the varying actions of the water upon blades in different quadrants has been described.

The particular part of this invention is to utilize factors of operation heretofore disclosed, and direct them in a special manner so as to obtain the highest efficiency of operation when operating at the normal speed of the operation.

Under recognition of the principle that the most favorable pitch of a mechanical screw as regards efficiency is obtained when H over D equals 1, with H being the pitch, and D the diameter of the screw thread, the improved propeller embodies this principles for hydraulic uses.

The invention consists in disposing the blades of a blade wheel propeller under conditions of normal operations, so that the average pitch of the blades within the forward running blade semicircle equals approximately π, while the average pitch of the blades within the rearward running blade semicircle is slightly larger or smaller than π, and further in that pitches of the blades in the rearward semicircle are somewhat larger than the pitches of the blades in the corresponding or reflective positions in the forward semicircle.

The invention will be hereinafter further described, embodiments thereof shown in the drawings, and the invention will be finally pointed out in the claims.

In the accompanying drawings:

Figure 1 is a diagrammatic plan view showing the disposition of blades of a blade wheel propeller giving the highest efficiency under normal speed conditions;

Figures 2 and 3 are similar views of a part of the number of the blades shown in Figure 1, to explain the actions of the blades under the designated pitch π; and

Figures 4 to 6 are diagrammatic plan views used to explain certain laws of action of the blades, which form the basic underlying concepts which led to the present invention.

Figure 7 is a plan view showing the positioning of the blades and the means for operating the same arranged in accordance with Figure 3, Figure 7 being shown turned 90° in respect to Figure 3, and Figure 8 is a perspective view of Figure 7, with additional parts shown above the parts shown in Figure 7.

Fig. 9 is a plan view of the blades and showing the curves through which the center shaft of the blades, as also their front and rear ends pass, when the normals of the forward moving blades intersect the orbit and the diameter transverse to the direction of movement of the ship, the normals of the other blades intersecting the extension of said diameter beyond the orbit.

Similar characters of reference indicate corresponding parts throughout the various views.

Referring to the drawings, and more particularly to Figures 1 and 2, the blade wheel orbit is shown by the circle K, the center of rotation of the blades by O, the direction of movement of the boat by the arrow T, and the direction of rotation of the blades, with the boat moving in the direction of the arrow T, by the arrow P. The semicircle *cba* is the forward running semicircle, and the semicircle *cda* is the rearward running semicircle. The semicircle *dcb* is the forward semicircle and the semicircle *dab* is the aft or rearward semicircle. The diameter D^1, extending from c through O to a is the diameter of the circle K, in alignment with or parallel with the longitudinal axis of the boat and the diameter D is at right angles to D^1, extending from d through O to b or athwartship. The diameter D is the important diameter in respect to the present invention. Utilizing the known advantages of adjustable pitch in regard to magnitude as well as direction, and of blades having the same entrance edge all the time, the blade pitch of the blades S is equal to or approximately equal to π, preferably for all of the blades.

The invention consists in making the pitch of the blades S while traveling in the forward running semicircle *cba* equal to π, and the pitch of the blades while running in the rearward running semicircle somewhat larger or smaller than π. This pitch of the blades gives a most efficient pitch, maintains the entrance edge of the blades, and gives arbitrary adjustability of the blade pitch without having to accept the disadvantages of earlier proposals. The invention may also be defined by the blade normals of the blades. In Figure 1, the blade normals are indicated by the lines R, these normals being perpendicular in each case to the longitudinal axis of each blade, indicated by the lines B. The normals R of the blades in the forward running blade semicircle *cba* intersect the diameter D substantially at its end point *d*, either on the blade circle or in its immediate vicinity. The normals R of the blades in the rearward running blade semicircle *cda* intersect an extension D^2 of the diameter D outside of the circle K, or intersect in some cases the diameter D within the circle K. The normals of the blades of the forward running semicircle *cba* intersect nearer the blade circle K, than the normals of the blades of the rearward running semicircle *cda*. The pitch of the blades of the forward semicircle *dcb* is somewhat smaller than the pitch of the blades in the rearward semicircle *dab*. The intersecting points N_1 and N_1' are at or in the vicinity of the circle K with the point N_1' slightly greater in distance from the center O than N_1. The intersecting points N_2 and N_2' intersect, in the embodiment shown, the extension D^2 of the diameter D, the intersecting point N_2' being at a greater distance from the center O than the point N_2.

Referring to Figure 2, the blade normals R of the blades in the forward running semicircle *cba* intersect the diameter D at the point N_1, in this embodiment directly at the circle K; and the normals R of the blades with the rearward running semicircle intersect an extension D^2 of the diameter D at N_2 outside of the circle K. The distance of the point N_2 outside of the circle is dependent upon various considerations; on the one hand, this point must not be too far away from the blade circle, as otherwise the efficiency of that particular blade circle half decreases too much, and on the other hand, the intersecting must not be too close to the circle, as this would require excessive forces to turn the blades about their axis, inasmuch as the torque to be imparted on the blade will be greater the smaller the distance between the intersecting point outside the blade circle and the circle. These considerations are embodied in the embodiment shown in Figure 1.

Referring to Figure 3, the intersection point N_2 of the blade normals of the blades in the rearward running blade circle *oda* is located inside of the circle K, whereby the distance of this point is dictated by similar considerations as those which were set forth in connection with Figure 2, that is the efficiency and the acceleration forces required for turning the blades must be taken into consideration in this blade wheel semicircle *cda*. The normals of blades S in the forward running semicircle *cba* intersect the diameter D at N_1. Radial lines drawn from center O through the blade centers form an angle α of 90°, as shown in Figure 6, and the center line of this angle α is identical with the diameter D at its portion *dO* and at high pitch values the relative velocity and therefore the work component influencing the efficiency are comparatively negligible.

The efficiency of a blade wheel built in accordance with the present invention may in a known manner be further improved by increasing the angles between the blade and tangent to the blade circle K through the blade axes in the rearward blade semicircle compared with the corresponding angles in the forward blade semicircle. This will effect a load increase in the rearward blade semicircle, thus equalizing the irregularities caused by the fact that the flow velocity is larger in the rearward semicircle *dab* than in the forward half of the wheel *dcb*, due to the acceleration imparted on the fluid in the forward half of the wheel. This improvement of efficiency may be effected by placing the intersection of the blade normals closer to the wheel center O, when the blades move through the forward half *dcb*, than the intersection points of the blade normals belonging to the blades moving through the rearward wheel half *dab*.

The foregoing is based upon the following considerations:

As stated at the outset, the greatest efficiency with a mechanical screw is obtained when H over $D\pi$ equals 1. Applying this to blade wheel propellers of either cylindrical or conical blade dispositions, this hydraulic maximum efficiency is reached if the entrance velocity of the fluid equals the peripheral velocity *u* of the blade wheel, that is, the relation of *ve* over *u* equals 1. This condition is fulfilled if the blade normals, that is, the normals to the chords of the profiles of the blades through the blade centers intersect on the blade circle K. More precisely stated, the intersection takes place at or in proximity of the diameter D and the blade circle K. In designing ship propellers, the proportion of H over D designates the pitch of the propeller, in which H is the distance traveled by the blade wheel per resolution under no-load condition (pitch) and D is the diameter. Between this ratio and the relation of *ve* over *u* mentioned before, the following relation exists:

$$\frac{H}{D\pi}=\frac{ve}{u}$$

On the left hand of this equation the values refer to one revolution of the blade wheel, while on the right hand all the values refer to time. If ve/u equals 1, we obtain

$$\frac{H}{D}=\pi$$

Figure 4 shows the different positions of the blades of a blade wheel propeller having a pitch of

