

Jan. 4, 1966

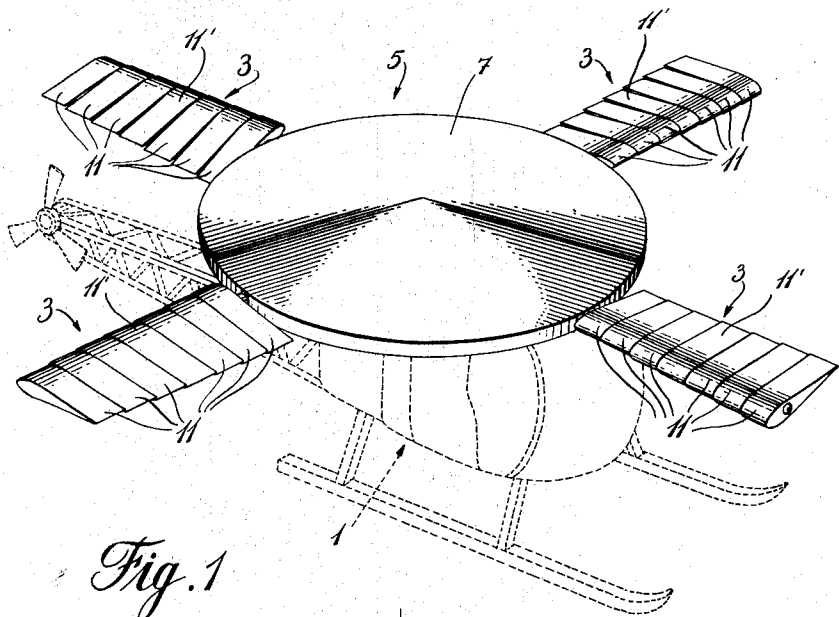
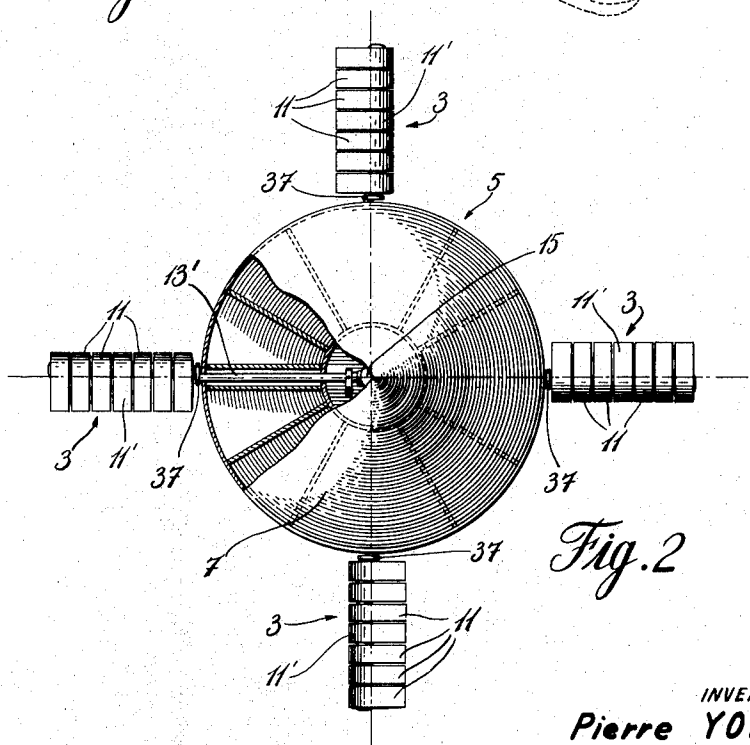
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3,227,221

BLADE CONSTRUCTION FOR HELICOPTER

Filed Nov. 29, 1963

4 Sheets-Sheet 1



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BLADE CONSTRUCTION FOR HELICOPTER

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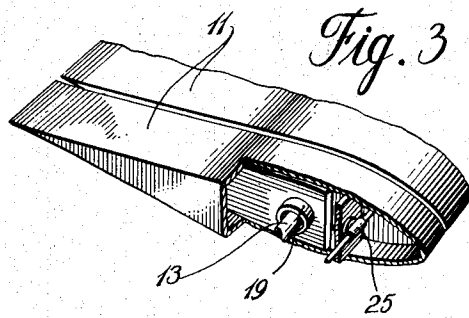


Fig. 6

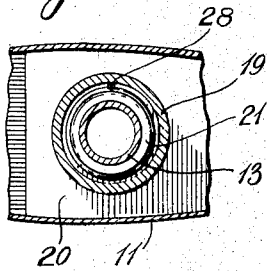
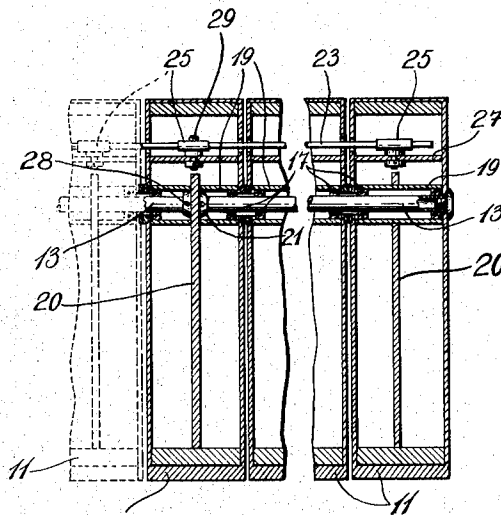


Fig. 5

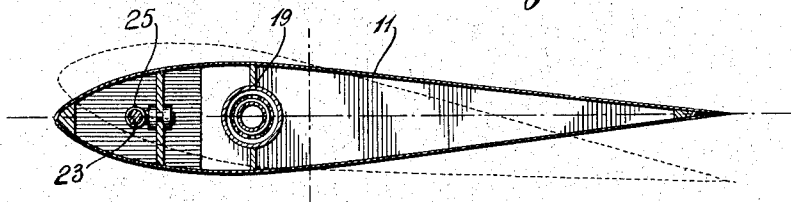


Fig. 7

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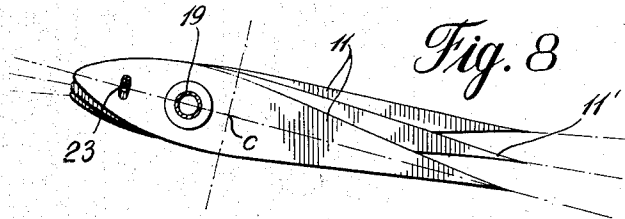
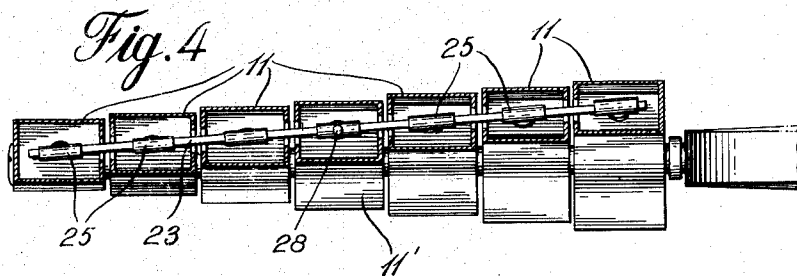
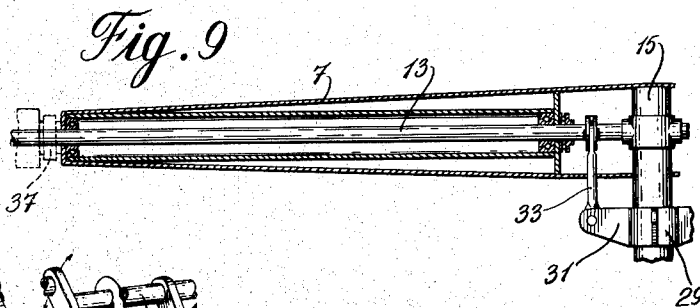
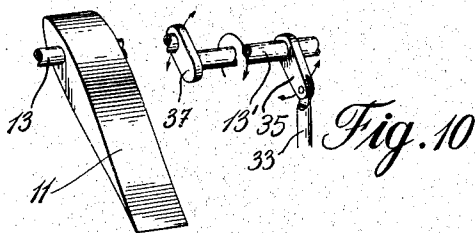
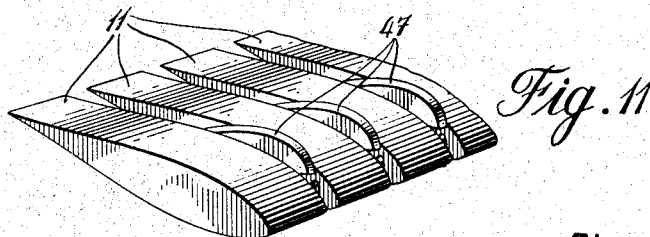
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BLADE CONSTRUCTION FOR HELICOPTER

Filed Nov. 29, 1963

4 Sheets-Sheet 3



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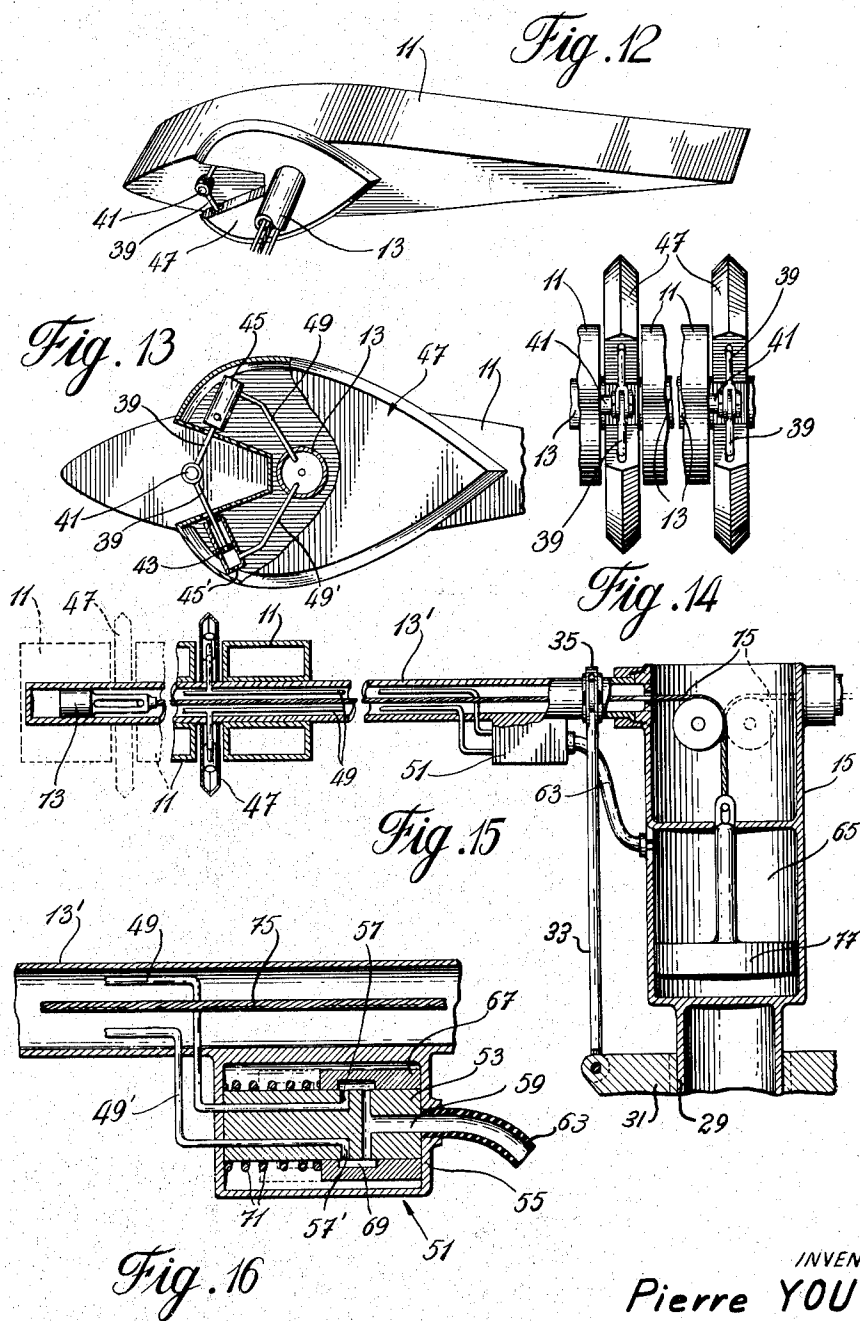
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BLADE CONSTRUCTION FOR HELICOPTER

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4 Sheets-Sheet 4



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BLADE CONSTRUCTION FOR HELICOPTER
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3 Claims. (Cl. 170-160.33)

The present invention relates to a novel blade construction for helicopter.

