Feb. 14, 1933. J. DE LA CIERVA 1,897,042

SUSTAINING ROTOR CONSTRUCTION FOR AIRCRAFT

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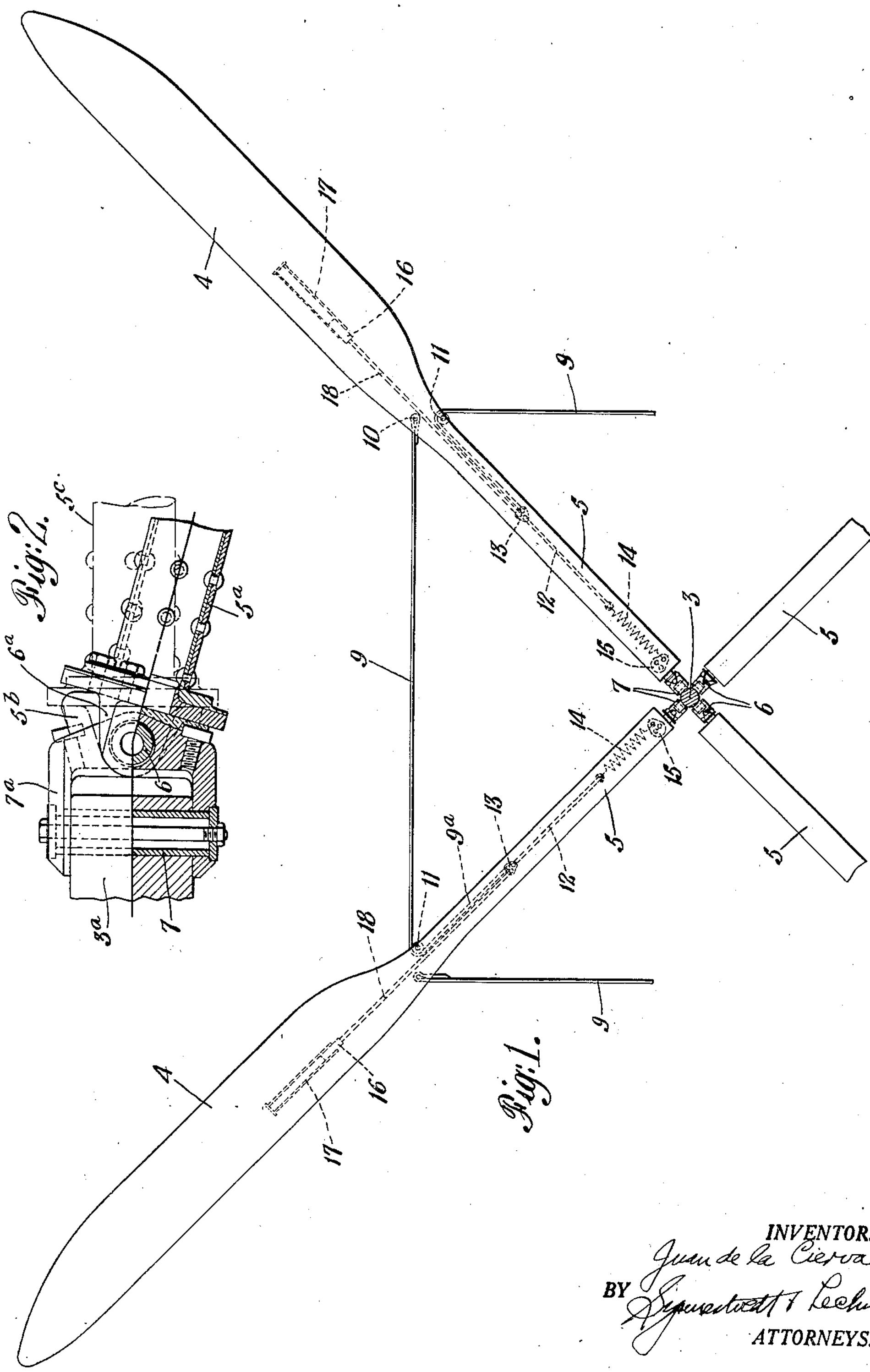

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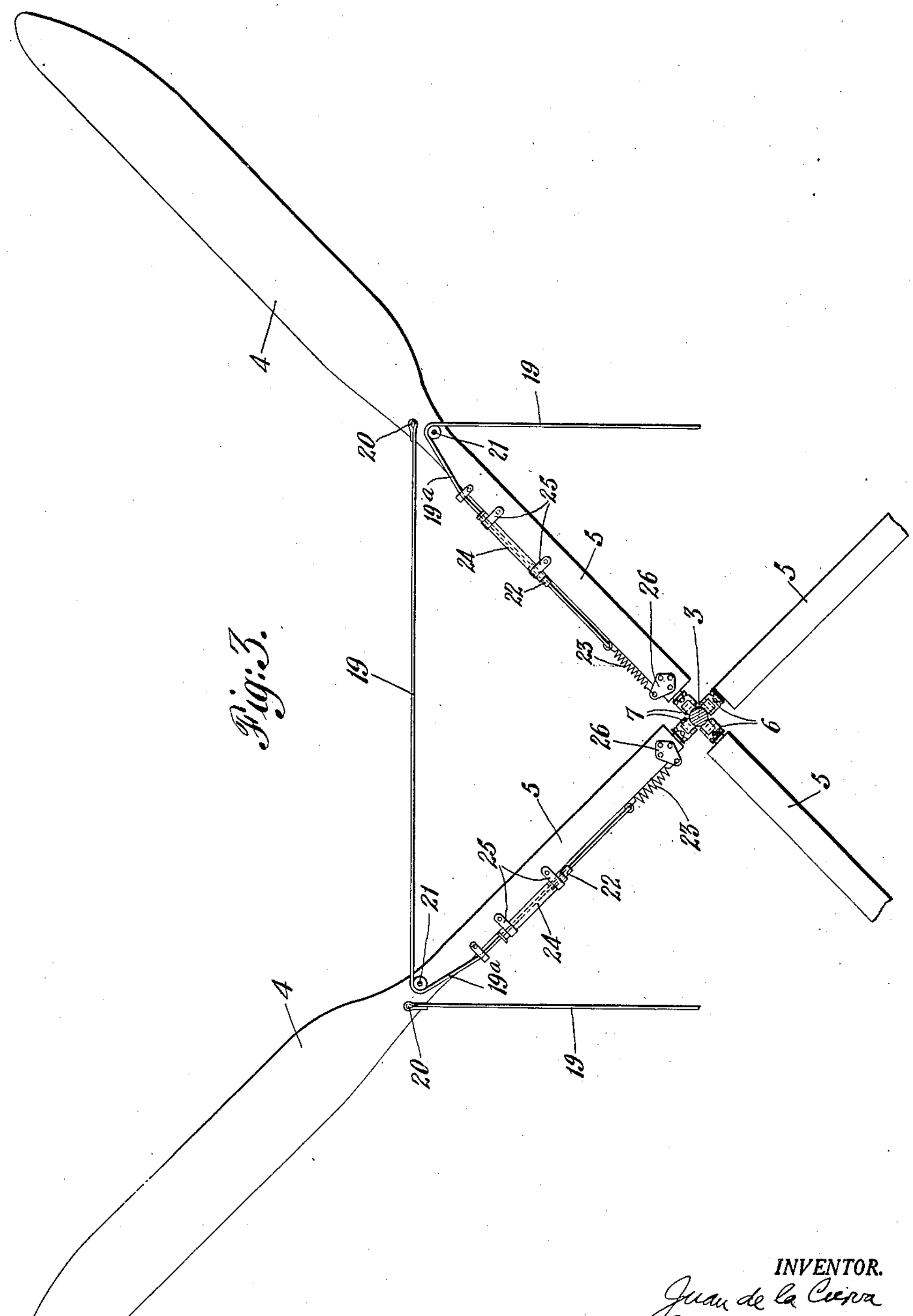

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Patented Feb. 14, 1933 **1,897,042**

UNITED STATES PATENT OFFICE

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SUSTAINING ROTOR CONSTRUCTION FOR AIRCRAFT

Application filed December 4, 1930. Serial No. 500,062.

This invention relates to sustaining rotor constructions for aircraft, and is particularly concerned with the general type of rotor construction which includes a plurality or set of sustaining blades or wings mounted for rotation about a common substantially vertically disposed axis. The invention, furthermore, is especially useful in connection with rotor constructions of this character which are adapted to be actuated by relative air-flow such for example, as results from movement of the craft through the atmosphere.

The general nature, objects and advantages of this invention can best be understood from a consideration of some of the characteristics of rotor constructions of the type in question.

The sustaining blades or wings of the type here involved are preferably mounted or arranged in such manner as to provide for relative blade movements both within and transversely of the general path of rotative travel of the set. To this end, blades of this character are preferably individually articulated or pivotally mounted with respect to a common hub member, so that the blades are free to assume various positions, independently of each other, under the influence of centrifugal, lift, drag, anti-drag and other forces to which they are subjected during rotation and flight operation.

It has been found to be desirable to control, limit or yieldingly resist at least certain blade movements or displacements of the character hereinbefore referred to, and to this end blade interconnections are preferably employed, an example of one type of blade interconnection being disclosed in my copending application, Serial No. 145,655, filed November 1st, 1926. In addition, resilient means, which are operable as to the several blades independently of each other, are also preferably provided in order to effect still further control in a manner fully set forth herebelow.

In many instances when rotor constructions of this type are operating at flight speed, the resistive forces of the blade interconnections need not be very great and, indeed, might even be dispensed with or eliminated under some circumstances. This is probably due, at least in part, to the greatly increased effect of inertia forces on the blades themselves when they are operated at flight speeds, so that the blades tend to retain, more closely, their normal (substantially radial) positions.

At slow speeds of rotation and particularly in starting or initiating rotation of the blade system prior to takeoff, it is highly desirable that, at least, the larger blade movements should be materially restricted or controlled. However, since the effect of inertia forces on the blades in starting and at slow speeds is not sufficient to maintain the desired blade position, the use of some other means to accomplish the desired control should be provided.

With the above-noted conditions in mind, the present invention contemplates the use of means which provide relatively great control or restraint at starting and at slow speeds of rotation and which, at the same time, has relatively little or no effect at normal flight speeds of rotation.

The mechanism of the present invention, furthermore, is advantageous when used in combination either with a mechanical starting device such, for example, as illustrated in my issued Patent No. 1,692,082, dated November 20th, 1928, in which torque is applied to the hub of the blade system, or with an air-flow or slip-stream starter such as disclosed in my copending application, Serial No. 423,773, filed March 3rd, 1930, in which rotation is initiated by the effect of a current of air moving across the blades themselves.

In addition to the foregoing, the present invention contemplates the use of a form of mechanism or apparatus which is not only simple and rugged, but also highly efficient from the standpoint of structure and aerodynamics.

Other objects and advantages will appear herebelow.

How the apparatus of the present invention may be applied to sustaining rotor constructions, is illustrated in the accompanying drawings in which—

Figure 1 is a top plan view of a rotor construction of the general character here involved, certain of the sustaining blades thereof being broken away for the sake of simplicity in the drawing;

Figure 2 is an enlarged fragmentary top view, partly in section and partly in elevation, of the hub end portion of one of the blades with various blade pivot parts associated therewith; and

Figure 3 is a view similar to Figure 1 but illustrating a modified structure.

In both Figures 1 and 3 the reference character 3 designates a central blade mounting or hub member which, it will be understood, is arranged or mounted for free rotation with the blades under the influence of relative airflow. In each one of these figures, furthermore, the sustaining blades are indicated by the reference numeral 4, each one of the blades being provided with a shank portion 5 which is secured or attached to the structure 3 preferably by means of a plurality of pivot or articulated joints, the parts being arranged in such manner as to provide for individual pivotal movement of the blades on two different axes which are disposed at right angles to each other as indicated in the main views (Figures 1 and 3) at 6 and 7.

From the inspection of Figure 2 it will be seen that the hub or inner end 5*a* of each blade is provided with the joint part including spaced and apertured lugs 6*a*. The pivot pin 6 serves to connect the part 6*a* with another joint part 7*a* which, of course, is suitably apertured to receive the pin 6. The joint part 7*a*, furthermore, is also provided with spaced and apertured lugs through which the pin 7 extends and between which the block 3*a* of the hub structure is positioned. Additionally, a rubber block such as indicated at 5*b* is positioned or disposed between relatively moving surfaces of the joint parts 6*a* and 7*a* preferably, in such manner as to remain under compression in all relative positions of the said parts 6*a* and 7*a*. It might also be noted that in Figure 2 the full line showing of the blade stub 5*a* indicates a considerably flexed position, while the dot and dash showing at 5*c* illustrates the position which the blade will occupy with respect to the joint part 7*a* when the former is in its normal or substantially radial position.

The structure just described, i. e., the parts employed in the pivotal mounting of the blades with respect to the common hub, is not a part of the present invention per se but is described, illustrated and claimed in my copending application, Serial No. 496,872, filed November 20th, 1930.

Referring now particularly to Figure 1 it will be seen that, in accordance with the present invention, blade interconnections in the form of cables or wires 9 are provided between adjacent blades, and each cable 9 is suitably secured at one end to a blade at a point such as indicated at 10, the said point being spaced substantially from the hub member 3. Each cable 9 extends from its point of attachment 10 on one blade to another blade which carries a suitable roller 11, the cable being passed over this roller and extending internally of the blade as indicated at 9*a*. This cable section 9*a* is preferably extended within the shank portion 5 of the blade and is secured therein to an additional cable 12 by means of a connecting or coupling device 13. The cable 12 in turn is attached to one end of a resilient mechanism such as the spring 14, the other end of such spring being fixedly mounted preferably toward the inner end of the blade shank as at 15. A weight 16, furthermore, is disposed within the blade and arranged for sliding movement within a suitable guide such as the tube 17. This weight is coupled or connected to the device 13, and thus to the cable sections 9*a* and 12, by means of a shaft, cable or the like, shown at 18.

According to the application of this mechanism illustrated in Figure 3, a wire or cable 19 is attached as at 20 to one blade 4 externally thereof, from which point the cable 19 extends to an adjacent blade carrying a roller 21 over which the cable passes to provide a section thereof, 19*a* extending substantially lengthwise of the blade shank 5. In this instance, however, the weight 22 is interposed between the cable 19 and the spring device 23 and, if desired, the cable section 19*a* may be extended directly to the outer end of such spring, in which case the weight 22 may be secured to or mounted thereon. This arrangement is clearly illustrated in Figure 3, and from this figure it will also be seen that these parts are all disposed externally of the blade structure so that they may readily be attached to very simple or small blade structures. Additionally, the weight 22 is preferably provided with suitable guide means such as the tube 24 mounted externally of the blade shank 5 as by means of clamps or brackets 25. The inner end of the spring 23, of course, is secured to a stationarily mounted or fixed part such as the bracket or plate 26.

The operation of both forms of the invention above described, generally, is quite similar and includes briefly a very substantial restraint or restriction of individual blade movements during initiation of their common rotative movement which may be effected, for example, by means of either a mechanical or slip-stream type of starter mechanism such as those hereinbefore referred to. This substantial restriction or control results from the combined effect of the blade interconnections above described and of the resilient block or device 5*b* which is associated with the blade pivot parts. In view of the fact that the rubber blocks 5*b* are constantly under compression, they always exert a force tending to maintain a substantially radial blade position. These stops, therefore, serve to prevent substantial blade movements within the general path of travel thereof when the sustaining system is inactive or at rest. However, as brought out clearly in my copending application, Serial No. 496,872 above referred to, resilient stops of this character are preferably so designed as to permit the blades to move freely or, at least, without any substantial restraint during normal flight rotation, it being noted that it is highly desirable that the blades should be free, independently, to assume various positions of equilibrium under the influence of centrifugal, lift, drag and anti-drag forces. This relative freedom in flight, also as brought out in the last mentioned co-pending application, is due to the fact that the restrictive force exerted by the rubber blocks or cushions is not sufficient to materially hamper or impair movements which are caused by the normal flight forces such as those just referred to.

The resistive value of the blade interconnections disclosed herein, in the preferable arrangement, is so proportioned with respect to that of the resilient cushions associated with the blade pivots and the effect of centrifugal force on the blades themselves, that, just after initiation of rotation and during the lower rotational speeds, the blade interconnections serve to exert a substantial resisting force as to the movements of one blade with respect to another in their general path of travel. In this connection, it should be borne in mind that shortly after initiation of rotation, the action of centrifugal, drag and anti-drag forces is such as to materially reduce the effect of the resilient stops or cushions at the blade hubs so that at such times, and before flight speed of rotation is attained, the blade interconnections serve to substantially prevent any undesirably great individual blade movements under the influence of the starting force which is being applied to the system. However, as flight speeds of rotation are approached, the weight devices 16 or 22 which are associated with the blade interconnections are affected sufficiently by centrifugal force to materially reduce, if not completely eliminate, the effect of the blade interconnections, it being noted that at flight speeds of rotation the action of inertia forces on the blades is, in many instances, sufficient to maintain the desired blade positions. I prefer, therefore, to relatively arrange and proportion the resistive value of the blade interconnections and the weight devices in such manner as to substantially eliminate the effect of the blade interconnections at flight speeds of rotation.