$$\frac{H}{D}=\pi$$

The blade normals R of blades S intersect in a point N located on diameter D and blade wheel circle K. The arrow P indicates the direction of rotation of the wheel and arrow T the direction of thrust, i. e., the direction of travel of the ship. This law of blade motion, as indicated in Figure 4, requires that entrance and discharge edges of the blades alternate in such a way that, as illustrated in Figure 4, symmetrical profiles must be selected. These, however, do not permit to obtain the theoretically highest values of efficiency based on the most favorable blade pitch. A further disadvantage of these well known blade wheels is, that the intersection N of the normals may not be shifted to a point within the circle, which means that the blade pitch, once selected, cannot be changed. The peripheral velocity *u* in these blade wheels at no-load equals the entrance velocity *ve* of the liquid; *w* designates the relative velocity. Blade wheels in which in addition to the advantage, if only limited, of adjustable pitch, they also permit a favorable shape of the profile of the blades, are also known. But in these blade wheels it is not possible to realize the most efficient pitch π. The law of blade motion of these wheels is shown in Figure 5. This figure will be easily understood as the same reference characters have been used as in Figure 4. The intersecting point N of the blade normals R lies outside of circle K on an extension D^2 of diameter D. The peripheral velocity *u* under no-load condition in these blade wheels is smaller than velocity *ve* as may be seen from velocity triangle *u, ve, w,* in Figure 5. A further known variety of blade wheels is shown in Figure 6. In this case the intersecting point N of the normals is located inside of the blade wheel circle. It may arbitrarily be shifted to various positions within the blade circle, permitting the propeller thrust to be varied in respect to its magnitude from a maximum to zero and in respect to its direction from ahead to astern, to starboard and to port, merely by shifting the intersecting point N of the normals. However, even in this case it is likewise impossible to obtain under normal conditions of operation the maximum values of pitch, inasmuch as the proportion ve/u does not equal 1, but must be smaller than 1, as can easily be seen from the velocity triangle *u, ve, w,* in Figure 6.

From the foregoing it is seen that this invention as described in connection with Figure 1, solved a problem by making the pitch of the blades exactly (substantially) equal to π, in forward running semicircle *abc*, and somewhat larger or smaller than π in the rearward running semicircle *cda*. Otherwise stated, the solution results from having the normals R of the forward running semicircle *cba* intersect the diameter D at or in proximity to its end point *d*, like Figure 2, and from having the normals of the semicircle *cda* intersect on an extension D^2 of this diameter outside of the blade circle, or on the diameter inside of the blade circle, like Figure 3. Finally, the blade pitches in the aft semicircle *dab* are somewhat larger than the blade pitches in the reflective or counterpart positions in forward semicircle *dcb*, the counterpart being considered in respect to the athwart diameter D. This solution combines the advantages of the three known varieties of blade wheels exemplified in Figures 4, 5 and 6, namely, most efficient pitch, maintains the entrance edge of the blades, and gives arbitrary adjustability of the blade pitch, without, however, having to accept the disadvantages of the types shown in Figures 4, 5 and 6.

In Fig. 7 is shown the orbit *abcd*, with the center O. Concentric to the orbit *abcd* is a ring K^2 which is rotatable with the blades in the orbit *abcd*. Another ring K^3 when in initial position is concentric with ring K^2 and with the orbit, and the orbit and the two rings are concentric. But the ring K^3 is shiftable and in Figure 7 it is shown as shifted from its concentric position to an eccentric position in respect to ring K^2, whereby the center O^3 is shifted along the diameter *db*, as shown. The diameter *db* is also marked D and is transverse to the longitudinal direction of the ship. The normals of the blades intersect the transverse diameter D as shown. To each blade or to a rod secured thereto, which rod in plan view is above the blade profiles, a link L is pivoted, the other end of which is pivoted to one end of an elbow lever L^1, having its angle pivoted to the ring K^2. The other leg of this elbow lever is arranged in a slide K^4, pivoted to the ring K^3. Thus by shifting the ring K^3 into the position shown in the drawings in Figure 7, the forward moving blades in the semicircle *abc*, a little after and a little before the blades at the positions *a* and *c*, have their perpendiculars pass through a point at the intersection of the orbit K and diameter D. The front end of all the blades pass through another orbit Y^1. In Figure 1, the front end of the blades pass through the orbit Y shown in dot-dash line in Figure 1. The orbit Y^1 in Figure 7 is that resulting from a disposition of the blades in accordance with Figure 3. The intersection points N^1 and N^1_1 are in the circular orbit K and in the diameter D, whereas the points N2 and N3 as also N^1_2 and N^1_3 are within the orbit, on the diameter D. In Figure 7 the ship moves in the direction of the arrow marked "Forward" and the blades rotate in the direction of the arrow marked P. The positioning of the blades in Figure 7 conforms to the pitches described hereinbefore. The criterion is the pitch of π as stated to give the highest efficiency under high speed or normal operation.

