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(54) ANTI-CAVITATION TUNNEL FOR MARINE PROPELLERS

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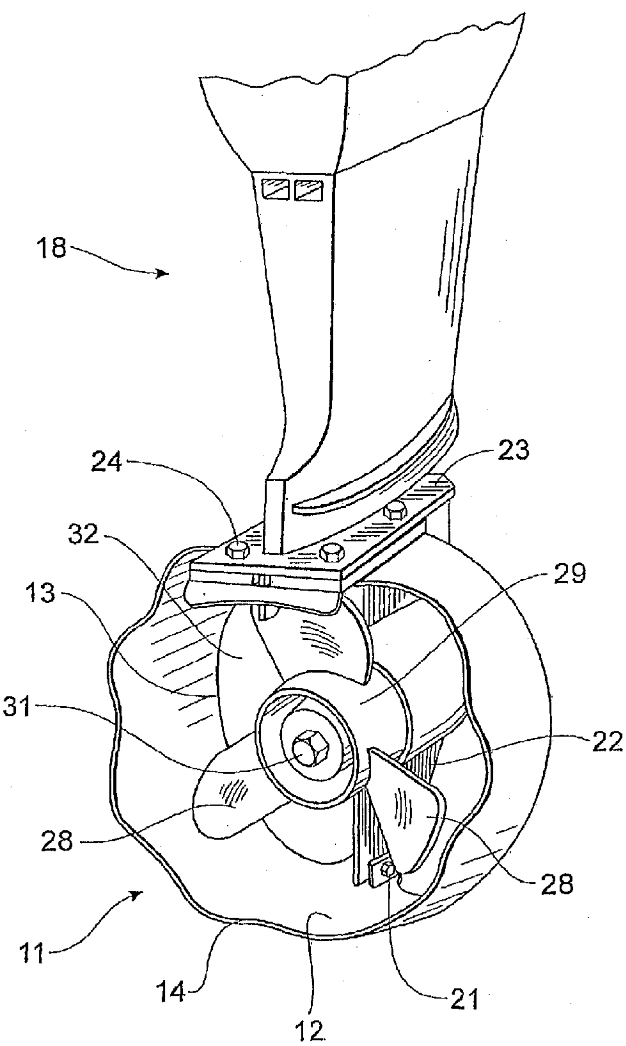
(57) ABSTRACT

An anti-cavitation tunnel (11) for a watercraft (20) has a non-convergent, plain (ie., non-aerofoil) section cowling (12) with a leading edge (13) located in or forwardly of a plane including the leading edges of the blades (28) of the propeller (25) and a trailing edge (14) which is located forwardly of the rearmost points (27) of the blades (28) of the propeller (25).



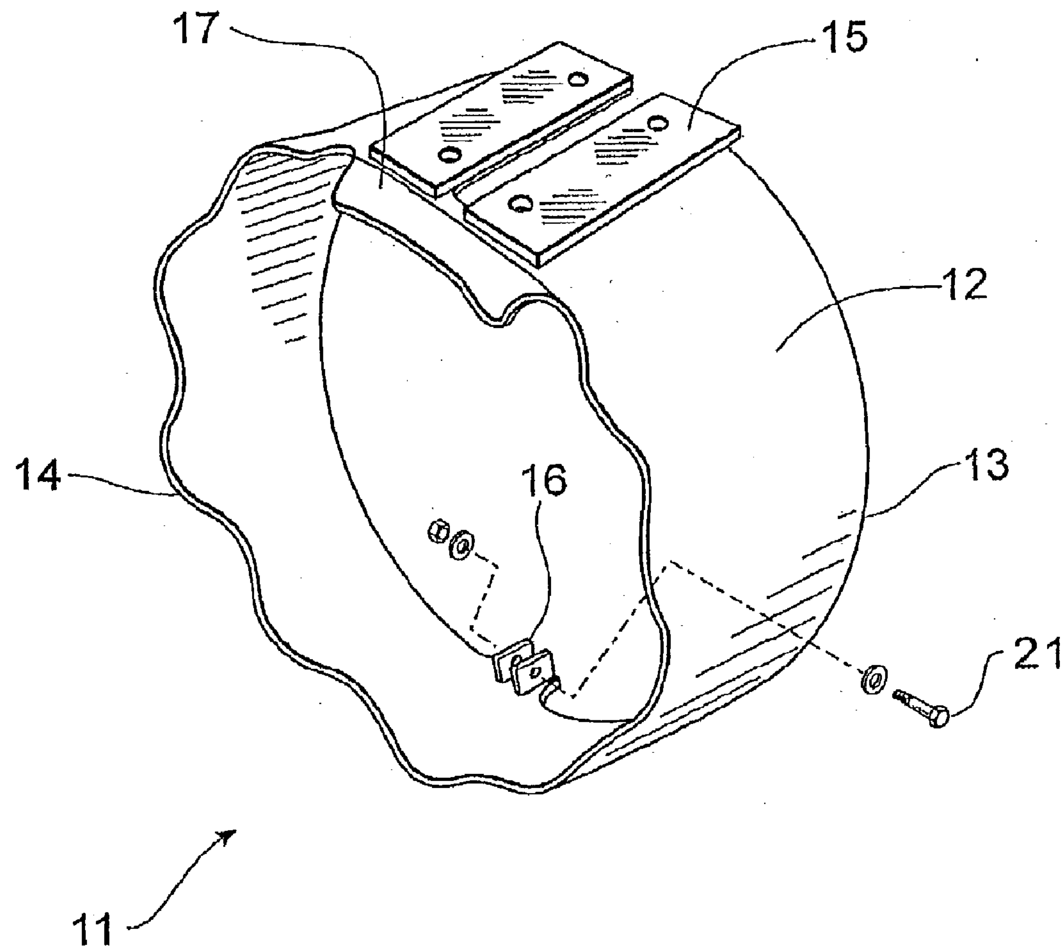


FIG. 1

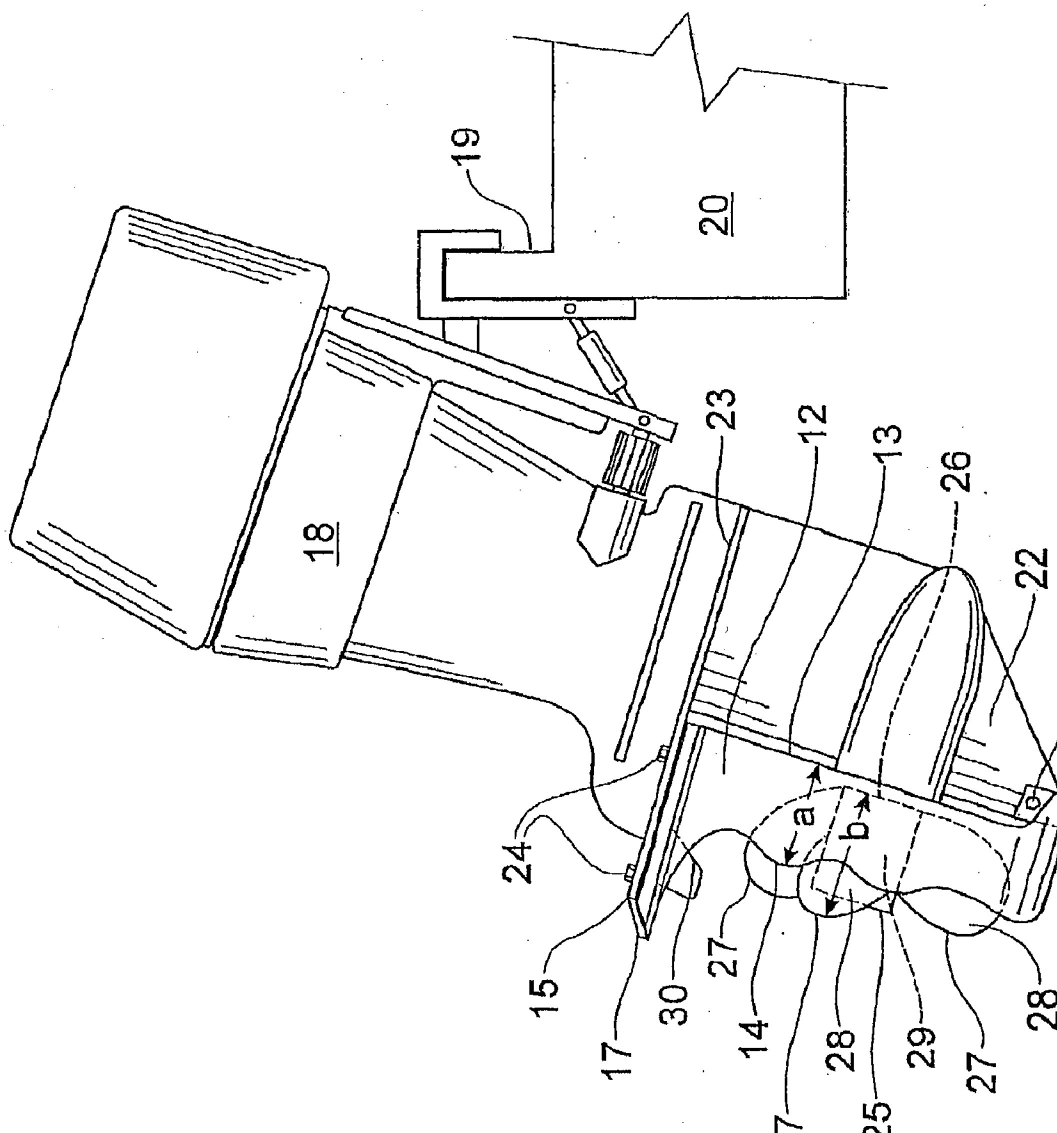


FIG. 2

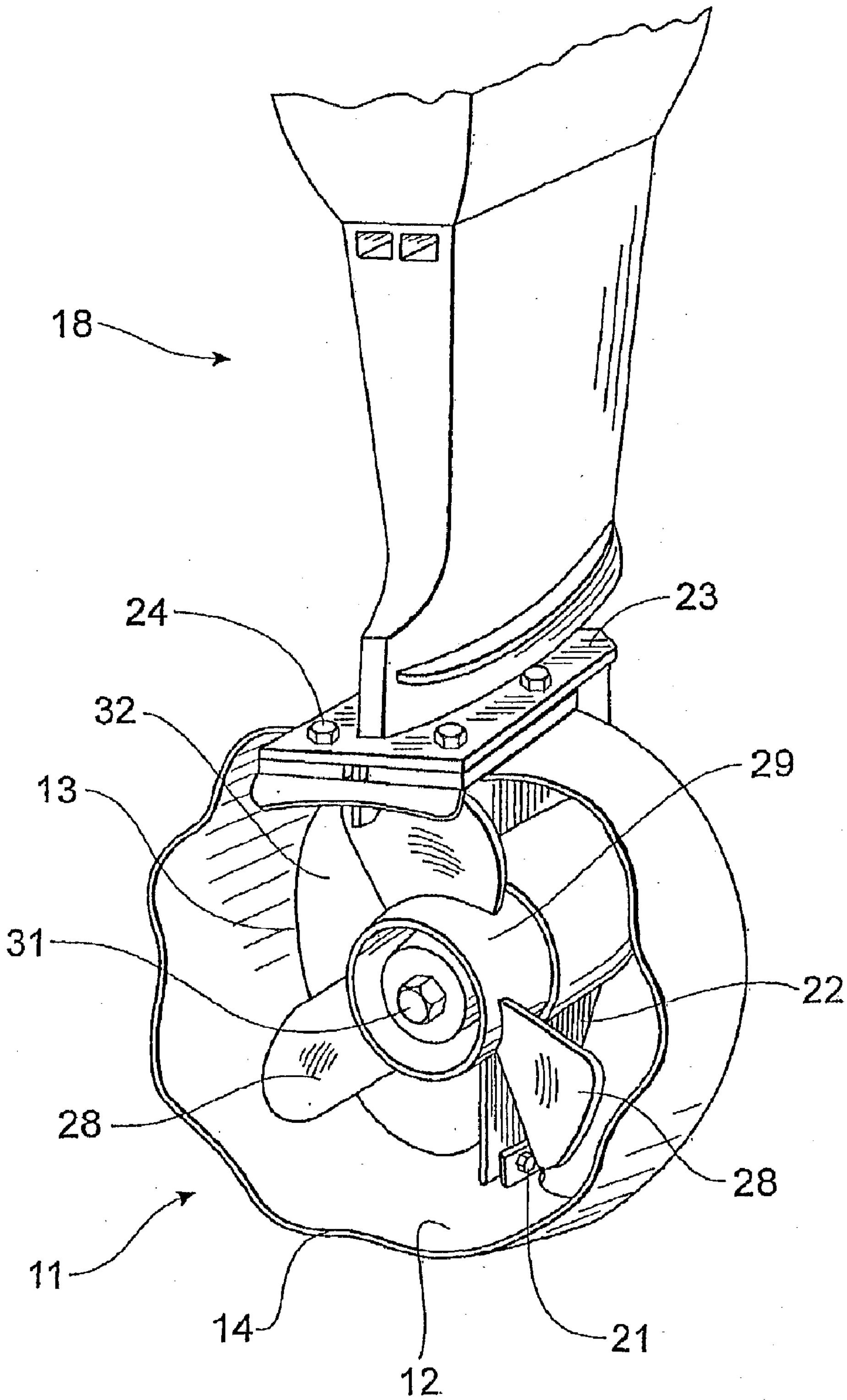


FIG. 3

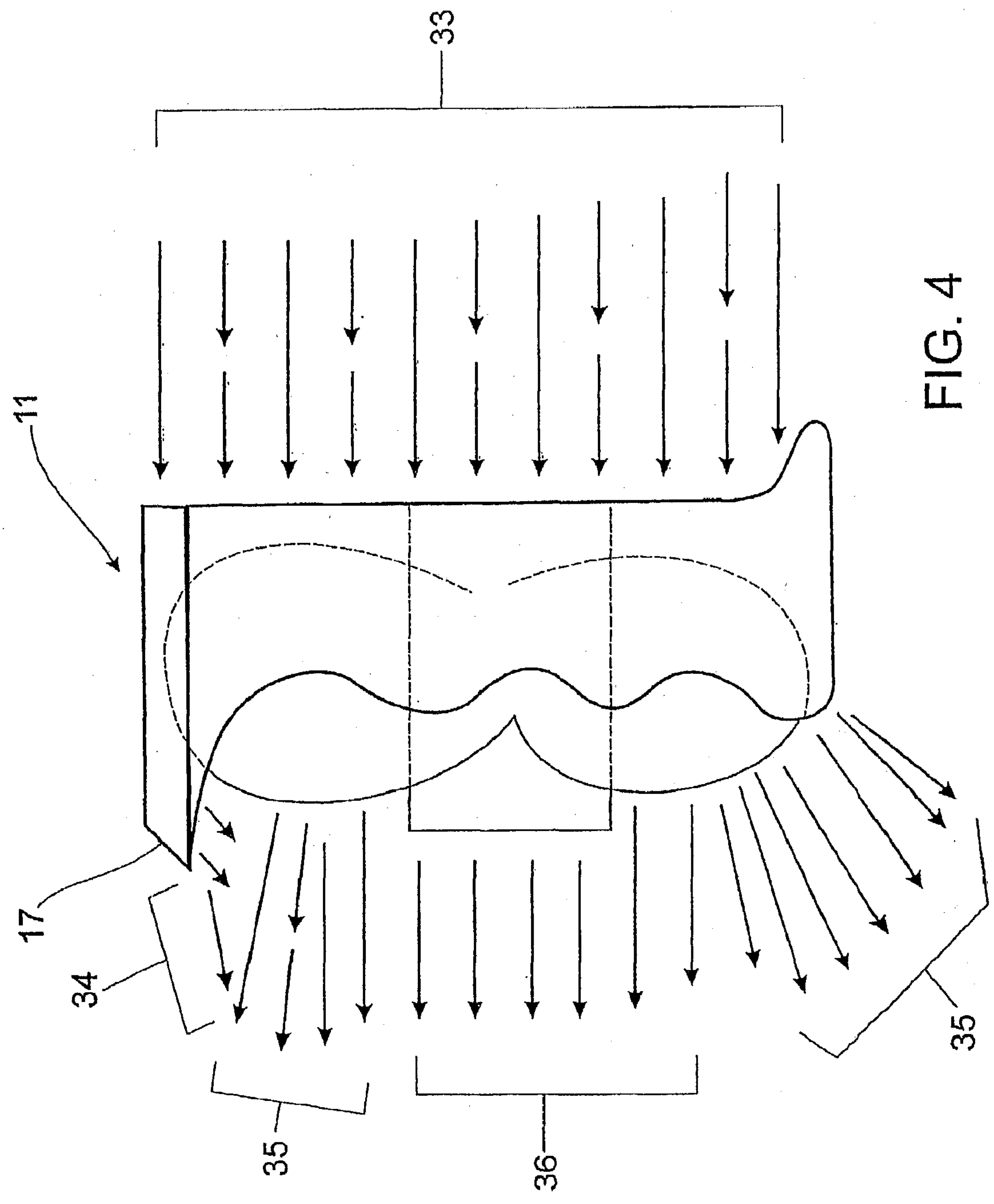


FIG. 4

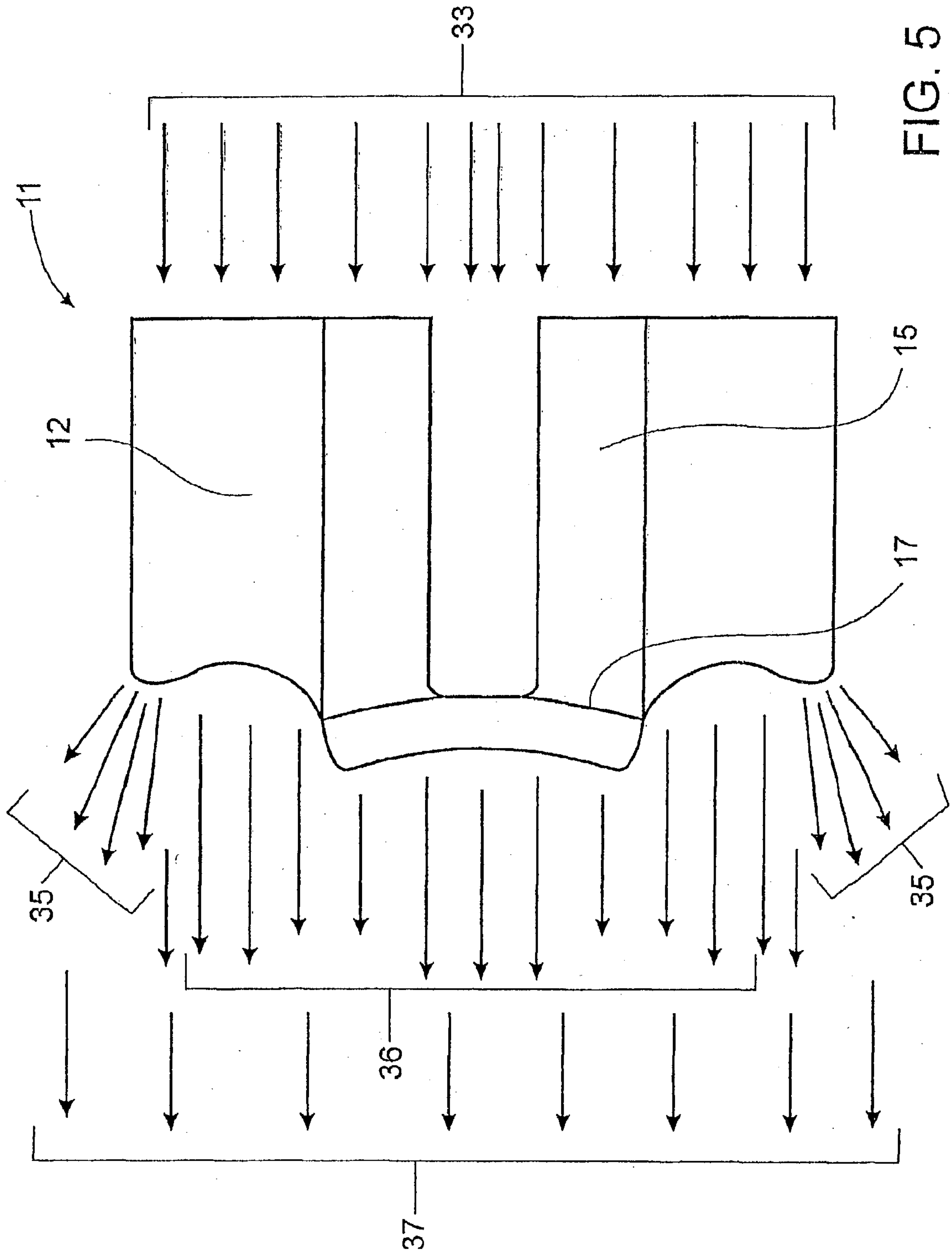


FIG. 5

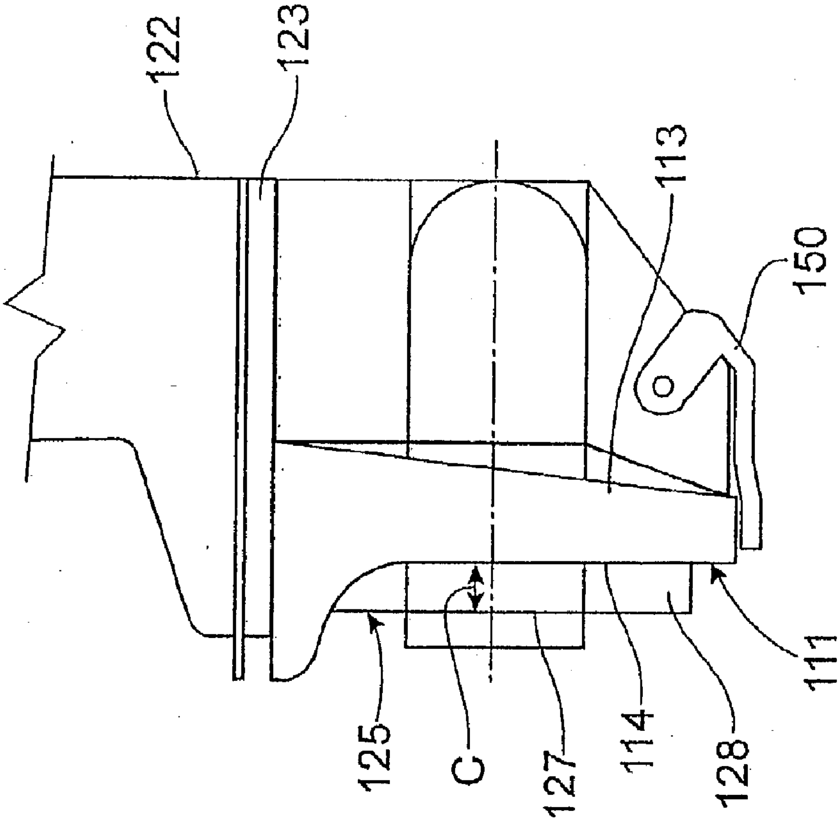


FIG. 7

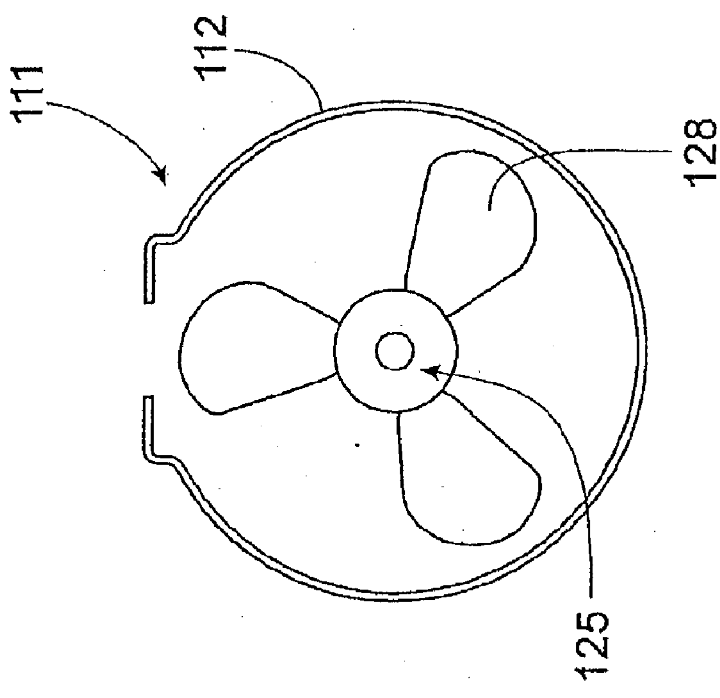


FIG. 6

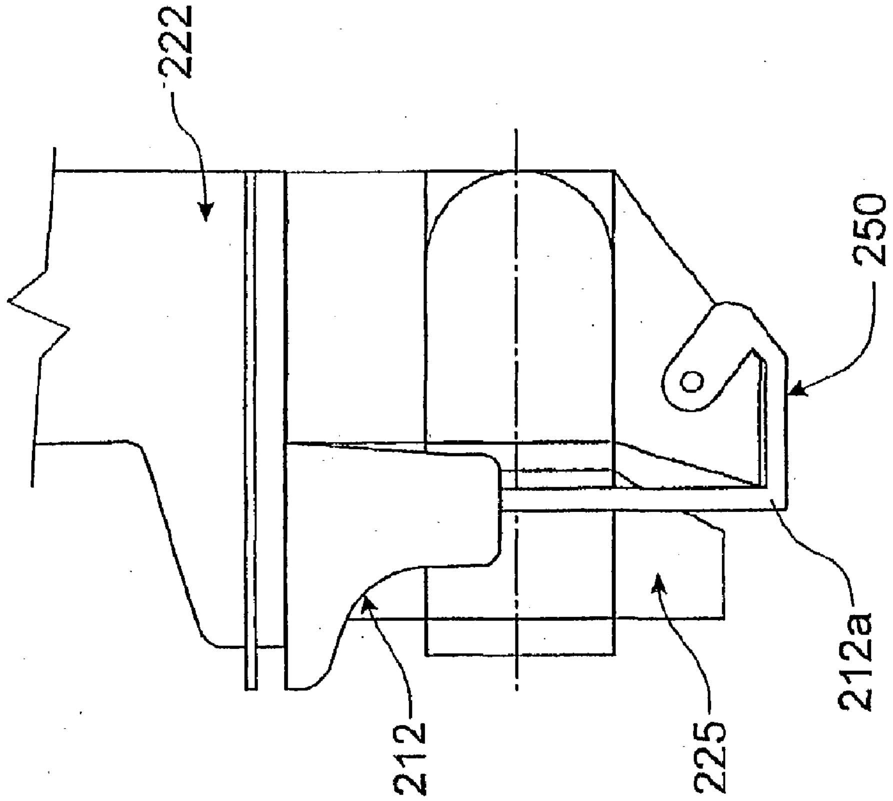


FIG. 9

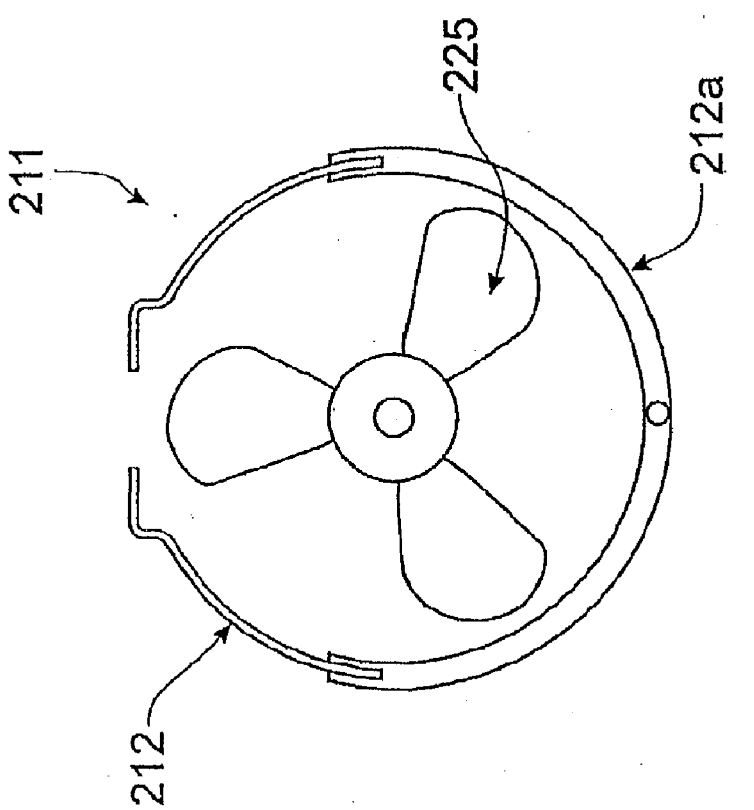


FIG. 8

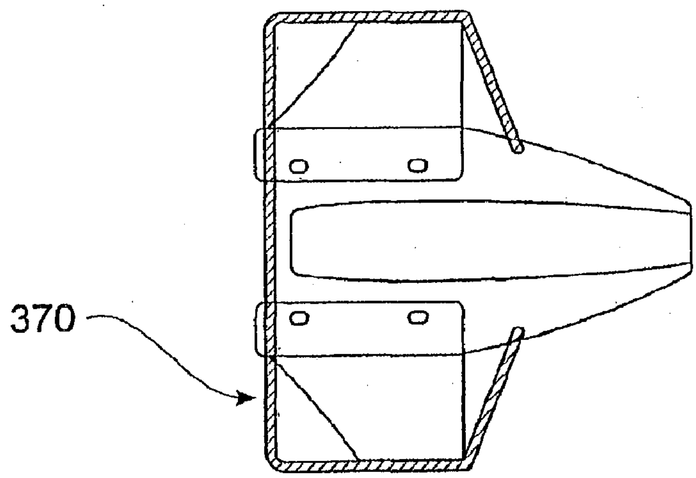


FIG. 12

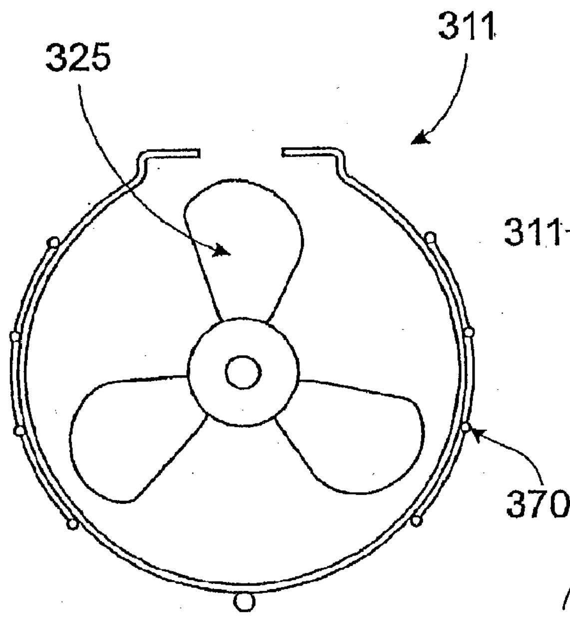


FIG. 10

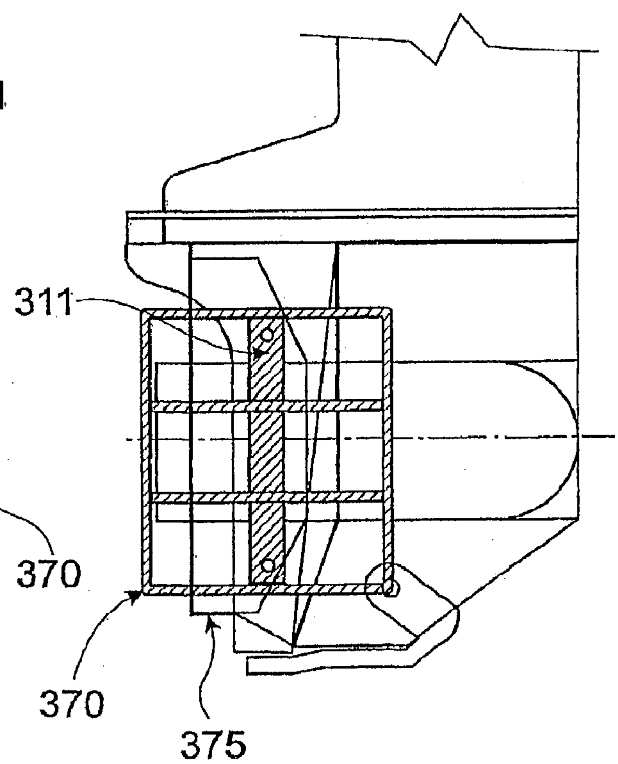


FIG. 11

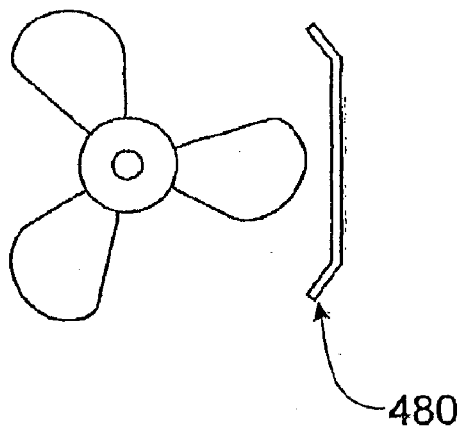


FIG. 13

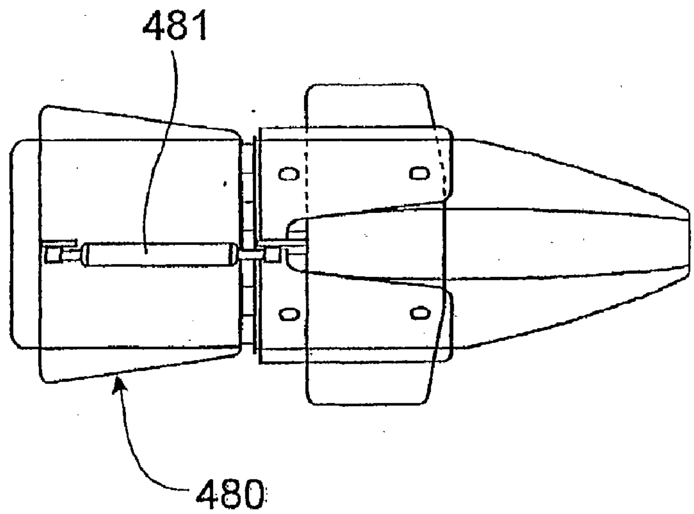


FIG. 15

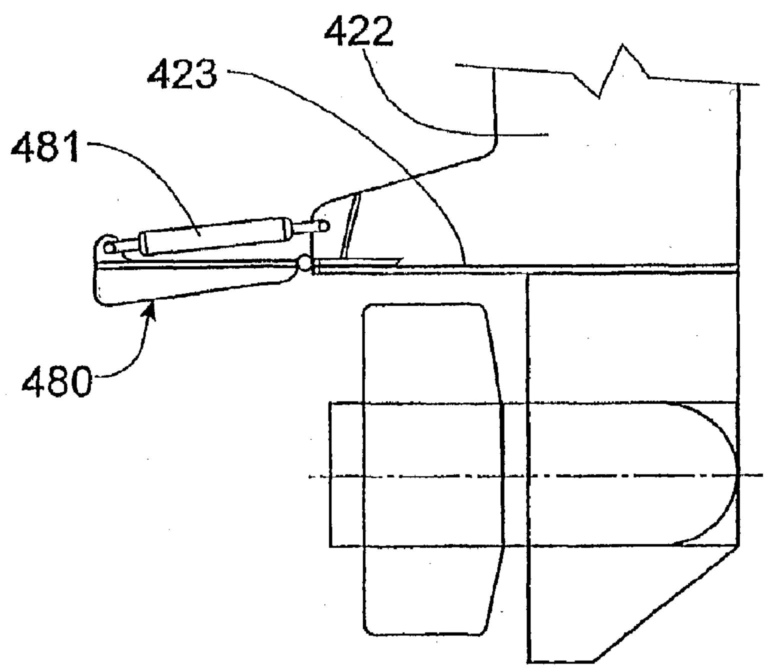


FIG. 14

ANTI-CAVITATION TUNNEL FOR MARINE PROPELLERS

FIELD OF THE INVENTION

[0001] THIS INVENTION relates to propellers for boats and, in particular, anti-cavitation devices to improve the efficiency of boat propellers.

BACKGROUND ART

[0002] Marine engineers and boat builders have devoted considerable energies to establishing principles for creating a range of propeller types for different tasks in vessels. In addition, various devices have been developed to enhance the efficiency of conversion from propeller rotation to thrust delivered to a vessel.

[0003] U.S. Pat. No 2,030,375 to Kort discloses a nozzle for location around a ship's propeller. This device, and similar, have become widely known as Kort nozzles and are suitable for use with screw driven ships to increase the propulsive efficiency of the propeller. However, this nozzle is primarily of use at low-revolution-speed of propellers and, in particular, in large vessels. The nozzle has proven particularly suitable for tug boats in providing maximal bollard pull and increased low speed thrust. When used on small fast moving vessels and particularly those propelled by outboard, a Kort nozzle may act as a drag when the vessel is planing or approaching maximum velocity.

[0004] U.S. Pat. No. 5,906,522 to Hooper discloses a thrust enhancer for marine propellers. The device includes a peripheral ring with an exhaust ring concentrically supported within the peripheral ring by a series of struts. The struts may further support individual blades. The aim of the device is to cause the propulsive force of a marine propeller to be channelled more generally towards a single rearward direction. It is a relatively complex piece of equipment.

[0005] An even more complex device is disclosed in U.S. Pat. No. 4,637,801 to Schultz for a thrust enhancing propeller duct assembly for watercraft. This duct has two coaxial cowlings which are staggered relative to each other. They are also nozzled to create a venturi effect. The invention is particularly directed to increasing the towing efficiency of watercraft at low speeds, particularly at periods of high slip, such as takeoff.

[0006] Other prior art devices are disclosed in (a) JP 58-126288A (MITSUI ZOSEN KK); (b) DE 4223570 C1 (SCHINEEKLUTH); and (c) JP 58-16981A (NIPPON KOKUM KK). JP 58-126288 A (MITSUI) provides a convergent ring (of aerofoil section) about a propeller with inclined tips to the vanes. DE 4223570 C1 (SCHNEEKLUTH) provides a ring "diffuser" (**4**) about the device shaft forwardly of, and of reduced diameter relative to, the propeller (**1**) JP 58-126288A (NIPPON) provides a convergent ring (**2**) about the propellor (**1**), the ring (**2**) having an aerofoil section, where respective aerofoil sections (**21, 22**) are separated by a slot.

[0007] The above devices are, in general, directed towards increased efficiency at low speed and vessel takeoff.

[0008] It would be of advantage to provide a thrust enhancing anti-cavitation tunnel that was effective at both low and high propeller revolution speeds. It would also be advantageous if such a device were relatively simple to manufacture and install.

[0009] It would also be advantageous if the device could protect the propellor against damage, eg., due to striking the sea/river bed, rocks, reefs, etc.; and/or to protect marine creatures against propeller strikes. Examples of such protective devices are disclosed in (a) EPO 433510 A1 (TABRAT); (b) U.S. Pat. No. 5,176,550 (HOOPER); (c) U.S. Pat. No. 2,983,246 (MANLEY); and (d) WO 93/17907 (TAYLOR).

OBJECT OF THE INVENTION

[0010] It is an object of the present invention to overcome or at least ameliorate one or more of the above disclosed deficiencies in the prior art.

[0011] Other preferred objects will become apparent from the following description.

SUMMARY OF THE INVENTION

[0012] In one form, although it need not be the only or indeed the broadest form, the invention lies in an anti-cavitation tunnel for a propeller of a watercraft, said anti-cavitation tunnel comprising:

> [0013] a cowling having a leading edge and a trailing edge;
>
> [0014] wherein the maximum distance between the leading edge and the trailing edge of the cowling is less than the maximum depth of a vane of the propeller.

[0015] In a further form, the invention resides in an anti-cavitation tunnel for use with a propeller of a watercraft, said anti-cavitation tunnel comprising:

> [0016] a cowling having a leading edge and a trailing edge; and
>
> [0017] attachment means for securing the cowling in an operating position in relation to the propeller;
>
> [0018] wherein the maximum distance between the leading edge and the trailing edge of the cowling is less than the maximum depth of a vane of the propeller.

[0019] Preferably, the cowling is non-convergent along its length and is of plain (ie., non-aerofoil) section.

[0020] The trailing edge may be planar or describe at least one rearward projection.

[0021] Preferably, the trailing edge may describe a series of continuous curved rearward projections. Preferably, the projections are in diametrically opposed pairs. The trailing edge may describe a continuous sine or wave pattern.

[0022] Preferably, the attachment means comprises at least one bracket engageable with an outboard motor. Suitably, the operating position is such that the leading edge of the cowling is located in the vicinity of a plane including an anterior surface of the propeller. The attachment means may be in the form of integral moulding. The attachment means may be plastic welding.

[0023] Most preferably, the leading edge is substantially located at, or rearwardly of, the plane including the anterior surface of the propeller.

[0024] Preferably, the maximum distance between the leading edge and the trailing edge of the cowling is in the range of ½ to ¾ of the depth of a vane of the propeller. Most preferably, the maximum distance between the leading and trailing edge is ⅔ of the depth of a vane of the propeller.

[0025] Preferably, the lower portion of the cowling encloses approximately one-half to three-quarters of the length of the propeller and an upper portion of the cowling encloses substantially all of the top of the propellor and tapers down to enclose approximately one-half to three-quarters of the propeller.

[0026] The anti-cavitation tunnel may further comprise a fin located in an upper region of the cowling.

[0027] The anti-cavitation tunnel may also comprise a transition zone between the trailing edge and an upper bracket.

[0028] In a further aspect, the invention resides in a method of improving the efficiency of a propeller of a watercraft, said method include the step of:

[0029] installing an anti-cavitation tunnel according to any one of the above described embodiments in an operative position in relation to the propeller.

[0030] The method may further include the step of installing the anti-cavitation tunnel so that a leading edge of the tunnel is substantially in the same plane as an anterior surface of the propeller.

[0031] In yet a further aspect, the invention may reside in a method of improving the efficiency of a propeller of a watercraft, said method including the step of:

[0032] locating an anti-cavitation tunnel so that it shrouds an anterior portion of the propeller and exposes a rearward portion of the propeller.

[0033] Preferably, the shrouded anterior portion is equal to or larger than the exposed rearward portion when calculated on the depth of the propeller.

[0034] Most preferably, the anterior portion is twice as large as the exposed rearward portion when calculated on the depth of a vane of the propeller.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] **FIG. 1** is a perspective view of a first embodiment of an anti-cavitation tunnel according to the present invention;

[0036] **FIG. 2** is a side view of the anti-cavitation tunnel of **FIG. 1** attached to an outboard motor;

[0037] **FIG. 3** is a perspective view of the anti-cavitation tunnel and outboard motor of **FIG. 2**;

[0038] **FIG. 4** is a schematic side view of the anti-cavitation tunnel of the present invention showing water flow during use;

[0039] **FIG. 5** is a schematic top view of the anti-cavitation tunnel of **FIG. 4** showing water flow during use;

[0040] **FIG. 6** is a rear view of a second embodiment of the anti-cavitation tunnel;

[0041] **FIG. 7** is a side view of the anti-cavitation tunnel of **FIG. 6** attached to an outboard motor;

[0042] **FIG. 8** is a rear view of a third embodiment of the anti-cavitation tunnel;

[0043] **FIG. 9** is a side view of the anti-cavitation tunnel attached to an outboard motor;

[0044] **FIG. 10** is a rear view of a fourth embodiment of the anti-cavitation tunnel;

[0045] **FIGS. 11 and 12** are respective side and top plan views of the anti-cavitation tunnel of **FIG. 10** attached to an outboard motor;

[0046] **FIG. 13** is a rear view of an adjustable fin which may be used with the anti-cavitation tunnels of FIGS. **1** to **12**;

[0047] **FIGS. 14 and 15** are respective side and top plan views of the adjustable fin of **FIG. 13** attached to an outboard motor.

DETAILED DESCRIPTION OF THE DRAWINGS

[0048] Referring to **FIG. 1**, there is shown a first embodiment of the anti-cavitation tunnel **11** comprising a substantially circular cowling **12** with a leading edge **13** and trailing edge **14**. The cowling **11** is non-convergent along its length and is of plain (ie., non-aerofoil) section. The cowling **12** has an upper attachment bracket **15** and lower attachment bracket **16**. The anti-cavitation tunnel **11** also includes a fin **17** located just aft of upper attachment bracket **15** in an upper region of the cowling **12**.

[0049] Referring to **FIG. 2**, there is shown the anti-cavitation tunnel **11** affixed to an outboard motor **18** which, in turn, is attached to the stern **19** of a boat **20**.

[0050] The anti-cavitation tunnel **11** is attached by a bolt **21** passing through an aperture in lower attachment bracket **16** and through the guide skeg **22**. The anti-cavitation tunnel **11** is also attached to the cavitation plate **23** of the outboard motor **18** by bolts **24** passing through apertures drilled in the cavitation plate **23** and into upper attachment bracket **15**. As can be seen in this view and importantly for the invention, the cowling **12** does not completely cover the propellor **25** in a fore and aft direction. The leading edge **13** is located level with or around a plane including the propellor leading edge or anterior surface **26**. The trailing edge **14**, however, is forward of the rearmost points **27** of the propellor vanes **28**.

[0051] The attachment means may be any suitable means known to a skilled addressee. For example, the cowling **12** may be integrally moulded with the outer casing of the outboard leg. Alternatively, plastic welding may be used to attach the cowling. A frame may be used to hold the cowling **11** in position relative to the propellor **25**. the cowling may be formed or continuous with any appropriate surrounding structure, for example, the hull of a vessel with a fixed propellor.

[0052] The propellor vanes **28** are supported by a central hub **29** which, in turn, is engaged with a drive shaft (not shown).

[0053] The maximum distance between the leading edge 13 of a cowling and the trailing edge 14 of the cowling is the distance "a". The maximum length of the propellor vanes 28 is "b" which is a fore and aft measurement of a vane of the propellor. The inventor has discovered that, importantly, the distance "a" must be less than the distance "b" for the anti-cavitation tunnel to work effectively. Preferably, "a" is in the range of ½ to ¾ of "b". Most preferably, "a" is in the range of ½ to ⅔ of "b".

[0054] Typically, the radial clearance between the cowling 12 and the blades 28 of the propellor 25 (for an outboard motor in the 10-140 HP range) will be in the range of 10-30 mm.

[0055] The scalloped trailing edge 14 is shown as a regular sinusoidal curve around the edge. The trailing edge 14 may, in fact, have just a single rearward projection rather than multiple projections as shown. Preferably, however, there are at least two rearward projections creating a curved trailing edge and those projections are ideally located to balance the action of the cowling. A plurality of projections, as shown, may be used wherein the projections are arranged in diametrically opposed pairs, thereby creating balance in the function of the anti-cavitation tunnel 11. Although a regular curve is shown, it is clear to a skilled addressee that other geometric shapes will be suitable for the function of the anti-cavitation tunnel and any suitable configuration may be adopted including shapes that are angular. It is also clear to a skilled addressee that, in fact, the trailing edge 14 may be an even edge substantially parallel to leading edge 13 giving a ring effect to the cowling 12.

[0056] This view also shows an upward arc 30 of cowling 12 to meet upper attachment bracket 15, thereby forming a transition zone between cowling 12 and bracket 15. This feature provides an additional advantage in that it creates lift during water flow through anti-cavitation tunnel 11 which increases the efficiency of thrust delivery by the outboard motor 18 leading to the boat 20 rising onto the plane quicker and more efficiently. This action is enhanced by the presence of fin 17 which projects into the water flow through the cowling 12 and further increases the provision of lift to the motor 18 and efficiency of planing of the boat 20.

[0057] Referring to FIG. 3, there is shown a perspective view of anti-cavitation tunnel 11 of the invention located on an outboard motor. The cowling 12 is attached via bolt 21 and upper bolts 24 to the skeg 22 and cavitation plate 23, respectively. The propeller vanes 28 are attached to central hub 29 which, in turn, is attached to a drive shaft (not shown) by retention nut 31. Leading edge 13 describes an intake opening 32 through which water enters in use.

[0058] Referring to FIG. 4, there is shown a schematic vector diagram for water flow through the anti-cavitation tunnel 11 when viewed from the side. As the boat, motor and anti-cavitation tunnel 11 pass through the water, water flows in the direction of the intake arrows 33. The flow around fin 17 is shown by the arrows at 34 with a resultant lift to the anti-cavitation tunnel 11 and outboard motor. Circular, angular lateral propulsion is provided by the flow from arrows at 35, whereas outward rear lower propulsion is provided by arrows as shown at 36.

[0059] A further flow schematic is seen in top view in FIG. 5. Again, intake arrows are seen at 33. Circular angular lateral propulsion is seen at 35. Outward lower rear propulsion is shown as 36. An improved outward higher rear propulsion is shown at 37 formed by the combined circular angular lateral propulsion and outward rear lower propulsion. The invention may use the lateral forces to gain efficiency in a forward motion. By maximising the lateral forces to increase efficiency, the anti-cavitation tunnel is intended to channel the lateral thrust towards the rear of the propeller. This concentrates the lateral forces to the rear of the propeller but also requires a balancing percentage of the propeller to remain partially exposed, as this allows a more effective flow of lateral thrust.

[0060] A pulsing action is created by the wave effect or scalloped shape of the trailing edge 14 of the cowling 12. It is believed this uses the maximum lateral force to create a pulsing effect which improves the lateral propulsion and helps to improve performance. As noted above, however, the cowling may be produced without the wave effect on the trailing edge. A smaller percentage of exposed propeller to a larger frontward percentage enclosed by the cowling is preferred.

[0061] Referring now to FIGS. 6 and 7, the anti-cavitation tunnel 111, again of non-convergent, plain (ie., non-aerofoil) section, has a leading edges 113 which is inclined at any angle in the range of 5° to 15° to the vertical (taken as a plane perpendicular to the axis of rotation of propellor 125); while the trailing edge 114 is substantially vertical but spaced forwardly of, the rearmost points 127 of the vanes of the propellor 125. The cowling 112 is attached to the cavitation plate 125. The cowling 112 is attached to the cavitation plate 123 of the guide skeg 122 by four fasteners (not shown) and to the lower end of the skeg 122 by a lower skeg bracket 150.

[0062] The inclined leading edge 113 provides improved acceleration characteristics as the angle of inclination allows efficient intake flow of the water through the tunnel 111 due to the natural tilt position of the boat in the water. The angle in conjunction with the tilt position reduces drag or resistance.

[0063] The trailing edge 114 is preferably spaced a distance C forwardly of the rearmost parts of the propellor 1256, where C is preferably ¼ to ½ of b, ie., approximately one-quarter to one-half of the lower portion of the propellor 125 is exposed. As shown in FIG. 7, the cowling 112 is configured to cover all of the top of the propellor 125 and then cascades down to cover one-half to three-quarters of the propellor 125 in the upper half (ie., one-quarter to one-half of the propellor 125 is exposed).

[0064] It has been found by experimentation that the two cascading surface areas described above (and illustrated in FIG. 7) maximises the internal forces. The use of the two specific areas has shown the pressurisation of two separate surface areas decreases cavitation by a large percentage.

[0065] Because of the partial exposure of the propellor, and due to the cascading surface areas, there is little, or no, loss of top speed. Using the larger cascading surface area at the top of the cowling 12 produces an unevenly distributed directional flow and also produces an effective and instantaneous lift of the boat onto the plane.

[0066] For larger boats (eg., working boats) pushing heavier work loads, the cowling 212 of the anti-cavitation tunnel **211** of **FIGS. 8 and 9** extends only over the upper portion of the propellor **225**, the lower portion being surrounded by a (stainless steel)rod **212***a,* attached to the skeg by a lower skeg bracket **250**.

[**0067**] The rod **212***a* protects the propellor **225** against heavy impacts.

[**0068**] The cowling **212** with its cascading surface area, provides improved performance over a propeller without the tunnel **211**, including improved timing ability.

[**0069**] FIGS. **10** to **12** show a fourth embodiment of the anti-cavitation tunnel **311**, which is protected by a cage **370** which totally protects the tunnel **311** (and propeller **325**) without diminishing the performance advantages provided by the tunnel **311**.

[**0070**] The performance of the boat, fitted with any one of the anti-cavitation tunnels hereinbefore described, can be further improved by the fitting of an adjustable fin **480**, hingedly mounted at the rear of the cavitation plate **423** on the skeg **422** and adjustable manually (via a turnbuckle) or mechanically (via a pneumatic or hydraulic ram **481**). The fin **480** co-operates with the tunnel to improve lift generated by the propellor.

[**0071**] The anti-cavitation tunnel may be manufactured in any suitable material, including stainless steel, aluminium or high density plastic.

[**0072**] The inventor has found that the anti-cavitation tunnel increases the performance of marine craft, including increasing the thrust and fuel efficiency of the drive system and decreasing cavitation around the propeller (eg., enabling a 70 HP motor to provide the same thrust as a standard 90 HP motor without the tunnel). The invention has also provided increased stability in steering and, due to the channelling of the water, appears to quieten the exhaust note of an outboard motor.

[**0073**] The top end speed of a boat may also be increased and the vessel will have better turning characteristics when the device is used with an outboard motor.

[**0074**] No reduction in reversing characteristics has been noted in testing.

[**0075**] Although the invention has been primarily described in relation to an outboard motor, it is clear to a skilled addressee that the device may be applied to other forms of propeller drive systems, such as inboard motors with drive shafts connected to an external propeller.

[**0076**] Rubber gaskets may be used in the attachment of the invention to a motor to prevent water leakage into bolt holes and also minimise the effects of vibration.

[**0077**] In a further embodiment, the cowling of the anti-cavitation tunnel may be formed by a truncated cylinder with a leading edge perpendicular to its longitudinal access and a trailing edge angled to that axis having the widest portion of the cowling at the bottom of the cowling.

[**0078**] Throughout this specification, the aim has been to describe the preferred embodiments of the invention without limiting the invention to any one embodiment or specific collection of features.

1. (amended) an anti-cavitation tunnel for a propellor of a watercraft, said anti-cavitation tunnel comprising:

a cowling, non-convergent along its length and of plain (non-aerofoil) section, having a leading edge and a trailing edge wherein the leading edge of the cowling is substantially located in, or rearwardly of, the plane including the anterior surface of the propellor, the trailing edge of the cowling is substantially located in, or forwardly of, the plane including the posterior surface of the propellor, and the maximum distance between the leading edge and the trailing edge of the cowling is less than the maximum fore and aft length of a vane of the propellor.

2. (Amended) An anti-cavitation tunnel for use with a propellor of a watercraft, said anti-cavitation tunnel comprising:

a cowling, non-convergent along its length and of plain (non-aerofoil) section, having a leading edge and a trailing edge; and

attachment means for securing the cowling in an operating position in relation to the propellor;

wherein the leading edge of the cowling is substantially located in, or rearwardly of, the plane including the anterior surface of the propellor, the trailing edge of the cowling is substantially located in, or forwardly of, the plane including the posterior surface of the propellor, and the maximum distance between the leading edge and the trailing edge of the cowling is less than the maximum fore and aft length of a vane of the propellor.

3. (Amended) A tunnel as claimed in claim 1 or claim 2 wherein:

the trailing edge is planar or describes at least one rearward projection.

4. (Amended) A tunnel as claimed in claim 3 wherein:

the trailing edge describes a series of continuous curved rearward projections, the projections being in diametrically opposed pairs.

5. (Amended) A tunnel as claimed in claim 2 wherein:

the attachment means comprises at least one bracket engageable with an outboard motor.

6. (Amended) A tunnel as claimed in claim 1 or claim 2 wherein:

the maximum distance between the leading edge and the trailing edge of the cowling is in the range of ½ to ¾ of the length of a vane of the propellor.

7. (Amended) A tunnel as claimed in claim 6 wherein:

the maximum distance between the leading and trailing edge is ⅔ of the length of a vane of the propellor.

8. (Amended) A tunnel as claimed in claim 6 or claim 7 wherein:

the lower portion of the cowling encloses approximately one-half to three-quarters of the length of the propellor and an upper portion of the cowling encloses substantially all of the top of the propellor and tapers down to enclose approximately one-half to three-quarters of the propellor.

9. (Amended) A tunnel as claimed in any one of claims 1 to 8, and further comprising a fin located in an upper region of the cowling.

10. (Amended) A tunnel as claimed in any one of claims 1 to 9, and further comprising a transition zone between the trailing edge and an upper bracket.

11. (Amended) A method of improving the efficiency of a propellor of a watercraft, said method including the steps of:

installing an anti-cavitation tunnel according to any one of claims 1 to 10 in an operative position in relation to the propellor.

12. (Amended) A method of improving the efficiency of a propellor of a watercraft, said method including the steps of:

locating an anti-cavitation tunnel as claimed in any one of claims 1 to 10 so that it shrouds an anterior portion of the propellor and exposes a rearward portion of the propellor.

13. (Amended) A method as claimed in claim 12 wherein:

the shrouded anterior portion is equal to or larger than the exposed rearward portion when calculated on the depth of the propellor.

14. (Amended) A method as claimed in claim 13 wherein:

the anterior portion is twice as large as the exposed rearward portion when calculated on the depth of a vane of the propellor.

15. (New) An anti-cavitation tunnel for a propellor of a watercraft, said anti-cavitation tunnel comprising:

a cowling, non-convergent along its length and of plain (non-aerofoil) section, having a leading edge and a trailing edge wherein the leading edge of the cowling is substantially located in, or rearwardly of, the plane including the anterior surface of the propellor and the maximum distance between the leading edge and the trailing edge of the cowling is less than the maximum fore and aft length of a vane of the propellor; wherein:

the lower portion of the cowling encloses approximately one-half to three-quarters of the length of the propellor and an upper portion of the cowling encloses substantially all of the top of the propellor and tapers down to enclose approximately one-half to three-quarters of the propellor.

16. (New) An anti-cavitation tunnel for use with a propellor of a watercraft, said anti-cavitation tunnel comprising:

a cowling, non-convergent along its length and of plain (non-aerofoil) section, having a leading edge and a trailing edge; and

attachment means for securing the cowling in an operating position in relation to the propellor;

wherein the leading edge of the cowling is substantially located in, or rearwardly of, the plane including the anterior surface of the propellor, and the maximum distance between the leading edge and the trailing edge of the cowling is less than the maximum fore and aft length of a vane of the propellor; and wherein:

the lower portion of the cowling encloses approximately one-half to three-quarters of the length of the propellor and an upper portion of the cowling encloses substantially all of the top of the propellor and tapers down to enclose approximately one-half to three-quarters of the propellor.

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