It will be seen, therefore, that the size or mass as well as the disposition of the weights 16 and 22 may be arranged, relatively to various forces acting on the blades, either to completely eliminate the action of a blade interconnection or, at least, to substantially reduce such action, as desired.

Also, as it may be desirable in certain instances to increase the effect of centrifugal force on the outer portions of the blades at flight speeds of rotation, the weight devices may be so proportioned and arranged with respect to mass and extent of movement under the influence of centrifugal force as to suitably alter the center of gravity of the blade lengthwise thereof and thus provide for automatic shift of the center of gravity of the blade outwardly as flight speeds of rotation are approached.

According to the foregoing, therefore, the present invention makes provision for relatively great restriction or control of individual blade movements in their general path of travel at starting and at the same time provision for relatively great, or, if desired, complete, freedom for such movements during normal flight operation. In addition, the present invention accomplishes the above as well as other objects and advantages hereinbelow pointed out, by the use of a simple, convenient and effective form of apparatus.

In connection with the application of the structure illustrated in Figure 1, it should be noted that, in this instance, all of the operating or movable parts of the interbracing system, with the exception of a single section of cable extending between adjacent blades, is housed or mounted within the blade itself so that parasite drag or wind resistance is reduced to a minimum.

On the other hand, the structure of Figure 3 is of a somewhat simpler arrangement and may be desirable for certain installations for this reason. In addition, the simplicity of the construction illustrated in Figure 3 greatly facilitates application thereof externally of the blade and, therefore, in some cases, especially where the blade structure itself does not readily lend itself to the internal application, this particular arrangement is very desirable. It will be understood, of course, that with this last type of application, the parts which are located externally of the blades may be suitably faired or stream-lined with the shank portions of the blades.

I claim:

1. In an aircraft, a set of sustaining blades mounted for rotation about a common axis with freedom for movement of one blade with respect to another, and a mechanism for controlling said movement, together with means associated with said mechanism and influenced by the action of centrifugal force during rotation of the set of blades to progressively decrease the controlling effect as the speed of rotation increases.

2. In an aircraft, a set of sustaining blades mounted for rotation about a common axis with freedom for movement of one blade with

respect to another, and a mechanism for controlling said movement, together with means associated with said mechanism and influenced by the action of centrifugal force during rotation of the set of blades to progressively decrease the controlling effect substantially to the zero point at normal flight speeds of rotation.

3. In an aircraft, a set of sustaining blades mounted for rotation about a common axis with freedom for movement of one blade with respect to another, and a mechanism for controlling said movement, including means yieldingly resisting said movement and means operative by the action of centrifugal force, during normal flight rotation of the set of blades, to reduce the resistance value of the resisting means.

4. In an aircraft, a set of sustaining blades mounted for rotation about a common axis with freedom for movement of one blade with respect to another, and a mechanism for controlling said movement, including blade interconnections yieldingly resisting said movement and a device associated with the blade interconnections and influenced by the action of the centrifugal force during rotation of the set of blades to progressively decrease the controlling effect as the speed of rotation increases.

5. In an aircraft, a set of sustaining blades mounted for rotation about a common axis with freedom for movement of one blade with respect to another, and a mechanism for controlling said movement, together with means associated with said mechanism and influenced by the action of the centrifugal force during rotation of the set of blades to decrease the controlling effect as the speed of rotation increases.

6. In an aircraft, a set of sustaining blades mounted for rotation about a common axis with freedom for movement of one blade with respect to another, and a mechanism for controlling said movement, including blade interconnections yieldingly resisting said movement and a device associated with a blade interconnection and influenced by the action of centrifugal force during rotation of the set of blades to decrease the controlling effect as the speed of rotation increases.

7. An aerial device having a set of sustaining blades mounted for rotation about a common axis with freedom for movement of one blade with respect to another in addition to the common rotation of the set and means for controlling relative blade movement including a resilient device associated with a plurality of blades and weight means associated with the resilient device and arranged for movement, under the influence of centrifugal force during the said common rotation of the set of blades, to control the effective resilience of said device.

8. An aircraft having a set of movable sustaining blades, a blade mounting structure providing for rotation of the set about a common axis and relative movement thereof in addition to the common rotation and a mechanism for controlling relative blade movements including tension blade-interconnecting means and a weight arranged for movement under the influence of centrifugal force and associated with said interconnecting means in such manner as to control the tension thereof.

9. An aircraft having a set of movable sustaining blades, a blade mounting structure providing for rotation of the set about a common axis and relative movement thereof in addition to the common rotation and a mechanism for controlling relative blade movements including tension blade-interconnecting means and a weight arranged for movement under the influence of centrifugal force and associated with said interconnecting means in such manner as to control the tension thereof, said weight being carried by a blade.

10. An aircraft having a set of movable sustaining blades, a blade mounting structure providing for rotation of the set about a common axis and relative movement thereof in addition to the common rotation and a mechanism for controlling relative blade movements including tension blade-interconnecting means and a weight arranged for movement under the influence of centrifugal force and associated with said interconnecting means in such manner as to control the tension thereof, said weight being mounted within a blade.

11. An aircraft having a set of movable sustaining blades, a blade mounting structure providing for rotation of the set about a common axis and relative movement thereof in addition to the common rotation and a mechanism for controlling relative blade movements including blade interconnecting means, a device adapted to place the interconnecting means under tension and a weight arranged for movement under the influence of centrifugal force and associated with said device in such manner as to control the tension thereof.

12. An aircraft having a set of movable sustaining blades, a blade mounting structure providing for rotation of the set about a common axis and relative movement thereof in addition to the common rotation and a mechanism for controlling relative blade movements including blade interconnecting means, a device adapted to place the interconnecting means under tension and a weight arranged for movement under the influence of centrifugal force and associated with said device in such manner as to control the tension thereof, said weight and said device being mounted internally of a blade.

13. An aerial device having a set of sus-

taining blades, a mounting structure for said blades including means providing for rotation of the set about a common axis and means providing for pivotal movement of one blade with respect to another, means associated with the pivot means for controlling pivotal movements and a device associated with a plurality of blades for controlling such pivotal movements, said device including means operable under the influence of the centrifugal force incident to the common rotation of the set of blades to vary the controlling effect of the device.

14. An aerial device having a set of sustaining blades, a mounting structure for said blades including means providing for rotation of the set about a common axis and means providing for pivotal movement of one blade with respect to another, means associated with the pivot means for controlling pivotal movements and a device associated with a plurality of blades for controlling such pivotal movements, said device including means operable under the influence of the centrifugal force incident to the common rotation of the set of blades to reduce the controlling effect of the device as the speed of rotation increases.

15. An aerial device having a set of sustaining blades, a mounting structure for said blades including means providing for rotation of the set about a common axis and means providing for pivotal movement of one blade with respect to another, means associated with the pivot means for controlling pivotal movements and a device associated with a plurality of blades for yieldingly resisting such pivotal movements, said device including means operable under the influence of the centrifugal force incident to the common rotation of the set of blades to vary the effective resistive value of the device.

16. An aerial device including a set of movable sustaining blades, a blade mounting structure providing for rotation of the set about a common axis and relative movement thereof in addition to the common rotation and means associated with a blade and operable under the influence of changes in the effect of centrifugal force at different speeds of rotation to alter the position of the center of gravity of the blade.

17. In an aircraft, a sustaining rotor with a blade mounted thereon, having means permitting blade displacement movements under the influences of various forces, means controlling movements of the blade, and weight means mounted in association with said blade for movement generally along its axis under the influence of variations in centrifugal force to alter the effect of the control means.

18. In an aircraft, a sustaining rotor with a blade mounted thereon, having means permitting blade displacement movements under the influences of various forces, means controlling movements of the blade, and means acting progressively as rotational speed increases, to decrease the effect of the control means.

19. In an aircraft, a set of sustaining blades mounted for rotation about a common axis with freedom for movement of one blade with respect to another, and a mechanism for controlling said movement, together with means associated with said mechanism and influenced by the action of centrifugal force during rotation of the set of blades to decrease the controlling effect substantially to the zero point at normal flight speeds of rotation.

In testimony whereof, I have hereunto signed my name.

JUAN DE LA CIERVA.