April 5, 1927.

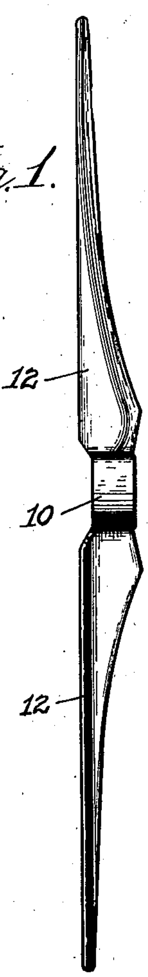
1,623,420

W. H. LEINWEBER

PROPELLER

Filed June 27, 1925

Fig. 1.



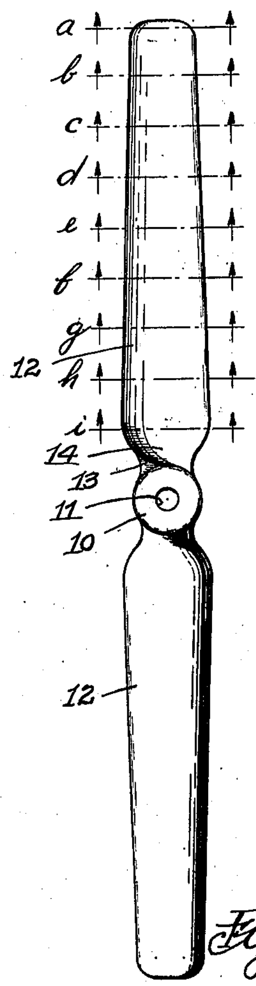
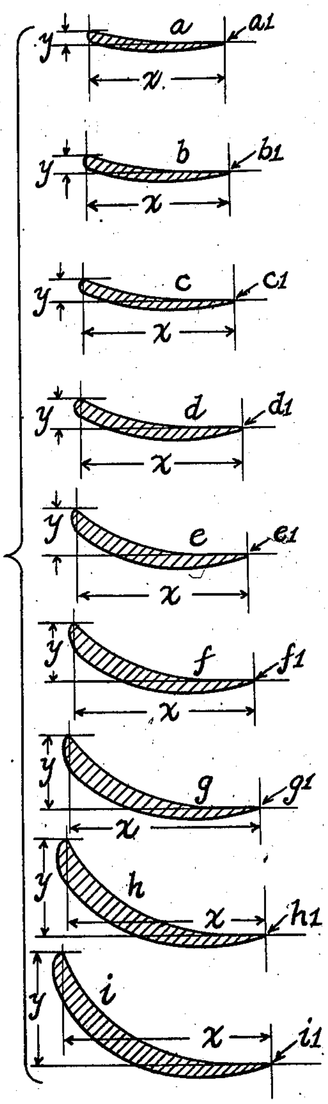


Fig. 2.

Fig. 3.



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Patented Apr. 5, 1927.

1,623,420

UNITED STATES PATENT OFFICE.

WILLIAM H. LEINWEBER, OF CHICAGO, ILLINOIS, ASSIGNOR OF ONE-THIRD TO VICTOR H. LEINWEBER AND ONE-THIRD TO CURTIS H. LEINWEBER, BOTH OF CHICAGO, ILLINOIS.

PROPELLER.

Application filed June 27, 1925, Serial No. 39,957, and in Canada January 25, 1924.

My invention relates to propellers used for setting in motion fluid whether liquid or gaseous by rotation of the propeller and for moving if desired, the structure supporting the propeller relatively to the fluid instead of maintaining the said structure stationary and producing motion of the fluid only. In other words my improved propeller is adapted for any purpose for which fans and propellers may be used, whether for producing currents of air or other gases for ventilating and circulating purposes, currents for water circulating purposes, motion of air craft, or motion of boats.

My invention is characterized by an improved construction of the surfaces engaging the fluid, in such a manner that at any part of the operating surface of the fan, the surface at its edge entering the fluid is in a plane through the entering edge at substantially right angles to the axis of the propeller shaft, from which entering edge the operating surface is displaced progressively across the operating surface towards the trailing edge of the blade in the direction of thrust on the fluid in such a manner that for equal increments across the surface angularly, the displacement increases at a greater rate than proportionally to the angular travel across the operating surface, or in other words the operating surface at any radius of the fan blade is a curve, which preferably imparts uniform acceleration to the fluid from the entering edge to the trailing edge of the blade, assuming that the propeller is held against axial motion, or theoretically, assuming the fluid to be non-yielding, that would produce uniform acceleration during the same interval of the supporting structure and fan if the latter were movable axially of the propeller. More specifically, the curvature of the blade extending laterally of the propeller is such that each increment of angular travel at any radius across said operating surface, imparts an increment of velocity to the fluid, assuming the propeller to be held against axial motion, these increments being so related that each increment of velocity, for equal increments of travel across the operating surface at said radius of the blade, is equal to each other increment of velocity. In this manner the inertia of the mass set in motion axially of the propeller by its rotation, whether it be the mass of the fluid or the mass of the supporting structure of the propeller, is overcome with maximum efficiency. The particular curvature given the operating surface of the blade is determined by the maximum displacement axially of the propeller, which is desired at that particular radius of the propeller blade and is expressed by the formula given below. The sharpness of curvature of the operating surface at any radius and for any desired displacement at that radius, is determined by the width of the operating surface of the blade at that radius, this curvature being less sharp for a wide blade than it is for a narrow blade under these conditions.

A further feature of my invention consists in proportioning the operating surface of the propeller to distribute the thrusts upon it uniformly over said surface radially of the propeller. This I accomplish by changing the maximum displacement of the operating surface of the blade axially of the propeller, so that it progressively decreases as the radius of the operating surface increases, the maximum axial displacements at different radii being inversely proportional to the radii. In this manner I produce a large displacement near the axis of the propeller where the lineal travel of the operating surface angularly is small and a small displacement of the operating surface at the outer end of the blade where the lineal travel of the operating surface is great, the relation preferably being such that the product of said lineal travel at any radius, by the maximum displacement axially of the operating surface at that radius of the blade, is equal to the similar product for any other radius of the blade. In this manner each radial increment of operating surface produces the same amount of thrust as each other radial increment and the thrust produced by the blade is uniformly distributed over its surface radially. A result of the curved conformation laterally of the operating surface of the blade, above described, is that the thrust produced by any radial increment of operating surface is uniformly distributed over said increment laterally of the blade. In this manner I produce not only uniform distribution of thrust radially of the blade but also laterally thereof, or in other words each unit of the operating surface of the blade has exerted upon it the same pressure as each other unit of said operating surface.

My invention will best be understood by reference to the accompanying drawings showing one form in which my invention may be embodied, said drawings being as follows:

Fig. 1 shows a propeller in accordance with my invention, in side elevation,

Fig. 2 shows the propeller illustrated in Fig. 1, in front elevation, and

Fig. 3 is a sectional view showing a plurality of sections *a*—*i* inclusive taken along corresponding lines through one of the blades of the propeller shown in Fig. 2.

Similar numerals refer to similar parts throughout the several views.

As shown in the drawings, my propeller consists of a hub 10 having a central bore 11 to receive a supporting shaft, from which hub opposite blades 12, 12 extend radially. The propeller may be made of any desired material for example wood or metal depending upon the purpose for which it is to be used and if made of metal it may be made in any desired manner adapted for the intended purpose. It will further be understood that I do not limit myself to a propeller consisting of two blades nor to a propeller having any particular size or proportion of blades; the number of blades employed, and the particular size, shape and proportion of the blades may be determined in any case according to the requirements of that case and the particular fluid to be engaged by the operating surfaces of the blades. The essential feature of my invention is that the operating surface of each blade shall be shaped to realize the improved operation characterizing my invention. To secure this result each of the blades, for example the upper blade shown in Fig. 2, is provided with an operating surface having a curvature of the nature generally described above, for example that illustrated by the several sections of said blade shown in Fig. 3, said sections being taken at the correspondingly lettered lines in Fig. 2, that is to say section *a* is adjacent the outer end of the blade, section *b* is taken somewhat nearer the axis of the propeller and so on, section *i* being taken near the hub 10 of the propeller. In each of the sectional views shown in Fig. 3, the right hand edge of the section is the entering edge of the blade into the fluid to be acted upon, said entering edge being designated a^1, b^1 . . . i^1 for the sections, *a*, *b*, . . . *i* respectively. The curvature of the operating surface of the blade laterally thereof at each section is determined as follows: the light horizontal lines through the edges a^1, b^1, . . . i^1, are each in the plane of rotation of the corresponding entering edge, that is to say in a plane at right angles to the axis of the propeller. In each section, the light vertical lines are through the entering and trailing edges of the blade at the corresponding section; the distance apart of the entering and trailing edges for each section is designated by x and the axial displacement of the trailing edge from the plane of rotation through the entering edge for any section is designated by y.

The curvature of the operating surface of the blade laterally at any radius of the blade, for example at section *i*, is such that for equal increments of the abscissa x laterally of the operating surface, relatively to the point i^1 as a reference point or origin, the ordinate or y value of the curve shall progressively increase by successively greater increments each than the preceding in a manner to continuously accelerate fluid engaged by the operating surface, assuming the propeller to be held against axial displacement. I have found that this curve may be expressed by the formula

$$y=\frac{(x^2+x)}{2}f,$$

where y is the axial displacement of the curve, or its ordinate at any point referred to a base line or x axis through the entering edge i^1 in the plane of the rotation of the entering edge, x is the distance of the point laterally from the point i^1 or the abscissa of that point, and f is a factor determining the value of y at the trailing edge of the blade for any particular width of operating surface. In practice I find it advisable and desirable to maintain the factors f for the different radii of the operating surface of any blade inversely proportional to said radii, that is to say the value of the factor f at the extreme outer end of the operating surface should be half the value of the said factor at a point on the operating surface half way from the axis of the propeller to the outermost radius of the operating surface and so on for the operating surface at other radii. It will be observed that the nature of the curve is the same for any value of the factor f whether the curve is relatively flat or relatively abrupt being expressed in each case by the expression

$$y=\frac{(x^2+x)}{2}.$$

In using this formula, to determine the value of the factor f for the curvature of the blade at any particular radius, a desired width and axial displacement of the operating surface are determined upon for the particular amount of thrust it is desired to produce in view of the fluid acted upon and the speed at which the propeller is to be driven. These values give the maximum values of x and y which are substituted in the formula and the value of f if then equal to y divided by

$$\frac{(x^2+x)}{2}.$$

The value of the factor f being determined for this particular radius, its values for other radii are determined by the inversely proportional relation above referred to.

As a result of the construction described, the operating surface has a curvature at any particular radius which uniformly accelerates fluid set in motion by it moving across said operating surface for uniform rotation of the propeller blade, assuming the propeller to be held against axial motion, and further provides that this uniform acceleration shall be the same across the operating surface at any radius. The above formula applies to propeller blades whether they are of uniform width or tapered longitudinally, the only difference being that in the first case the value of x maximum is constant, whereas in the latter case it decreases in the direction of convergence of the width of the operating surface. From the above it will be observed that the operating surface for my improved propeller is curved both laterally and longitudinally, the former curvature imparting the uniform acceleration referred to and the latter curvature compensating for increasing lineal travel of the operating surface from adjacent the hub of the propeller outwardly radially to the extreme outer end of the operating surface and that in this manner each unit surface of the operating surface is subjected to the same thrust as each other unit surface thereof.

To engage the fluid with maximum efficiency adjacent the hub 10, the trailing edge of the operating surface is continued towards the axis of the propeller in the form of a smooth curve 13 tangent to the circumference of the hub 10 forming a pocket 14 receiving the fluid adjacent the hub and acting upon it substantially as described for the major portion of the operating surface. In this way undesirable eddy currents and losses are prevented adjacent the hub portion of the propeller.

Each of the blades of any particular propeller is preferably provided with the same kind of an operating surface determined as above set forth and the number of blades in any propeller, and the width of the blades relatively to the spaces between them, are determined by principles well known in the art applying to the particular conditions involved in any particular case.

The formula above given for the lateral curvature of the propeller blades is equally applicable for fluid media of different degrees of mobility as follows: Without modification, the formula and its method of application described applies to fluids theoretically immobile; from data well known in the art concerning any particular fluid, approximately the amount of slip due to mobility of the fluid may be ascertained for the particular speed of operation contemplated; the factor of slip being determined and expressed as increased displacement required, the factor "f" in the formula is multiplied by the slip factor and in this manner the degree of curvature laterally is affected in a manner to compensate throughout its extent for the said slip. The resulting factor "f" then becomes the basis for determining the similar factors at other radii of the operating surfaces of the propeller blades. In a similar manner any other practical condition departing from theoretical operation, may be compensated for.

While I have shown my invention in the particular embodiment above described, it will be understood that I do not limit myself to this exact construction, but that I may employ equivalents known to the art at the time of the filing of this application without departing from the scope of the appended claims.

What I claim is:

1. A propeller having a plurality of operating surfaces, each curved laterally with axial displacements increasing progressively more rapidly than proportional to the traverse of said surface from its entering edge to its trailing edge, the plane of the entering edge of each of said surfaces being substantially perpendicular to the axis of the propeller, and each of said surfaces being curved radially of the propeller making the maximum axial displacements of said surface at different radii substantially inversely proportional to said radii.

2. A propeller having a plurality of operating surfaces, each curved laterally with axial displacements increasing progressively more rapidly than proportional to the traverse of said surface from its entering edge to its trailing edge, and each of said surfaces being curved radially of the propeller making the maximum axial displacements of said surface at different radii substantially inversely proportional to said radii.

3. A propeller having a plurality of operating surfaces, each curved laterally from its entering edge to its trailing edge substantially proportional to the formula

$$y=\frac{(x^2+x)}{2},$$

where y is the axial displacement of said surface at any point from the plane of rotation of its entering edge and x is the lateral distance of said point from said entering edge, and having axial displacements at its trailing edge substantially inversely proportional to the distances of said displacements from the propeller axis.

In witness whereof, I hereunto subscribe my name this 24th day of June, A. D. 1925.

WILLIAM H. LEINWEBER.