Nov. 24, 1953 R. DOUSSAIN ET AL 2,660,252

VARIABLE PITCH SCREW PROPELLER ARTICULATED BLADE MOUNTING

Filed May 1, 1947 5 Sheets-Sheet 1

Fig. 1.

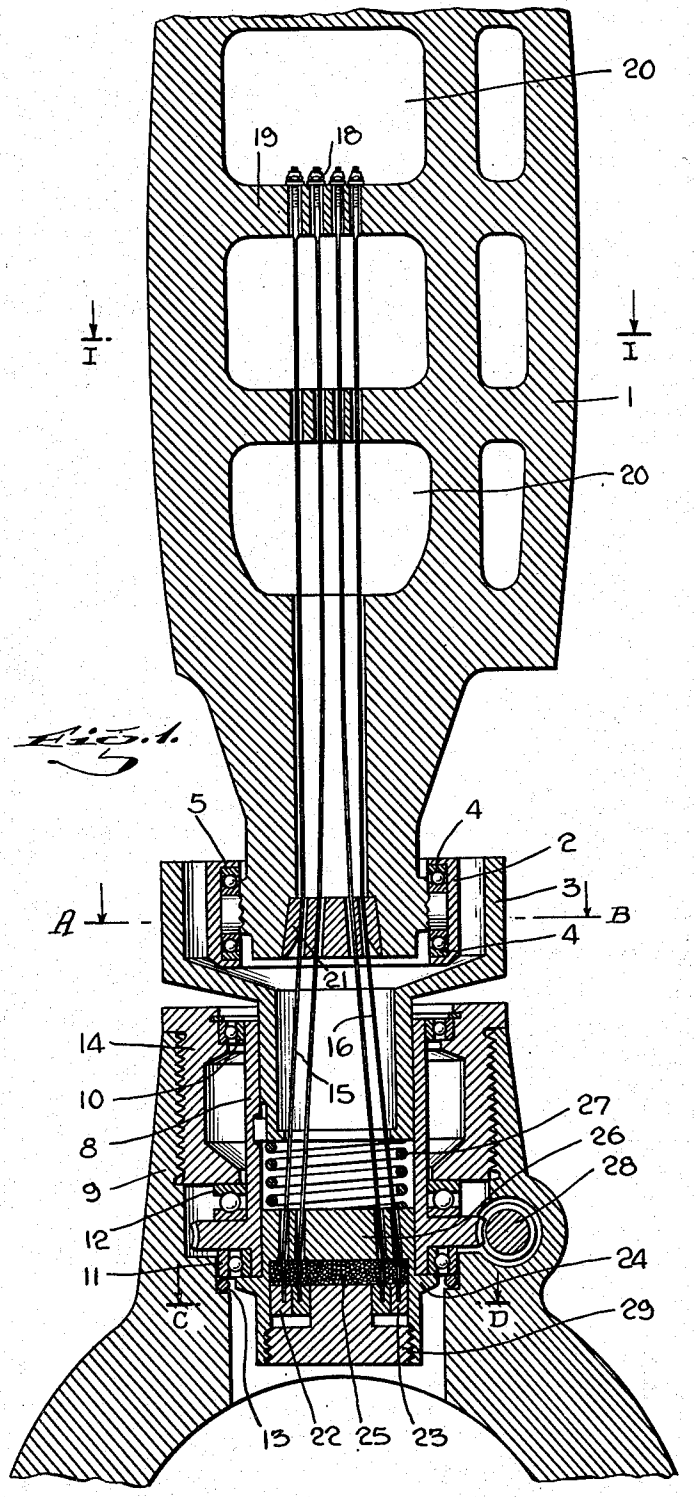


Fig. 3.

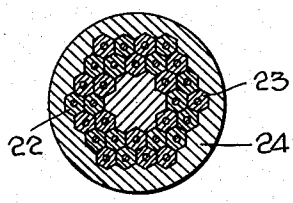
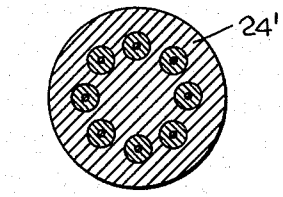


Fig. 3a.



INVENTORS
Robert Doussain
Robert Doussain
BY Louis Perrier
Brown & Seward
ATTORNEYS

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Filed May 1, 1947 5 Sheets-Sheet 2

Fig. 4

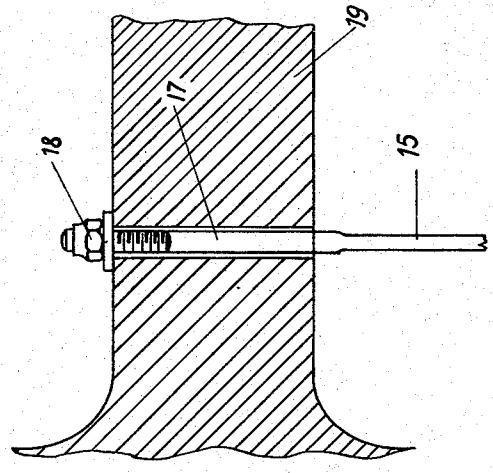
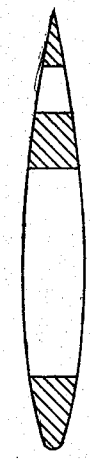


