Dec. 8, 1970 J. W. SCHROETER ET AL 3,545,884

ADJUSTABLE FAN CONSTRUCTION

Filed Sept. 12, 1968

Fig. 1.

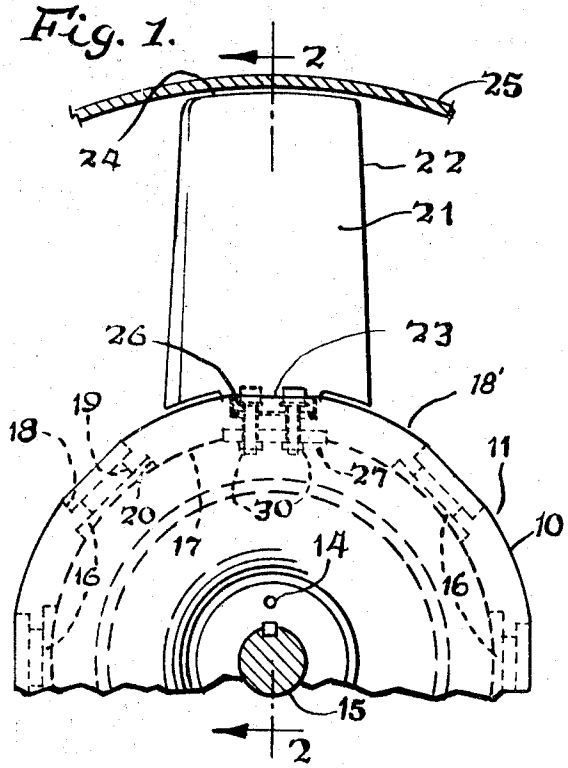



Fig. 2.

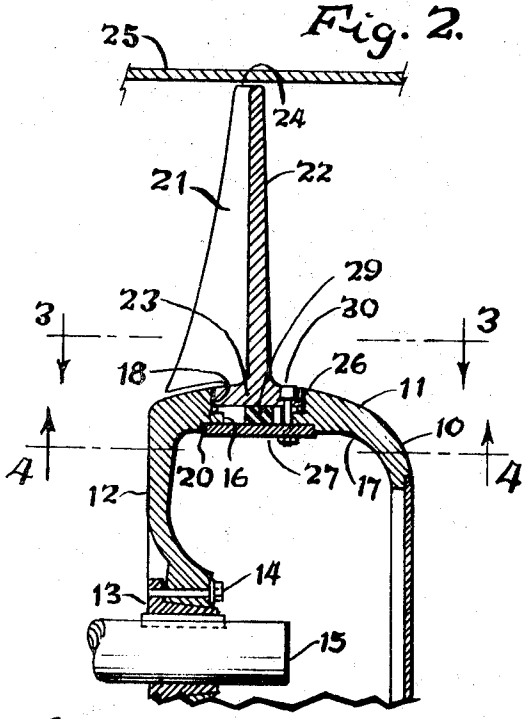



Fig. 3.

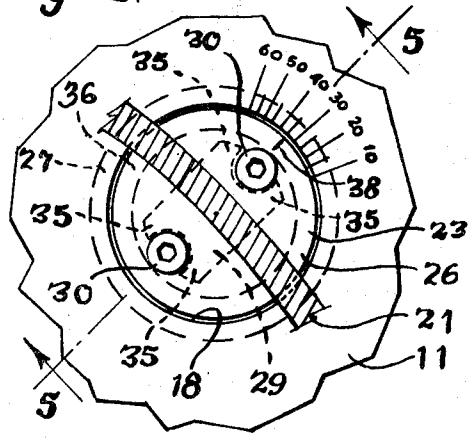



Fig. 4.

