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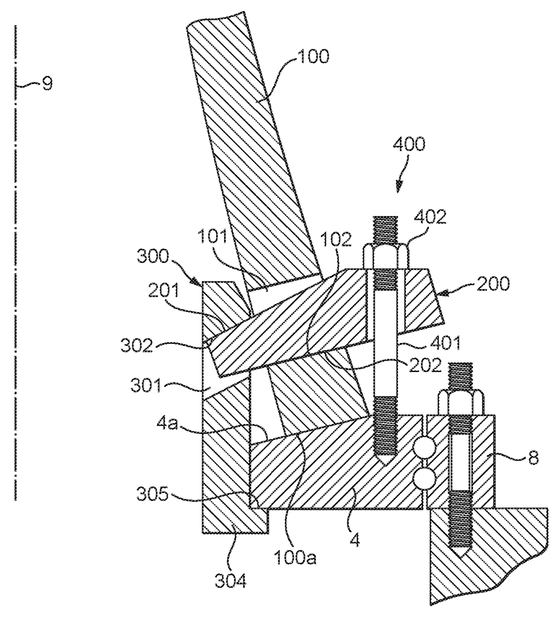
(54) Title of the Invention: **Turbine assembly**
Abstract Title: **Connection mechanism for a turbine blade**

(57) A turbine assembly comprising a turbine blade, a turbine member and a mounting assembly; wherein the turbine blade comprises a root mounting portion having a wall and a hole extending through a thickness of the wall, the hole being partially defined by an engagement surface facing away from a root end of the turbine blade; wherein the mounting assembly comprises a peg and a clamping member, the clamping member being coupled to the turbine member; wherein the peg extends through the hole and comprises fist and second opposed bearing surfaces, the first bearing surface engaging a clamping surface of the clamping member and the second bearing surface engaging the engagement surface of the hole. A kit of parts for a turbine assembly and a method for assembling a turbine assembly are disclosed.

FIG. 4



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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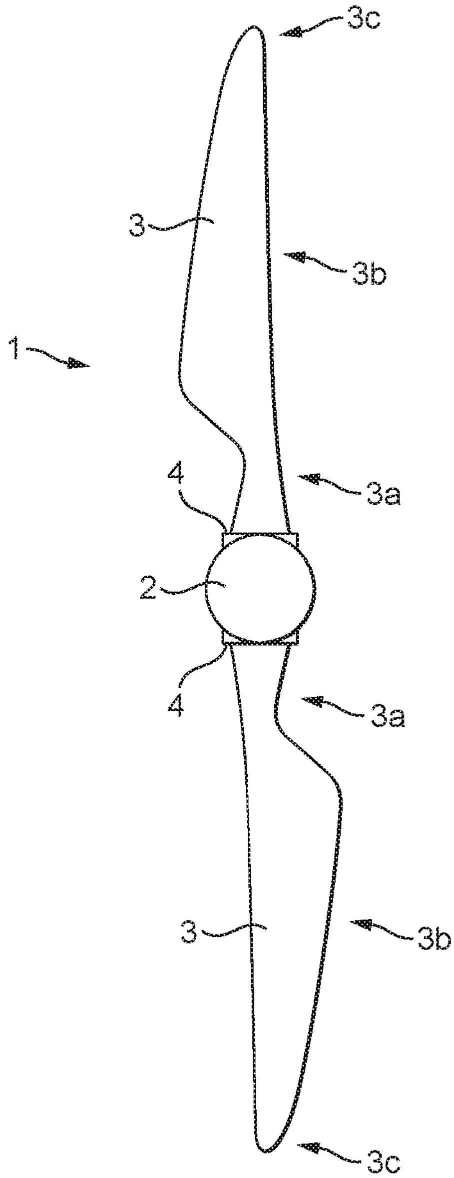

FIG. 1

30 11 15

30 11 15

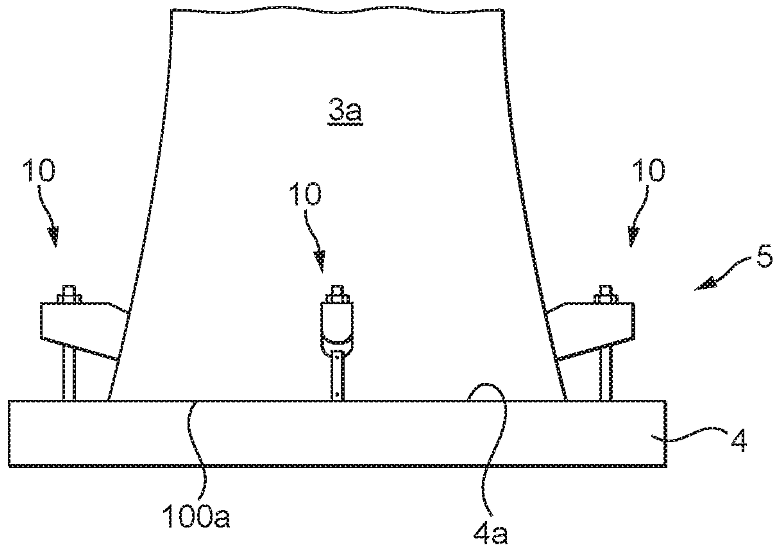

FIG. 2

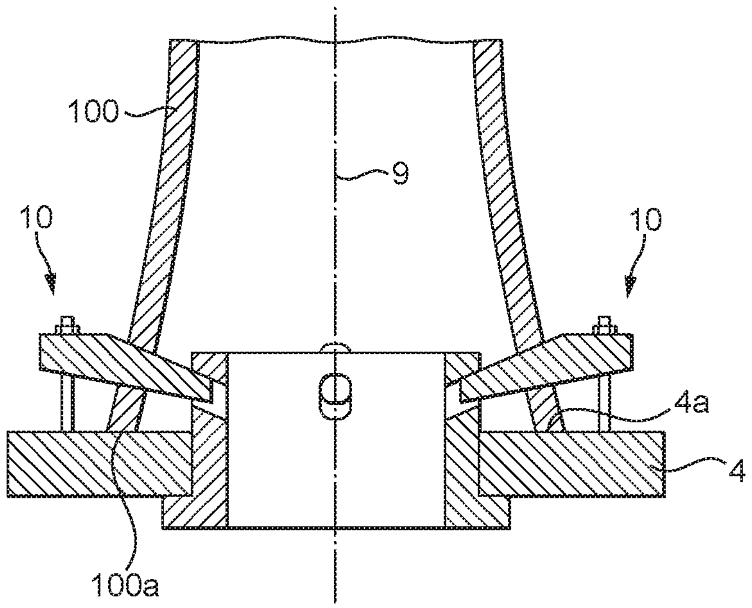

FIG. 3

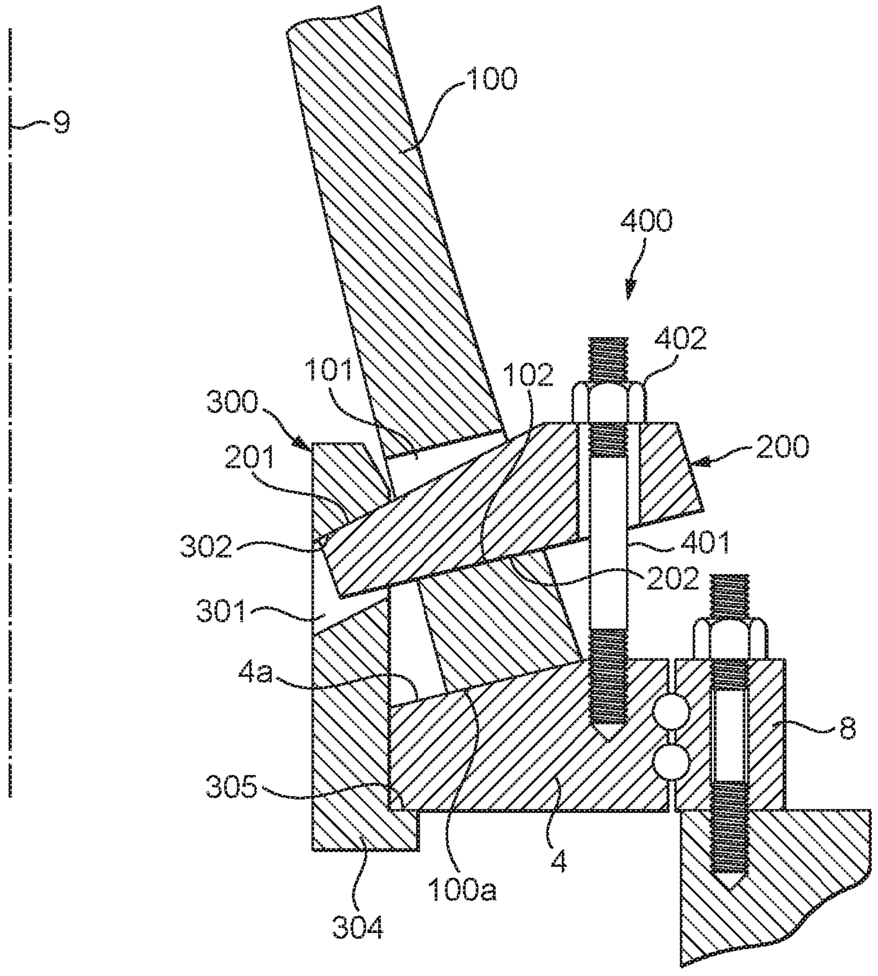
100
9
400
402
101
102
300
200
201
302
401
202
301
4a
8
305
4
100a
304

FIG. 4

30 11 15

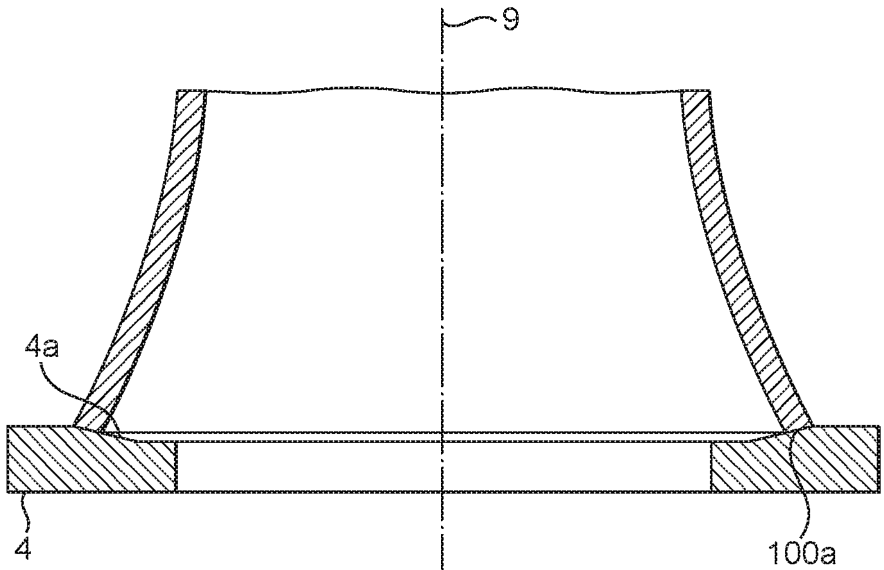

FIG. 5

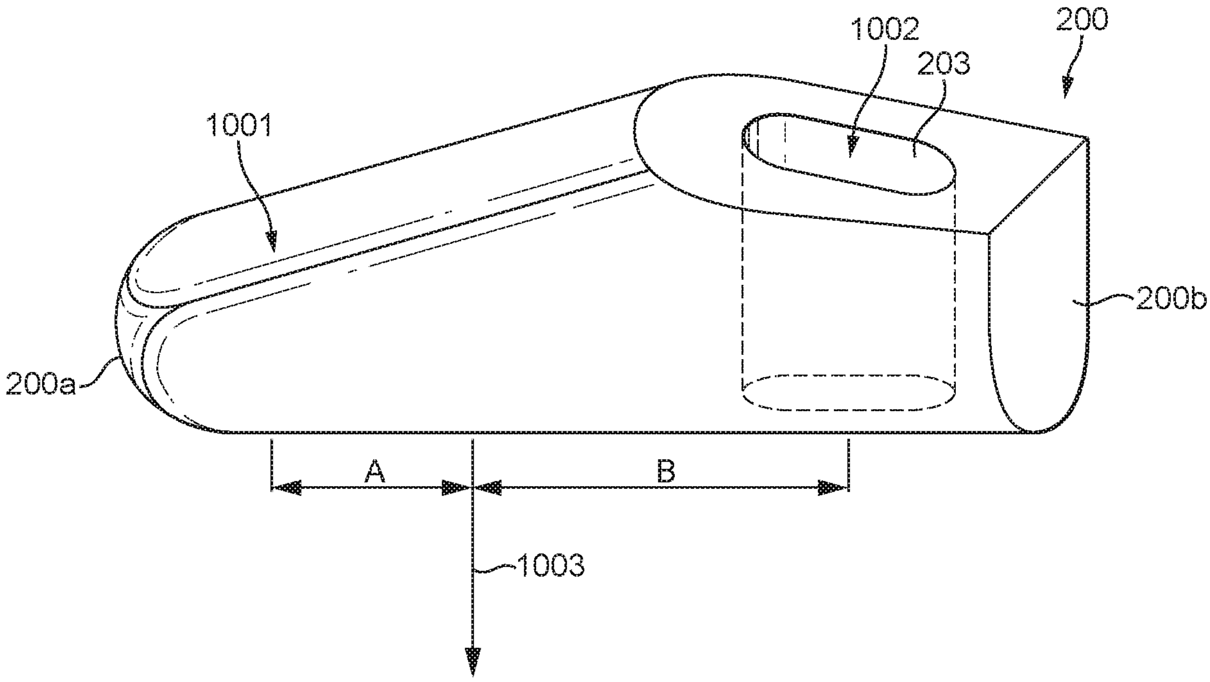

FIG. 6

30 11 15

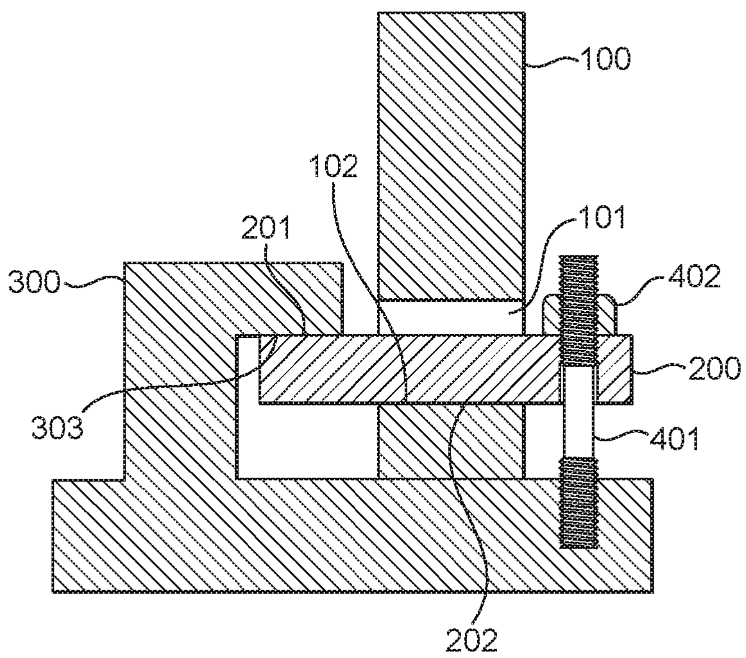

FIG. 7

TURBINE ASSEMBLY

The present invention relates to a turbine assembly, a kit of parts for a turbine assembly and a method of assembling a turbine assembly. The present invention relates particularly to turbines for tidal generators.

Wind and tidal turbine blades are typically formed of laminated composite material (for fatigue resistance), bolted to the turbine hub using steel bolts. A connection therefore needs to be made between the bolts and the composite blade. Tidal hubs are usually sealed, and hence there is no access inside the hub for tightening the nuts on the blade connecting bolts. Small wind turbines also have limited or no manual access due to the size of the hub.

There are a number of known techniques to affix such blades.

In one known technique, each hub spindle includes an enlarged circumferential flange to which the blade root is affixed using T-bolts. However, that structure exhibits the problem of poor hydrodynamics. There are further problems in that despite a heavy and expensive spindle, the spindle is susceptible to fatigue failure at the internal radius of the flange.

In another known technique, the blade root incorporates a radially outwardly directed circumferential flange, and studs are screwed into blind holes in a hub spindle. Nuts are fitted onto the outboard end of the studs. This arrangement suffers from the problem that the flanges are not strong enough when fabricated from fibre reinforced resin matrix composite material due to through thickness tensile (Brazier) loads at the tight radius, and so the flange tends to be made in steel or spheroidal graphite iron (SGI), which then needs to be connected to the composite blade, typically by an adhesive joint. The difference in stiffness between the composite material and steel/SGI can lead to the existence of stress concentrations in the adhesive joint. This in turn can result in a problem of the lowering of the fatigue resistance of the adhesive, particularly when subjected to underwater environments.

There is therefore a need for an improved coupling between turbine blades and a hub that improves performance and reliability, and which reduces the cost and complexity of manufacture and assembly.

A first aspect of the invention provides a turbine assembly according to claim 1.

A second aspect of the invention provides a kit of parts for a turbine assembly according to claim 39. A kit of parts according to the second aspect of the invention may be used to form a turbine assembly according to the first aspect of the invention. The kit of parts may therefore include any of the features described in relation to the first aspect of the invention.

A third aspect of the invention provides a method of assembling a turbine assembly according to claim 44.

Preferred features are defined in the dependent claims.

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings, in which:

Figure 1 shows a schematic front view of a turbine;

Figure 2 shows a schematic front view of a root mounting portion of a turbine blade having a turbine assembly according to one embodiment of the present invention;

Figure 3 shoes a schematic cross-section of the root mounting portion shown in Figure 2;

Figure 4 shows a more detailed view of a portion of the schematic cross-section of Figure 3;

Figure 5 shows a schematic exemplary interface between a turbine member and a root mounting portion of a turbine blade;

Figure 6 shows a schematic perspective view of a peg used in one embodiment of the present invention, and

Figure 7 shoes a schematic cross-section of a portion of a root mounting portion of a turbine blade having a turbine assembly according to another embodiment of the present invention.

Figure 1 shows a tidal water-driven turbine 1 having a rotatable hub 2 with two turbine blades 3 mounted to the hub. In other embodiments the turbine may be any other turbine, especially a water-driven or air-driven turbine, having any number of blades.

Each turbine blade 3 is coupled to a respective turbine member 4 which is in turn coupled to a main body of the hub 2 by a mounting arrangement 8. Each turbine member 4 is generally cylindrical, as shown in Figures 3 and 5, although other configurations are possible. The turbine members 4 are manufactured separately from the main body of the hub 2 to simplify the manufacture of the hub. In other embodiments the turbine blades may be coupled directly to the hub such that the hub or a portion of the hub acts as a turbine member as described below. The hub 2 and the turbine members 4 are typically composed of a metal.

Each turbine blade 3 includes a root mounting portion 3a at a proximal end for coupling the turbine blade to its respective turbine member 4, and a main body portion 3b located outboard of the root mounting portion and extending outwardly to a tip 3c. Each root mounting portion 3a includes a wall 100 which extends in a continuous, substantially circular closed loop, as shown in Figures 3, 4, 5. In other embodiments the wall may be elliptical or have any other shape, and may not form a closed loop.

The wall 100 includes an end mounting surface 100a which engages a complementary mounting surface 4a of the turbine member 4. The end mounting surface 100a is inclined at an angle to a plane extending transversely to a longitudinal axis 9 of the root mounting portion 3a. The angle is preferably an acute angle, more preferably between 2° and 30°, and most preferably between 5° and 10°. As shown in Figure 5, the end mounting surface 100a is upwardly and outwardly tapered such that a radially outer edge is further towards the tip end 3c of the turbine blade than a radially inner edge. In other embodiments the end mounting surface may be downwardly and outwardly tapered such that a radially inner edge is further towards the tip end. In other embodiments the end mounting surface 100a and complementary mounting surface 4a may be substantially planar or have some other shape. In other embodiments a locating spigot may be provided which engages an inner surface of the wall 100. In other embodiments there may be one or more intervening components between the end mounting surface 100a and the complementary mounting surface 4a, for example a seal.

The wall 100 extends away from the end mounting surface 100a towards the tip end 3c of the turbine blade 3 at an acute angle to the longitudinal axis 9 of the root mounting portion 3a, such that the root mounting portion 3a tapers inwardly away from the end mounting surface. A taper is particularly desirable in water-driven turbines to reduce drag. A taper commencing from the root end is desirable to minimise drag and reduce or eliminate the need for a double curvature. In other embodiments the taper may commence from a point outboard of the end mounting surface 100a (but preferably between the end mounting surface and the hole 101 described below), or alternatively the root mounting portion may not be tapered inwardly.

The turbine blades 3 are typically composed of reinforced composite material, for example laminated layers of fibre-reinforced polymer formed using prepreg or resin-infused plies, although the other materials may be used. Typically at least some of the laminated layers of reinforcement extend continuously out from the root mounting portion 3a into the main body portion 3b of the turbine blades 3.

The wall 100 of each root mounting portion 3a has four holes 101 extending through a thickness of the wall, although a different number of holes is possible as will become clear from the following description. The holes 101 are spaced apart along a width direction of the wall 100 and each hole is partially defined by an engagement surface 102 facing away from the end mounting surface 100a of the turbine blade. In other embodiments the number of holes 101 may be significantly greater, for example at least 10 or at least 20 or at least 30 or at least 40. In one particular preferred embodiment the number of holes is 34.

Each turbine blade 3 is coupled to its respective turbine member 4 by a turbine assembly 5 as shown in Figure 2 and in cross-section in Figure 3. The coupling of one of the turbine blades 3 to its respective turbine member 4 will now be described, although it will be understood that both turbine blades are coupled to their respective turbine members using similar turbine assemblies.

The turbine assembly 5 includes the root mounting portion 3a of the turbine blade 3, the turbine member 4 and four mounting assemblies 10. Each of the mounting assemblies corresponds to a respective one of the four holes 101 through the wall 100. In other embodiments any other number of holes and corresponding mounting assemblies may be used, including one.

The mounting assembly 10 includes a peg 200, a clamping member 300 and a retaining member 400. The following description generally refers to a single mounting assembly 10, shown in detail in Figure 4, although it will be understood that each of the mounting assemblies are arranged and function in a similar manner.

The peg 200 extends through the hole 101 and has first 201 and second 202 opposed bearing surfaces. The term "opposed bearing surfaces" means bearing surfaces which generally face in different directions, and includes bearing surfaces which are laterally offset from each other instead of directly opposed, and which are angled with respect to each other instead of parallel as shown in Figure 4.

The second bearing surface 202 engages the engagement surface 102 of the hole 101. The second bearing surface 202 and the engagement surface 102 are curved with curvature about a longitudinal axis of the peg. An interface between the second bearing surface 202 and the engagement surface 102 is therefore arched. The complementary curved surfaces of the peg and the wall need not be exactly aligned with the longitudinal axis of the peg. In other embodiments these complementary bearing surfaces may be part spherical (with curvature in two directions) or substantially planar or any other shape.

The first bearing surface 201 engages a clamping surface 303 of the clamping member 300 (which is described below). The first bearing surface 201 and the clamping surface 303 are also curved with curvature about a longitudinal axis of the peg. An interface between the first bearing surface 201 and the clamping surface 303 is therefore arched. The complementary curved surfaces of the peg and the clamping member need not be exactly aligned with the longitudinal axis of the peg. In other embodiments these complementary bearing surfaces may be part spherical (with curvature in two directions) or substantially planar or any other shape. In any case, the first bearing surface and the clamping surface are substantially continuous bearing surfaces and may be moved towards each other into engagement or out of engagement and away from each other when not constrained by other components. The movement may be in a direction normal to the interface between the first bearing surface and the clamping surface and/or in a direction parallel to the interface.

The peg 200 also has a bore 203 extending through its height in a direction generally towards the turbine member 4, as shown in Figure 6. The bore 203 is for receiving a stud 401 of a retaining member 400 (described below). In other embodiments there may be multiple bores for receiving multiple studs. In other embodiments the bore(s) may be replaced by one or more open notches or grooves configured to engage a portion of a retaining member. In other embodiments a bore/notch/groove may not be required.

The peg 200 comprises a taper with an increasing dimension from a first end 200a located towards the clamping member 300 to a second end 200b located towards the retaining member 400 (which is described below). The taper increases the height of the peg 200 in a direction aligned with the longitudinal axis 9 of the root mounting portion 3a. The hole 101 in the wall 100 is straight sided, as shown in Figure 4, but in other embodiments may have a corresponding tapered shape. The taper allows manufacturing tolerances to be compensated for during assembly of the turbine 1 by pushing the peg 200 further into the hole 101. The bore 203 through the peg 200 is preferably enlarged compared to the stud which passes through it (as described below) and/or slotted with an increased dimension in a direction aligned with the longitudinal axis of the peg to allow for positional adjustment of the peg with respect to the hole 101. Alternatively or additionally, the peg may be tapered in a width direction of the peg which is perpendicular to the longitudinal axis of the root mounting portion and perpendicular to a longitudinal axis of the peg. Again, the hole in the wall may or may not have a corresponding tapered shape. In other embodiments the peg may not be tapered.

The peg 200 is taller in the height direction than the width direction to improve its bending strength in its primary load carrying direction. The hole 101 in the wall 100 is correspondingly taller (in a direction aligned with the longitudinal axis 9 of the root mounting portion 3a) than it is wide (in a direction perpendicular to the longitudinal axis of the root mounting portion and parallel to the width direction of the wall) to reduce the required hole width. The peg 200 and the hole 100 may have a substantially oval shape or alternatively any other shape.

The clamping member 300 is spaced apart from the wall 100 on a first side of the wall. The clamping member 300 is located on an inside of the closed loop formed by the wall 100. The clamping member 300 comprises an annular wall 301 within the closed loop, the wall extending around the inside of the root mounting portion 3a. The annular wall 301 may be, for example, cylindrical or frusto-conical in shape.

The clamping member 300 has a plurality of holes 302 extending through the thickness of its annular wall 301, each hole corresponding to a respective one of the mounting assemblies 10 and providing a clamping surface 303 facing generally towards the turbine member 4. In other embodiments the clamping surfaces 303 may be provided by recesses and/or overhanging portions (as shown in Figure 7) instead of holes. In each case the clamping surface 303 is preferably formed in the wall 301 or on a portion of the clamping member which is integrally formed with the wall or otherwise rigidly fixed to the wall. In other embodiments multiple clamping members may be provided, each providing clamping surface(s) for one or more of the mounting assemblies 10 instead of a single clamping member providing clamping surfaces for all of the mounting assemblies, and the clamping member may not be annular.

The clamping surface 303 is curved. As described above with reference to the peg 200, the clamping surface 303 has curvature about a longitudinal axis of the peg (as does the first clamping surface of the peg).

As shown in Figure 4, the clamping surface 303 extends in a direction away from the longitudinal axis 9 of the root mounting portion 3a and towards the wall 100 of the root mounting portion, and is generally inclined at an acute angle to a plane extending transversely to the longitudinal axis of the root mounting portion. The clamping surface 303 is inclined inwardly towards a centre of the root mounting portion and downwardly away from the tip end 3c of the turbine blade 3 such that an inner-most portion of the clamping surface (with respect to the clamping member) is located further away from the tip of the turbine blade and further towards the turbine member 4 than an outer-most portion of the clamping surface.

The clamping member 300 has an annular projecting portion 304 providing a second clamping surface 305 opposing the first clamping surface 303. The second clamping surface 305 is located on an opposite side of the turbine member 4 to the first clamping surface 303, and engages an underside of the turbine member 4 to couple the clamping member to the turbine member. The clamping member 300 is held in position by the forces transferred between the clamping member 300 and the peg 200, as described below. In other embodiments the second clamping surface 305 may not be provided by annular ring 304 but by one or more projections and/or recesses. Alternatively, or additionally, the clamping member 300 may be coupled to the turbine member 4 in some other way, for example by one or more mechanical fasteners and/or other interlocking features. In other embodiments the clamping member 300 may be integrally formed with the turbine member 4, as shown in Figure 7.

The retaining member 400 is spaced apart from the wall and is located on the outside of the loop formed by the wall 100 (that is on the opposite side of the wall to the clamping member 300). The retaining member 400 includes a stud 401 passing through the bore 203 in the peg 200 and a nut 402 coupled to a threaded portion of the stud. The nut 402 bears against a portion of the peg 200 located on the same side as the first bearing surface 201 and opposite the second bearing surface 202. As can be seen in Figures 3 and 4, the retaining member 400 and clamping member 300 engage the peg 200 at opposite end portions of the peg.

The stud 401 may further include a second threaded portion for coupling the stud to the turbine member. In other embodiments there may be multiple studs passing through one or more bores through each peg. In other embodiments the retaining member may take some other form, for example a component having a bearing surface facing generally towards the turbine member which engages the peg.

The first clamping surface 303 of the clamping member 300 engages the first bearing surface 201 of the peg 200, and the clamping member transfers a first force to the peg in a first direction 1001 towards the turbine member 4, as shown in Figure 6. The nut 402 of the retaining member 400 engages the peg 200 and the retaining member transfers a second force to the peg in a second direction 1002 towards the turbine member 4. The second bearing surface 202 of the peg 200 engages the engagement surface 102 of the hole 101, thereby transferring a third force to the root mounting portion 3a of the turbine blades 3 in a third direction 1003 towards the turbine member 4. In this way, the peg 200 urges the root mounting portion 3a into engagement with the turbine member 4 and pre-loads the root mounting portion in compression, thereby retaining the turbine blade 3 on the turbine member. The first, second and third directions may each be angled with respect to each other, as shown in Figure 4, but in other embodiments may be substantially parallel, as shown in Figure 7.

The nut 402 of the retaining member 400 is adjustable along the threaded portion of the stud 401 towards and away from the turbine member 4. The retaining member 400 may therefore be tightened to increase the pre-loads in the root mounting portion 3a and in the retaining member, and loosened to reduce the pre-loads.

The location at which the clamping member 300 engages the peg 200 is separated from the location at which the peg 200 engages the wall 100 by a first distance A, and the location at which the peg 200 engages the wall 100 is separated from the location at which the retaining member 400 engages the peg 200 by a second distance B, as shown in Figure 6. The second distance B is greater than the first distance A such that the clamping member 300 carries a greater load than the retaining member 400, thereby reducing the loading of the retaining member such that smaller diameter studs and/or fewer mounting assemblies are required. In other embodiments the distance A may be greater than the distance B or the distances A and B may be substantially equal.

The engagement surface 102 of the hole 101 and the complementary second bearing surface 202 of the peg 200 are substantially perpendicular to the wall 100 at the location of the hole, such that the force transferred from the peg to the wall is aligned with the direction of the wall. For a wall made from composite layers this is advantageous in order to avoid through-thickness stresses in the wall. In other embodiments these complementary bearing surfaces may not be substantially perpendicular to the wall.

The engagement surface 102 of the hole 101 and the complementary second bearing surface 202 of the peg 200 are inclined at an acute angle to a plane extending transversely to the direction 1002 of the force transmitted to the peg by the retaining member (which is aligned with the longitudinal direction of the stud 401). The force transmitted to the peg 300 by the retaining member 400 therefore acts to urge the peg inwardly into the hole 101, resisting any tendency of the taper angle of the peg to push the peg outwards. The engagement surface 102 of the hole 101 and the complementary second bearing surface 202 of the peg 200 are also inclined at an acute angle to the first bearing surface 201 of the peg and the first clamping surface 303 of the clamping member 300. In other embodiments the engagement surface 102 of the hole 101 and the complementary second bearing surface 202 of the peg 200 may be substantially perpendicular to the force transmitted to the peg by the retaining member 400 and/or substantially parallel to the first bearing surface 201 of the peg 200 and the first clamping surface 303 of the clamping member 300, as shown in Figure 7.

The turbine assembly is assembled by the following steps:

a. Couple the clamping member 300 to the turbine member 4 (this step is eliminated in embodiments where the clamping member is integrally formed with the turbine member);
b. Position the root mounting portion 3a with respect to the turbine member 4 with the end mounting surface 100a engaging the complementary mounting surface 4a;
c. Insert the pegs 200 through the holes 101 until the first bearing surfaces 201 engage the clamping surfaces 303 and the second bearing surfaces 202 engage the engagement surfaces 102;
d. Insert the studs 401 through the bores 203 formed in the pegs 200 and couple the studs to the turbine member 4;

e. Thread the nuts 402 onto the studs and tighten the nuts onto the upper surfaces of the pegs 200, thereby securing the root mounting portion 3a to the turbine member 4 and pre-loading the root mounting portion in compression;

f. Adjust the nuts 402 to generate the required pre-loads in the studs 401 and in the root mounting portion 3a.

The skilled person will appreciate that the above steps need not be carried out in the order in which they are presented. For example, one or more pegs 200 may be inserted through the holes 101 before the root mounting portion 3a is positioned relative to the turbine member 4.

The turbine assembly may be disassembled by reversing the above steps.

The root mounting portion 3a, turbine member 4 and mounting assembly 5 are arranged such that the peg 200 may be inserted through the hole 101, the first bearing surface 201 brought into engagement with the clamping surface 303 and the second bearing surface 202 brought into engagement with the engagement portion 102 and the assembly secured together without requiring access to the side of the wall 100 on which the clamping member 300 is located. Therefore the turbine assembly and method described above do not require access to the inside of the root mounting portion 3a or the inside of the turbine hub 2 when assembling, adjusting and disassembling the turbine assembly, thereby increasing the ease and reducing the cost of erecting, maintaining and decommissioning of the turbine 1.

The clamping surface 303 of the clamping member 300 and the first bearing surface 201 of the peg 200 are arranged to allow relative movement between the peg and the clamping member in an axial direction of the peg. Relative movement between the peg 200 and the clamping member 300 is substantially prevented by friction at the mating surfaces when the turbine assembly is fully assembled with the retaining members 400 tightened. However, if the retaining members 400 are loosened to reduce or eliminate the loading at the bearing surfaces, the peg may be adjusted in its axial direction. This may be done, for example, during assembly, maintenance or disassembly of the turbine. The movement may be sliding movement while second bearing surface 201 remains in contact with the clamping surface 300, or alternatively the second bearing surface may be moved apart from the clamping surface before or during axial movement of the peg.

Preferably the peg 200 is not attached directly to the clamping member 300 by any mechanical fasteners or interlocking features so that it can be readily moved relative to the clamping member during assembly, maintenance and disassembly of the turbine assembly without requiring access to the inside of the loop formed by the wall 100 (that is the side of the wall on which the clamping member 300 is located). In other embodiments one or more mechanical fasteners and/or interlocking features may be employed at the interface between the clamping surface 303 and the first bearing surface 201 of the peg.

Various other modifications will be apparent to those skilled in the art.

CLAIMS

1. A turbine assembly comprising a turbine blade, a turbine member and a mounting assembly; wherein the turbine blade comprises a root mounting portion having a wall and a hole extending through a thickness of the wall, the hole being partially defined by an engagement surface facing away from a root end of the turbine blade; wherein the mounting assembly comprises a peg, a clamping member and a retaining member; the clamping member and the retaining member being located on opposite sides of the wall; wherein the clamping member and the retaining member are respectively coupled to the turbine member and respectively coupled to opposite end portions of the peg; wherein the peg extends through the hole and comprises first and second opposed bearing surfaces, the first bearing surface engaging a clamping surface of the clamping member and the second bearing surface engaging the engagement surface of the hole.
2. A turbine assembly according to claim 1, wherein the wall extends in a closed loop.
3. A turbine assembly according to claim 2, wherein the clamping member is located on an inside of the closed loop formed by the wall.
4. A turbine assembly according to claim 3, wherein the clamping member comprises an annular wall within the closed loop formed by the wall of the root mounting portion.
5. A turbine assembly according to any preceding claim, wherein the clamping surface extends in a direction away from a longitudinal axis of the root mounting portion and towards the wall of the root mounting portion.
6. A turbine assembly according to any preceding claim, wherein the clamping surface is generally inclined at an acute angle to a plane extending transversely to a longitudinal axis of the root mounting portion.

7. A turbine assembly according to claim 6, wherein the clamping surface is inclined inwardly towards a centre of the root mounting portion and downwardly away from a tip end of the turbine blade.

8. A turbine assembly according to any preceding claim, wherein an interface between the clamping surface and the first bearing surface of the peg is free of any interlocking features.

9. A turbine assembly according to any preceding claim, wherein an interface between the clamping surface and the first bearing surface of the peg is free of any mechanical fasteners.

10. A turbine assembly according to any preceding claim, wherein the clamping surface and the first bearing surface allow relative movement between the peg and the clamping member in an axial direction of the peg.

11. A turbine assembly according to any preceding claim, wherein the clamping surface and the first bearing surface may be moved towards each other into engagement or out of engagement and away from each other.

12. A turbine assembly according to any preceding claim, wherein an interface between the clamping surface and the first bearing surface is curved.

13. A turbine assembly according to claim 12, wherein the clamping surface is curved about a longitudinal axis of the peg.

14. A turbine assembly according to claim 13, wherein the first bearing surface has a curvature which corresponds to the curvature of the clamping surface.

15. A turbine assembly according to any preceding claim, wherein the clamping member is formed as a separate part to the turbine member.

16. A turbine assembly according to claim 15, wherein the clamping member further comprises a second clamping surface opposing the first clamping surface, wherein the

second clamping surface engages the turbine member to thereby couple the clamping member to the turbine member.

17. A turbine assembly according to any preceding claim, wherein the retaining member transmits a force to the peg in a direction towards the turbine member.

18. A turbine assembly according to claim 17, wherein the retaining member is adjustable in a direction towards the turbine member.

19. A turbine assembly according to claim 17 or 18, wherein the retaining member comprises a stud passing through a bore in the peg.

20. A turbine assembly according to claim 19, wherein the bore is enlarged compared to the stud and/or slotted with an increased dimension in a direction aligned with a longitudinal direction of the peg.

21. A turbine assembly according to claim 19 or 20, wherein the stud includes a helically threaded portion, wherein the retaining member further comprises an annular member having a complementary helically threaded portion coupled to the helically threaded portion of the stud, the annular member bearing against a surface of the peg.

22. A turbine assembly according to any of claims 17 to 21, wherein the location at which the clamping member engages the peg is separated from the location at which the peg engages the wall by a first distance, and the location at which the peg engages the wall is separated from the location at which the retaining member engages the peg by a second distance, the second distance being greater than the first distance.

23. A turbine assembly according to any of claims 17 to 22, wherein the second bearing surface of the peg is inclined at an acute angle to a plane extending transversely to the direction of the force transmitted to the peg by the retaining member.

24. A turbine assembly according to any preceding claim, wherein the second bearing surface of the peg is inclined at an acute angle to the first bearing surface.

25. A turbine assembly according to any preceding claim, wherein the second bearing surface of the peg is substantially perpendicular to the wall at the location of the hole.

26. A turbine assembly according to any preceding claim, wherein the second bearing surface of the peg is curved about a longitudinal axis of the peg.

27. A turbine assembly according to any preceding claim, wherein the peg is taller in a direction aligned with a longitudinal axis of the root mounting portion than it is wide in a direction perpendicular to the longitudinal axis of the root mounting portion and to a longitudinal direction of the peg.

28. A turbine assembly according to any preceding claim, wherein the peg comprises a first end located on a first side of the wall and a second end located on a second side of the wall, wherein the peg comprises a taper with an increasing dimension from the first end towards the second end.

29. A turbine assembly according to any preceding claim, wherein the root mounting portion comprises an end mounting surface engaging a complementary mounting surface of the turbine member.

30. A turbine assembly according to claim 29, wherein the wall extends away from the end mounting surface towards a tip end of the turbine blade at an acute angle to a longitudinal axis of the root mounting portion.

31. A turbine assembly according to claim 29 or 30, wherein the end mounting surface is inclined at an angle to a plane extending transversely to a longitudinal axis of the root mounting portion.

32. A turbine assembly according to any preceding claim, wherein the root mounting portion comprises a reinforced resin composite material.

33. A turbine assembly according to claim 32, wherein the reinforced resin composite material comprises laminated layers of fibrous reinforcement material.

34. A turbine assembly according to claim 32 or 33, wherein at least some of the laminated layers of fibrous reinforcement material extend continuously out from the root mounting portion of the turbine blade into a main body portion of the turbine blade outboard of the root mounting portion.

35. A turbine assembly according to any preceding claim, wherein the wall comprises a plurality of holes spaced apart from each other along a width of the wall, wherein the turbine assembly comprises a plurality of mounting assemblies, each mounting assembly including a peg passing through a respective one of the plurality of holes.

36. A turbine assembly according to claim 35, wherein a plurality of pegs located within a respective plurality of holes each engage a common clamping member.

37. A turbine assembly according to any preceding claim, wherein the turbine member is coupled to a rotatable hub, or is a rotatable hub or a part of a rotatable hub.

38. A turbine comprising one or more turbine blades, wherein the or each turbine blade is coupled to a turbine member by a turbine assembly according to any preceding claim.

39. A turbine according to claim 38, wherein the turbine is a water-driven turbine or an air-driven turbine.

40. A kit of parts for a turbine assembly, the kit comprising a turbine blade root mounting portion and a mounting assembly; wherein the root mounting portion has a wall and a hole extending through a thickness of the wall; wherein the mounting assembly comprises a peg and a clamping member; wherein the peg is adapted to extend through the hole and comprises first and second opposed bearing surfaces; wherein the first bearing surface is adapted to engage a clamping surface of the clamping member and the second bearing surface is adapted to engage an engagement surface of the hole; wherein the peg is adapted to be coupled to a retaining member located on

an opposite side of the wall to the clamping member with the clamping member and the retaining member respectively coupled to opposite end portions of the peg.

41. A kit according to claim 40, wherein the root mounting portion is integrally formed with or adapted to be attached to a main body of a turbine blade.

42. A kit according to claim 40 or 41, further comprising a turbine member, wherein the root mounting portion is adapted to engage the turbine member, wherein the peg is adapted to urge the root mounting portion into engagement with the turbine member and to pre-load the root mounting portion in compression

43. A kit according to any of claims 40 to 42, further comprising a retaining member adapted to be located on an opposite side of the wall to the clamping member.

44. A kit according to claim 43, wherein the retaining member is adapted to transmit a force to the peg in a direction towards the turbine member.

45. A method for assembling a turbine assembly, the method comprising the steps of:

   a. Providing a clamping member coupled to a turbine member;
   b. Positioning a root mounting portion of a turbine blade with respect to the turbine member, the root mounting portion having a wall and a hole extending through a thickness of the wall, the hole being partially defined by an engagement surface facing away from a root end of the root mounting portion;
   c. Inserting a peg through the hole, the peg having a first bearing surface and an opposed second bearing surface;
   d. Bringing the first bearing surface of the peg into engagement with a clamping surface of the clamping member and bringing the second bearing surface of the peg into engagement with the engagement surface of the hole;
   e. Securing the peg using a retaining member located on an opposite side of the wall to the clamping member.

Intellectual Property Office

Application No:	GB1415335.7	**Examiner:**	Mr Colin Walker
Claims searched:	1 to 45	**Date of search:**	2 March 2015

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 to 45	CN101922406 A (XUNREN) - See figures and WPI abstract (accession number : 2011-A94895)
X	1 to 45	WO2009/151181 A1 (WON) - See figures and page 3 line 2 to page 4 line 13
X	1 to 45	US2013/189103 A1 (TOBIN et al) - See figure 5 and paragraphs 29 to 40
X	1 to 45	SU1657762 A1 (SIROTIN et al) - See figures and WPI abstract (accession number : 1992-173613)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F01D; F03B; F03D

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
F01D	0005/30	01/01/2006