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[54] **ROTOR HUB AND BLADE FOLDING SYSTEM**
18 Claims, 8 Drawing Figs.

[52] U.S. Cl. 416/1,
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[51] Int. Cl. B64c 27/10,
B64c 27/50
[50] Field of Search. 416/142,
143, 121, 124, 1

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ABSTRACT: A system for folding a first pair of rotor blades with a second pair of rotor blades in rotary wing aircraft. Each pair of rotor blades is attached to a separate hub arrangement. The first hub is fixed to the mast for rotation therewith in the normal fashion. A second hub is mounted on the mast and is movable, along splines, up and down the mast from an upper end position to a lower end position. When the second hub is in the upper end position, the second hub is keyed, by virtue of the splines, to the mast for rotation with the mast. Thus, when in the upper end position, the second hub, like the first hub, will rotate with the mast and the rotor blades will rotate in their normal fashion. However, the second hub may be lowered along the splines to the lower end position. When in the lower end position, the second hub is free to rotate relative to the mast. Thus, when the second hub is moved down the mast to the second end position, it may be rotated relative to the first hub to cause the second pair of rotor blades to align or fold with the first pair of rotor blades and reduce the space requirements, transverse to the rotary wing aircraft, for stowage.

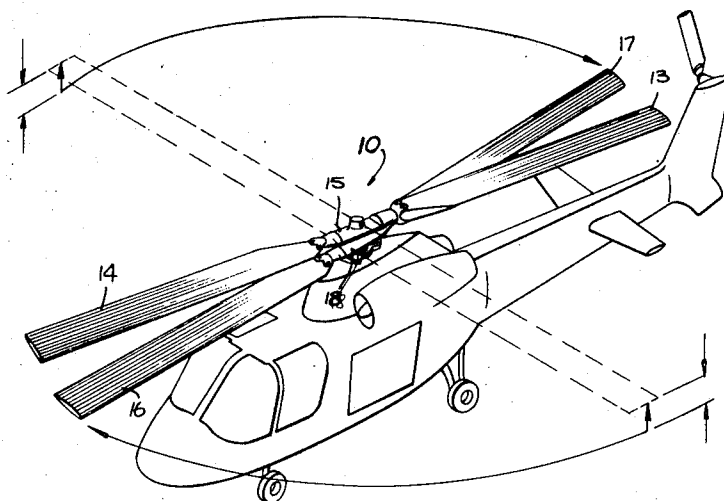
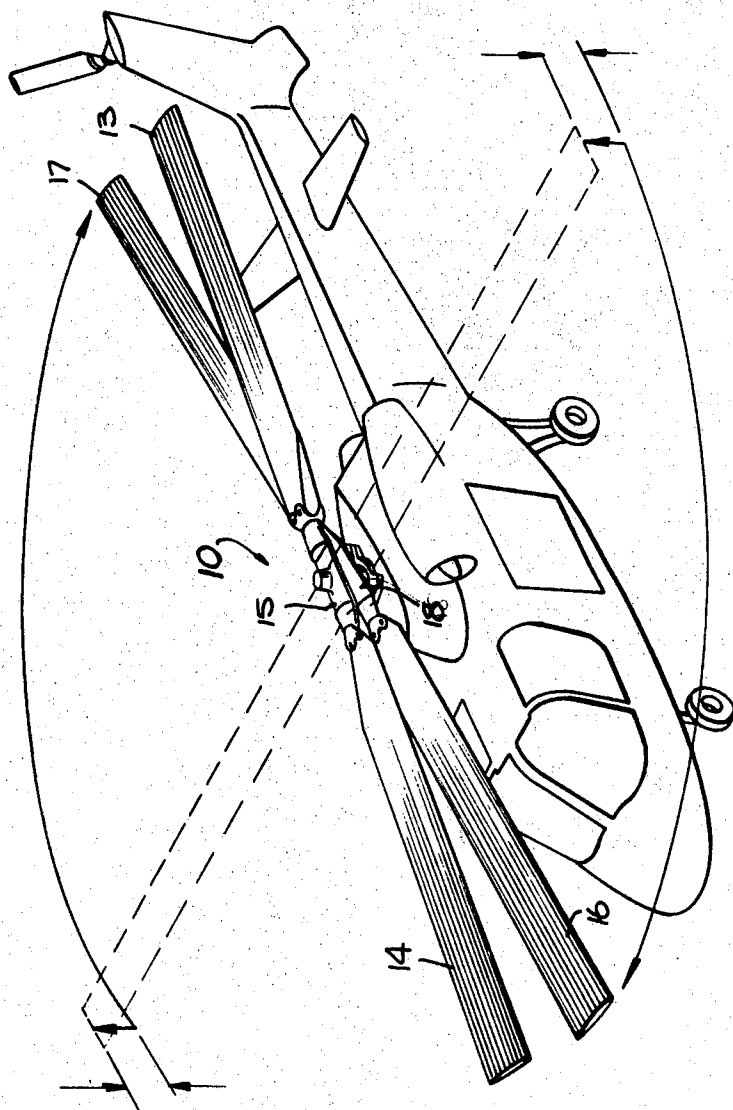


Fig. 1.



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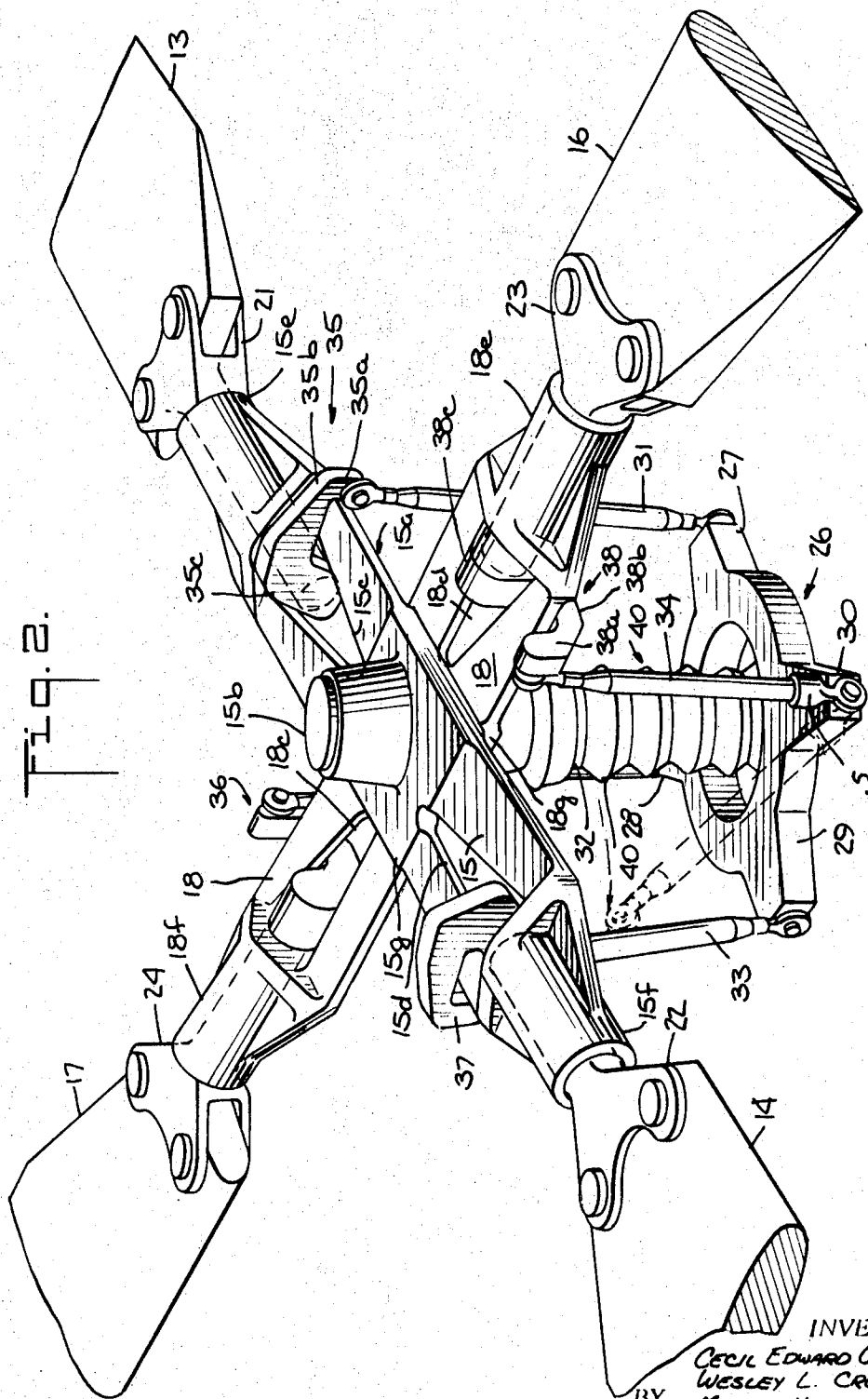


Fig. 2.

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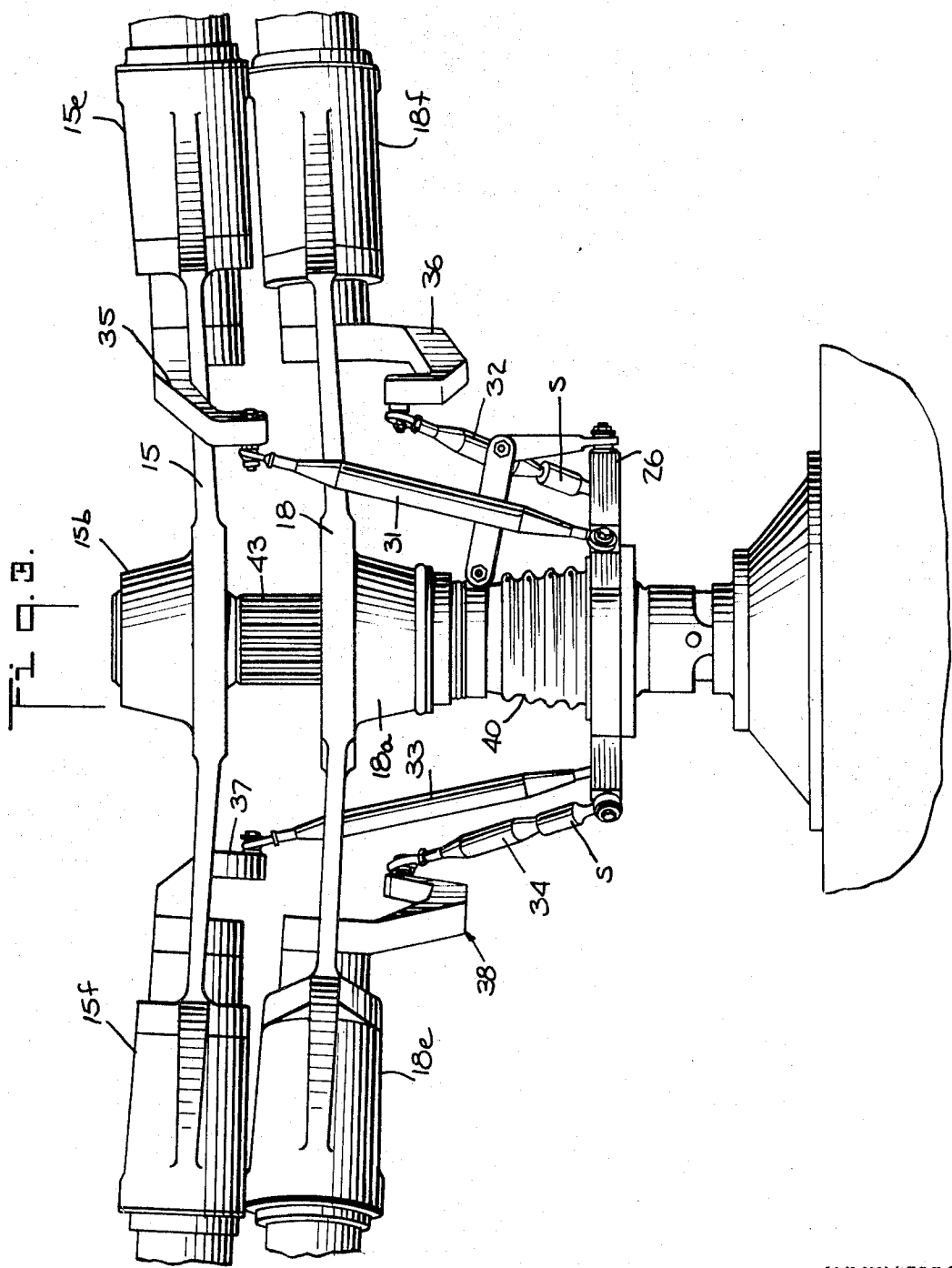
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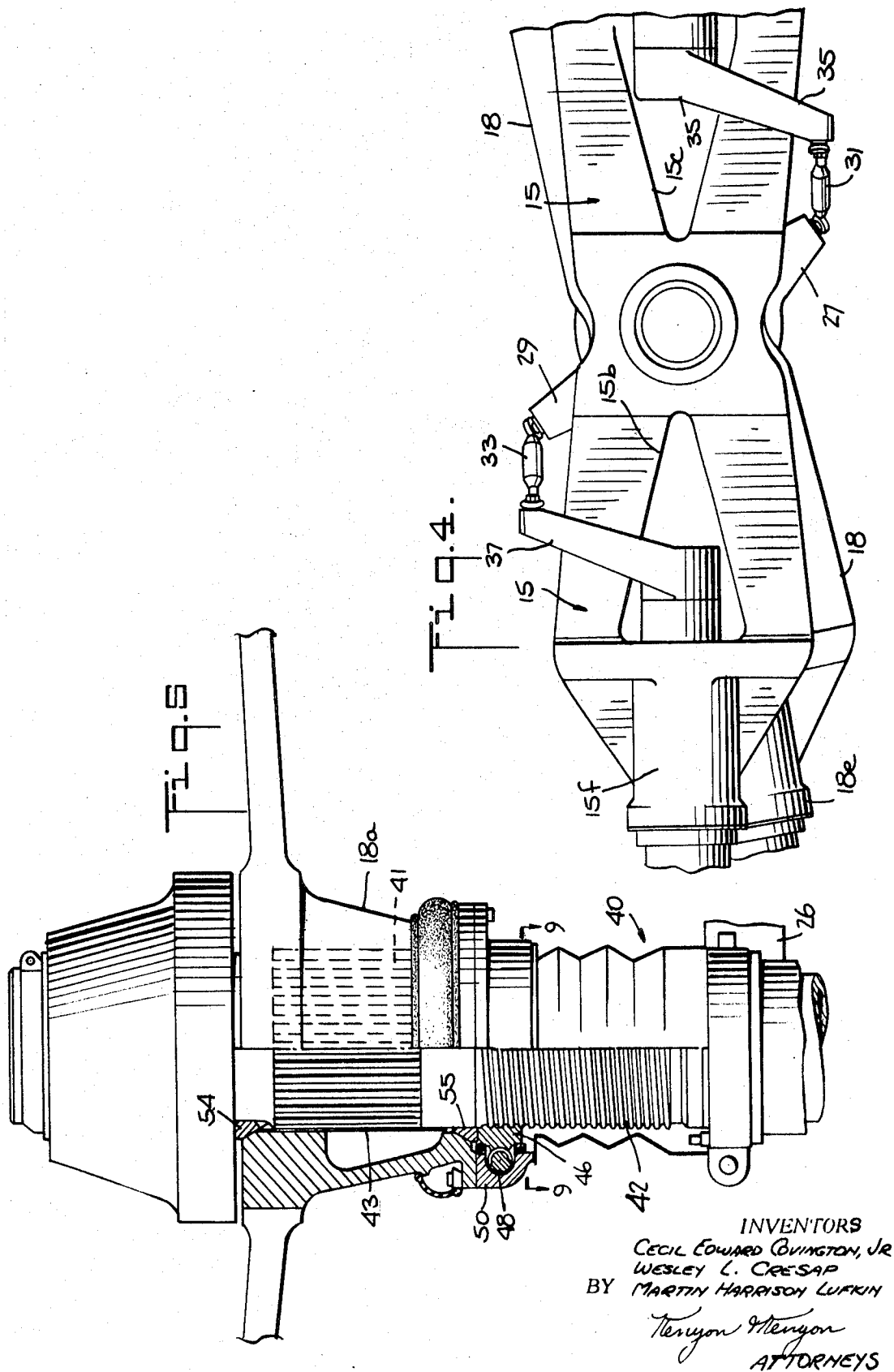
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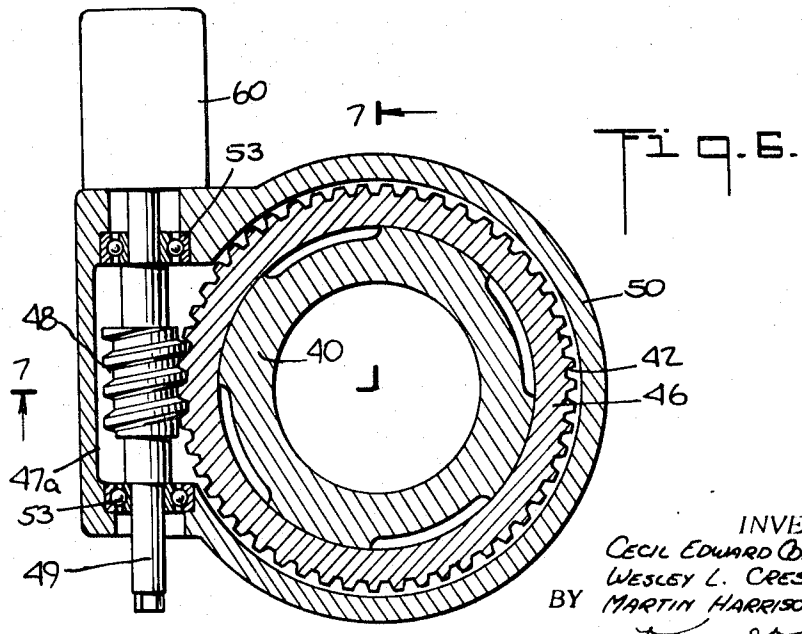
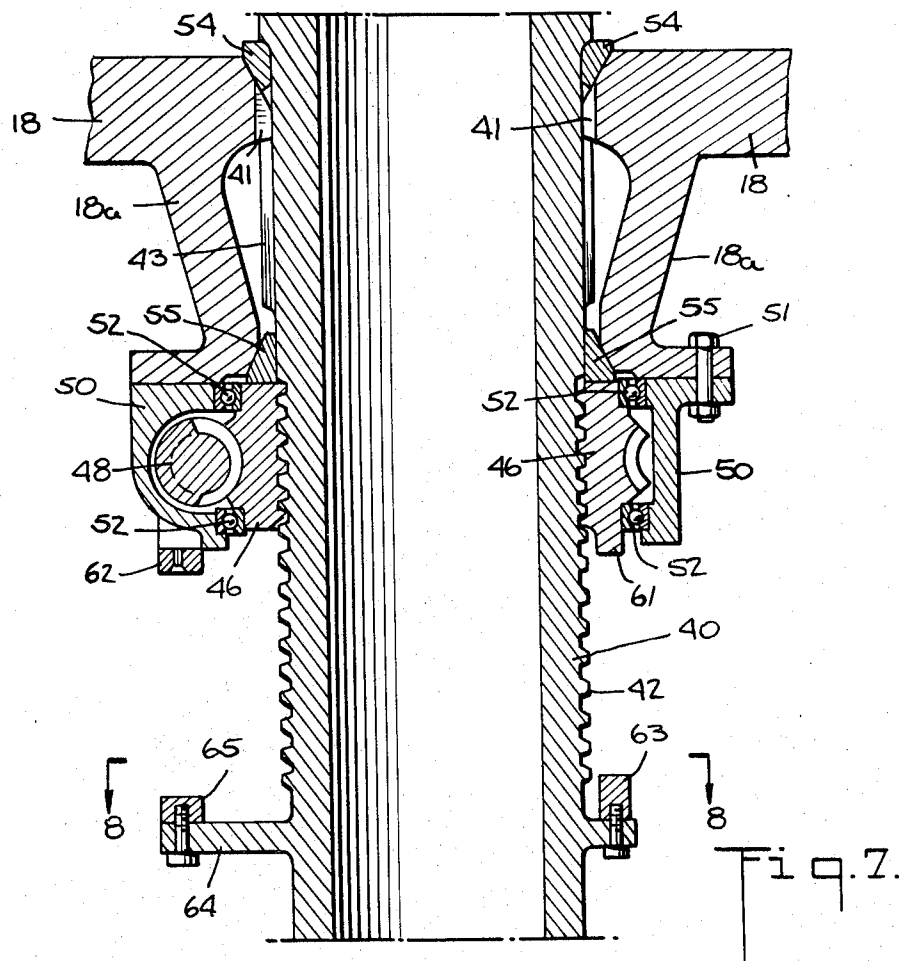
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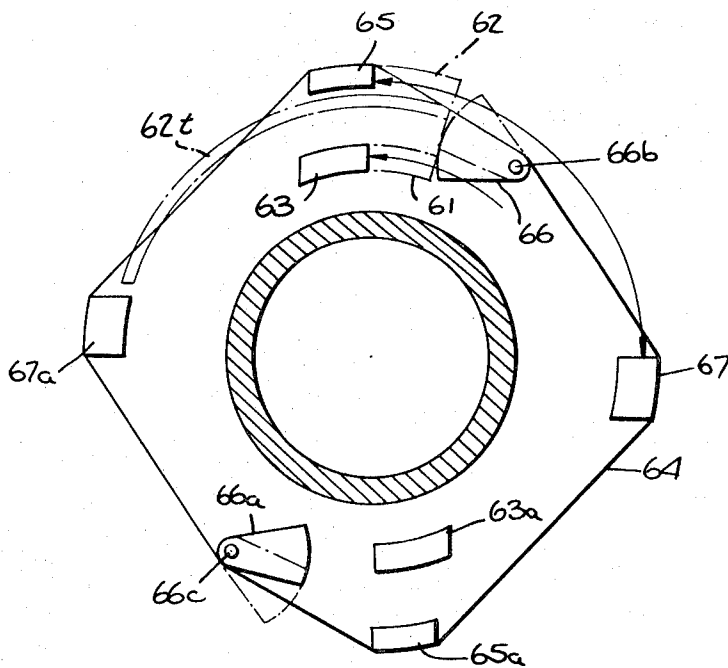


Fig. 8.

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ROTOR HUB AND BLADE FOLDING SYSTEM

This invention relates to a technique for folding rotary wing aircraft blades relative to one another and more particularly to a technique for folding a four-bladed helicopter rotor system either on the ground for storage or in-flight on a composite aircraft.

BACKGROUND OF THE INVENTION

When it is desired to park helicopters having more than two blades for a period of time, as during transportation and for servicing, it is desirable to minimize the area that each helicopter will require so that as many helicopters as possible can be parked in a given area. One way to minimize the amount of space required for a parked helicopter is to fold the blade assemblies relative to one another and align them along the longitudinal axis of the helicopter fuselage.

The large stowage space requirement does not arise in connection with two bladed helicopters since the two blades (which constitute a single blade assembly) can be aligned with the longitudinal axis of the helicopters during stowage. However, in a four-bladed helicopter, constituting two blade assemblies normally perpendicular to one another, this space problem becomes significant. Folding one of the two blade assemblies relative to the other blade assembly and aligning both blade assemblies along the longitudinal axis of the fuselage will serve to reduce the amount of space required by the helicopter in a direction lateral to the helicopter fuselage.

An additional application of this folding feature is to provide in-flight rotor blade folding on vertical takeoff high-speed composite aircraft. Furthermore, this folding feature can be employed to provide folding of a four-bladed rotary assembly of a size or function such that it might be deemed a propeller assembly.

There are known techniques for aligning multiple helicopter blade assemblies along the helicopter fuselage. These known techniques generally require a complicated system of actuators and lockpins; the lockpin device being required to hold the helicopter blade assemblies fixed relative to each other, particularly during flight conditions. Other problems that arise in known proposed systems is that such systems are frequently very heavy and do not maintain their center of gravity throughout the folding and aligning sequence.

It should be noted herein that the process of rotating one of the helicopter blade assemblies relative to the other so that both can be aligned with the helicopter fuselage is called "folding." This is the term by which this technique has become known in the art and distinguishes from the aligning of the blade assemblies with the fuselage itself. The folding may or may not be complete. The two rotor blade assemblies may be folded by an amount sufficient to reduce the lateral space requirements to whatever degree is required.

Accordingly, it is a major object of the invention to provide a helicopter rotor blade system in which the rotor blade assemblies can be reliably and simply folded and unfolded relative to one another without compromising in any way the safety of the helicopter when it is airborne.

Another object of this invention is to provide such a rotor blade assembly folding and unfolding system that will operate without significantly shifting the center of gravity of the helicopter during the folding or unfolding operation.

