Nov. 10, 1953 PIOTR F. LAPIDOVSKY 2,658,575
NOW BY JUDICIAL CHANGE OF NAME
PETER T. STONE
HELICOPTER ROTOR

Filed July 17, 1946 3 Sheets-Sheet 1

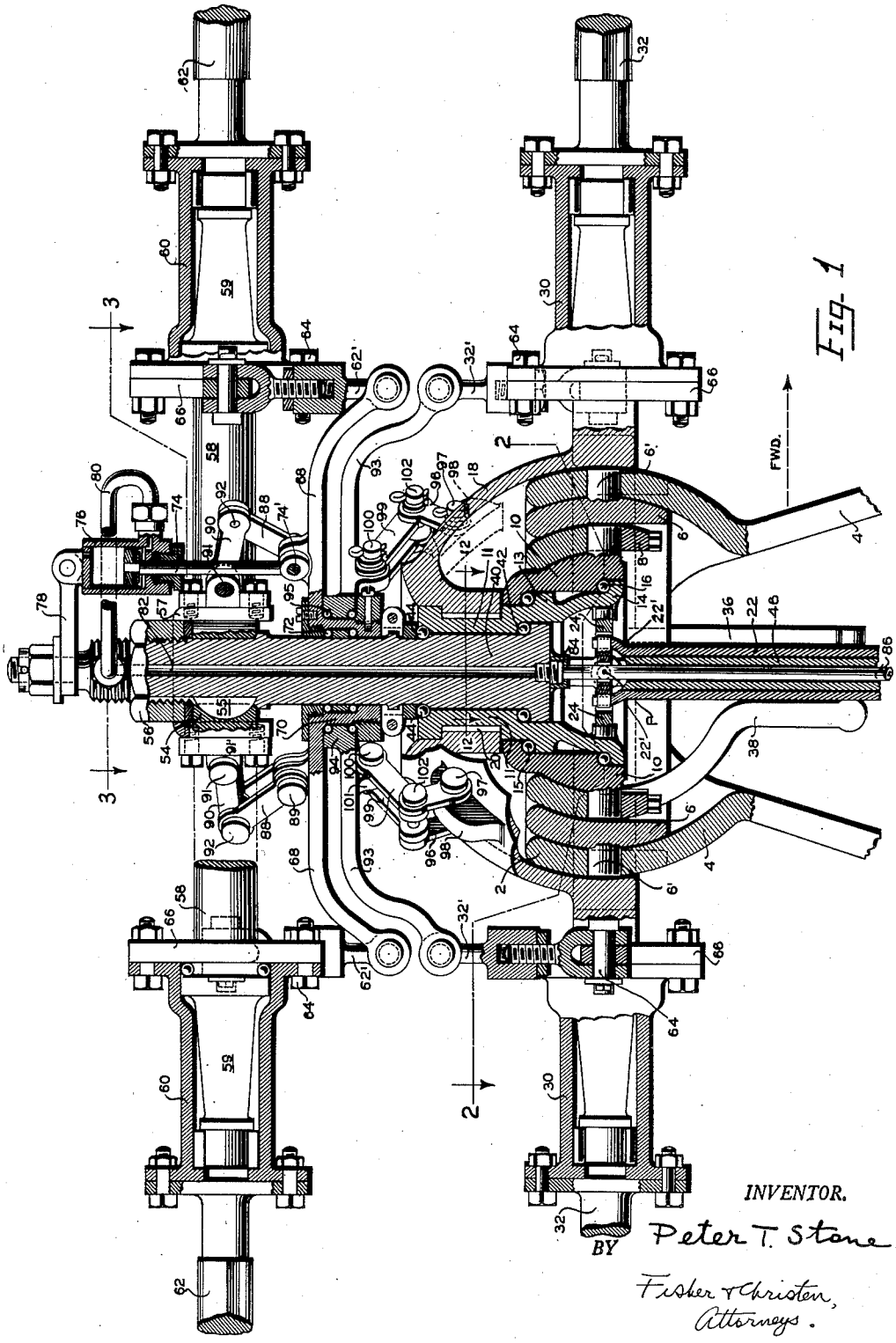


Fig. 1

INVENTOR.
Peter T. Stone
BY
Fisher & Christen,
Attorneys.

Nov. 10, 1953 PIOTR F. LAPIDOVSKY 2,658,575
NOW BY JUDICIAL CHANGE OF NAME
PETER T. STONE
HELICOPTER ROTOR

Filed July 17, 1946

3 Sheets-Sheet 2

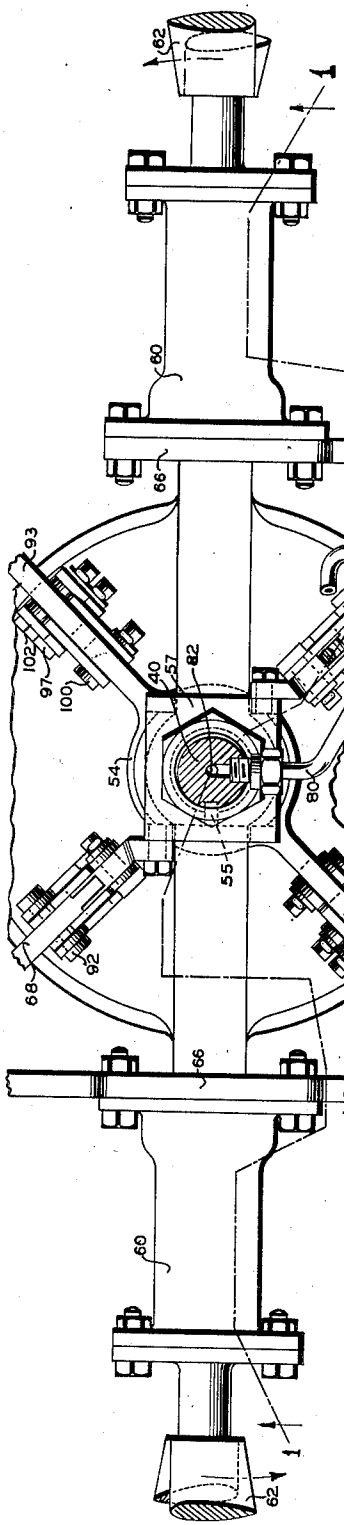


Fig. 3

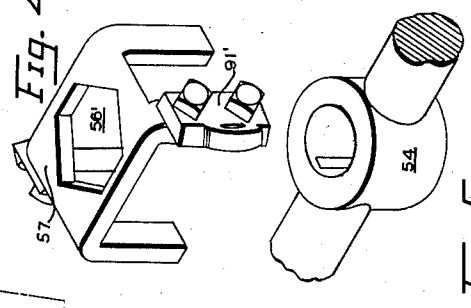


Fig. 4

Fig. 5

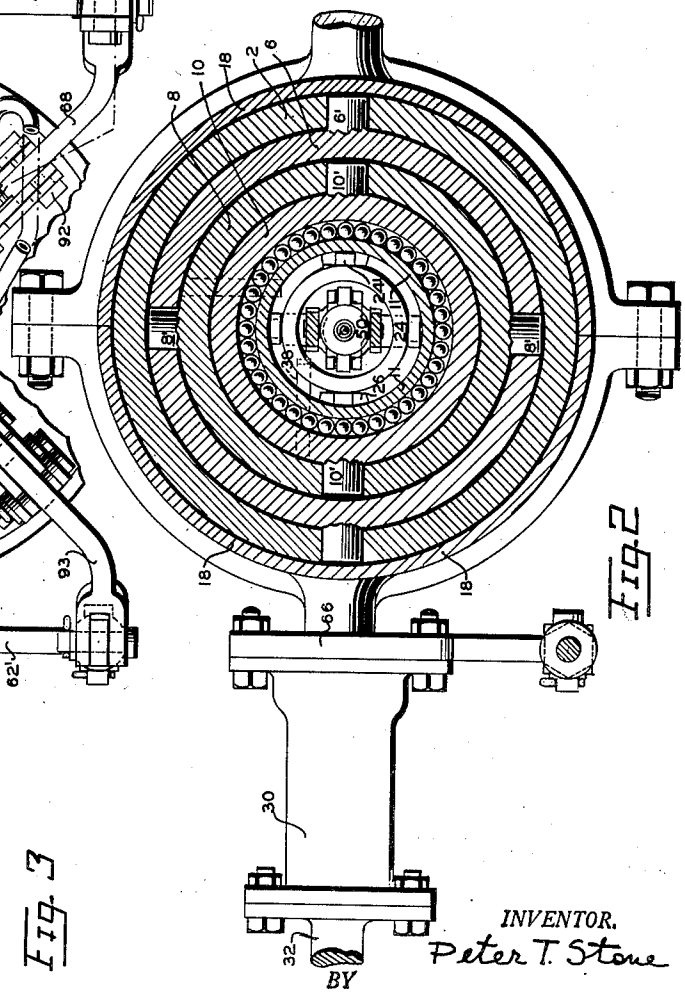
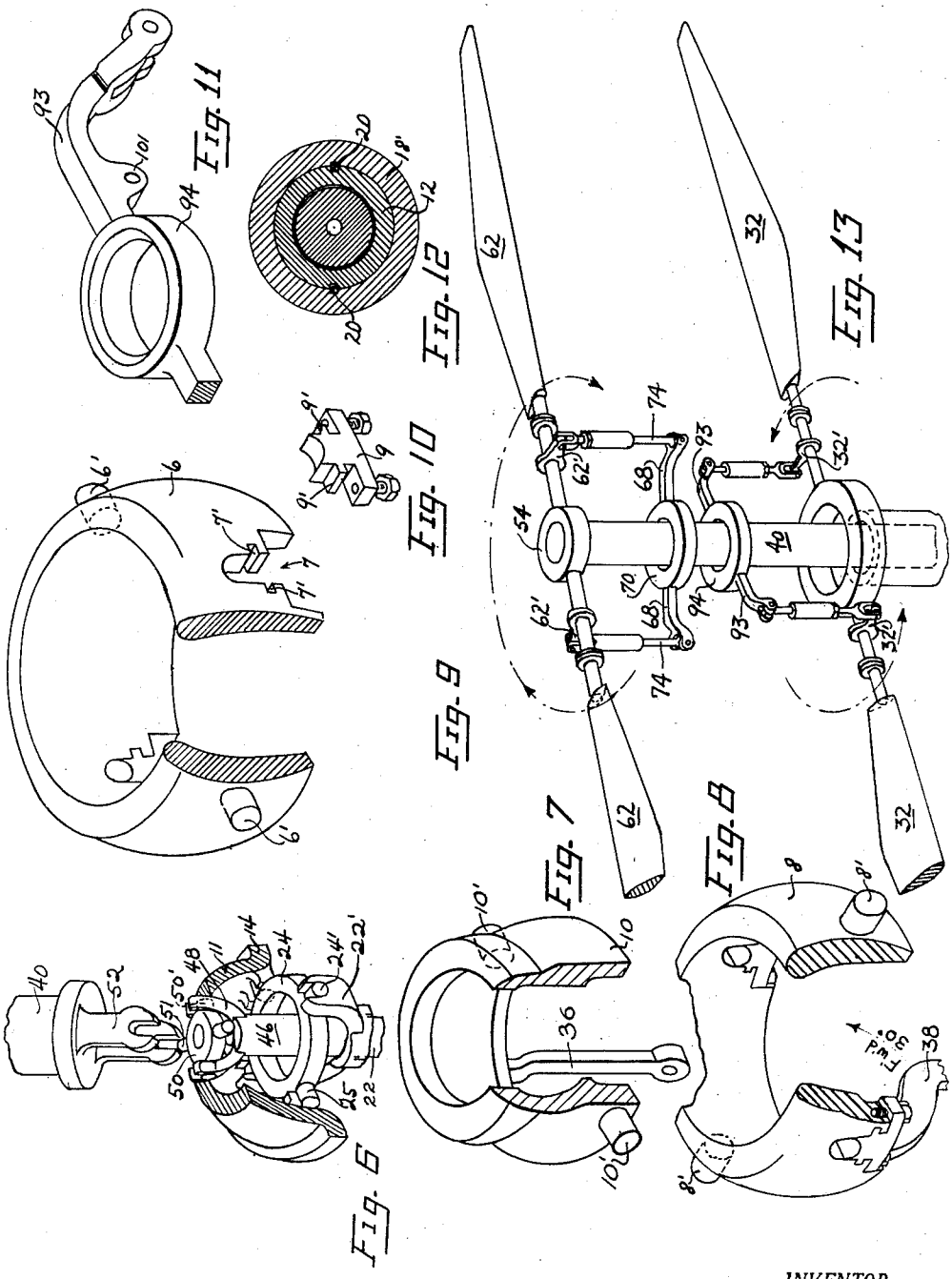


