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(72) Inventors:
• **Giorgi, Ettore**
20090, Segrate (IT)
• **Besani, Marco**
21011, Casorate Sempione (IT)

(71) Applicant: **Cofimco S.R.L.**
28050 Pombia (IT)

(74) Representative: **Gervasi, Gemma et al**
Notarbartolo & Gervasi S.p.A.
Corso di Porta Vittoria, 9
20122 Milano (IT)

(54) **Composite shank for axial fan blades**

(57) The present invention relates to a shank for axial fan blades, in particular for axial fans used in industry in large heat exchangers, condensers, cooling towers and similar applications.

The shank for axial fan blades according to the present invention allows to reduce the weight of the shank-blade group and at the same time it is more flexible with respect to the shanks known in the art, thus achieving the result consisting of reducing the stresses on the shank itself and the vibrations transmitted to the whole structure of the fan.

Moreover, the shank according to the present invention is characterized by an improved resistance to chemical attack, and this results in an improved liability of the fan also when it is working in aggressive environment.

Not least, another object achieved by the present invention is to provide a shank for axial fan blades which is lighter with respect to the known type of steel shank, thus reducing the total weight of the shank-blade group and the bending stress on the shank itself.

All these results are achieved by the shank made of composite materials as per the description and the claims.

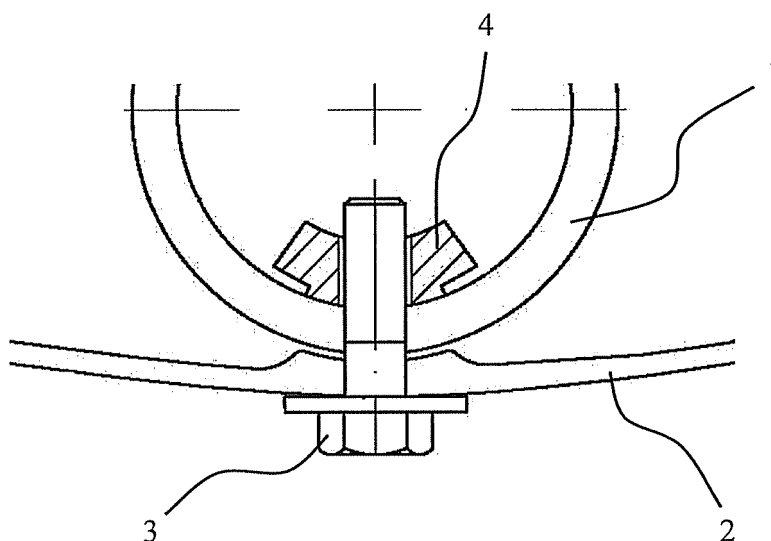


Fig. 3

Description

[0001] The present invention concerns a shank for supporting the blades of a fan, in particular axial fans used in industry.

[0002] It is known that axial fans are mainly used in large heat exchangers, condensers, cooling towers and similar applications, their purpose being to cool down water, steam or other types of fluids.

[0003] Usually, the axial fan is placed below or above the heat exchanger, the blades of the fan lying on an horizontal plan, and their diameter ranges up to 12-13 meters (42 feet).

[0004] Due to the large dimensions of the fan and to the rotational velocity which can be up to 750 rpm depending on fan's diameter, several problems concerning the static and dynamic forces acting on the blades of the fan arise.

[0005] First of all, especially for large diameters, the fan is influenced by the weight of the shank-blade block. In fact, as previously mentioned, since the fan is positioned horizontally, the blades lying on an horizontal plan, the weight of the shank-blade block tends to bend downwardly the shank which connects the blade to the fan's hub, proportionally to the flexibility of the shank.

[0006] Moreover, the fan is influenced by the vibrations consequent to the rotation of the blades.

[0007] During the blades rotation the air load acting on the blade tends to bend the shank downwardly. Another force acting on the shank-blade block during the functioning of the fan is the centrifugal force. The static forces are related to the weight of the shank-blade block. The centrifugal force is a function of the weight and of the rotational velocity of the fan. The air load is a function of the rotational speed and of the wing airfoil.

[0008] Nowadays, are known in the art several different kind of fans. In particular, in known type of fans the blades are linked to the hub of the fan by means of different ways.

[0009] A first kind of known fan realizes the blade and the shank in one single element made of fibreglass.

[0010] This known type of shank-blade block, however, features a number of drawbacks.

[0011] The first drawback of the shank-blade block made of fibreglass consists in that it is a rigid system.

[0012] When the link between the fan hub and the blade is a rigid link there is no dumping effect, and all the forces acting on the blade cooperate to increase vibrations level and to decrease the mechanical reliability of the whole structure. In fact, as a consequence of the rigidity of the shank-blade block the vibrations produced by the fan are transmitted to the supporting structure.

[0013] Another main drawback of a rigid shank-blade system consists of a limited fatigue resistance. In fact, through the elastic deformation of a flexible system is possible to dissipate part of the forces acting on the blade.

[0014] Another drawback afflicting this kind of blade is a consequence of the fact that the blade and the shank

are obtained by means of the same mould operation: in fact, the production process results to be discrete and very expensive due to the high number of manual manufacturing operations. The term discrete means that it is possible to obtain one single blade at a time by moulding the fibreglass, being necessary to provide a new mould for each different blade size.

[0015] Another kind of known fan realizes a rigid link between the blade and the hub by means of a shank made of steel associated with an extruded aluminium blade.

[0016] This known kind of shank is moderately flexible, and the whole weight of the shank-blade block is high. This solution implies several drawbacks.

[0017] First of all the rigidity and the weight of the system implies the same drawbacks above mentioned with reference to the fibreglass shank-blade block.

[0018] Secondly, the steel shank is subject to mechanical fatigue. Due to the horizontal position of the fan and to the rigidity of the shank-blade group, the air load acting on the blade cooperates with the weight of the shank-blade group resulting in shank bending. One side of the pipe is compressed and the opposite side is extended, the bending forces acting on the shank during the fan functioning resulting in fatigue stress of the pipe.

[0019] Also, an additional drawback or disadvantage afflicting the known steel shank is the sensibility to chemical attack. In fact, being the fan working in aggressive environment, e.g. in wet applications like cooling towers, it is a requirement for the liability of the fan to use materials which resists to chemical corrosion.

[0020] Therefore, the aim of the present invention is to provide a shank for axial fan blades suitable to overcome the drawback afflicting the known solutions.

[0021] In the scope of this aim, one object of the present invention is to provide a shank for axial fan blades with improved flexibility in order to realize a flexible link between the blade and the fan hub.

[0022] Another object of the present invention is to provide a shank for axial fan blades with improved resistance to chemical attack, thus to improving the fan liability also when it is working in aggressive environment.

[0023] Not least, another object of the present invention is to provide a shank for axial fan blades which is lighter with respect to the known type of steel shank, thus reducing the total weight of the shank-blade group and the bending stress on the shank itself.

[0024] A further object of the present invention is to provide a shank for axial fan blades which is suitable to efficiently discharge electrostatic charge, thus fulfilling the requirements of the ATEX norms concerning the safety of the fan when it is working in explosive environment.

[0025] It is also an object of the present invention to provide a shank for axial fan blades which has an improved mechanical resistance in particular with respect to mechanical fatigue.

[0026] Moreover, is another object of the present in-

vention to provide a shank for axial fan blades which has an improved flexibility and which can be obtained by means of a process which is less expensive with respect to the process for the fibreglass shank-blade block production.

[0027] Furthermore, it is also an object of the present invention to provide a shank for axial fan blades which allows to realize, with the same aerodynamic efficiency and performance of the fan, to realize a fan which is smaller or which has a smaller number of blades.

[0028] This aim and these objects, and others that will be more clear after the detailed description of a preferred embodiment of the present invention, are achieved by a shank for axial ventilating fan blades, said fan comprising an axial rotation shaft and an hub at the end of said shaft, the fan further comprising a plurality of blades each one of said blades being connected to said hub by means of a shank which is realized independently from said blade and which is steady connected to said blade by means of fixing elements, characterized in that said shank is made of composite material.

[0029] Moreover, the blade shank for axial fans according to the present invention is characterized by the fact that said composite material comprises at least a resin in which fibers are impregnated by means of filament winding or pultrusion.

[0030] The present invention refers in particular to a blade shank for axial fans as described more fully in the claims, which are an integral part of this description.

[0031] Further characteristics and advantages of this invention will become clear from the following detailed description of a preferred embodiment, that is merely illustrative and not limitative and is shown in the figures that are attached hereto, in which:

- figure 1 shows a cross section of a first embodiment of the shank according to the present invention which is realized by means of filament winding;
- figure 1a shows a top view of the shank of figure 1a realized by means of filament winding and a detail of the fiber orientation;
- figure 2a shows a cross section of a second embodiment of the shank according to the present invention which is realized by pultrusion;
- figure 2b shows a top view of the shank of figure 2a realized by means of pultrusion and a detail of the fiber orientation;
- figure 3 shows in detail the fixation means connecting the shank to the blade;
- figure 4 shows the connecting means suitable to steady link the shank to the hub of the fan;
- figure 5 shows a cross section of the composite shank of figures 2a and 2b realized by pultrusion where are indicated layers with unidirectional fiber orientation and layer with oriented fibers.

[0032] According to a preferred embodiment of the invention, illustrated in the mentioned figures, the shank 1

according to the present invention has the shape of a tube, i.e. with an annular cross section, with a nominal thickness of about 10 mm. The wall thickness depends upon the general dimension of the fan, therefore it can vary as a function of the diameter of the fan and of the surface of the blades.

[0033] Different shape of the shank could be considered, e.g. rectangular or polygonal cross section.

[0034] At one end, the shank 1 is fixed to the blade 2, just partially shown in figure 3, by means of fixation means. In particular, a part of the shank is inserted into the blade, which usually has an hollow profile, and the fixation means can comprise bolts 3 and specially designed threaded inserts 4 suitable to be inserted in the shank 1 in order to avoid deformations of the shank consequent to the tightening of the bolts.

[0035] In order to fix the shank 1 to the blade 2, both the elements 1, 2 are provided with one or more holes suitable to receive a bolt 3. Then, the threaded insert 4 is inserted into the shank in a position which corresponds to said holes and the bolt 3 is inserted and tightened.

[0036] The fixation of the shaft 1 to the blade 2 can be achieved with a plurality of bolts.

[0037] More in detail, it is preferable to provide at least a couple of bolts diametrically opposed with respect to the diameter of the shank. More preferably, a plurality of couples should be provided along the shank part which results inserted into the blade profile.

[0038] At its opposite end the shank 1 is connected to the hub of the axial fan by means of connecting means.

[0039] As schematically shown in figure 4, the connecting means comprise pillow blocks 5a, 5b generally made of aluminium, are tightened by means of tightening means, e.g. the bolts 7a, 7b, surrounding the shank 1. In order to avoid shank deformations created by the compression load introduced by the bolts, a metallic insert 6 is conveniently inserted into the shank 1.

[0040] The shank is made of composite material whose properties give to the shank a suitable flexibility and rigid links, and at the same time gives a high chemical resistance.

[0041] The composite shank can be constructed with two different technologies, filament winding, as shown in figure 1, and pultrusion, as shown in figure 2.

[0042] These technologies are known, but in order to achieve the necessary mechanical strength, flexibility and chemical resistance to aggressive environments, it is necessary to strictly control the fiber orientation and the composition of the resin mixture. Therefore, either though the shank is obtained by filament winding or by pultrusion, it is extremely important to control the production process.

[0043] When produced by means of filament winding, the best fiber orientation is around 20° with respect to the shank axis A.

[0044] When produced by pultrusion the best lamination sequence is to apply two layers of +/-45° at the outer and inner surfaces of the tube and to manufacture the

rest of the tube in uniaxial fibers, as shown in figure 5.

[0045] It has been found experimentally that this fiber orientation allows to achieve the best results in terms of fatigue resistance.

[0046] The fibers are impregnated in resin which can comprise polyester or vinylester, the latter having a better chemical and mechanical resistance.

[0047] In terms of chemical resistance the usage of composite materials is a very reliable solution even in the most aggressive environment like cooling towers, where the environment is humid and warm with the contemporary presence of chemical agents like chlorinates and so on.

[0048] As above explained, in terms of mechanical resistance the main requirement is the fatigue resistance to the load acting on a blade of the rotating fan. Due to the higher elongation at break of the composite material with respect to steel, the composite shank has an higher flexibility with respect to the known solutions which comprise a steel shank or a fibreglass moulded shank-blade block.

[0049] In order to obtain a shank with an antistatic behaviour, that is extremely important when the fan works in explosive environment, conductive reinforcing fibers, like carbon fibers, can be inserted in the resin while producing the composite shank.

[0050] The same result could be achieved by inserting suitable additives in the resin.

[0051] In both cases, it has been found that the composite material of the shank fulfils the requirements of the ATEX norms.

[0052] It has been shown that the composite shank for axial fan blades according to the present invention achieves the purpose and the objects proposed.

[0053] In particular, it has been shown that, according to the present invention, the composite shank for axial fan blades has improved flexibility, thus realizing a flexible link between the blade and the fan hub. The flexibility of the shank allows to reduce the vibrations consequent to the air load and to the rotational velocity of the fan and transmitted from the blades to the whole structure.

[0054] Moreover, the composite shank according to the present invention has an improved resistance to chemical attack, thus improving the fan liability also when it is working in aggressive environment.

[0055] Also, a further object achieved by the composite shank for axial fan blades according to the present invention is lighter with respect to the known type of shanks, thus reducing the total weight of the shank-blade block, the bending stress on the shank itself and the vibrations consequent to the fan rotation.

[0056] A further object achieved by the composite shank according to the present invention is to provide a shank for axial fan blades which is suitable to efficiently discharge electrostatic charge, thus fulfilling the requirements of the ATEX norms concerning the safety of the fan when it is working in explosive environment.

[0057] Another object achieved by the present inven-

tion is to provide a shank for axial fan blades which has an improved mechanical resistance in particular with respect to mechanical fatigue.

[0058] It will be apparent to the person skilled in the art that various modifications can be conceived and reduced to practice without departing from the scope of the invention.

[0059] Therefore, the scope of the claims is not limited to the illustrations or the preferred embodiments shown in the description as an example, but rather the claims include all the patentable novelties deriving from this invention, including all the equivalent embodiments for a person skilled in the art.

Claims

1. Shank (1) for axial ventilating fan blades (2), said fan comprising an axial rotation shaft and an hub at the end of said shaft, the fan further comprising a plurality of blades (2) each one of said blades (2) being connected to said hub by means of a shank (1) which is separated from said blade (2) and is steady connected thereto by means of fixation means (3, 4), **characterized in that** said shank is made of composite material.
2. Shank for axial ventilating fan blades according to the preceding claim, **characterized in that** said composite shank is made of fibers impregnated in a resin solution.
3. Shank for axial ventilating fan blades according to the preceding claim, **characterized in that** said composite shank is realized by a pultrusion process.
4. Shank for axial ventilating fan blades according to the preceding claim, **characterized in that** said composite shank has the shape of a tube, with an annular cross section, and comprises an inner layer and an outer layer with fibers orientation of +/- 45° with respect to the shank axis.
5. Shank for axial ventilating fan blades according to claim 2, **characterized in that** said composite shank is realized by a filament winding process.
6. Shank for axial ventilating fan blades according to the preceding claim, **characterized in that** said composite shank, realized by means of filament winding, has a fiber orientation of about 20° with respect to the shank axis.
7. Shank for axial ventilating fan blades according to any of the preceding claims, **characterized in that** said composite shank comprises a polyester resin solution.

8. Shank for axial ventilating fan blades according to any of the claims from 1 to 7, **characterized in that** said composite shank comprises a vinyl ester resin solution.

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9. Shank for axial ventilating fan blades according to any of the preceding claims, **characterized in that** said composite shank further comprises conductive reinforcing fibers, like carbon fibers, thus obtaining a shank with antistatic properties.

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10. Shank for axial ventilating fan blades according to any of the claims from 1 to 8, **characterized in that** the resin comprises further additives suitable to make the composite material antistatic.

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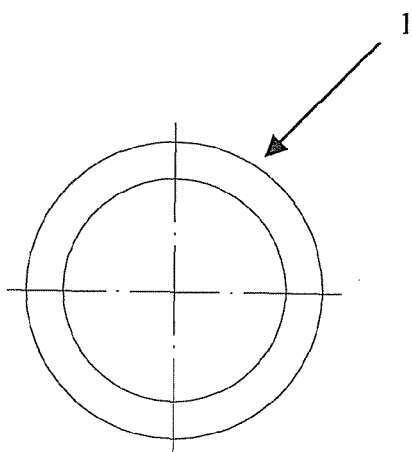


Fig. 1

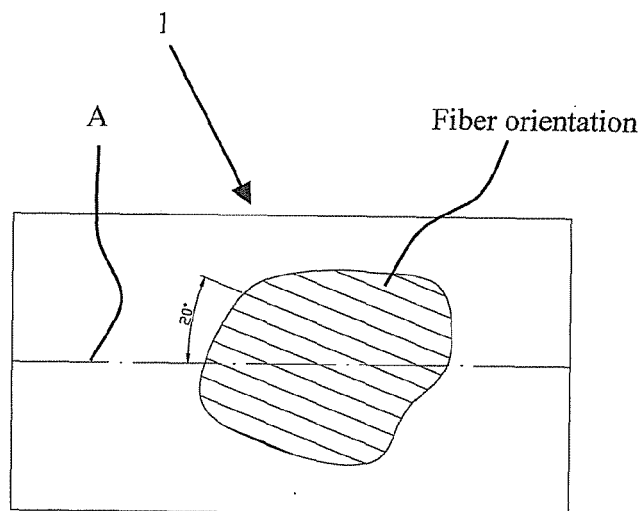
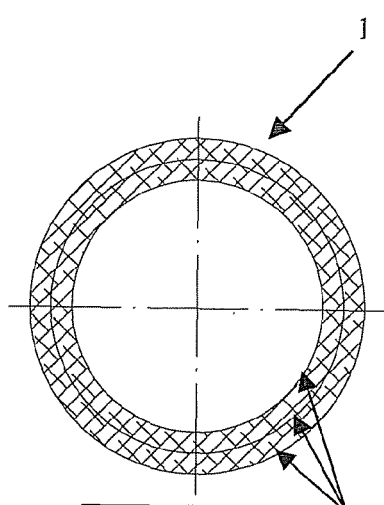


Fig. 1a



Layers with +/- 45° fibres orientation

Fig. 2a

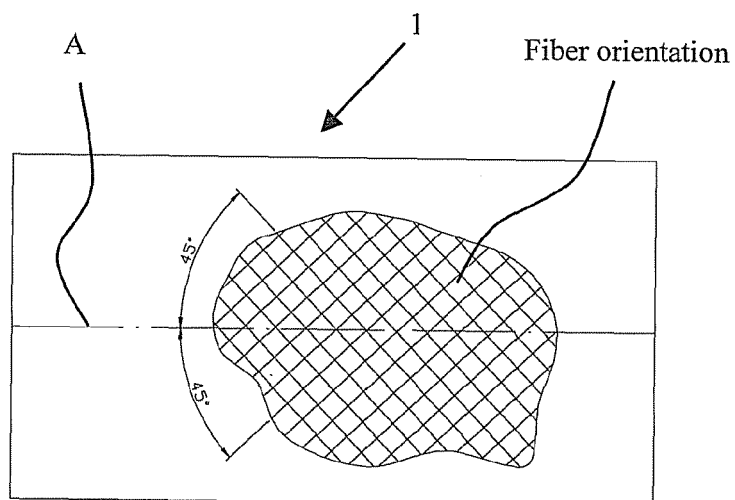


Fig. 2b

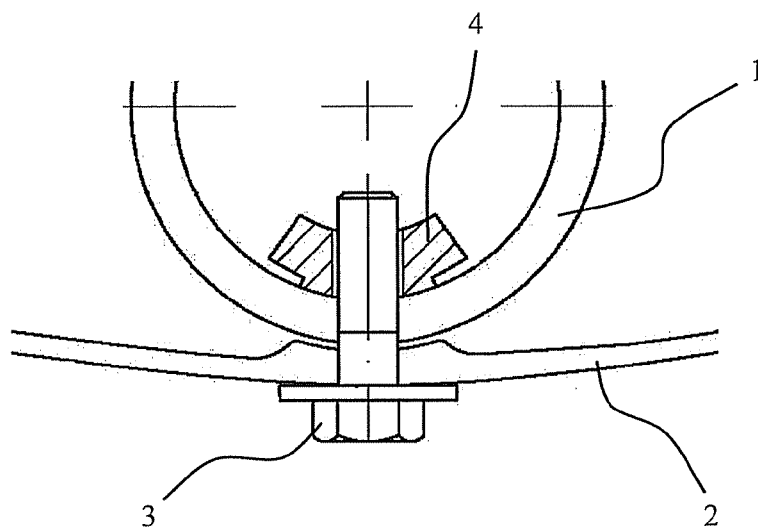


Fig. 3

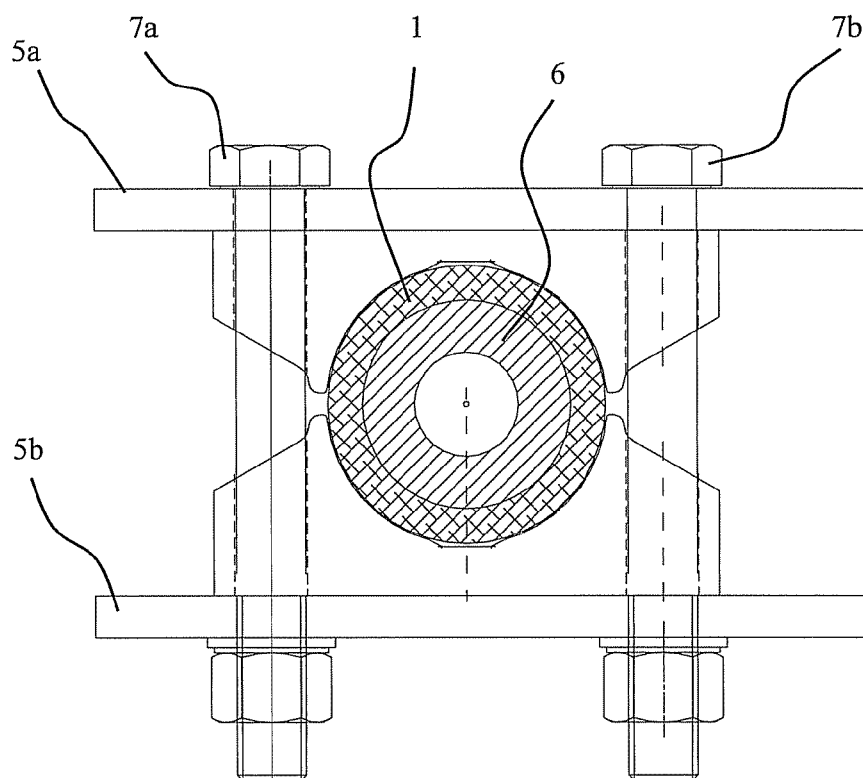


Fig. 4

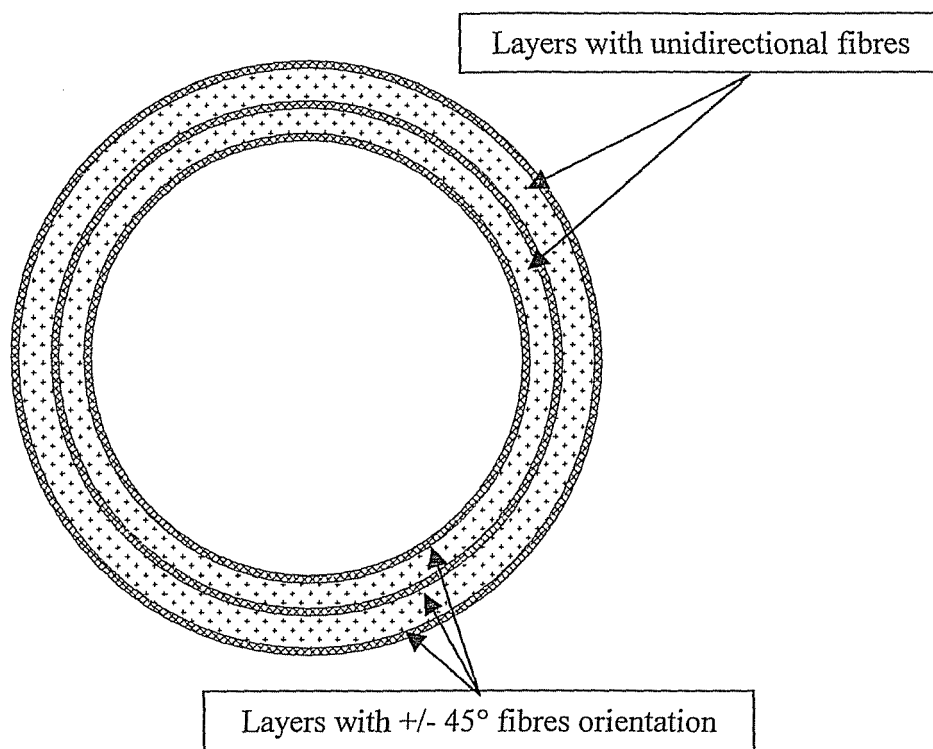


Fig. 5



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 07 12 2730

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Place of search The Hague		Date of completion of the search 23 May 2008	Examiner Ingelbrecht, Peter
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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