United States Patent [19]

Gear

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[54] **ROTARY WING AIRCRAFT**

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[21] Appl. No.: **221,610**

[30] **Foreign Application Priority Data**

Feb. 5, 1971 Great Britain 4,011/71

[52] **U.S. Cl.** **244/17.11,** 416/142

[51] **Int. Cl.** **B64c 27/50**

[58] **Field of Search** 244/17.11, 17.17, 244/17.19; 416/142, 143, 153

[56] **References Cited**

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Assistant Examiner—Paul E. Sauberer
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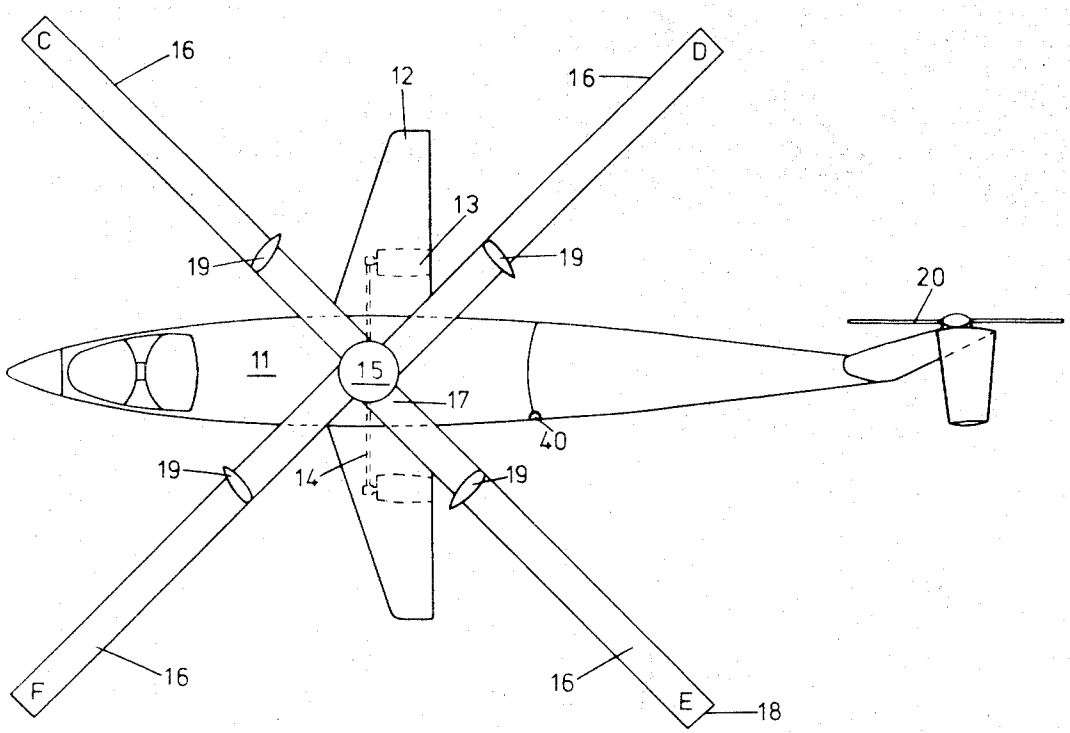
[57] **ABSTRACT**

A means for folding a helicopter rotor blade includes a generally chordwise hinge located intermediate the root and tip ends of the blade, the outboard portion of the blade being rotatable about the hinge to a folded position in which it overlaps the inboard portion of the blade along at least part of its length. The hinge is formed in a generally cylindrical hollow member of aerofoil shape having leading and trailing sections and a rotatable central section. The inboard portion is secured to the leading and trailing sections, and the outboard portion is secured to the rotatable central section. A motor located in the hollow hinge, acting through a spline connection, rotates the central section relative to the leading and trailing sections. An arm formed integral with the central section abuts a surface formed in the inboard portion of the rotor blade adjacent the hinge when the outboard portion of the rotor blade is in its fully extended position. The hinge is locked and unlocked by a ram which, when extended, locates through mating holes in the arm and the abutting surface.

10 Claims, 6 Drawing Figures



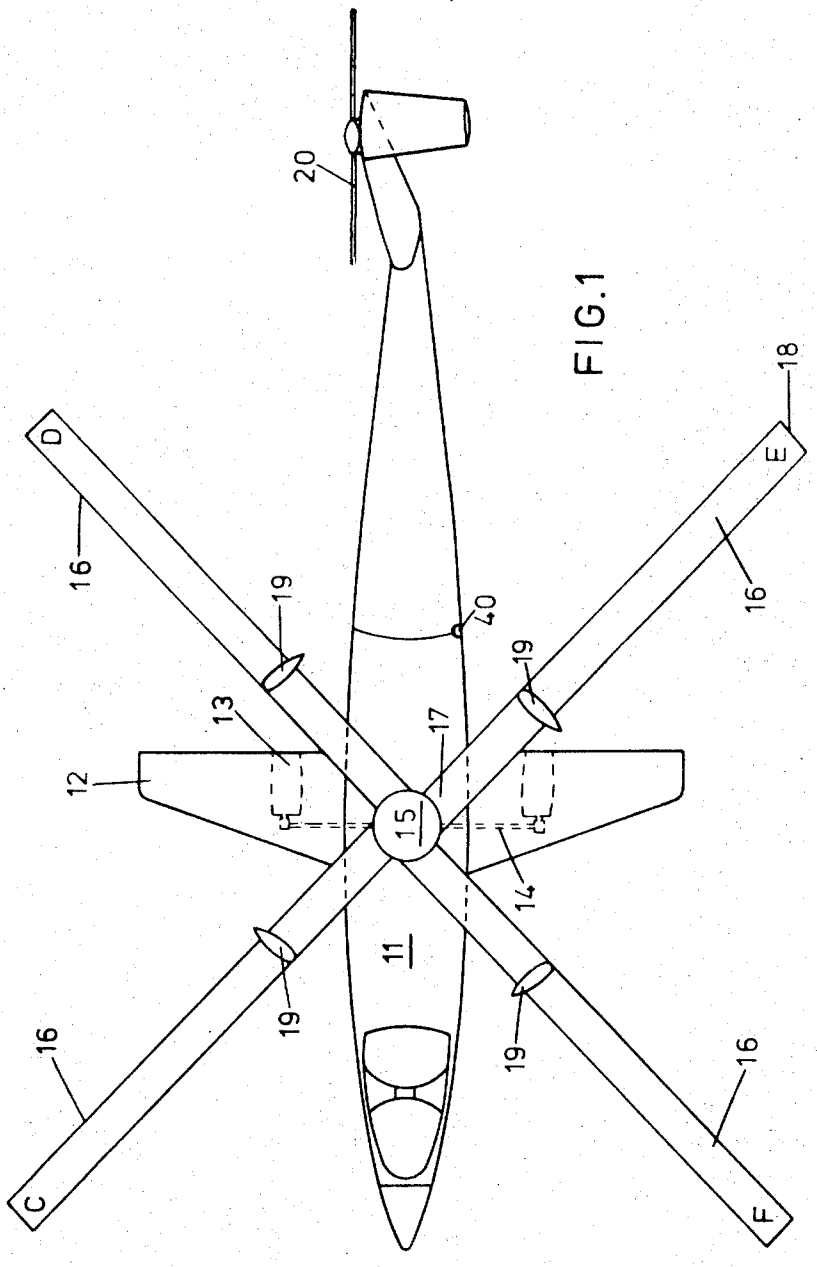
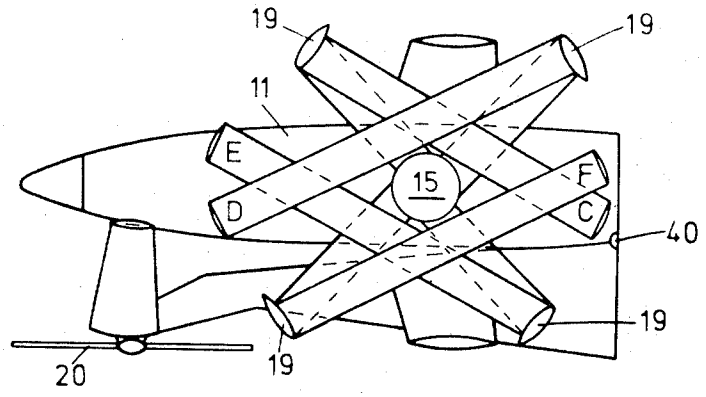