Fig. 2

INVENTOR.
Peter T. Stone
BY
Fisher & Christen,
Attorneys.

Nov. 10, 1953 PIOTR F. LAPIDOVSKY 2,658,575
NOW BY JUDICIAL CHANGE OF NAME
PETER T. STONE
HELICOPTER ROTOR

Filed July 17, 1946 3 Sheets-Sheet 3



INVENTOR.
Peter T. Stone.
BY
Fisher & Christen
Attorneys.

Patented Nov. 10, 1953

2,658,575

UNITED STATES PATENT OFFICE

2,658,575

HELICOPTER ROTOR

Piotr F. Lapidovsky, now by judicial change of name Peter T. Stone, Wilmington, Del.

Application July 17, 1946, Serial No. 684,373

7 Claims. (Cl. 170—135.26)

1

This invention relates to helicopters, and is particularly concerned with the blade mounting, where either one or two sets of rotating blades is used.

The principal object of the invention is to provide a blade mounting where the blades are tiltable as a unit about a point which is midway between a set of rotating blades and in axial alinement therewith.

Another object of the invention is to provide a blade assembly where two sets of blades rotate in opposite directions, and are tiltable as a unit about a point which is midway between the lower set of rotating blades and in axial alinement therewith.

Another object of the invention is to provide an improved assembly for either a single set of rotating blades or a double set, where the two sets rotate in opposite directions, as usual.

Another object of the invention is to provide an improved mechanism varying the angle of incidence of each of the blades, whether a single set or a double set is used.

Reference is now made to the accompanying drawings illustrating the preferred way of carrying out the invention.

In these drawings:

Fig. 1 is a central vertical longitudinal section of the helicopter, taken substantially on line 1—1 of Fig. 3;

Fig. 2 is a horizontal section taken on line 2—2 of Fig. 1;

Fig. 3 is a horizontal section taken substantially on line 3—3 of Fig. 1;

Fig. 4 is a perspective view of a lock plate;

Fig. 5 is a detail perspective view of the upper hub and portions of the attached axles;

Fig. 6 is a sectional perspective view of the central drive shaft structure;

Fig. 7 is a sectional perspective view of the innermost, revoluble rocking bearing member;

Fig. 8 is a perspective view, partly in section, of the first, innermost rocking member;

Fig. 9 is a perspective view, partly in section, of the outermost rocking member;

Fig. 10 is a detail perspective view of one of the plate inserts for the rocking members, serving to retain the trunnions in bearing positions;

Fig. 11 is a fractional perspective view of the mid-hub showing the arrangement of the actuating arm;

Fig. 12 is a cross section taken on line 12—12 of Fig. 1;

Fig. 13 is a schematic view of the rotor system and the feathering mechanisms therefor.

