O. G. HALVORSEN.

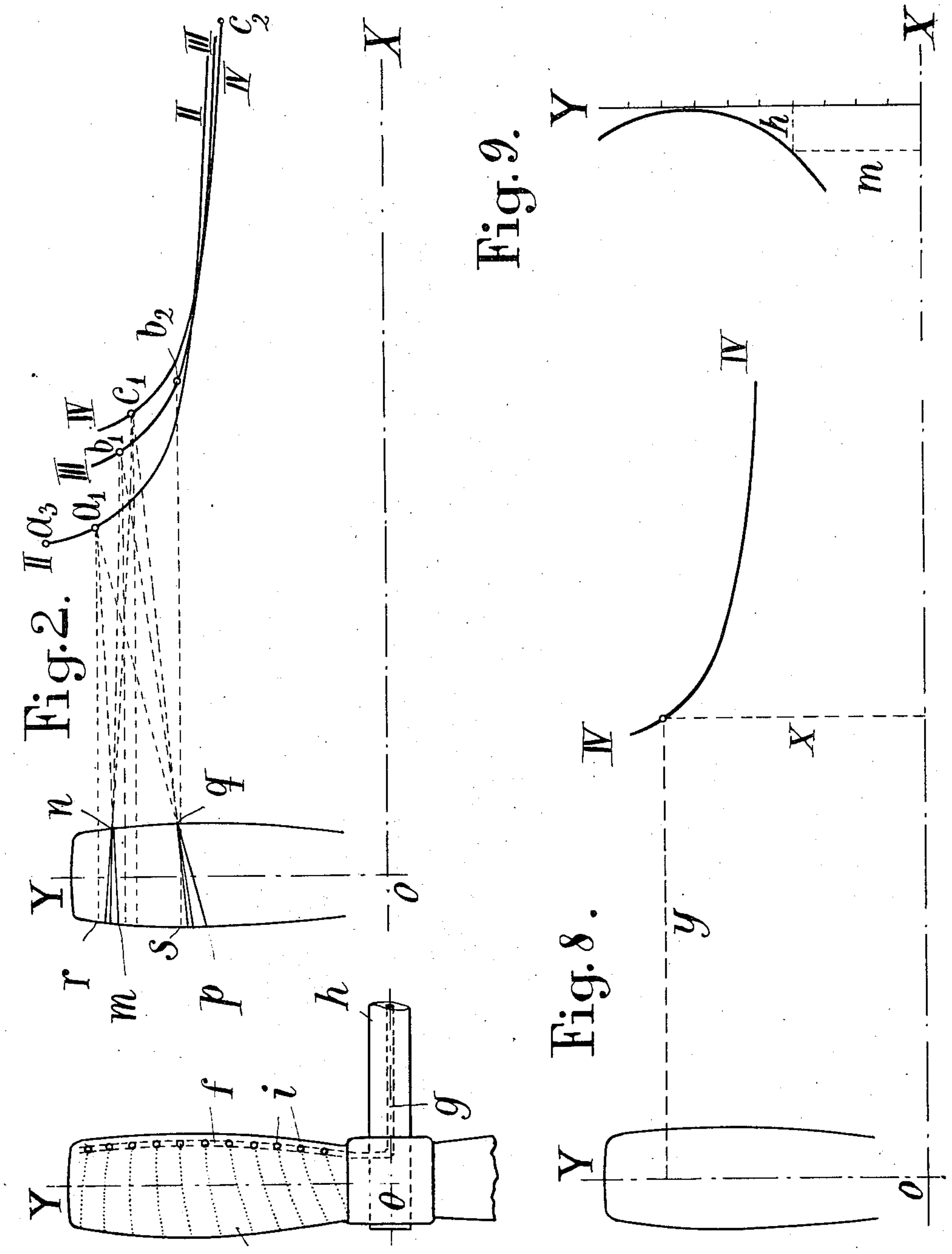
SCREW PROPELLER.

APPLICATION FILED NOV. 14, 1910.

1,031,545.

Patented July 2, 1912.

2 SHEETS—SHEET 1.



Witnesses:

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2 SHEETS—SHEET 2.

Fig. 3.

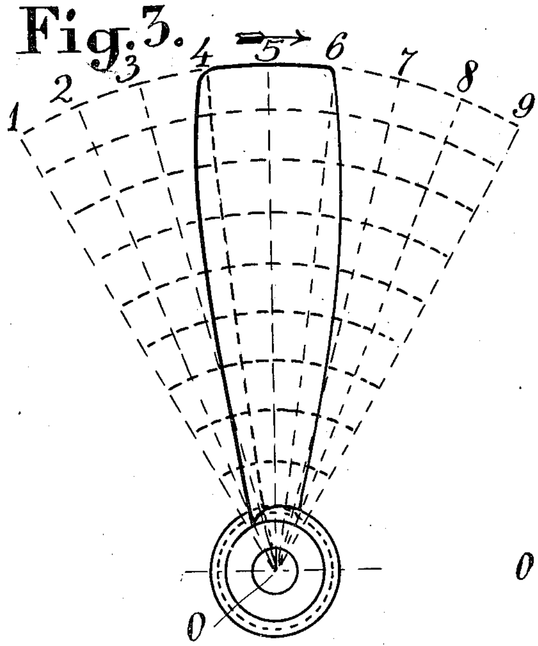


Fig. 4.

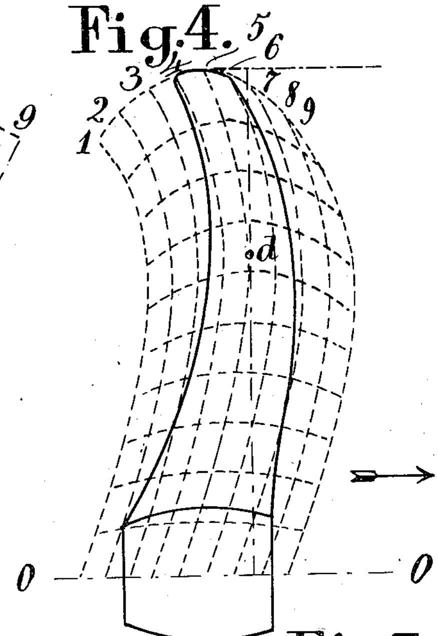


Fig. 5.

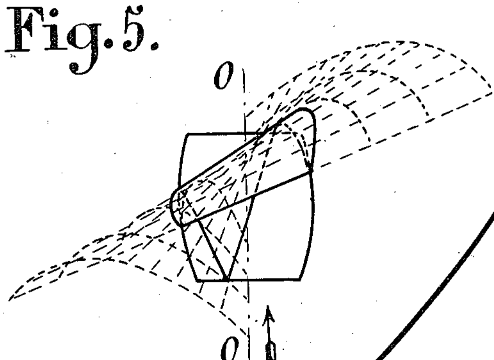


Fig. 6.

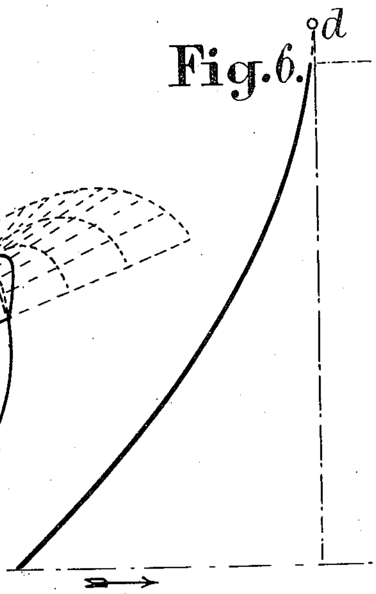
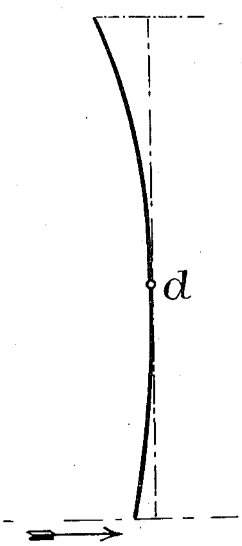


Fig. 7.



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UNITED STATES PATENT OFFICE.

OLE GUNERIUS HALVORSEN, OF TRONDHJEM, NORWAY.

SCREW-PROPELLER.

1,031,545. Specification of Letters Patent. Patented July 2, 1912.

Application filed November 14, 1910. Serial No. 592,306.

To all whom it may concern:

Be it known that I, OLE GUNERIUS HALVORSEN, a subject of the King of Norway, residing at Trondhjem, Norway, have invented certain new and useful Improvements in Screw-Propellers; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification.

This invention relates to screw propellers and the object of the invention is to provide a screw propeller, which is so formed, that the particles nearest to the face of the propeller blades are prevented from describing paths relative to said surface, other than true screw lines lying on the surface of a cylinder, the longitudinal axis of which coincides with the axis of rotation of the propeller.

Figure 1 illustrates a propeller for determining the paths of the water particles across the face thereof. Fig. 2 is a diagram illustrating the method of determining at what point along the propeller blade the water will move across the same in a true helical path. Figs. 3, 4 and 5 are, respectively, a plan, a side elevation and an end view of a propeller blade made in accordance with my invention with various positions of the generatrix projected into the planes of these figures. Figs. 6 and 7 show two forms of generatrix for a propeller face. Fig. 8 illustrates the method of determining the surface of a four bladed propeller, and Fig. 9 shows the method of determining the shape of the generatrix for the face of a propeller blade.

By experiments made by me with a propeller in water, it is substantiated that the particles of water nearest to the face during the propeller's rotation do not all describe true screw lines in relation to the axis of rotation. These experiments have been carried out by means of a device as illustrated in Fig. 1. This drawing shows a propeller blade e along the forward edge of which is formed a channel f, communicating with a channel g in the propeller shaft h. At suitable intervals the channel f has orifices i, opening on the pressure side of the blade. The blade is coated with black asphaltum varnish and the channel in the shaft connected with a reservoir of petroleum.

The propeller is set in rotation in a suitable vessel, allowing a circulation of the water, so that it will pass the propeller at a right angle to its plane, and thereupon petroleum is pumped into the channel. Petroleum then will pass out in fine streams through the orifices i and take part in the movement of the water nearest to the surface of the blade; after a short while the petroleum will have dissolved the varnish, and lines will be visible commencing at the orifices and crossing the blade, as indicated in the drawing. These lines will as shown not be concentric screw lines, but they will diverge rearwardly, assuming a uniform radial pitch and imagining the real paths of the water particles drawn on the face of the blade, the continuation of the tangents to these paths will, according to what the trials show, at all distances from the axis of rotation reckoned from the center line of the blade cut one another at the same point (point of convergence), the face of the blade being thought twisted to form a plane perpendicular to the axis of rotation. This is illustrated in Fig. 2, in which the lines m—n and p—q represent tangents to two spontaneous actual paths described by the particles of water. The continuation of these tangents cut one another in the point a_1, which is then the point of convergence for all of the tangents to the paths for a given pitch ratio $\left(\frac{\text{pitch}}{\text{diameter}}\right)$ and a given number of blades. If the line a_1—r be drawn parallel to the X—axis, the distance between the former and latter will indicate the radius of the blade at which the path of the water particles naturally describe part of a true screw line or helix. At both sides of this place the real paths do not coincide with the true screw line. The special point of convergence a_1 lies on the curve II, which contains the points of convergence, or is the locus of the points of convergence for all two bladed propellers. The experiments have also substantiated that the location of the point of convergence on one and the same curve is dependent upon the pitch ratio of the blade, and not upon the number of revolutions. The curves III and IV similarly are the loci for all the points of convergence for the 3- and 4-bladed propellers respectively. The points b_1 and c_1 are thus corresponding points of convergence for the 3-bladed and 4-bladed propellers of the same pitch. It is evident from this that the coördinates of the point of convergence for the same pitch ratio vary with the number of blades of the propeller.

The peculiarity of the curves II, III and IV is now shown by the above. If the number of blades and the pitch ratio of the propeller to be constructed are agreed upon, a point of convergence corresponding to these may be found on the curve III as for instance b_2. The coördinates of this point will now be decisive for the form of the propeller blades in a way, which shall be described later. The ordinate to the point b_2 will now, according to the above, indicate that place on the face of the blade of the propeller, where the path of the water particles naturally coincides with the true screw line.

By the above presentation of the real facts, it is evident that there arise during the rotation of the propeller radial movements of the particles of water nearest to the face of the blade, which do not affect the work of propulsion of the propeller. In order to prevent the formation of the above mentioned motion of the water, I suggest giving the generatrix of the propeller-blade such a form, that there come into existence radial components of pressure opposite in direction and equal in magnitude to those, that produce the useless radial motions of water. Thereby the water relative to the face of the blade will describe paths, that coincide with real screw lines.

In the following I shall now proceed to explain how a propeller blade is to be formed in accordance with my invention.

Fig. 3 shows the projection of the face of a propeller blade on a plane perpendicular to the axis of rotation of the propeller. The lines 0—6, 0—7, 0—8, etc., represent the generatrix of the face in different angular positions. The projection of the generatrix in this plane is a straight line. Fig. 4 shows the projection of the same face on a radial plane. The projection of the generatrix in this plane will be the curved line 0—5, the position of which, 0—6, 0—7, etc., corresponds to 0—6, 0—7, etc., in Fig. 3. Fig. 5 shows an end view of the face, and the generatrix in different angular positions projected on the plane of the paper.

Regarding the form of curvature of the generatrix this must be made in such a way, according to the preceding, that there occur as a consequence of the curvature of the generatrix, radial pressure components equal in value but reverse in direction to the previously mentioned forces, which produce the radial motions of the water. Fig. 4 shows that the generatrix has a tangent perpendicular to the axis of rotation 00 of the propeller. This tangent touches the generatrix at the point d, the distance of which, from the axis of rotation, is equal to the ordinate of the point of convergence; as at this distance from the axis of rotation the particles of water, according to the above, move relatively to the face in a true screw line. The special case shown in Fig. 4 holds good for a 3-bladed propeller, where the relation between the diameter of the propeller and the pitch is for instance 0,8. For this case the point of convergence then is to be found on the curve III and is marked b_2, Fig. 2. As, according to Fig. 1 the water within the neutral line b_2—s (the line parallel to X—axis through the point of convergence b_2 has a tendency to be sucked in toward the center of rotation, a tendency, the degree of which is dependent on the distance of the point considered from the axis of rotation, the generatrix must be given such a form that there arises all over on this part a radial outward pointing pressure component, the magnitude of which is equal to the above mentioned inward striving tendency of the water at the point considered. In the same manner the part of the generatrix outside the neutral line b_2—s must be given a form which produces radial inward pointing pressure components. For this special case, with the point of convergence b^2, the generatrix will then obtain the form shown in Fig. 4, viz. 0—5, where distance of d from 0—0 is equal to the ordinate to b_2 in Fig. 2. The form of the generatrix will, as the preceding representation shows, be completely dependent upon the number of blades and the location of the point of convergence on the curves II, III and IV, Fig. 2. The consequence of this is, that the generatrix will obtain the form for instance of Fig. 6, for the point of convergence a_3 on the curve II, Fig. 2 (for a 2-bladed propeller), where the relation between the diameter of the propeller and pitch is for instance =0,3 and the form of Fig. 7 for the point of convergence c_2 on the curve IV, Fig. 2 (for a 4-bladed propeller), where the relation between the diameter of the propeller and pitch is for instance =1,0. Fig. 6 shows that the outer convergence point d (see above) falls outside the diameter of the propeller, which is easily seen by Fig. 2, as the ordinate of the point of convergence a^3 is larger than the radius of the propeller.

I shall now give the necessary particulars for designing a fourbladed propeller according to the principles above explained. Referring to Fig. 8, the curve IV may be drawn by means of the following table, which gives the coördinates x and y for the point of convergence for six different pitch ratios. The first column contains the figure representing the ratio between the diameter of the propeller and the pitch ratio.

	$x=$	$y=$
$\frac{\text{Diameter}}{\text{Pitch ratio}}$=0,5:	1,440	0,805
" =0,6:	1,502	0,737
" =0,7:	1,618	0,669
" =0,8:	1,825	0,601
" =0,9:	2,323	0,533
" =1,0:	3,775	0,465

The form of the generatrix may be determined by means of the following table, reference being had to Fig. 9. m represents the ordinates expressed as a fraction of the radius $\left(\frac{D}{2}\right)$ and h represents the abscissæ.

	m=0,3	m=0,4	m=0,5	m=0,6	m=0,7	m=0,8	m=0,9	m=1,0
	h=	h=	h=	h=	h=	h=	h=	h=
$\frac{\text{Diameter}}{\text{Pitch ratio}}$=0,7	0,059	0,034	0,015	0,002	0	0,010	0,034	0,074
" =0,8	0,035	0,017	0,004	0	0,006	0,023	0,056	0,106
" =0,85	0,025	0,011	0,0019	0,0018	0,009	0,030	0,066	0,118
" =0,9	0,017	0,006	0	0,002	0,013	0,036	0,071	0,125
" =1,0	0,006	0,001	0,002	0,004	0,015	0,034	0,063	0,102

The numerals in both tables are the actual measures in feet or meters for a propeller radius measuring 1 foot or 1 meter respectively. To find the actual measures for a propeller of another radius, the numerals must be multiplied by the radius in question.

It will also be understood from the above account that the generatrix need not necessarily be bent in a plane through the axis of rotation as considered above. The same effect on the water-particles can also be obtained by curving the generatrix in a plane perpendicular to the axis of rotation, a curvature, which in the same manner is based on the principle treated above and shown in Figs. 1 and 2. The projection of the generatrix in a plane through the axis of rotation will then be a straight line perpendicular to the same. Finally the same effect on the particles of water can be produced by varying the radial pitch of the blade, a variation which will likewise be determined according to the above treated law shown in Figs. 1 and 2.

Experiments have proved, that the same result as in water is obtained by a propeller moving in air.

What I claim is:

A screw propeller the blades of which are formed by a curved generatrix dependent upon the angle formed between a radius and a tangent to the generatrix at the point in question, said generatrix varying from point to point in accordance with the relative magnitude of radially directed forces acting on the particles of the medium in which the blade acts at the said successive points when a propeller of the same dimensions, number of blades and pitch ratio, but having a straight generatrix, is set in rotation in the same medium, substantially as described.

In testimony that I claim the foregoing as my invention, I have signed my name in presence of two subscribing witnesses.

OLE GUNERIUS HALVORSEN.

Witnesses:
JOHN HOLST,
INGEBORG ROKNESS.