The purpose of the invention is to ensure greater stability and better performance of the craft by overcoming some of the problems arising out of the fact that, in flight, because the velocity increases from the lifting rotor to the tips of the blades, the lifting power is unevenly distributed, being smaller near the rotor hub, at the root end of the blades, than at the tips thereof and that, while some blades travel against the wind, others simultaneously travel with the wind. These shortcomings result in the necessity to provide unduly long blades in order to obtain the necessary lifting force and result in causing a tendency for the craft to overturn due to the fact that the resultant lifting force acting on the side of the craft where the blades travel against the wind is greater than on the side where the blades travel with the wind. Also, on the latter side, and at a certain distance from the rotor hub, the relative velocity of the air and of the blade is nil, giving rise to vibrations.

It is consequently a main object of the invention to provide a novel blade construction wherein the lifting power is evenly distributed along the longitudinal axis of the blade so that the latter may be made shorter.

Another object of the invention resides in the provision of a new blade construction wherein the inboard portion of the blade is cut off to prevent vibration caused by the fact that at a point close to the blade root, the relative velocity between the air flowing over the blade and the blade itself is nil.

The above noted objects may be obtained in a helicopter having a lifting rotor and provided with a rotor blade made according to the invention which comprises: a series of spars operatively connected to said lifting rotor, and for each spar a plurality of separate airfoil-contour blade sections mounted thereon; means to cause rotation of the spar and linking means interconnecting all sections and responsive to rotation of the spars to cause the sections to assume positions resulting in substantially equal lifting forces.

More specifically, and in one embodiment of the invention, each but one of the airfoil-contour blade sections is freely mounted on the spar along a transverse axis thereof forwardly of the center of lift and towards the leading edge thereof while the remaining section is fixed to the spar; wherein means is provided to rotate the spar to change the angle of incidence of the said remaining section which is fixed to the spar and wherein the linking means comprises a slender torsion rod parallel to the spar and extending through and connected to each blade section.

In another embodiment of the invention, the airfoil-contour blade sections are all freely mounted on the spar and the construction comprises at least one piston rod pivotally connected at one end to each section at a point forward of the spar towards the leading edge of the section; a fluid pressure cylinder, having a piston therein connected to each rod, the cylinder being fixed to the spar to rotate therewith; tubing, interconnecting all cylinders, provided to apply fluid pressure to the said pistons whereby all pistons and rods are subjected to the same pressure; wherein means supplying pressure fluid to said tubing and cylinders is also provided and, finally, there is a further means which is adapted to cause rotation of the spars about the normal axis thereof and to cause rotation of the cylinders mounted thereon whereby as the spars rotate a uniform pressure is applied to all pistons forcing the air-

foil-contour blade sections to assume positions resulting in substantially equal lifting forces acting thereon. In both embodiments, the blade construction includes a non-lifting generally flat circular disk mounted on the lifting rotor for rotation therewith; the spars having an inboard portion extending through the disk to be connected, at the inner end, to the rotor.

A better understanding of the invention will now be had by the description that follows having regard to the appended drawings wherein:

FIG. 1 is a general perspective view of the blade construction as shown mounted on a helicopter;

FIG. 2 is a plan view of the blade construction with part broken away to show the internal structure thereof;

FIG. 3 is a perspective fragmentary view, partly in section, of a blade section;

FIG. 4 is a longitudinal cross-sectional view of the assembly of blade sections forming a blade;

FIG. 5 is a fragmentary horizontal cross-sectional view of the blade sections of the first embodiment;

FIG. 6 is a partial cross-sectional view, on an enlarged scale, taken along line 6-6 of FIG. 5;

FIG. 7 is a longitudinal cross-section view of a blade section made according to the first embodiment;

FIG. 8 is a side elevation view of a group of blade sections having different incidence angles;

FIG. 9 is a cross-sectional view of the non-lifting disk;

FIG. 10 is a perspective fragmentary view intended to illustrate the means to rotate the blade section fixed to the spar;

FIG. 11 is a perspective fragmentary view of a blade according to a second embodiment of the invention;

FIG. 12 is a perspective view of a blade section assembly according to the second embodiment of the invention;

FIG. 13 is a partial longitudinal side elevation view of a blade section assembly with part taken away to show the internal structure of the hydraulic system;

FIG. 14 is a fragmentary front elevation view, with part broken away, of the hydraulic system;

FIG. 15 is a cross-sectional view of a blade according to the second embodiment of the invention and intended to show more particularly the hydraulic system;

FIG. 16 is a cross-sectional view of the hydraulic circuit cut-off valve.

The blade construction of the invention, for mounting on a helicopter 1, generally comprises a series of rotor blades 3 projecting out of a generally flat non-lifting disk 5 having a slightly conical top 7.

As noted in FIGS. 1 and 2, blades 3 are formed of a plurality of blade sections 11 mounted on spars 13 radiating from a central lifting rotor 15 in a manner to be more fully described hereinafter.

The use of disc 5 is to occupy the space which is left free by the absence of the section blades around the lifting rotor. The centrally located section blades which are affected by the reversed flow as it is known are eliminated.

Each blade section 11 has a chord having an airfoil-contour as illustrated in FIGS. 3 and 7, particularly.

In a first embodiment of the invention, all but one of the blade sections 11 are freely mounted on spar 13 as through suitable bearings 17 secured in the bore of a pipe 19 mounted within each section 11 and, of course, coaxial with spar 13. It should be particularly noted, at this point, that the axis of both spar 13 and pipe 19, of a section, lies a short distance forward of the center of lift C of each section as illustrated in FIG. 8. As will be seen later, the positioning of the pivoting axis of the blade sections is so chosen that, at equilibrium, the eccentric action of the lifting forces will adjust the angle of incidence of the various sections in proportion to the

resistive force developed by the velocity of the blade itself. It is, of course, to be remembered that the velocity of the blade sections closer to central disk 7 is much smaller than the velocity of the blade sections at the outer end of spar 13.

The remaining blade section 11' is, as illustrated in FIGS. 4, 5, and 6, fixed to spar 13 in any suitable manner such as by means of collars 21 secured to section web 20 and suitably clamped on the said spar 13.

All blade sections 11 are linked together through section 11' by means of a slender torsion rod 23 slidably received in sleeves 25 pivotally mounted on a transverse web 27 in each section 11 while the said rod is fixed in pivoting sleeve 25' of blade section 11' by means of a screw 28 or other similar clamping means (see FIGS. 4 and 5).

From the above description, it will be understood that if spar 13 is rotated, the central blade section 11' which is fixed thereto will change its angle of incidence and so will the remaining sections 11 to a degree depending on the reaction of the blade section itself due to its linear speed and the resiliency of torsion rod 23. Thus, the speed of a blade section at the inboard end of spar 13 being smaller than that of a section at the outboard end thereof, the lifting force acting on the former will be smaller than the lifting force acting on the latter. Consequently, the resiliency of torsion rod 23 being uniform throughout its length, the angle of incidence of a section at the inboard end will be greater than that of a section at the outboard end. It follows that the vertical component of the lifting forces will tend to be equal throughout the length of the blades, that is, the said component will tend to be the same for all rotor blade sections 11.

The device for causing rotation of spar 13 is illustrated particularly in FIGS. 9 and 10 and will be seen to consist of a collar 29 slidably mounted on lifting rod 15, the collar being provided with four radially projecting ears 31, one for each rotor blade. At the outer end of each ear 31 is fixed an operating arm 33 to the end of which is pivotally mounted a connecting rod 35 (FIG. 10) which is, itself, fixed to spar 13'.

The longitudinal axis of the inboard portion of spar 13', within disk 7, extends through the centers of lift C of the blade sections 11 and 11', as indicated in FIG. 8, while the outboard portion 13, outside disk 7, is offset from the said centers of lift. This, of course, necessitates a bend 37 to connect the portions inside and outside the non-lifting disk 7.

From this, it can be seen that if collar 29 is raised or lowered by means, not shown, this movement will cause rotation of spar 13, a change in the angle of incidence of blade section 11' and, subsequently, a change in the angle of incidence of all other sections 11, a degree which depends on their location on spar 13, as explained above.

In the embodiment shown in FIGS. 11 to 16 inclusive, the change in the angle of incidence of the various sections 11 is brought about by hydraulic means.

It should first be pointed out that all sections 11 in this particular embodiment are freely mounted on spar 13 which, in this instance, is a hollow member.

The hydraulic means mentioned above comprises, for each section 11, a pair of rods 39 pivotally mounted, at one end, to a common point 41 on each section 11, forwardly of spar 13 and towards the leading edge of the section. Rods 39 are secured, at the other end, to pistons 43 slidable in cylinders 45 mounted within fin-like supports or housings 47 secured to spar 13 so as to rotate therewith. An upper tubing 49 interconnects all upper cylinders 45 while a lower tubing 49' interconnects all lower cylinders 45'. Tubings 49 and 49' are connected to a cut-off valve generally denoted by numeral 51 in FIGS. 15 and 16.

The said cut-off valve 51 comprises a central sleeve 53 secured within a casing 55 and through which tubings 49 and 49' extend to approximately the center thereof

where they turn radially outwardly to form outlet conduits 57, 57'. A T-shaped passage 59 through the same sleeve 53 opens into a nipple 61 to which is secured a flexible hose 63 the other end of which is connected to the upward part of a fluid chamber 65 formed within a hollow part of the lifting rotor 15.

Slidably mounted over sleeve 53 is a cylinder 67 having the forward end of its bore cut out to define a groove 69 adapted to overlap outlet conduits 57, 57' and the bars of T-passage 59 when in the position shown in FIG. 16, that is, pressed against one end of casing 55 by a spring 71.

As said previously, the spar of this embodiment is hollow and an inertia mass 73 is received therein for slidable displacement. Inertia mass 73 is connected by means of a cable or chord 75 to a piston 77 slidably received within the fluid housing 65. The said housing 65, in the inoperative position with piston 77 lying at the bottom thereof, and fluid tubings 49, 49' are filled with oil.

From the above description, it will be seen that as lifting rotor 15 is rotated, inertia mass 73 through the action of the centrifugal force will be driven outwardly thus forcing piston 77 to rise which, in turn, pressurizes the oil in fluid housing 65 and tubings 49, 49'. The said pressure is the one which acts simultaneously on pistons 43 of the upper and lower cylinders 45, 45', previously mentioned.

After the blades have attained a certain speed, the cylinder 67 will start to move towards the left against the action of spring 71 to eventually close the T-shaped passage 59 thus insulating tubings 49, 49' from each other and from the fluid source in housing 55.

As can be seen from FIG. 15, spar 13 is rotated in a manner similar to that of the first embodiment as shown in FIG. 10.

Consequently, should spar 13 be rotated, because of the intercommunication of all cylinders 45, 45', the resistive force of the blade sections 11 to the action of the lifting force will be the same throughout the blades so that the lifting force acting on the inner blades being smaller than that acting on the outer blades, the angle of incidence of the former will change to a greater degree than the angle of incidence of the latter. The result will be that the vertical component of the lifting force will be about equal throughout the full length of the blades.

I claim:

1. In a helicopter having a lifting rotor, a rotor blade construction therefor comprising:

- (a) a series of hollow spars operatively connected to said lifting rotor, and for each spar;
- (b) a plurality of separate airfoil-contour blade sections mounted on said spar along a transverse axis of said sections forwardly of the center of lift and towards the leading edge thereof, the said sections responsive to the aerodynamic flow to vary their relative incidence angle;
- (c) the sections are freely mounted on said spar and constitute a rotor blade;
- (d) for each section, an upward and a downward piston rod having one end secured to a common point on the section forwardly of the spar and towards the leading edge of the section;
- (e) a support corresponding to each section and fixed to the spar for rotation therewith;
- (f) a pair of cylinders secured to each support, each cylinder having a piston therein connected to one of the piston rods for the corresponding sections;
- (g) tubing interconnecting all cylinders whereby all pistons and rods are subjected to the same pressure;
- (h) means applying pressure through the said tubing and cylinders;
- (i) further means adapted to cause rotation of said spar about the longitudinal axis thereof and to cause

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rotation of the cylinders mounted thereon, whereby as said spars rotate a uniform pressure is applied to all pistons forcing the airfoil-contour blade sections to assume positions resulting in equal lifting forces acting thereon;

- (j) a fluid housing in said rotor to the upper end of which said tubing is connected; 5
- (k) a piston at the bottom of said housing in inoperative position of said rotor;
- (l) an inertia mass in said hollow spar projected outwardly by centrifugal force as said spar rotates about said rotor; 10
- (m) a cord joining said mass and said piston whereby as said spar rotates about said lifting rotor, said piston is raised in said housing to increase the pressure in said housing. 15
2. A rotor construction as claimed in claim 1, wherein a cut-off valve, located between said tubing and said fluid housing is actuated by centrifugal force to cut-off said tubing from said housing at a predetermined speed of said spar. 20
3. A construction as claimed in claim 1, including a non-lifting generally flat circular disc mounted on said lifting rotor for rotation therewith; said spars having an

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inboard portion extending through said disc to be connected, at the inner end, to said rotor.

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