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(71) Applicant: **RingProp Marine Ltd.**
Chichester, West Sussex PO18 8ET (GB)

(72) Inventors:
- **Chapple, Mark**
  Chichester, West Sussex, PO18 8ET (GB)
- **Morley, Carl**
  Lara, Victoria 3212 (AU)

(74) Representative: **Jansen, Cornelis Marinus et al**
V.O.
Johan de Wittlaan 7
2517 JR Den Haag (NL)

(54) Marine propellers

(57) Some embodiments relate to a propeller having a hub and a plurality of radially extending blades, wherein a radial extreme of each of the blades is integral with an end plate defining a ring segment coaxial with the propeller hub, each ring segment having a concave inner surface and conforming generally to a frustoconical ring, the radial cross section of which is angled at between 0° and 15° to an axis of rotation of the propeller.

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Description

Technical Field

[0001] Embodiments generally relate to marine propellers and relates particularly to propellers suitable for use with marine craft of all types. Some embodiments are particularly directed towards shrouded or ringed propellers in which the outer tips of propeller blades are connected by a ring or shroud of substantially circular configuration. However, Embodiments are also applicable to propellers having blade tip end plates or wing tips wherein the propeller blade tips are provided with a ring segment, with the ring being discontinuous between the end plates or tips.

Background

[0002] Shrouded, or ring, propellers are well known and are sometimes formed by welding or otherwise securing a ring to the blade tips. More desirably, however, a ringed propeller is formed by casting, die moulding or other production processes whereby the propeller hub, blades and ring are formed as an integral unit. Ring propellers are particularly desirable from a safety point of view when used with leisure watercraft or other vessels as the ring, or shroud, provides a barrier to an object engaging the blades through lateral relative movement and prevents many types of laceration injury which might otherwise be caused by the blade tips, were they not enclosed by the ring.

[0003] Many designs of ring propeller have been proposed, particularly with the aim of optimising propulsive efficiency and other aspects of performance. A particular goal of such designs has been to emulate the performance of unshrouded, or open-bladed, propellers. However, previous designs of ring propeller have generally exhibited inherent differences in performance to that of an unshrouded propeller.

[0004] One factor important in the design of propellers is the flow contraction angle: for any given propeller geometry and blade loading, the "flow contraction angle" is caused by the fluid being accelerated through the propeller disc. This is true for any screw propeller of any geometry, with or without a shroud or ring. It has been found in testing that propellers of higher loading, or lower pitch/diameter ratio, will have larger contraction angles. More generally, however, it can be said that different propeller disc loadings will require different propeller geometries, and this then results in different contraction angles.

[0005] The inflow or contraction angle has been used historically by designers to attempt to optimise propeller performance for certain conditions. For example, it is important in the design of "ducts", which are held stationary in relation to the marine craft, and within which the propeller rotates. Such a duct may have an inner surface shaped along its length to control the flow, and its contraction angle, and produce a specific effect. Such a duct design may contribute directly to forward thrust, and it is said to have positive circulation.

[0006] It is also possible to design a duct that is decelerative. Such a design or structure results in the addition of drag, and is said to have negative circulation. While accelerative ducts can have the effect of increasing propeller efficiency by providing additional forward thrust with no addition of torque, in some operating conditions their use may lower the pressure through the propeller disc by too great a magnitude and thus cause a simultaneous reduction in thrust and efficiency, particularly if the propeller is operated in a cavitating regime.

[0007] Decelerative ducts can increase the pressure through the propeller disc and thus have a positive effect on the efficiency of the blades to offset the drag caused on the ring directly. The increase in pressure is also desirable for suppression of cavitation.

[0008] In the case of a shrouded or ring propeller, the "duct" is actually attached to the blade tips of the propeller. Therefore, the rotating shroud or ring adds to the torque load of the propeller which must be driven by the engine.

[0009] In the case of outboard and stern drive propellers, most operate in or near a cavitating condition. Therefore, an accelerating ring can lower the pressure such that loss of thrust is effected on the blades due to increased cavitation. This in turn can lead to an overall reduction in propeller efficiency. However, a decelerative ring may suppress cavitation and also significantly increase the thrust produced by the blades such that any drag caused directly by the ring is at least negated.

Summary

[0010] Some embodiments relate to a propeller having a hub and a plurality of blades, the radial extremes (outer edge) of each of which are integral with an end plate defining a ring segment coaxial with the propeller hub, each ring segment having a concave inner surface (i.e. cambered inwards) and conforming generally to a frustoconical ring, the radial cross section of which is angled (canted) at between 0° and 15° to the propeller axis.

[0011] In some embodiments, the ring segments form part of a continuous shroud or ring. In other embodiments, however, the ring segments comprise end plates or wing tips on each blade tip which are not connected with the end plate or wing tip of the next adjacent blade.

