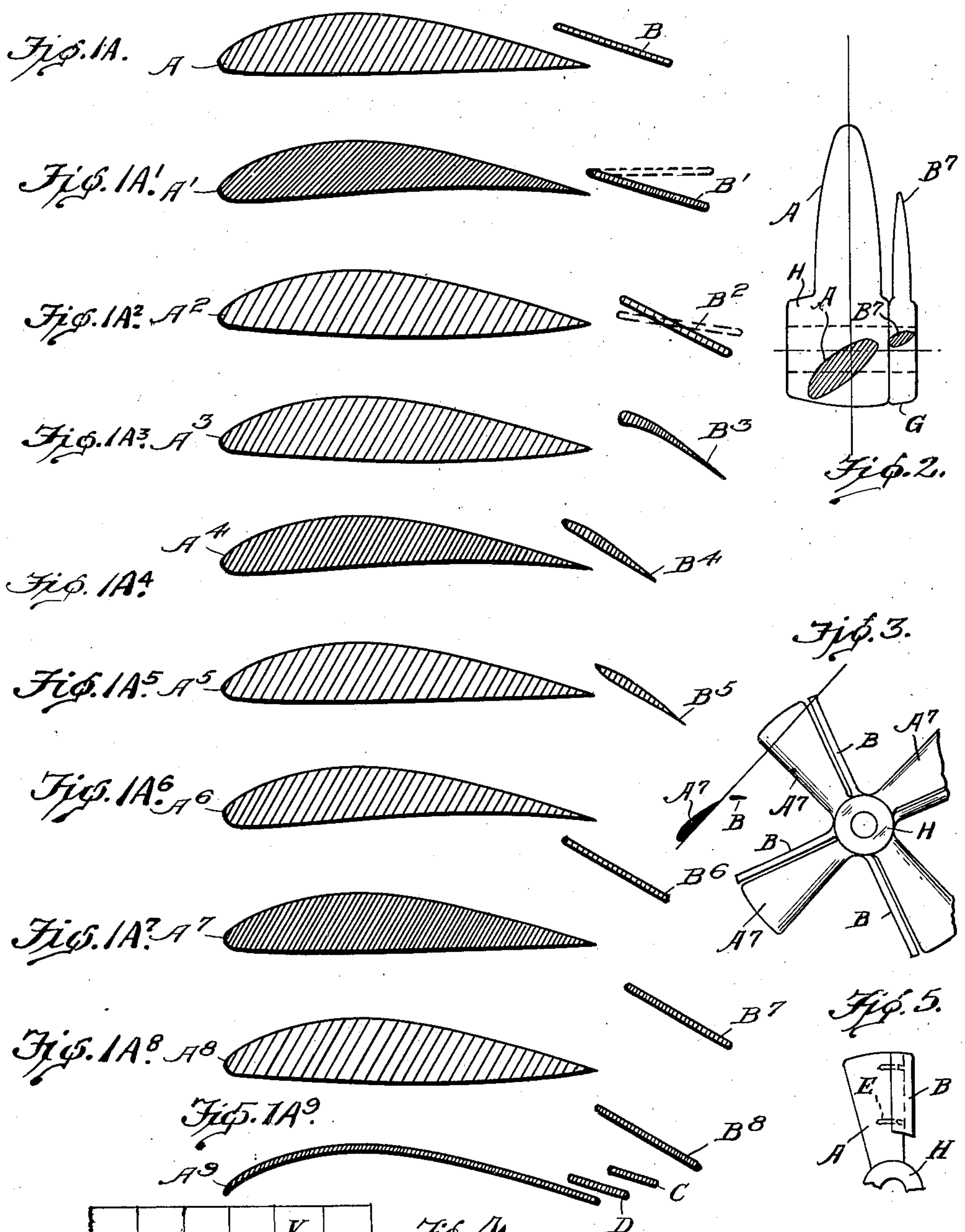
Sept. 18, 1928. | C. A. WRAGG | 1,684,567

PROPELLER

Filed Dec. 30, 1925



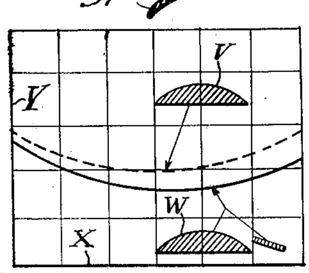


Fig. 4.