Fig. 1a



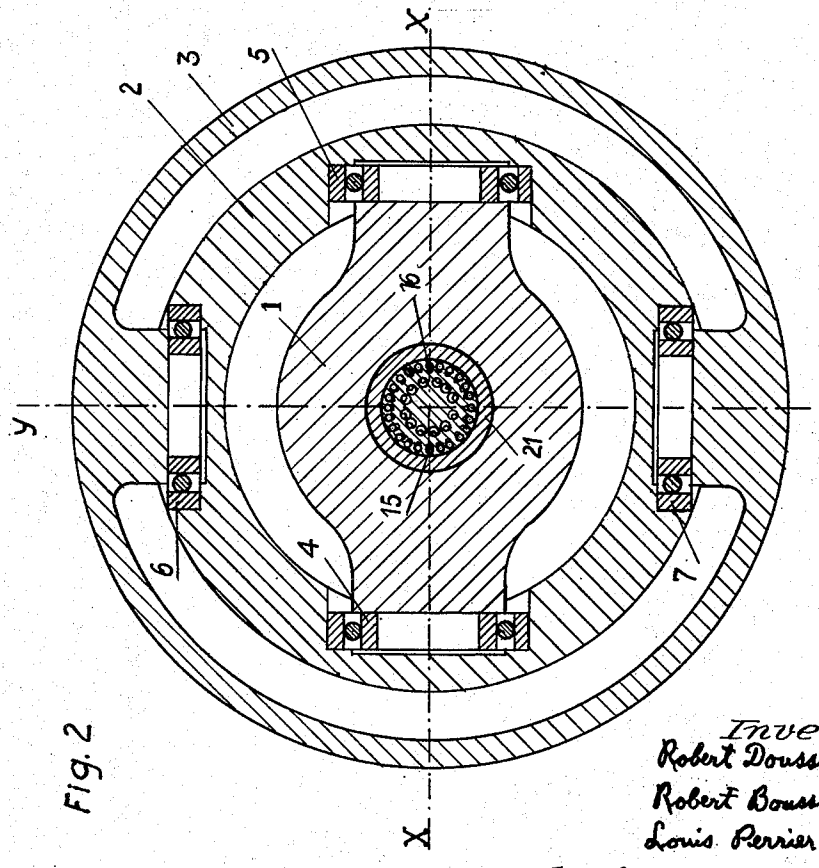


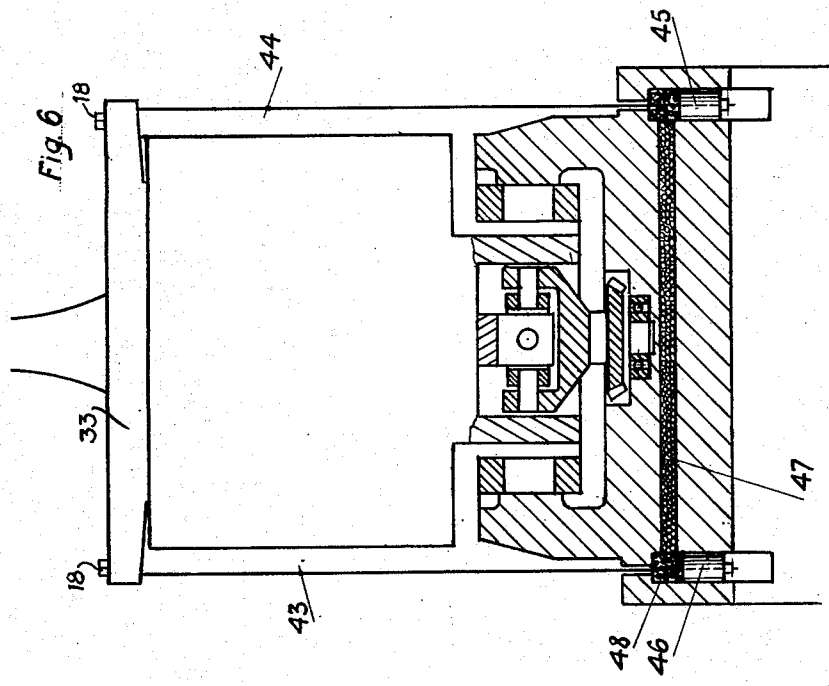
Fig. 2

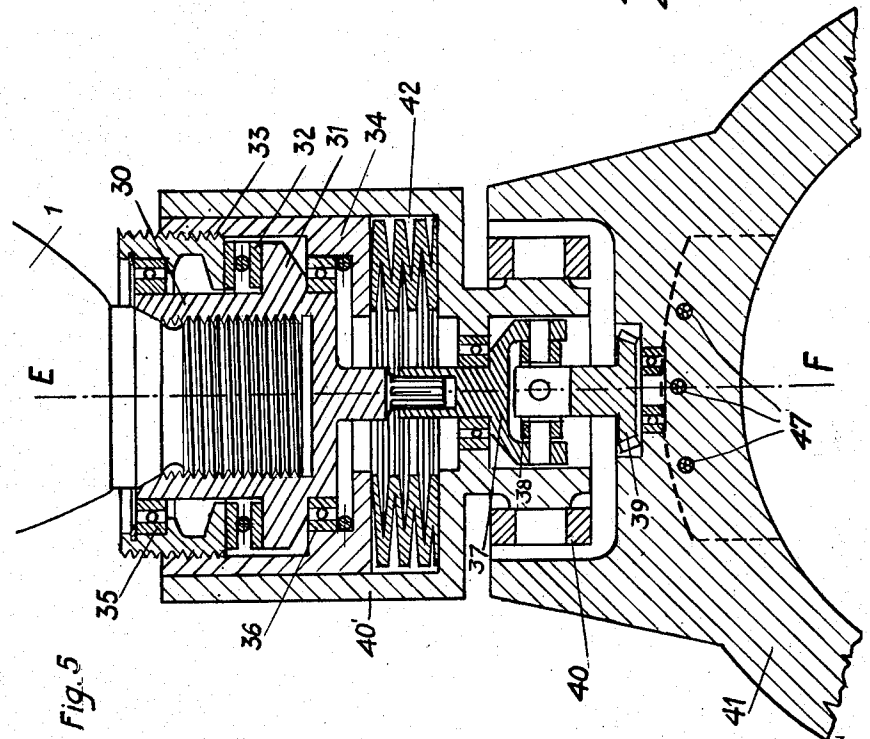
Inventors:-
Robert Doussain
Robert Bousson
Louis Perrier
By Brown & Seward
Attorneys

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VARIABLE PITCH SCREW PROPELLER ARTICULATED BLADE MOUNTING