It goes without saying that these data are to be considered on approximate bases only, for, it would be possible within the frame of this invention, on the one hand, to deviate from pitch π in the forward running half circle within the limits of fairly high hydraulic efficiency, while on the other hand it would likewise be possible to select that section of the blade wheel circle in which the blade normals intersect outside or inside the blade circles, larger or smaller than the half circle.

In Fig. 9 is shown the blades S in the same position as shown in Fig. 1. The center of each blade passes through the orbit K, and the tip of each blade through the path or curve Y, as in Figure 1. In Fig. 9 is also shown the path or curve through which the tail or rear end of each blade passes, which path or curve is necessarily a reverse curve to curve Y, and is indicated by Z. If now these paths or curves K, Y, and Z, be shaped into grooves as shown by the double and spaced lines in Figure 9, stems on such blades as generally indicated by the small circles, will follow such grooves, when the blades are moved with their central shafts or stems in the orbit K. Any intermediate portion of a blade between those shown will necessarily be controlled by the same relationship. Thus when the rotor is supplied with such grooves Y, K and Z, and the blades moved by their stems in the orbit groove K, the tips and rears of the blades will take the positions shown, as long as their normals intersect the orbit at its intersection with the transverse diameter D in respect to the forward going blades, and the normals of the other blades intersect the extended diameter beyond the orbit.

The tip of the blades is indicated by Y^1, the center shaft by K^1, and the rear end by Z^1.

Reference is made to my co-pending application, Serial No. 250,949, filed January 14, 1939, and to U. S. Letters Patents Nos. 1,681,500 of August 21, 1928; Voith 1,922,606 of August 15, 1933; and Ehrhart No. 2,037,069 of April 14, 1936.

I have described several embodiments of my invention, but it will be clear that changes may be made within the principle of the invention described, without departing from the scope of the subjoined claims.

I claim:

1. A blade wheel propeller having blades the axes of which in respect to the axis of rotation of the propeller describes a cylinder or a cone, and having means to arbitrarily adjust the blades as to magnitude and direction of thrust, said blades moving on their axes in a circular orbit having a diameter disposed front to aft and a diameter at right angles thereto, athwartship, with the semicircle at the right side of the longitudinal diameter being for the forward running blades and the semicircle at the left side of said longitudinal diameter being for the rearward running blades, the semicircle fore of the athwart diameter being the forward semicircle and the semicircle at the rear thereof being the aft semicircle, comprising means for axially shifting said blades during the rotation of the propeller for maintaining the blades while in forward running position at an average pitch of π, with their perpendiculars to the blade profiles intersecting said athwart diameter and said rearward running semicircle of said orbit, and means for simultaneously maintaining the blades while in the rearward running position at a pitch larger or smaller than π, with their perpendiculars to the blade profiles intersecting said athwart diameter within or without said orbit, the blades in their forward semicircle being in advance of the blades in the aft semicircle while in the fluid current during the forward movement of the propeller as an entirety.

2. A blade wheel propeller having blades the axes of which in respect to the axis of rotation of the propeller describe a cylinder or a cone, and having means to arbitrarily adjust the blades as to magnitude and direction, said blades moving on their axes in a circular orbit having a diameter disposed front to aft and a diameter at right angles thereto, athwartship, with the semicircle at the right side of the longitudinal diameter being for the forward running blades and the semicircle at the left side of said longitudinal diameter being for the rearward running blades, the semicircle fore of the athwart diameter being the forward semicircle and the semicircle at the rear thereof being the aft semicircle, comprising means for axially shifting said blades during the rotation of the propeller for maintaining the blades while in forward running position at an average pitch of π, with their perpendiculars to the blade profiles intersecting said athwart diameter and said rearward running semicircle of said orbit, means for simultaneously maintaining the blades while in the rearward running position at a pitch larger than π, with their perpendiculars to the blade profiles intersecting said athwart diameter without said orbit, the blades in their forward semicircle being in advance of the blades in the aft semicircle while in the fluid current during the forward movement of the propeller as an entirety, and means for moving the pitch of the blades in the aft semicircle of the blades, reflective thereof or counterpart thereto, in the forward semicircle.

ERNST SCHNEIDER.