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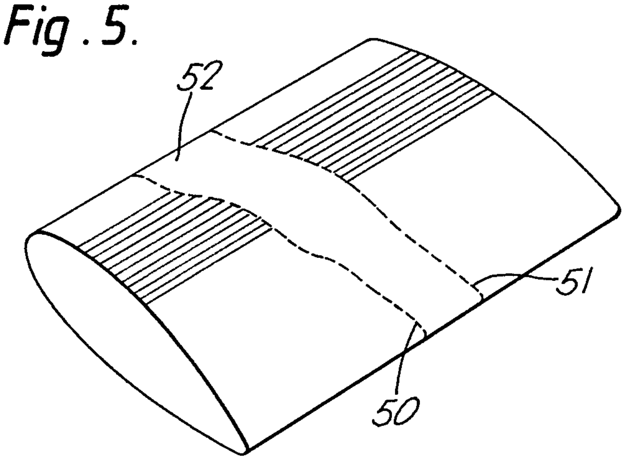
B7W

(54) Helicopter rotor blades

(57) Helicopter rotor blades are described. The blades are formed at least in part of fibre reinforced material including blade sections having increased concentrations of fibres of high stiffness such that stiffness in a bending plane is increased with respect to stiffness in an intervening blade section 52 to provide an area of hinging action under blade loading in that plane. Various blade constructions are also described.

Fig. 5.



The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

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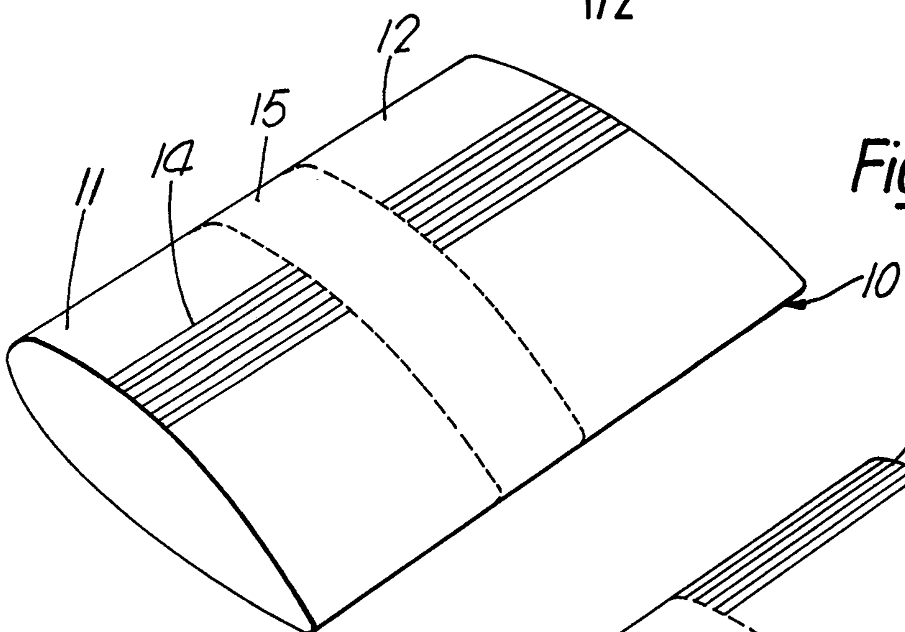


Fig. 1.

