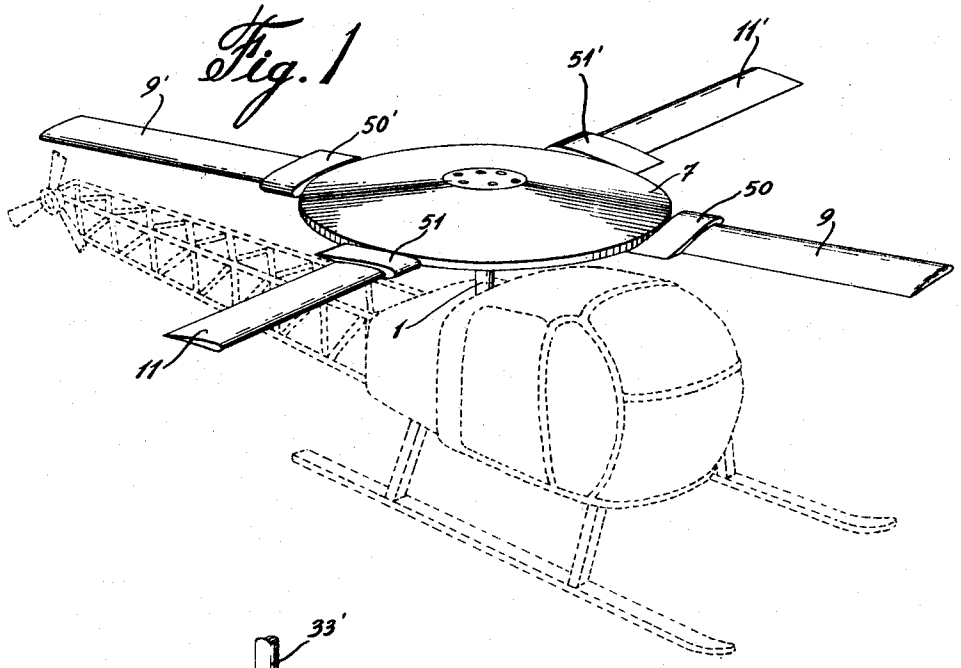
July 23, 1968 P. YOU 3,393,750

LIFTING CONSTRUCTION FOR HELICOPTERS

Filed June 26, 1967 3 Sheets-Sheet 1

Fig. 1



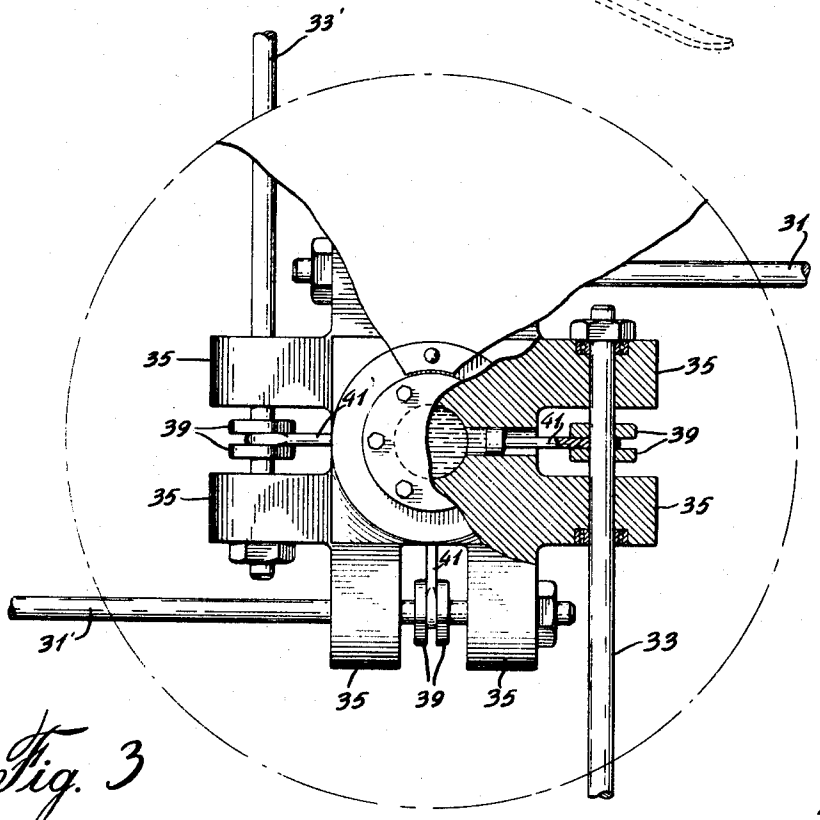


Fig. 3

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LIFTING CONSTRUCTION FOR HELICOPTERS

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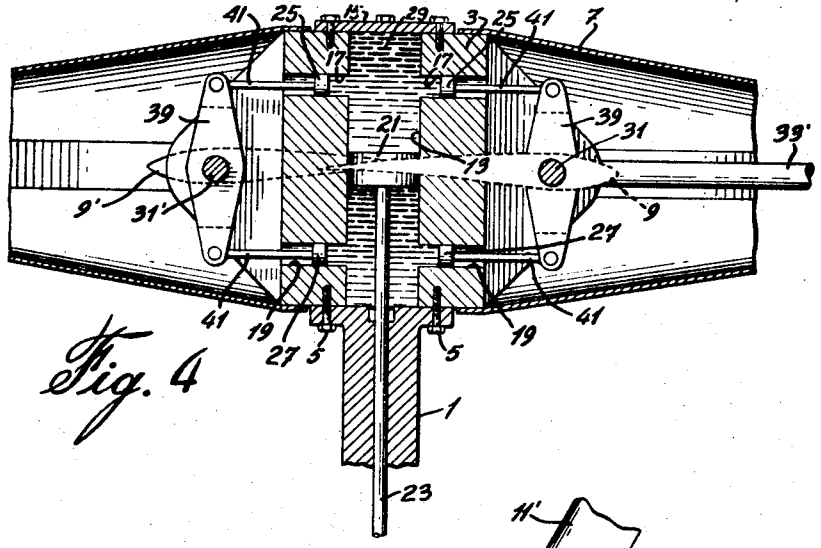


Fig. 4

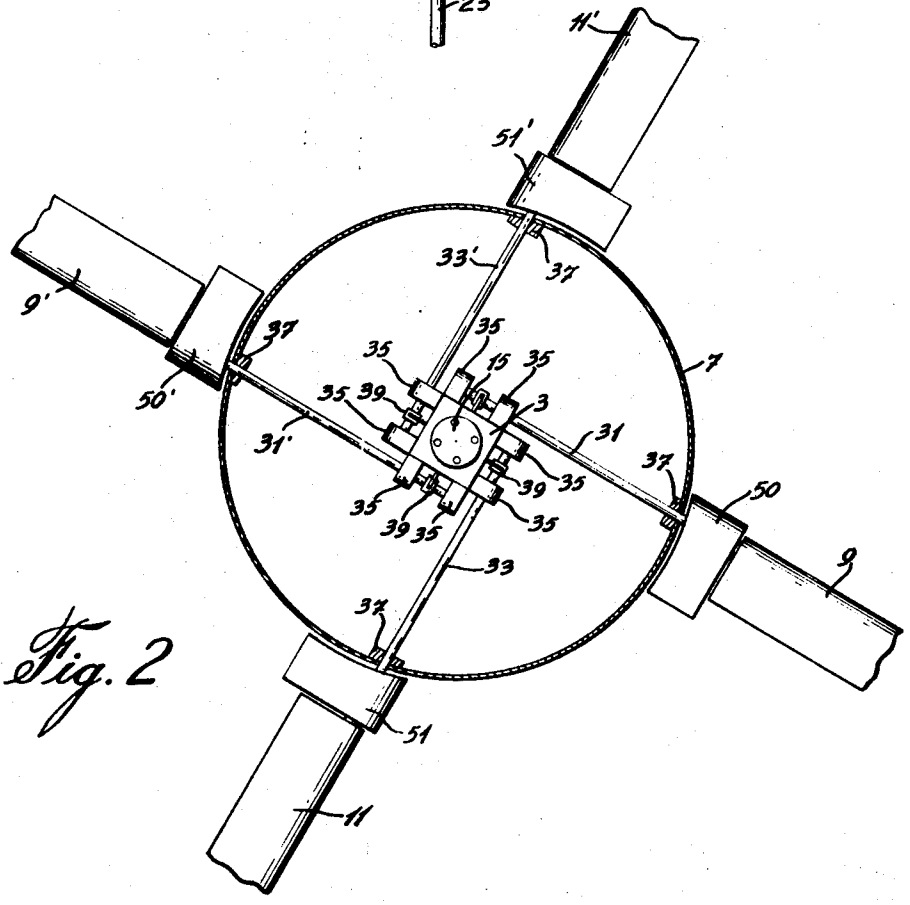


Fig. 2

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LIFTING CONSTRUCTION FOR HELICOPTERS

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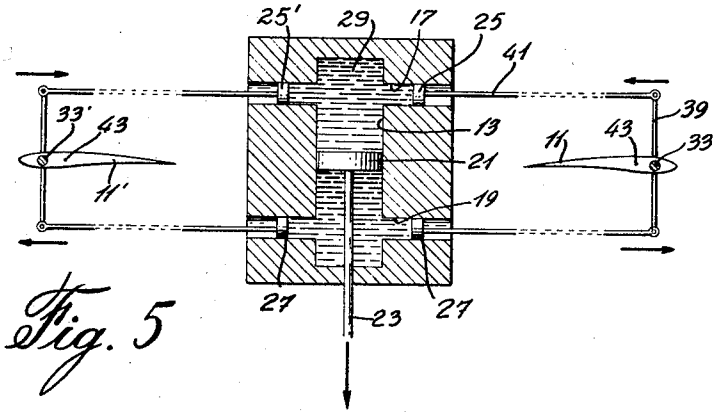


Fig. 5

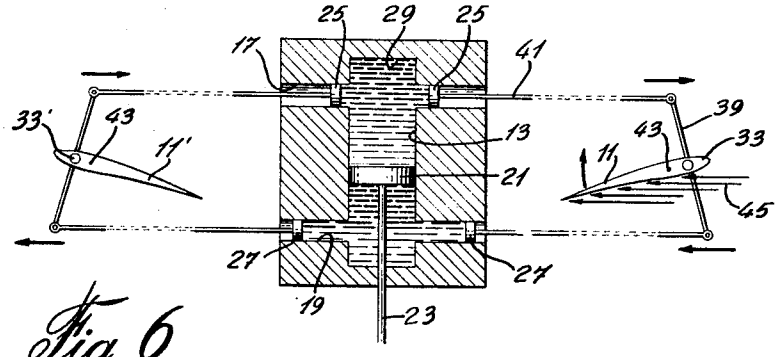


Fig. 6

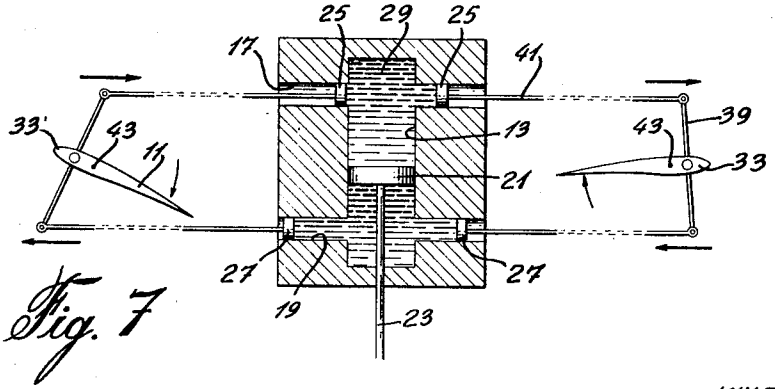


Fig. 7

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United States Patent Office 3,393,750 Patented July 23, 1968

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LIFTING CONSTRUCTION FOR HELICOPTERS

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5 Claims. (Cl. 170—160.55)

ABSTRACT OF THE DISCLOSURE

A lifting construction for helicopter wherein a vertical rotor has a rotor head at the top thereof formed with a closed chamber into which open two pairs of coaxial upper passages and two pairs of lower coaxial passages. A primary piston is mounted in this chamber for displacement between the upper and lower passages. A secondary piston is mounted for displacement in each of the upper and lower passages. The construction has four blades in cross arrangement fixed to spars, each of which is mounted for axial rotation each on one face of the square rotor head. An operating lever is fixed at the end of each spar and two operating rods connect the ends of the operating lever to one lower and one upper secondary pistons. The chamber is completely filled with a hydraulic fluid.

The instant invention relates to a lifting construction or combination for a helicopter.

The device of the invention is of the general type disclosed in my prior U.S. Patents Nos. 3,227,220 and 3,227,221 of Jan. 4, 1966, which provides for the reduction in the flapping effect of the helicopter blades by equalizing the lifting forces acting on the blades as they rotate and as the helicopter advances, and by providing a non-lifting generally flat circular disc mounted on the lifting rotor and which is the only way to provide a support for the rotation of the blades while avoiding flapping effects and the only way to allow control of the cyclic pitch by the pilot and intended to cause banking of the helicopter for translation thereof.

An object of the present invention is to provide a construction of this nature which is of great simplicity and which quickly and efficiently responds to changes in the aerodynamic forces acting on the blades.

Another object is to provide a construction wherein control of the collective pitch or incidence angle is independent of the control for the cyclic pitch.

These objects can be obtained with a lifting construction according to the invention comprising a rotor having means, at the top thereof, that define a closed chamber completely filled with a hydraulic fluid. A pair of spars and blades, mounted on the spars, project horizontally from the rotor top and in opposite directions. The top of the rotor is formed with one pair of coaxial horizontal upper passages and one pair of lower passages, such passages opening into the chamber. A primary piston is displaceable in the chamber and one secondary piston in each of the passages. Means operatively connect each spar with one upper secondary piston and one lower secondary piston for axial rotation of the blades so that displacement of the primary piston changes the incidence angle of the blades and, under aerodynamic forces acting on the blades, the resulting lifting forces are equalized through movement of the hydraulic fluid.

A better understanding of the invention will be afforded by the following description of a preferred embodiment having reference to the appended drawing wherein:

FIGURE 1 is a perspective view of a lifting construction according to the invention, shown in full lines, as mounted on a helicopter, shown in dotted lines;

FIGURE 2 is a plan view of the lifting construction of

FIGURE 1, the central disc being shown in horizontal cross-section with the top removed;

FIGURE 3 is a plan view, on a larger scale, of the rotor head, partially shown in cross-section and with the top of the central disc partially cut-away;

FIGURE 4 is a vertical cross-sectional view of the rotor top and rotor head;

FIGURES 5, 6 and 7 are diagrams illustrating the operation of the rotor constructions, in three successive positions of the blades, with the rotor head shown in cross-section.

The lifting construction of the invention generally comprises a vertical central rotor or rotary shaft **1** at the top of which is secured a rotor head **3** (FIGURE 4) secured to the rotor **1** by any known means such as screws **5**. A hollow non-lifting disc **7** is fixed, centrally thereof, to the rotor head **3** in any conventional manner.

Two pairs of helicopter blades **9**, **9'** and **11**, **11'** are connected to the rotor head in a manner to be more fully described hereinafter.

The use of the central disc such as **7** is known and it suffices to mention that it must be of such a diameter that the tangential speed of the inboard ends of the blades **9**, **9'**, **11**, **11'** is greater, at all time, than the translation speed of the helicopter.

As best illustrated in FIGURES 4 to 7, the rotor head **3** is formed, centrally thereof and along a vertical axis in line with the axis of the rotor **1**, with an inner chamber **13** closed at the bottom by the upper surface of rotor **1** and at the top by a plate **15** suitably screwed to the rotor head **3**. The said head **3** is further formed at the top with two pairs of coaxial horizontal passages **17** and at the bottom with two similar pairs of coaxial passages **19**, it being understood from FIGURES 4 to 7 that two such pairs of top and bottom passages **17**, **19** have their axes in one vertical plane whereas the other two pairs of passages (not shown for the sake of clearness) have their axes lying in another vertical plane normal to the first-mentioned plane. It should also be pointed out that all passages **17**, **19** are of equal diameters.

A primary piston **21** is provided in chamber **13** to be displaced between the upper and lower passages **17**, **19**. An operating piston rod **23** is fixed at one end to the primary piston **21** and extends centrally of the rotor **1** to be operated by the pilot in any known manner.

Secondary pistons **25**, **27** are provided for slidable displacement in passages **17**, **19** respectively.

Chamber **13** is completely filled with a hydraulic fluid **29**, such as oil and may be said to be of constant volume.

Referring now to FIGURE 2, the helicopter blades **9**, **9'**, **11**, **11'** are respectively fixed to spars **31**, **31'**, **33**, **33'** each of which being mounted for axial rotation on a pair of spaced bearings **35**, each pair projecting laterally from one face of the square rotor head **3**. The spars are also supported by bearings **37** secured at the periphery of the disc **7**.

Finally, means is provided to operatively connect each spar with one upper secondary piston **25** and one lower secondary piston **27** for axial rotation of the spars and blades whereby displacement of the primary piston **21** changes the incidence angle of the blades and, under aerodynamic forces acting on the blades, the resulting lifting forces are equalized through movement of hydraulic fluid **29**, as more fully explained hereinafter.

The above means comprises, for each spar and corresponding blade, a lever **39** fixed centrally thereof, to the corresponding spar (**31**, **31'** in FIGURE 4) and perpendicularly to the plane of the corresponding blade (**9**, **9'**, in FIGURE 4). The said means also comprises a pair of connecting rods **41** articulated at one end to the cor-

responding lower and upper secondary pistons **25, 27** and, at the other end, to the upper and lower ends of levers **39**.

The operation of the lifting construction of the invention will now be described in relation to FIGURES 5, 6 and 7. In FIGURE 5, the condition is that of rest with the blades in the position shown in FIGURE 1, that is, blades **9, 9'** extending lengthwise of the helicopter and blades **11, 11'** extending crosswise thereof with blades **11** moving in the direction of displacement of the helicopter and blade **11'** moving against the said direction. The condition of FIGURE 6 is the dynamic condition at the application of an incidence angle to the blades whereas the condition of FIGURE 7 is that after equilibrium in the lifting forces has been reached.

It should first be pointed out that the axes of all spars extend between the leading edges of the blades and the centers of pressure or axes of lift **43** whereby to obtain the necessary torsional moments which is broadly proportional to the lifting force.

In FIGURE 5, the primary piston **21** stands generally midway between the upper and lower passages **17** and **19**, the blades **11, 11'** are horizontal and the secondary pistons **25, 27** stand about midway in the corresponding passages **17, 19**.

In FIGURE 6, the pilot has pulled on the operating rod **23** to lower piston **21** in chamber **13** to obtain an angle of incidence of the blades **11, 11'**. In lowering piston **21**, movement of the hydraulic fluid **29** has pushed the lower secondary pistons **27** slightly outwardly forcing blades **11, 11'**, through levers **39** and connecting rods **41**, to move downwardly thereby giving the required angle of incidence. Simultaneously, the secondary upper pistons **25** move inwardly a corresponding amount due to the displacement of fluid **29** created by the lowering of piston **21**.

As the blades rotate and the helicopter moves forward, aerodynamic forces **45** start acting on the blade **11** forcing it to straighten an amount depending on the magnitude of the said forces to reach a position shown in FIGURE 7. This, of course, shifts the rightward lower piston **27** inwardly while the leftward piston **27** is moved outwardly a corresponding amount thus forcing blade **11'** to increase its angle of incidence. Upper pistons **25** are similarly shifted, as will be understood. This is precisely what is desired since blade **11'** (as shown in FIGURE 1) travels against the direction of translation of the helicopter. Although the aerodynamic forces acting on blade **11'** are smaller than those acting on blade **11** for the above reason, the angle of incidence being greater, the lifting forces produced by the four blades will be about equal in any azimuthal position of the blades, resulting in improved stability of the helicopter.

In known manner, two pairs of flaps **50, 50', 51, 51'** are freely mounted for rotation on spars **31, 31', 33, 33'**, respectively, to be operated by the pilot in any conventional manner to control the cyclic pitch independently of the above-described control of the collective pitch. The cyclic pitch is obtained by tilting the central disc **7** through the flaps **50, 50', 51, 51'**.

Although a specific embodiment has just been described, it will be understood that various modifications may be made thereto without departing from the spirit of the invention, the scope of which is to be construed from the appended claims.

I claim:

1. In a helicopter, a lifting construction thereof, comprising:

(a) a vertical rotor;

(b) means defining a closed chamber of constant volume at the top of said rotor;

(c) a pair of spars and blades fixed thereon projecting horizontally from said rotor top in opposite directions;

(d) one pair of coaxial horizontal passages at the top and one pair at the bottom of said chamber, said passages opening in said chamber and being of equal diameter;

(e) a primary piston displaceable in said chamber between said top and bottom passages and one secondary piston displaceable in each of said passages;

(f) a hydraulic fluid completely filling said chamber, on either side of said primary piston, and said passages up to said secondary pistons; and

(g) means operatively connecting each spar with one upper secondary piston and one lower secondary piston for axial rotation of said spars and blades whereby displacement of said primary piston changes the incidence angle of said blades and, under aerodynamic forces acting on said blades, the resulting lifting forces are equalized through movement of said hydraulic fluid in said passages.

2. In a helicopter, a lifting construction therefor, comprising:

(a) a central vertical rotor;

(b) a rotor head at the top of said rotor; said head formed with a closed vertical hydraulic fluid chamber of constant volume;

(c) at least one pair of blade spars, said spars mounted at one end for axial rotation on either side of said rotor head to project horizonally away from said head and in opposite directions;

(d) a primary piston vertically displaceable in said fluid chamber between said top and bottom passages;

(e) said head formed with one pair of upper and one pair of lower horizonal coaxial passages opening into said fluid chamber, said primary piston displaceable between said pairs of passages;

(f) a secondary piston displaceable in each of said passages;

(g) a blade operatively secured on each spar;

(h) a hydraulic fluid completely filling said chamber, above and below said primary piston, and said passages up to said secondary pistons; and

(i) means operatively connecting each spar with one upper secondary piston and one lower secondary piston for axial rotation of said spars and blades whereby displacement of said primary piston changes the incidence angle of said blades and whereby, under aerodynamic forces acting on said blades, the resulting lifting forces are equalized through movement of said hydraulic fluid in said passages.

3. A lifting construction as claimed in claim **2**, wherein each operating means comprises:

a lever fixed to the corresponding spar normal to the plane of the blade thereof; and

a pair of connecting rods articulated at either end of said lever and on one of the corresponding secondary pistons.

4. A lifting construction as claimed in claim **3**, including a hollow horizontal non-lifting disc secured, centrally thereof, to said rotor head at the top and bottom thereof, said spars extending through said disc and said blades being connected to said spars outwardly of said disc.

5. A lifting contruction as claimed in claim **2**, wherein said rotor head has a square contour and two pairs of spars and blades are provided, each mounted for rotation on one face of said square and wherein said head is formed with two pairs of passages, secondary pistons and operating means to accommodate said two pairs of spars and blade.

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