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Inventors:-
Robert Doussain
Robert Bousson
Louis Perrier
by Brown & Brown Attorneys

Nov. 24, 1953 R. DOUSSAIN ET AL 2,660,252

VARIABLE PITCH SCREW PROPELLER ARTICULATED BLADE MOUNTING

Filed May 1, 1947 5 Sheets-Sheet 4

fig. 7

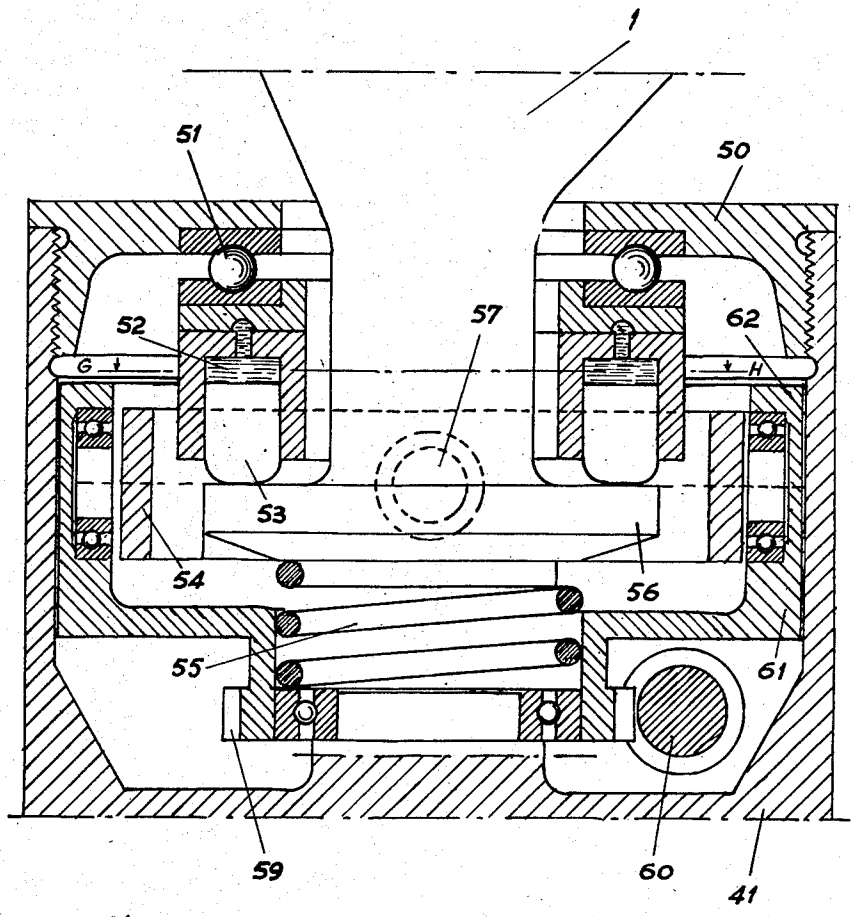
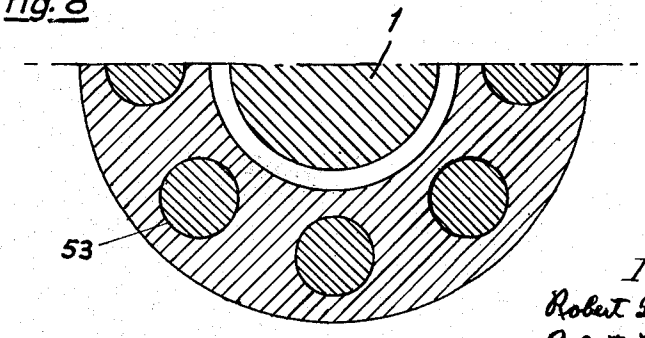


fig. 8



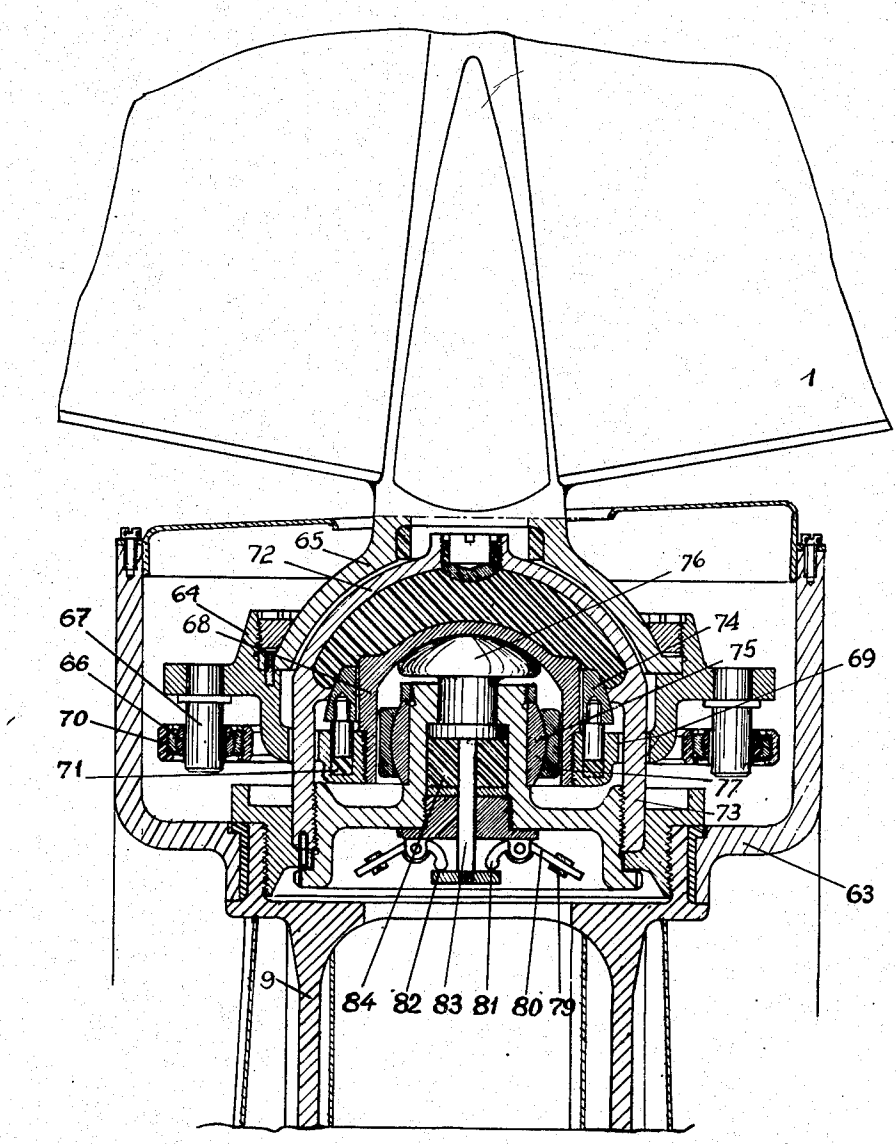
Inventors:-
Robert Doussain
Robert Bousson
Louis Perrier
by Brown & Seward
Attorneys

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VARIABLE PITCH SCREW PROPELLER ARTICULATED BLADE MOUNTING

Filed May 1, 1947 5 Sheets-Sheet 5

Fig. 9



Inventors:-
Robert Doussain
Robert Bousson
Louis Perrier
by Brown & Seward
Attorneys

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2,660,252

VARIABLE PITCH SCREW PROPELLER ARTICULATED BLADE MOUNTING

Robert Doussain, Villeurbanne, and Robert Bousson and Louis Perrier, Lyon, France, assignors to Office National d'Etudes et de Recherches Aeronautiques, Paris, France, a company of France

Application May 1, 1947, Serial No. 745,360

Claims priority, application France May 9, 1946

9 Claims. (Cl. 170—160.56)

1

This invention relates to articulation mountings for connecting to a hub a propeller blade angularly movable with respect to said hub.

It is known that at present the development of turbo-jet propulsion units forces the manufacturers of conventional motor propelled equipment making use of screw propellers, to improve their material in order to cope with the increasing competition of turbo-jet reaction engines. To this end they are compelled to reduce as much as possible the specific weight of the propeller, i. e. its weight related to the available useful power. In fact although turbo-jet reaction engines are characterized by a very high fuel consumption, they are on the other hand extremely light. On the contrary the conventional moto-propulsive units are compelled, in the field where they still can compete with power jet engines, to have propellers of very large diameters or else propellers having a great number of blades. This leads to an increase of the weight of these parts causing a reduction of the useful load which can be transported.

It is, therefore, an object of this invention to provide an improved articulation mounting for a propeller blade permitting substantially decreasing the weight of the blades and also reducing the reaction forces applied to the hub as a result of aerodynamic and centrifugal forces, with substantial reduction also of the weight of the hub.

In carrying out these objects the articulation mounting comprises a universal joint between the blade and the hub of the propeller and independent means for absorbing the forces acting in the direction of the axis of the blade, said independent means being so constructed that said articulation mounting is relieved from stresses due to said forces.

In order to bring forth more clearly the advantages which may be obtained by the use of the new articulation mounting, it may be useful to recall the forces acting on a propeller blade. These forces depend on one hand on the mass of the blades (gravity and inertia forces due to centrifugal and tangential accelerations) and on the other hand on the aerodynamical reactions which constitute the very essence of a propeller operation.

Generally, if one considers a propeller operating at a constant speed, it can be determined that the main stresses, at any point of a blade, are due to centrifugal forces which translate themselves into tensile stresses and to bending moments due to aerodynamical reactions.

In order to avoid a too great increase of the

2

blade cross-section, and consequently of its weight, necessary to resist these efforts, attempts have been made to make propellers in which the axis of a blade is offset angularly in the direction of the resultant of centrifugal and aerodynamical forces acting on the same. The direction of this inclination and its amplitude are generally determined by the maximum load.

With such a propeller rotating at a constant predetermined speed the bending moments due to aerodynamical forces are nullified and it is possible therefore to decrease the size of the cross-section of the blades and consequently their weight. However, very often the possibility of reducing the stresses in a blade is only theoretical, as for all other speeds of operation these stresses are increased due precisely to said inclination of the blade. This is particularly apparent in the case of modern screw propellers adapted to be used to produce a braking action on the plane by the reversal of the pitch of the blades which results in a reversal of the bending moment exerted on the blades, due to aerodynamical reactions. This reversal of the bending moment and the difficulty of compensation by a fixed inclination of the blade axis upon the construction of propellers results practically in an increase of the weight of propellers instead of a decrease thereof. It can be mentioned also that propellers made of wood or of other light materials require increase of cross-sections of the blades, resulting in a considerable reduction of aerodynamic efficiency of propellers and that finally the use of hollow blades made of materials of great stress resistance is not interesting except for propellers exceeding certain size and in general requires a costly tooling which cannot be amortized if the manufacture is not based on mass production.

It seems therefore that the ideal solution consists in making propeller blades automatically adjustable at any time following the direction of the resultant of aerodynamic forces producing bending moments and the action of centrifugal forces. However, this principle of free oscillating blades with automatic compensation, whilst having been applied for a long time to blades of helicopters and the like has not been used industrially in relation with screw propellers, ventilators or similar apparatus, principally due to the importance of centrifugal forces acting on the articulation mounting of such blades.

To cite an example, it will be sufficient to mention that a helicopter blade of 4 meters in radius, of a weight of 40 kgs. and rotating approximately

at 120 R. P. M. is subjected to a tensile stress due to centrifugal forces of the order of 2 tons at maximum, whilst in the case of an airplane propeller made of Duralumin, of 4 meters in diameter and of a weight per blade, of 40 kgs., the propeller rotating at 1200 R. P. M., the tensile stress developed under the action of centrifugal forces is 50 times greater and may attain 100 tons. It can be easily understood that such efforts lead inevitably to heavy structures and make illusory any possibility of reduction of the weight of the blade.

The improved articulation mounting according to the invention may be applied equally to propellers with fixed pitch as well as to propellers with a variable pitch, the axes of articulation forming a Cardan suspension which may be connected either to the hub or to a blade. For instance, in the case of a variable pitch propeller with axes of articulation connected to the hub, a blade may be mounted in a sleeve in which it can rotate and which in its turn will be adapted to oscillate with respect to the hub, the pitch variation of the blade being controlled by a second oscillating coupling concentric with respect to the first.

The above and other objects and features of the invention will be better understood from the consideration of the following description and the annexed drawings showing, by way of an example only and solely for the purpose of explanation, certain embodiments of the articulation mounting according to the invention applied to screw propellers with oscillating blades.

On the drawings:

Figure 1 shows in section made perpendicularly to the axis of rotation of the propeller a blade root and its oscillatory mounting in the hub socket;

Fig. 1*a* is a section taken on the line I—I of Fig. 1;

Figure 2 is a section made following line AB of Fig. 1 and showing the universal articulation;

Figure 3 is a section made following line CD of Fig. 1;

Figure 3*a* is a similar view to that of Fig. 3 and showing a modified structure;

Figure 4 is a detail view showing the manner of attachment of flexible connectors to the blades;

Figure 5 is a section similar to that of Fig. 1 showing another form of embodiment;

Figure 6 is a section made following axis EF of Fig. 5;

Figure 7 shows another modified construction;

Figure 8 is a section view taken on the line GH of Fig. 7 and

Figure 9 shows another embodiment of the invention.

