Nov. 13, 1934. J. DE LA CIERVA 1,980,169

AIRCRAFT SUSTAINING ROTOR CONSTRUCTION

Filed April 24, 1931 2 Sheets-Sheet 1

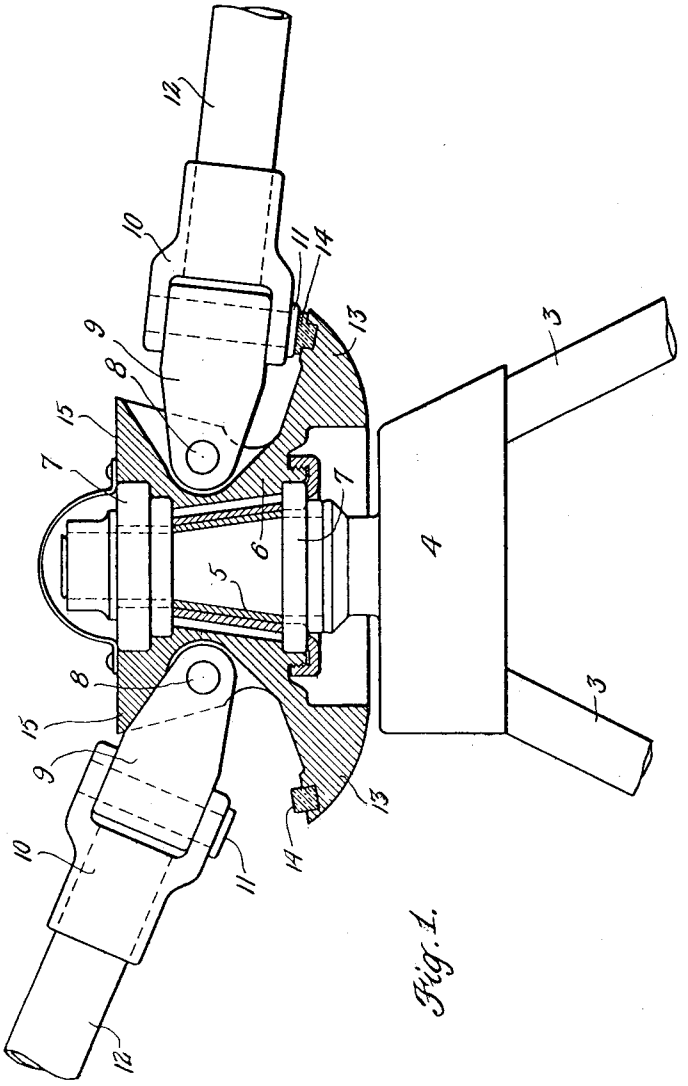



Fig. 1.

INVENTOR
Juan de la Cierva
BY
Symmetvedt & Lechner
ATTORNEYS

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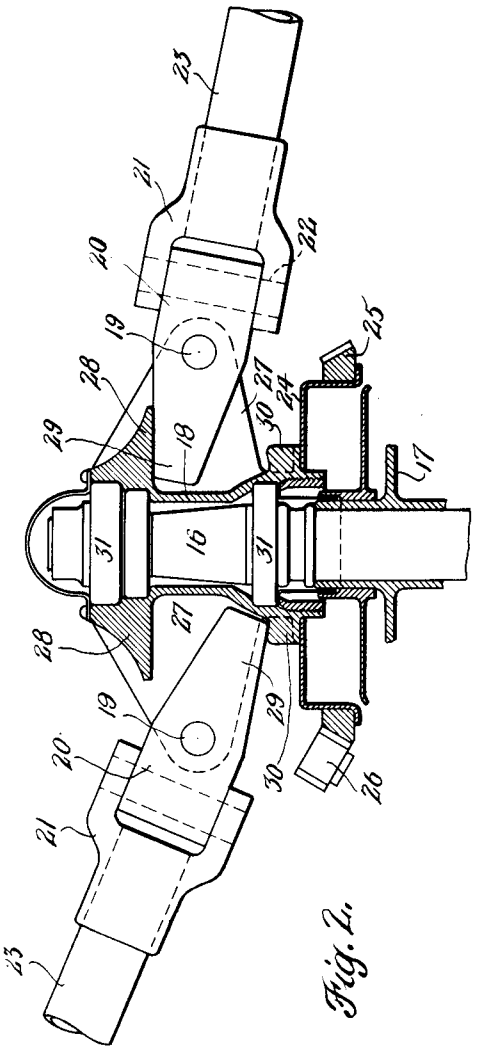



Fig. 2.

INVENTOR
Juan de la Cierva
BY
Synnestvedt & Lechner
ATTORNEYS

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# UNITED STATES PATENT OFFICE

1,980,169

## AIRCRAFT SUSTAINING ROTOR CONSTRUCTION

Juan de la Cierva, Madrid, Spain, assignor to Autogiro Company of America, Philadelphia, Pa., a corporation of Delaware

Application April 24, 1931, Serial No. 532,604

2 Claims. (Cl. 244—19)

This invention relates to aircraft sustaining rotor construction and is particularly concerned with certain features of a mounting structure therefor. The invention, furthermore, is especially useful in connection with the type of sustaining rotors which include a plurality of blades mounted for rotation about a common substantially vertically disposed axis under the influence of relative air-flow such, for example, as results from movement of the craft in the atmosphere. In addition, the invention is particularly adapted to constructions of this general type in which the several blades thereof are arranged or mounted in such manner as to be free independently to assume various positions under the influence of lift, drag and anti-drag, and inertia forces.

It should also be borne in mind that the present invention involves certain improvements over the construction illustrated in my issued Patent No. 1,682,893, of September 4th, 1928.

Usually, rotor constructions of this character, for example, as indicated in my issued Patent No. 1,590,497, of June 29th, 1926, include a plurality of sustaining blades which are mounted for movement independently of each other, generally, transversely of the mean path of travel of the set about its common axis. In addition, as brought out more fully in my copending application, Serial No. 145,655, filed November 1st, 1926, it is desirable that each blade of the rotor system should be arranged for individual movement relative to other blades within the general path of travel of the set.

The present invention has in view the provision of a novel type of stop mechanism for limiting certain of the individual blade movements particularly when the rotor system is not operating at flight speeds of rotation as, for example, in starting or stopping, or at rest. According to the present invention, the foregoing is accomplished by the use of structure which is simple and rugged as well as highly efficient from the standpoint of aerodynamics.

As a further object, this invention contemplates a rotor mounting structure, including stops or stop means of the character above referred to, which provides for ready removal or replacement of the sustaining rotor as a whole or of individual blades thereof for purposes of lubrication, inspection or repair.

How the foregoing, together with other objects and advantages are obtained, as well as the specific manner in which the invention is carried out, will be more apparent from a consideration of the following description taken with the accompanying drawings, in which—

Figure 1 is a side view of a sustaining rotor hub structure including portions of certain blades thereof as well as portions of the mounting structure for the rotor, the view being taken partly in vertical section and partly in elevation; and

Figure 2 is a view similar to Figure 1 of a modified construction.

Referring first to Figure 1, a rotor supporting construction is here shown as including a plurality of pylon legs 3 extending upwardly from the body of the craft and secured at their upper ends in an apex structure or box 4. Above the box, I have provided a spindle or axis member 5 on which the rotor hub member 6 is mounted for free rotation, suitable bearings 7 being interposed between the relatively movable parts 5 and 6.

According to this figure, the blades of the rotor are pivoted to the hub member 6 by means of substantially horizontally disposed pivot pins 8 which cooperate with joint parts 9. The parts 9, in turn, are pivoted to bifurcated joint parts 10 by means of the substantially vertically disposed pivot pins 11. In this figure, it will be seen that the shank portion or spar 12 of each blade is secured to a joint part 10. With pivots or articulations arranged in this manner, the blades are free, independently, to assume various positions transversely of as well as within their general path of rotative movement about the axis member 5.

The present invention is particularly concerned with stop means for limiting movement of the individual blades on their substantially horizontally disposed pivot pins 8 and with this in mind the hub member 6 is preferably provided with a peripheral extension or projection at its lower edge as indicated at 13. This projection is preferably disposed in such manner as to underlie the blade joint parts 9. In addition, it will be noted that the extension 13 preferably carries individual resilient cushions which may conveniently be made of rubber, as indicated at 14. The blocks 14, furthermore, are preferably arranged to contact with the substantially vertically disposed pivot pins 11 when the blades swing downwardly.

