

## SPECIFICATION

## Impeller for a Variable Pitch Axial Flow Fan

This invention relates to impellers for variable pitch axial flow fans, that is to say impellers in which the pitch angle of the blades can be varied while the impeller is rotating.

In such impellers the blades are commonly supported in bearings carried by a hollow hub, so as to be rotatable about respective axes extending radially from the axis of rotation of the impeller, the inner ends of the blades carrying arms which extend outwardly with respect to the blade axes, and which are coupled to an actuator movable parallel to the impeller axis so as to effect a rotation of the blades within the respective bearings, and thereby vary their pitch angle. The invention is concerned especially with impellers of this kind, which will hereinafter be referred to as of the kind specified.

It is well known that if a body, rotatable about its own axis, is rotated about a perpendicular axis, the centre of mass of the body will have a strong tendency to align itself with the plane of rotation of the body axis.

In a variable pitch axial flow fan this is manifested by a turning force which tends to reduce the blade pitch angle, that is to say the angle measured between the chord line and said plane of rotation.

It is common to compensate for this turning moment in impellers of the kind specified by attaching counterweights to the blade assembly within the hub. The actuator is then arranged to rotate the blades in either direction, a relatively strong return spring being provided for rotating the blades in the opposite direction. However in such arrangements the hub has to be sufficiently wide to accommodate the counterweights, and moreover since the counterweights add considerably to the weight of the blade assemblies, it must be made of suitably strong and heavy material to withstand the additional radial thrust developed under centrifugal force.

An object of the invention is to provide a form of impeller in which the use of counterweights can be provided.

According to the invention in an impeller of the kind specified for a variable pitch axial flow fan, the actuator is arranged to rotate the blades towards their maximum pitch angle, and the inherent blade turning moment provides the restoring force for moving the blades towards their minimum pitch angle.

Moreover the invention enables a relatively smaller and lighter hub to be used compared with those employed in counterweighted blade impellers.

In addition it has been found that the actuating forces in the planes of the blade bearings are very small compared with the centrifugal thrust forces exerted by the blades when the impeller is operating. Under these circumstances very simple axial thrust bearings can be utilised without recourse to the addition of journal bearings for the

blades; the line of action of the resultant forces on the bearing remaining within the ball tracks.

The actuator is preferably arranged to be operated by pneumatic pressure from a suitable source via a rotary seal.

The invention will be further described by reference to Figures 1 and 2 of the accompanying drawings, in which Figure 1 illustrates an axial section through half of one impeller in accordance with the invention for an axial flow fan, and Figure 2 shows a transverse section of a part of the impeller.

In the drawing 1 represents the impeller hub shown bolted to a hollow boss 2 which is arranged to be secured to the shaft of an electric motor (not shown).

Around the periphery of the hub there are a number of uniformly spaced radially directed holes 3 into which are fitted the root portions 4 of respective aerofoil section blades 5 (shown only in part).

Each blade 5 is held in position by means of a circular retaining plate 6 which is secured to the inner end of the blade root 4 by means of a nut 7, which is screwed on to the protruding end of a threaded insert 8 captive within the blade root, a flange 10 at the outer end of the blade root being located in a recess around the outer end of the respective hole 3. A washer or pad 11 is located between the flange and the bottom of the recess.

Two dowels 15 are fitted between the blade 5 and the retaining plate 6 to provide location.

A thrust bearing 9 is clamped between the plate 6 and an inwardly facing surface of the hub 1 and, in use, when the impeller is rotating, the blades are urged outwardly under centrifugal force, the bearing 9 facilitating the rotation of the blade about its axis relative to the hub.

The thrust bearing 9 comprises a number of hardened steel balls 12 interposed between an annular inner race 13 adjacent the plate 6 and an outer race 14 adjacent the hub surface. The balls are arranged to roll in shallow annular grooves provided in the facing surfaces of the races 13 and 14 and are equidistantly spaced around the grooves by an annular bearing cage 16 having a relatively low mass, and formed, for example, from a suitable plastics material such as acetal resin or from nylon impregnated with graphite or molybdenum disulphide. The bearing cage 16 has a substantially channel shaped cross-section having in its base a plurality of uniformly spaced holes which accommodate the bearing balls 12, and is arranged so that in use either the base or the edges of its side walls bear against the surface of the outer race 14. The bearing 9 contains a lubricant having a density substantially the same as the material of the bearing cage 16.

The bearing 9 is enclosed by an annular housing 20 which is of channel-shaped cross-section having its mouth directed radially inwards towards the impeller axis, the depth of the walls of the housing being such that the bearing is accommodated entirely within the channel which

thus serves to keep the balls and the cage of the bearing covered with lubricant despite the effect of centrifugal force when the impeller is in use. Clearances are provided between the sides of the housing 20 and the inner ball race 13 and plate 6 to permit the blade to rotate freely.

Adjustment of the pitch angle of the blades 5 is effected by means of an arm 21 extending transversely from the plate 6 and supporting at its end a pin 22 carrying a roller 23 which locates within a channel 24 in the periphery of a common actuator 25. The actuator 25 is in the form of a shell formed in two parts 29, 30 joined around their periphery, the rear part 29 carrying a cylindrical flange 39 which surrounds the boss 2 but is free to move axially along it on a bearing 26.

The boss 2 carries coaxially at its end a circular plate 27 located within the actuator providing a backing for a diaphragm 28 which is clamped around its periphery between the two parts 29, 30 of the actuator 25 as shown. The plate 27 supports coaxially a stub shaft 31 which provides a guide for the front part 30 of the actuator which is free to slide axially along the shaft 31 on a bearing 32. The inner edge of the diaphragm 28 is secured to the plate 27 around the stub shaft 31, by an annular clamping plate 50 and screws 51.

In use of the impeller the inherent blade turning moment will tend to rotate the blades to their minimum pitch angle position as shown in Figure 1 of the drawing. In order to increase the pitch angle air under pressure is arranged to be admitted into the space between the front part 30 of the actuator and the diaphragm 28, via a rotatable coupling 35, and a duct formed by a gap or gaps (not shown) in the bearing 32. This produces a forward movement of the actuator 25 and so increases the pitch angle of the blades by an amount depending upon the admitted air pressure.

When the pressure is released the inherent blade turning moment causes the blades to be returned towards the minimum pitch angle position which is pre-determined by the positioning of the dowels 15 in the blade 5 and the retaining plate as described above. The minimum pitch angle is set before fitting the items 27, 30 and 41, by pulling the member 29 forward until it contacts adjusting nuts 17 carried on studs 18 screwed into the hub 1. The nuts 17 are adjusted until all the blades are at the desired pitch angle.

After assembly of the parts 27, 30 the impeller is completed by the attachment of a relatively thin-walled dome-shaped fairing 41 to the front of the hub 1 as shown.

The assembly of the impeller is facilitated by constructing the rear wall 42 of the actuator channel 24 in castellated form as shown more clearly in Figure 2, with the gaps 43 between the upstanding portions 44 of the wall of sufficient width to allow the passage of the rollers 23. After the rollers 23 have been located in the channel 24 the actuator is rotated relative to the hub to bring

the upstanding portions opposite the rollers, which may then be prevented from rolling out of engagement with the upstanding portions by fixing a screw 19.1 between the front and rear walls of the channel 24 on one side of the roller. A fixed dowel 19 extending between the walls of the channel 24 on the opposite side of the roller 23 prevents the roller from moving too far in the opposite direction.

## 75 Claims

1. An impeller for a variable pitch axial flow fan incorporating a plurality of blades extending outwards from a hollow hub, and supported by respective bearings so that they can be rotated about their axes with respect to the hub, the inner ends of which blades carry arms which extend outwardly with respect to the blade axes and are coupled to an actuator which is movable parallel to the axis of the impeller to rotate the blades within their bearings and so vary their pitch angle, wherein the actuator is operable to rotate the blades towards their maximum pitch angle, and the inherent blade turning moment when the impeller is rotating provides substantially the whole of the restoring force for moving the blades towards their minimum pitch angle.

2. An impeller according to Claim 1 having an adjustable stop which limits the movement of the actuator towards the maximum pitch angle position, adjustment of the stop enabling the maximum pitch angle of the blades to be set to a predetermined value.

3. An impeller according to Claim 1 or 2 wherein each blade has a root portion formed integrally with the blade and extending inwards through an opening in the wall of the hub, the blade being retained against radially inward movement by a flange at the outer end of the root portion, and against radially outward movement by a retaining member secured to the inner end of the root portion, a thrust bearing being located between said retaining member and the inner surface of the hub.

4. An impeller according to Claim 3 wherein each bearing comprises an outer race adjacent the hub, an inner race adjacent the retaining member, and a plurality of balls supported between the bearing races in a bearing cage, wherein in use, the bearing cage is supported against centrifugal forces by the outer race.

5. An impeller according to Claim 3 wherein the thrust bearing incorporates a bearing cage formed of a plastics material such as acetal resin or nylon impregnated with molybdenum disulphide or graphite.

6. An impeller according to Claim 3, 4 or 5 wherein each blade bearing is accommodated within an annular housing of channel-shaped cross-section having an open mouth directed towards the impeller axis, the walls of the housing extending inwards beyond the operative face of the inner bearing race.

7. An impeller according to any one of Claims 3 to 6 wherein the retaining member carries a said

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7. An impeller according to any one of Claims 3 to 6 wherein the retaining member carries a said

arm which is coupled to the actuator, said arm terminating in a roller which engages in a peripheral channel in the actuator.

- 5 8. An impeller according to Claim 7 wherein one wall of said peripheral channel is formed with uniformly spaced gaps for facilitating the introduction of the rollers into the channel during

assembly of the impeller.

- 10 9. An impeller according to any preceding Claim wherein the actuator is operable by pneumatic pressure.

10. An impeller substantially as shown in and as hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.

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