[0012] In some embodiments, the leading edge of the ring segments is at a greater radius than the trailing edge, thereby defining the cant angle of the ring segments. In order to achieve a desirable level of negative circulation, the ring must exceed a certain minimum angle. However, the larger this angle is, the greater is the drag created. Therefore, it is preferred that the optimum ring design uses the minimum ring cant angle possible and deploys camber in addition in order to create the required circulation. Thus, some embodiments employ an asymmetric ring segment section such that the camber of the section is outwards defined by the concave internal surface.

[0013] It will be appreciated that the angle may vary around the ring circumference so as to optimise the structure for blade loading and flow. Thus, the angle of the ring segments adjacent a blade tip may be different to the angle between blades. In some embodiments, the section angle will be between 1° and 15°, more particularly between 2° and 10°, and more specifically between 4° and 6°. In some embodiments, camber ratios will range from 1/40 to 3/40, although other ratios may also be adopted.

[0014] In some embodiments, the external surface of each ring segment is convex. In other embodiments, the external surface of each ring segment is substantially flat.

[0015] Propellers designed to be used with outboard or stern-drive engines often have blades, the pitches of which reduce with radius, to thereby unload the blade tips. This is partly due to the fact that the blades of conventional propellers are less efficient towards their tips ("tip losses"). (Blade circulation approaches zero at the tips). With a propeller designed according to described embodiments, however, the blades suffer only minimal tip losses and can therefore be loaded to advantage. It may therefore be advantageous to have increasing blade pitch towards the tips. Accordingly, embodiments are formed with blades, the pitches of which increase with radius.

[0016] Still further, embodiments may incorporate blades with increased chord length towards the blade tips, such that a larger proportion of blade area is carried at a larger radius.

[0017] Propellers in accordance with some embodiments with decelerative ring segments with concave internal surfaces may be used with blades having a pitch which increases with radius, or a chord length which increases with radius or with blades having a negative skew.

[0018] In embodiments having a ring segment forming an end plate on the blade tips, the end plate may extend at a canted angle from the tip of the blade, with a leading edge at a greater diameter than the trailing edge, as described. The end plate can extend outwards from the blade forwardly or rearwardly, or in both forward and rearward directions. Thus, embodiments may include end plates with various chord length distributions of the end plate and various axial displacements of the plate relative to the blade tip.

[0019] According to features of described propeller structures, it is intended to achieve improved efficiencies without disadvantageous cavitation. It is also intended to provide a propeller in some embodiments which, in at least one mode of operation, operates in a decelerative fashion. Some embodiments may provide a propeller, particularly a ring or shrouded propeller, which maximises overall thrust and efficiency by appropriate selection of blade shape, ring shape and orientation. Some embodiments may also provide a propeller, particularly a ring propeller or a propeller, with end plates or wing tips with enhanced pressure through the propeller disc.

Brief Description of the Drawings

[0020] Particular embodiments are illustrated by way of example in the accompanying drawings.

Figure 1 is an end elevational view of a propeller in accordance with some embodiments.

Figure 2 is a side elevational view of the embodiment of Figure 1.

Figure 3 is a cross sectional view of a ring of the embodiment of Figure 1.

Figure 4 is a front elevational view of further embodiments.

Figure 5 is a rear elevational view of the embodiment of Figure 4.

Figure 6 is a side elevational view of the embodiment of Figure 4, and

Figure 7 is a perspective view of the propeller of Figure 4.

Detailed Description

[0021] Referring to the drawings, Figures 1 and 2 illustrate embodiments having a ring 12 connected to the tips of each of three blades 14, the ring 12 being concentric with the propeller hub 16 (which is not shown in detail in the interests of clarity). The ring extends in a plane perpendicular to the axis of rotation of the propeller 10.

[0022] In such embodiments, the cord length "C" (Figure 3) and the cross section of the ring 12 is constant around the circumference of the ring 12.

[0023] The geometry of the ring 12, which is more particularly seen in Figure 3, has a leading edge 17 and a trailing edge 18. The radius of the leading edge 17 from the propeller axis is greater than that of the trailing edge 18 such that the ring is canted at an angle "α" to a line parallel to the axis of rotation of the propeller, indicated by line "a". In the preferred embodiment, this angle will be between 4° and 6°. As stated above, the larger this angle is, the greater is the drag created. Therefore, it is preferred that the optimum ring design uses the minimum ring cant angle possible, and deploys camber in addition in order to create the required circulation.

[0024] To this end, the inner surface 19 of the ring 12 is formed as a concave internal surface which provides an amount of camber in addition to the cant angle. The extent of camber is a function of the curvature of the surface 19, and will be selected in conjunction with the cant angle to minimise drag whilst optimising thrust and efficiency of the propeller. The amount of camber defined by the internal surface 19 will vary from a ratio of between about 1/40 to 3/40, indicated by the camber offset "f" in Figure 3.

[0025] The outer surface 20 of the ring 12 in this embodiment is curved, in a general aerofoil shape, to assist in shaping the fluid flow across the ring surface. In other embodiments, the outer surface 20 may be flat or formed of a plurality of connected planar and/or curved surface shapes, which may be symmetrical or asymmetrical in extent in either or both rotational and axial directions.

[0026] Referring to Figures 4 to 7, the form of propeller illustrated has blade end plates 21 comprising ring segments on the tip of each blade 14. A cross section of the end plates 21 in an axial plane will be similar to the section illustrated in Figure 3. However, the end plates 21 are shaped to define a pair of leading edges 22a and 22b, relative to the direction of propeller rotation, the leading edges 22a and 22b diverging away from a leading, generally pointed front edge 24, and a corresponding trailing edge 23, in addition to the leading and trailing edges 17 and 18 relative to the axial direction of propeller movement. These edges, while curved in circumferential and camber directions, may have planar or curved surfaces.

[0027] In the embodiment illustrated, the end plate cant angle is constant through the circumferential length of each end plate 21. Similarly, the camber of each end plate 21 is constant through the length thereof such that the end plates 21 define part surfaces of a frustoconical ring. However, the angle and camber may vary in other embodiments.

[0028] It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

Claims

1. A propeller having a hub and a plurality of radially extending blades, wherein a radial extreme of each of the blades is integral with an end plate defining a ring segment coaxial with the propeller hub, each ring segment having a concave inner surface and conforming generally to a frustoconical ring, the radial cross section of which is angled at between 0° and 15° to an axis of rotation of the propeller.

2. The propeller of claim 1, wherein the ring segments form part of a continuous shroud or ring.

3. The propeller of claim 1, wherein the ring segments comprise end plates or wing tips on each blade tip which are not connected with the end plate or wing tip of a next adjacent blade.

4. The propeller of claim 3, wherein the end plate extends outwards from the blade forwardly.

5. The propeller of claim 3, wherein the end plate extends outwards from the blade rearwardly.

6. The propeller of claim 3, wherein the end plate extends outwards from the blade both forwardly and rearwardly.

7. The propeller of any one of claims 1 to 6, wherein the leading edge of the ring segments is at a greater radius than the trailing edge, thereby defining a cant angle of the ring segments.

8. The propeller of any of claims 1 to 7, wherein the ring section is asymmetric such that a camber of the ring section is outwardly defined by the concave internal surface.

9. The propeller of any of claims 1 to 8, wherein the angle of the ring segments varies between one blade tip and another.

10. The propeller of claim 9, wherein a section angle adjacent to a leading edge of a blade is between 1° and 15°.

11. The propeller of claim 9, wherein a section angle adjacent to a leading edge of a blade is between 2° and 10°.

12. The propeller of claim 9, wherein a section angle adjacent to a leading edge of a blade is between 4° and 6°.

13. The propeller of any of claims 1 to 12, wherein the pitch of each blade increases with increasing radius.

14. The propeller of any of claims 1 to 13, wherein the blades increase in chord length towards the blade tips, such that a larger proportion of blade area is carried at a larger radius.

15. The propeller of any of claims 1 to 14, wherein the ring camber ratio is between 1/40 and 3/40.

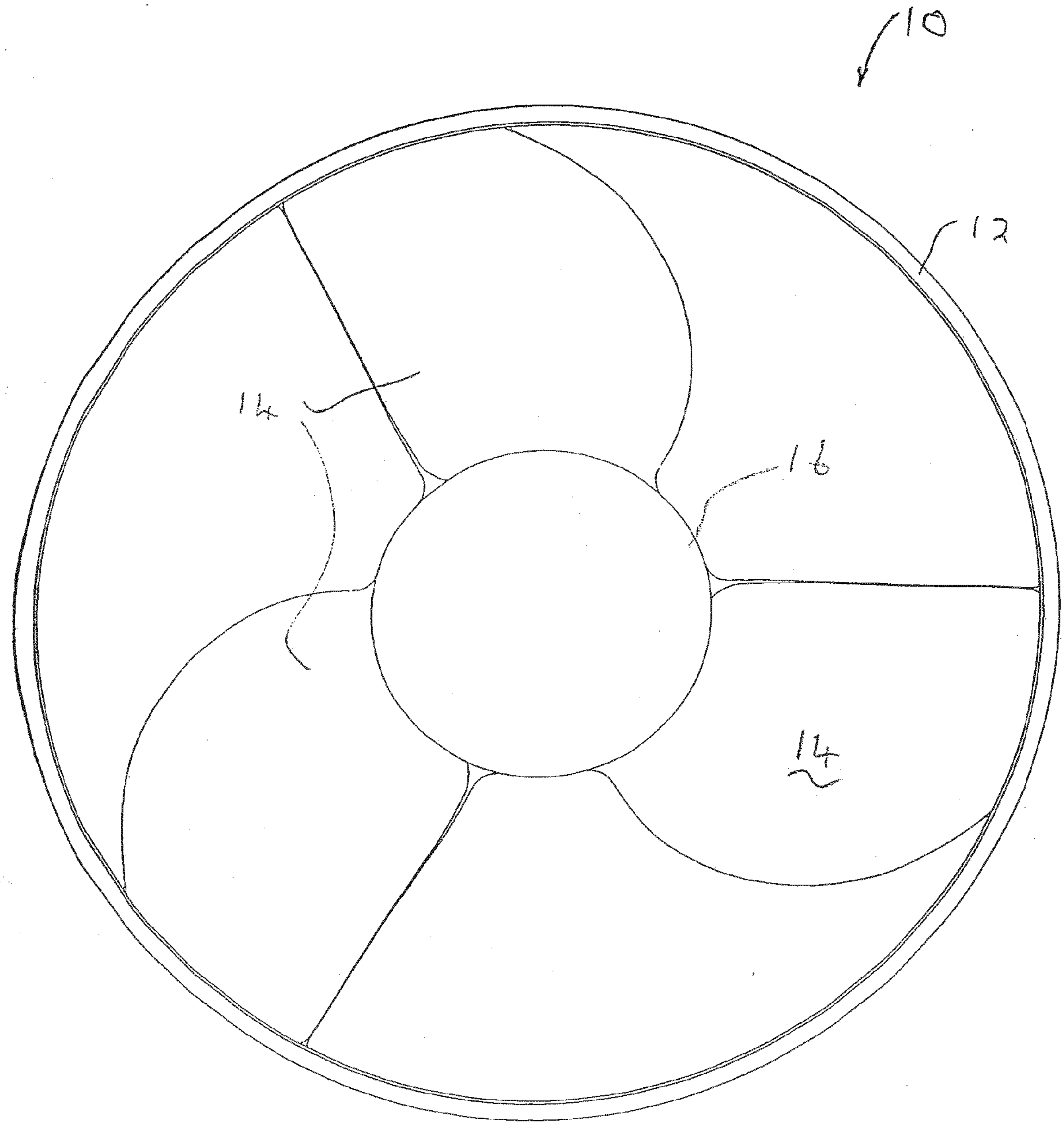

FIG 1

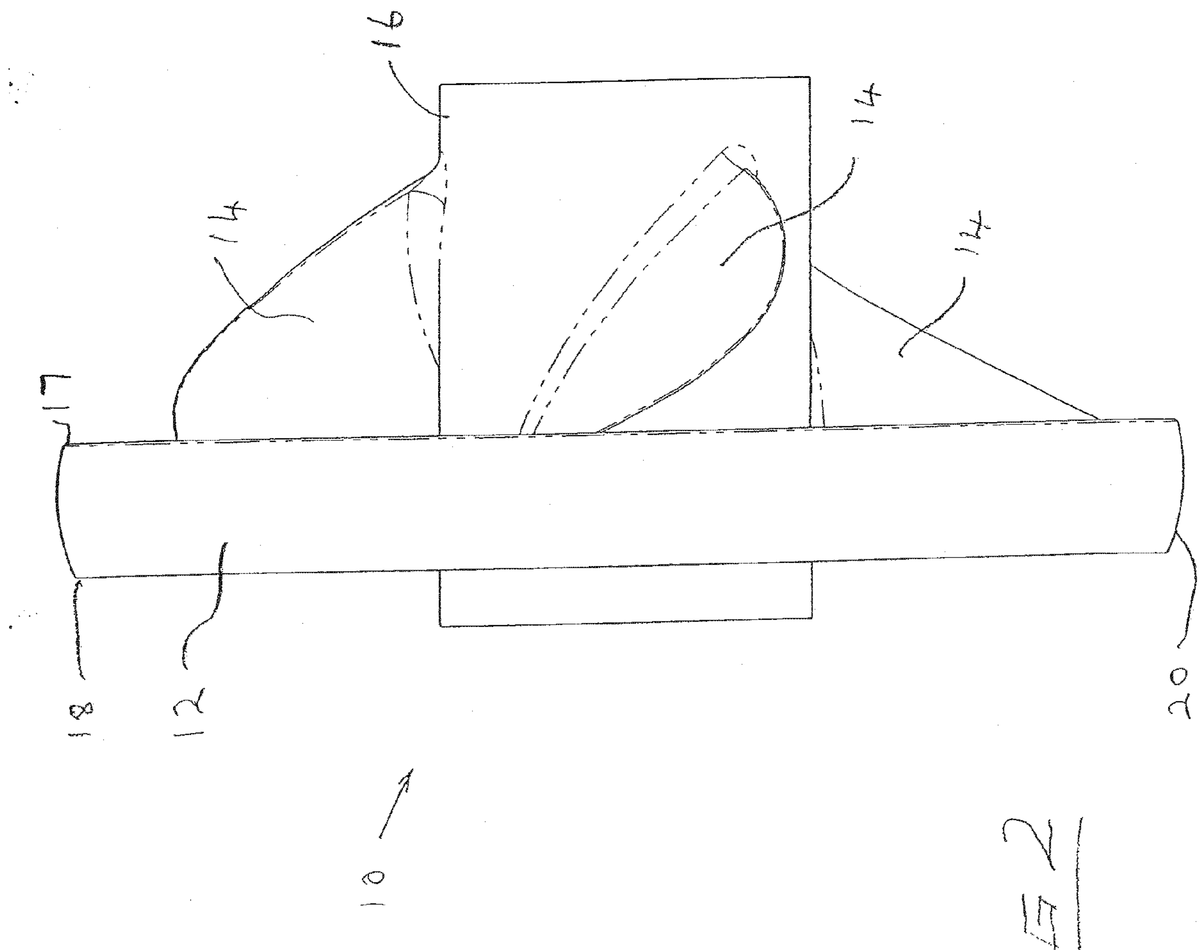

FIG 2

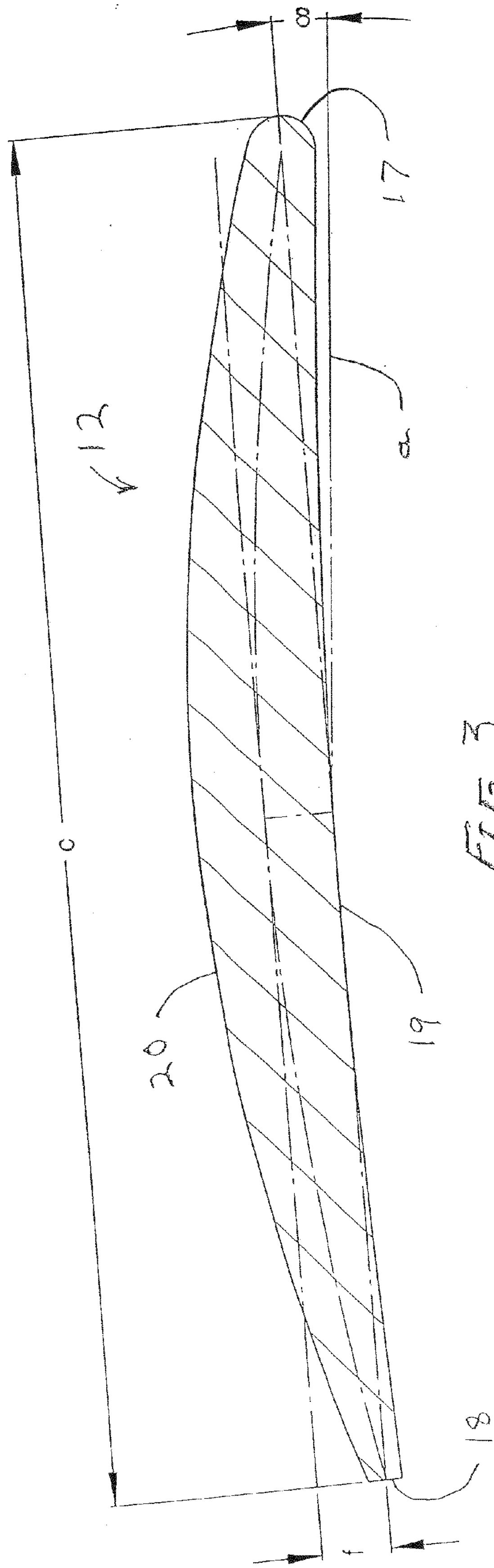

FIG 3

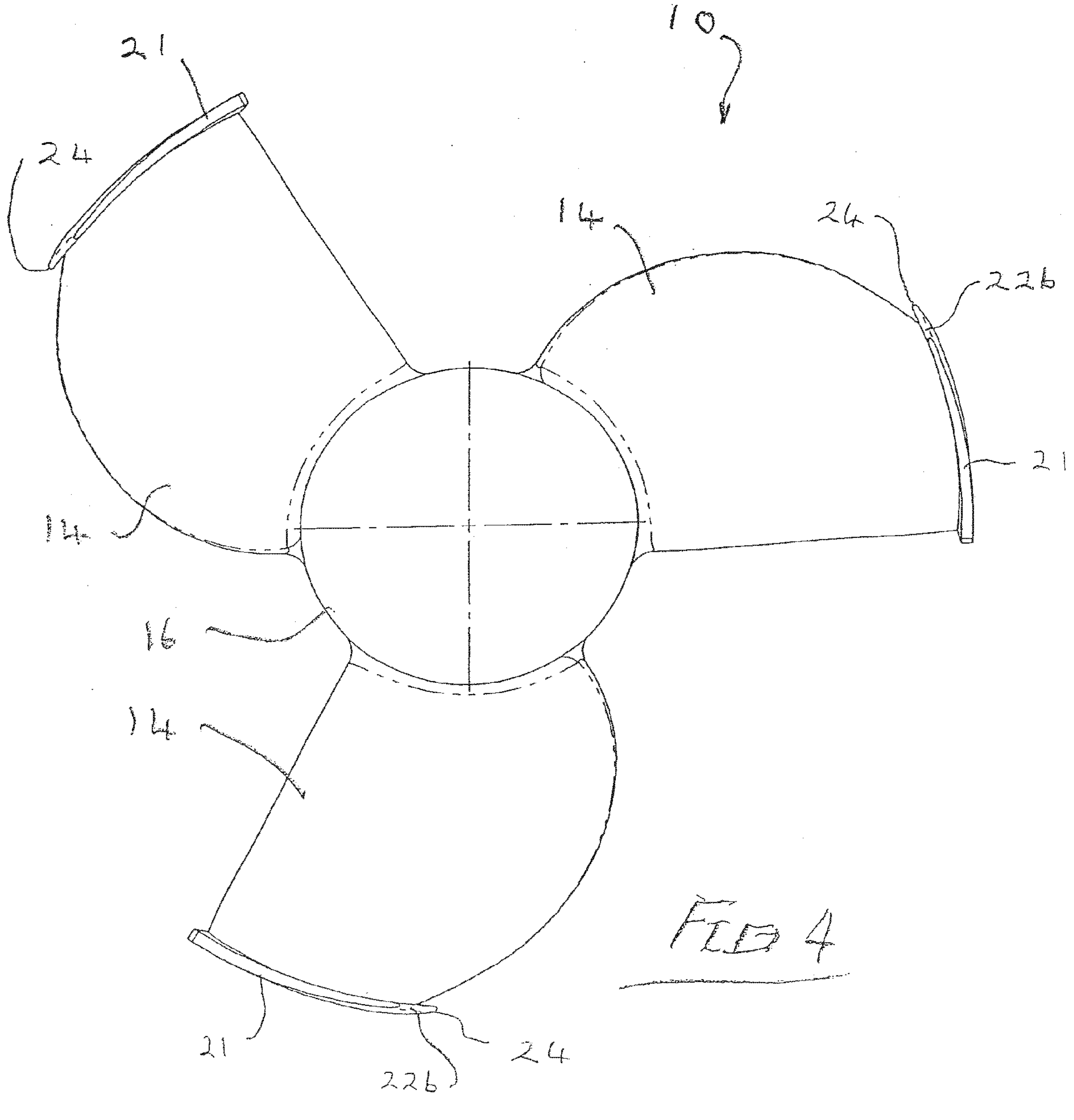

FIG 4

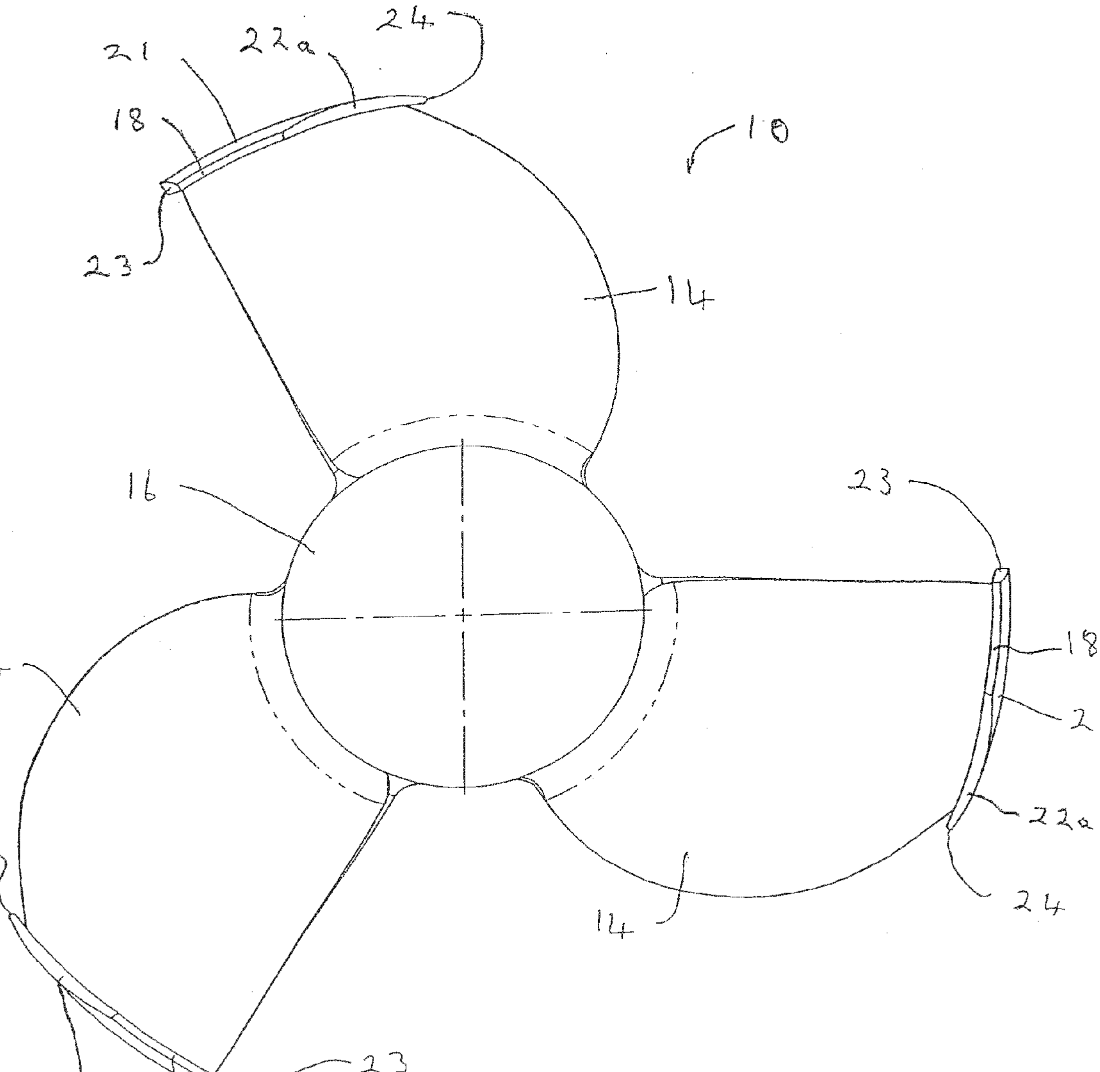

FIG 5

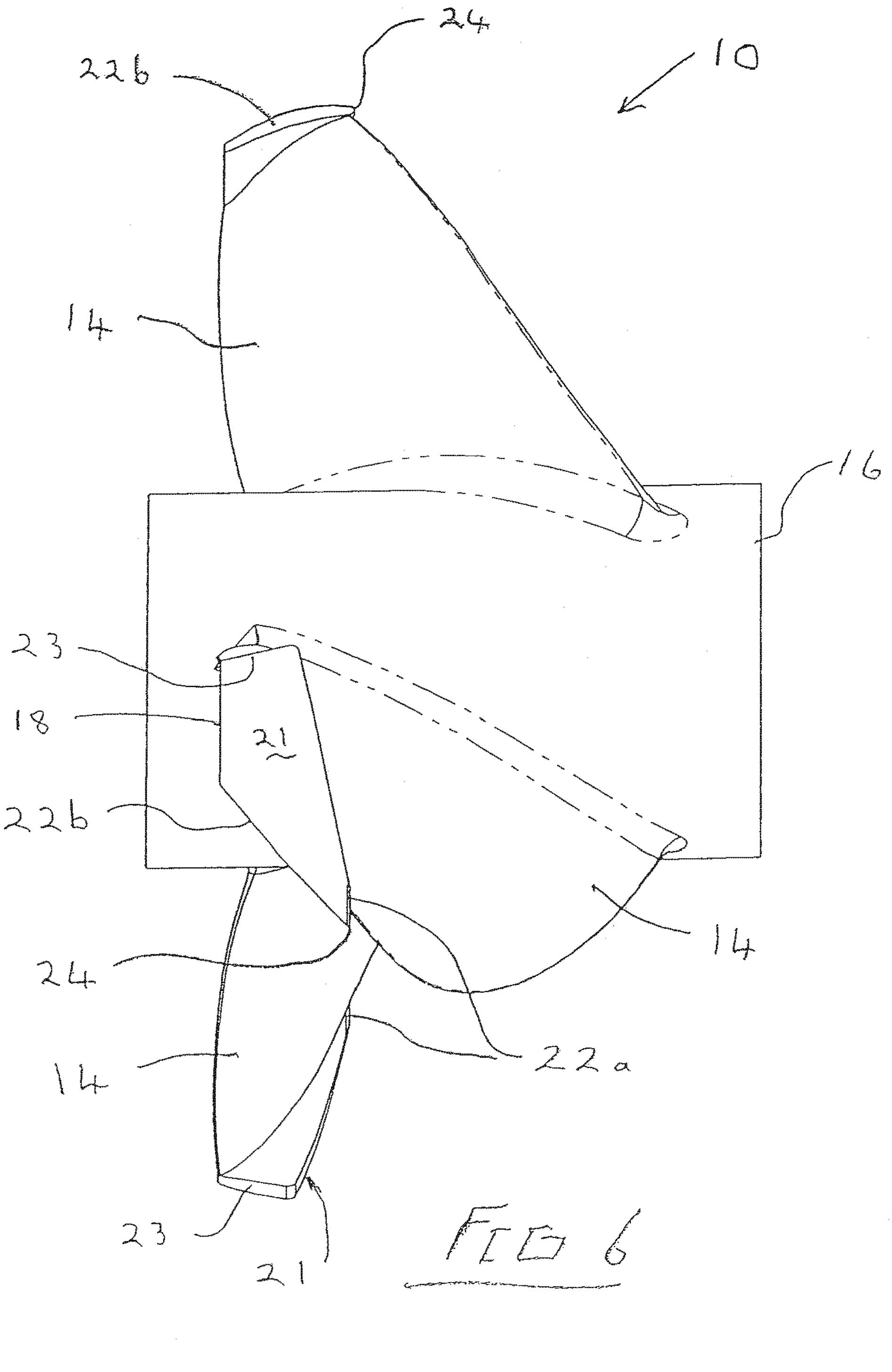

FIG 6

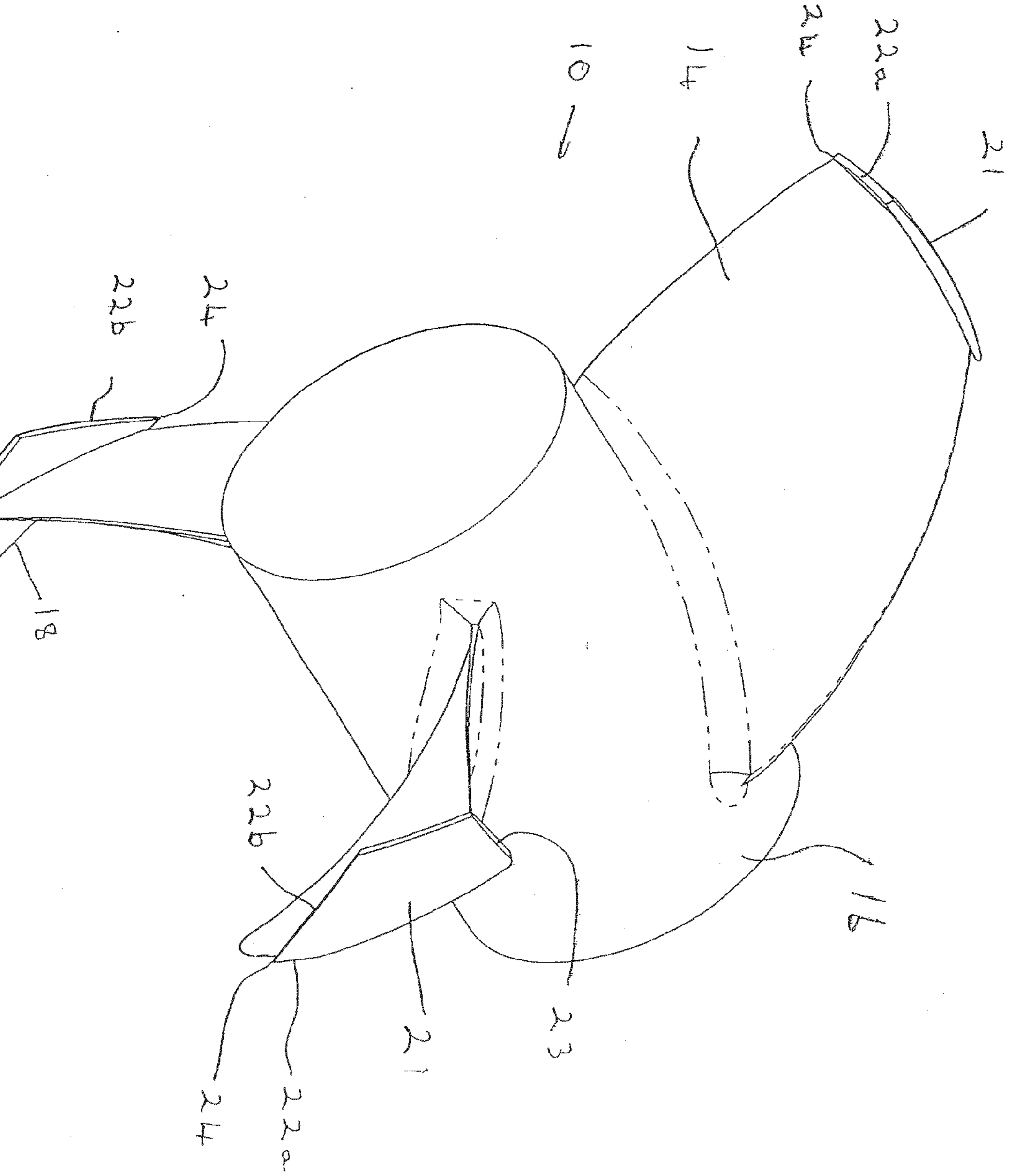

FIG 7

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EUROPEAN SEARCH REPORT

Application Number
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1

Place of search	Date of completion of the search	Examiner
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