2

Referring now particularly to Fig. 1, 2 is the main supporting ring which is integral with or secured to downwardly extending arms 4, which are attached to the fuselage. Mounted just within ring 2 is the outer gimbal ring 6 having oppositely extending pivots 6', 6', pivotally mounted in suitable recesses in the main ring 2. 8 is an inner gimbal ring mounted just within ring 6, and provided with outwardly extended pivots 8', pivoted in suitable bearings in the outer ring 6. The axes defined by pivots 6', 6' and 8', 8' are at right angles to each other. Mounted just within the inner gimbal ring 8 is an inner supporting ring 10, having outwardly extending pivots 10', mounted in bearings in the inner gimbal ring 8.

For convenience in assembling the pivots 10' in ring 8, or pivots 8' in ring 6, the ring to receive the pivot may be recessed as shown at 7, Fig. 9, to receive a bearing fitting 9, Fig. 10, recess 7 including slots 7' for receiving shoulders 9' on the fitting.

A main annular rotatable drive collar 11 is mounted within ring 10, and extends for some distance above it. This collar 11 has annular flanges 13 and 14 cooperating with suitably formed portions of the ring 10 to define raceways for ball bearings 15 and 16.

An annular housing or dome 18 is keyed to the upper part of the main drive collar 11 by keys 20, so that dome 18 is rotated by the drive collar 11.

The main drive collar 11 and dome or casing 18 are driven, preferably clockwise, by a vertical drive tube 22, see Fig. 6, driven by the engine. This tube has forks 22' in which are seated pins 24' projecting from ring 24. Ring 24 has another pair of pins 25 which are seated in oppositely located sockets 26 carried on the interior of drive collar 11. Rotation of tube 22 therefore drives collar 11 and dome 18.

Dome 18 supports and drives the bearing housing 30 for the lower helicopter blades 32.

In order to tip the blade assembly for steering in one direction, ring 10, Fig. 7, is provided with a downwardly extending control arm 36, attached to the lower edge thereof; by actuation of this arm, the ring 10 and the blade assembly may be tilted about pivots 10'. In order to tip the blade assembly for steering in another direction, ring 6, Figs. 1 and 8, is provided with a downwardly extending control arm 38, by actuation of which ring 8 may be tilted about pivots 8', 8', a matter of 20°–30° or so. Arm 36 may be laterally offset as shown in Figure 7 to avoid tube 22. Arm 38 may be similarly offset.

From the described construction, the support-

ing and driving assembly for the lower blades 32 is free to pivot in any direction about the point P, which point is at the intersection of axial lines drawn through pivots 10', 10' and 8', 8'. This point would also be located at the center of ring 24 and would be in line with and directly above the center of gravity of the entire helicopter, including the fuselage, engine, fuel tanks, etc.

The blade assembly for the upper set of blades is supported, and driven in the opposite direction, by a main shaft 40. This shaft is journaled or swiveled inside collar 11; the lower portion of shaft 40 is flanged, and collar 11 is correspondingly shaped or grooved to provide raceways for ball bearings 42; further up, these parts are formed to provide raceways for ball bearings 44.

In order to drive shaft 40, drive tube 46, driven from the engine, is provided with a fork 48, Fig. 6, in the ends of which are seated pins 50', projecting from ring 50; ring 50 carries two other pins 51, engageable with a pair of forked members 52 secured to and projecting down from shaft 40. Lines drawn through the axes of the pins 50' and 51 would pass through point P.

The hub 54 for the upper set of blades is keyed to the upper end of shaft 40 by key 55 and is held in place by nut 56, the nut being locked in place by a U-shaped locking plate 57, Fig. 4, having a hexagonal hole 56' for nut 56. The hub carries a shaft or tube 58, on the outer part 59 of which is journaled the housings 60 for the upper blades 62.

The angle of incidence of all four blades is varied by hydraulic or pneumatic means. This comprises the mechanism shown in Fig. 1, and shown diagrammatically in Fig. 13.

The angle of incidence of the blades is controlled by movable control arms 62' for the blades 62, and by control arms 32' for the blades 32, these control arms being connected by bolts 64 to brackets 66, carried by and extending outwardly from blade housings 60 and 30.

The upper control arms 62' are pivoted to the outer ends of actuating arms 68, secured to or integral with a collar 70 surrounding shaft 40, so as to be movable a few inches up or down on the shaft, on ball bearings 72. This up and down movement of collar 70 is effected by a piston rod 74, pivoted at 74' to an arm 68, the piston rod having a piston working in a fluid pressure or pneumatic cylinder 76, held in place by arm 78. To increase the angle of incidence, fluid under pressure, such as oil or air, is supplied by pipe 80 to cylinder 76. When the fluid pressure is lessened, the reaction of the air on the blades reduces the angle of incidence. Fluid under pressure is supplied to pipe 80 from a central passage 82 in shaft 40, connected by a swivel connection 84 to a flexible, high pressure hose 86, leading to a suitable manual pressure control in the fuselage.

Arms 68 must turn with the helicopter blades; accordingly, they are linked to the hub 54 by heavy double links 88, pivoted at 89 to arms 68, and by similar links 90, conveniently pivoted at 91 to brackets 91', Fig. 4, carried by plate 57. The pair of links are pivoted to each other at 92. This linkage still permits up and down movement of collar 70 on shaft 40.

The other two actuating arms 93, for the blades 32, which rotate in the opposite direction, are connected with a collar 94, which is swiveled on collar 70 by ball bearings 95. These arms 93 are driven and steadied by heavy double links 96, pivoted by pins 97 to heavy lugs 98 projecting from

the outer surface of dome 18. Double links 99 are pivoted by pins 100 to lugs 101 formed on the underside of arms 93. Links 96 and 99 are pivoted to each other by pins 102. Since the collars 70 and 94, for the respective upper and lower actuating arms 68 and 93, are secured together, the piston rod 74, when pressure is applied, moves both collars, downward movement increasing the angle of incidence of all the helicopter blades; when the pressure is relieved, all blades will decrease their respective angles of incidence, due to the reactive effect of the air.

Summary of the operation

Referring particularly to Fig. 1, blades 32 are rotated in one direction by outer drive tube 22, which in turn drives ring 24 and main drive collar 11. Collar 11 drives dome 18 and blade housings 30 of the blades 32.

Blades 62 are rotated in the opposite direction by inner drive tube 46, which in turn drives ring 50 and drive shaft 40 and hub 54 for the upper set of blades, in the opposite direction.

The angle of incidence of each of the upper and lower blades is controlled by collars 70 and 94, which, while rotating in opposite directions, move as one up and down on shaft 40 a matter of a few inches, and move the upper actuating arms 68 and lower actuating arms 93, which cause all the blades to turn about their longitudinal axes in unison and in the same sense, that is, to greater or lesser angles of incidence.

The fulselage is suspended from the blade assembly by arms 4, the blade assembly being tiltable by control arms 36 or 38 about axes at right angles to each other. This tilting takes place about the point P, which may be regarded as at substantially the center of gravity of the assembly of the two lower blades 32 and their cooperating mechanism. That is to say, where only one set of blades, such as 32, is used, such single set of blades would pivot about the center of gravity of the assembly, which is at the point P. This point P is also in substantial vertical alinement with the center of gravity of the fuselage and its load, considered as a unit.

