(Model.)

2 Sheets—Sheet 1.

A. DUROY DE BRUIGNAC.

SCREW PROPELLER.

No. 329,822. Patented Nov. 3, 1885.

Fig. 1.

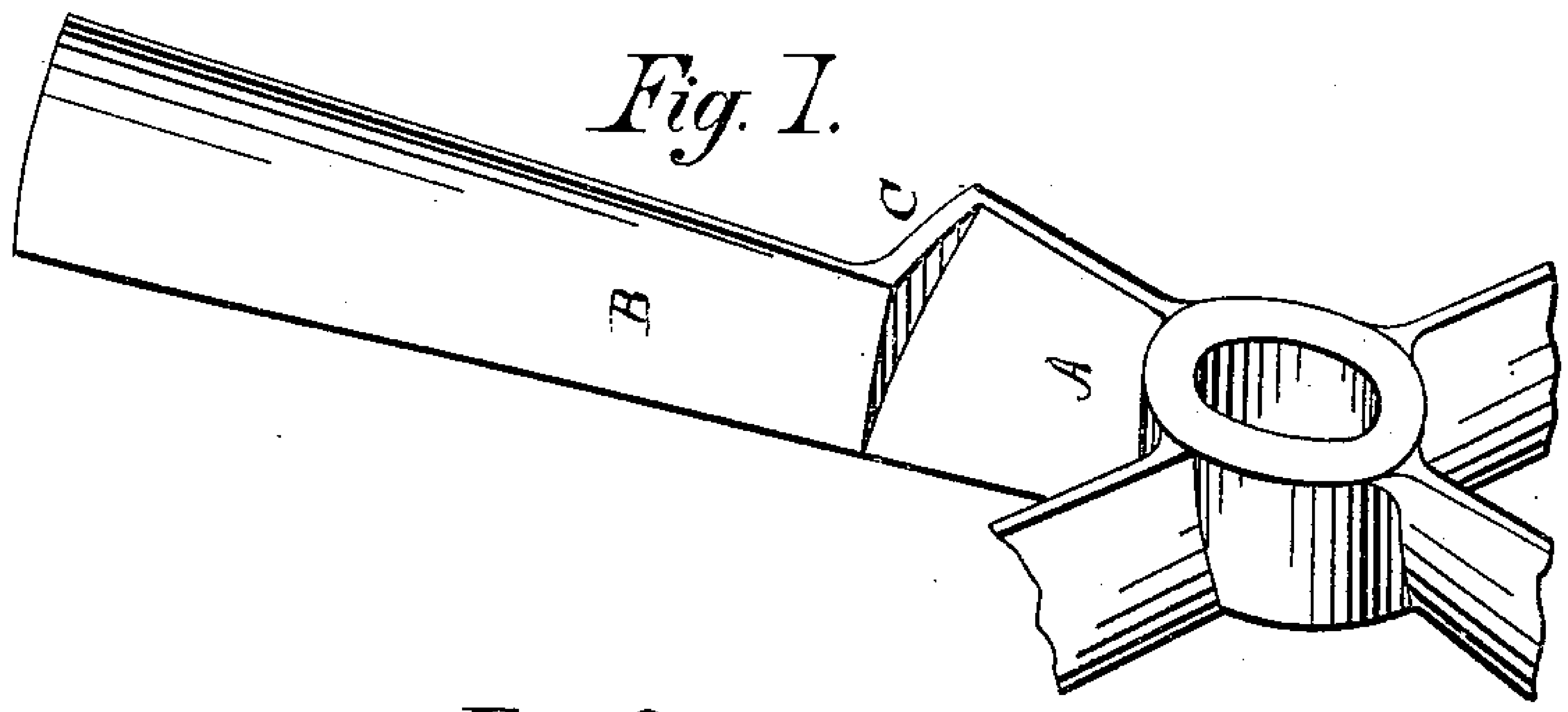


Fig. 2.