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PROPELLER.

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This invention relates to a device comprised of main blades and auxiliary blades compounded to form a unit having increased efficiency.

The primary object of this invention is to provide a structure which eliminates or reduces the phenomena usually designated energy disturbances, eddy losses, power losses, etc. as variously described by authors, theorists, and practical observers and users. It will be understood that it is in no way the purpose of this specification to uphold any particular theory of fluid flow, but to describe a new device that will meet the requirements for reduction of waste energy which is fundamentally involved in all theories whatever is the terminology used.

It is known that one of the difficulties of securing high power efficiency in propellers and the like is the problem of eliminating turbulence, eddying, cavitation, burbling and such like designations for general disturbances in flow which affect the factors or quantities used in the computation of efficiency. According to certain theories the flow of any fluid about a relatively moving object is such that various differences in pressure, velocity, or force potential are caused in the stream, the contours of the surfaces of the relatively moving object having the effect of augmenting or reducing the pressure, velocity, etc. in relation to that of the surrounding medium. This difference in pressure, velocity, or force potential, according to whatever theory may be advanced, results in thrust, lift, torque, or velocity etc. quantities, any or all of which may be utilized.

In devices designed to give a thrust reaction from the relatively moving object, hereinafter termed blade, there is always involved a loss of power due to the above mentioned disturbances.

I have discovered and proved by a long series of tests that if a small auxiliary blade is introduced into or near the region of turbulence or cavitation the effect is to reduce the loss of energy in eddies over the whole of the compounded blades and to result in greater overall efficiency. I do not claim that the number of so-called eddies will necessarily be reduced but that the sum total of energy losses however expressed will be reduced in actual quantity.

In air propellers it has been difficult also to coordinate the revolutionary blade speed giving maximum thrust efficiency with the revolutions per minute of the shaft required for maximum engine efficiency; the usual compromise being to run the propeller at somewhat higher revolutions and the engine at somewhat lower revolutions per minute than is most desirable in the respective cases. With my compound propeller however this compromise is partially if not altogether eliminated because the propeller may be rotated at higher velocity without drop in the thrust curve. Further, high efficiency can be maintained over a wider range of angles at which the blades meet the air.

A further object is the reduction of noise from ventilating and cooling fans of all kinds including exhaustion and compression devices.

Further advantages and applications of my compound blade will be more particularly referred to and pointed out hereinafter.

Referring to the accompanying drawings:

Figures 1A, $1A^1$, $1A^2$, $1A^3$, $1A^4$, $1A^5$, $1A^6$, $1A^7$, $1A^8$ and $1A^9$ show cross-sectional views of ten blades in which A to A^9 inclusive are different types of conventional members of a screw or fan having any number of such blades attached to a hub. B to B^8 inclusive in Figs. 1A to $1A^8$ are cross-sectional views of an auxiliary blade which is compounded with the main blade by setting it in the flow near the said main blade to affect the region of turbulence. C and D in Fig. $1A^9$ show a pair of sub-auxiliary blades in conjunction with one main blade, and it will be understood that more than one auxiliary may be used above or below the chord of a main blade.

Fig. 2 is a view containing a root-section of one form of my compound propeller with the two blades of the unit having individual hubs.

Fig. 3 is a fragmentary view of a turbine runner or propeller in which the auxiliary B is set in a plane below the blade A^7 but mounted on the same hub.

Fig. 4 shows drag curves of a wind tunnel test on a single blade model, illustrated in cross-section at V, and a test of the same blade compounded by the addition of an auxiliary as shown at W. In these tests the auxiliary was a small thin flat section set tangent to the upper curve of the main blade at the rear portion. The curves shown, in which the vertical heights Y give relative values of drag forces for various angles of attack X, are obtained by plotting figures representing the actual drag force, and show clearly the remarkable reduction in drag due to my compounding arrangement.

Fig. 5 illustrates different lengths and locations of an auxiliary B with stream line braces E for attachment to the main blade at points other than the hub.

