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McMurtry

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[54] **VARIABLE PITCH ROTARY BLADING**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **416/145,** 416/139, 416/157, 416/167

[51] **Int. Cl.** **B64c 11/06**

[58] **Field of Search** 416/145, 139, 155–157, 416/167

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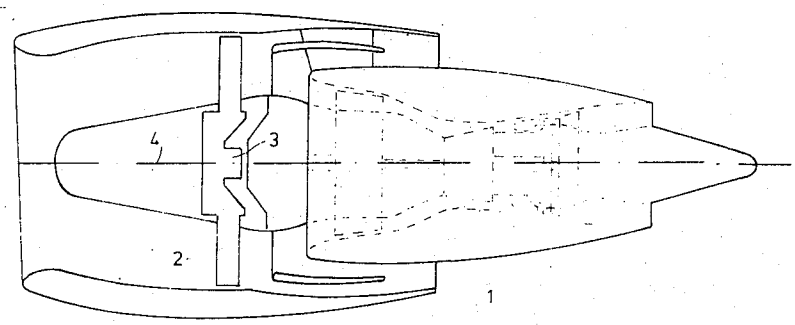
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Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

The centrifugal turning moments on a variable pitch fan blade are counter balanced by the centrifugal force on a cam follower member which is reacted by a cam member connected to the blade to provide a turning moment on the blade opposite to the centrifugal turning moment. The cam member is a cylinder surrounding the blade root and having at least one cam track. A reaction member in the form of a second cylinder concentric with the cam member and having oppositely inclined corresponding cam tracks is connected to structure stationary relative to the blade. The cam follower member is a roller engaging the cam tracks on both the cam member and the reaction member.

4 Claims, 3 Drawing Figures



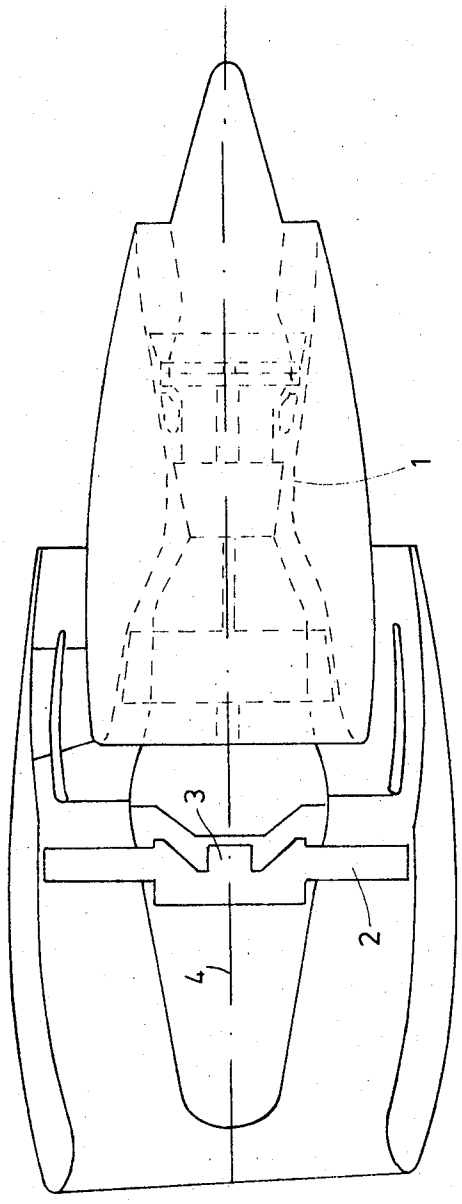


FIG. 1.

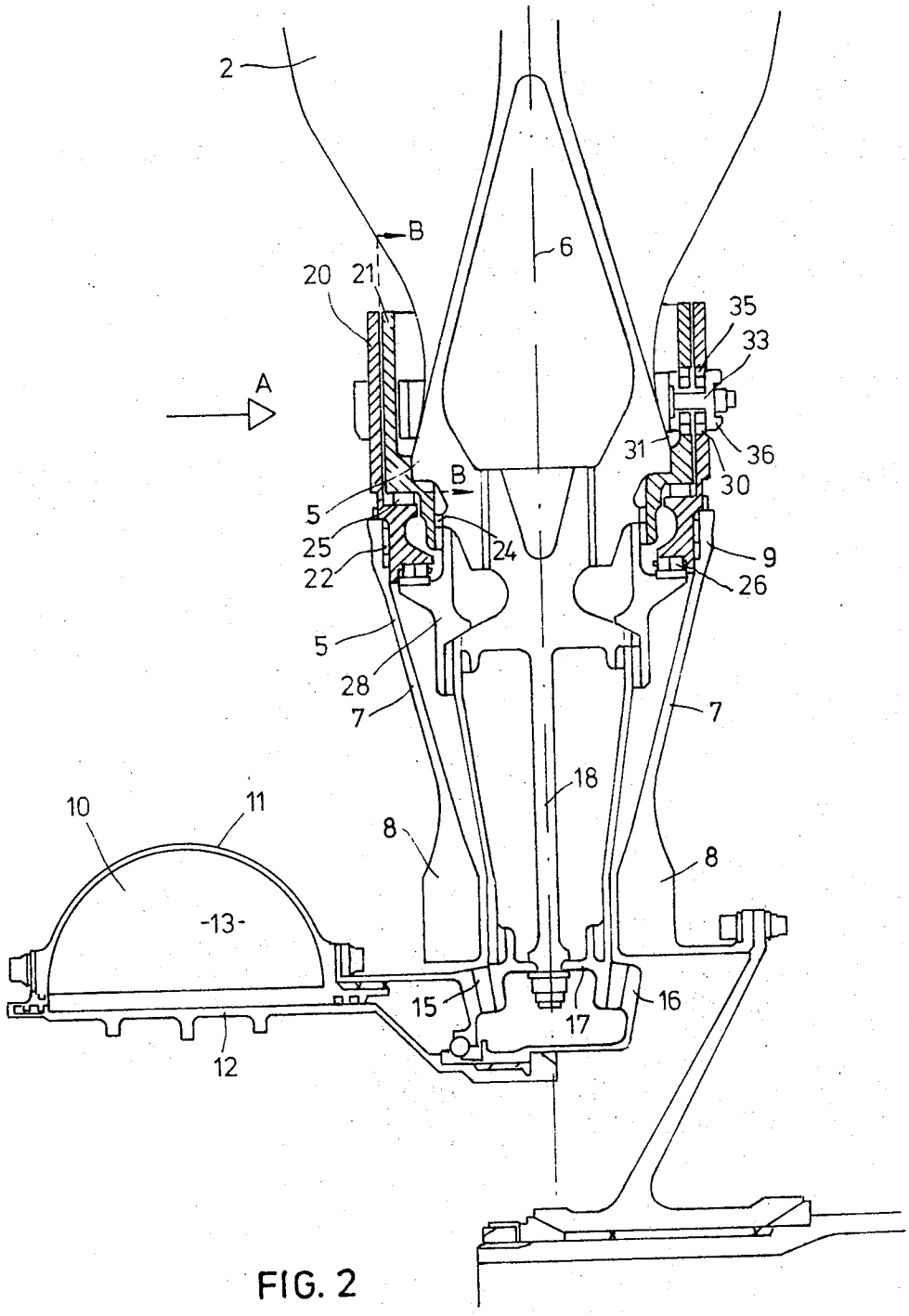

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FIG. 2

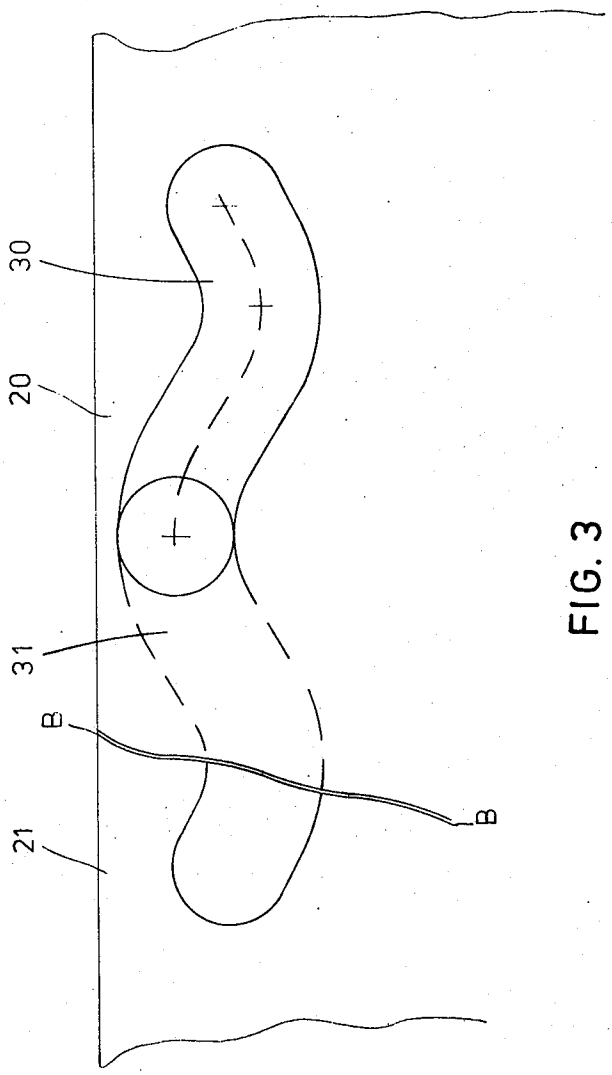


FIG. 3

VARIABLE PITCH ROTARY BLADING

The present invention relates to variable pitch rotary blading, for example, variable pitch fans or propellers, and relates in particular to means for counterbalancing the centrifugal turning moments produced on the blading due to rotation of the blading about an axis perpendicular to the plane of the rotor on which the blading is mounted.

The invention is particularly applicable to a gas turbine engine driving a variable pitch fan.

When a fan or propeller blade is rotated about an engine axis a centrifugal moment is generated which tends to turn the blade into fine pitch. This moment, known as the centrifugal turning moment, varies with both speed of rotation and pitch setting, being maximum when the blade is at 45° to the engine axis. In a fixed pitch fan or propeller engine, the blades cannot turn and the centrifugal turning moment is reacted by the blade root fixing. With a variable pitch fan or propeller where the blades can turn, it is necessary to design some for m of means to react against the moment to prevent the blades from turning, in order to minimise the size of the pitch changing mechanism, which would otherwise have to be big enough to turn the blades against the centrifugal turning moments thereon.

According to the present invention variable pitch rotary blading comprises a rotor mounted for rotation about a main axis and on which a plurality of blades is mounted for rotation about their longitudinal axes to vary their pitch, there being provided in association with each blade a cam member, a cam following member and a reaction means, one of the members being connected to the blade to rotate therewith about the longitudinal axis thereof, one of the members being radially movable under centrifugal force due to rotation of the rotor about the main axis, the cam member being profiled and co-operating with the cam following member and reaction means so as to provide a turning moment on the blade derived from the centrifugal force of the movable member to substantially balance the centrifugal turning moment of the blade itself.

Thus the profiles of the cam tracks may be such that whatever the pitch setting of the blades, the turning moments produced by the cam tracks balance the centrifugal turning moments so that there is no movement of the blades from their desired pitch setting. The turning moments produced by the cam tracks may, however, be arranged to be slightly greater than the centrifugal turning moments, so that there is always a force on each blade root tending to turn the blade to the feathered position in case of a failure in the pitch control mechanism.

Additionally the cam tracks may be profiled to counterbalance the gas turning moments on the blades.

In one preferred form of the invention the cam members are cylindrical members, having three cam tracks in the form of slots in the walls thereof, the reaction means are concentric cylinders having a corresponding number of cam slots which have oppositely inclined cam surfaces, and there are three cam following members for each cam member which engage both cam slots simultaneously, one cam member being connected to each blade for rotation therewith about the longitudinal axis thereof, the reaction members being connected to the rotor so as to be stationary relative to the blades, and the cam following members are movable under centrifugal action.

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

FIG. 1 is a diagrammatic view of a variable pitch fan engine incorporating the present invention,

FIG. 2 is a sectional elevation of a fan blade root and disc showing the cam members of the invention, and,

FIG. 3 is a developed view on Arrow A of FIG. 2 partly sectioned along the line B—B and showing only the cam tracks on the cam members.

Referring now to the drawings a gas turbine engine comprises a gas generator or core engine **1**, which drives a fan **2** through a gear box **3**. The core engine comprises the usual compressor means, combustion equipment and turbine means (not shown) as are well known in the art, all of which rotate about a main axis **4**.

Referring to FIG. **2**, the blades of the fan **2** each have a root portion **5** which is mounted for rotation of its respective fan blade about its longitudinal axis **6**. The root portions **5** are mounted in a rotor disc which is of open-ended channel section, having two inclined side walls **7** terminating in radially inner hub portions **8** and a radially outer end wall **9**.

The variable pitch mechanism extends up through the hollow interior of the disc so that the pitch (i.e., angle of attack) of the blades can be varied. The mechanism comprises a vane motor **10** which has a semicircular outer casing **11** carrying integral radially inwardly extending vanes, and a cylindrical inner casing **12** carrying a second set of vanes which co-operate with the vanes on the outer casing to form chambers **31** into which hydraulic fluid under pressure can be pumped. Both the outer casing and the inner cylinder rotate under the influence of the hydraulic fluid and are provided with gear teeth **15** and **16** which mesh on opposite sides of a toothed bevel **17** which acts via a radially extending shaft **18** to change the pitch of the blades.

Since the blades are arranged to rotate about their longitudinal axes to vary their pitch, in operation, the centrifugal turning moments acting on the blades will tend to turn them to the fine position. In order to balance this turning moment, each blade is provided with a pair of cylindrical cam members **20** and **21** which surround the blade roots. The outer cam member **20** is splined to the disc through a splined connection **22** to keep it stationary with respect to the disc. The inner cam member **21** is splined to the blade root through a splined connection **24** and rotates with the fan blade when the pitch of the blade is varied. A bearing **25** is provided between the two cam members **20** and **21** to allow relative rotation between the two. A bearing **26** is provided between the outer cam member **20** and a locking member **28** which is splined to the blade root, to allow relative rotation between the blade root and the disc.

Each cam member **20** and **21** is provided with a cam track **30** and **31**, (see FIG. **3**) and a pin **33** is provided which passes through both cam members. Each pin carries a roller **35** supported in a cage **36** and which rolls on the surfaces of the cam tracks.

The cam tracks on the two members are oppositely inclined so that the centrifugal force on the rollers which urges them radially outwardly, causes a force on

the two cam tracks which tends to rotate the cams in opposite directions. Since cam **20** cannot move, it becomes a reaction means whereby the whole of the centrifugal load is transmitted to the track on the movable member, and due to the track inclination a force component is produced tending to rotate the movable cam member.

Thus when it is required to change the pitch on the fan blades the vane motor **10** is operated and rotates the blade root via gears **15, 16** and **17** and this in turn causes rotation of the inner cam tracks **21,** the power of the vane motor being sufficient to overcome the frictional resistance of the system. Once the desired pitch setting has been reached, any further change in pitch due to the centrifugal turning moment on the blades is opposed by the reaction of the centrifugal force on the rollers in the cams. Since the centrifugal turning moment is different for each pitch setting of the blades the cam tracks are profiled to produce a different component of the roller centrifugal force at each of the different positions, by varying the angles of the tracks.

By this means the centrifugal turning moments on the blades are balanced without having to be reacted through the pitch change mechanism which can therefore be made smaller. In addition the profiles of the cam tracks can be modified to take into account also the turning moment on the blades due to gas forces so that these two can be counter-balanced for any given position of the blade. Thus the pitch change mechanism need only be sufficiently large to turn the blades, i.e. to overcome friction in the system and need not react other forces.

The profiles of the cams may additionally be such that the net moment on the blades produced by the cam members, the cam following members and the reaction means, is a moment tending to turn the blades towards the "feathered" position. Thus in case of a failure in the pitch changing mechanism the blades would automatically feather.

I claim:

1. Variable pitch rotary blading comprising a rotor mounted for rotation about a main axis, a plurality of blades each having a root portion and means for rotatably mounting said root portion on the rotor for rotation of the blade about its longitudinal axis to vary the pitch thereof, there being provided in association with each blade a pair of concentric cylindrical members mounted to surround the root portion of the blade, one of the members being mounted for rotation with the root portion about the longitudinal axis of the blade, the other of the members being mounted on the rotor in a fixed position relative thereto, one of the members having means defining at least one slot therein, the other of the members having at least one corresponding slot therein, said slot defining a pair of oppositely inclined cam surfaces one on each member, a roller engaging both cam surfaces of a said pair, the roller being movable under centrifugal force due to rotation of the rotor about the main axis, the cam surfaces being profiled to provide a turning moment on the blade derived from the radial movement of the roller to oppose the centrifugal turning moment of the blade itself.

2. Variable pitch rotary blading as claimed in claim **1** wherein the cylindrical members around one blade root have means defining three slots to provide three pairs of oppositely inclined cam surfaces and three rollers are provided one for each pair of cam surfaces.

3. Variable pitch rotary blading according to claim **1** and wherein the cam surfaces are additionally profiled so that the turning moment produced on each blade by the roller substantially balances the sum of the centrifugal turning moments on the blades and the turning moments due to the gas loads on the blades.

4. Variable pitch rotary blading according to claim **1** and wherein the cam surfaces are profiled so that the turning moments produced on the blades by the rollers are slightly greater than the centrifugal turning moments on the blades so that there is a net moment tending to turn the blades into the feathered position.

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