FIG.1

FIG. 2



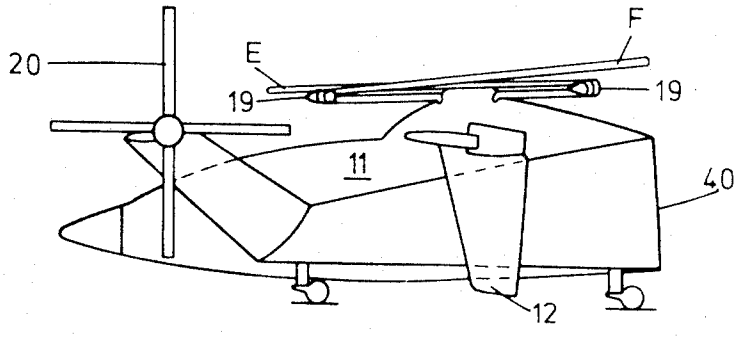
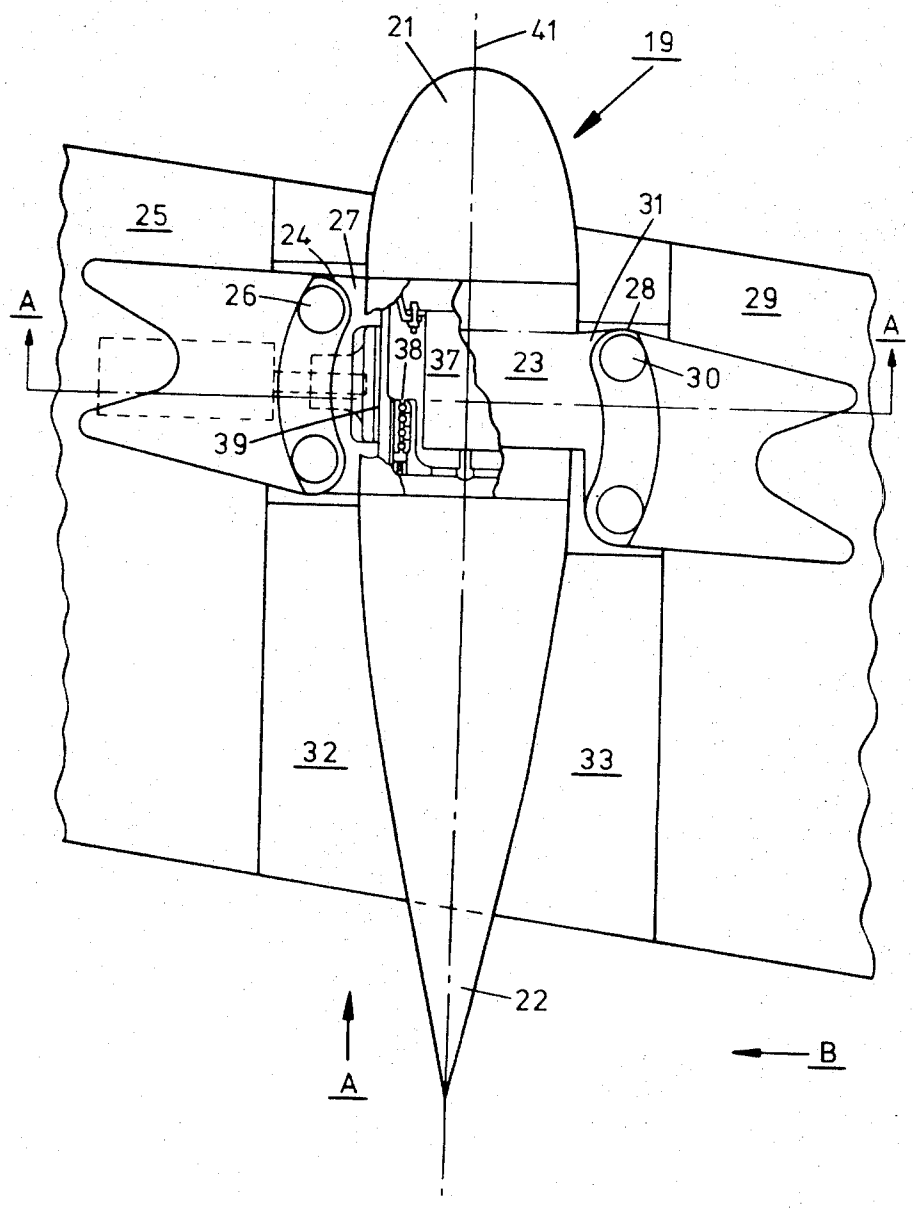


FIG. 3

FIG. 4



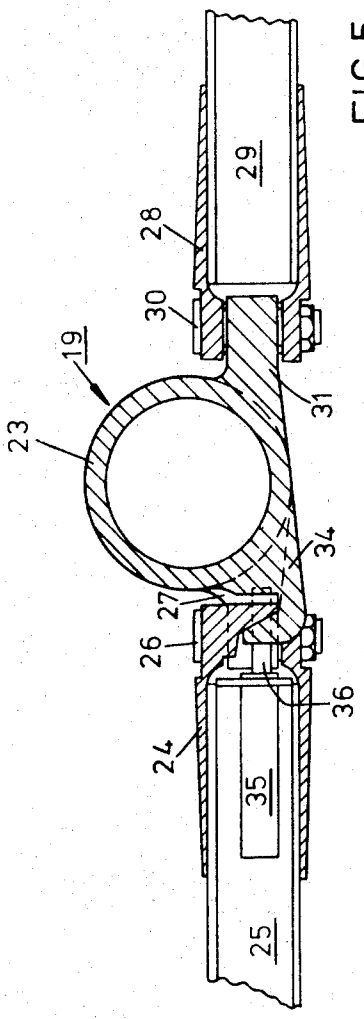
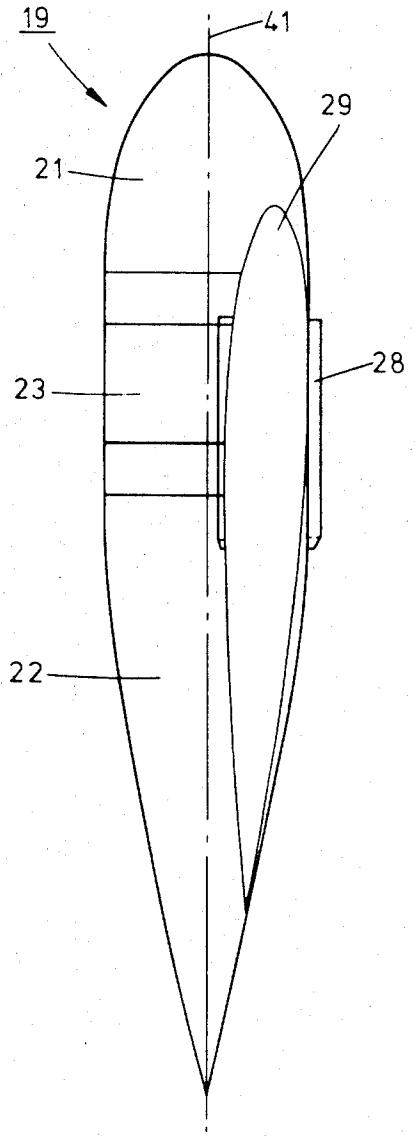


FIG.5

FIG. 6



ROTARY WING AIRCRAFT

This invention relates to helicopters and more particularly to a power operated system of folding the rotor blades thereon between an extended operational position and a folded position.

Existing power folding arrangements usually comprise hinges mounted adjacent the rotor head about which all blades are folded in a generally rearward direction to lie either above or adjacent the fuselage and tail cone, the folded length being further reduced by folding the rearmost extremity of the tail cone forwardly. This means that the folded length must be at least the sum of a blade length plus the length of the fuselage forward of the rotor head, and has resulted in severe limitations in the size of helicopters designed for operation and storage in confined spaces such as encountered in shipborne operations. Designers have been forced to limit the size of rotor blades to that capable of being folded into an available space and have not been free to design a rotor system whose diameter is determined solely by an optimisation based on flight considerations. This type of folding arrangement results frequently in a reduction in length between the flying length and the folded length of approximately 30 per cent.

A further disadvantage with known systems is that the operating mechanisms are very complicated and heavy and have an unclean aerodynamic shape which results in reliability and maintenance problems and imposes serious operational limitations, due to the weight penalty and high drag characteristics.

Generally according to the invention, in or for a helicopter, there is a rotor blade having a root end and a tip end, the root end being adapted for connection to a rotor head, and a generally chordwise extending hinge located intermediate the root and tip ends thereof to separate the blade into inboard and outboard portions, the outboard portion being foldable about the hinge to a position in which it overlaps the inboard portion along at least part of its length, wherein the hinge is formed in a generally cylindrical hollow member of aerofoil shape having leading and trailing sections and a rotatable central section. Other and further features of the invention will be apparent from the ensuing description of a preferred embodiment taken in conjunction with the accompanying drawings, and from the attendant claims.

The invention will now be described by way of example only with reference to the accompanying drawings, in which:

FIG. 1 is a plan view of a helicopter with its rotor blades extended,

FIG. 2 is a plan view of the same helicopter with its rotor blades and fuselage folded,

FIG. 3 is a side view of FIG. 2, in which two of the rotor blades have been omitted for clarity,

FIG. 4 is a plan view of one suitable mechanism for folding the blades in which parts are broken away to show more detail,

FIG. 5 is a sectional view on line A—A of FIG. 4, and

FIG. 6 is a view on arrow B of FIG. 4.

Referring now to FIG. 1, a helicopter has a fuselage 11 and an aerofoil member in the form of a stub wing 12 extending from each side of the fuselage. The wing 12 houses two engines 13 connected through a suitable transmission system 14 to drive a rotor system which

includes a rotor head 15 and four rotor blades 16, marked C, D, E and F. The root end 17 of each blade is secured to the rotor head 15 by any of a number of suitable methods well known to persons skilled in the art, and extends radially outwardly from the root end to terminate at the tip end 18. A conventional tail rotor assembly 20 is located at the rear of the fuselage 11.

A hollow bullet-shaped member 19 is located chordwise of the blade intermediate the root and tip ends and includes a hinge about which the tip end can fold and also a housing for an operating mechanism for mechanically completing the folding operation. In the embodiment shown the member 19 is approximately 9 inches in diameter and is located at approximately one third of the blade radius. Details of the member 19 and the operating mechanism are shown in FIGS. 4, 5 and 6, and will be described later in the specification.

It will be clear from FIG. 1 that the members 19 are located at an angle other than normal to the longitudinal axis of their respective blades, the angle being shown as approximately 7° in FIG. 4. This ensures that when the tip end 18 is folded to the position shown in FIG. 2 it does not foul the rotor head 15 but does in fact lie tangential to it.

Referring now to FIGS. 4, 5 and 6, the member 19 comprises a leading section 21, a trailing section 22 and a central section 23 which is rotatable relative to the leading and trailing sections 21 and 22 about a hinge centreline 41.

Flanges 24 formed on the inboard portion 25 of the rotor blade are secured by two bolts 26 to a flange 27 which is secured to the leading and trailing sections 21 and 22 of the member 19. Flanges 28 formed on the outboard portion 29 of the rotor blade are secured by bolts 30 to a flange 31 formed integral with the central rotatable portion 23 of the member 19. In this way the member 19 provides a hinge about which the outboard portion 29 of the rotor blade can rotate with respect to the inboard portion 25.

A moulding 32 of aerofoil shape corresponding to the rotor blade is located between the inboard portion 25 of the rotor blade and the member 19, and is bonded to the leading and trailing sections 21 and 22. A moulding 33 of similar aerofoil shape is located between the outboard portion 29 of the rotor blade and the member 19, and is bonded to the outboard portion 29 of the blade.

An electric motor 37 is secured within the central area of the member 19 and is arranged to rotate the central section 23 through a high ratio reduction gearing 38 arranged concentrically about the motor 37 and the hinge centreline 41 and splines 39 formed on the inner diameter of the central section 23. It will be clear, therefore, that energisation of the motor 37 causes rotation of the central section 23, which in turn rotates the outboard portion 29 of the rotor blade about the hinge centreline 41.

In a particular embodiment the reduction ratio between the motor and the blade drive is over 6,000 to 1; however, it is to be understood that this ratio can be varied within wide limits to suit other designs. Reduction ratios of this order mean that a small lightweight motor can be used, a two horsepower unit being chosen for the particular embodiment described.

An arm 34 (FIG. 5) formed integral with the central rotatable section 23 is arranged so that when the rotor blade is in the extended position (FIGS. 3, 4 and 5), the

arm **34** enters a recess formed in the flange **24** to mate with a surface of the recess and provide an effective blade stop. A blade lock actuator **35** is housed in the inboard portion **25** of the rotor blade and arranged so that when a ram **36** is extended from the actuator **35** it locates in mating holes formed in the arm **34** and the flange **24** to effectively lock the blade in the extended position.

The blade lock actuator **35** may be either electrically, pneumatically, or hydraulically operated; however, it is obviously convenient to operate the motor **37** and the actuator **35** by the same medium.

The blade operating, locking and stop arrangements described are one example only of many possible methods of operating the novel rotor blade folding system disclosed herein. Another example of a suitable operating mechanism is disclosed in our co-pending British Patent application No. (U.S. Appln. Ser. No. 225,576), and includes an automatic locking arrangement. Incorporation of this mechanism would, therefore, dispense with the necessity of providing the separately operable blade locking means hereinbefore described in relation to the present invention.

When it is required to fold the rotor blades according to the present invention, the rotor head **15** is positioned so that each of the four rotor blades **16** extends at an angle of approximately 45° to the longitudinal centreline of the fuselage. The ram **36** is retracted by the actuator **35** to unlock the outer portion **29** from the inner portion **25.** The electric motor **37** is energised and acts through the reduction gearing **38** to rotate the outer portion **29** about the hinge in a direction initially upwardly and through an arc of approximately 180° to the overlapping folded position shown in FIGS. **2** and **3.** In FIG. **3,** the pair of blades E and F only are shown to more clearly illustrate the folded overlapping configuration of the blades on one side of the helicopter, the other pair of blades C and D moving to a similar configuration on the other side, as shown in plan in FIG. **2.** In the particular embodiment shown the blades are moved in pairs through their "up and down" movement, commencing with pair C and E followed by pair D and F, blades C and F moving in a generally rearward direction and blades D and E moving in a generally forward direction. The order of folding can be automatic by arranging sequential operation of the blade lock actuators **35** and the motors **37,** and limit switches are incorporated to de-energise the motor when the blade reaches its extended and folded positions. The folding arrangement disclosed eliminates the need to lock the blade in pitch during the folding operation, which avoids the excessive loads placed on the flight controls during folding by conventional methods.