SUMMARY OF THE INVENTION

Briefly, in accordance with the present invention, the foregoing and other objects are accomplished in a helicopter having two rotor blade assemblies, each assembly being mounted on a separate rotor blade hub. One of the two hubs is affixed to the mast under all conditions. The second or foldable hub is positioned on the mast such that in a normal, that is unfolded, position vertical splines on the inside of the hub engage vertical drive splines on the outside of the mast. A nut that surrounds the mast is turned to apply a force to the movable hub to lock the movable hub to the mast between center-

ing cones. Inner threads on the nut engage circumferential threads on the mast. Worm gear teeth on the outside of the nut mesh with a worm gear. Rotation of the worm gear thus serves to rotate the nut. The nut and worm gear constitute a worm gear set. The housing for this worm gear set is connected to the second rotor hub.

When folding the movable hub, the worm gear is rotated, causing the nut to rotate around the mast and to climb down along the circumferential threads on the mast, thus pulling the foldable hub down along the mast. The foldable hub cannot rotate relative to the mast because the splines on the foldable hub are engaged with the mast splines. After a predetermined amount of movement of the foldable hub down the mast, the vertical splines disengage and this permits the movable hub to rotate relative to the mast. When the vertical splines disengage, the worm wheel nut contacts a rotational stop mounted on the mast. Thus further rotation of the worm gear will cause the worm wheel housing and hub to rotate around the mast together until the hub contacts a folding stop. In this fashion, the blades on the foldable hub are brought around to approximate alignment with the blades on the fixed hub.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, aspects and features of the present invention will become apparent from the following description and drawings in which:

FIG. 1 is a perspective view showing how one hub and associated blade structure of a helicopter may be folded relative to another hub and associated blade structure;

FIG. 2 is an enlarged view of the hubs, rotor blades and swashplate of the present invention wherein the hubs and associated rotor blades are shown in their unfolded flight position;

FIG. 3 is an enlarged elevation view of the hubs, rotor blades, swashplate and mast structure of the present invention wherein the hubs and associated rotor blades are shown in their folded position;

FIG. 4 is a top view of the structure shown in FIG. 3;

FIG. 5 is a view, in partial section and partial elevation, of portions of the helicopter mast, portions of the foldable hub, and the mechanism used to fold and unfold the hubs and associated blades in accordance with the present invention;

FIG. 6 is a horizontal cross-sectional view through the mast showing the gearing arrangement used to fold and unfold the hubs and associated rotor blades;

FIG. 7 is a vertical sectional view of the worm gear, worm wheel and mast structure used to fold and unfold the hubs and associated blades and is taken along the right-angle section 7-7 of FIG. 6; and

FIG. 8 is a cross-sectional view along lines 8-8 of FIG. 7 showing the stops that limit travel of the worm wheel nut relative to the foldable hub and that limit the travel of the foldable hub relative to the mast and other hub.

DESCRIPTION OF THE PREFERRED EMBODIMENT STRUCTURE

Referring now to the drawings, and more particularly to FIGS. 1 through 3, wherein a helicopter 10 is seen to include two rotor hubs 15, 18 and a pair of blades 13, 14 and 16, 17 fixed to each hub with the hubs movable between a foldable position where the upper hub 15 and its blades 13, 14 are nearly aligned with the lower hub 18 and blades 16, 17 and an orthogonal or unfolded position in which one hub and its blades are orthogonal to the other hub and blades.

As is seen most clearly in FIG. 2, blades 13 and 14 are attached to the upper hub 15 whereas blades 16 and 17 are attached to the lower hub 18, the manner of attachment of the blades to the respective hubs to be hereinafter described. Hubs 15 and 18 are similar to each other and thus a description of one hub will suffice to describe that other hub with like parts in each hub having a corresponding alphabetical reference designation. Hub 15 includes a generally flat yoke

portion 15a that has a cap 15b which holds the yoke fast to the helicopter mast 40. Yoke 15a is seen to include opposed triangularly shaped slots 15c and 15d with the base of each slot being adjacent sleeves 15e and 15f, respectively. Hub 15 also includes grips 21 and 22 which rotatably project through sleeves 15e and 15f, respectively and are rotated in a manner hereinafter described. Each grip 21, 22 is rotatable within its respective sleeve 15e, 15f by suitable bearings. Attached to grips 21 and 22 are blades 13 and 14, respectively. The midportion 15g of yoke 15a is flat and is of generally a constant cross-sectional area. The portions of yoke 15a which include slots 15c and 15d are on opposite sides of midportion 15g of yoke 15a.

The upper surface of the midportion of the lower yoke 18 when in the unfolded position shown in FIG. 2, faces and is adjacent to the surface of the bottom midportion of the upper yoke 15a. Grips 23 and 24 are joined to blades 16 and 17 and are each rotatable by suitable bearings in sleeves 18e and 18f, respectively.

Swashplate 26 surrounds the helicopter mast 40 and has four horns 27, 28, 29 and 30 symmetrically positioned about the helicopter mast. The swashplate 26 can be lowered and raised along the helicopter mast as is known in the art. The lower ends of pitch links 31, 32, 33 and 34 are pivotally connected to the swashplate horns 27, 28, 29 and 30, respectively. In addition, swivels S at the lower end of pitch links 32, 34 permit these links to rotate about their own axes. This swiveling action is required during the folding and unfolding operation as will hereinafter be explained. Pitch horns 35, 36, 37 and 38 are pivotally attached to the upper ends of the pitch links 31, 32, 33 and 34, respectively.

As can be seen in FIG. 2, pitch horn 38 is generally an upwardly facing U-shaped member having a first leg 38a pivotally attached to pitch link 34 and a second leg 38c projecting upwardly through the slot 18d of the yoke 18a. A connecting member 38b joins these two legs. Grip 23 rotatably projects through sleeve 18f to be rigidly fastened to pitch horn leg 38c. Downwardly facing U-shaped pitch horn 35 is similarly pivotally attached to pitch link 31 at leg 35a and is passing over a portion of the yoke 15a so that leg 35c of the horn may project downwardly through slot 15c of yoke 18a. Grip 21 projects through sleeve 15e to be secured to leg 35c of horn 35. The pitch horn 35 is spaced a sufficient distance above yoke 15a so that as the swashplate 26 and pitch link 31 are lowered the short distance that is required to unfold the helicopter hubs and blades, as hereinafter described, the pitch horn 35 will not abut yoke 15a until at least the swashplate and pitch link are lowered the required distance.

Pitch horn 36 cooperates with pitch link 32, slot 18c and grip 24 in a manner similar to the way pitch horn 38 cooperates with slot 18d, pitch link 34 and grip 23, as described above.

Pitch horn 37 cooperates with pitch link 33, slot 15d and grip 22 in the same way pitch horn 35 cooperates with pitch link 31, slot 15c and grip 21, as described above.

As can be seen in FIGS. 5 and 7, the helicopter mast 40 includes circumferential threads 42 are a series of vertical drive splines 43 on the mast that are parallel to the axis of the helicopter mast. A portion of the yoke 18a completely surrounds the upper portion of the helicopter mast 40 and includes internal vertical yoke splines 41 which normally engage mast splines 43.

A worm wheel or nut 46 (best seen in FIGS. 5 and 7) surrounds the mast 40 and is internally threaded to engage the circumferential mast threads 42. The external teeth of the worm wheel 46 engage a worm gear 48. The shaft 49 of the worm gear 48 is rotated by a drive motor 60. The worm wheel 46 and worm gear 48 are housed in a housing 50, which housing 50 is bolted to the yoke 18a of the lower hub 18 by means of a bolt assembly 51. Bearings 52 permit the worm wheel 46 to rotate about the mast 40, within the housing 50, without requiring rotation of the housing 50. Bearings 53 permit the worm gear 48 to rotate relative to the housing 50, about its own shaft axis.

An upper rotor mounting cone 54 is attached to the mast 40 and a lower rotor mounting cone 55 is attached to the housing 50. The foldable rotor hub 18 is wedged between these mounting cones 54, 55 during normal in-flight conditions so that the rotor hub is properly positioned and kept from undesirable vertical movement during flight.

In connection with the following description, it should be kept in mind that FIG. 7 is a sectional view along the right-angle section 7-7 shown in FIG. 6.

Two worm wheel lugs 61 (only one is shown in FIG. 7) extend from diametrically opposed portions of nut 46. Two housing lugs 62 (only one is shown in FIG. 7) extend from diametrically opposed portions of housing 50. The housing lugs 62 are at a greater diameter than are the worm wheel lugs 61 from the mast center, as can be seen in FIG. 7. Each housing lug 62 at its innermost portion includes an annular tail section 62t, shown in broken lines in FIG. 8. Unfold stops 65 and 65a (see FIG. 8) are symmetrically positioned on the opposite outer extremities of plate 64 which is rigid with mast 40. As best seen in FIG. 8, worm wheel lug stops 63, 63a are positioned on the plate 64 diametrically inward from unfold stops 65, 65a respectively. The worm wheel lug stops 63, 63a are closer to the mast center than are the unfold stops 65, 65a to correspond to the worm wheel lugs 61 and housing lugs 62, respectively.

Fold stops 67 and 67a are positioned about 180° from each other on the plate 64 and are displaced about 90° from the unfold stops 65 and 65a.

Pivotally mounted on plate 64 are identical pivot stops 66 and 66a. Pivot stop 66 is pivotable about a post 66b which is fixed relative to plate 64 and located in close proximity to unfold stop 65 and wheel lug stop 63 while pivot stop 66a is pivotable about post 66c which is fixed relative to plate 64 with post 66c being in close proximity to unfold stop 65a and wheel lug stop 63a. Each of the pivot stops 66a, 66b increases in width in a direction going away from the respective pivot posts. Pivot stops 66 and 66a are positioned on plate 64 so that the distance between the center of plate 64 and the respective pivot posts is greater than the distance between the center of plate 64 and the worm wheel lug stops but less than the distance between the center of plate 64 and the unfold stops.

Operation

For purposes of illustration let us assume that the helicopter hubs 15, 18 and associated blades are in the unfolded flight position shown in FIG. 2 and that it is desired to fold the hubs and associated blades to the folded position seen in FIGS. 1 and 3. Since the cooperation of the first worm wheel lug 61, first worm housing lug 62, unfold stop 65, fold stop 67 and pivot stop 66 is the same as is the cooperation between the second worm wheel lug 61, second housing lug 62a, and stops 65a, 67a and 66a, a description of the cooperation of the former elements will be sufficient for an understanding of the invention.

Preparatory to the blades being folded, the swashplate 26 is lowered along mast 40 so that all four pitch links 31, 32, 33, 34 are lowered. The lowering of pitch link 31 causes pitch horn 35 to rotate in a clockwise direction (as seen in FIG. 2) so that rotor blade 13 via grip 21 also rotates in a clockwise direction. In a similar manner blades 14 and 16 rotate in a counterclockwise direction while blade 17 rotates in a clockwise direction. The blades are thus brought to their maximum pitch positions.

The shaft of the worm gear 48 is then rotated by motor 60 causing the worm wheel 46 to rotate around mast 40. Yoke 18a, and hence worm gear housing 50 will not rotate since the mast splines 43 and yoke splines 41 are engaged. Thus the worm wheel 46 rotates around mast 40 and climbs down the circumferential threads 42; also lowering therewith worm gear 48, housing 50, hub 18 and blades 16 and 17.

As the hub 18 is lowered, it carries along with it the sleeves 18e, 18f, the grips 23, 24, and the associated rotor blades 16, 17. The pitch horns 36, 28, being connected to the grips 23,

24 also tend to be lowered. However, the pitch horns 36, 37 are connected to the pitch links 32, 35, respectively, and these pitch links cannot move directly down because they in turn are attached to the swashplate 26. But the pitch links 32, 34 are pivotally connected to the end of the respective pitch horns 36, 38. Thus, as the hub 18 descends, the pitch horns 26, 28 will rotate about their pivot point with their respective pitch links 32, 34 until the associated rotor blades 16, 17 are returned to a state of near minimum pitch. If minimum pitch conditions were encountered, the pitch horns 36, 38 would prevent bringing the hub 18 down any further and thus it is that the hub splines 41 must disengage the mast splines 43 before this point.

As hub 18 is descending, and just before the splines disengage with each other, worm wheel lug 61 hits pivot stop 66 moving the pivot stop 66 to the dotted position shown in FIG. 8. Housing lug 62, which is descending vertically with the lowering of housing 50 and hub 18, is lowered to the position shown in dotted lines in FIG. 8 between unfold stop 65 and pivoted stop 66. The relationship between the housing lug 62 and unfold stop 65 must be such that until the housing lug 62 is in position between stops 66 and 65, the splines 41, 43 (on hub 18 and mast 40) will not have disengaged. With housing lug 62 positioned as shown in FIG. 8, splines 41 and 43 disengage. The worm wheel 46 will continue to rotate until the lug 61 hits stop 63, as illustrated in FIG. 8. Then the counterclockwise rotation of the worm wheel 46 will cease.

Continued rotation of worm shaft 49 now moves the housing 50 (and thus the housing lug 62) in a clockwise direction, as viewed in FIG. 8. The housing lug 62 hits a cammed surface on pivoted stop 66 pivoting the stop 66 to the position shown in solid lines in FIG. 8. This serves to hold the worm wheel lug 61 trapped between the worm wheel stop 63 and the pivoted stop 66. As the housing 50 rotates, the lower hub 18 rotates until the housing lug 62 abuts the fold stop 67. At this point the lower hub 18 will have moved into near alignment with the upper hub 15, as illustrated in FIGS. 1 and 3. The tail 62t on housing lug 62 insures that the pivoted stop 66 is kept in the position shown in solid lines in FIG. 8 so that it will, along with nut stop 63, hold in position the worm wheel lug 61 and thus worm wheel 46.

When the lower hub 18 is being folded, the pitch link 34, which is rotatably mounted to the swashplate 26, not only swings over to the dotted position shown in FIG. 2 but also rotates about its own axis on its swivel. A similar axial rotation occurs with the pitch link 32 (see FIG. 3) on its swivel. When the pitch links 32, 34 so swing and swivel, the associated pitch horns 36, 38 rotate back to a near maximum pitch condition. Thus, in the folded state, the blades 16, 17 are in their maximum pitch condition and tend to nest with the blades 13, 14. The blades 13, 14 are in their maximum pitch state because the swashplate 26 was lowered preliminary to rotating the worm gear 48.

Thus, it may be seen that the amount of travel of the hub down the mast 40 is limited by the amount that the pitch horns 36, 38 will permit in going from their position of maximum pitch to their position of minimum pitch. In order to permit folding after only this relatively limited amount of downward travel of the hub 18, it is important that the design of the hubs 15, 18 be, as is shown in FIG. 2, as flat as possible. In particular it is important that the upwardly facing surface of the lower hub 18 and the downwardly facing surface of the upper hub 15 be as flat as possible so that there will be no projections to interfere with folding of these two hubs relative to one another.

One factor which makes this simplified folding design practical for a wide variety of helicopters is that the folding need not involve a complete 90° fold in order to obtain maximum economy of stowage space. Because of the tail rotor, possible tail fins and the width of the cabin, a certain amount of lateral space is required. The two rotor blade assemblies thus need only be folded as much as is necessary to bring them within the lateral space otherwise required by the craft, as shown in FIG. 1.

To unfold, the direction of rotation of motor 60 is reversed from the direction in which it had been rotating during the folding sequence. This results in housing lug 62 moving from its folded position adjacent fold stop 67 about mast 40 (along with housing 50 and hub 18) to a position in abutment with unfold stop 65. Worm wheel 46 will not rotate as the worm wheel lug 61 is trapped between worm wheel lug stop 63 and pivot stop 66, with tail 62t preventing the pivot stop from rotating to the dotted position illustrated in FIG. 8. Rotation of housing 50 and lower hub 18 to the unfolded position will cause pitch link 34 to swing to the position shown in solid lines in FIG. 2, with the pitch link rotating in its swivel, bringing blade 16 to a near minimum pitch condition. A similar swivel occurs with pitch link 32 bringing blade 17 to a near minimum pitch condition. Blades 13 and 14 will be in a maximum pitch condition from the previous lowering of swashplate 26 during the folding sequence.

When the housing lug 62 reaches fold stop 65, splines 41 and 43 will be in alignment and the tail 52t will no longer be in a position to prevent movement of pivot stop 66 to the dotted position shown in FIG. 8. When housing lug 62 has rotated (counterclockwise as seen in FIG. 8) and abuts the housing stop 65, further rotation of worm gear shaft 49 will result in the worm wheel and worm wheel lug 61 rotating in a counterclockwise direction (as seen in FIG. 8). In so rotating, the worm wheel lug 61 will push the pivotal lug 66 to the dotted position seen in FIG. 8. Then the worm wheel 46, worm gear 48, housing 50, hub 18 and blades 16 and 17 will ascend mast 49 until hub 18 contacts mounting cone 54. The ascension of hub 18 up mast 49 will bring blades 16 and 17 to a maximum pitch condition. Swashplate 26 is then raised to restore all the blades to the minimum pitch condition illustrated in FIG. 2.

It is to be appreciated from reading the foregoing specification that the pitch links, swivels and horn structure of the present invention allow pitch changes, clearances and allowances sufficiently great so that folding and unfolding operations can take place without the different parts of the hub structure being interfered with during these operations.

It should be apparent from the foregoing description that the present invention could be employed to provide folding of a four-bladed rotary assembly which is of a size or function so that it might be deemed a propeller assembly. It is of course to be understood that the invention is intended to include all variations of different four-bladed rotary assemblies including rotor blades on composite aircraft and propeller blades.

What is claimed is:

1. A method of folding a first rotor blade assembly movable with and about a drive structure relative to a second rotor blade assembly which is approximately orthogonal to the first rotor blade assembly wherein the second rotor blade assembly is fixed relative to the drive structure comprising the steps of:

- a. moving the first rotor blade assembly axially along the drive along the drive structure away from the second rotor blade assembly to a predetermined distance from the second rotor blade assembly, and
- b. rotating the first rotor blade assembly at the predetermined axial distance from the second rotor blade assembly about the drive structure and relative to the second rotor blade assembly to bring the assemblies into near alignment with each other.

2. A method according to claim 1 further comprising the steps of:

- changing the pitch of the rotor blades of the first and second rotor blade assemblies to a maximum in one direction prior to axially moving the first rotor blade assembly away from the second rotor blade assembly,
- changing the pitch of the blades of the first rotor blade assembly in the opposite direction as the first rotor blade assembly is moved axially away from the second rotor blade assembly, and
- changing the pitch of the blades of the first rotor blade assembly in the one direction as the first rotor blade assembly is rotated relative to the second rotor blade as-

sembly, whereby the rotor blades of the first and second rotor blade assemblies will nest together as the assemblies are brought into near alignment with each other.

3. In a foldable rotor blade system of the type having a rotor mast, a first rotor blade assembly including a first hub movably mounted on the mast with a first pair of variable pitch blades extending radially therefrom, and a second rotor blade assembly including a second hub fixed to the mast with a second pair of variable pitch blades extending radially therefrom, the improvement comprising:

means for controllably moving the hub of the first rotor blade assembly on the mast relative to the second rotor blade assembly between a first fixed position and a second fixed position, the second position being displaced from the first position both longitudinally and angularly relative to the rotational axis of the mast.

4. The system of claim 3 comprising:

engagement means for securing the hub of the first rotor blade assembly from rotation relative to the mast when the first assembly is at the first fixed position.

5. The system of claim 4 wherein the engagement means comprises:

first surfaces fixed to the rotor mast and having components lying in planes that include the axis of the rotor mast and second surfaces fixed to the first hub for mating engagement with the first surfaces when the first assembly is at the first position.

6. The system of claim 5 wherein the moving means comprises:

means for translating the hub of the first rotor blade assembly along the mast between the first position and a third position angularly aligned with the first position and longitudinally aligned with the second position and

means for rotating the hub of the first rotor blade assembly around the mast between the third and second positions.

7. The system of claim 6 wherein:

the first surfaces comprise a first set of parallel splines extending longitudinally along a first portion of the periphery of the rotor mast, and

the second surfaces comprise a second set of parallel splines extending longitudinally along the interior of the first hub, the first and second set of splines being in mating engagement with each other when the first hub is at the first position and disengaged when the first hub is at the third position.

8. The system of claim 7 wherein the translating means comprises:

screw threads extending along a second portion of the periphery of the rotor mast, the second portion being longitudinally displaced from the first portion in the direction of movement of the first hub from the first to the third position;

a threaded nut rotatably connected to the first hub and surrounding the rotor mast, the threads of the nut engaging the screw threads of the rotor mast for movement therealong when the nut is rotated relative to the mast, the outer periphery of the nut including a set of worm gear teeth; and

a worm having a shaft rotatably connected to the first hub, with the axis of the wormshaft positioned in a plane perpendicular to the axis of the rotor mast for meshing engagement of the worm with the gear teeth of the nut, whereby rotation of the wormshaft causes rotation of the nut relative to the first hub, in turn causing movement of the nut along the screw threads of the rotor mast, in turn causing axial movement of the first hub along the rotor mast between the first and third positions, so long as the first and second set of splines remain in mating engagement with each other.

9. The system of claim 8 wherein the means for rotating the hub of the first rotor blade assembly around the mast between the third and second positions comprises:

first stop means for preventing rotation of the nut relative to the mast when the first and second set of splines disengage at the third position, whereby rotation of the wormshaft, causing rotation of the first hub relative to the nut, results in rotation of the first hub relative to the rotor mast between the third and second positions.

10. The system of claim 9 wherein the first stop means comprises:

a first stop fixed to the threaded nut;

a second stop fixed to the rotor mast for engagement with the first stop when the first hub is at the third position, for preventing rotation of the nut in one direction relative to the rotor mast; and

a third stop movably connected to the rotor mast for selective engagement with the first stop when the first hub is at the second position, for preventing rotation of the nut in an opposite direction relative to the rotor mast, and for selective disengagement from the first stop when the first hub is at the third position.

11. The system of claim 10 comprising:

second stop means for limiting the rotation of the first rotor blade assembly relative to the rotor mast to between the third and second positions.

12. The system of claim 11 wherein the second stop means comprises:

a fourth stop fixed to the hub of the first rotor blade assembly;

a fifth stop fixed to the rotor mast for engagement with the fourth stop when the first rotor blade assembly is at the third position for preventing rotation of the first hub in a direction further away from the second position; and

a sixth stop fixed to the rotor mast for engagement with the fourth stop when the first rotor blade assembly is at the second position for preventing rotation of the first hub in a direction further away from the third position.

13. The system of claim 12 comprising:

means for selectively engaging the third stop with the first stop when the first rotor blade assembly is between the third and second positions.

14. The system of claim 13 wherein:

the third stop comprises a camming member pivotally connected to the rotor mast for movement of a camming surface of the member into and out of engagement with the first stop, and

the means for selectively engaging the third stop with the first stop comprises a boundary surface fixed to the hub of the first rotor blade assembly for maintaining the camming surface of the third stop in engagement with the first stop, the boundary surface subtending an angle sufficient to maintain contact with the third stop when the first rotor blade assembly is at or between the second position and a point adjacent the third position

15. The system of claim 14 wherein the angle of engagement contact between the camming surface of the third stop and the first stop is such that pressure of the first stop against the camming surface tends to pivot the third stop out of engagement with the first stop, whereby as the first rotor blade assembly rotates from the second to the third position, the third stop will disengage from the first stop when the boundary surface releases the third stop as the first rotor blade assembly reached the third position.

16. The system of claim 3 wherein:

the first hub comprises a substantially flat midportion facing the second hub and extending in opposite radial directions from the mast and

the second hub comprises a substantially flat midportion facing the first hub and extending in opposite radial directions from the mast, said first hub being positioned adjacent the second hub when the first rotor blade assembly is at the first position.

17. The system of claim 16 comprising:

a swashplate surrounding the rotor mast and axially spaced from the first and second rotor blade assemblies,

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a pair of pitch links for connecting the swashplate to the blades of the first rotor blade assembly, and swivel means at each end of each pitch link to permit each pitch link to swivel about its axis when the first rotor blade assembly is folded to near alignment with the second rotor blade assembly. 5

18. The system of claim 7 wherein the first hub includes a pair of slots, each slot being positioned along the main axis of the first rotor blade assembly on opposite sides of the mast, the system further comprising: 10
a pair of U-shaped pitch horns, each pitch horn having a

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first end connected to the swivel means at one end of one of the pitch links and a second end extending through one of the slots and fixed to a separate rotor blade of the first assembly, with the midportions of the U-shaped pitch horns arranged on the side of the first hub away from the second hub, whereby axial movement of the first rotor blade assembly away from the second rotor blade assembly will permit the pitch horns to rotate about their second ends without contacting the first hub.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,625,631 Dated December 7, 1971

Inventor(s) Cecil Edward Covington, Jr. et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

- Column 2, line 73, "that" should be -- the --
- Column 3, line 13, "15C" should be -- 15c --
- Column 3, line 58, after "42" insert -- . Spaced a distance
above the circumferential threads 42 --
- Column 3, line 64, "5" should be -- 6 --
- Column 4, line 75, "28" should be -- 38 --
- Column 5, line 2, "35" should be -- 34 --
- Column 5, line 8, "26, 28" should be -- 36, 38 --
- Column 6, line 30, "49" should be -- 40 --
- Column 6, line 31, "49" should be -- 40 --
- Column 6, line 55, delete "along the drive "
- Column 7, line 15, "displaces" should be -- displaced --
- Column 8, line 45, "of" (first occurrence) should be -- on --
- Column 8, line 63, "reached" should be -- reaches --

Signed and sealed this 3rd day of October 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents