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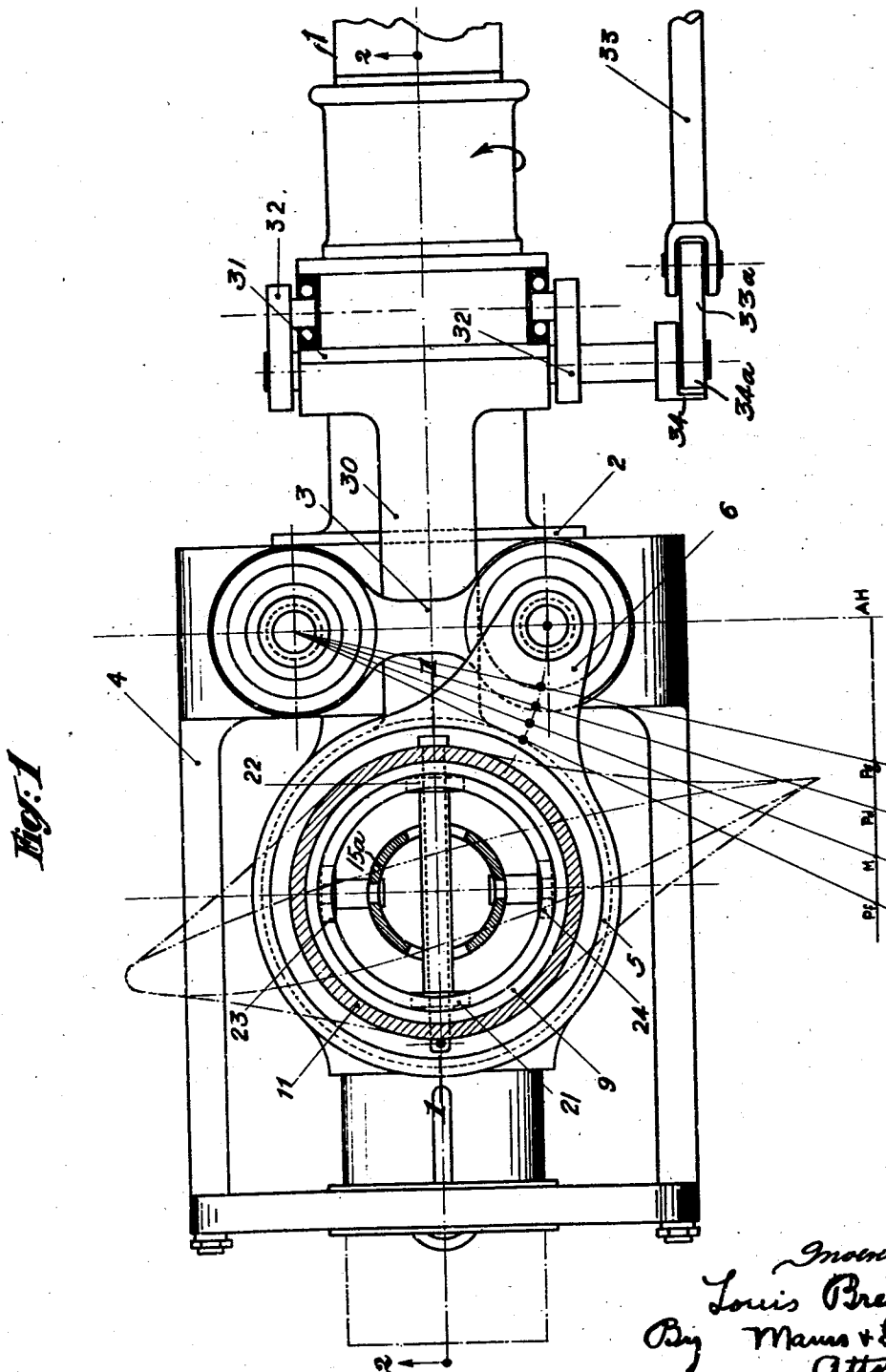
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DEVICE FOR REGULATING THE PITCH OF VARIABLE PITCH PROPELLERS DURING FLIGHT

Filed Sept. 30, 1931

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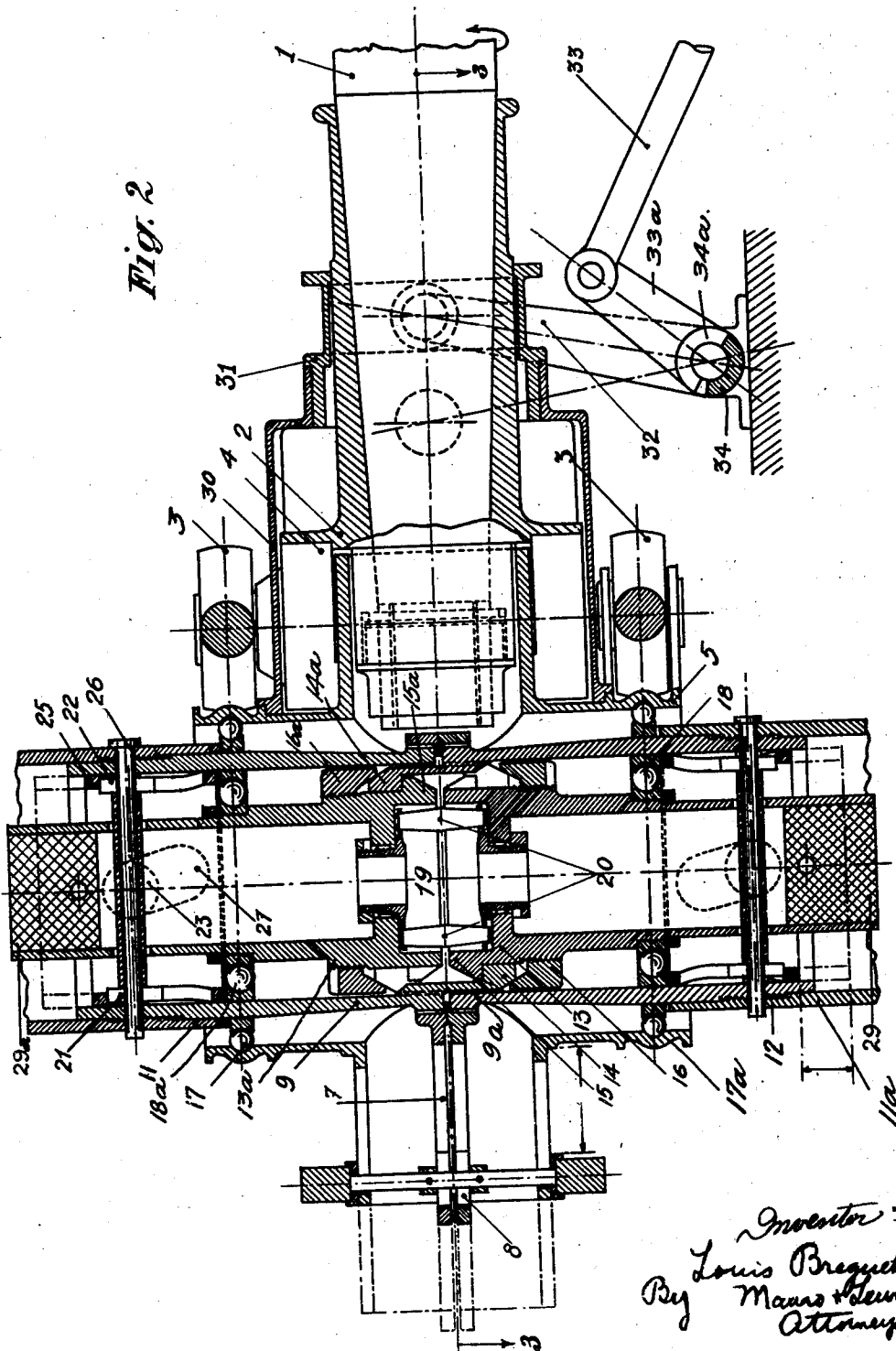
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Filed Sept. 30, 1931

4 Sheets-Sheet 2

Fig. 2



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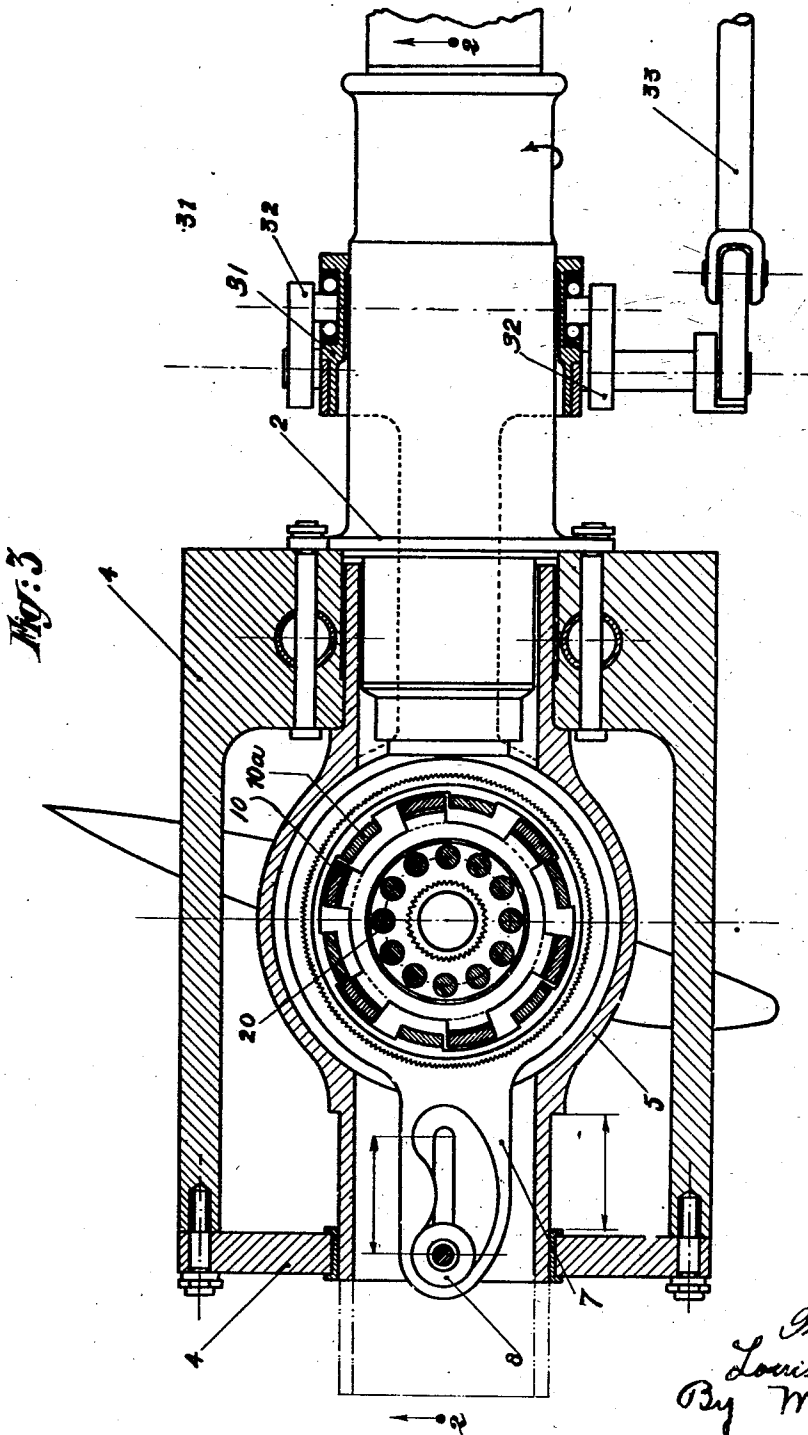
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4 Sheets-Sheet 4

Fig. 5

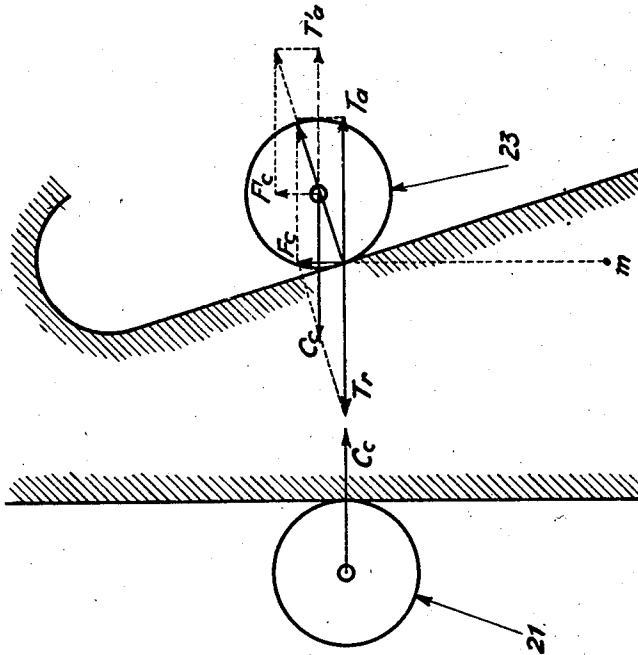
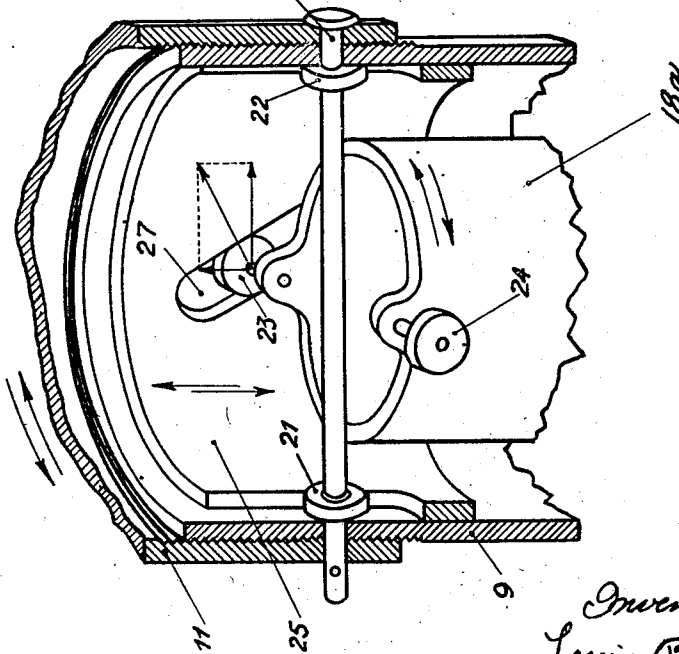


Fig. 4



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UNITED STATES PATENT OFFICE

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DEVICE FOR REGULATING THE PITCH OF VARIABLE PITCH PROPELLERS DURING FLIGHT

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8 Claims. (Cl. 170-163)

In the French Patent No. 697,692, filed June 19, 1930, and granted November 4, 1930, there is described a device for automatically adjusting the pitch of variable pitch propellers and of revolving wings in which the variation of the pitch is obtained through a regulating mechanism constructed and operating so that the angle of incidence of the propeller blades is a function of the ratio T/C of the traction T exerted by the propeller on the driving shaft to the driving couple or resistance couple C of the propeller. For instance, said mechanism may be so devised that the propeller hub is mounted so as to be able to slide and to rotate on the driving shaft and is connected to this shaft through a cable, a connecting rod, or a roller guided by a rail of suitable outline, the variations of relative position of the propeller shaft and of the hub being transmitted to the propeller by a suitable transmission mechanism. Said transmission mechanism may for instance consist of an arm, fixed on the driving shaft, the end of which is adapted to be displaced by a cam of suitable outline, secured to the propeller blade the angle of incidence of which is to be adjusted.

My present invention relates, in a general way, to all devices for automatically regulating the pitch of propellers, but more particularly to devices of the type described in the above mentioned French patent.

The object of my invention is to provide improvements in the devices for regulating the pitch of propellers with a view to reducing the stresses to which the hub and the controlling gear are subjected, and; therefore, to reducing their weight, the space they occupy, and also their wear and tear.

The improvements according to my invention also increase the sensitiveness of the automatic control mechanism and moreover they allow the pilot to interfere personally, either to assist and complete the action of the automatic control mechanism (which may then be considered as a servo-motor), or to modify, within determined limits, the position of equilibrium automatically obtained.

It will readily be understood that, besides the pull or traction and the resisting torque transmitted by the propeller hub to the driving shaft, said hub itself is subjected to the internal stresses resulting from:

The torsion torque transmitted by the blades to the hub through the bearings in which they are fitted in a rotatable manner;

The traction produced by the component, along the axis of revolution of the blades about themselves, of the centrifugal force acting upon said blades;

The torsion produced by the centrifugal torque

which acts upon the blade, said centrifugal torque acting in a direction tending to reduce the pitch;

The improvements according to the present invention make it possible to reduce or balance these stresses, to control the position of equilibrium of the blades, and finally allow, as above stated, the pilot to interfere personally in order to modify the working of the device.

Said improvements consist:

1. In disposing the bearings in which each propeller blade is fitted on either side of the axis of revolution of the propeller, as opposed to what exists in the usual arrangement (which, in particular is described in the French patent above referred to) and in which said bearings are both located on the same side of the axis of the driving shaft. Each blade is screwed on a sleeve provided with a prolonged piece extending beyond the axis of the driving shaft, and fitted in the opposite blade, the whole of the two blades then acting as a continuous beam. That arrangement has the advantage of reducing the stress resulting from the traction exerted on the outer bearing of a blade, since that bearing only supports the traction of said blade and not the sum of said traction and of the reaction of the inner bearing as in the usual arrangement. Furthermore as the reaction of the outer bearings is equal to the quotient of the driving torque divided by the distance between the bearings, the increase of said distance substantially reduces the value of said reaction.

2. In disposing the outer bearing of one blade and the inner bearing of the opposite blade in the same plane so as to reduce to a minimum the stresses to which they are subjected, and therefore their dimensions and the friction due to the rotation of the blades when the pitch is varied.

3. In balancing directly the centrifugal efforts of one blade by those of the other blade, by means of a single thrust piece located in the central part of the mechanism and which accordingly is not subjected to the centrifugal force.

In the arrangements utilized up to the present time, these centrifugal efforts were supported by two thrust pieces corresponding each to a separate blade. Said thrust pieces had to withstand not only the centrifugal force of the blade itself but also that due to the weights of the sleeve, of the ball bearings, and of the roller track of the thrust piece which is integral with the blade. The fact of placing a single thrust piece at the center of the mechanism, together with the above described disposition of the bearings, reduces to a great extent the stresses to which said thrust piece is subjected. Said thrust piece is only subjected to the centrifugal force due to the blade itself, or rather to a portion of that force, owing to the provision of the balancing device which will

be hereinafter described. Furthermore, whereas, in the case of two thrust pieces, the reaction of each blade was transmitted to the other blade through the medium of the hub casing, in the present arrangement the reaction of one blade is exerted directly on the other, and the casing has no action to perform, which makes it possible to reduce its weight.

4. In balancing, either wholly or partly, each blade taken separately by a fixed weight located in the prolonged part of, said blade and on the opposite side of the axis of the driving shaft from the blade proper. The passive resistances exerted on the thrust piece are thus reduced.

5. In balancing the centrifugal torque of each blade by means of a compensating weight which is inserted tangentially between said blade and the prolonged part of the opposite blade.

It is known that the centrifugal force exerted on one blade can be split up into a force parallel to the axis of said blade, and which is absorbed by the thrust piece, and a torque which tends to reduce the pitch and which, within the limits that are utilized, varies in the same direction as the pitch. In order to make possible the controlling of the pitch, each blade must be balanced as regards the centrifugal torque, which may be obtained by means of two balancing weights, identical and working simultaneously. Said weights have a certain stroke and are necessarily subjected to the centrifugal force. Each of them is annular and slides, without any relative angular displacement, along, and inside of, the sleeve of one blade. It is inserted between said sleeve and the prolonged part of the opposite blade and creates a torque equal and opposite in direction to the half centrifugal torque of said blade.

6. In providing transmission means connected to the hub and serving on the one hand to indicate to the pilot the value of the propeller pitch for each position of equilibrium of said propeller, and on the other hand to allow the pilot to control during the flight the variation of the pitch in order, either to help the working of the automatic control arrangement, which then acts as a kind of servo-motor, or to modify, within certain limits, the law of variation of the pitch that corresponds to the controlling system that has been adopted, and, in particular in the case of the above mentioned French patent, the law of variation of the pitch that corresponds to the shape of the cams that serve to connect the propeller hub to the blades.

In one particular embodiment of said transmission means it is possible to provide a sufficiently loose coupling so that the propeller hub will move freely and the action imparted by the pilot will be transmitted only when the play that has been purposely provided will have been taken up.

A preferred embodiment of my invention will be hereinafter described with reference to the appended drawings, given merely by way of example, and in which:

Fig. 1 is a plan view of the hub, the blades being removed;

Fig. 2 is a sectional view on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view on the line 3—3 of Fig. 2;

Fig. 4 is a perspective view, partly in section, of the device for balancing the centrifugal torque, in which the fixed weight disposed in the prolonged piece of the blade has not been shown for the sake of simplicity;

Fig. 5 is a diagram showing how the forces are distributed in a device according to my invention.

The whole of the mechanism for varying the pitch of the propeller is connected to the engine through a plate 2 to which it is secured by means of bolts in the proper axial position, said plate in turn being connected to driving shaft 1 through the usual means. The above mentioned mechanism essentially comprises: a frame such as 4, rigidly secured to plate 2, a hub casing 5 enclosing the mechanism proper and adapted to both slide in a frontward direction along the driving shaft and rotate about said shaft; finally rotatable propeller blades and their accessories, which follow the displacements of the casing and are further capable of being given a rotary displacement for varying the incidence.

Small connecting rods 3, jointed to frame 4 through ball and socket joints provided with ball bearings transmit the driving torque to the casing of hub 5 through lugs such as 6 (Fig. 1). They also transmit the traction exerted by the propeller to frame 4 and driving shaft 1 and take a position of equilibrium which is a function of ratio

$$\frac{T}{C}$$

of the traction or pull to the driving torque.

When the propeller moves in a frontward direction, cams, such as 7, engaging rollers 8 secured to frame 4, cause sleeves 9 and 9a to rotate in opposite directions but through equal angles according to a given law which is materialized by their outline. Said law may be so chosen for instance as to cause the engine to give its full power for the chief conditions of working (fixed point, climb, horizontal flight, ceiling). Each blade, 11 or 11a, is screwed on its sleeve 9 or 9a which is provided with a prolonged part 13 or 13a. Each sleeve 9 or 9a and each corresponding prolonged part 13 or 13a are made integral with one another through tenons 14, 15 or 14a, 15a provided in each of them, cotters (which are not shown in the drawings) and a conical nut 16 or 16a. The continuous beam thus formed is adapted to rotate in an outer bearing 17 or 17a and an inner bearing 18 or 18a which serve to secure the blade in the propeller casing 5.

It will be seen that the outer bearing of one blade is located on the same side of the driving shaft as the inner bearing of the other blade, and in particular that said two bearings are located in the same plane. It is possible, with this arrangement to obtain a maximum spacing of the bearings of one blade.

The sleeve 9 or 9a of the blades interengage one into the other, said sleeves being provided with teeth 10 or 10a and with intermediate apertures, as shown in Fig. 3. The teeth 10 of the sleeve 9 pass through the apertures of the sleeve 9a and vice-versa the teeth 10a of the sleeve 9a pass through the apertures of the sleeve 9. This arrangement results in that the centrifugal strains tending to draw apart from the driving shaft, the blades 11, 11a and the corresponding sleeves 9, 9a, tend to force one against the other the prolonged parts 13 and 13a. The reaction of a prolonged part on the other is absorbed by a thrust piece 19 interposed between said prolonged parts.

The housing of this thrust piece 19 is located along the axis of the driving shaft. It may be provided, as shown in the drawings, within the two prolonged parts of the sleeves of the blades. The thrust piece may comprise balls or preferably

a certain number of small rods such as 20, having spherical ends and having a shape corresponding to the buckling stress to which they are subjected. Said rods, which are parallel to the axis when the angle of attack of the blades has its mean value, act exactly in the same manner as balls having the same curvature as their ends within the limits of rotation for which they are provided. A weight 29 fitted in prolonged part 13, serves to balance blade 11 and its sleeve 9. Vice-versa a weight 29a fitted in prolonged part 13a, serves to balance blade 11a and its sleeve 9a.

Fig. 2 and also Figs. 4 and 5 make it possible to fully understand the operation of the means for automatically compensating for the centrifugal torque of the blades. Said torque results from the obliquity, with respect to the axis of revolution of the blades, of the elementary centrifugal efforts which are exerted on either side of said axis. The sum of all these efforts may be reduced to a force parallel to the axis of revolution of the blade, and which is absorbed by the thrust piece, and a torque which tends to reduce the pitch, and which, within the limits of utilization, varies in the same direction as the pitch.

Fig. 4 is a diagrammatic perspective view, partly in section on the line 1-1 of Fig. 1 of the mechanism fitted in the upper sleeve. The annular balancing mass 25, which is adapted to slide within sleeve 9, is guided by means of two rollers 21 and 22 carried by an axis 26 integral with the sleeve. Said mass is also operatively connected to the prolonged part 13a of the sleeve 9a of the opposite blade 11a by two rollers 23 and 24 engaging two slots such as 27 provided in said annular mass 25. It will readily be seen that the position of each balancing mass and its distance from the axis of rotation is, accordingly, a function of the angular position of the two blades. On the other hand, the centrifugal force which acts upon said balancing mass 25 is imparted to roller 23 along line Fc (Fig. 5) and pushes it obliquely. The resultant, which is at right angles to the edge of the slot, may in turn be split up into two forces, one Fc directly opposite to the centrifugal force acting upon the lower blade and which is therefore to be subtracted therefrom, and the other Ta (tangential force) which produces a couple opposed to the half centrifugal couple of said blade. The reaction of the couple is directed along Tr and is imparted to the upper blade through the medium of roller 21. The complementary controlling device shown by way of example in the accompanying drawings comprises two arms such as 30 (Figs. 1 and 2) which transmit the axial displacement of casing 5 to a sleeve 31 adapted to slide along the driving shaft. A groove provided in said sleeve acts through a fork 32 upon a system of rods 33 leading to the pilot's cockpit. It will be readily understood that, to any displacement of the hub will correspond a proportional displacement of the rods so that the pilot will be able to see on a dial, by means of a cursor or through any other means, what is the position of equilibrium of the propeller blades and consequently their pitch. Said system of transmission through rigid means further enables the pilot, by exerting an effort in a direction opposite to that of the displacement produced by the mechanism, to correct the working of said mechanism so as to obtain the best possible position of equilibrium. The pilot may also, by acting in the same direction as the mechanism, complete and improve the automatic action of said mechanism.

But on either side of the position of equilibrium, the effort to be exerted increases sufficiently quick to prevent any important variation from taking place as a result of a false move. In other words, said control mechanism makes it possible to modify within certain limits the predetermined law of variation of the pitch, the automatic device acting as a servo-motor.

Another embodiment of the last mentioned control mechanism comprises a hub that is partly independent of the transmission gear so as to reduce the passive resistances. That result may easily be obtained by interposing a loose coupling device, shown in a diagrammatical manner in Fig. 2, in the gear, said device comprising for instance tenons 34 and 34a respectively provided on the fork 32 and the lever 33a pivotally connected to the rod 33. The play provided between the tenons 34 and 34a corresponds for instance to the whole stroke of the hub, but the pilot is however capable of knowing the position of equilibrium and of modifying said position by merely taking up the play in one direction or the opposite one.

While I have disclosed what I deem to be a preferred embodiment of my invention it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement disposition and form of the parts without departing from the principle of my invention as comprehended within the scope of the appended claims.

What I claim is:

1. In a device for automatically regulating the pitch of a propeller, a driving shaft, a hub slidably and rotatably mounted on said shaft, at least one connecting rod between said shaft and said hub for transmitting the stresses from one to the other, at least two propeller blades, at right angles to said shaft journaled in said hub in line with each other on either side of the axis of said shaft, two bearings in said hub for rotatably supporting each propeller blade about an axis at right angles to said shaft, said two bearings being disposed on either side of the axis of said shaft respectively, a support rigidly fixed to said shaft, a roller carried by said support, and a cam carried by each of said propeller blades adapted to cooperate with said roller for adjusting the pitch of said blade according to the position of said hub on the axis of the driving shaft.

2. In a device for automatically regulating the pitch of a propeller, a driving shaft, a hub slidably and rotatably mounted on said shaft, at least one connecting rod between said shaft and said hub for transmitting stresses from one to the other, at least two propeller blades at right angles to said shaft journaled in said hub in line with each other on either side of the axis of said shaft, two bearings in said hub for rotatably supporting each propeller blade about an axis at right angles to said shaft, said two bearings being disposed on opposite sides of the axis of the driving shaft respectively, the two bearings disposed on the same side of the axis of said driving shaft, and which therefore correspond to opposite blades respectively, being located in the same plane, a support rigidly fixed to said shaft, a roller carried by said support, and a cam carried by each of said propeller blades adapted to cooperate with said roller for adjusting the pitch of said blade according to the position of said hub on the axis of said driving shaft.

3. In a device for automatically regulating the pitch of a propeller, a driving shaft, a hub slid-

ably and rotatably mounted on said shaft, at least one connecting rod between said driving shaft and said hub for transmitting stresses from one to the other, at least two propeller blades at right angles to said shaft disposed in line with each other, two tubular elements for supporting said propeller blades respectively, said two tubular elements extending into each other beyond the axis of the driving shaft, two bearings for rotatably supporting each propeller blade about an axis at right angles to said shaft, one of said bearings being disposed between the corresponding tubular element and the hub and the other one between the last mentioned tubular element and the other tubular element, said two bearings being disposed on opposite sides of the axis of the driving shaft respectively, a support rigidly secured to said shaft, and camming means interposed between said support and each of said tubular elements for adjusting the pitch of the corresponding propeller blade according to the position of said hub along the axis of said driving shaft.

4. In a device for automatically regulating the pitch of a propeller, a driving shaft, a hub slidably and rotatably mounted on said shaft, at least one connecting rod between said driving shaft and said hub for transmitting stresses from one to the other, at least two propeller blades at right angles to said shaft disposed in line with each other, two tubular elements for supporting said propeller blades respectively, said two tubular elements extending into each other beyond the axis of the driving shaft, two bearings for rotatably supporting each propeller blade about an axis at right angles to said shaft, one of said bearings being disposed between the corresponding tubular element and the hub and the other one between the last mentioned tubular element and the other tubular element, said two bearings being disposed on opposite sides of the axis of the driving shaft respectively, the two bearings disposed on the same side of the axis of said driving shaft, and which therefore correspond to opposite blades respectively being located in the same plane coaxially with each other, a support rigidly secured to said shaft, a roller carried by said support, and a cam carried by each of said propeller blades adapted to cooperate with said roller for adjusting the pitch of said blade according to the position of said hub along the axis of said driving shaft.

5. In a device for regulating the pitch of a propeller, a driving shaft, a hub casing slidably and rotatably mounted on said shaft, two rods each interposed between said driving shaft and said hub casing, two coaxial tubular parts on said hub casing extending on either side of the driving shaft at right angles thereto, two sleeves disposed in said tubular parts in coaxial relation therewith on either side of the axis of the driving shaft, two prolonged tubular pieces of smaller diameter rigidly secured to said sleeves respectively, each prolonged tubular part extending on the opposite side of the axis of the driving shaft from the sleeve to which it is secured into the other sleeve, two propeller blades rigidly secured to the outer ends of said sleeves respectively, two bearings interposed between the tubular parts of the hub casing and the corresponding sleeves respectively, said bearings being disposed at equal distances from the axis of the driving shaft, two other bearings each in-

terposed between one prolonged tubular piece and the sleeve corresponding to the opposite blade respectively, the two last mentioned bearings being disposed in the same planes as the two first mentioned bearings respectively, a support rigidly secured to said driving shaft, a roller carried by said support and a cam carried by each of said propeller blades for adjusting the pitch of said blade according to the position of said hub along the axis of said driving shaft.

6. In a device for regulating the pitch of a propeller having a driving shaft, a hub on said driving shaft, two propeller blades disposed in line with each other and adapted to be driven from said hub, and means for varying simultaneously the pitch of the propeller blades; the combination of two tubular elements interengaging into each other for supporting said propeller blades respectively, each of said elements passing through the other element and having a prolonged part projecting into said other element beyond the axis of the driving shaft, two bearings for supporting each propeller blade, one of said bearings being disposed between the corresponding tubular element and the hub and the other between each tubular element and the prolonged part of the other tubular element, said two bearings being disposed on opposite sides of the axis of the driving shaft respectively and a thrust bearing located on the axis of the driving shaft, interposed between the prolonged parts of said two tubular elements.

7. In a device for regulating the pitch of a propeller having a driving shaft, a hub on said driving shaft, two propeller blades disposed in line with each other and adapted to be driven from said hub, and means for varying simultaneously the pitch of the propeller blades; the combination of two tubular elements interengaging into each other for supporting said propeller blades respectively, each of said elements passing through the other elements and having a prolonged part projecting into said other element beyond the axis of the driving shaft, a weight mounted on the end of each prolonged part remote from the corresponding blade for compensating the centrifugal strains of said blade, two bearings for supporting each propeller blade, one of said bearings being disposed between the corresponding tubular element and the hub and the other between the last mentioned tubular element and the other tubular element, said two bearings being disposed on opposite sides of the axis of the driving shaft respectively and a thrust bearing located on the axis of the driving shaft, interposed between the prolonged parts of said two tubular elements.

8. A device regulating the pitch of a propeller according to claim 6 further comprising an annular compensating member disposed between each tubular element and the prolonged part corresponding to the other tubular element, said annular compensating member being adapted to slide longitudinally inside the first mentioned tubular element without rotating therein, and means for operatively connecting said annular compensating member to said prolonged part in such manner that a radial displacement of said annular compensating member may correspond to an angular relative displacement of said member and of said prolonged part.

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