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(54) A variable pitch blade assembly

(57) A variable pitch propeller or fan blade is provided which allows easy removal or loading of the propeller or fan blade from the propeller or fan rotor hub, and does not disturb the bearings during removal or loading.

The variable pitch propeller blade 32 comprises an aerofoil portion 33 and a root portion 56, the root portion is rotatably mounted in a casing 60 by a bearing assembly 58. The bearing assembly, the root portion and the casing form an integral assembly 34 which allows the variable pitch blade to be removably secured to the propeller hub 30.

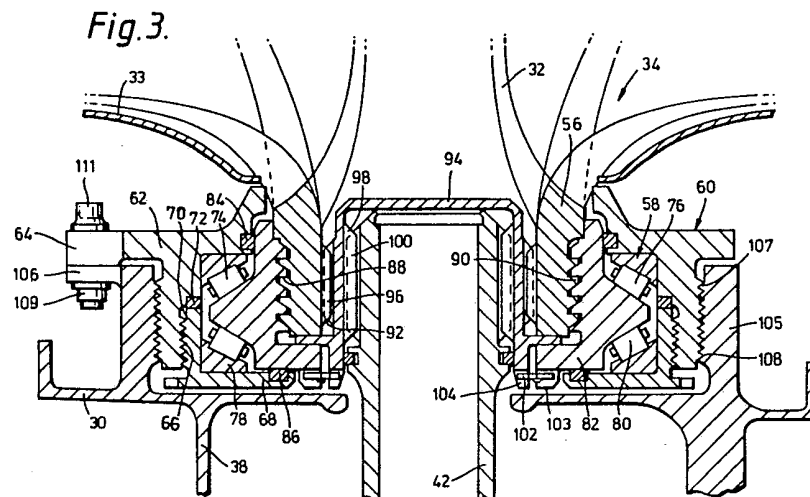


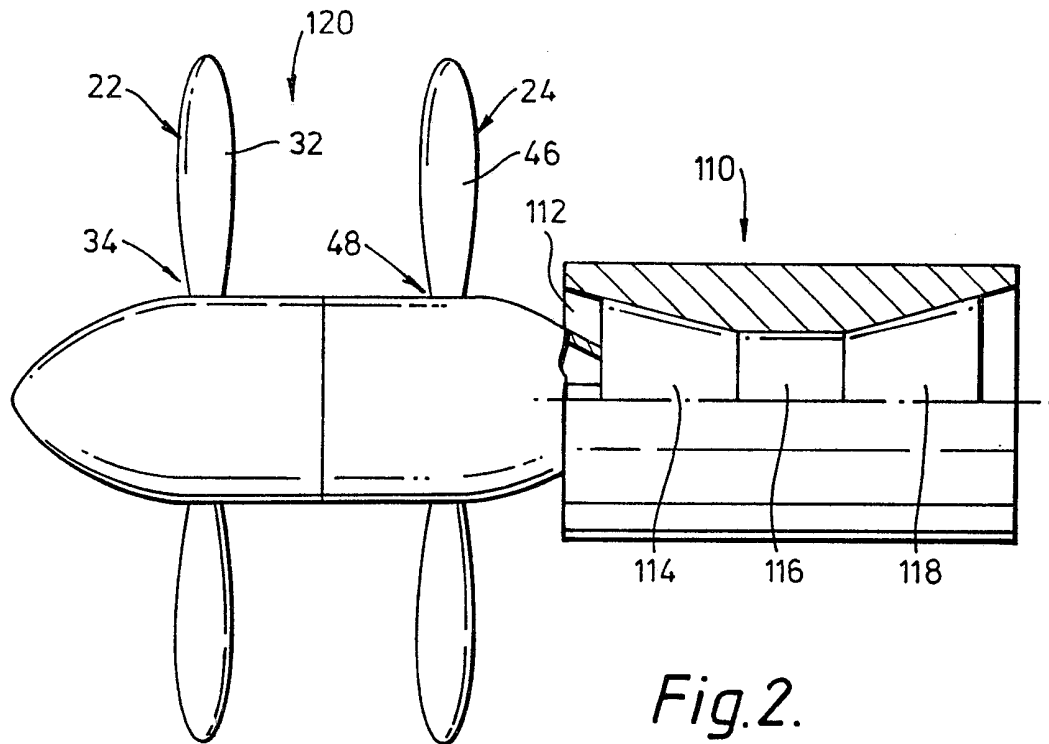
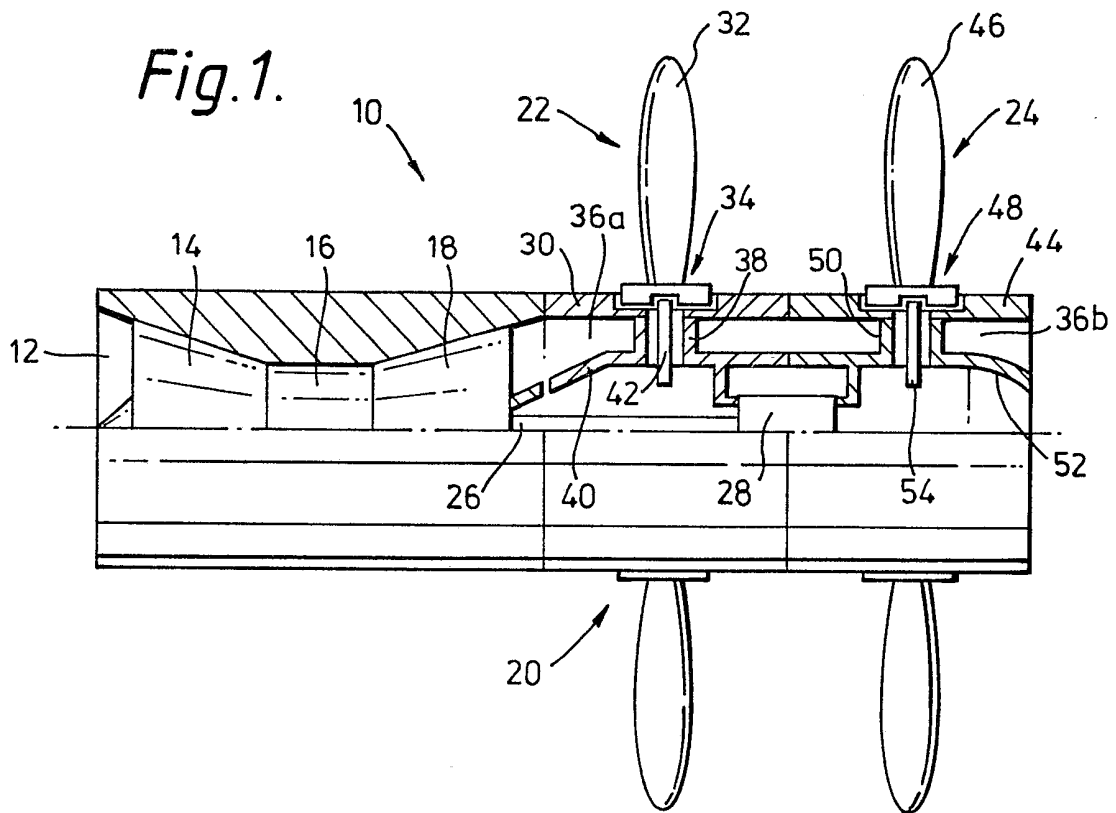
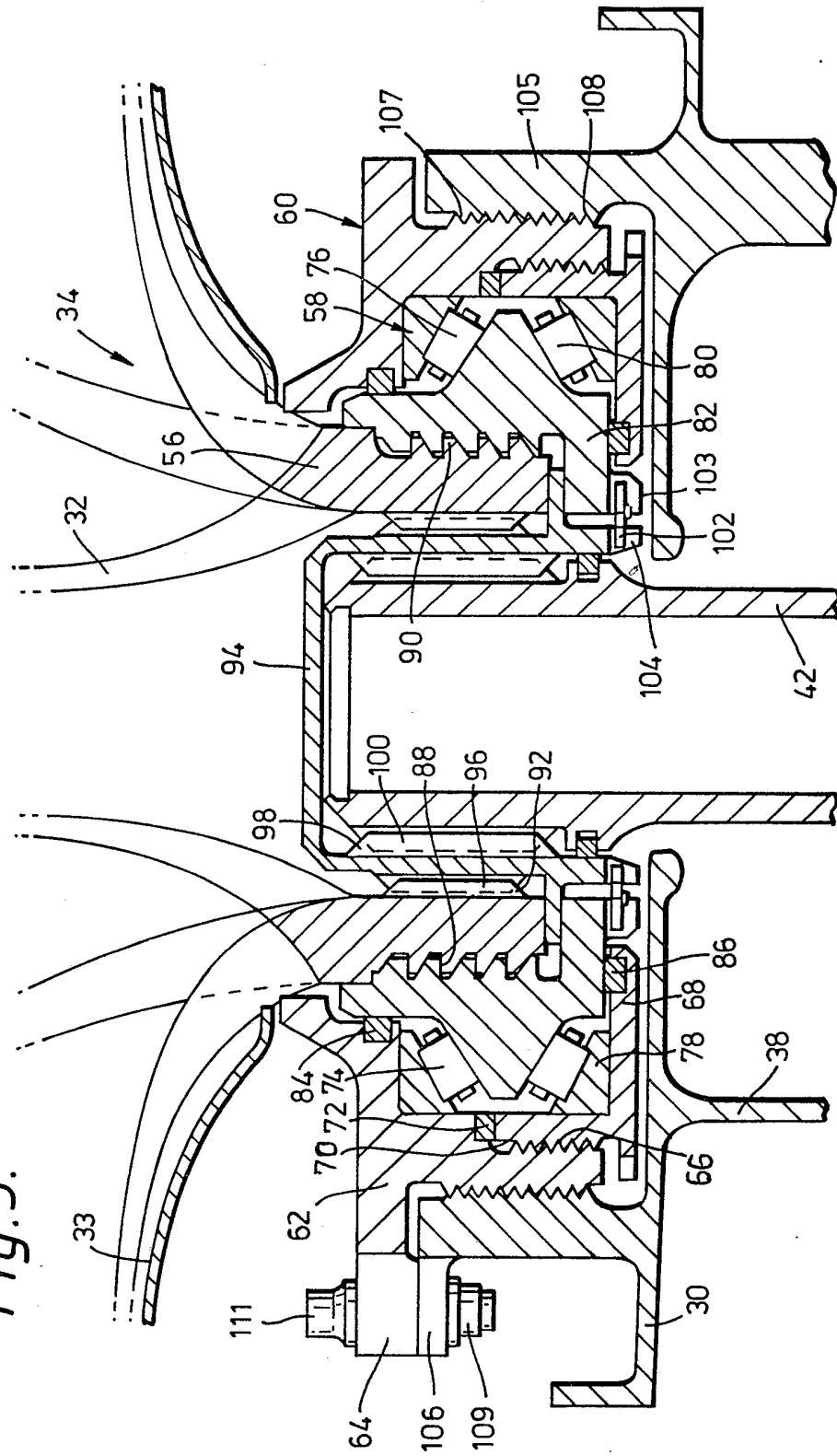
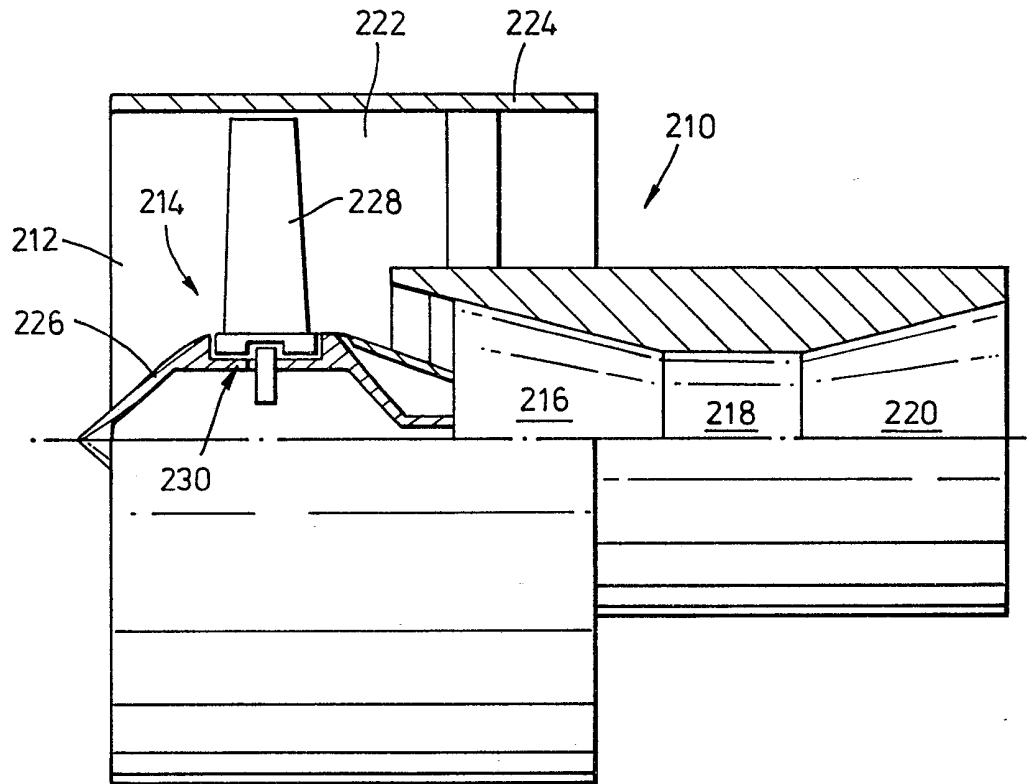
Fig.1.*Fig.2.*

Fig. 3.



*Fig.4.*

SPECIFICATION

A variable pitch blade assembly

- 5 The present invention relates to variable pitch blades, particularly for turbopropeller or turbofan gas turbine engines.

The propeller blades of turbopropeller gas turbine engines are rotatably mounted on a propeller hub so that pitch changes of the propeller blades may be affected.

- 10 The propeller blades are normally secured at or by their roots to the propeller hub by bearings with split races. This arrangement does not allow easy removal or loading of the individual propeller blades. Also in removing the propeller blades from the propeller hub the bearings are disturbed.

20 The present invention seeks to provide a variable pitch propeller or fan blade assembly which allows easy removal or loading of the propeller or fan blades from the propeller or fan hub.

25 The invention also seeks to provide a variable pitch propeller or fan blade assembly in which the bearings are not disturbed during removal or loading of the propeller or fan blade from the propeller or fan hub.

30 Accordingly the present invention provides a variable pitch blade assembly comprising an aerofoil portion and a root portion, the root portion being rotatably mounted in a casing by a bearing assembly, the bearing assembly, the root portion and the casing forming an integral assembly whereby the variable pitch blade may be removably secured to a rotor hub to allow the variable pitch blade to be more easily secured to or removed from the rotor hub.

40 The root portion may be secured coaxially to and within a tubular bearing member to at least reduce fretting to the outer surface of the root portion.

45 The bearing assembly may comprise a first roller bearing and a second roller bearing, the first and second roller bearings each having a first bearing race mounted on the casing, the first and second roller bearings each have a second bearing race on the tubular bearing member.

50 The first and second roller bearings may be taper roller bearings, the tubular bearing member having conical outer surfaces forming the second bearing races.

55 The casing may comprise a ring nut and a sleeve nut, the ring nut having a screw thread on its internal surface and the sleeve nut having a screw thread on its external surface for engagement with the screw thread on the ring nut.

60 The first roller bearing may have its first bearing race on the ring nut and the second roller bearing has its first bearing race on the sleeve nut. A washer may be positioned axially between the ring nut and sleeve nut to preload the bearing assembly.

70 The blade root may be tubular and has a plurality of splines on its interior surface, an inner sleeve is positioned coaxially within the tubular blade root, the inner sleeve has a plurality of splines on its exterior surface which engage and lock with the splines on the tubular root portion to at least reduce fretting to the interior surface of the root portion. The inner sleeve may be hollow and has a plurality of splines on its interior surface adapted to engage a plurality of splines on the exterior surface of a coaxial pitch changing shaft when secured to the rotor hub.

80 A locking ring may prevent relative rotation between the tubular bearing member and the inner sleeve.

The variable pitch blade may be a propeller blade or a fan blade.

85 The invention also provides a rotor assembly comprising a rotor hub having a plurality of circumferentially arranged housings for receiving variable pitch blades, at least one variable pitch blade having an aerofoil portion and a root portion, the root portion being rotatably mounted in a casing by a bearing assembly, the bearing assembly, the root portion and the casing forming an integral assembly whereby the variable pitch blade is removably secured coaxially in one of the housings of the rotor hub.

95 The housings may be tubular and have screw threads on their interior surfaces, the casing having a screw thread on its exterior surface for engaging the screw thread on said one of the housings for securing the variable pitch blade coaxially in said one of the housings of the rotor hub.

100 The housing may have flanges, the casing having flanges, the flanges of the said one of the housings and the casing are secured together to prevent relative rotation of the said one of the housings and the casing.

110 The present invention will be more fully described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a partially cut away view of a pusher turbopropeller gas turbine engine having variable pitch propeller blades according to the present invention.

115 Figure 2 is a tractor propeller gas turbine engine having variable pitch propeller blades according to the present invention.

120 Figure 3 is a cross-sectional view to an enlarged scale of a portion of a variable pitch propeller blade according to the present invention.

Figure 4 is a turbofan gas turbine engine having variable pitch fan blades according to the present invention.

125 A pusher turbopropeller gas turbine engine 10 is shown in Figure 1 and comprises an unobstructed inlet 12, a compressor 14, a combustion chamber 16, and a turbine 18 arranged in flow series. A propeller module 20 is positioned downstream of the turbine 18,

and the propeller module comprises a first and second propeller 22 and 24 respectively.

The gas turbine engine works conventionally in that air is compressed in the compressor and is supplied into the combustion chamber. Fuel is injected into, and burnt in the compressed air in, the combustion chamber to produce hot gases. The hot gases flow out of the combustion chamber and drive the turbine. The turbine drives the compressor *via* a shaft (not shown), and also drives the propellers *via* a shaft 26 and a gearbox 28. The gearbox is arranged to drive the propellers 22 and 24 in opposite directions.

The first propeller 22 comprises a propeller hub 30 which carries a plurality of circumferentially arranged propeller blades 32. The propeller blades 32 comprise aerofoil portions 33 and root portions and are secured to the propeller hub 30 by an integral blade root, bearing and casing assembly 34. The propeller hub 30 is hollow and an annular exhaust passage 36a is formed therethrough. A plurality of vanes 38 extend radially across the annular exhaust passage 36a to an inner casing 40 which is driven by the gearbox 28. A pitch changing quill shaft 42 extends radially through each vane 38 to a respective integral blade root, bearing and casing assembly 34 so as to enable pitch changing of each propeller blade 32 of propeller 22.

The second propeller 24 comprises a propeller hub 44 which carries a plurality of circumferentially arranged propeller blades 46. The propeller blades 46 are secured to the propeller hub 44 by an integral blade root, bearing and casing assembly 48. The propeller hub 44 is hollow and an annular exhaust passage 36b is formed therethrough as a continuation of passage 36a. A plurality of vanes 50 extend radially across the annular exhaust passage 36b to an inner casing 52 which is driven by the gearbox 28. A pitch changing quill shaft 54 extends radially through each vane 50 to a respective integral blade root, bearing and casing assembly 48 so as to enable pitch changing of each propeller blade 46 of propeller 24.

A tractor propeller gas turbine engine 110 is shown in Figure 2 and comprises an annular intake 112, a compressor 114, a combustion chamber 116 and a turbine 118 arranged in flow series. A propeller module 120 is positioned upstream of the compressor 114, and the propeller module comprises a first and second propeller 122 and 124 respectively. The turbine drives the compressor 114 *via* a shaft (not shown), and also drives the propellers 122 and 124 *via* a shaft 126 and a gearbox 128, the gearbox drives the propellers in opposite directions.

The first and second propellers 122 and 124 also have integral blade root, bearing and casing assemblies 134 and 148 which are identical to those in Figure 1.

An integral blade root, bearing and casing assembly 34 of a variable pitch propeller blade 32 is shown more clearly in Figure 3, and comprises a tubular blade root 56 of the propeller blade 32, a bearing assembly 58 and a casing 60. The root portion 56 of the propeller blade is rotatably mounted coaxially in the casing 60 by the bearing assembly 58. The integral assembly 34 of root portion 56, bearing assembly 58 and casing 60 allows the propeller blade 32 to be removably secured to the propeller hub to allow the propeller blade to be easily removed from or secured to the propeller hub, for example for servicing or replacing of the propeller blades. Also the integral assembly of root portion, bearing assembly and casing allows the propeller blade to be removed from the propeller hub without disturbing the bearing assembly, therefore loss of bearing grease or lubricant is prevented and foreign bodies cannot enter the bearing assembly.

The casing 60 comprises a ring nut 62, which has one or more flanges 64 and an internal screw thread 66, and a sleeve nut 68 which has an external screw thread 70. The sleeve nut 68 and ring nut 62 are threaded together, and a washer 72 is positioned radially between confronting surfaces on the sleeve nut and ring nut.

The bearing assembly 58 comprises a first roller bearing and a second roller bearing positioned in the casing 60. A first taper bearing race 74 of the first roller bearing is located on the ring nut 62 and a first taper bearing race 78 of the second roller bearing is located on the sleeve nut 68. A tubular bearing nut 82 has an outer surface which has opposed conical surfaces which form the second bearing races of the first and second bearings. A plurality of bearing rollers 76 are adapted to run on race 74 and bearing nut 82, and a plurality of bearing rollers 80 are adapted to run on race 78 and tubular bearing nut 82.

Seals 84 and 86 positioned between and sealingly engaging the ring nut 62 and tubular bearing nut 82, and between and sealingly engaging the sleeve nut 82 and tubular bearing nut 82 respectively close the bearing assembly to retain the bearing grease.

The tubular bearing nut 82 has a thread 88 on its interior surface which engages a thread 90 on the exterior surface of the tubular root portion 56, to secure the blade root portion coaxially to the bearing nut. The tubular root portion 56 has a plurality of axially extending splines 92 on its interior surface which engage and are locked with a plurality of splines 96 on the exterior surface of a generally top-hat shaped inner sleeve 94. The interior surface of the inner sleeve 94 has a plurality of splines 98 which are adapted to engage a plurality of splines 100 on the pitch changing quill shaft 42.

A locking ring 102 engages teeth 103 on

the tubular bearing nut 82 and teeth 104 on the inner sleeve 94, to prevent relative rotation between the propeller root 56 and the bearing nut 82.

- 5 The integral blade root, bearing and casing assembly 34 of the propeller blade is secured to the propeller hub 30 and is secured coaxially within one of a plurality of circumferentially arranged housings 105 formed on the
10 propeller hub. The exterior surface of the ring nut 62 is provided with a screw thread 107 which engages a screw thread 108 on the interior surface of the housing 105. A number of nuts 109 and bolts 111 secure together
15 the flanges 64 and 106 on the casing 60 and housing 105 respectively, to prevent relative rotation of the casing 60 and housing 105.

- The quill shafts 42 are driven by variable pitch means, for example hydraulic, electric,
20 pneumatic or mechanical motors, so as to change the pitch of the propeller blades 32. The splines on the radially outer ends of the quill shafts drive, but are free to articulate with the splines on the inner sleeve to accom-
25 modate eccentricities or other misalignments. The splines on the inner surface of the propeller root and outer surface of the inner sleeve are locked to prevent or reduce fretage.

- The provision of the bearing nut between
30 the bearing rollers and the root portion of the propeller blade reduces or prevents fretage, or wearing of the exterior surface of the root. Similarly the provision of the inner sleeve between the root portion of the propeller blade
35 and the quill shaft reduces or prevents fretage of the interior surface of the root.

- The washer 72 and sleeve nut 66 can be used to preload the taper roller bearings, by
40 varying the amount by which the sleeve nut is threaded onto the ring nut, and by choice of the washer.

- The propeller blade is simply removed from the propeller hub by releasing the nuts and bolts, unthreading the casing ring nut from the
45 housing of the propeller hub, and this disengages the splines of the quill shaft and inner sleeve by movement of the propeller blade axially of the blade and quill shaft or radially of the gas turbine engine.

- 50 To load the propeller blade, the splines of the quill shaft and inner sleeve are engaged, and the casing ring nut and housing are threaded together, and finally the nuts and bolts secure the flanges of the casing and
55 housing.

In Figure 1 the bearing chamber is also isolated from the hot gases in the annular exhaust passages 36a and 36b.

- Figure 4 shows a turbofan gas turbine engine 210 which comprises an inlet 212, a fan 214, a compressor 216, a combustion chamber 218 and a turbine 220 arranged in flow series. The gas turbine engine works conventionally in that air is compressed initially by
60 the fan, and a portion of the air flows through

a fan duct 222 defined by a fan casing 224 and the remainder of the air flows into the compressor to be further compressed. The air is supplied into the combustion chamber, where fuel is burnt in the compressed air to produce hot gases. The hot gases flowing through and driving the turbine, which is arranged to drive the fan and compressor *via* a shaft or shafts (not shown).

- 70 The fan comprises a fan hub 226 which carries a plurality of circumferentially arranged variable pitch fan blades 228. The fan blades are secured to the fan hub by an integral blade root, bearing and casing assembly 230 similar to that in Figure 3.

- The fan hub carries generally more blades than a propeller hub resulting in less space for the integral root, bearing and casing assembly. The use of these integral assemblies for the
85 fan is still possible. In order to remove or load these fan blades, the fan casing must be moved or removed at least partially so as to allow access to the fan blades.

- The use of the integral root portion, bearing
90 and casing assembly is applicable to all types of propeller blades and fan blades, whether the blades are solid, hollow blades formed from titanium sheets with a honeycomb filler or if it is a fibre reinforced spar with a super-
95 plastically formed diffusion bonded shell or other equally practicable structure.

- The integral root portion, bearing and casing assembly is applicable to any variable pitch propeller blades, and is not limited to counter-rotating propellers, and any variable pitch fan blades whether a front turbofan or an aft turbofan gas turbine.

- The use of other bearings besides taper roller bearings may be possible as is clear to those skilled in the art.

CLAIMS

1. A variable pitch blade assembly comprising an aerofoil portion and a root portion, the root portion being rotatably mounted in a casing by a bearing assembly, the bearing assembly, the root portion and the casing forming an integral assembly whereby the variable pitch blade may be removably secured to a rotor hub to allow the variable pitch blade to be more easily secured to or removed from the rotor hub.

2. A variable pitch blade assembly as claimed in claim 1 in which the root portion is secured coaxially to and within a tubular bearing member to at least reduce fretage to the outer surface of the root portion.

3. A variable pitch blade assembly as claimed in claim 2 in which the bearing assembly comprises a first roller bearing and a second roller bearing, the first and second roller bearings each having a first bearing race mounted on the casing, the first and second roller bearings each have a second bearing race on the tubular bearing member.

4. A variable pitch blade assembly as claimed in claim 3 in which the first and second roller bearings are taper roller bearings, the tubular bearing member having conical outer surfaces forming the second bearing races.

5. A variable pitch blade assembly as claimed in any of claims 1 to 4 in which the casing comprises a ring nut and a sleeve nut, the ring nut having a screw thread on its internal surface and the sleeve nut having a screw thread on its external surface for engagement with the screw thread on the ring nut.

6. A variable pitch blade assembly as claimed in claim 5 when dependent upon claim 3 or claim 4 in which the first roller bearing has its first bearing race on the ring nut and the second roller bearing has its first bearing race on the sleeve nut.

7. A variable pitch blade assembly as claimed in claim 5 or claim 6 in which a washer is positioned axially between the ring nut and sleeve nut to preload the bearing assembly.

8. A variable pitch blade assembly as claimed in any of claims 1 to 7 in which the blade root is tubular and has a plurality of splines on its interior surface, an inner sleeve is positioned coaxially within the tubular blade root, the inner sleeve has a plurality of splines on its exterior surface which engage and lock with the splines on the tubular root portion to at least reduce fretting to the interior surface of the root portion.

9. A variable pitch blade assembly as claimed in claim 8 in which the inner sleeve is hollow and has a plurality of splines on its interior surface adapted to engage a plurality of splines on the exterior surface of a coaxial pitch changing shaft when secured to the rotor hub.

10. A variable pitch blade assembly as claimed in claim 8 or claim 9 when dependent upon claims 2 to 7 in which a locking ring prevents relative rotation between the tubular bearing member and the inner sleeve.

11. A variable pitch blade assembly as claimed in any of claims 1 to 10 in which the variable pitch blade is a propeller blade.

12. A variable pitch blade assembly as claimed in any of claims 1 to 10 in which the variable pitch blade is a fan blade.

13. A rotor assembly comprising a rotor hub having a plurality of circumferentially arranged housings for receiving variable pitch blades, at least one variable pitch blade having an aerofoil portion and a root portion, the root portion being rotatably mounted in a casing by a bearing assembly, the bearing assembly, the root portion and the casing forming an integral assembly whereby the variable pitch blade is removably secured coaxially in one of the housings of the rotor hub.

14. A rotor assembly as claimed in claim

13 in which the housings are tubular and have screw threads on their interior surfaces, the casing having a screw thread on its exterior surface for engaging the screw thread on said one of the housings for securing the variable pitch blade coaxially in said one of the housings of the rotor hub.

15. A rotor assembly as claimed in claim 13 in which the housings have flanges, the casing having flanges, the flanges of the said one of the housings and the casing are secured together to prevent relative rotation of the said one of the housings and the casing.

16. A rotor assembly as claimed in claim 13, claim 14 or claim 15 in which the rotor is a propeller and the variable pitch blade is a variable pitch propeller blade.

17. A rotor assembly as claimed in claim 13, claim 14 or claim 15 in which the rotor is a fan rotor of a gas turbine engine and the variable pitch blade is a variable pitch fan blade.

18. A variable pitch blade assembly substantially as hereinbefore described with reference to and as shown in Figure 3.

19. A variable pitch propeller blade substantially as hereinbefore described with reference to and as shown in Figures 1 to 3.

20. A variable pitch fan blade substantially as hereinbefore described with reference to and as shown in Figure 4.

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