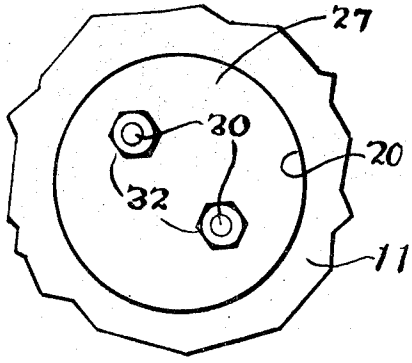



Fig. 5

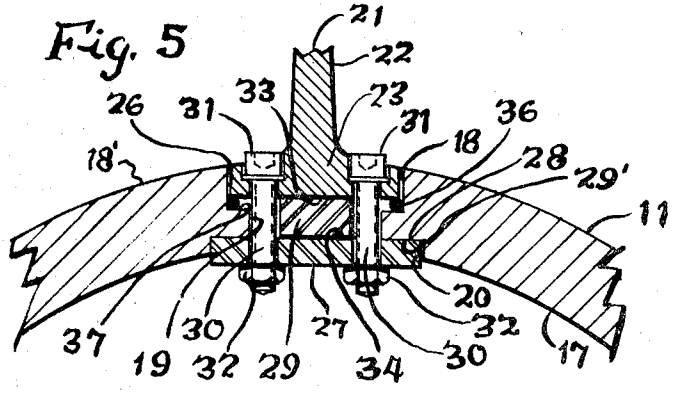



Fig. 6.




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# ADJUSTABLE FAN CONSTRUCTION

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Int. Cl. B64c 11/06
U.S. Cl. 416—205 11 Claims

## ABSTRACT OF THE DISCLOSURE

An adjustable fan construction including a plurality of blade assemblies mounted on an associated hub and each having a base assembly for sandwiching the hub including an upper base portion and a retaining disk fastened by a plurality of prestressed bolts with a spacer therebetween, and a resilient member interposed between the base assembly and the hub for holding the blade in any adjusted position but permitting it to be manually moved to any other desired position, without loosening of any retaining or locking members.

## BACKGROUND OF THE INVENTION

The present invention relates to an axial fan and more particularly to an improved construction for adjustably mounting individual fan blades on an associated hub.

In the past, various constructions have been utilized for adjustably mounting fan blades on the hub of an axial fan without requiring access to the inside of the hubs. However, the constructions for effecting such adjustments always required that bolts or other fastening members be loosened prior to adjusting the airfoil portion of the blade, and thereafter retightened after the adjustment was complete. Not only was this a troublesome and time consuming procedure but, in addition, if the bolts were not tightened sufficiently to properly prestress them they might under certain conditions fail because of fatigue. If a bolt failed, the fan blade held thereby could be thrown out from the hub and might be struck by the other rapidly rotating blades which could result in destruction of the entire fan. It is with an improved axial fan construction which overcomes the foregoing deficiencies of the prior art that the present invention is concerned.

## SUMMARY OF THE INVENTION

It is accordingly one object of the present invention to provide an improved axial fan construction in which the pitch of the airfoil portions of the blade can be changed by merely turning the blades without requiring the loosening and retightening of retaining bolts or other locking devices as in previous constructions.

Another object of the present invention is to provide an improved axial fan construction in which the bolts holding the blade assemblies on their associated hub can be tightened to a predetermined prestressed value during assembly at the factory and thus need not be changed in the field by virtue of the fact that the retaining or locking bolts need not be loosened and retightened incidental to adjusting the pitch of the blades.

A further object of the present invention is to provide an improved adjustable axial fan construction in which the base portion of the blade which mounts the blade assembly on its associated hub provides a good stable mounting which will not permit the blade to change pitch in use and which will retain the airfoil portions of the blades in their adjusted positions regardless of the forces to which they are subjected in use.

Yet another object of the present invention is to provide an improved axial fan which is constructed in an extremely simple manner for accomplishing its intended



function, and which can be manufactured with relatively low tolerances. Other objects and attendant advantages of the present invention will readily be perceived hereafter.

The improved adjustable fan constructiton of the present invention includes an hub having an inner surface and an outer surface, a plurality of spaced apertures in the hub extending between said inner and outer surfaces, and a blade assembly adjustably mounted in each of the apertures, each blade assembly comprising an airfoil portion and a base portion secured thereto which includes an outer base portion located proximate the outer surface of the hub, a retaining member spaced from the outer portion and located proximate the inner surface of the hub, fastening means for securing the retaining member to the remainder of the base portion, and holding means located between the hub and the base portiton for exerting a force between the base portion and the hub, which force is sufficiently large to maintain the base portion in a fixed position on the hub but which is sufficiently small so that it can be overcome by the application of a turning force to the blade without loosening the fastening means, thereby to permit adjustment of the blade pitch as desired. During rotation, the centrifugal force of the blade assembly provides an additional force which locks it to the hub. In addition, a spacer block may be located between the outer base portion and the retaining member of the base portion so that the fastening members, which are preferably bolts, may be prestressed to a proper degree to prevent fatigue during fan operation, because there is no requirement to loosen or tighten the bolts incidental to making the necessary pitch adjustment. The present invention will be more fully understood when the following portions of the specification are read in conjunction with the accompanying drawings wherein:

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a rear elevational view of the improved fan construction of the present invention;

FIG. 2 is a view taken substantially along line 2—2 of FIG. 1;

FIG. 3 is a view taken substantially along line 3—3 of FIG. 2;

FIG. 4 is a view taken substantially along line 4—4 of FIG. 2;

FIG. 5 is a view taken substantially along line 5—5 of FIG. 3; and

FIG. 6 is a perspective view of a modified form of resilient member which may be utilized for holding the blade assembly in position on its associated hub.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGS. 1 and 2 a hub **10** is shown having a circumferential annular peripheral wall portion **11** and a web **12** which is in turn mounted on a tapered sleeve **13** by means of a plurality of screws **14**, said tapered sleeve being attached to shaft **15** which is driven by a suitable motor, not shown.

The peripheral annular wall **11** of hub **10** has a plurality of circumferentially spaced apertures **16** therein, the number of which may vary depending on the number of fan blades which are to be used on a particular hub. The inner surface **17** of hub **11** is round to permit the same hub to be used as a blank for any number of apertures **16** which are required. Each aperture **16** includes a central portion **19**, an inner counterbored portion **20** and an outer counterbored portion **18** proximate the outer surface **18'**. See FIG. 5.

A blade assembly **21** fits into each bore **16**. In the interest of brevity only one blade assembly **21** will be described, it being appreciated that each aperture **16** will contain an identical blade assembly. Blade assembly

21 includes an airfoil portion 22 and a base portion 23. Each airfoil portion 22 has an outer tip 24 which is located proximate the cylindrical duct 25 which houses the complete fan assembly.

The base portion 23 holds the blade assembly 21 in any fixed position to which it has been adjusted and permits movement of the airfoil portion 21 to any desired position without requiring that any part of the base portion 23 be loosened. More specifically, the base portion 23 includes an outer generally cylindrical base portion 26, formed integrally with blade portion 22, which is of a diameter which is slightly smaller than counterbore 18 so that it fits easily therein. A cylindrical retaining disk 27 fits within counterbore 20 and includes a surface 28 which abuts inner surface 29' of hub 11. The clearance between disk 27 and bore 20 and between upper base portion 23 and counterbore 18 is such as to permit convenient assembly, but is sufficiently small so that in the event the blade 21 tends to cock the sides of these members will move into engagement with the sides of the bores. In addition, the circular configuration of upper base portion 23 and disk 27 provide stability in all directions.

A spacer 29 is interposed between outer base portion 23 and retaining disk 27 and is firmly clamped between these portions by bolts 30 having heads 31 with hexagonal holes therein, for receiving a wrench, and nuts 32 mounted on their opposite ends and abutting retaining disk 27. If desired nuts 32 may be welded to disk 27. A washer, not numbered, underlies the head 31 of each bolt. Bolts 31 are drawn up sufficiently tight to prestress them, that is, to place them in tension and thus eliminate the possibility of fatigue failure of said bolts. It can be seen from FIG. 3 that spacer 29 includes end portions 35 which extend along the sides of bolts 30 to provide the necessary support against bending either disk 27 or outer base portion 23 due to the tightening of bolts 30. The spacer 29 also causes a constant pressure to be applied to the O-ring 36 independently of applied bolt torque. Spacer 29 can take any other desired form, namely, it can comprise nipples encircling central portions of bolts 30 and extending between surface 34 of disk 27 and surface 33 of upper base portion 23. Any other type of spacer can be used as long as it accomplishes the intended function. It can readily be seen that bolts 30 extend through the central portions 19 of the apertures in hub 11. While two bolts have been shown, any number can be used.

In accordance with the present invention a resilient member such as annular O-ring 36 is interposed between the undersurface 33 of upper base portion 23 and ledge 37 extending between counterbore 18 and central aperture 19. Because of the fact that surface 33 is located a predetermined distance from upper surface 34 of disk 27 by the thickness of spacer 29, and because the radial length of central bore portion 19 is known, the thickness of O-ring 36 is selected so that it will be placed in compression when the base assembly is fully tightened with bolts 30 in the required tension. It can thus be seen that the compressed O-ring 36 will therefore force the surface 28 of disk 27 into firm contact with hub surface 29' at the end of counterbore 20. Furthermore, because O-ring 36 is in compression it will exert a force which will maintain the blade assembly 21 in position. The use of the O-ring obviates the need for close tolerances between the machined parts in a direction through the hub thickness as the O-ring compensates for such non-close tolerances. It will be appreciated that when the fan is rotating at high speeds, the centrifugal force exerted against blade assembly 21 will cause the force of disk 27 against surface 29' to be increased to the extent where the blades cannot be rotated about their longitudinal axes under any circumstances by the air and torsional forces to which they are subjected.

The above described construction of the base permits adjustment of each blade about its longitudinal axis by merely applying a manual force thereto when the fan assembly is at rest. Under these circumstances there is no centrifugal force forcing disk 27 against surface 29' and the only force holding the blade assembly in position is the force produced by the compressed O-ring 36. However, this can be overcome by applying a manual turning force to the airfoil portion 22 of the blade. Loosening of bolts 30 is not required. In order to adjust the airfoil portion 22 to any predetermined pitch an indexing mark 38 is placed on outer base portion 26 for alignment with the numbered indexing marks on the outer surface of hub 11.



It will be appreciated that bolts 30 need not extend through central bore 19. In this respect, any suitable fastening arrangement may be used to secure disk 27 to the remainder of the blade. For example, bolts 30 may extend through suitable holes in spacer 29 which may completely occupy central bore 19. Alternatively, spacer 29 may be formed integrally with outer base portion 26 or with disk 27. Any suitable type of fasteners may be used in the foregoing arrangements.

It will be appreciated that spacer 29 can be eliminated in which event the advantages flowing from its existence will not be obtained, namely, the stabilizing of the entire assembly and the prestressing of the bolts 30. However, the basic concept of the present invention can be practiced in a rudimentary form without spacer 29.

In FIG. 6 an alternate form of compression member is shown which can be substituted for O-ring 36. In this respect certain environments will cause deterioration of rubber O-ring 36 and it is therefore desirable to use a resilient member such as corrugated resilient metal washer 39 which provides the same ultimate result as washer 36 but is not subject to deterioration on exposure to various gases which could deteriorate rubber.

The present invention may also be practiced with an embodiment which eliminates the O-ring 28 or analogous structure such as corrugated washer 39. In this respect, a friction fit between the hub and the various portions of the base of the blade is relied on to retain the blade in position. More specifically, in such an embodiment and referring to FIG. 5, if the O-ring 36 were eliminated, the spacer 29 would be made of a thickness, in a direction radially of the hub, which was slightly less than the thickness of central hub portion 19. This would cause surface 33 of base portion 26 to engage surface 37 of the counterbore and cause surface 28 of disk 27 to engage surface 29' of the hub when bolts 30 were tightened. This engagement would be with a friction fit which would be sufficient to hold the blade assembly in any adjusted position but which would not produce so great a clamping force as to prevent the blade from being turned manually to any other adjusted position without loosening bolts 30. It will be appreciated that when the fan is rotating the centrifugal force would lock the blade in position, as discussed in detail above relative to the other embodiments. The advantage of the foregoing construction is that the base portion is made up of a plurality of members, namely, an outer base portion, such as 26, a spacer member such as 29 and a retaining member such as 27 which when assembled will provide a predetermined distance between surfaces 28 and 33 so that the amount that the base portion is tightened relative to the central hub portion 19 is not left to chance by virtue of the fact that the central hub portion 19 also has a predetermined thickness. In other words, the predetermined spacing between the outer base member 26 and disc 27 and the predetermined thickness of central portion 19 will determine the force of the friction fit with which the blade base is mounted on the hub regardless of the amount to which the bolts, such as 30, are tightened. Thus, the amount of tightening of bolts 30 will not affect the force of the friction fit with which the blade base is clamped to the hub.

In the preceding portions of the specification, reference has been made to prestressing the bolts 30, which ap-

plies to all embodiments of the invention. This means that the bolts are tightened and thus placed in tension of a predetermined number of pounds per square inch which exceeds the maximum pounds per square inch which could be applied to them by the centrifugal force of rotation and other forces. This eliminates stretching and contracting of the bolts in operation in response to fluctuations of such forces, and thus tends to obviate fatigue stressing of the bolts which could result in their failure after a certain number of cycles of stress fluctuations.

We claim:

1. A blade insert for mounting on a hub of a fan construction comprising an airfoil portion and a base portion and said base portion including an outer base portion proximate said airfoil portion, a retaining member, spacer means independent of said hub, interposed between said retaining member and said outer base portion, and fastener means extending between said outer base portion and said retaining member for drawing said outer base portion and said retaining member together with said spacer member therebeteween so that said fastener means can be prestressed while said outer base portion and said retaining member remain spaced apart a distance which is dependent on the thickness of said spacer member.

2. A blade insert for a fan construction as set forth in claim 1 including a resilient member located proximate said outer base portion and lying between said retainer member and said outer base portion.

3. An adjustable fan construction comprising a hub having an inner surface and an outer surface, a plurality of spaced apertures in said hub extending between said inner and outer surfaces, a blade assembly adjustably mounted in each of said apertures each comprising an airfoil portion, a base portion secured to said airfoil portion including an outer base portion located proximate said outer surface, a retaining member spaced from said outer base portion and located proximate said inner surface, fastening means for securing said retaining member to the remainder of said base assembly, holding means located between said hub and said base portion for exerting a force between said base portion and said hub which is sufficiently large to maintain said base portion in a fixed position on said hub when external forces are not applied thereto, said force being sufficiently small so that it can be overcome by the application of a turning force to said blade assembly without loosening said fastening means, and spacer means positioned between said outer base portion and said retaining member for permitting said fastening means to be prestressed and for positively spacing said outer base portion a predetermined distance from said retaining member.



4. An adjustable fan construction as set forth in claim 3 wherein said fastening means comprises a plurality of bolts located on opposite sides of said airfoil portion and located on opposite sides of spacer member, said bolts extending between said outer base portion and said retaining member.

5. An adjustable fan construction as set forth in claim 4 wherein both said retaining member and said outer base portion are cylindrical and fit within counterbores in said hub proximate said inner and outer hub surfaces, respectively.

6. An adjustable fan construction as set forth in claim 3 wherein said holding means comprises a resilient member.

7. An adjustable fan construction as set forth in claim 5 wherein said resilient member is effectively located between said outer surface and said outer base portion of said blade assembly.

8. An adjustable fan construction as set forth in claim 7 wherein said fastening means comprises a plurality of bolts located on opposite sides of said airfoil portion and located on opposite sides of said spacer member.

9. An adjustable fan construction as set forth in claim 8 wherein said resilient member comprises an O-ring.

10. An adjustable fan construction as set forth in claim 8, wherein said resilient member comprises a corrugated metal washer.

11. An adjustable fan construction as set forth in claim 8 wherein both said retaining member and said outer base portion are cylindrical and fit within counterbores in said hub proximate said inner and outer hub surfaces, respectively.


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U.S. Cl. X.R.

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(5/69)

# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,545,884 Dated December 8, 1970

Inventor(s) Joachim W. Schroeter and Derrel N. Stewart

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

Column 5, line 14 (claim 1), change "and" to --with--; line 16, after "hub" cancel the comma; line 21, change "therebeteween" to --therebetween--.

Column 6, line 4 (claim 4), after "of" insert --said--.

Signed and sealed this 23rd day of March 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents