July 29, 1941. H. MUELLER ET AL 2,250,772

BLADE WHEEL

Filed Dec. 3, 1937 3 Sheets-Sheet 1

Fig. 1

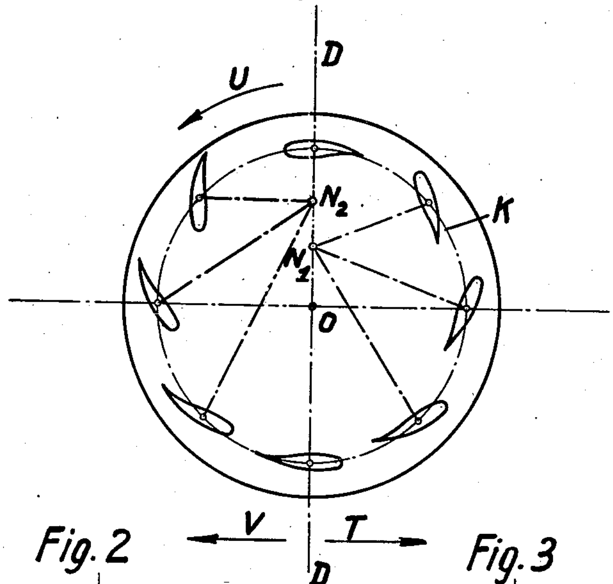


Fig. 2

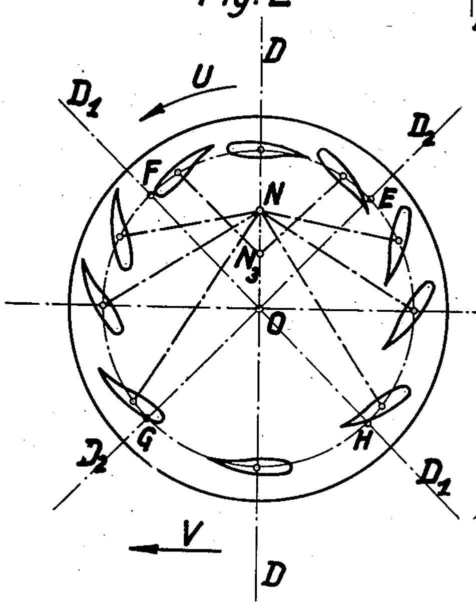
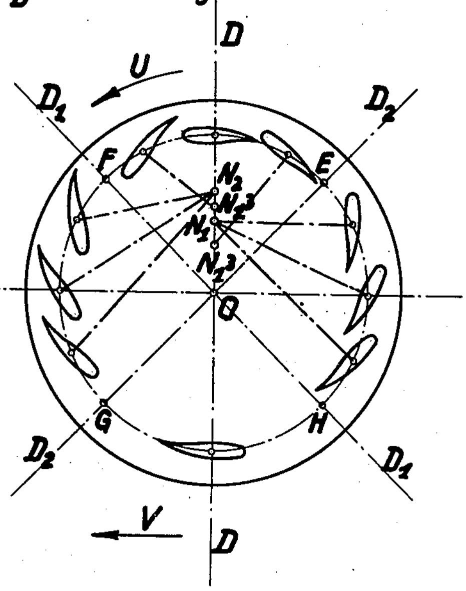


Fig. 3



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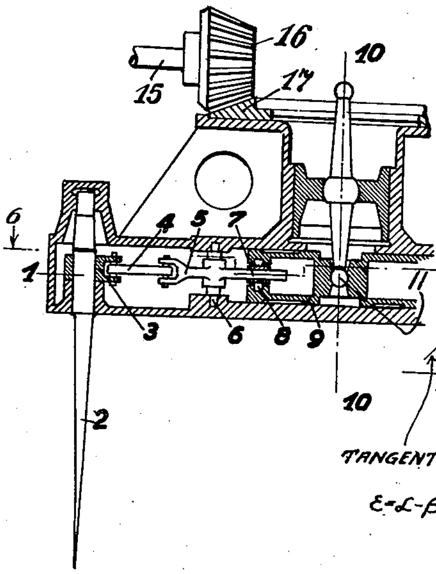

Fig. 4.

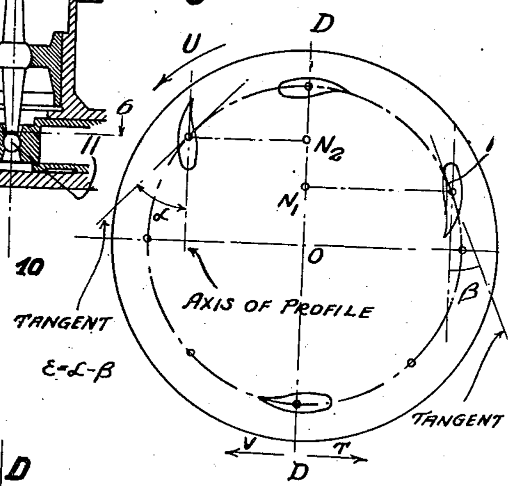

Fig. 8.

Fig. 5.

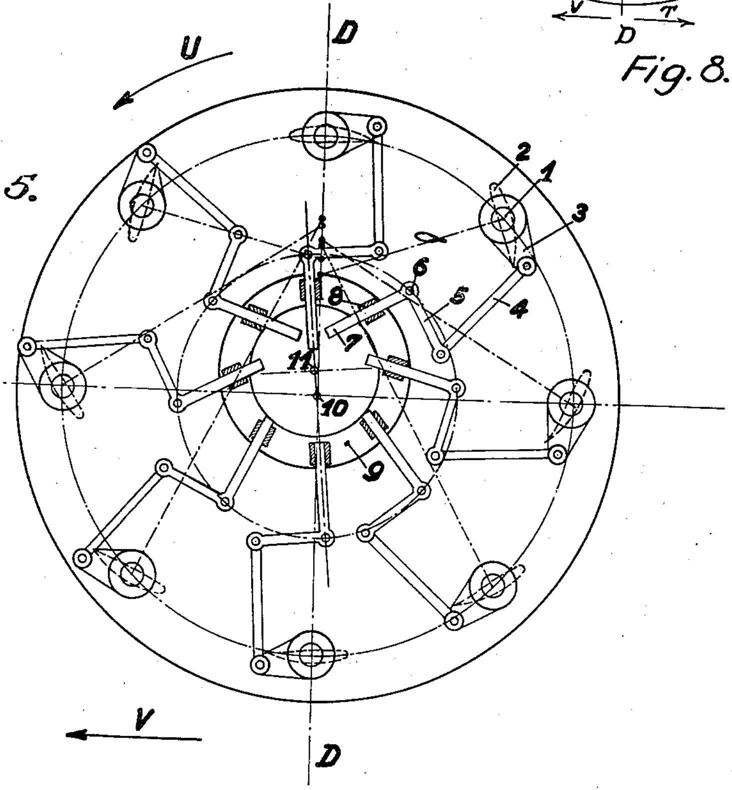

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Fig. 6.