When a double set of blades is used, for greater lift, the reactive torque of one set balances the torque of the other set and the gyroscopic forces balance each other. The center of gravity of the double set assembly would be in the center of shaft 40, at about the level of collar 70. Tilting about point P, however, would displace this upper center of gravity only a very small amount out of the vertical, so that proper balance and control of the entire helicopter, fuselage and all, is not affected.

As will be apparent to one skilled in the art, the described controls may be actuated automatically, as well as manually.

While the preferred construction of the helicopter has been shown in detail, it should be understood that the invention is not limited to the exact details shown, but may be carried out in other ways.

I claim as my invention:

1. In a helicopter, a pair of supporting arms extending downwardly to the fuselage, a pair of cooperating gimbal rings pivoted between the upper ends of said arms, a supporting ring, pivoted within the inner ring of said pair of gimbal rings, a drive collar rotatably mounted within said supporting ring, a dome member driven by said collar, a lower set of helicopter blades carried by and driven by said dome member, an upwardly extending vertical shaft journaled in

said drive collar, an upper set of helicopter blades carried by and driven by the upper part of said vertical shaft, a universal joint for driving said drive collar, a second universal joint at the same level for driving said upwardly extending shaft, said universal joints being at the same level as the axes of said pair of gimbal rings, means for driving said universal joints in opposite directions for thereby rotating the two sets of blades in opposite directions, the entire assembly being tiltable about the center of said two universal joints.

2. The combination as set forth in claim 1, wherein the blades are axially tiltable, and further including a collar slidable on the intermediate portion of said upwardly extending vertical shaft, and means operatively connecting said slidable collar to said axially tiltable blades, whereby movement of said collar above said shaft serves to tilt all the blades for simultaneously varying their angles of incidence.

3. The combination as set forth in claim 1, wherein one of the cooperating gimbal rings that mount the lower set of helicopter blades is each provided with a downwardly extending control arm, a second control arm secured to said supporting ring, said control arms being set 90° apart, for effecting tilting movement of the entire assembly of lower and upper blades.

4. In a helicopter, means, including a dome member and a pair of cooperating gimbal rings, for mounting a lower set of helicopter blades for universal tilting movement, a supporting ring, pivoted within the inner ring of said pair of gimbal rings, a drive collar rotatably mounted within said supporting ring, and fixed to said dome member, a vertical drive shaft rotatably mounted within said drive collar, a second set of helicopter blades keyed to and driven by the upper part of said vertical drive shaft, a pair of concentric vertical oppositely driven members, and a pair of universal joints, respectively

connecting the upper ends of said oppositely driven members to said drive collar and to said vertical drive shaft, for thereby driving the two sets of helicopter blades in opposite directions.

5. The combination as set forth in claim 4, wherein the blades are tiltable on their own axes, and further including a collar slidable on the intermediate portion of said upwardly extending shaft, and means operatively connecting said slidable collar to the axially tiltable blades, whereby movement of said collar along said shaft serves to vary the angles of incidence of all the blades.

6. The combination as set forth in claim 1, wherein said center of said universal joints is in vertical alignment with the center of gravity of the helicopter.

7. The combination as set forth in claim 4, wherein said vertical drive shaft is in vertical alignment with the center of gravity of the helicopter.

PIOTR F. LAPIDOVSKY.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
954,574	Koegler	Apr. 12, 1910
1,294,361	Nash	Feb. 11, 1919
1,656,468	Braugh	Jan. 17, 1928
2,037,745	Vaughn	Apr. 21, 1936
2,074,342	Platt	Mar. 23, 1937
2,156,334	Bothezat	May 2, 1939
2,163,893	Schairer	June 27, 1939
2,230,811	Pecker	Feb. 4, 1941
2,264,943	Larsen	Dec. 2, 1941
2,394,846	Cox	Feb. 12, 1946
2,415,999	Frasher	Feb. 18, 1947
2,440,225	Pullin	Apr. 20, 1948
2,444,070	Stanley	June 29, 1948
2,450,491	Solovioff et al.	Oct. 5, 1948