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Braikevitch

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[54] **AXIAL WATER FLOW MACHINES**

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[51] **Int. Cl.** **F01d 7/00**

[58] **Field of Search** 416/189, 170, 190, 416/191, 193, 207, 225; 415/135, 136, 216, 217, 107, 133, 160

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[57] **ABSTRACT**

In an axial water flow pump or turbine in which the runner comprises a hub, vanes extending radially from the hub, and a rim disposed around the vanes for example for carrying an electrical rotor, the rim is attached to the hub by tie bars. Preferably one tie bar is associated with each vane and extends through a bore or slot formed in the vane. Whilst tangential forces can be transmitted between the rim and the hub by the vanes, radial forces are carried by the tie bars. Thus bending stresses to which the rim is subjected are reduced, the rim will remain more nearly circular and radial clearance between the rim and its surroundings can be reduced.

6 Claims, 6 Drawing Figures

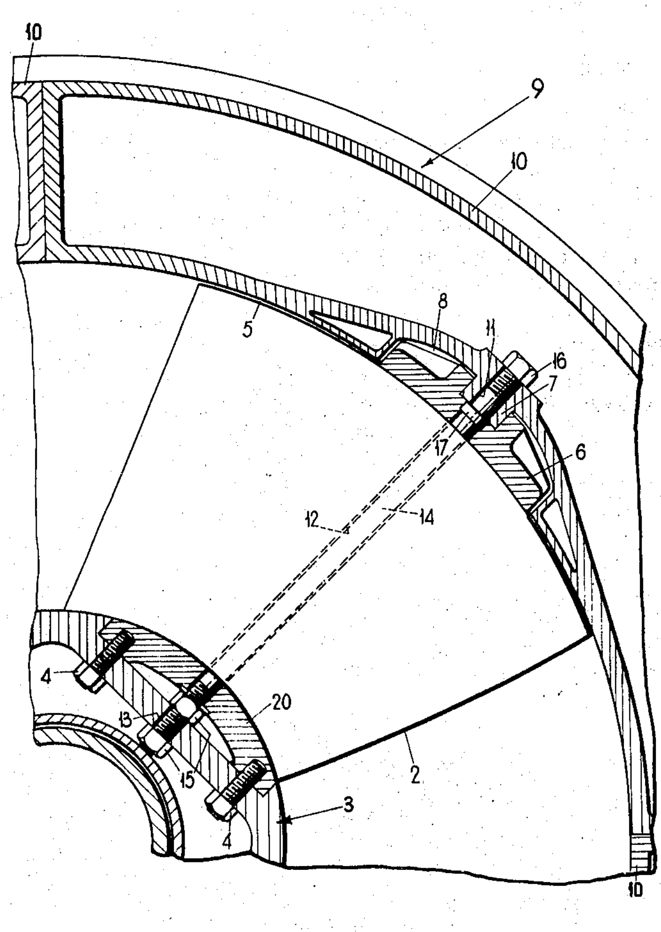
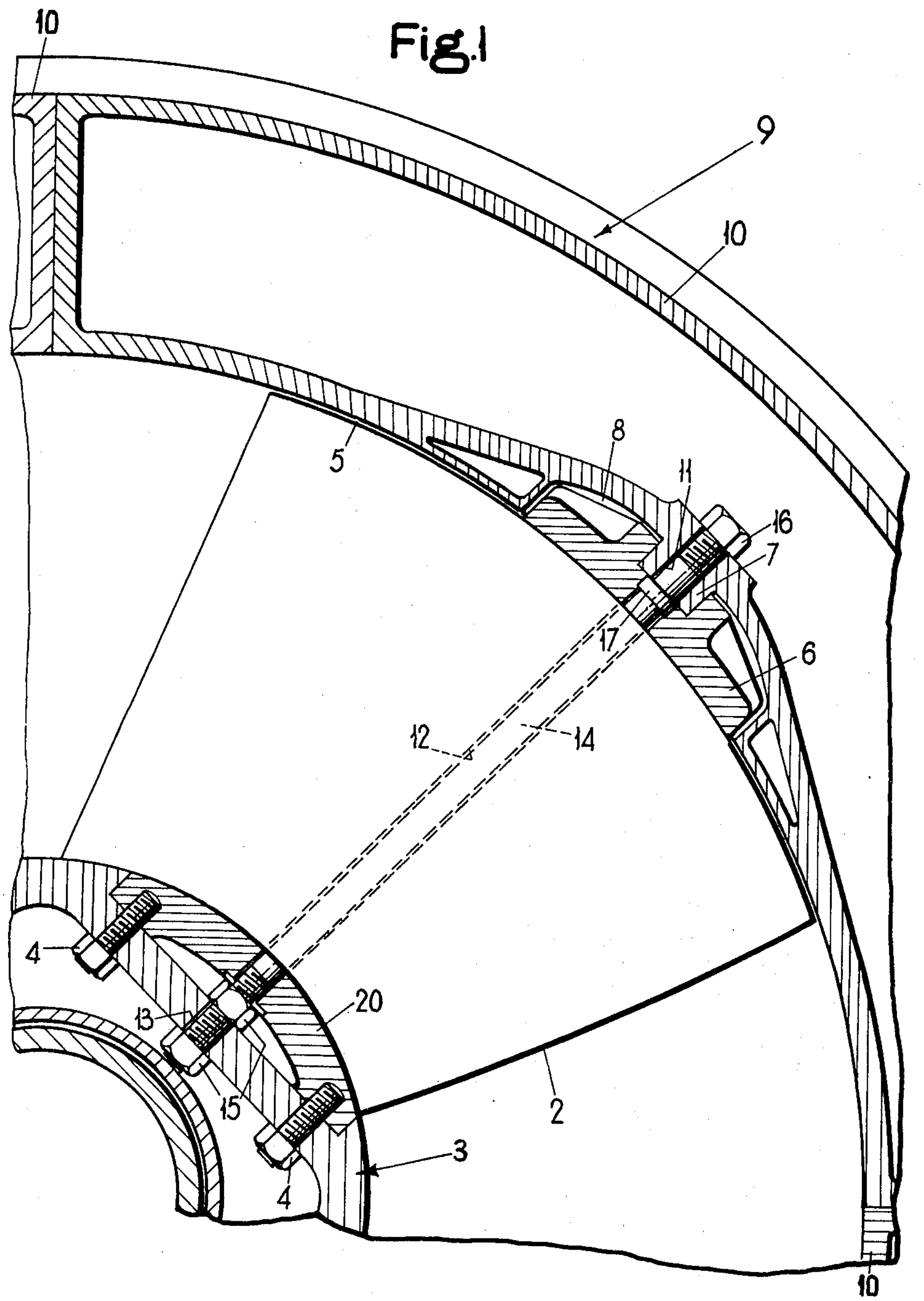


Fig.1



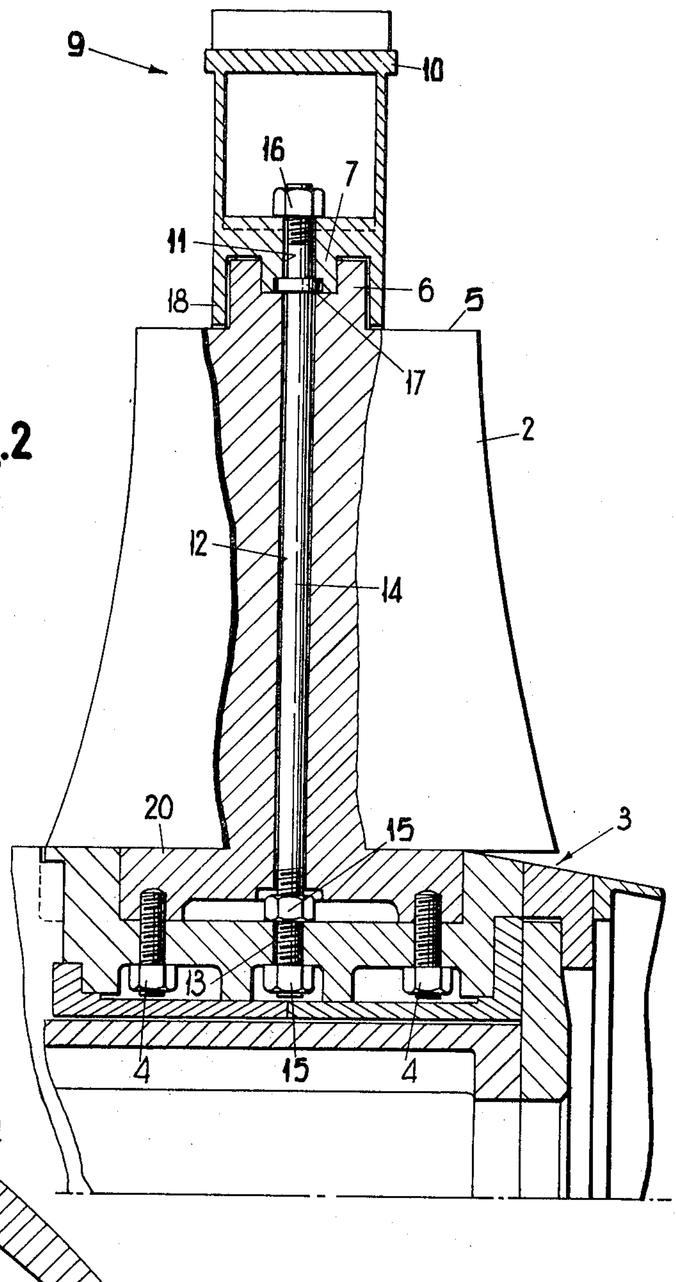


Fig.2

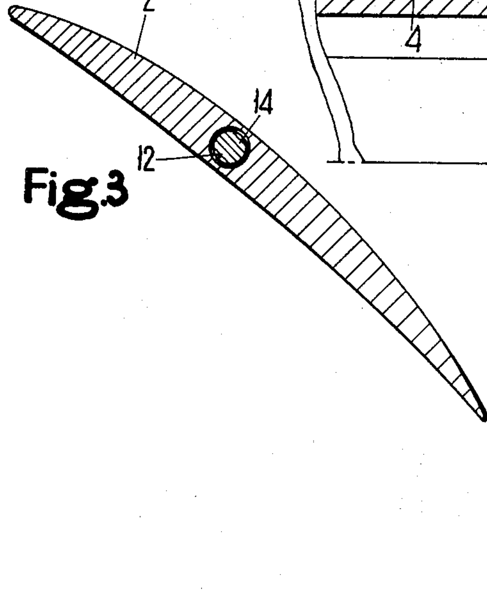


Fig.3

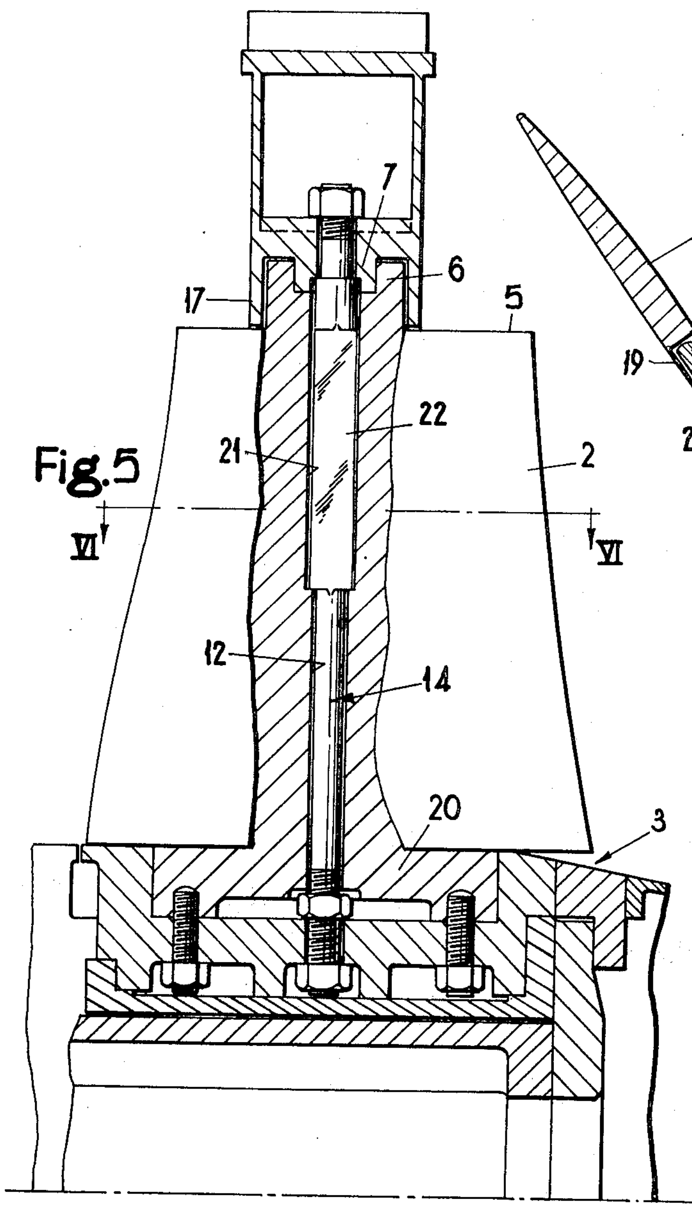


Fig.5

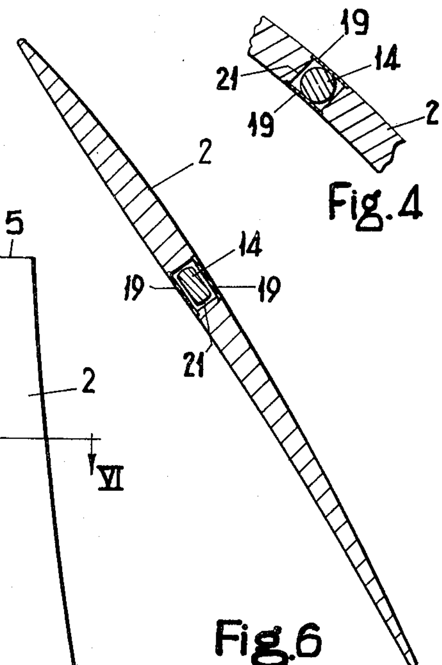


Fig.6

Fig.4

AXIAL WATER FLOW MACHINES

This invention relates to axial water flow machines in which there is provided a runner which comprises a hub, a plurality of radially extending vanes, and a peripheral drive member disposed circumferentially around the vanes. The drive member may support an electrical rotor, or alternatively an annular gear wheel.

Such machines may be turbines or pumps or pump-/turbines and find application in, for example, tidal flow hydro-electric schemes in which the runner may advantageously be disposed for rotation about a substantially horizontal axis.

During running of such a machine the runner vanes will assume substantially the temperature of the water passing over them whereas, where for example the peripheral drive member is a rim supporting an electrical rotor, the rim may become heated to 60°C. or more above the water temperature. In addition the rim will tend to expand owing to centrifugal effects.

With the smaller runner diameters hitherto employed these thermal and centrifugal effects while not presenting a very great problem could however be accommodated, but with the much larger diameters up to the order of 10 metres and the consequently higher peripheral speeds now proposed both the vanes and the drive member could become over stressed if a rigid radial connection between vane and rim were to be attempted. If a degree of pre-stressing were to be provided, assembly of the runner could be extremely difficult. Further, distortion of the drive member owing to over stressing would require enlargement of the clearance between a rotor and co-operating stator and this could significantly reduce the electrical efficiency of the machine.

According to the present invention, a runner for an axial water flow machine includes:

a hub;

a plurality of vanes extending generally radially from the hub;

a peripheral drive member disposed circumferentially around the vanes and held axially and circumferentially by the radially extending outer end of each vane, but being movable radially relative to the radially extending outer end of each vane; and

a plurality of tie members each connected at one end to the hub and at the other end to the drive member and arranged to locate the drive member radially relative to the hub.

Preferably each tie member comprises a radially extending tie bar, each tie bar being associated with a respective vane.

Each tie bar may pass through a bore in its respective vane, and each vane may be rotatable about its tie bar.

Alternatively each tie bar is disposed in a slot in its respective vane, and a fairing is associated with each slot for preserving the contour of the vane.

Two embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, of which:

FIG. 1 is a fragmentary sectional end elevation of the turbine runner of the first embodiment;

FIG. 2 is fragmentary a sectional side elevation of the turbine runner shown in FIG. 1;

FIG. 3 is a transverse section of a vane of the runner shown in FIGS. 1 and 2;

FIG. 4 is a fragmentary transverse section of a modified turbine runner vane of the second embodiment;

FIG. 5 shows a fragmentary sectional side elevation of a further modified turbine runner of the second embodiment; and

FIG. 6 is a transverse section on the line VI—VI of FIG. 5 of a turbine vane of the turbine runner shown in FIG. 5.

Referring to FIGS. 1, 2 and 3 a horizontally mounted turbine runner comprises four vanes 2 (only one is shown) carried on a hub 3. Each vane 2 is secured to the hub by studs 4, and has at the radially extending outer end 5 thereof an integrally formed bridge piece 6 provided for mechanical engagement with a boss 7 projecting radially inwards from a recess 8 formed in a peripheral drive member in the form of a rim 9. Radially extending surfaces of contact on the bridge piece 6 and the boss 7 hold the rim axially and circumferentially. The rim 9, which is arranged circumferentially around the ends 5 of the vanes, is divided into as many arcuate segments 10 as there are vanes 2, and carries poles (not shown) which form part of the rotor of an electrical generator (not shown).

The boss 7 is provided with a central radial bore 11 in axial alignment with a bore 12 extending longitudinally along the centre of the vane 2, and a hole 13 in the hub 3, and a tie bar 14 positioned in the bore 12 is secured at one end in the hole 13 by nuts 15, and at the other end in the bore 11 by a nut 16 and collar 17. A bearing (not shown) for the bar 14 is provided in the vane 2 at a point intermediate the rim and the hub for preventing buckling of the tie bar when it is loaded in compression. Thus a comparatively slender tie bar can be employed in order to achieve radial resilience between the rim and the hub. It will be appreciated that, in operation of the turbine, torque is transmitted from the vanes to the hub and to the rim by the vanes themselves. Thus, whilst tensile and compressive loading of the tie bars will occur, they will be substantially preserved from bending and sheer stresses. The diameters of the bar 14 and the bore 12 are such that the bar may slide within the bore, and the bridge piece 6 and boss 7 are clearanced so that, while the rim 9 is tied to the hub 3 by the bar 14, the boss 7 is free to slide in and out of the vane bridge piece 6 as the rim 9 expands or contracts radially. Mechanical drive from the vanes to the rim is obtained through the radially extending surfaces of contact between the bridge piece 6 and the boss 7. The bridge piece 6 is enclosed by end plates 18 of the rim 9 and although, as shown in FIG. 2, the end plates 18 are an integral part of the rim 9, they may be a subsidiary structure carried by the rim 9.

Water seals (not shown) are inserted in a recess in bridge piece 6 and boss 7 to keep the contact surfaces between boss and recess dry and to allow of their lubrication. Since the bar 14 does not move relative to the boss 7, and the rim 9, and is fixed in these items, it can be bored along its centre line and used for housing conductors connected to the generator rotor, and conduits for rotor cooling water.

When the turbine runner is stationary and two vanes are vertical the weight of the rim 9 is carried by two bars 14, the upper bar being in compression and the lower bar being in tension. The bearing in the vane prevents the upper bar from buckling. When the vanes are at 45° the weight of the rim 9 is carried by four bars.

Under operating conditions with the turbine runner being driven by water, mechanical drive from the vane 2 to the rim 9 is effected as aforesaid and the rim 9 may move radially relative to the vane 2 since the bars 14 have a greater resilience than the vanes 2. Thus centrifugal and thermal strains may be accommodated without causing radial overstressing of the vanes or rim, and the rim may remain substantially circular, thereby enabling the clearance between the rotor and a co-acting stator to be reduced.

Referring now to FIG. 4, if for hydraulic reasons it is desired to make part, e.g. the outer part, of the vane 2 thinner than would allow of convenient provision of the bore 12 the corresponding outer part of the bar may be located in a slot in the vane, the two sides of the slot being faired by thin cover plates 19 to preserve continuity of the vane surface, or alternatively, in a modification of this embodiment shown in FIGS. 5 and 6, if the diameter of the bar necessary for securing the rim 9 becomes excessive for the vane thickness, the outer part 22 of the bar 14 may be flattened in the region of the slot 21 and its diameter through the bridge piece 6 increased to a value corresponding to the larger dimension of the flattened part. The bar 14 can then be introduced into the vane 2 from the outer end 5 through the bridge piece 6 without increasing the diameter of the bore 12 in the thicker inner part of the vane near to a vane flange 20 fixing this vane to the hub 3. Cover plates 19 can then be fixed to the vane after the bar has been introduced.

Although the invention has been described with reference to turbines having fixed blades, it may also be advantageously applied to Kaplan or movable runner vane type turbines, wherein it is required to vary the "angle of attack" of the vane to the water flow. In this case the vane will rotate about the bar 14 but not be supported by it. The vanes may be located in the hub by any known means used for Kaplan turbines, and will carry loads usual with this type of turbine, namely the hydraulic axial and tangential thrust exerted by the water.

It should also be understood that the invention is not limited to the exact features of the embodiments hereinbefore described, and that the turbine runner may be provided with any number of vanes. Furthermore, it is envisaged that the bars 14 may be pre-tensioned so that when the weight of the rim 9 is applied to a vertical bar, in non-operative conditions, this subtracts from the pre-tension load and instead of producing a compressive stress, merely reduces the tension to a small value. It should also be remembered that when the turbine is operating, the centrifugal force is applied by the rim to the bar, which in any case reduces the compressive stress. As the rim heats up, further tension is applied which exceeds the compressive stress.

I claim:

1. A runner for an axial water flow machine, including:
   - a hub;
   - a plurality of vanes extending generally radially from the hub;
   - a peripheral drive member disposed circumferentially around the vanes and held axially and circumferentially by the radially extending outer end of each vane, but being movable radially relative to the radially extending outer end of each vane; and
   - a plurality of tie members each connected at one end to the hub and at the other end to the drive member and arranged to locate the drive member radially relative to the hub.

2. A runner according to claim 1, wherein each tie member comprises a radially extending tie bar, each tie bar being associated with a respective vane.

3. A runner according to claim 2, wherein each tie bar passes through a bore in its respective vane.

4. A runner according to claim 3, wherein each vane is rotatable about its tie bar.

5. A runner according to claim 2, wherein each tie bar is disposed in a slot in its respective vane.

6. A runner according to claim 5, wherein a fairing is associated with each slot for preserving the contour of the vane.

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