April 12, 1932. F. MELCHER 1,853,694

COUNTER RUNNING DOUBLE PROPELLER

Filed Aug. 14, 1930

Fig.1.

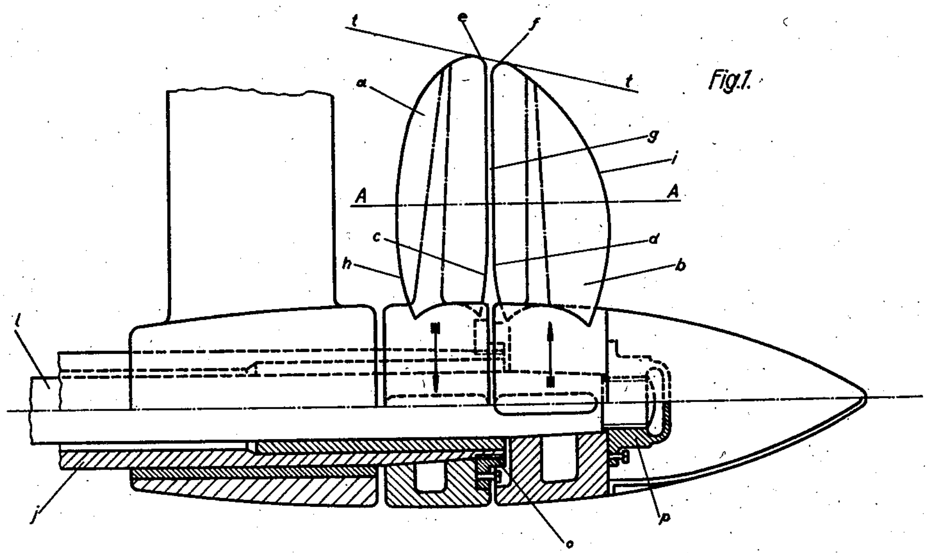


Fig.2.

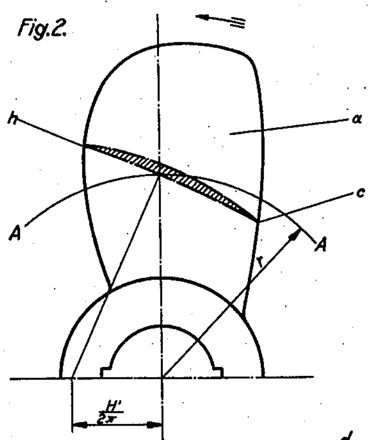


Fig.3.

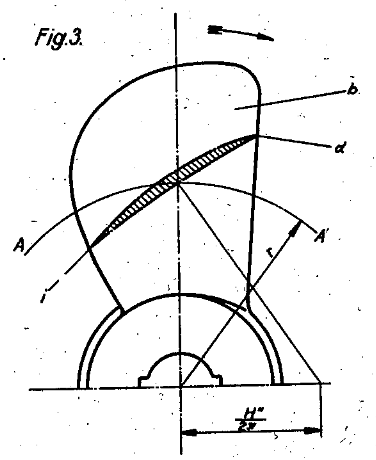
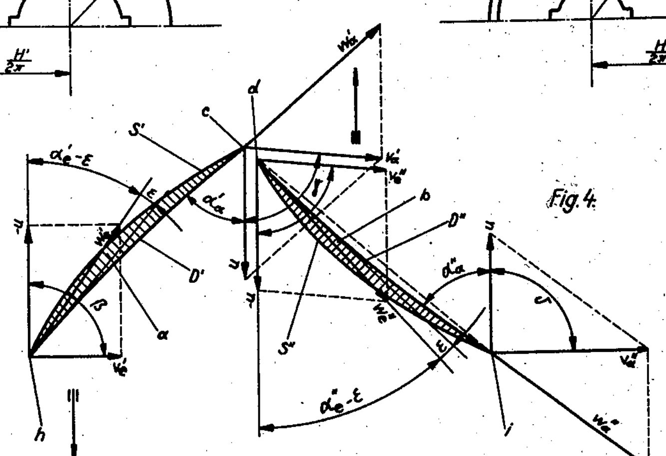


Fig.4.



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UNITED STATES PATENT OFFICE

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COUNTER RUNNING DOUBLE PROPELLER

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This invention relates to a double propeller with counter-rotation for operation in media of all kinds. Double counter-running propellers have hitherto been used only in certain special applications and in water, as for example in connection with torpedoes for the purpose of eliminating the reaction effect of the propeller which is assumed to be a left hand one and consequent turning of the torpedo body; but no attention has hitherto been paid to the exploitation of this counter-rotation from a purely hydraulic point of view.

There are many known forms of construction for single propellers in which the pitch of the blades both in a radial and in a circumferential sense is adapted to be adjustable to suit altering conditions of flow.

The present invention has for its object to achieve the highest possible propeller efficiency by the suitable choice of the respective pitch of the juxtaposed counter-running propellers and by a particular construction of the adjacent entry and discharge edges of the blades of these propellers. A further particular object of the invention is to employ the front propeller as a guide apparatus for effecting as favorable and uniform an admission as possible to the rear propeller.

In its application to aircraft this invention aims at the provision of propellers with approximately twice as great a thrust but with approximately the same disc-area and with at least the same degree of efficiency as single propellers of the usual type.

An example of a form of construction embodying the subject matter of the invention is illustrated in Figs. 1 to 4 of the accompanying drawings, in which:—

Fig. 1 is a longitudinal section of a counter-running double propeller.

Fig. 2 is a side elevation of the fore propeller.

Fig. 3 is an elevation of the rear propeller which is assumed to be a right hand one.

Fig. 4 represents developed projections of cylindrical sections of the blades of the fore and rear propeller respectively. The speeds of the medium relatively to the propellers *a* and *b* are shown diagrammatically by means of radius-vectors.

The propeller *a* is keyed to the hollow shaft *j* and the propeller *b* to the inner shaft *l*. The two shafts are driven in opposite directions. The locking of the propeller bosses on the tapered ends of the shafts can be effected in any desired manner, for instance by means of driving nuts *o* and *p*.

Given the resistance of the vessel or torpedo, and given the speed of rotation and the proportional working capacity of each propeller, all the relative entry and discharge speeds of the traversing medium for the entire range of the blades of both fore and rear propellers can first be calculated point for point in accordance with the impulse rule, provided the initial angle of the relative speed of entry to the pressure side is also given. After the plotting of the radius-vectors of the relative entry and discharge speeds in diagrammatic form (Fig. 4) the varying degrees of pitch of the propeller can be deduced.

In the diagram of Fig. 4 the axially directed absolute rate of flow-speed of the medium on entering the propeller is represented by the radius-vector $v_e'=v.\ (l-w)$, v being the speed of the ship and w the wake coefficient.

In the diagram u is the circumferential speed of the medium at the point concerned (A—A in Figs. 1 to 3), after allowance for reduction on account of slip which increases from the centre towards the circumference. The relative flow-speed w_e' in the propeller *a* at its entering edge *h* is the resultant of the absolute speed at entry v_e' and the negative circumferential speed $-u$.

The local pitch at the entering edge *h* is as follows:—

$H_e'=2\pi r.\ \text{tang}\ \alpha_e'$, r being the radius of the propeller at the point concerned (A—A) and α_e' the angle of pitch at the entering edge and on the pressure side D′ of the propeller; ϵ' is the initial angle at any one point between the relative direction of flow of the medium and the pressure side of the propeller.

Similarly $H_e''=2\pi r.\ \text{tang}\ \alpha_e''$ for the local pitch at the entering edge *d* of the rear propeller *b*, α_e'' being the angle of the pitch of the entering edge of the pressure side D″ of the propeller; ϵ'' is the initial angle at any one point.

Experience has proved that both for water and air propellers the most favorable conditions obtain when the initial angle is approximately 4°.

The following equations are in general valid for the correspondingly appropriate speeds and pitches:—

$$\text{tang }(\alpha-\epsilon)=\frac{v_e}{u}$$

tang $(\alpha-\epsilon=(\text{tang }\alpha-\text{tang }\epsilon):(l+\text{tang }\alpha\ \text{tang }\epsilon)$

If

$$\frac{H}{\pi D}$$

and $\pi D.n$ be substituted for tang α and u respectively it follows that

$$\text{tang }\epsilon=\frac{\frac{H}{\pi.D}=\frac{v_e}{u}}{l+\frac{v_e}{u}\cdot\frac{H}{\pi D}}$$

$$H=\frac{\pi D\left(\frac{v_e}{u}+\text{tang }\epsilon\right)}{l-\frac{v_e}{u}\cdot\text{tang }\epsilon}$$

From the absolute discharge speed v_a' of the front propeller only the discharge pitch H_a' can be calculated.

$v_a'=k.\ n.\ H_a'$; whereby n represents the number of revolutions and k a constant depending on the angle of convergence between the surfaces of the blade in cross-section at the discharge edge c; the angle of incidence $\gamma\leqq 90°$ between the direction of the absolute discharge speed v_a' and the direction at the circumference is known to be somewhat variable in a radial sense.

If the above described conditions be fulfilled the pressure side D′ of the developed cylindrical section presents a flattened curve corresponding to the varying pitch in a circumferential direction.

Theoretically the merely approximately axially directed absolute discharge speed v_a' of the fore propeller a would have to be equal to the absolute admission velocity v_e'' at the entering edge d of the rear propeller b. v_e'' will however be less than v_a' to the extent of a slight loss of impact in the gap g (Fig. 1).

In the diagrammatic determination of the speed and pitch triangles particular attention must be paid to the twist component in the discharge speed of the fore propeller, which component increases towards the boss of the propeller.

The pitch of the pressure side of the rear propeller b is again variable, so that the deduced axial discharge speed $v_a''=k.n.H_a''$ is the resultant of the circumferential speed $+u$ and of the relative rate of outflow speed w_a'' at the discharge edge i.

If the above elucidated fundamental conditions be fulfilled the fore propeller a acts as a guide apparatus for the rear propeller b, with the object of providing a favorable flow to the latter.

The double propeller a, b, which is to be regarded as constituting a single self-contained unit, thus describes in running an enclosed surface of rotation h-e-f-i, as if the latter were the enveloping surface of only one single propeller.

In the constructional example shown the projections shown in Fig. 1 of the juxtaposed inner discharge edge c and entering edge d are straight and uniformly distanced from each other; they can however be inclined to each other or curved in any desired manner, and the intermediate gap g can also be varied within slight limits so that this gap is somewhat larger in the vicinity of the boss, where irregularities of flow can occur, while in the most effective portion, for about the outer two-thirds of the length of the blades, the width of the gap remains uniform. It is advantageous to reduce the width of the gap g or the clearance between the two propellers to less than 5 per cent of the greatest diameter of the propeller. The external shape of the entering edge h of the fore propeller and of the discharge edge i of the rear propeller is immaterial. The diameter of the rear propeller b can also be somewhat less than that of the fore propeller a in accordance with the contraction of the screw-water as the speed increases, so that the tangent t to the enveloping surface in the gap is inclined towards the rear (Fig. 1).

I claim:—

1. A counter-running double propeller for operation in media of every kind characterized by the essential feature that the angle of pitch on the pressure sides at the entering edges is greater to the extent of a uniformly equal initial angle than the appertaining angle of incidence between the direction of the relative inflow speed to the working propeller and the negative direction at the circumference, whereby the local variable pitch of the discharge edge of the propellers corresponds to a given speed of rotation and a certain definite distribution of working capacity of each propeller.

2. A counter-running double propeller according to claim 1, characterized by the essential feature that the variation of the pitch of entry from the blade tip to the boss is of such a decreasing tendency that throughout this range the initial angle is approximately 4°.

3. A counter-running double propeller characterized by the essential feature that the clearance between the two propellers is

less than 5 per cent of their greatest diameter.

4. A counter-running double propeller characterized by the essential feature that the diameter of the rear propeller is less than that of the fore propeller to such an extent that the tangent to the blade tips of both propellers at a given speed is parallel to the local direction of flow, which direction is conditioned by the contraction of the screw-jet.

5. A counter-running double propeller for operation in media of every kind, consisting of a lefthand and a righthand propeller characterized by the essential feature that the angle of pitch on the pressure sides is greater in the amount of approximately 4 degrees than the appertaining angle of incidence between the direction of the relative inflow speed to the working propeller and the negative direction at the circumference by a certain definite distribution of working capacity of each propeller, whereby the clearance between the two propellers in the extent of about two thirds of the length of the blades of the propellers is less than 5 per cent of their greatest diameter and the diameter of the rear propeller is less than that of the fore propeller to such an extent that the tangent to the blade tips of the propellers at a given speed is inclined toward the rear according to the contraction of the screw-jet.

In testimony whereof I have affixed my signature.

FRANZ MELCHER.