An important matter to be observed in my invention is that greater reactive force may be obtained from the fluid media. Fig. 2 illustrates this type of propeller in which A is a leading blade and B^7 is a following blade attached together and to the shaft at their hubs H and G. The greater propelling power is gained by reason of the fact that the rear or auxiliary blade may have a larger angle relative to the shaft than the forward blade, exerting against fluid which has been acted upon by the forward blade before said fluid has time to react, thus, particularly at high velocities, utilizing energy in the fluid which is otherwise lost.

I am aware that air craft propellers have been used having more than two blades in different plane of rotation, but they have been spaced so far apart as to have no compound cooperation as herein stated. The blades of such disclosures are spaced at large angles, generally at right angles to each other, whereas the blades of each unit in my compound propeller are substantially parallel, and the said compound units may be arranged in groups of two, three, or more as is the case with the ordinary type of propeller. For instance, Fig. 3 is an example of a four-bladed propeller embodying my compound principle.

In the case of a mechanism such as a marine propeller operating in water it has been considered as a working hypothesis that when a cambered blade attached to a shaft at an angle of incidence thereto (usually termed pitch) is caused to rotate, the revolving blade will start a system of reactions by which a column of fluid is forced backward and the propeller is pushed forward. It has been found by such empirical work on the whole system in motion that there is a particular angle at which the blade should continuously meet the fluid medium for best efficiency. This "actual angle" as it is called is a resultant of the speed of translation, the speed of rotation, and the speed of the slipstream. In practice however the best combination of these cannot be maintained under the changing conditions of general usage which cause the "actual angle" to vary from that required for maximum efficiency. A practical instance of this is the case of a ship which, when loaded down or when steaming under adverse conditions, will have greater resistance to propulsion and require greater thrust for a given speed. The propeller must then turn at a higher rate than is ideal for the forward speed of the ship, thus changing the "actual angle" of the blades with consequent loss of energy and waste of fuel.

But by the use of this invention the auxiliary blade or blades in compound with a main blade enables the "actual angle" of the propeller system to vary through a wide range without the characteristic and hitherto unavoidable drop in efficiency.

The auxiliary blade or blades in my invention, as hereinbefore indicated, may be cast with a separate hub G and attached to the shaft beside the main hub H as shown in Fig. 2; or they may be cast integrally with the main hub H as shown in Fig. 3; or they may be attached to the main blade by suitable streamline braces as diagrammatically indicated at E in Fig. 5; they may also be pivoted so as to adjust themselves freely in the stream and take any angular position with reference to the main blade as shown diagrammatically at B^1 and B^2 in Figs. $1A^1$ and $1A^2$. Means may also be provided to adjust and hold, either automatically or otherwise, said blades B in any angular relationship with blades A.

It will be seen that several embodiments of the invention are more or less diagrammatically illustrated, as at B^1 and B^2 of Figs. $1A^1$ and $1A^2$, by way of example and not of limitation, for the purpose of explaining the broad features included in the invention. The combination A—B in Fig. 1A shows the auxiliary B overlapping the rear edge of blade A; B^1 Fig. $1A^1$ is substantially in vertical alignment with the rear edge of A^1; B^2 in Fig. $1A^2$ is somewhat to the rear of A^2; B^3, B^4, and B^5 in Fig. $1A^3$, $1A^4$ and $1A^5$ illustrate forms of cambered auxiliaries; B^6, B^7, and B^8 in Fig. $1A^6$, $1A^7$ and $1A^8$ show auxiliaries below the chord of blades A^6. A^7, and A^8 respectively; and Fig. A^9 is a diagrammatic figure of a blade such as is used in fans and the like. It will thus be understood that I do not bind myself to any particular combination of shape, relative size, or exact location of blades, and that the blades may be either cambered or flat.

The auxiliary blade shown in Fig. 2 is integral with a separate hub G; this auxiliary hub however is not to be considered as constituting an additional propeller but as a means for adjustment of the auxiliary blade B^7 relative to blade A. Fig. 3 of the drawing is intended to show that the hub of the auxiliary blades is cast or fashioned integrally with the hub H of the main blades.