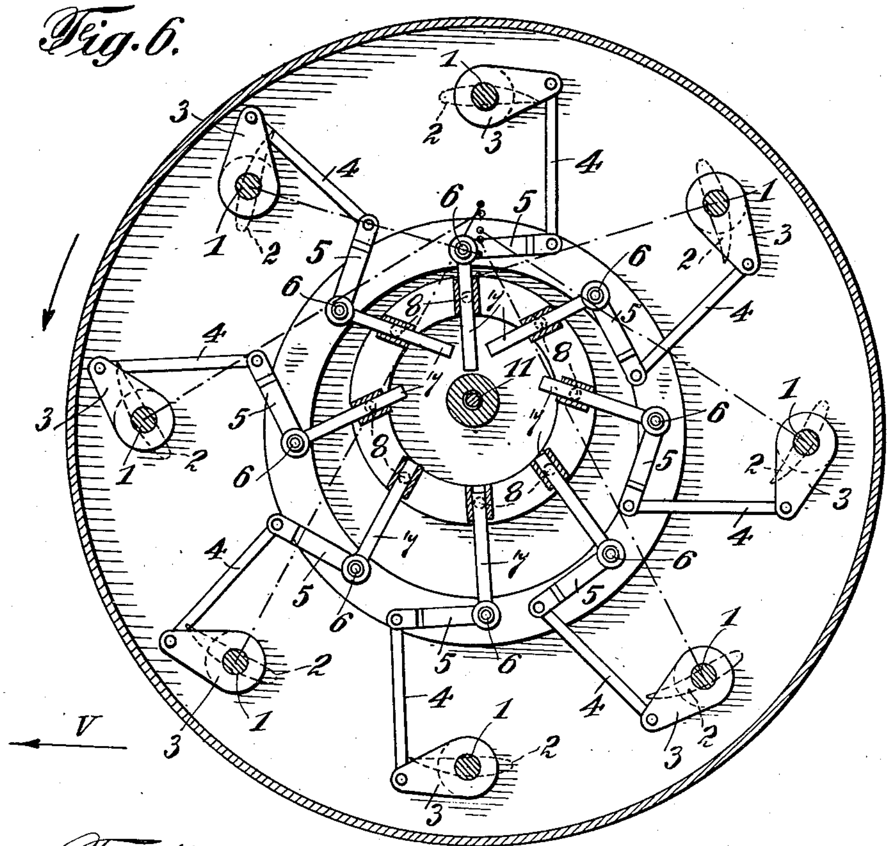
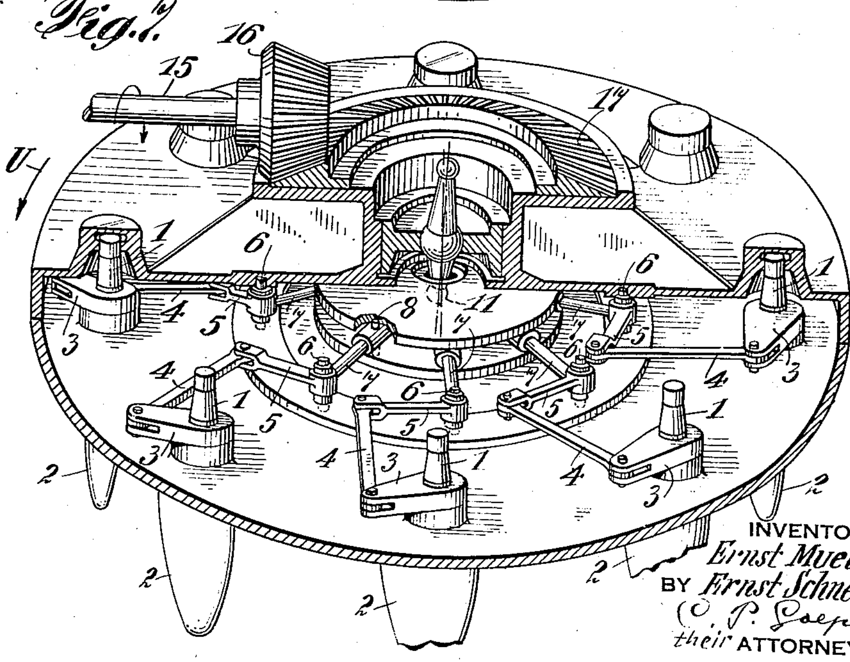


Fig. 7.



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2,250,772

UNITED STATES PATENT OFFICE

2,250,772

BLADE WHEEL

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Application December 3, 1937, Serial No. 177,886
In Germany December 9, 1936

11 Claims. (Cl. 170—148)

This invention relates to blade wheels, and more particularly to improvements therein. The type of blade wheels to which this invention is an improvement is shown in U. S. Letters Patent No. 2,015,514 as an example.

More particularly, the invention has for its object to provide means to compensate the working effect of rearward blades of a propeller wheel in respect to the front blades, to the variations in the velocities of the water at the rear and front of such propeller wheels. A further object is to so control the swinging of the blades when near their normal positions, that is, perpendicular to the diameter of the wheel at right angles to the longitudinal axis of the ship, so as to obtain the highest working effect from the blades, and also to prevent vibrations caused by rotating of the blades during too small an arc.

The invention further has for its object to provide a mechanism in which parts rotate isochronously to each other, and in which the linkage of the parts is so correlated to the blades that the blades follow the laws of action hereinafter fully described.

For this purpose, the invention consists in the means for so disposing the blades that the front blades have their radii vectors intersect the diametrical line perpendicular to the length of the ship, at a point nearer to the center of the propeller than the intersection of the radii vectors with said line of the rear blades, and that certain of the blades, those in quadrants in which said line is a median, have the intersections of the vectors with said line of the blades of the quadrant of the rearward going blades nearer to the center than the intersections of the vectors with said line of the blades of the quadrant of the forward going blades, considered in respect to corresponding blades along the width of the ship. By such means, the rear blades have a larger amplitude than the front blades to compensate for the variations of velocity of the water, and also the blades in the rearward going quadrant are not swung as sharply as heretofore, thus avoiding vibrations and losses.

Furthermore, the preferable angle is that defined by the formula mentioned herein.

Finally, the invention consists in the means to swing the blades and rotate the propeller, in accordance with the laws hereinafter set forth.

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

In the accompanying drawings:

Figure 1 shows a diagrammatic drawing, showing the blades acting in accordance with the present invention, in accordance with one rule of action thereof;

Figure 2 is a similar drawing, embodying another rule of action;

Figure 3 is a similar diagrammatic drawing embodying the rule of action of Figure 1 combined with that of Figure 2, and forming the present invention;

Figure 4 is a radial section to show how the parts are mechanically connected with each other, certain of the parts being shown in side view; and

Figure 5 is a plan view of mechanism, largely diagrammatically shown, to enable the blades to be swung during the rotation of the blade wheel on the propeller, when acting in accordance with the laws represented in Figure 4.

Figure 6 is a horizontal section taken on line 6—6 of Figure 4.

Figure 7 is a perspective view showing the connections of the parts, and

Figure 8 is a drawing showing the angle differential E, E being the angular difference between the largest angle in the front half and the largest angle in the rear half of the propeller.

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

In accordance with the invention, there must be used a guiding mechanism which, as schematically shown in Figure 1, must be so designed that the radius vectors, perpendicularly erected to the blades at their pivots, in the front part of the rotor meet in one point N_1, which is nearer the center of the wheel O than a guiding point N_2, in which the radius vectors of the blades in the rear part of the rotor intersect. The two points N_1 and N_2 are situated on the diameter D of the wheel which is normal to the direction of flow V. On the front part of the rotor the guiding point N_1 ensures the control of the radius vectors and in the rear part of the rotor the control passes over to the guiding point N_2.

In particular the angle between the tangential position and the blade position on the rear part of the rotor should be larger by a certain amount ϵ than the angle between the tangential position and the blade position on the front part of the rotor, whereat the angle difference ϵ, expressed in circular measure, should depend upon the degree of load according to the formula

$$0{,}01.\sqrt{1+c_s} < \epsilon < 0{,}06.\sqrt{1+c_s}$$

It will be noted that this formula consists merely of a number of dimensionless numbers and the value c_s, which likewise has no dimension. This value c_s is called "load factor," and it is calculated according to the following formula:

$$c_s=\frac{S}{F\times\frac{\gamma}{2g}\times v_e^2}$$

wherein S is the thrust developed by the propeller; F the swept area of the propeller; γ the specific gravity of the water or fluid upon which the propeller works; g is the acceleration of gravity; and v_e is the velocity of the fluid when entering the propeller. To further characterize the meaning of the load factor, it may be stated that for quick moving ships with sharp or fine lines, the load factor is small (0.5 to 1.0), while propellers for blunt or full lines have high load factors to about ten times that of propellers for ships with fine lines.

In case the blade wheel will be employed as a turbine, the conditions are vice versa, because the water that has been used on the front part of the rotor flows with diminished speed to the rear part of the rotor, so that the pitch has consequently to be diminished there, if the entrance angle shall remain equal or nearly equal. Should the blade wheel be used as a pump, the phenomenon will be the same as in case of propeller working.

The uplift of a blade is proportional to the entrance angle and the velocity of flow. If, at a considerable factor of uplift, the vacuum exceeds an admissible amount, cavitations are likely to occur. The entrance angle and flow velocity must therefore be kept within certain limits to prevent such cavitation.

The hydraulic conditions are, however, different on various points of the circle K in consequence of the particular characteristic of the blade motion, and there is especially an essential difference in the conditions in the region of the quadrants E—F as per Fig. 2 compared with that of the two quadrants F—G and H—E. These latter quadrants are limited by the diameters of wheel D_1, D_2 which intersect under 90° and are displaced by 45° against the diameter D on which the guiding point N is situated. Particular attention is, however, drawn to the fact that these quadrant limits shall not be considered as exact deliminations; they are only indicated as quadrant-like regions. The conditions in quadrant region E—F are also considerably different to those of the quadrant region G—H; but it will be sufficient if the blades in the quadrant region G—H are suited to the relative flow.

In the quadrant E—F the blades make a very quick turning movement. If one desires to maintain admissible angle values in the quadrant E—F, the pitch must be limited in this quadrant. The guiding point adjusted at N, according to Figure 2, for the quadrant E—F must approach the center O of the blade wheel and be displaced for example to N_3, as shown in Fig. 2. This can be done in such a degree that even in the case of a large pitch of the blades travelling along the quadrants F—G and H—E, the entrance angle for the blades travelling along the quadrant E—F will remain within admissible limits. It is therefore possible, in case of high speed of the ship, to increase the pitch in the front and the rear quadrant in order to diminish the rotational velocity. This can go so far that the guiding point N of Fig. 2 for the blades travelling along the front and the rear quadrant moves off in the direction of the diameter D—D so far from the center O of the wheel that it comes on the circle K or even out of it.

The nearer the guiding point N_3 will be approached to the center O of the wheel, the smaller becomes the pitch of the blades in the quadrant E—F, and in case of exceeding a certain limit of approach of the point N_3 to the center of the wheel, the blades in the quadrant E—F will act as turbine blades, namely by the fact that they will be driven by the water flow provocated by the blades in the front and rear quadrant. This may be desirable in certain cases, as it has already been proposed to reduce, in case of screw propeller, the pitch of the propeller blade towards the boss by such an amount that they work as turbine blades in the region of the boss or hub.

In the sense of the present invention, the "intersection" of the radius vectors with that diameter of the wheel which is in a normal position to the direction of the flow, will move to and fro for every blade at any working condition within certain limits i. e., in the sense of Fig. 1, for example between the position N_1 and N_2 and in the sense of Fig. 2 for example between the positions N and N_3. For propeller service, N_1 is, according to Fig. 1, the intersection for the blades covering the front part of the rotor, and N_2 the intersection for the blades covering the rear part of the rotor. As per Fig. 2, N is the intersection for the blades covering the front and rear quadrant, and N_3 is the intersection for the quadrant E—F situated at the side of the eccentricity of the intersections N_1 and N_2 of Figure 1, or N and N_3 of Figure 2. It is, however, not necessary at all that the points N_1 and N_2 of Figure 1, or N and N_3 of Figure 2 remain stationary for more or less of the large regions of the circular path of the blades; the intersections can also change their position from point to point of the blade circulation, but always by observing the explained principles. The intersections will therefore change their position within certain limits during every revolution of the blades in the sense of Figs. 1 and 2 i. e. of course for every blade in the same way and by the same measure. Now, it is advisable to put into effect at the same time the two rules of motion which are represented in Figs. 1 and 2, on one and the same blade wheel, to superpose two rules. For propeller service, the pitch on the front part of the rotor should be smaller than on the rear part (Fig. 1), but on the other hand, the pitch in the quadrant E—F on the side of the eccentricity should be smaller at the same time than the pitch in the front and rear quadrants E—H and F—G (Fig. 2).

The combination of the two motion rules is represented in Fig. 3. For a certain working condition four intersections of the radius vectors are indicated on the diameter D. Those belonging to the front part of the rotor or to quadrant E—H are marked with N_1, whilst those belonging to the rear part of the rotor or to quadrant F—G are marked with N_2. The two intersections belonging to the upper quadrant E—F (i. e. to that on the side of the eccentricity of all intersections) have however still received the index 3, so that these two intersections are marked with N_1^3 and N_2^3.

Instead of a guiding point for a certain working condition, there are regions of intersections within the limits of which the intersections move during the revolution of the blades for a certain working condition, i. e. by pumps or progressively. These regions can be displaced both diametrically and in the circle, in case the working conditions shall be changed.

The same applies also to any other use of such a blade wheel, i. e. also to such a blade wheel pump or blade wheel turbine.

If a desired position of a blade on any point of its circular path has been found as most favourable from the hydraulic viewpoint in accordance with the foregoing, it is not difficult to find a kinematic device which will be able to positively guarantee the positions of the blades. This can be done by means of correspondingly formed guides (or guiding systems); but it is also possible to enforce such motions by means of corresponding steering mechanism.

Figs. 4, 5, 6 and 7 show as an example a method of construction of a guiding mechanism suitable for the realization of the combined rule of motion.

The pivot 1 of each blade 2 is fixed to a lever 3 to which is pivotally connected a rod 4 the other end of which is pivotally connected with an arm 5 of an angle lever, the centre of rotation 6 of which is located on the wheel and the second link 7 of which is guided in a slot guide 8. This slot guide 8 is mounted on a ring 9 turnable round on axle center 11, which is parallel to the pivot axle 10 of the wheel. The ring 9 can be displaced against the wheel in radial direction and in addition, its center 11 can also be turned round the pivot 10. By different adjustments of the center 11 of the ring 9 in respect to the pivot 10, the working condition of the blade wheel can be changed.

Upon turning of the wheel, the ring 9 must be induced to turn isochronously. At this isochronously rotary motion of the wheel and the ring 9, the guiding mechanism of each of the blades works as shown in Figure 5, so that the blades will effect motions as represented in Fig. 3. The radius vectors indicated with dotted lines in Fig. 5 cross the wheel diameter D in different points as shown, i. e. according to the rule of motion.

In Figure 5 there are shown six N points or intersections instead of the four shown in Figure 3.

The arm 5 is longer than the lever 3 and the length of the lever 3 and the length of the rod 4 have been so selected that the arms 3 and 5 converge towards the pivots 1 and 6 in the most of positions. It results from the difference of the length of the arms 3 and 5 that the load of the blades will be increased compared with a similar guiding mechanism at which the arms 3 and 5 would have the same length. The mentioned convergence of these two arms induces the special distribution of the different loads as represented in Figure 3. The point in question is therefore to increase the derived motion of the arm 3 and consequently of the blade 2 compared with the guiding motion of the arm 5 and to furthermore provoke the necessary irregularity of the motion transmission.

The method of construction represented in Figure 5 shows that it is possible by relatively simple means to realize the above described blade motions from which it results that guiding mechanisms and transmission means of other kind can be made suited for the enforcement of such blade motions.

In Fig. 2, the orbit of the blade rotation is divided into four quadrants by two diametrical lines connecting points E and G, and F and H, respectively. In the quadrant E—F the blades move from front to rear, and this quadrant may be called the rearward going quadrant. The quadrant G—H may be called the forward going quadrant. The quadrant H—E may be called the front quadrant, and the quadrant F—G may be called the rear quadrant. The diametrical line perpendicular to the longitudinal axis of the ship is a median line to the forward and rearward going quadrants.

In Fig. 4, the housing supports a bevel gear 17 which is engaged by a bevel gear 16 on a driving axle 15. By suitable known means (not shown), the axle 15 may be rotated, and thereby the propeller rotated.

It will have been seen that the underlying invention of the foregoing description finds its embodiment in the structure shown in Figure 5, and as pointed out in the following claims.

Changes and modifications can, of course, be made by one skilled in the art, in accordance with the teachings of the foregoing.

It is not desired to be limited to the embodiments, as changes can be made therein without departing from the spirit of the invention as defined in the annexed claims.

We claim:

1. A blade wheel propeller having blades substantially parallel with the axis of rotation of the propeller and adapted to rotate in a circular orbit and to swing round their axes during the rotation of the propeller, means for rotating the propeller, means for swinging the blades of the front half of the propeller around their axes during the rotation of the propeller to increasing angles from a tangential position of the blade to decreasing angles to another tangential position, in respect to a predetermined largest angle in the front half of the propeller, means for swinging the blades in the rear half of the propeller to increasing angles from said last named tangential position of the blade to decreasing angles to said first named tangential position, in respect to a predetermined largest angle in the rear half of the propeller, and means for coordinating the working of the aforesaid two means so that the predetermined largest angle in the rear half of the propeller is larger than said predetermined largest angle in the front half of the propeller, said means including a connection with each blade and an eccentric to the propeller wheel operating said connection.

2. A blade wheel propeller having blades substantially parallel with the axis of rotation of the propeller and adapted to rotate in a circular orbit and to swing round their axes during the rotation of the propeller, means for rotating the propeller, means for swinging the blades of the front half of the propeller around their axes during the rotation of the propeller to increasing angles from a tangential position of the blade to decreasing angles to another tangential position, in respect to a predetermined largest angle in the front half of the propeller, means for swinging the blades in the rear half of the propeller to increasing angles from said last named tangential position of the blade to decreasing angles to said first named tangential position, in respect to a predetermined largest angle in the rear half of the propeller, and means for coordinating the working of the aforesaid two means that the predetermined largest angle in the rear half of the propeller is larger than said predetermined largest angle in the front half of the propeller by an amount ϵ, this amount ex-

pressed in circular measure being in agreement with the formula

$$0{,}01.\sqrt{1c_s} < \epsilon < 0{,}06.\sqrt{1c_s} \ldots,$$

said means including a connection with each blade and an eccentric to the propeller wheel operating said connection.