Referring now to the drawings, and beginning with Figs. 1 to 4, there is shown a propeller blade 1 articulated about an axis X—X (Fig. 2) on an intermediary annular member 2. This member 2 is articulated in its turn about axis Y—Y, perpendicular to axis X—X in a sleeve 3, these two axes constituting thus a universal mounting. Blade 1 is provided with two trunnions received into two ball bearings respectively 4 and 5 secured on the intermediary member 2. This member is provided with two depressions in which are fitted ball bearings 6 and 7 adapted to receive respectively two trunnions carried by sleeve 3 (Fig. 2). Sleeve 3, as can be seen on Fig. 1, is adapted to slide in a radial direction with respect to a sleeve 8 in which it is guided by a splined connection. Sleeve 8 is made integral with, or

may carry fixed thereon, a worm gear providing a pitch varying connection for the blade. This sleeve 8 is rotatably mounted in a corresponding hub socket 9 by means of two ball, or in general antifriction, bearings 10 and 11 whilst it is retained against movement in the radial direction by a thrust bearing 12.

Bearing 11 is directly fitted in a centered depression at the inner end of the hub socket 9 and rests upon a resilient gasket 13 whilst bearing 10 is fitted in a coaxial depression provided in a thrust nut 14 screwed into the hub socket 9.

The centrifugal force is resisted by a set of cables such as shown in section on Fig. 2, a pair of such cables 15 and 16 located diametrically opposite one to the other being indicated in Figs. 1 and 2.

Each cable is secured by one of its extremities to the blade in any suitable manner. Fig. 4 shows a particular manner in which these cables can be connected to the blade. In this example cable 15 for instance, terminated like a spoke of a bicycle wheel with a threaded portion 17 receiving a self-locking nut 18, permits establishing a connection between said cable and a strengthening member 19 inside the blade.

In the example shown in Fig. 1 the blade 1 is provided with hollow portions 20 designed on one hand to permit the mounting of cables and on the other hand to reduce the weight of the blade, this reduction of the weight being made possible as a result of an almost complete elimination of stresses due to bending moments and the absorption of tensile stresses resulting from the action of the centrifugal force, directly by the cables.

As shown in Figs. 1 and 2 the inner extremity of the blade is provided at the level of the universal mounting with a member 21 adapted to guide the cables upon oscillations of the blade.

Each of the cables, such as for example 15 and 16, is connected at its free extremity to a piston such as 22 and 23. In the example shown in Fig. 1 these pistons have either a prismatic form as shown in Fig. 3 or a cylindrical form as shown on Fig. 3*a* and slide in the bottom of an enclosed space or chamber 25.

This chamber 25 may be completely filled with an incompressible fluid or else as shown in the drawing with metallic balls of a reduced diameter. This latter arrangement eliminates all problems connected with the provision of a fluid-tight chamber. As has been shown by the two examples given on Figs. 3 and 3*a* the flexible connectors or cables and their pistons may be arranged to lie in the surface of a single or a plurality of cylinders.

Chamber 25 is closed by a cover 26 provided with passages for guiding the cables. It is formed in a hollow member 24 closed at one end by cover 26 and at the other end by a second cover 29. An outer shoulder or flange provided on member 24 bears against the inner edge of sleeve 8 and transmits thus through the intermediary of said last member the force of traction produced by centrifugal action to thrust bearing 12. Between member 24 and sleeve 3 there is provided a compression spring 27 which is designed to place initially under tension the connecting cables.

The pistons 22, 23, etc. have a freely sliding fit in a generally annular chamber (or annularly disposed series of chambers, Fig. 3*a*) so that each piston is free to move vertically. The chamber in which the pistons are fitted is a downward extension of the cylindrical chamber 25 which

is filled with a non-compressible material having fluid characteristics (a liquid or a mass of small metal balls). When one of the pistons, for instance piston 22, is pulled upward by its rod or cable 15, it forces said material to push downward by a corresponding amount the piston 23 so that the rod or cable 16 is maintained taut. Assuming that the pistons 22 and 23 lie in the plane in which the blade is moving with respect to its support at any given moment, it will be understood that the said pistons will move the greatest distance and that the pistons adjacent to 22 and 23 will move progressively decreasing distances upward or downward, respectively, while the pistons equi-distant from 22 and 23 will not be moved at all.

In the example shown the pitch variation of the blade is controlled by a worm 26 driving the worm gear carried by sleeve 8. It will be noted that in case of a variation of the speed of rotation of the engine, or in response to the action of ambient medium, for instance temperature variations, the connecting cables are permitted to extend due to the sliding mounting of sleeve 3 in sleeve 8. In the example just described the universal connection is carried by the blade and rotates with this latter upon rotation of the same about its axis of pitch variation. However, as it has been indicated previously, the articulation mounting according to the invention may be applied also to variable pitch propellers with oscillating blades in which the universal connection is carried by the hub. An example of such an arrangement is shown on Figs. 5 and 6.

Referring now to these figures, blade 1, as shown therein, is terminated at its root end by a threaded portion screwed into a sleeve 30 provided with an outer annular shoulder 31 which latter transmits the stresses due to the centrifugal force to a thrust bearing 32 which bears against a nut 33 screwed in a second sleeve 34. Sleeve 30 is on the other hand mounted concentrically in sleeve 34 by means of two ball or in general anti-friction bearings 35 and 36, sleeve 34 being adapted to slide radially with respect to member 40' which is adapted to oscillate with respect to hub 41 through the intermediary of a universal mounting.