As the general discussion and the aerodynamical theories, supplied in this specification and brought out by the wind-tunnel tests referred to, apply equally well to propellers, aerofoils and other elements having fluid pressure contacting surfaces, it is obvious that the invention also applies to such elements or surfaces.

It is evident that various changes, modifications and substitutions might be made in the relative lengths etc., hence it is not desired or intended to limit the invention to the exact disclosures hereof.

I claim:

1. In a propeller structure, a main blade and an auxiliary blade, the auxiliary blade being substantially parallel sided and positioned with its leading edge adjacent the trailing edge of the main blade and parallel thereto.

2. In a propeller structure, a main blade and an auxiliary blade, the auxiliary blade being substantially parallel edged and positioned with its leading edge adjacent the trailing edge of the main blade and parallel thereto, the adjacent faces of the blades being substantially parallel.

3. In a propeller structure, a main blade and an auxiliary blade, the auxiliary blade being substantially parallel edged and positioned with its leading edge adjacent the trailing edge of the main blade and parallel thereto, the adjacent surfaces of the blades being substantially parallel and means for rigidly securing the blades together, comprising a common hub upon which the blades are mounted.

4. In a propeller structure, the combination with a main blade, of a comparatively narrow, auxiliary blade having substantially parallel edges and positioned to compel an unbroken flow of fluid past the blades, the trailing edge of one blade being parallel and adjacent to the leading edge of the succeeding blade.

5. In a propeller structure, main and auxiliary blades, the auxiliary blade being rectangular and narrow and positioned with its edges parallel to the trailing edge of the main blade, and in the zone of eddy forming region of the main blade.

6. In a propeller structure, a main blade and an auxiliary blade of considerably different width, the auxiliary blade having substantially parallel edges and being positioned in the wake of the main blade and with its edges parallel to one edge of the main blade.

7. In a propeller structure, main and auxiliary blades, the auxiliary blade of rectangular shape and less width than the main blade and being positioned with its edges parallel to the trailing edge of the main blade and the adjacent surfaces of the blades being parallel.

8. In a propeller structure, main and auxiliary blades, the auxiliary blade having substantially parallel edges, its width being not over half the width of the main blade, the auxiliary blade being positioned with its leading edge parallel and adjacent to the trailing edge of the main blade.

9. A compound blade for propellers, comprising a main blade and an auxiliary blade arranged substantially in the region of turbulence, the blades having their adjacent surfaces and their trailing edges parallel, the auxiliary blade being rectangular and not over one half in width of the main blade.

10. A compound blade for propellers, comprising main and auxiliary blades arranged substantially in the zone of eddy forming region of the main blade to provide a continuous unbroken path for the fluid and with their trailing edges parallel, the auxiliary blade being rectangular and not over one half in width of the main blade.

11. A compound blade for propellers, comprising main and auxiliary blades, one of said blades being arranged substantially near the region of cavitation in order to provide a continuous unbroken path for the fluid and with their trailing edges parallel, the auxiliary blade being not over one half in width of the main blade and having parallel edges.

12. A compound propeller blade, comprising a main blade element and a series of auxiliary blade elements, the edges of the auxiliary blade element being substantially parallel with the edges of the main blade element and of a width less than half that of the main blade element and arranged in the region of turbulence.

13. A compound propeller blade, comprising a main blade element and a series of auxiliary blade elements, the edges of the auxiliary blade elements being substantially parallel with the edges of the main blade element and of a width less than half that of the main blade element and arranged in the region of turbulence, one element above the other.

14. In a structure cooperating with a relatively moving fluid, the combination with a main element, of a comparatively narrow auxiliary element having substantially parallel edges and positioned to compel an unbroken flow of fluid past the surfaces of said elements, the trailing edge of one of said elements being parallel with and adjacent to the leading edge of the succeeding element.

15. In a fluid pressure actuated structure, comprising main and auxiliary elements having fluid contacting surfaces, one of said elements being arranged near the region of turbulence in order to provide an unbroken path for the fluid, said elements each having parallel edges placed parallel with those of the other element, the surface of the auxiliary element being not over one half in width of the main surface.

In testimony whereof I hereunto affix my signature.

CHARLES ARTHUR WRAGG.