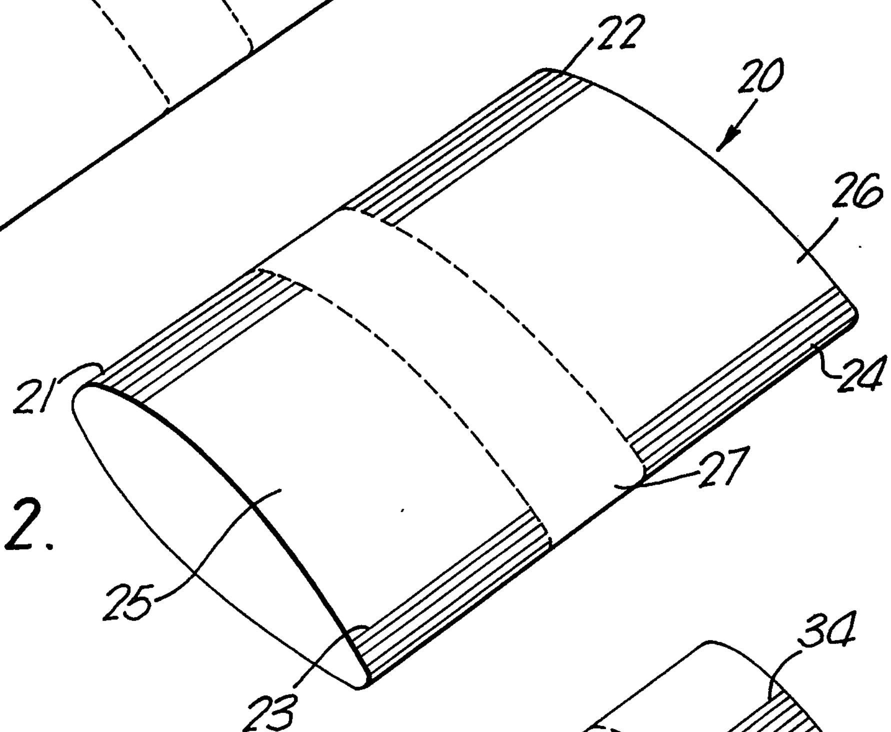


Fig. 2.

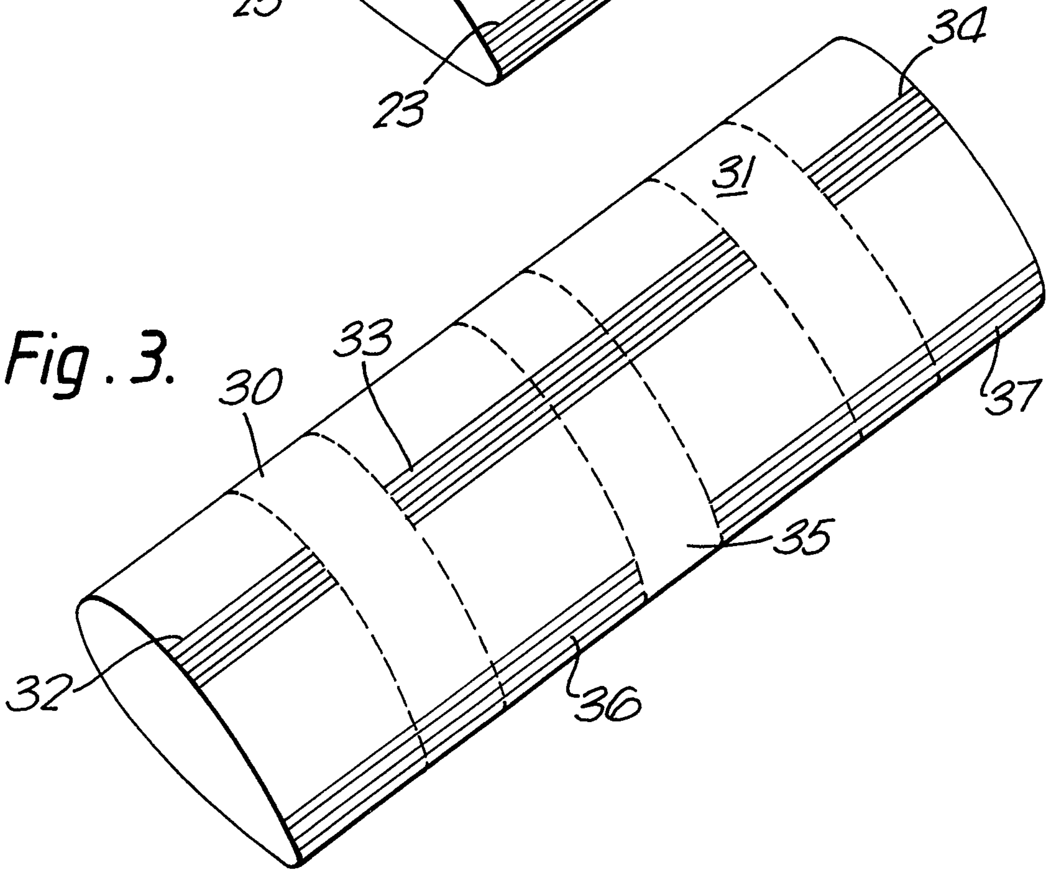


Fig. 3.

Fig. 4.

