(12) UK Patent (19) GB (11) 2452104 (13) C

(45) Date of Publication: **22.07.2009**

(54) Title of the invention: A meridional fan

(51) INT CL: ***F04D 29/38*** (2006.01)

(21) Application No: **0800582.9**

(22) Date of Filing: **14.01.2008**

(43) Date A Publication: **25.02.2009**

(56) Documents Cited:
FR 002753495 A1 **JP 100148199 A**
JP 010106998 A **SU 001339308 A1**
US 20060034697 A1 **US 20050106030 A1**

(58) Field of Search:
As for published application 2452104 A *viz:*
UK CL (Edition X) **F1V**
INT CL **F04D**
Other: **Online: WPI & EPODOC.**
updated as appropriate

(72) Inventor(s):
Anthony Geoffrey Sheard
Alessandro Corsini
Franco Rispoli

(73) Proprietor(s):
Flakt Woods Limited
(Incorporated in the United Kingdom)
Axial Way, Cuckoo Farm Business Park,
COLCHESTER, Essex, CO4 5ZD,
United Kingdom

(74) Agent and/or Address for Service:
Jensen & Son
366-368 Old Street, LONDON, EC1V 9LT,
United Kingdom

This is a reprint to rectify errors introduced in the course of reproduction - complete specification printed - 19.08.2009

A meridional fan

The present invention relates to meridional fans, particularly but not exclusively, to axial flow fans for large scale air ventilation and/or heating purposes in industrial buildings, industrial air conditioning units, underground railway systems and similar large infrastructures.

Such fans are typically located in a duct system and it is desirable for efficiency purposes for the area swept by the fan blades to be located in a cylindrical ring part of the duct system with a minimal clearance between the tips of the fan blades and the surface of the cylindrical ring. To achieve this, the outer surface of the tips of the fan blades have a contour in the form of an arc corresponding to the circle swept by the fan blades.

In operation, the fan aerodynamic work input establishes a higher pressure downstream of the fan than upstream. The pressure rise is obtained by means of aerodynamic forces at play when the air flows about the rotor blades. Owing to the design of the blade a pressure difference is established between the blade pressure surface or side and its suction surface or side. The result of this pressure difference means that air tends to spill back over the tip of the fan from the high pressure to the low-pressure side. This air movement reduces the efficiency of the fan and also increases the noise generated by the fan. A known method for reducing the amount of flow back air is to keep the gap between the fan tips and the cylindrical ring to a minimum and also to extend the length of the gap by incorporating on the tip of each blade an extending flange which increases the length of the gap in the direction of the leakage flow and thereby increases the resistance to flow back through the gap.

The present invention seeks to provide an improved form of a fan blade tip which increases the efficiency of the fan and at the same time reduces the noise generated by the fan.

Intuitively, the fan tips have, in the past, been made as a uniform as possible, but it has now, surprisingly, been discovered that a non uniform profile for certain sections of the blade tip can be advantageous in increasing the efficiency of the fan, reducing the power required to drive the fan at a given speed and pressure, and at the same time reducing the

noise generated by the fan. The uniform profile of the known conventional blade tips lead to the generation of tight vortices at the blade tip and it is believed that these vortices, when they reach a critical state suddenly expand very rapidly, to the extent of provoking vortex bursting or collapse, which generates a great deal of turbulence. This adverse effect is amplified if the vortices impinge on an adjacent fan blade at which point they burst on impact.

According to the present invention there is provided a meridional fan adapted to be rotatably mounted in a duct ring of circular cross section for impelling air through the duct, and having a plurality of fan blades with peripheral blade tips having a width defining an arc with a circumferential extent describing, in operation, a circular path adjacent the duct ring, the blade tips each having a leading edge, a trailing edge and a tip outer surface, a leakage path being formed between the tip outer surface and the duct ring, at least one of the edges and/or the outer surface having a non-uniform profile for influencing the flow of air through the flow leakage path, wherein the or each tip has a flange extending in the axial direction on the downstream, high pressure side of the fan, which increases the length of the leakage flow path..

Preferably, the axial extent of the flange varies along the width of the blade tip. In a further embodiment, the trailing edge of the blade tip includes a stepped shoulder extending at least partially across the width of the blade tip. In one form, the stepped shoulder consists of a plurality of stepped recesses spaced across the width of the blade tip. These stepped recesses preferably are regularly spaced, but may be irregularly spaced.

In a preferred embodiment, the outer tip surface has a non-uniform profile in the circumferential direction. Preferably the non-uniform profile may be formed by undulations or by grooves or a mixture thereof in the outer surface. The undulations and grooves may extend partially or completely along the axial extent of the outer surface. In a further embodiment (not shown) the fan tip includes a plurality of holes or perforations.

Preferred embodiments of the present invention will now be described by way of example, with reference to the accompanying into formal drawings in which:-

Figure 1 shows an axial view of an axial fan having four blades located in a cylindrical casing,

Figure 2 shows a radially inward view of a fan blade,

Figure 3 shows an axial section of a fan blade and the cylindrical casing,

Figure 4 shows a scrap of view of a fan blade in the direction of the Arrow B shown in Figure 3,

Figure 5 shows a scrap view of the trailing edge of a fan blade,

Figure 6 shows a corresponding view of the trailing edge of a further embodiment, and

Figure 7 shows a scrap view of the outer surface of a further embodiment of blade tip.

Referring now to Figure 1, there is shown an axial view of an axial flow fan having four fan blades 2 mounted for rotation about an axis 1 of a cylindrical ring part 3 of a duct system of an air ventilation system. The area swept by the fan is such that the blade tips 4 are very close to the cylindrical ring 3 with only a minimal gap there between. To minimise this gap, the outer surfaces of the blade tips 4 have an arcuate contour defined by the circle swept by the blades 2.

Referring now to Figure 2 also, it can be seen that the fan blade has on its tip a flange 5 serving to increase the circumferential extent of the gap between the outer surface of the tip and the cylindrical ring 3 to increase the resistance of airflow through the gap.
In this embodiment it can be seen that the edge 6 of the flange 5 has a undulating, non-uniform profile in the circumferential direction and at one end of the tip the outer surface is cut away to provide a non-uniform outer surface for the tip.

Figure 3 illustrates a schematic cross-section through the axis of the fan and cylindrical ring 3 illustrating be peripheral flange 5 with its non-uniform leading edge 6. The effect of the high pressure on the blade pressure side means that air tends to spill backwards at the periphery of the fan tips through the gap between the fan tip 4 and the cylindrical ring 3 as illustrated by the arrow 7. The gap thus forms a leakage flow path for air to flow from the high pressure, downstream side of the blade back to the upstream low pressure side and it is desirable to reduce this flow to a minimum

Figure 4 illustrates a scrap view of a fan blade 2 and its tip 4 in the direction of the arrow B in which the outer surface 8 of the tip has a non uniform profile in the circumferential direction formed by undulations. These undulations may be regular or irregular in size.

Figure 5 illustrates a schematic view of the fan blade tip 4 having on the low-pressure side a series of cutaway stepped shoulders 9 or recesses which serve to decelerate abruptly the airflow as it exits the gap between the blade tip 4 and the cylindrical ring 3. These recesses may be regularly spaced, of a regular size or may be irregularly spaced and irregularly sized.

Figure 6 illustrates an alternative embodiment of a rear view of the blade tip in which a continuous stepped shoulder 9 is provided across the full width of the fan blade. In this embodiment, the peripherally extending flange 5 has a non-uniform dimension in the circumferential direction formed by a gradual curving of the leading edge 6. In another embodiment, not shown, the variation in the circumferential extent of the flange may be formed in a stepped manner with regular or irregularly spaced steps.

Figure 7 shows a further embodiment in which the outer surface of the forwardly extending flange has a plurality of spaced recesses or grooves which may or may not extend through to the leading edge or trailing edge of the outer surface.

It will be appreciated that the different methods of providing a non-uniform profile for the outer surface, leading and trailing edges of the blade tip may be used individually or in any combination depending upon the particular size, design speed, number of blades etc of a particular fan. In this connection, although the specific embodiment shows a fan with four blades, it will be understood that the number of blades may vary depending upon the design parameters of the particular installation. Other forms of non-uniformity, such as a circumferential channel in the outer surface of the tip, may be provided. Although the described embodiment is an axial flow fan, the invention is also applicable to mixed flow fans. In such applications, the duct ring is not necessarily cylindrical but could be conical or have a diameter that increases exponentially.

CLAIMS

1. A meridional fan adapted to be rotatably mounted in a duct ring of circular cross section for impelling air through the duct, and having a plurality of fan blades with peripheral blade tips having a width defining an arc with a circumferential extent describing, in operation, a circular path adjacent the duct ring, the blade tips each having a leading edge, a trailing edge and a tip outer surface, a leakage path being formed between the tip outer surface and the duct ring, at least one of the edges and/or the outer surface having a non-uniform profile for influencing the flow of air through the flow leakage path, wherein the or each tip has a flange extending in the axial direction on the downstream, high pressure side of the fan, which increases the length of the leakage flow path..

2. A fan according to claim 1, wherein the circumferential axial extent of the flange varies along the width of the blade tip.

3. A fan according to claim 1 or 2, wherein the trailing edge of the fan tip includes a stepped shoulder extending at least partially across the width of the blade tip.

4. A fan according to claim 3, wherein the stepped shoulder comprises a plurality of stepped recesses spaced across the width of the blade tip.

5. A fan according to claim 4, wherein the stepped recesses are regularly spaced across the width of the blade tip.

6. A fan according to any one of the preceding claims, wherein the outer tip surface has a non-uniform profile in the circumferential direction.

7. A fan according to any one of the preceding claims wherein the outer tip surface has a non–uniform profile in the axial direction.

8. A fan according to claim 6 or 7, wherein the non-uniform profile is formed by undulations or by grooves or a mixture thereof.

9. A fan according to claim 8, wherein the undulations and/or grooves extend partially or completely along the axial extent of the outer surface.

10. A meridional fan substantially as described herein with reference to and as illustrated in the accompanying drawings.

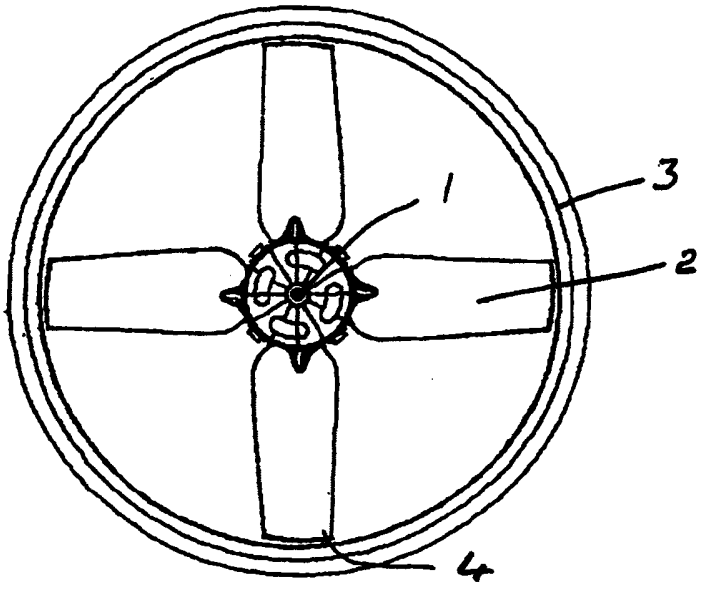

FIG 1

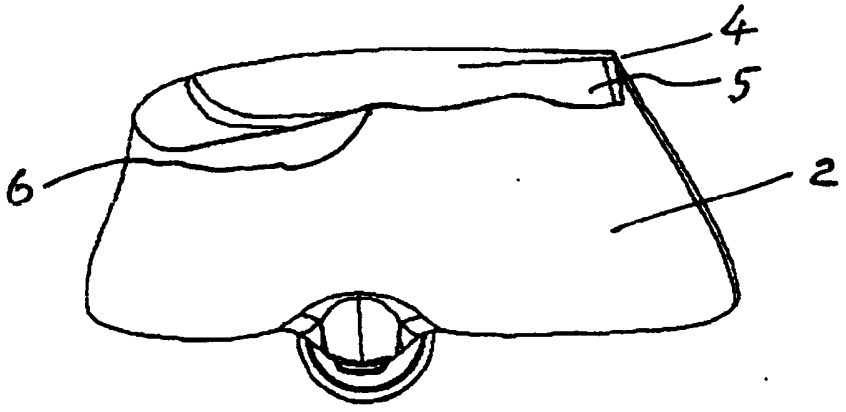

FIG 2

FIG 3

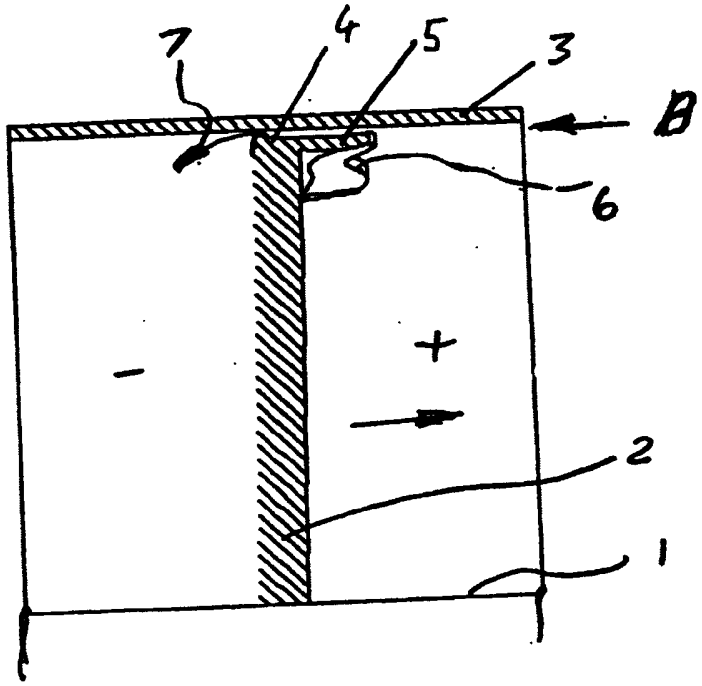

FIG 4

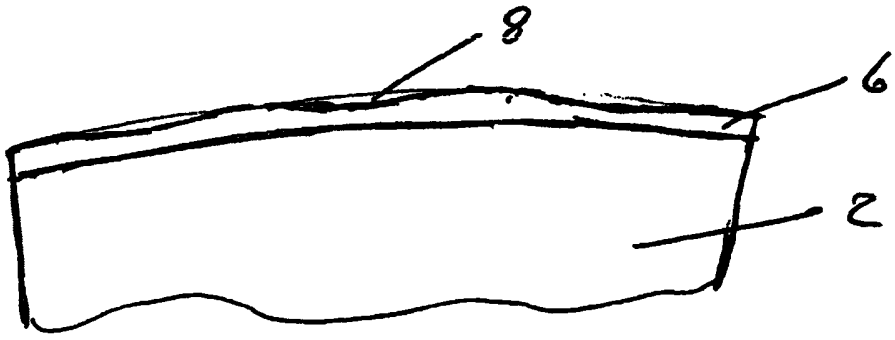

FIG 5

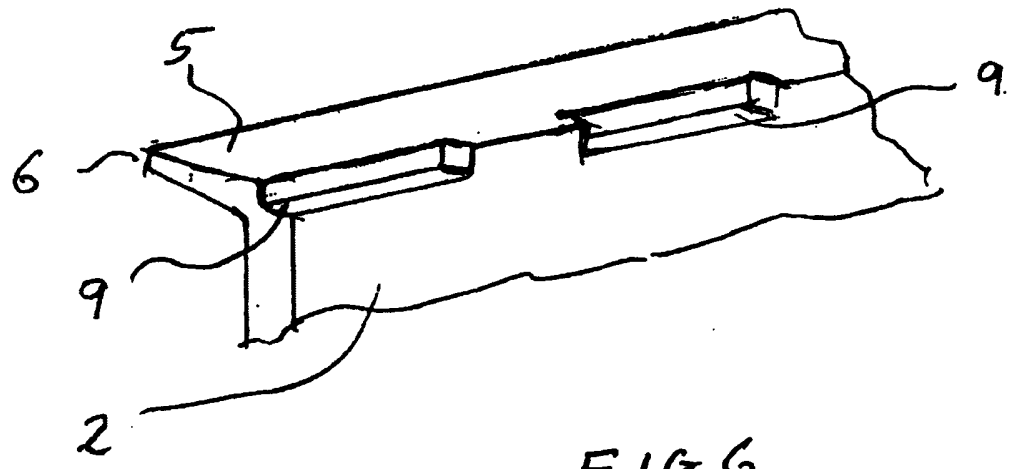

FIG 6

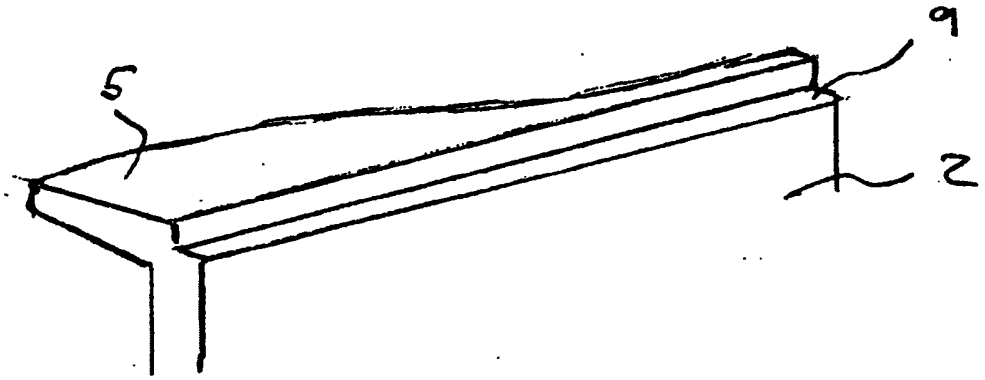

FIG 7