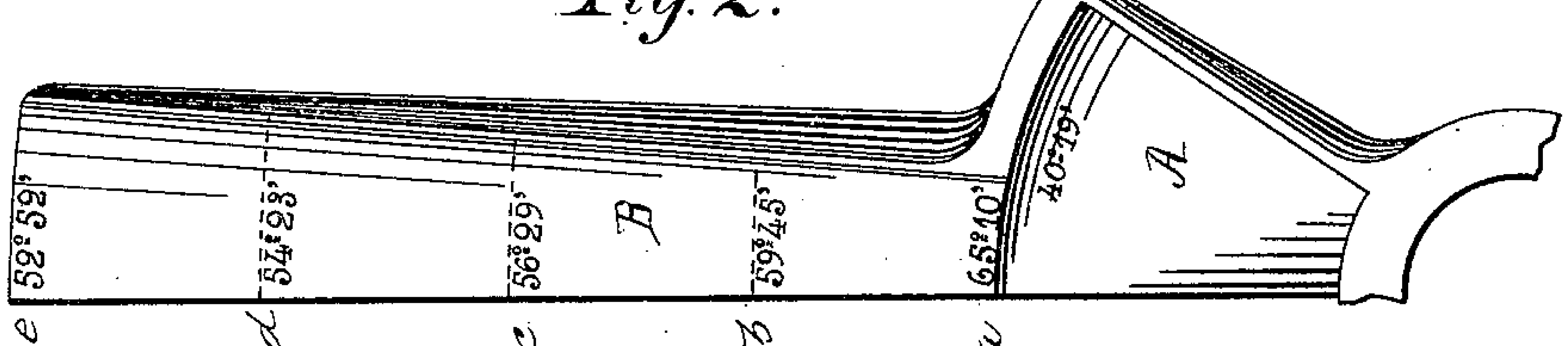


Fig. 4.

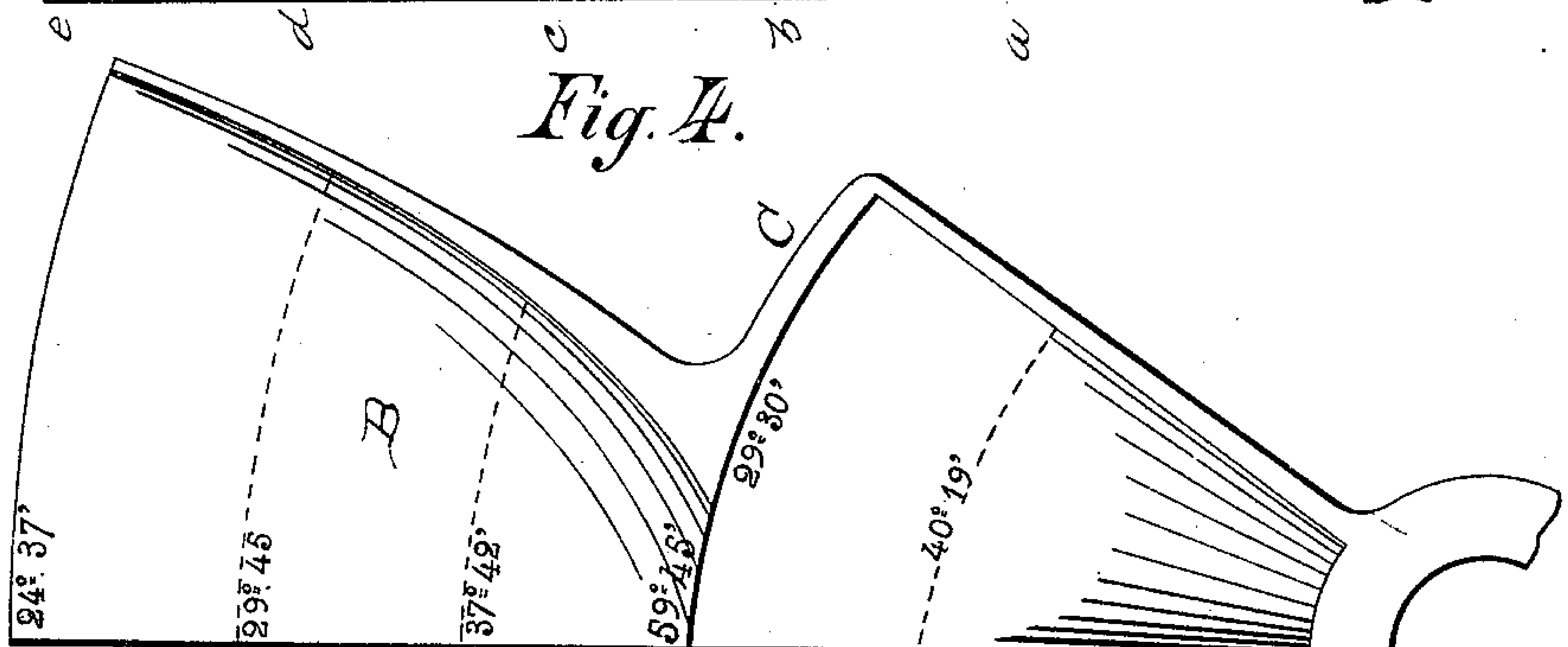
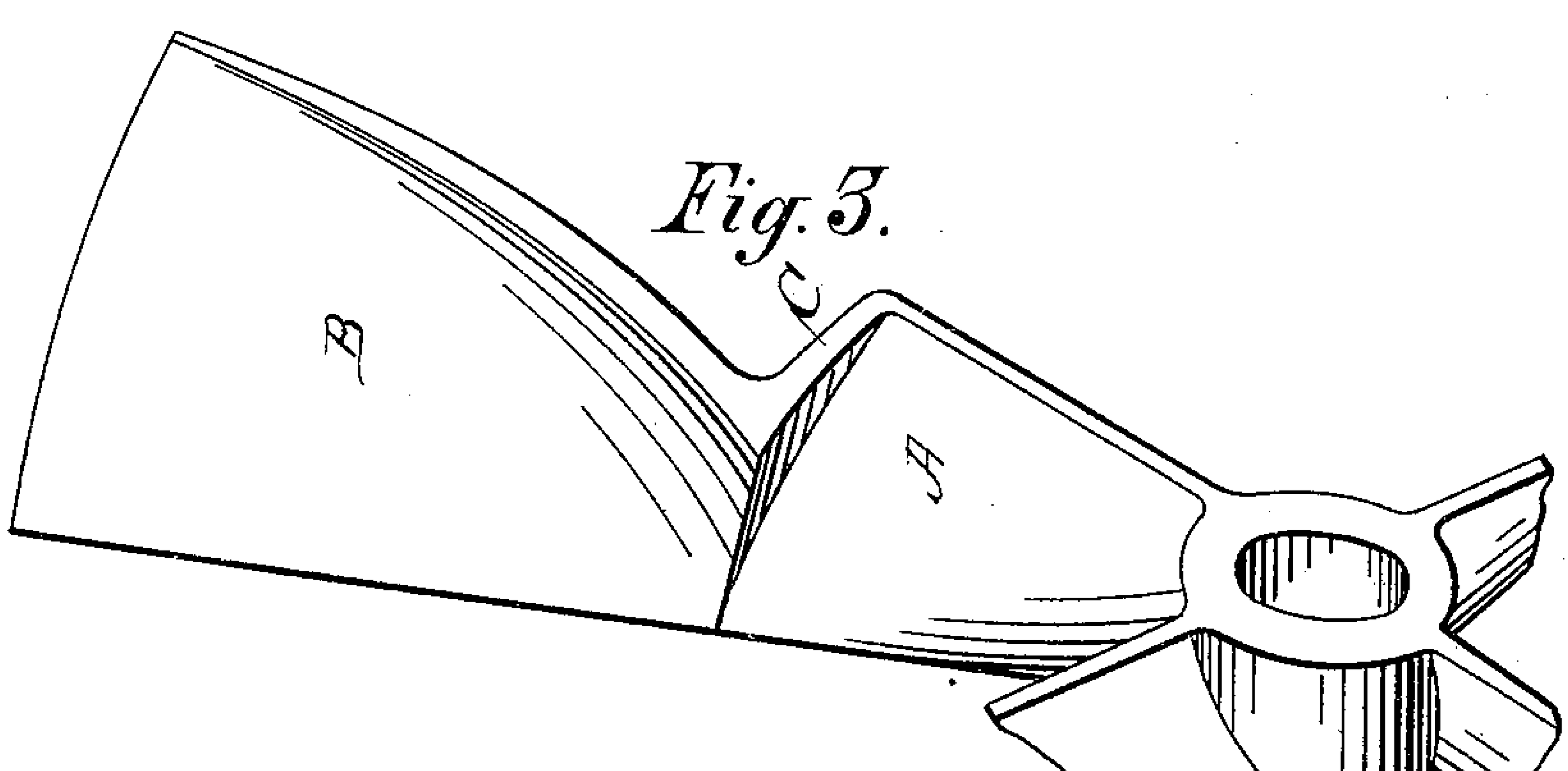


Fig. 3.



Witnesses:

[illegible]

[illegible]

Inventor:

Albert Duroy De Bruignac
by his attorney
Thomas Drew Stetson

N. PETERS. Photo-Lithographer, Washington, D. C.

(Model.)

2 Sheets—Sheet 2.

A. DUROY DE BRUIGNAC.

SCREW PROPELLER.

No. 329,822. Patented Nov. 3, 1885.

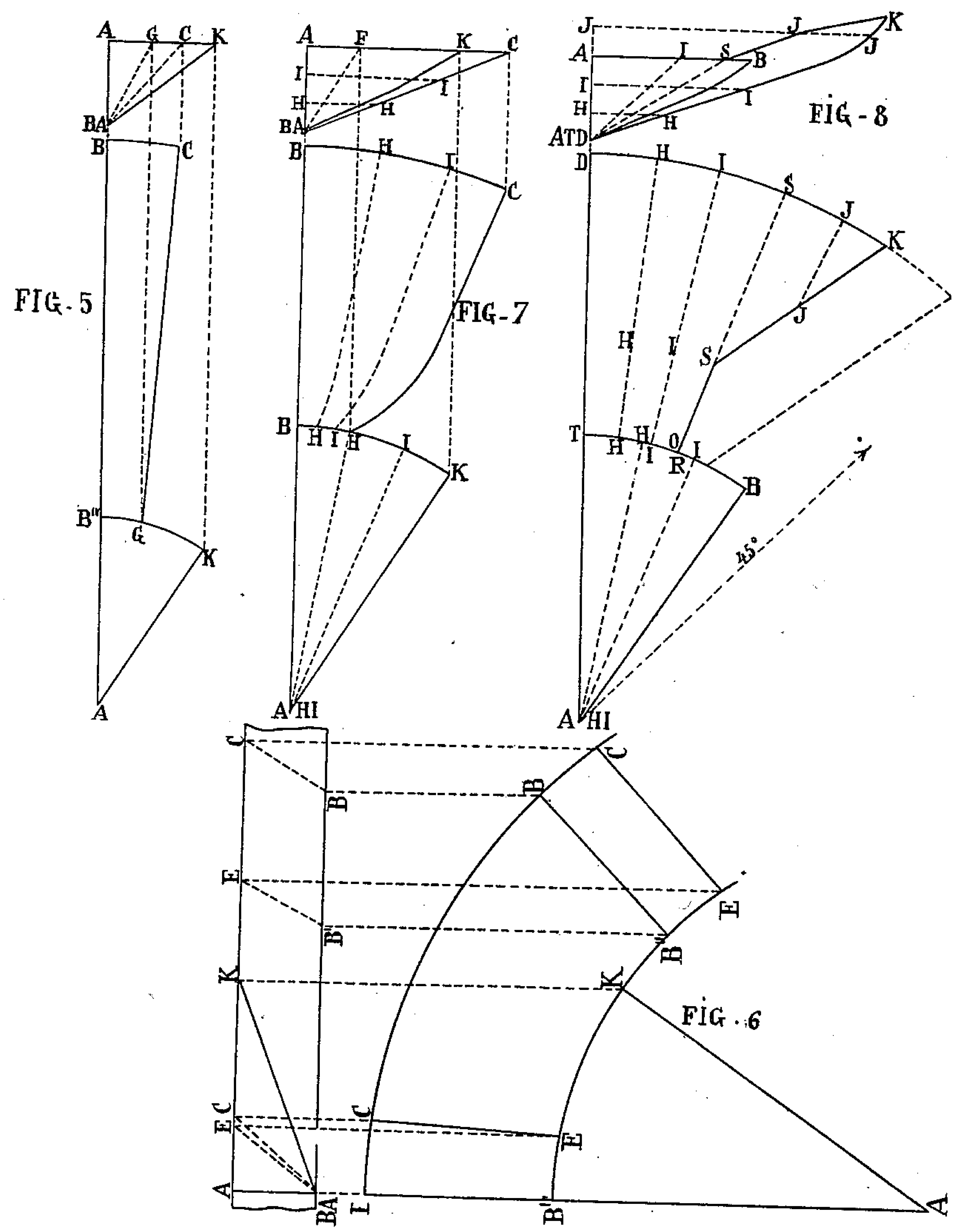


FIG. 5 FIG. 7 FIG. 8 FIG. 6

Witnesses:
Henry Smith
J. W. Hister

Inventor:
Albert Duroy De Bruignac
by his attorney
Thomas Drew Stetson

N. PETERS, Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

ALBERT DUROY DE BRUIGNAC, OF VERSAILLES, FRANCE.

SCREW-PROPELLER.

SPECIFICATION forming part of Letters Patent No. 329,822, dated November 3, 1885.

Application filed April 18, 1884. Serial No. 128,436. (Model.) Patented in France February 11, 1884, No. 160,244; in Belgium March 12, 1884, No. 64,481; in Italy March 14, 1884, No. 16,980; in Spain March 19, 1884, No. 6,191; in England March 28, 1884, No. 5,626; in Germany March 29, 1884, No. 30,146, and in Austria-Hungary April 4, 1884, No. 37,432 and No. 56,193.

To all whom it may concern:

Be it known that I, ALBERT DUROY DE BRUIGNAC, a citizen of the Republic of France, and a resident of Versailles, in the Department of Seine-et-Oise, France, have invented new and useful Improvements in Screw-Propellers, of which the following is a specification, the said invention having been patented to me as follows: England, March 28, 1884, No. 5,626; France, February 11, 1884, No. 160,244; Belgium, March 12, 1884, No. 64,481; Germany, March 29, 1884, No. 30,146; Austria-Hungary, April 4, 1884, No. 37,432 and No. 56,193; Italy, March 14, 1884, No. 16,980, and Spain March 19, 1884, No. 6,191.

The invention relates to propeller screws or blades formed by the juxtaposition of elementary helical curves, having each a constant pitch, but differing one from another, as distinguished from blades now in use, in which the elementary helical curves, similarly placed in juxtaposition, have all the same pitch.

In my system of blades the variations of pitch from one helix to another are not arbitrary, but the laws which determine them result, as we shall see further on, from the very nature of the propulsion that one wishes to obtain upon the zones or segments of that helix, and which allows me to determine the tangent at any point whatever of the helix; hence in this description the blade will be understood as made up of zones or annular concentric segments by means of the value of the tangent for each of said zones. I generally give to each elementary helix a pitch gradually increasing in the proportion hereinafter indicated.

The feature which constitutes the important characteristic of the invention is the peculiar forms of the blades as produced from the formulas and principles hereinafter set forth. As for the formulas themselves, it will be understood that they serve to bring out and make clear the invention; but the same blades could be constructed by other formulas furnishing the same results, but obtained by changing the system of comparison. By the "form" of the blade I mean not only the contour of the blade, but also the form of the surface of any part whatsoever of the same resulting from its principle of generation.

The following definitions of the formulas used are necessary. The initial line is the position of the generatrix, which, as the screw revolves, enters the water first.

Vm=velocity of movement—that is, the velocity of transition of the screw in a direction parallel to its axis—that is to say, the velocity of the vessel which the screw propels, for example.

Vp=velocity of propulsion—that is, the velocity which the blade ought to impart to the water in a direction parallel to the axis, but contrary to the course, in order to occasion in said water the resistance which causes the propulsion.

It is necessary, in order to determine the pressure of the water upon the blade and the work, to consider—

n=number of revolutions of the screw per second.

w=angle described by the blade; distance in meters measured upon the circumference of a circle having a radius equal to unity between the first position of the "initial line" and another assumed position of said line.

$u=2\,wr$ angular velocity of the blade.

r=radius of the blade in general—that is, the distance from a point of the blade to its axis.

r_0=initial radius—that is, reckoning from the extremity from which the blade commences to become propulsive.

x=angle of the blade determined by a plane tangent to the blade and a plane normal to the axis.

x_0=initial angle of the blade corresponding to r_0.

My improved propeller-blade has the following features of importance: first, initial line; second, inert portion; third, angles or useful portions.

First. I make the initial line straight, because it is more simple, and because I do not find any advantage in making it curved. Moreover, the methods of construction, which will presently be set forth, may be applied, reckoning from any line whatsoever, without anything being changed either in principle or results. The appearance alone would be changed, but it would be easy to recognize the principle of generation of the blade by determining successive directrices and seeing how their angles vary.

Second. In order to evade the backwater which is always produced in the neighborhood of the axis of the propeller-screws, I do not utilize the very feeble propulsion secured in such space, and I give to that portion of the blade the form of an ordinary helix of constant pitch, of which the tangents of each section have the value—

$$(1)\ \frac{Vm}{2wrn}.$$

It will be understood, indeed, that if a blade thus formed changes its place with the velocity of forward movement or transition, Vm, and the velocity of rotation, $2wrn$, it traverses the water without acting upon it and without receiving from it any pressure. I will call the angles whose tangents have the preceding value "angles of movement," xm. The inert blade or arm then will extend from the axis up to the extremity of r_0, defined above.

In practice, for solidity, the inert portion of the blade will have its sections of an elongated lenticular, a form yielding the necessary resistance with ease of transition in the water. This inert blade can be made of various thicknesses, and can be hollowed out or grooved, provided its principal inclination is preserved. In general, it will be expedient to make the blade in the direction of the radius as long as the draft of water and the other conditions of the ship will permit. Reckoning from the extremity of the radius, I take the necessary length for the useful blade, and all the rest up to the axis, as much as possible, will be inert blade, for the qualities of a helix increase with the radius.

Third. It is well known that the propelling action of the blade depends upon its angle. I will first indicate what should be the angle at the initial line in order to effect certain propulsions. I will then show what form the blade should have in order to continue over the remainder of the surface the propulsion obtained at the beginning.

The accompanying drawings illustrate the invention.

Figure 1 represents a perspective view of a screw, the form and angles corresponding to a case of maximum propulsion upon the initial line. Fig. 2 is a plan view of the same blade. Fig. 3 represents a blade in perspective corresponding to a case of equal propulsion upon the initial line, and Fig. 4 a plan view of the same. Fig. 5 represents a mathematical diagram of a screw-blade of my system (maximum propulsion) provided with an inert arm. Fig. 6 represents a like diagram of a part of a screw similar to the blade Fig. 4, having eight blades included between two concentric rims and four inert arms. Fig. 7 represents a like diagram of screw-blade of constant propulsion provided with an inert arm. Fig. 8 represents a like diagram of a screw-blade of constant propulsion having the same form of surface as the preceding.

In order that the blade should give at each point of the initial line the maximum propulsion in the direction of the vessel's movement which is requisite for said point, considering the conditions of movement imposed upon the vessel, it is necessary that the angles along the initial line should result from the formula:

$$(2)\ tqx=\frac{Vm}{2wrn}+\sqrt{\frac{Vm^2}{2wrn^2}+1},$$

or in terms of r_0, the minimum radius of the useful portion of the blade, assuming $r=Kr_0$—

$$(2')\ tqx=\frac{Vm}{2wrn}\left|\frac{1}{K}+\sqrt{\frac{1}{K^2}+\frac{2wr_0n^2}{Vm^2}}\right.$$

The velocity of propulsion corresponding to these angles is given by the formula:

$$(3)\ Vp=\frac{Vm}{2}+\sqrt{\frac{V^2m}{4}+\frac{}{wrn^2}}$$

If x is known, we have also—

$$(3')\ Vp=\frac{wrn}{tqx}$$

This formula, in which Vp results from the angle x, is necessary in order to calculate the pressure of water and the work.

If the peculiarities of the problem give at first the propelling velocity, the angle and the radius will be deduced from it by the formulas:

$$(3'')\ r=\sqrt{\frac{(Vp+Vm)\,Vp}{wn}};\quad tqx=\sqrt{\frac{Vp+Vm}{Vp}}$$

Fig. 5 in mathematical diagram represents a blade of this kind provided with an inert arm of one meter radius and based upon the following values:

$Vm=8$ meters; $n=1.5^m$; extreme radius $=3^m$.

Having given these values and the preceding formulas, I calculate the angles arising at different points of the initial line and the corresponding velocities of propulsion.

Figs. 1 and 2 represent a blade constructed in accordance with these formulas. In said figures is given the results of these calculations for lengths of radius other than fifty centimeters, indicating the corresponding velocities of propulsion:

For the radius of	1	meter	$x=65°\ 10'$	$Vp=2^m181$.	(See *a*.)
" " "	1.5	"	$x=59°\ 45'$	$Vp=4^m122$.	(See *b*.)
" " "	2	"	$x=56°\ 29'$	$Vp=6^m238$.	(See *c*.)
" " "	2.5	"	$x=54°\ 23'$	$Vp=8^m442$.	(See *d*.)
" " "	3	"	$x=52°\ 52'$	$Vp=10^m692$.	(See *e*.)

These values of x are thus indicated upon the drawings and model filed herewith, at *a*, *b*, *c*, *d*, and *e* in Fig. 2.

This blade is at least thirty-three per cent.

more powerful than the ordinary blade of constant pitch most nearly approaching it—that is to say, one which would have similarly the angle of 65° 10′ with a radius of one meter.

In diagram 6 I show the system for a screw having eight blades and four inert arms, the blades being included between two concentric rings. This screw, which provides eight active blades instead of four of the ordinary screw, has a power more than double that of the ordinary screw with four blades.

The power of which I speak is not rated superficially. It is the work calculated in accordance with an exact formula—*i. e.*, by multiplying the pressure at a certain point by the velocity in the direction of the vessel's movement. The pressure at a point is calculated with the aid of the velocity of propulsion by means of the relations known experimentally to exist between the velocity of a fluid and the pressure which it exerts. From the initial line on, the directrices of these blades are all helices of exactly constant pitch.

To set forth the system as applied to propeller-blades more specifically, I will mention same particular cases.

First. When I do not need all the power which it is possible to obtain, and when I prefer to have a lesser propulsion permitting me to economize motive force, I propose to produce a blade which, constructed like the preceding one at a certain initial section, preserves over the remainder of its surface the power of propulsion of said initial section without augmenting it. Let it be supposed that the blade is only an inert arm up to this initial section. In such case I would commence by determining by means of the formulas 2 and 3 the angle and the propulsive velocity at the extremity of the inert portion of the blade—*i.e.*, for the radius of r_0 at that point. (I could also take one of these quantities arbitrarily between the limits within which the formulas remain real.) For every radius greater than r_0 the initial angle would be determined by the formula—

$$(4)\ tqx=\frac{wrn}{\mathrm{V}p};\ \sqrt{\left(\frac{wrn}{\mathrm{V}p}\right)^2\ \frac{\mathrm{V}p+\mathrm{V}m}{\mathrm{V}p}},$$

or

$$(4')\ tqx=x\sqrt{\frac{\mathrm{V}m+\mathrm{V}p}{\mathrm{V}p}}\times(\mathrm{K}-\sqrt{\mathrm{K}^2-1})$$

if in preceding equation we replace r by $\mathrm{K}r_0$.

If at such a section we have at first the angle, the formula of $\mathrm{V}p$ would be—

$$(4'')\ \mathrm{V}p=\frac{2wrntqx-\mathrm{V}m}{1+tq^2x}$$

It should be remarked that the relations expressed in 4 and 4″ are entirely general and accommodate themselves to the section of any blade whatever, on condition that such section be a helix of constant pitch, and that one regards these relations as applied to quantities of that single section taken alone. They are relations between the quantities of a single section.

As for the relation 4′, it is specially applicable to a blade of constant propulsion whose initial section at r_0 is of maximum propulsion.

Fig. 7 represents in mathematical diagram a blade constructed in accordance with these conditions and provided with an inert arm of 1.50 meters. The initial section B H of the active blade (having radius 1.50 meters) is parallel to the section of like radius of blade, Fig. 4. All the remainder of the active blade has at every point the same propulsive power as upon the section B H. The calculations of the angles of said blade give—

For the radius of 1.50^{m}	$x=59°\ 45'$	$\mathrm{V}p=$	4.12 meters.
" " " " 2^{m}	$x=37°\ 42'$	$\mathrm{V}p=$	" "
" " " " 2.50^{m}	$x=29°\ 45'$	$\mathrm{V}p=$	" "
" " " " 3^{m}	$x=24°\ 37'$	$\mathrm{V}p=$	" "

(See Fig. 4 and the model filed herewith.) In the various sections of this blade after B H the pitch increases slowly. This growth, which the figure cannot show, does not attain at the largest end of the section one degree of increase from the initial angle of the section. I have determined by exact formulas the increase of pitch and the theoretic eccentricity of the sections. I have discovered that under conditions of practice—that is, for blades whose angular opening normally to the water does not exceed forty-five degrees—the eccentricity may be neglected, and the increase of pitch does not exceed one degree. For this reason I do not give those formulas, which are complicated. In practice it suffices to determine the increase of pitch by the eye in accordance with the indications before given. The increase of propelling-power obtained is calculated exactly. It is the quotient obtained by dividing the propelling work by the sum of the propelling and resisting works. The resisting "work" of a blade at a given point is obtained by multiplying the pressure at that point by the velocity of rotation thereat.

Second. If I wish, always starting from a certain initial section—such as B H, Fig. 6—to have a constant propulsion no longer in the direction of travel, as in the preceding case, but normally to the surface of the blade, I arrive at the following formulas, in which $\mathrm{V}p_0$ and x_0 are the quantities of the initial section chosen (such as 59°45′ and 4^{m} 12 in the preceding instance) and r $\mathrm{V}p$ x, the quantities of the point which is to be determined.

$$(x-xm)=\frac{\mathrm{V}p\cos xm}{\cos x_0\,2wrn};\quad \mathrm{V}p=\frac{\mathrm{V}p_0\cos x}{\cos x_0.}$$

I could by the same principles work out other conditions, starting from the same initial section.

It results from what has been said that for a given ship I can construct a screw whose propulsive force would be greater than that of an ordinary screw, and that this fact would materially economize fuel.

With the foregoing description it will only be necessary to refer to the drawings by letter—as, A designates the inert arm, B the active portion, and C the concentric rings which form the junction of the parts A and B.

What I claim as new is—

1. A propeller-blade having an inert portion of constant pitch adjacent to the axis of motion, and having an active portion extending from the inert portion outward and provided with curved helical surfaces determined, as set forth, from an initial line common to both inert and active portions, as specified.

2. A propeller-blade having an inert portion, as A, of constant pitch and without propelling action arranged adjacent to the axis of motion, and an active portion, B, having curved helical surfaces determined, as set forth, from the single initial line, the said active portion extending from the inert portion outward, with their junctions formed into segments C concentric with the axis of motion, as set forth.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

ALBERT DUROY DE BRUIGNAC.

Witnesses:

ROBT. M. HOOPER,

EUG. DUBUIE.