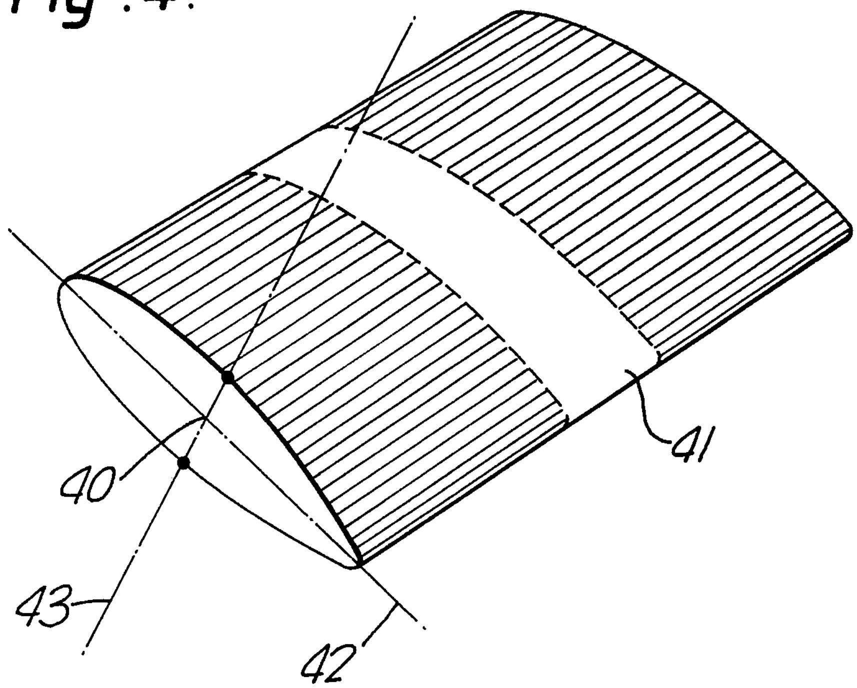
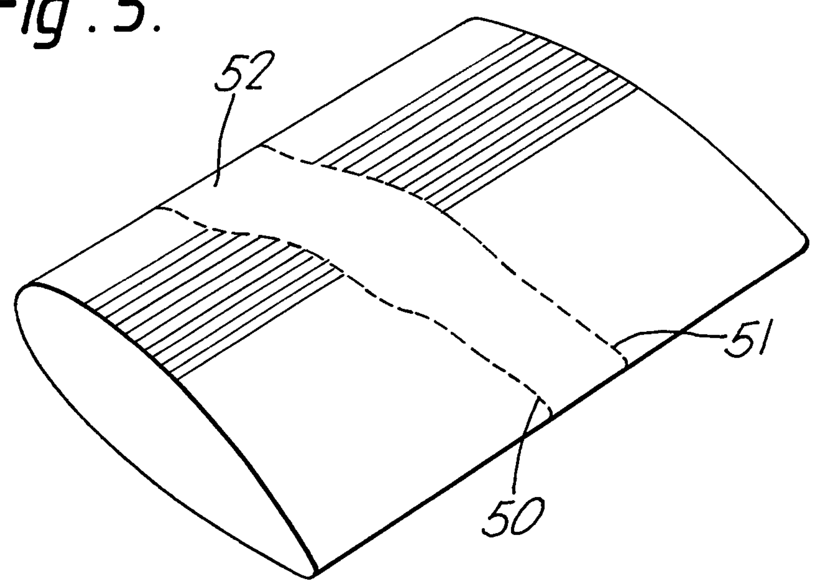


Fig. 5.



SPECIFICATION

Helicopter rotor blades

This invention relates to helicopter rotor blades and in particular to helicopter rotor blades constructed at least in part of fibre reinforced material.

Since the realisation that fibre reinforced materials have advantages for the construction of helicopter rotor blades, many blade designs have been based on such materials. Unfortunately the properties of the two types of fibre commonly used are not ideally suited to blade construction. Glass fibre has the property of providing a very good fracture strain figure. Carbon fibre can provide very high stiffness, but with inferior fracture strain. Unfortunately in order to overcome the problems associated with helicopters it is usually a design aim to provide a blade of good fracture strain and high stiffness. Particular attention is currently being devoted to blades which do not droop excessively under the static conditons, and which have good performance under adverse static loading as occurs for example when a military helicopter is stored in readiness on the deck of a ship.

One of the helicopter's main disadvantages is the high level of vibration present throughout the structure, a major contribution to this vibration being the rotor blades with their high aspect ratios. a rotor blade is prone to bend in three modes, namely in the flapping plane, normal to the direction of motion of the blade, in the lagging plane along the line of motion of the blade and pitching about the axis of the blade. Of these modes flapping and lagging are the most significant.

Much design effort is now centred on reducing these effects in combination with exploitation of the properties of fibre reinforced materials.

According to the present invention a helicopter rotor blade formed at least in part of fibre reinforced material includes blade sections having increased concentration of fibres of high stiffness such that stiffness in a bending plane is increased with respect ot stiffness in an intervening blade section to provide an area of hinging action under blade loading in that plane.

Preferably the high stiffness fibres in the sections of increased stiffness are carbon, other blade structure being provided with glass fibres. The intervening section may be solely of glass fibre reinforced material. The fibres of high stiffness may advantageously be placed towards the stucture surface.

In preferred forms of the present invention high stiffness fibres are placed substantially spanwise. Fibre concentration around the blade neutral axis in lag motion provides a hinging action in the flapping plane. Fibre concentration around the blade neutral axis in flap motion provides a hinging action in the lagging plane. A blade may advantageously include sections providing hinging action in both flapping and lagging planes, which may be made coincident along the blade span.

In an alternative form of the present invention the boundaries between the sections of increased stiffness and the intervening section may be skew to the spanwise direction thereby providing torsional coupling under blade loading.

Advantageously a plurality of areas of hinging action are provided along the blade span. These are preferably located to alleviate the effects of blade bend and vibration.

In order that features and advantages of the present invention may be appreciated some embodiments and examples will now be described with reference to the accompanying diagramatic drawings of which:

Figure 1 represents part of a helicopter rotor blade in accordance with the present invention, and

Figures 2, 3, 4 and *5* represent alternative embodiments.

In an area of helicopter rotor blade 10 (Figure 1) formed of fibre reinforced material blade sections 11 and 12 have an increased concentration of high stiffness carbon fibres, such as fibres 14, such that stiffness in the flapping plane is increased with respect to stiffness in an intervening blade section 15. The intervening section 15 is of glass fibre (not shown) reinforced material, as is the rest of the blade structure in sections 11 and 12, fabricated in accordance with known composite material techniques. In the present embodiment carbon fibre is thus present only in the stiffened sections. The carbon fibre content of the blade thus comprises discontinuous fibres.

It will be realised that when the blade is subjected to loading in the flapping plane blade section 15 intervening sections 11 and 12, constitutes an area of hinging action. Such an area will hereinafter be referred to as a pseudo hinge.

In an alternative embodiment (Figure 2), an area of helicopter rotor blade 20 includes cabon fibre concentrations 21, 22, 23, 24 along the edges of the blade in blade sections 25, 26. It will be realised that a pseudo hinge in the lagging plane is thereby provided about intervening blade section 27.

In a further embodiment (Figure 3) pseudo hinges about blade sections 30, 31 intervening stiffened sections 32, 33 and 33, 34 respectively are provided in the flapping plane; a pseudo hinge about blade section 35 intervening blade sections 36, 37 is provided in the lagging plane. It will be noted that pseudo hinges in each plane need not necessarily be coincident along the blade span.

In a blade construction where the fibre concentration is increased all round the blade, such as in blade area 40 (Figure 4) it will be appreciated that coincidental pseudo hinges about intervening section 41 are provided in both the flapping and lagging planes. This construction may be advantageous in some applications since the stiffening fibres are not crowded at the neutral axes of flexure. Thus in blade area 40, having pseudo hinges in both flapping and lagging planes, there is no fibre crowding around neutral axis 42 (flap motion) or neutral axis 43 (lag motion) in intervening section 41.

In a further alternative embodiment (Figure 5) notional boundaries 50, 51 defining intervening section 52 about which a pseudo hinge is provided in the flapping plane are skew to the blade spanwise direction. This construction provides a degree of torsional coupling so that a pitch flap motion may be included during blade loading.

It will be realised that in a blade constructed in accordance with the present invention, pseudo hinges may be formed at sections along the blade span to influence blade flexure so that vibration and other adverse blade reactions may be alleviated. Thus blade stiffness may be tailored in each plane along the span to improve blade behaviour. For example, a series of pseudo hinges along the blade span of the form described with reference to Figure 5 with the boundaries skewed forward or backward from the spanwise direction may be used to produce a blade distortion underload intended to lead to favourable blade loading.

In particular the teaching of GB 1 526 433 with regard to enforcing areas of increased and reduced stiffness may be applied by means of the present invention. Other stiffness regimes may also be applied.

It will now be appreciated that the present invention exploits the properties of both glass fibre and carbon fibre reinforced materials in that overall blade stiffness may be high due to spanwise carbon fibres of high stiffness but that in hinging areas subjected to fatiguing loads (the intervening sections) glass fibres only, or carbon fibre in reduced concentrations, are present.

CLAIMS

1. A rotor blade formed at least in part of fibre reinforced material including blade sections having increased concentration of fibres of high stiffness such that stiffness in a bending plane is increased with respect to stiffness in an intervening blade section to provide an area of hinging action under blade loading in that plane.

2. A rotor blade according to claim 1 and wherein the material of which the blade is formed at least in part of glass fibre and the fibres of high stiffness are carbon.

3. A rotor blade according to claim 2 and wherein the high stiffness fibres are incorporated towards the structure surface.

4. A rotor blade according to claim 3 and wherein the high stiffness fibres are orientated substantially spanwise.

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