At its inner extremity sleeve 30 is provided with a longitudinally grooved extension, by means of which it is mounted into a correspondingly splined extremity of shaft 37, so as to be able to slide radially along such shaft, this connection being designed to control pitch variation of the blade under the control of a bevel pinion 38 and through the intermediary of the universal mounting 39. The universal mounting 39 is arranged concentrically with respect to the universal mounting provided to permit oscillations of sleeve 34 with respect to the hub, this latter universal connection being indicated at 40. A spring 42 produces the initial tension of connecting cables 43, the arrangement of which is shown on Fig. 6, two diametrically opposite cables 43 and 44 being indicated on said figure. These cables connect sleeve 34 to the body of hub 41; they carry at their inner extremities pistons 45 and 46 which may slide in a common enclosed space or chamber 47 completely filled with an incompressible fluid or, as shown in the drawings, with metallic balls of a small diameter, the operation of this device being identical to that described with reference to Figs. 1 to 4.

Figs. 7 and 8 show a modified embodiment of the invention also applied to a propeller blade and in which a member suitably mounted on the blade bears against a system comprising an enclosed space or chamber of constant volume and variable form. On said figures, there is shown at 1 the blade and at 41 the hub of the propeller. The blade is provided with an annular shoulder 56 and is mounted in a universal suspension 54. This universal suspension 54 is mounted in its turn in a sleeve 61 adapted to slide with the interposition of a bushing 62 in the socket of hub 41. Into the outer extremity of the hub socket there is screwed a retaining ring 50 receiving a ball bearing 51. There is shown at 52 a chamber completely filled with an incompressible medium and cooperating with a series of circularly distributed plunger-pistons 53 against which bears shoulder 56 of the blade. There is shown at 55 a spring which applies against the root of the blade a resilient force. The pitch variation of the blade is produced by means of a worm gear 59 integral with sleeve 61 and meshing with a worm 60. Fig. 8 shows a section made following line GH of Fig. 7.

Referring now to Fig. 9 there is shown at 1 a propeller blade and at 9 a propeller hub. The blade is mounted on a lateral projection 64 of a blade-carrying member 68 which is mounted for oscillating about a ball joint 75 supported by a central tubular member. A hollow socket member 72 is connected to hub 9 by means of lower portions 73 traversing, each with a certain amount of play, a corresponding slot 69 provided in the lateral projection 64 of blade-carrying member 68, which is also provided with pins 67 engaging the ball joints 66 carried by a member 70 supported by hub 9. The space left between the inner face of the spherical upper portion of socket 72 and the outer surface of blade-carrying member 68 is filled by a rubber body, the whole constituting a universal suspension permitting the blade to take any desired inclination.

According to the invention, the universal mounting is relieved from any stresses acting in the direction of the blade axis by said rubber body confined in the enclosed space between socket 72 and blade-carrying member 68, due to its comparative incompressibility, without preventing oscillating movement of the blade-carrying member 68 about ball joint 75.

It will be understood that reference to "rubber" as the material used to fill certain spaces or cavities described herein, is intended to include suitably compounded natural or synthetic rubber and mixtures thereof; the rubber masses, in each instance, being operably interposed between relatively moving parts of the sockets and blades to permit rocking motion of the blades without appreciable radial displacement thereof with respect to the axis of the hub. The rubber may, desirably, be made adherent to the surfaces enclosing it, so as to assist, to some extent, in returning the blade to its neutral position.

In order to eliminate any risk of jamming between the lateral walls of member 68 and the edges of part 72 the thrust member is made of two parts, one of them forming a central piston 68 and the other an annular member 74 adapted to slide with respect to member 68, the displacements of said annular member being damped by means of a cavity or by a series of cavities of variable volume 71, which cavities may be filled with rubber. In order to insure the locking of piston 68 at low speeds the device is completed by a member 76 resiliently applied against the interior side of member 68, the displacement of

said member 76 towards member 68 being limited by any suitable device, so that, upon the centrifugal force exceeding a certain value, member 68 is displaced out of contact with member 76 and becomes free to take any inclination (within the obvious limitations of the structure shown).

According to another feature of the invention the device limiting the displacement of member 76 is adapted to act in response to centrifugal force. Thus as soon as the centrifugal force reaches a predetermined value, member 76 is urged by said force in the direction of unlocking. In the example shown this device comprises centrifugal masses 79 mounted on arms 80 pivoted about fixed axes and acting by levers 81 on a flange 82 provided on a rod 83 rigid with member 76. There is shown at 84 a resilient ring urging member 76 in the direction opposite to that corresponding to unlocking.

It will be noted finally that, in order to avoid any jamming, there is left a certain play between member 68 and ring 77 provided between said member and the spherical bearing 75, as well as between pins 67 and spherical bearings 66 in order to permit the sliding of ring 66 following axis 67.

It will be thus understood that the invention provides a system of propeller blade mounting which may receive thrust forces as well as traction forces, while completely relieving the universal mounting of a blade from the forces directed following a general direction perpendicular to the plane of the universal mounting, these forces, in the case of a propeller, being constituted by centrifugal forces.

Although several embodiments of the invention have been illustrated and described, various changes in the form or relative arrangement of parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention. Reference is therefore to be made to the appended claims for a definition of the limits of the invention.

What we claim is:

1. An articulation mounting for connecting to a hub structure a propeller blade angularly movable with respect to said hub structure about at least one axis comprising, a universal joint between said blade and said hub arranged to permit swiveling of said blade with respect to the hub, an anchor member for said blade disposed upon said hub, means for retaining said anchor member in operative association with said hub against centrifugal force, and means for anchoring said blade to said anchor member against centrifugal force independently of said universal joint, said means including an enclosed space of constant volume interposed between said anchor member and at least one blade attachment member, said enclosed space being entirely filled with a deformable mass confined within said space and of a consistency to flow in the manner of an incompressible liquid, the entire filling and the incompressibility of the mass together preventing any radial displacement of said blade away from said hub so as to relieve said joint from the action of centrifugal force, and the deformable character of said mass providing said swiveling of the blade.

2. An articulation mounting for connecting to a propeller hub a propeller blade adapted to angularly adjust itself freely with respect to said hub about two mutually perpendicular axes comprising, means for mounting said blade on said hub for rotation about said axes so that the longitudinal axis of said blade can assume, under the action of forces acting thereon, a more or less banked position with respect to a general direction perpendicular to the plane containing said axes, an anchor member for said blade disposed upon said hub, means for retaining said anchor member in operative association with said hub against centrifugal force, and means for substantially relieving said axes of articulation from the action of forces acting on the blade in the direction of its longitudinal axis away from the hub, said means including an enclosed space of constant volume interposed between said anchor member and at least one blade attachment member, said enclosed space being entirely filled with a deformable mass confined within said space bearing upon said anchor member and said hub and of a consistency to flow in the manner of an incompressible liquid, the incompressibility of which prevents any radial displacement of said blade away from said hub so as to relieve said joint from the action of centrifugal force, the fluent character of the mass providing said free angular adjustment of the blade.

3. An articulation mounting for connecting to a hub structure a propeller blade angularly movable with respect to said hub structure, comprising a socket member rotatably mounted on said hub, a Cardan joint between the blade root and said socket member adapted to transmit rotational movement from the socket member to said blade root while permitting free swivel movement of the blade, an anchor member for said blade constituted by an inner transverse wall within said socket member, and means for anchoring said blade to said anchor member including a recess within a face of said inner wall opposite said blade root, a flowable mass entirely filling the space and interposed between relatively movable parts thereof, said mass constituted by a quantity of balls of a size to flow in the manner of an incompressible liquid within said recess, an outer transverse wall disposed within said socket member to completely cover said recess and having an inwardly projecting central portion, said relatively movable parts comprising a plurality of plunger pistons slidably mounted around said central portion, said plunger pistons and said central portion being contiguous with the surface of said deformable mass so as to confine the same within said recess, a number of apertures provided in said inner transverse wall corresponding to the number of said plunger pistons, and means for connecting said blade to said plunger pistons through said apertures, the arrangement being such that any radial displacement of said blade away from said hub is prevented by the incompressibility of said deformable mass so as to relieve the axes of said Cardan joint from the action of centrifugal force whilst the deformability of said mass allows said free swivel movement of the blade.

4. An articulation mounting for connecting to a propeller hub a propeller blade adapted to angularly adjust itself freely with respect to said hub about two mutually perpendicular axes comprising, means for mounting said blade on said hub for rotation about said two mutually perpendicular axes so that the longitudinal axis of said blade can assume, under the action of forces acting thereon, a more or less banked position with respect to a general direction perpendicular to the plane containing said axes and independent means for preventing any radial displacement of said blade away from said hub, said

independent means comprising a chamber element formed in the hub and interposed between the hub and blade, said chamber element being formed in a configuration to provide cylinders and passage means interconnecting said cylinders, a plurality of pistons on the blade, said pistons arranged in a circle on the blade mounting means, the cylinders being arranged on a like circle in the hub with the pistons movably mounted therein but of such a size as to close the chamber, the chamber including the passage means being completely filled with a substantially non-compressible flowable mass constituted by a quantity of balls of such a size as to flow in the manner of an incompressible liquid, flexible connectors secured to the blade and arranged to lie approximately along the lines of a cylindrical surface the axis of which coincides with the axis of said mounting means, the opposed ends of said connectors connected to respective pistons, said connectors being of such a length as to apply pressure to said flowable mass.

5. An articulation mounting according to claim 1, in which the enclosed space comprises at least one chamber of a constant volume and of a variable form and in which the deformable mass is a rubber composition.

6. An articulation mounting according to claim 1, in which the enclosed space has the shape of a semi-spherical head and is located coaxially with the axis of the pivotal mounting means of the blade and between a member rigid with said blade and a member rigid with the hub.

7. An articulation mounting according to claim 6, in which the deformable mass is a rubber composition adhered to the walls of the enclosed spaced.

8. An articulation mounting according to claim 6, in which the enclosed space is bounded in one direction by a semi-spherical surface of the member rigid with the hub and in the opposite direction by a semi-spherical surface of the member rigid with the blade.

9. An articulation mounting of a propeller blade according to claim 4, in which there is provided an even number of said pistons, each of said pistons having a corresponding one of said pistons located diametrically opposite thereto in said circle whereby the two pistons of each pair are movable in opposite directions upon oscillation of the blade.

ROBERT DOUSSAIN.
ROBERT BOUSSON.
LOUIS PERRIER.

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