3. A blade wheel propeller having blades substantially parallel with the axis of rotation of the propeller and adapted to rotate in a circular orbit and to swing round their axes during the rotation of the propeller, means for rotating the propeller, means for swinging the blades of the front half of the propeller around their axes during the rotation of the propeller to increasing angles from a tangential position of the blade to decreasing angles to another tangential position, in respect to a predetermined largest angle in the front half of the propeller, means for swinging the blades in the rear half of the propeller to increasing angles from said last named tangential position of the blade to decreasing angles to said first named tangential position, in respect to a predetermined largest angle in the rear half of the propeller, and means for coordinating the working of the aforesaid two means so that the predetermined largest angle in the rear half of the propeller is larger than said predetermined largest angle in the front half of the propeller, said means including a connection with each blade and an eccentric to the propeller wheel operating said connection, said swinging means including means disposing the blades to the front and rear halves so that radii vectors of the front blades intersect at a common point nearer the center of the propeller than the common point of intersection of radii vectors of the corresponding rear blades, said correspondence of blades being considered in respect to the length of the ship.

4. A blade wheel propeller having blades substantially parallel with the axis of rotation of the propeller and adapted to rotate in a circular orbit and to swing round their axes during the rotation of the propeller, means for rotating the propeller, means for swinging the blades of the front half of the propeller around their axes during the rotation of the propeller to increasing angles from a tangential position of the blade to decreasing angles to another tangential position, in respect to a predetermined largest angle in the front half of the propeller, means for swinging the blades in the rear half of the propeller to increasing angles from said last named tangential position of the blade to decreasing angles to said first named tangential position, in respect to a predetermined largest angle in the rear half of the propeller, means for coordinating the working of the aforesaid two means so that the predetermined largest angle in the rear half of the propeller is larger than said predetermined largest angle in the front half of the propeller, said means including a connection with each blade, and an eccentric to the propeller wheel operating said connection, said swinging means including means disposing the blades to the front and rear halves so that radii vectors of the front blades intersect at a common point nearer the center of the propeller than the common point of intersection of radii vectors of the corresponding rear blades, said correspondence of blades being considered in respect to the length of the ship, and means for swinging the blades in that quadrant of the orbit in which the diameter of the orbit perpendicular to the ship's axis is a median, and in which the blades move rearwardly so that their radii vectors intersect at a point nearer the center of the propeller than the intersection of the radii vectors of the other blades.

5. A blade wheel propeller having blades substantially parallel with the axis of rotation of the propeller and adapted to rotate in a circular orbit and to swing round their axes during the rotation of the propeller, means for rotating the propeller, means for swinging the blades of the front half of the propeller around their axes during the rotation of the propeller to increasing angles from a tangential position of the blade to decreasing angles to another tangential position, in respect to a predetermined largest angle in the front half of the propeller, means for swinging the blades in the rear half of the propeller to increasing angles from said last named tangential position of the blade to decreasing angles to said first named tangential position, in respect to a predetermined largest angle in the rear half of the propeller, means for coordinating the working of the aforesaid two means so that the predetermined largest angle in the rear half of the propeller is larger than said predetermined largest angle in the front half of the propeller, said means including a connection with each blade, and an eccentric to the propeller wheel operating said connection, said swinging means including means disposing the blades to the front and rear halves so that radii vectors of the front blades intersect at a common point nearer the center of the propeller than the common point of intersection of radii vectors of the corresponding rear blades, said correspondence of blades being considered in respect to the length of the ship, and means for swinging the blades in that quadrant of the orbit in which the diameter of the orbit perpendicular to the ship's axis is a median, and in which the blades move rearwardly, so that the intersections of the radii vectors with the said median are nearer to the center of the propeller for the blades moving in said rearward moving blade quadrant than the intersections of the radii vectors of the other blades.

6. A blade wheel propeller having blades substantially parallel with the axis of rotation of the propeller and adapted to rotate in a circular orbit and to swing round their axes during the rotation of the wheel propeller, means for rotating the propeller, means including an eccentrically adjustable ring, means rotating said ring isochronously with the wheel of the propeller, a guiding device, one for each blade turnably mounted on said ring, elbow levers pivotally mounted at their angular parts on said wheel, one leg of each of said levers being guidingly connected with each guide device, the other legs having free ends, rods fixed to the blades at an angle to the longitudinal axes of the blades and having free ends, and links connecting the free ends of said elbow levers and the free ends of the rods, the length of each leg of the elbow levers connected with the links, being longer than the length of the blade rods, and the length of the links being such that when in the position corresponding to that of the blades in tangential position to said orbit, the said other leg and blade rod converge in the direction towards the pivot of the said other leg.

7. In a blade wheel propeller having blades substantially parallel with the axis of rotation of the propeller and adapted to rotate in a circular orbit and to swing round their axes during the rotation of the propeller, means for rotating the

propeller, means including an eccentrically adjustable ring, means rotating said ring isochronously with the wheel of the propeller, a guiding device, one for each blade turnably mounted on said ring, elbow levers pivotally mounted on said wheel at the angular parts thereof, one leg of each of said levers being guidingly connected with each guide device, the other legs having free ends, rods fixed to the blades at an angle to the longitudinal axes of the blades and having free ends, and links connecting the free ends of said elbow levers and the free ends of the rods, the length of each leg of the elbow levers connected with the links, being longer than the length of the blade rods, and the length of the links being such that when in the position corresponding to that of the blades in tangential position to the said orbit, the said other leg and blade rod converge in the direction towards the pivot of the said other leg, the amplitude of swinging of the swinging movement of the eblow levers being less than the amplitude of the swinging movement of the blades.

8. In a blade wheel propeller having blades substantially parallel with the axis of rotation of the propeller and adapted to rotate in a circular orbit and to swing round their axes during the rotation of the propeller, the orbit of the blade rotation being divided into four quadrants, with a diametrical line passing through the axis of rotation of the propeller perpendicular to the thrust produced by the propeller when the direction of thrust is in line with the ship's axis as a median to two opposite quadrants, one of the last named quadrants being for the rearward going blades, means disposing the radii vectors of the blades of the rearward going quadrant to intersect with said median line, means disposing the radii vectors of the blades through the remaining quadrants to intersect with said median line and means coordinating said two means so that the points of intersection of the second-named radii vectors are at points further from the axis of the propeller than the points of intersection of said first named radii vectors.

9. In a blade wheel propeller, the combination of a blade substantially parallel with the axis of rotation of the propeller and pivoted thereto, a lever for said blade for moving it on its pivot, and having a free end, an elbow lever having a free end, a shiftable guide for the other lever of the elbow lever, a pivot on the propeller for the corner of the elbow lever, and a link pivotally connecting said free ends of the first lever and of the elbow lever, the length of the link being such that the first lever and free end of the elbow lever converge towards each other and towards the pivots of the first and second levers at the blade and at the propeller.

10. In a blade wheel propeller, the combination of a blade substantially parallel with the axis of rotation of the propeller and pivoted thereto, a lever for said blade for moving it on its pivot, and having a free end, an elbow lever, having a free end, a shiftable guide for the other lever of the elbow lever, a pivot on the propeller for the corner of the elbow lever, a link connecting said free ends of the first lever and of the elbow lever, the length of the link being such that the levers converge towards each other and towards the pivots of the first and second levers, at the blade and at the propeller, and means to actuate the shiftable guide, said means including a shiftable center for slidingly controlling the angular position of said shiftable guide relative to a radius of the propeller during its rotation about its axis.

11. In a blade wheel propeller, the combination of a wheel, a plurality of blades supported thereby adapted to move in an orbit upon the revolution of the wheel, a lever for each blade, a ring shiftable eccentrically in respect to the orbit of said blade, an elbow lever connected at its angle with the wheel and at one leg with the ring, a link connecting the lever on the blade with the other leg of the elbow lever for swinging the blade upon the movement of the ring while the blades are moving through their orbit, and means for rotating the ring in respect to the wheel, whereby upon the rotation of the wheel and the ring, the varying position of the ring controls the swinging action of the blades while moving in its orbit.

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