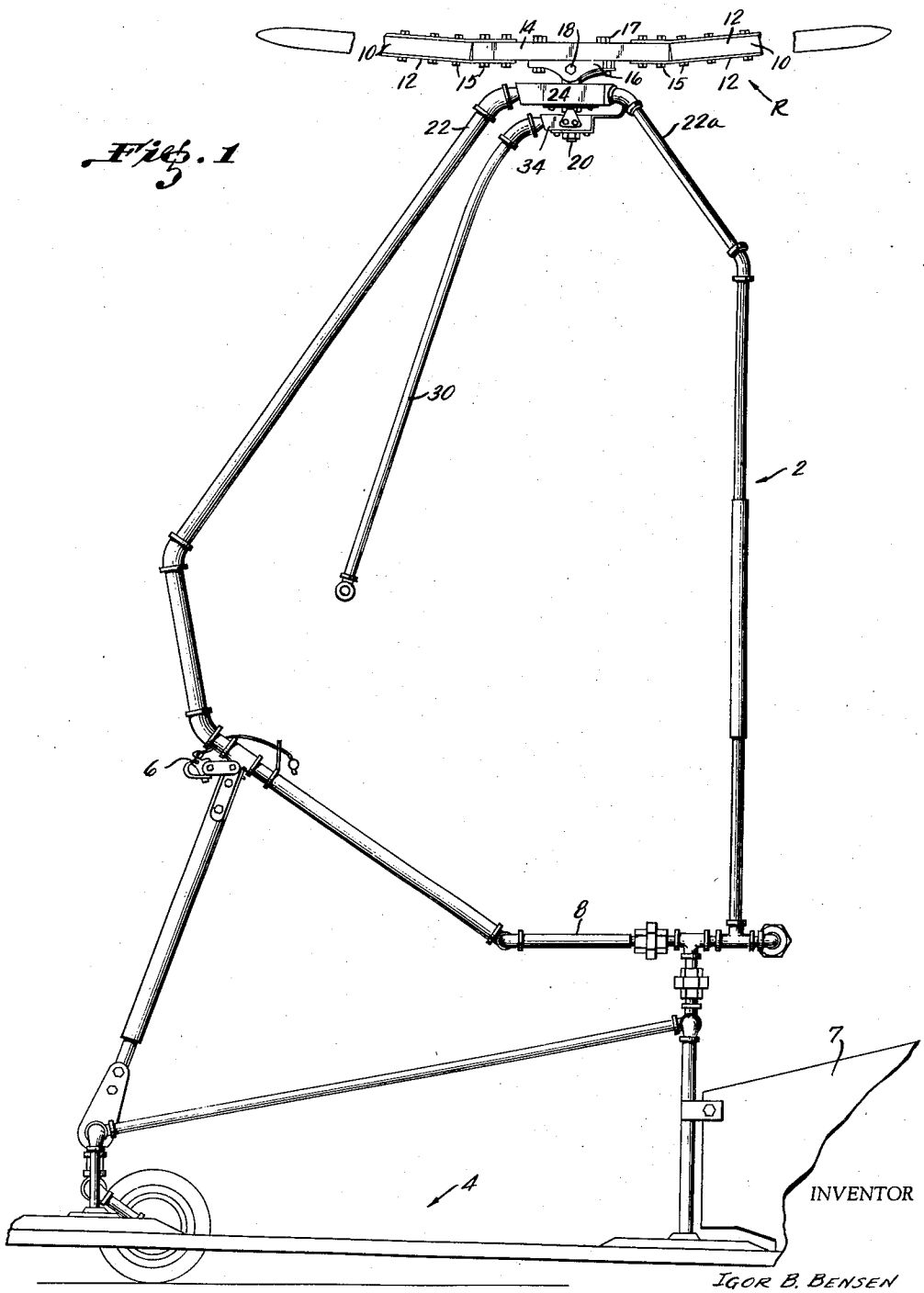
Nov. 25, 1958 I. B. BENSEN 2,861,641

CONTROL MOUNTINGS FOR HELICOPTER ROTORS

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Fig. 1



INVENTOR
IGOR B. BENSEN

BY James H. Littlefield

ATTORNEY

Nov. 25, 1958 I. B. BENSEN 2,861,641

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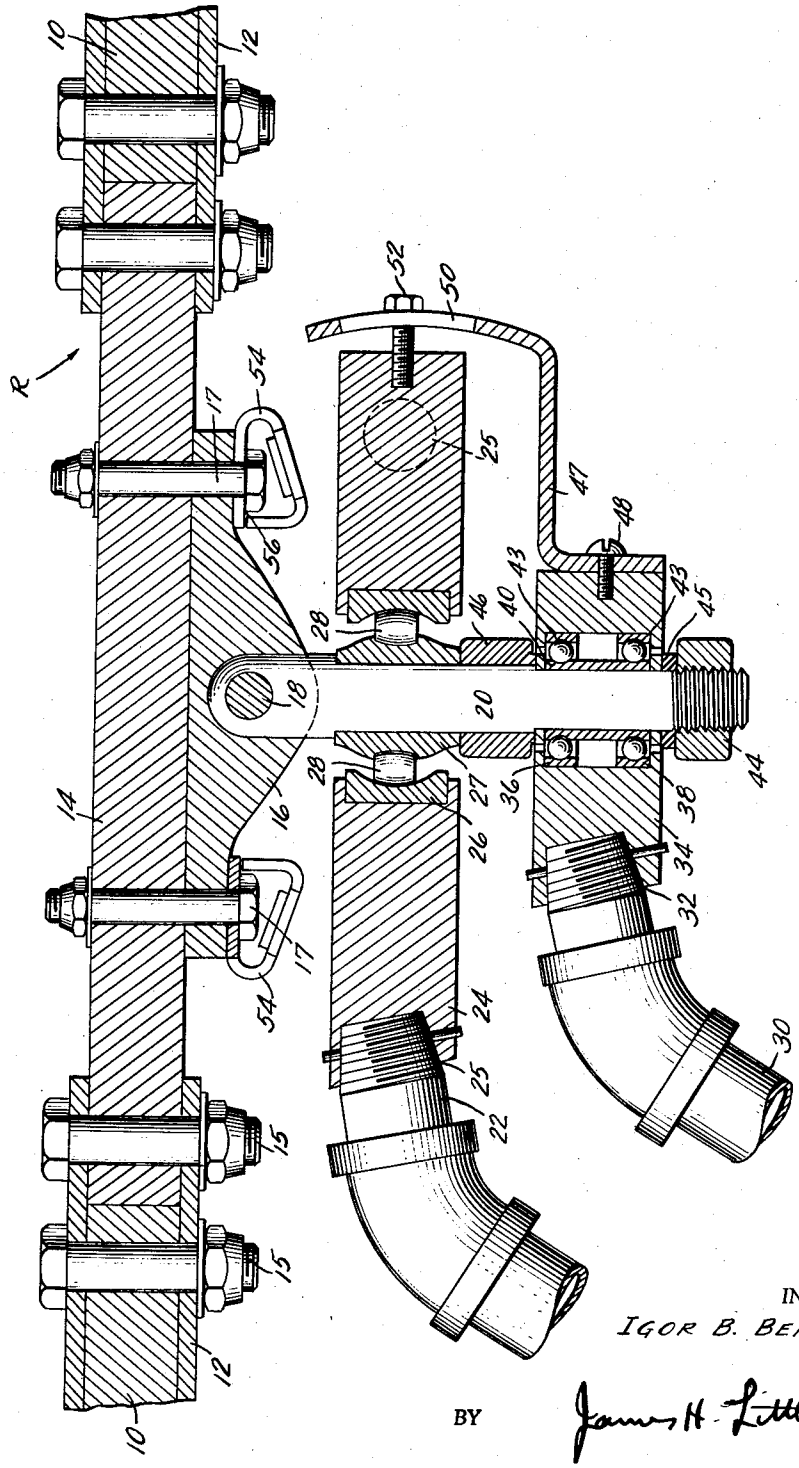


Fig. 2

INVENTOR
IGOR B. BENSEN

BY James H. Littlepage

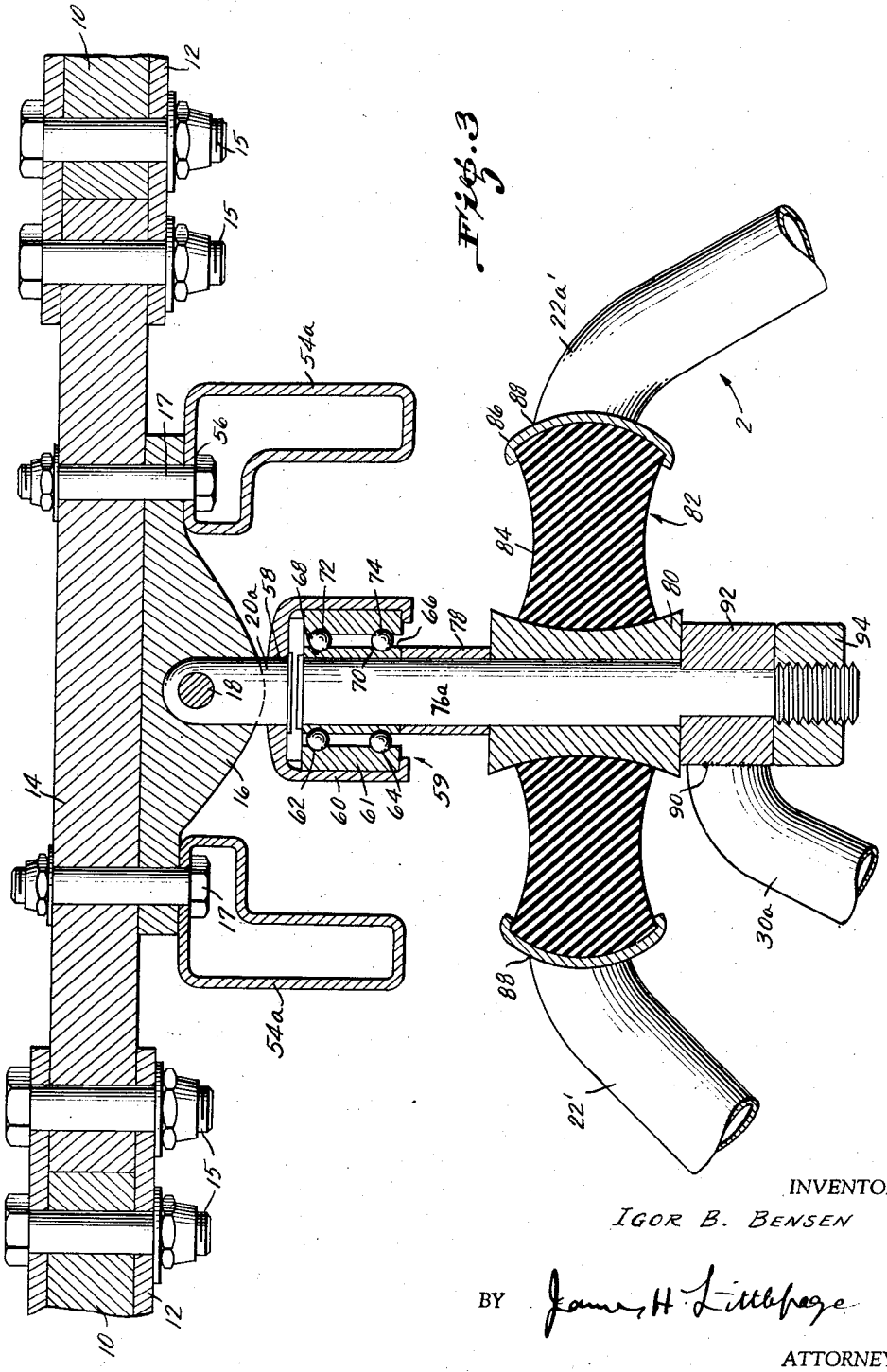
ATTORNEY

Nov. 25, 1958 I. B. BENSEN 2,861,641

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Fig. 3



INVENTOR

IGOR B. BENSEN

BY James H. Littlefield

ATTORNEY

Nov. 25, 1958 I. B. BENSEN 2,861,641

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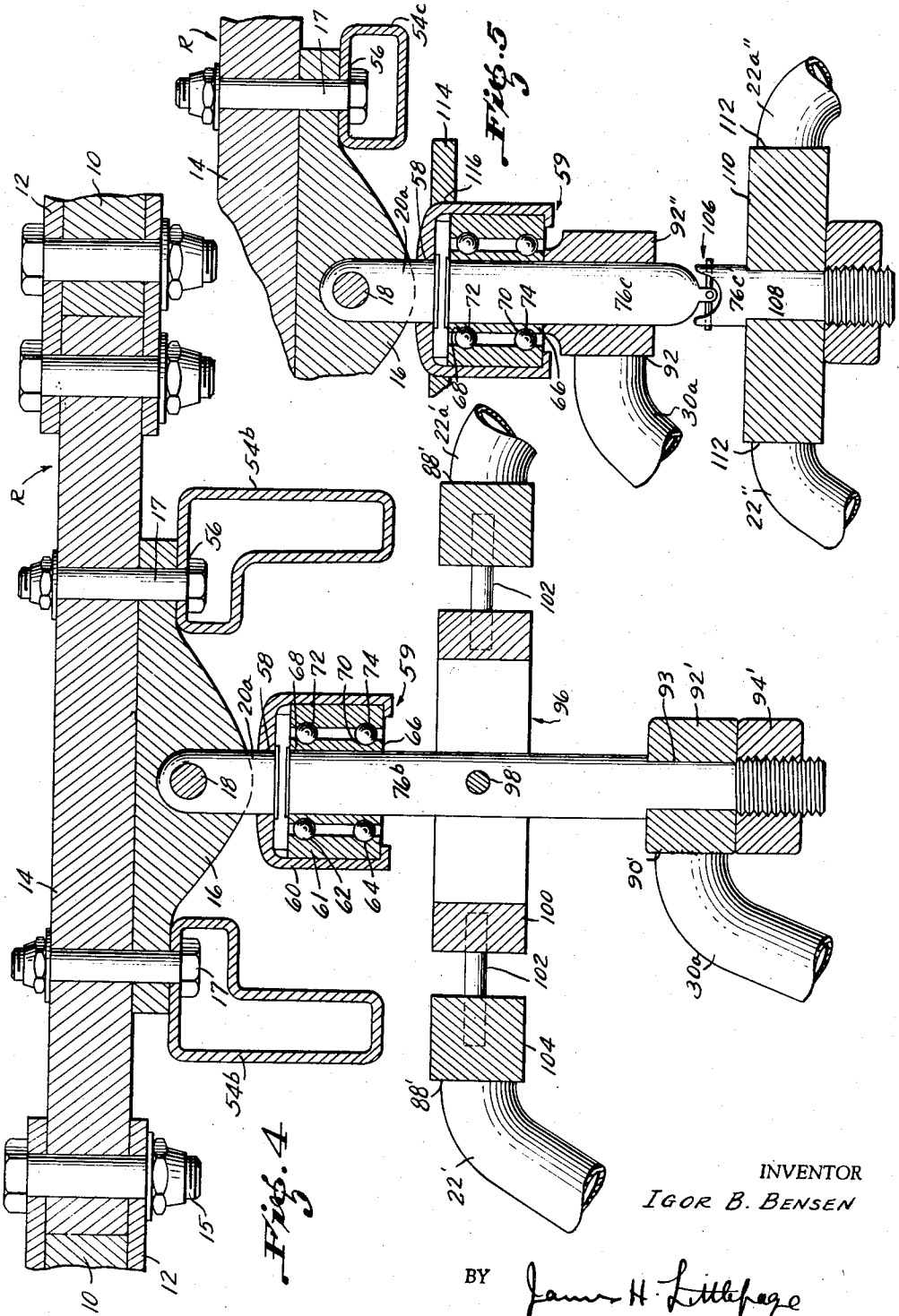


Fig. 4

Fig. 5

INVENTOR
IGOR B. BENSEN

BY James H. Littlepage
ATTORNEY

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CONTROL MOUNTINGS FOR HELICOPTER ROTORS

Igor B. Bensen, Raleigh, N. C.

Application February 28, 1955, Serial No. 490,883

2 Claims. (Cl. 170—160.27)

This invention relates to helicopters and, more particularly, to combined rotor mount and control assemblies.

The object of the invention is to provide an extremely simple, light and durable assembly for mounting a rotor on the top of a fuselage, whereby the axis of rotation of the rotor may be universally tilted, and whereby the pilot maintains direct and instinctively natural control over the tilting adjustments of the rotor.

More particularly, it is intended now to provide a generally vertical rotor shaft pivotally mounted on the fuselage above the pilot seat of a helicopter, the rotor turning on the shaft above the fuselage, and a control stick extending downwardly from the rotor shaft so that when the control stick is swung forwardly and rearwardly, or from side to side, the rotor shaft is correspondingly tilted about its pivotal mounting, and the rotor follows the tilting of the rotor shaft. The instinctively natural reaction obtained by the control system of this invention has to do with the native balancing reactions of a pilot, i. e., when he desires to travel to the right, for example, the natural motion of a control stick suspended from a point above the pilot is to the left. Similar reactions prevail for the up-and-down tiltings of the helicopter obtained in this instance by back and forward motions of the control stick.

The illustrated embodiments of the invention are in association with a gyro glider, although it will be apparent that the invention may be adapted to powered helicopters, wherein the saving of weight, simplicity of construction, and ease of operation are of the essence. In contrast with the usual control systems utilizing blades individually pivoted on a hub for adjustment about their feathering axes to vary the total and cyclic pitch, and comparatively elaborate linkage for controlling the blades, this invention provides a tiltable rotor shaft, and a rotor hub pivotally mounted on the rotor shaft so that the axis of rotation of the teetering rotor will follow the tilting motions of the rotor shaft.

In one embodiment of the invention, it is intended that the rotor shaft shall turn with the rotor, the rotor hub being rockably mounted on the rotor shaft, and the rotor shaft being rotatably mounted in a spherical bearing in the top of the fuselage so that the rotor shaft may be universally tilted from its normally vertical position.

In second, third and fourth forms of the invention, the rotor hub is mounted through a teeter hinge over a straight thrust bearing on a non-rotating rotor shaft so that the rotor will both turn and teeter on the non-rotating shaft. Provision is made for tilting the rotor shaft with respect to the fuselage on which it is mounted, one form including a resilient bearing in the fuselage, another form consisting of gimbals, and still another form comprising a universal joint.

These and other objects will be apparent from the following specifications and drawings, in which:

Fig. 1 is a side elevation of a gyro glider embodying one form of the invention;

Fig. 2 is an enlarged view of the upper portion of the fuselage illustrating in vertical cross-section, the details of the Fig. 1 embodiment;

Fig. 3 is a view similar to Fig. 2 but illustrating a second form of the invention;

Fig. 4 is a view similar to Figs. 2 and 3 but illustrating a third form of the invention; and,

Fig. 5 is a fragmentary view similar to Figs. 2, 3 and 4, but illustrating a fourth form of the invention.

Referring now to the drawings in which like reference numerals denote similar elements, the gyro-glider illustrated in Fig. 1 comprises a fuselage **2** of open-box-like configuration having a landing gear **4**, and a cable hitch **6** by which it is towed. Fins **7** stabilize flight and counteract tendencies toward side thrusts resulting from resilient function in the hub. The pilot sits in a seat **8**, and lift results from rotation of a rotor R comprising rotor blades **10** fastened by plates **12** at their inner ends to a rotor hub **14** by bolts **15**. Pillow blocks **16** fastened as indicated at **17** at the center of hub **14** are connected by a teeter pin **18** to the upper end of a rotor shaft **20** which is supported generally vertically between the converging ends of the members **22**, **22***a* at the upper end of the fuselage. It will be understood that while in the present embodiment there are three such members converging inwardly and upwardly from the respective corners of the fuselage, that various other fuselage structures and configurations may be used. This invention is concerned primarily with the mounting of rotor shaft **20** in fuselage **2**, the mounting of rotor hub **14** on the rotor shaft, and their relationship to the control stick **30** detailed hereinafter.

Referring now to Fig. 2, there is shown an annular plate-shaped rotor head bearing block **24** secured, as at **25**, to the inner ends of fuselage members **22**, the rotor head bearing block supporting in its inner periphery an outer race of a spherical bearing **26**. An inner bearing race **27** affixed around rotor shaft **20** rollingly supports a plurality of barrel-shaped rollers **28** so that, thus rotatably mounted, rotor shaft **20** is free to tilt, within certain prescribed limits, from the vertical. It will be understood that conventional bearing retainers and installation structures are used with the bearing parts.

Control stick **30**, which extends downwardly in front of the pilot station, is fixed, as at **32**, to a control stick bearing housing **34** having, near its center, a pair of outer ball races **36**, **38** lying opposite inner ball races **40**, **42** on shaft **20**. Bearing balls **43** rolling between the inner and outer races provide for free rotation of shaft **20** within the control stick bearing housing. A nut **44** and washer **45** hold the assembly on the lower end of shaft **20**, and a spacer **46** separates the bearing assemblies from one another. Thus, when control stick **30** is swung in one direction or another, rotor shaft **20** is correspondingly tilted from its normal generally vertical position.

An anti-rotation and travel-limit coupling is provided between the rotor head bearing block **24** and control stick bearing block **34**, this being a guide strip **47** secured as at **48** to control stick bearing block **34** and provided, near its other end, with a slot **50** through which projects a pin bolt **52** rigidly projecting from rotor head bearing block **24**. By this means, control stick **30** is prevented from turning with rotor shaft **20**, and limits the motion of the rotor shaft **20** in its spherical bearing **26** by abutting engagement of pin bolt **52** with the ends of slot **50**. The teeter motion of rotor R is limited by stops **54** secured as at **56** to the hub bolts **17** so that teetering of the rotor assembly beyond desired limits

is prevented by engagement of stops 54 with the top of rotor head assembly block 24.

When control stick 30 is, for instance, pulled back, rotor shaft 20 tilts in spherical bearing 26 so that its upper end tilts forwardly. As the rotor R teeters about teeter pin 18, its axis of rotation soon follows and coincides with the axis of rotor shaft 20 so that a forward drive and upward lift of the craft is imparted by rotor R.

Tilting of the control stick to the right or left results in differential pitch control of the opposite blades 12, 12 in that the angle of attack of the blade momentarily disposed towards the front of the craft is increased, whereas the attack angle of the blade momentarily at the rear is correspondingly decreased.

In the embodiments illustrated in Figs. 3, 4 and 5, the structure and mounting of rotor R on teeter pin 18 is the same as in Figs. 1 and 2. However, rotor shaft 20*a* is affixed, as at 58 on a straight thrust bearing 59 having a housing 60, containing a cylinder 61 having outer bearing races 62, 64 therein. A sleeve 66 is formed with inner bearing races 68, 70 so that bearing ball sets 70, 72 rotatably support rotor shaft 20*a*.

Referring now to Fig. 3, sleeve 66 of the thrust bearing assembly is affixed around a post 76*a*. Around post 76*a* are affixed a spacer 78 and the inner metal annulus 80 of a resilient mount 82 which supports the rotor assembly on fuselage 2. An annular disc 84 of resilient material, such as rubber, fits tightly around inner annulus 80 and is confined within an outer metal annulus secured at 88 to the inner ends of fuselage members 22', 22*a*'. Below inner annulus 80, control stick 30*a* is welded at 90 to a mounting sleeve 92 held on post 76*a* by a nut 94 threaded on the lower end of the post. Teeter motion stops 54*a* secured at 56 by bolt 17 engage the top of outer annulus 86 so as to limit the teeter motion.

In operating the Fig. 3 embodiment, rotor R teeters about pin 18, and shaft 20*a* is rotatably mounted by thrust bearing 59 on post 76*a*, the entire assembly being universally tiltable by manipulating control stick 30*a*. The resilient disc 84 provides elastic centering forces tending to return post 76*a* to its normally vertical position. Disc 84 also absorbs vertical vibration and prevents rotation of control stick 30*a* about the rotor axis.

The embodiment illustrated in Fig. 4 is comparable to that of Fig. 3 except in that post 76*b* is supported for universal tilting movement by gimbals 96, which include a pivot pin 98 extending across an inner ring 100 and through post 76*b*, and transverse pivot pins 102 pivotally supporting inner ring 100 in an outer ring 104, the outer ring being fastened at 104 to fuselage members 22', 22*a*'. Control stick 30*a* is secured at 90' to a sleeve 92' held on the reduced lower end 93 of post 76*b* by nut 94' threaded around the lower end of the post. As in the previous embodiments, teeter motion stops 54*b* are secured at 56 by bolt 17 to hub 14 so that, upon predetermined teetering of rotor R, outer gimbals ring 104 is engaged by stop 54*b* to prevent excessive teetering motion.

In the Fig. 5 embodiment, the supporting post for thrust bearing 59 is formed with upper and lower portions 76*c*, 76*c*' connected by a universal joint 106 so that rotor R may be universally tilted. Affixed around upper portion 76*c* above the universal joint is a sleeve 92'' to which control stick 30*a* is welded, as at 92. The reduced lower end 108 of lower post portion 76*c*' is supported in an apertured base plate 106 in which the inner ends of fuselage frame members 22'', 22*a*'' are affixed at 112. Tilt limit stops, not shown, are mounted on base plate 110 to engage upper post portion 76*c* on four sides thereof upon predetermined tilting of the assembly above the universal joint 106, thereby stopping upper post portion 76*c* and the elements supported thereon from flopping over when rotor R is inactive, but permitting sufficient universal tilting of upper post portion 76*c* to effect the desired controls. A teeter stop 54*c* secured at 56 by bolt 17 to hub 14 engages an abutment collar 114 welded at 116 around bearing housing 60 to prevent excessive teetering of rotor R.

The invention has been found to be particularly useful in a gyro-glider of such elementary form that it can be assembled by beginners who, self-taught, learn to fly it by being towed behind an automobile or by practicing in the prop-wash of an airplane, or simply kiting in a strong wind.

The invention is equally applicable to powered helicopters and all other types of rotary ring aircraft.

The invention described above is not limited to the illustrated details, but is intended to cover all substitutions, modifications and equivalents within the scope of the following claims.

I claim:

1. In a rotating wing aircraft, a fuselage, a rotor comprising a hub and blades affixed to and radiating therefrom, a normally generally vertical rotor shaft, bearing means rotably supporting said hub on said shaft whereby the rotative plane of said blade may tilt with respect to the axis of said shaft, universal pivot means supporting said shaft in said fuselage whereby said shaft may be tilted with respect to said fuselage, said universal pivot means comprising a resiliently deformable supporting member connected at spaced portions thereof to said shaft and fuselage, respectively, said member providing elastic centering forces tending to maintain said shaft vertical and providing a resilient support for said shaft in said fuselage, and control means for tilting said shaft, said member comprising a generally flat annular disc having inner and outer peripheries, the connection at spaced portions thereof to said shaft and fuselage comprising means affixing the inner periphery of the disc around the shaft and means affixing the fuselage to the outer periphery of the disc, substantially the entire weight of the aircraft being supported by said disc.

2. In a rotating wing aircraft, a fuselage including a plurality of frame members converging at the upper end of the frame, a ring rigidly affixed to the converging ends of said frame members, a substantially flat annular disc of resiliently deformable material having an outer periphery compressed within said ring, said disc being disposed substantially horizontally and the diametrical extent of the material forming the upper and lower sides thereof being substantially greater than the axial thickness thereof, a normally vertical shaft extending axially within the inner periphery of the disc, means substantially rigidly affixing the inner periphery of the disc around said shaft, a bearing rotatably mounted on said shaft above said disc, a rotor comprising a hub and blades radiating therefrom, a teeter connection between said hub and said bearing, and a control stick rigidly affixed on said shaft below said disc, the resilient deformability of said ring providing for universal tilting movements of said shaft by said control stick and also providing elastic centering forces tending to maintain said shaft in vertical disposition.

References Cited in the file of this patent

UNITED STATES PATENTS

2,224,357	Pecker	Dec. 10, 1940
2,264,942	Larsen	Dec. 2, 1941
2,429,502	Young	Oct. 21, 1947
2,510,006	Young	May 30, 1950
2,631,679	Hiller	Mar. 17, 1953
2,658,575	Stone	Nov. 10, 1953
2,677,431	Prince	May 4, 1954
2,689,011	Zakhartchenko	Sept. 14, 1954
2,702,601	Nagler	Feb. 22, 1955

FOREIGN PATENTS

459,070	Canada	Aug. 23, 1949