Still further, the present invention makes provision for limiting upward swinging of the blades on the pins 8 and in accordance with the showing of Figure 1, in order to accomplish this purpose, additional projections or extensions 15 are pro-

vided on the hub member 6 above or overlying the blade joint parts 9.

In connection with the stop mechanisms above described, it should be noted that during usual or normal flight operation of the craft the lift and inertia forces acting on the blades are so proportioned as to maintain them in positions substantially spaced from the upwardly as well as the downwardly arranged stop devices. During normal flight operation, therefore, the blades are free to move substantially, under the influence of various flight forces, on their horizontally disposed pivots, it being noted that, during such operation, the stop mechanisms come into action or are effective only in limiting or restricting abnormal or very large individual blade movements. However, when the craft is at rest on the ground with the rotor system inactive or operating at very low speeds, it is desirable to support the individual blades in order that they may not drop sufficiently to contact with or strike any other part of the craft such, for example, as the propeller or the tail structure. The lower stop construction 13, including the rubber blocks 14, is arranged in such manner as to support the blades, under these circumstances, in positions in which they will clear other portions of the craft. Heretofore, it has been found necessary where the individual blades of the rotor are independently pivoted on their common hub or axis member, to extend said member upwardly and provide droop cables or other supports extending from the top of said extension to the several blades, in order that, while maintaining them against dropping too low at rest, they might have free individual swinging movement in flight. Such forms of support have been particularly necessary where both horizontal and vertical pivot axes have been provided, as in such construction the blades are free to swing laterally as well as up and down. Such prior supporting devices, while effective, have had the disadvantages of excessive parasite drag, whipping-around of the droop cables, and, on occasion breakage of the supports with consequent damage to the blades.

In the present construction, the upper stop mechanism 15, it is noted, is arranged to limit undue upward swinging of the blades, when they are idle or rotating at low speeds, under the influence of gusts of wind or the like, which is not provided for by prior constructions involving droop cables. Preferably the stop mechanism 15 is also arranged and disposed in such manner that when a blade is swung upwardly and is limited or stopped thereby, its downward swinging movement will not be of sufficient travel to impose any undue or very large force or stress on the lower stop structure. In this way freedom for all normal flight movement of the blades is provided, and, at the same time abnormal movements thereof are restricted sufficiently to prevent damage to or breakage of the blades or the rotor hub construction, especially when standing on the ground. If found desirable blocks similar to rubber stops 14 may also be provided on the upper stop structure 15.

Still further, it should be noted, the arrangement of the blocks 14 in position to contact with the pins 11 provides for absolute freedom of movement of the blades on their substantially vertically disposed pivot pins 11 at all times, including during initiation of rotation of the rotor. In this last mentioned condition the blades, of course will be supported by the blocks 14 but, by virtue of the arrangement thereof, the blades may move freely on the pins 11, it being noted that the application of starting power or force usually produces a tendency to relatively large blade movements on the vertical pins.

In accordance with the showing of Figure 2 a rotor axis member 16 is supported or mounted on a pylon box structure fragmentarily indicated at 17. This form also includes a rotor hub member 18, mounted for free rotation about the axis member 16, to which the blades are pivoted as by means of horizontally disposed pins 19 cooperating with outwardly extending apertured lugs 27, a blade pivot part 20 being associated with each one of these pins. Suitable bearings 31 are disposed between the parts 16 and 18. In this instance, forked joint parts 21 and substantially vertically disposed pivot pins 22 are associated with the members 20 in such manner as to provide individual blade movement within the general path of travel of the set. The blade supports 23, of course, are socketed in or secured to the bifurcated or forked joint members 21.

The construction of Figure 2, furthermore, illustrates an application of a starter mechanism for the rotor, the said mechanism including a drum 24 arranged at the lower end of the hub member 18, carrying a bevel ring gear 25 with which a suitably driven pinion 26 is adapted to mesh. In this connection it should be understood that the starter mechanism is employed only for the purpose of initiating rotation of the rotor system. Furthermore no claim is made herein to this starter mechanism per se, as the same is disclosed and claimed in the copending application of Joseph S. Pecker, Serial No. 512,383, filed January 30, 1931 and assigned to the assignee of this application. In addition, if desired, the drum 24 may be employed as a part of a rotor brake mechanism, it being noted also that such braking mechanism is not claimed per se herein, but forms the basis of the copending application of Joseph S. Pecker, also assigned to the assignee of this application, and bearing Serial No. 545,451, and filing date of June 19th, 1931. In connection with the starting and braking mechanism just referred to, it should be noted that they are briefly described herein in order to illustrate the manner in which such parts or mechanisms may be applied to a rotor head construction including stop mechanisms of the character herein disclosed and claimed.

The stop mechanism of the construction illustrated in Figure 2 includes outwardly projecting lugs or parts 28 which are disposed over the inwardly extending portions 29 of the blade pivot parts 20. The stops 28, if desired, may be provided with resilient cushions similar to those indicated at 14 in Figure 1. The hub member 18 also carries stop projections 30 disposed below the joint parts 20 in position to cooperate with the inward extensions 29 thereof in order to limit upward swinging of the blades on their pivot pins 19. At this point attention is called to the fact that the constructions of Figures 1 and 2 differ from each other, generally, by the relative disposition and arrangement of the substantially horizontally disposed pivot pins and the upper and lower stop structures. In accordance with the showing of Figure 1, the horizontally disposed pins 8 are located relatively close to the axis member 5 and the stops are arranged to cooperate with the joint parts 9 at points radially beyond the pins 8. On the other hand, in Figure 2, the horizontally disposed pins 19 are spaced substantially from the axis member 16

and the stop devices are arranged to cooperate with inward extensions 29 of the joint parts 20. Thus, in the construction of Figure 1, downward swinging movement of the blades is limited by stop devices which are located therebelow, while in Figure 2 such downward movements are limited by means of stops which are positioned above the blade joint parts. The other stops, of course, are complementarily or oppositely disposed in the two constructions.

In connection with both forms of the invention, attention is called to the fact that when it is desired to remove the rotor head or hub structure including the blades secured thereto, for purposes of lubrication or inspection, this may readily be accomplished for the reason that no external blade supporting cables or wires are employed, and, therefore, need not be detached from the blades or the hub structure. The removal of individual blades is also greatly facilitated by virtue of this construction, it being noted that for such removal the horizontally or the vertically disposed pivot pins only need be displaced.

The two constructions herein disclosed, furthermore, with the upper and lower stop devices arranged, generally in the planes of the upper and lower bearings which are disposed between the hub structure and the axis member, and with the horizontal pins arranged, vertically between the upper and lower bearings, provide great strength as well as direct and uniform distribution of forces or shocks to which the stop mechanisms are subjected. Additionally both forms of structure herein disclosed are highly efficient from the standpoint of aerodynamics in view of the fact that no exposed cables or wires are employed and also because of the material reduction in the height of the hub structure as compared to that formerly employed.

The construction of Figure 1, furthermore, is advantageous for the reason that it provides for location of the horizontally disposed pivots relatively close to the center of rotation of the rotor system.

On the other hand, in accordance with the showing of Figure 2, an application of certain particular types of rotor brake as well as starter mechanisms is provided for in a convenient manner with a desirable degree of accessibility in such parts. It will be understood, of course, that a similar application of such mechanisms may be made to the structure of Figure 1, the showing thereof in Figure 2 being by way of example. The arrangement of Figure 2, furthermore, is especially adapted to constructions in which various characteristics of the craft as a whole make it desirable to arrange the horizontally disposed pivots spaced substantially from the center of rotation.

Still further attention is called to the fact that in Figure 2, the stop mechanisms are arranged and disposed to operate entirely independently of the vertically disposed pivot pins.

I claim:

1. In an aircraft sustaining rotor construction, an axis member, a plurality of blades mounted for common rotation about the axis and for individual pivotal movements on substantially horizontally and vertically disposed pivots and stop means for limiting blade movements on said horizontally disposed pivots, said stop means being arranged to react against the vertically disposed pivots.

2. An aircraft sustaining rotor construction including a hub member mounted to rotate about an upright axis, a plurality of sustaining wings, substantially horizontal pivot means connecting each wing to the hub member for substantially independent upward and downward swinging movements under the influence of flight forces, a stop member movable with each wing during its swinging movements and extended generally radially inwardly of said pivot means, and stop means on the hub member positioned to cooperate with the stop members radially inwardly of said pivot means, so as to arrest excessive swinging movements of the wings.

JUAN DE LA CIERVA.