As will be seen from FIGS. **2** and **3,** full advantage of the blade folding arrangement disclosed is obtained on the helicopter shown by folding the stub wings **12** downwardly and by folding the rear of the fuselage **11** about a hinge **40** to a folded position adjacent one side of the front part of the fuselage **11.** Because of the folding arrangement disclosed in which each blade is in fact doubled back over part of its length to utilise the hitherto unused area of the fuselage **11** in front of the rotor hub **15** as a blade stowage area, the hinge **40** is located much further forward on the fuselage **11** than has been possible in previous arrangements. This, of course, has a very significant effect on the folded length of the helicopter, and results, in the particular embodiment shown, in an overall reduction in length of approximately 55 per cent. A reduction of overall width of approximately 70 per cent is also achieved. Such a reduction is obviously of tremendous significance in the design of helicopters for operation from areas where storage space is an important criterion, as is the case, for example, in shipborne operation. Longer blades can be incorporated than would otherwise be possible, which means that a larger helicopter capable of carrying larger and heavier loads and with improved hovering and operational properties can be stowed in an area which would be impossible with existing folding arrangements.

Although one embodiment only of the invention has been described and illustrated, it is to be understood that modifications can be made without departing from the scope of the appended claims. The rotor blade folding arrangement disclosed is not limited for use on any particular fuselage configuration, similar advantages to those described being attained by its incorporation on any single rotor helicopter.

I claim as my invention:

1. For a helicopter, a rotor blade having a root end and a tip end, the root end being adapted for connection to a rotor head, and a generally chordwise extending hinge located intermediate the root and tip ends thereof to separate the blade into inboard and outboard portions, the outboard portion being foldable about the hinge to a position in which it overlaps the inboard portion along at least part of its length, wherein the hinge is formed in a generally cylindrical hollow member of aerofoil shape having leading and trailing sections and a rotatable central section.

2. A rotor blade as claimed in claim **1,** wherein the inboard portion is secured to the leading and trailing sections of the hinge and the outboard portion is secured to the rotatable central section.

3. A rotor blade as claimed in claim **2,** wherein an arm formed integral with the central section is arranged so that, when the outboard portion of the rotor blade is in its fully extended position, the arm extends inwardly to abut a surface formed in the inboard portion of the rotor blade adjacent the hinge.

4. A rotor blade as claimed in claim **3,** wherein an actuator is fitted in the inboard portion of each rotor blade adjacent the hinge and operates a ram which when extended locates through mating holes in the arm and abutting surface.

5. A helicopter having a fuselage and at least one power source arranged to drive a main rotor system, the rotor system including a rotor head and a plurality of rotor blades as claimed in claim **4.**

6. A rotor blade as claimed in claim **2,** wherein a motor is located in the hollow hinge member to drive a high ratio reduction unit arranged coincidental with the hinge centreline, the output of the reduction unit mating with splines on the internal diameter of the central rotatable section to rotate the central section relative the leading and trailing sections.

7. A helicopter having a fuselage and at least one power source arranged to drive a main rotor system, the rotor system including a rotor head and a plurality or rotor blades as claimed in claim **6.**

8. A helicopter having a fuselage and at least one power source arranged to drive a main rotor system, the rotor system including a rotor head and a plurality of rotor blades as claimed in claim **2.**

9. A helicopter having a fuselage and at least one power source arranged to drive a main rotor system, the rotor system including a rotor head and a plurality of rotor blades as claimed in claim **3.**

10. A helicopter having a fuselage and at least one power source arranged to drive a main rotor system, the rotor system including a rotor head and a plurality of rotor blades as claimed in claim **1.**

* * * * *

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,750,982 Dated August 7, 1973

Inventor(s) JOHN P. GEAR

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

In the heading, after the inventor's name and address there should be inserted: --, assignor to Westland Aircraft Limited, Yeovil, Somerset, England--.

Signed and sealed this 5th day of February 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents