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[Continued on next page]

(54) Title: MARINE PROPELLER BLADES WITH REVERSE CUPPING

(57) Abstract: A propeller (10) has a plurality of blades (12, 14, 16) extending radially outwardly of a hub (18) and a plurality of cups (32, 36, 40) respectively affixed to the plurality of blades. Each of the plurality of blades has a facing surface and a back surface. The blade has a leading edge and a trailing edge. The cup is affixed to the back surface of the blade in spaced relation to the trailing edge and in spaced relation to the outer edge. The cup is affixed to a greatest thickness of the blade. The cup has a curvature corresponding to a curvature of the blade. The blade is positioned at approximately 2/3 of a width dimension from the leading edge.

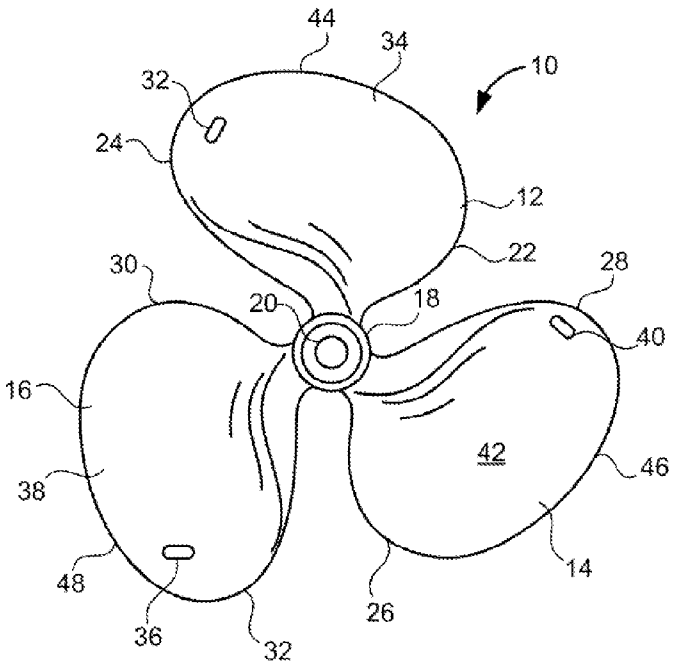

FIG. 1

WO 2016/069709 A1

Published:

— *with international search report (Art. 21(3))*

MARINE PROPELLER BLADES WITH REVERSE CUPPING

FIELD OF THE INVENTION

[0001]The present invention relates to marine propellers. More particularly, the present invention relates to marine propellers wherein the power is enhanced when the propeller is rotated in a reverse direction. The present invention also relates to reverse cupping as applied to marine propeller blades.

BACKGROUND OF THE INVENTION

[0002]A propeller is the most common propulsor on ships and boats. Propellers serve to impart momentum to a fluid which causes force to act on the ship. The ideal efficiency of any size propeller is that of an actuator disk in an ideal fluid. An actual marine propeller is made up of sections of helicoidal surfaces which act together so as to "screw" through the water. Three, four or five blades are the most common in marine propellers, although designs which are intended to operate at reduced noise will have more blades. The blades are attached to a hub. With fixed pitch propellers, the blades and the hub are usually part of a single casting.

[0003] Cavitation is the formation of vapor bubbles in water nearing a moving propeller blade in regions of low pressure due to Bernoulli's principle. It can occur if an attempt is made to transmit too much power or if the propeller is operating at a very high speed. Cavitation can waste power, create vibration and wear, and cause damage to the propeller. It can occur in many ways on a propeller. The two most common types of propeller cavitation are suction side surface cavitation and tip vortex cavitation.

[0004] Suction side cavitation forms when the propellers operating at high rotational speeds are under heavy load. The pressure on the upstream surface of the blade can drop below the vapor pressure of the water, resulting in the formation of a vapor pocket. Under such conditions, the change in pressure between the downstream surface of the blade and the suction side is limited, and eventually reduced as cavitation is increased. When most of the blade surface is covered by cavitation, the pressure difference between the pressure side and the suction side of the blade drops considerably, as does the thrust produced by the propeller. Operating the propeller under these conditions wastes energy, generates considerable noise, and as the water bubbles collapse it rapidly erodes the screw's surface due to localize shockwaves against the blade surface.

[0005] One of the problems which is frequently encountered in operating a marine vehicle in reverse results from cavitation of the water at the trailing face of each blade on the propeller. As the

submerged propeller is rotated in water, the water accelerates around the edges of each blade, causing a reduction in water pressure at the trailing face of the blade until the pressure of the water eventually reaches the vapor pressure of the water. Consequently, cavitation occurs at the trailing face of the blade as the water vaporizes in small bubbles of air form in the water. Cavitation of the water at the trailing face of each blade when the vehicle is operated in reverse typically results in vibration of the propeller and may compromise the reverse thrust capability of the marine vehicle.

[0006] In certain marine applications, such as in tugboats, the propellers are inefficiently adapted for reverse operation. Many tugboats are utilized to transport barges of a considerable length and a considerable weight. As such, when it is desired to slow or stop the movement of the barges, the propellers of the tugboat are reversed so as to eventually slow the tugboat and the associated barges. Unfortunately, the slowing or stopping of the tugboat may take an extreme distance (up to one mile) because of the inefficiency caused as a result of the reverse operation of the propeller. As such, a need has developed to improve the efficiency of the propeller when in the reverse direction. There is also a need to provide such reverse efficiency for the stopping of large loads transported or moved by tugboats.

[0007] In the past, various patents have issued relating to marine propellers. For example, U.S. Patent No. 1,623,868, issued on April 5, 1927 to J. Fischer, describes a marine propeller that has a hub with blades radiating therefrom. Each blade has leading and trailing faces. The transverse curvature of the trailing face is greater than that of the leading face from a point inwardly of the leading edge of the blade to point inwardly from the trailing edge thereof. The blade is provided along its trailing edge with a transversely curved fin of gradually decreasing width from its inner to its outer end and merging at its outer end with the margin of the leading face of the blade near the tip of the blade. The free margin of the fin over hangs the leading face for a major distance of the length.

[0008] U.S. Patent No. 3,033,293, issued on May 8, 1962 to O. L. Bihlmire, discloses a boat propeller that includes a nylon base material. The blades include a plurality of reinforcing ribs extending on the forward surface of each blade. The rear surface is smooth and unobstructed.

[0009] U.S. Patent No. 4,778,419, issued on October 18, 1988 to Bolle et al., discloses a reversed thrust propeller that includes a propeller shaft, a lower unit rotatably supporting the propeller shaft,

and a propeller adapted to be submerged in water and including an inner hub connected to the propeller shaft. The propeller includes an outer hub connected to and spaced from the inner hub so as to define a propeller exhaust passageway having an inlet in communication with the lower unit exhaust passageway. A plurality of blades extend from the outer hub rearwardly of the inlet.

[0010] U.S. Patent No. 5,470,263, issued on November 28, 1995 to Griffiths et al., teaches a marine drive that has a reverse thrust cup on the propeller shaft between the propeller hub and the rear retaining nut. The reverse thrust cup permits the propeller hub to slide on the propeller shaft fore and aft. When the marine dive is in the forward direction, the rearward thrust of the propeller forces the propeller hub to the forward position thereby directing engine exhaust out of the rear of the propeller hub. When the marine drive is in the reverse direction, the forward thrust created by the propeller hub forces the propeller hub to the rearward position thereby directing exhaust out a forward exhaust opening forward of the propeller blade so as to increase the reverse thrust of the marine drive.

[0011] U.S. Patent No. 5,791,874, issued on August 11, 1998 to W. P. Lang, describes a marine propeller including a hub rotatable about a longitudinal axis and having a plurality of blades extending outwardly from the hub. Each of the propeller blades includes a fixed propeller blade stem and a removable cup extension. The cup extension defines the trailing edge of each propeller blade and is removably mounted to the propeller blades stem. The cup extensions can be selectively removed from the blade stands and new cup extensions attached in order to modify the amount of cupping included on the propeller.

[0012] U.S. Patent No. 6,390,776, issued on May 21, 2002 to D. Gruenwald, shows a marine propeller with increased performance in reverse. The marine propeller has a hub and a multiplicity of blades extending radially outwardly. A portion of the trailing edges of some or all of the blades are modified the lessen interference between blades and increase the bite of those blades when operated in reverse.

[0013] U.S. Patent No. 7,637,722, issued on December 29, 2009 to Koepsel et al., teaches a marine propeller that is provided with three blades. The blades have a skew angle of approximately 33° and a break angle of approximately 28.5°. A blade area ratio is provided of approximately 60°. The rake is progressive. Each of the blades is tail-loaded.

[0014] U.S. Patent No. 8,636,469, issued on January 28, 2014 to C. S. Powers, shows a marine

propeller with a reverse thrust cup. The marine propeller includes a propeller hub, and propeller blades each having a leading blade face and a trailing blade face provided on the propeller hub. A reverse thrust cup is provided in the trailing blade face of each of the propeller blades.

[0015] It is an object of the present invention to provide a marine propeller that has reverse thrust cupping.

[0016] It is another object of the present invention provide a marine propeller that enhances power when the propeller is operating in the reverse direction.

[0017] It is another object of the present invention to provide a marine propeller that enhances efficiency and reduces fuel consumption when in the reverse direction.

[0018] It is another object of the present invention to provide a marine propeller that is easy to manufacture, easy to use and relatively inexpensive.

[0019] These and other objects and advantages of the present invention will become apparent from a reading of the attached specification and appended claims.

BRIEF SUMMARY OF THE INVENTION

[0020] The present invention is a marine propeller apparatus that includes a blade having a facing surface and a back surface. The blade has a leading edge and a trailing edge, along with an outer edge. A cup is affixed to the back surface of the blade. The cup is in spaced relation to the trailing edge and in spaced relation to the outer edge.

[0021] In the present invention, the blade has a variable thickness between the leading edge and the trailing edge. The blade has a greatest thickness in an area between the leading edge and the trailing edge. The cup is affixed to the blade at this greatest thickness. The cup has a curvature corresponding to a curvature of the blade. The cup is positioned in an area corresponding to 80 to 90% of the radius of the blade. The cup is also positioned in a location corresponding to 2/3 of the width dimension of the blade. In particular, the cup is positioned approximately 2/3 of the width dimension from the leading edge. The cup will extend outwardly of the back surface of the blade for distance between 3/8 inch and 1/2 inch.

[0022] In the present invention, the blade is rotatable in a forward direction and a rearward direction. As used herein, the leading edge is the leading edge of the blade when the blade is rotated in the rearward direction. The cup can also be mechanically affixed, such as by bolting, to the blade. The

cup is a generally longitudinal member. In the preferred embodiment the present invention, the cup has a generally curved outer surface.

[0023] In the present invention, the marine propeller includes a plurality of blades that extend radially outwardly of the hub. A plurality of cups, of the type described hereinabove, are respectively affixed to the plurality of blades.

[0024] This foregoing Section is intended to describe, with particularity, the preferred embodiments of the present invention. It is understood that modifications to this preferred embodiments can be made within the scope of the present invention. As such, this Section should not to be construed, in any way, as limiting of the broad scope of the present invention. The present invention should only be limited by the following claims and their legal equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIGURE 1 is rearward view of the marine propeller in accordance with the preferred embodiment of the present invention.

[0026] FIGURE 2 is a side elevational view of the marine propeller in accordance with the preferred embodiment of the present invention.

[0027] FIGURE 3 is a cross-sectional view of the blade of the marine propeller of the present invention.

[0028] FIGURE 4 is a cross-sectional view of the blade of the marine propeller the present invention showing an alternative technique for the attachment of the cup.

[0029] FIGURE 5 is an isolated view of a single blade of the marine propeller of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0030] Referring to FIGURE 1, there is shown the marine propeller 10 in accordance with the preferred embodiment of the present invention. The marine propeller 10 includes a first blade 12, a second blade 14 and a third blade 16. Blades 12, 14 and 16 are arranged so as to extend outwardly of a hub 18. The hub 18 includes an interior 20 suitable for securing the propeller 10 to the shaft of a marine vessel, such as a tugboat. FIGURE 1 illustrates a rearward view showing the back surfaces of the blades 12, 14 and 16.

[0031] In FIGURE 1, it can be seen that the blade 12 has a first edge 22 and a second edge 24. When

the marine propeller 10 is in the reverse mode, the first edge 22 will be the leading edge and the second edge 24 will be the trailing edge. Similarly, the second blade 14 includes a leading edge 26 and a trailing edge 28. The third blade 16 includes a leading edge 30 and a trailing edge 32.

[0032] As can be seen in FIGURE 1, a cup 32 is affixed to the back face 34 of the first blade 12. Another cup 36 is affixed to the back surface 38 of the blade 16. Another cup 40 is affixed to the back surface 42 of the blade 14. Cups 32, 36 and 40 are considered as reversed thrust cuppings. As such, they cooperate with the flow of water across the back surfaces 34, 38 and 42 of blades 12, 16 and 14 during the reverse rotation of the marine propeller 10.

[0033] The first blade 12 has an outer edge 44. It can be seen that the cup 32 is in spaced relationship to the second edge 24 and in spaced relationship to the outer edge 44. Similarly, the blade 14 has an outer edge 46. The cup 40 is positioned in spaced relationship to the trailing edge 28 and also in spaced relationship to the outer edge 46. The blade 16 also has an outer edge 48. The cup 36 is positioned in spaced relationship to the trailing edge 32 and also in spaced relationship to the outer edge 48. Importantly, in the present invention, it can be seen that each of the cups 32, 36 and 40 is located in an identical location on each of the blades. It is important that these cups are positioned in identical locations on the blades so as to avoid possible vibration problems associated with unbalanced blades. Also, each of the cups 32, 36 and 40 should have a similar weight and volume. Once again, the proper balancing of the cups 32, 36 and 40 will serve to properly balance the blades 12, 14 and 16 and further avoid vibration problems.

[0034] FIGURE 2 is a side view of the marine propeller 10 of the present invention. In particular, FIGURE 2 shows blades 12, 16 and 14. The blade 12 of the marine propeller 10 includes a facing surface 50 and a back surface (not shown). Similarly, the blade 14 of the marine propeller 10 includes the back surface 42. The blade 16 has a facing surface 52 and a back surface 38. The cup 40 is illustrated as positioned on the back surface 42 of the blade 14.

[0035] FIGURE 3 is a cross-sectional view of the blade 12. In particular, it can be seen that the blade 12 has a variable thickness from the first edge 22 to the second edge 24. The cup 32 is affixed to the back surface 34 of the blade 12 in a location corresponding to the greatest thickness of the blade 12. There is a surface 60 that extends from the cup 32 to the second or trailing edge 24. In normal use, when the blade 12 rotates in the reverse direction, the flow of water will pass over the back surface

34 and eventually encounter the cup 32. Cup 32 will serve to kick the molecules so as to make them travel further before passing over the trailing edge 24. This will generate greater lift. This also serves to reduce cavitation in the section 30 past the cup 32 toward the trailing edge 24.

[0036] In FIGURE 3, the cup 32 is illustrated as having a generally curved outer surface. In the preferred embodiment of the present invention, cup 32 can be affixed to the back surface 34 in the form of a welding bead. Generally, the cup 32 will extend outwardly of the back surface 34 for distance of between 3/8 inch and 1/2 inch. The cup 32 is generally in a location corresponding to 2/3 of the width dimension of the blades 12 from the leading edge 22 toward the trailing edge 24.

[0037] FIGURE 4 shows an alternative embodiment of the blade 70 of the present invention. In blade 70, the cup 72 is mechanically attached to the back surface 74 of the blade 70. In particular, the cups 72 includes flanges 76 and 78 that extend outwardly therefrom. Flanges 76 and 78 are secured to the blade 70 through the use of respective bolts 80 and 82. As such, in this embodiment of the present invention, a pair of holes can be drilled through the thickness of the blade 70. The bolts 80 and 82 can be installed through holes in the flanges 76 and 78. Ultimately, a fastener can be used so as to secure the bolts 80 and 82 in place on the opposite face of the blade 70.

[0038] FIGURE 5 illustrates the arrangement of the cup 32 on the blade 12. It should be noted that each of the other blades 14 and 16 will have an identical configuration. The blade 12 extends outwardly of the hub 18. Hub 18 includes an interior opening 20 which the can be secured to the shaft of a motor of the marine vessel.

[0039] In FIGURE 5, it can be seen that the cup 32 has a curvature generally corresponding to the curvature of the blade 12. The cup 32 is illustrated as positioned in an area (illustrated by broken lines 90 and 92) that is approximately 80 to 90% of the radius of the blade 12. The cup 32 is located at a location corresponding to 2/3 of the width from the leading edge 22 toward the trailing edge 24. The cup 32 is properly spaced from the trailing edge 24 in the manner illustrated hereinabove. The end 94 of the cup 32 is also spaced from the outer edge 44 of blade 12.

[0040] Throughout the reverse rotation of the propeller 10 of the present invention, the trailing blade edge of each blade presents a gentle angle of attack to the water so as to minimize cavitation and drag on the propeller 10. Water initially traverses the leading blade edge and then flows across the cup surface. The cup tends to deflect the trajectory of the water away from the blade. Consequently,

cavitation of the water at the cup is eliminated or substantially reduced. This enhances the reverse thrust of the marine vessel as well as enabling the operator of the marine vessel to more precisely control the reverse speed on the body of water.

[0041] In operation, the propeller 10 of the present invention is particularly applicable for use in association with tugboats. These tugboats exhibit a great deal of power. The tugboats are often used to push on larger vessels or barges. Whenever barges are transported by tugboats, it is important to be able to effectively slow or stop the momentum of such heavy and long lengths of barges. As such, the present invention utilizes the reverse thrust cup so as to improve stopping efficiency of the tugboat when in the reverse direction.

[0042] The foregoing disclosure and description of the invention is illustrative and explanatory thereof. Various changes in the details of the illustrated construction can be made within the scope of the appended claims without departing from the true spirit of the invention. The present invention should only be limited by the following claims and their legal equivalents.

CLAIMS

I claim:

1. An apparatus comprising:

a blade having a facing surface and a back surface, said blade having a leading edge and a trailing edge, said blade having an outer edge; and

a cup affixed to said back surface of said blade, said cup being in spaced relation to said trailing edge and in spaced relation to said outer edge

2. The apparatus of claim 1, said blade having a variable thickness between said leading edge and said trailing edge, said blade having a greatest thickness in an area between said leading edge and said trailing edge, said cup affixed to said blade at said greatest thickness.

3. The apparatus of claim 1, said blade having a curvature, said cup having a curvature corresponding to said curvature of said blade.

4. The apparatus of claim 1, said blade having a radius, said cup positioned in an area between 80% and 90% of said radius.

5. The apparatus of claim 1, said blade having a width dimension between said leading edge and said trailing edge, said cup positioned at a location corresponding to 2/3 of said width dimension.

6. The apparatus of claim 1, said cup extending outwardly of said back surface of said blade for a distance between 3/8 inch and 1/2 inch.

7. The apparatus of claim 1, said blade rotatable in a forward direction a rearward direction, said leading edge being in a rearward direction.

8. The apparatus of claim 1, said cup being mechanically affixed to said blade.

9. A propeller comprising:

a plurality of blades extending radially outwardly of a hub, each of said plurality of blades having a facing surface and a back surface, each of said blades having a first edge and a second edge and an outer edge; and

a plurality of cups respectively affixed to said plurality of blades, each of said plurality of cups affixed to said back surface of the blade, said cup being in spaced relationship to said second edge and in spaced relationship to said outer edge.

10. The propeller of claim 9, each of said blades having a variable thickness between said first edge and said second edge, each of said blades having a greatest thickness in an area between said first edge and said second edge, the cup affixed to the blade at said greatest thickness.

11. The at the propeller of claim 9, each of said plurality of blades having a curvature, each of said plurality of cups having a curvature corresponding to the respective curvature of the blade.

12. The propeller claim 9, each of said plurality of blades having a radius, the cup positioned in an area corresponding to 80% to 90% of the radius.

13. The propeller of claim 9, each of said plurality of blades having a width dimension between said first edge and said second edge, the cup positioned at a location corresponding to 2/3 of the width dimension from said first edge.

14. The propeller of claim 9, the cup extending outwardly of the back surface of the blade for a distance of between 3/8 inch and 1/2 inch.

15. The propeller of claim 9, said plurality of blades being rotatable in a forward direction and a rearward direction, said first edge being a leading edge when in said rearward direction, said second edge being a trailing edge when in said rearward direction.

16. The propeller of claim 9, each of said plurality of cups being respectively mechanically affixed to each of said plurality of blades.

17. A reverse cupping apparatus comprising:

a blade having a forward surface and a rearward surface, said blade having an outer edge and a first edge and a second edge opposite said first edge, said blade having a radius extending from a hub to said outer edge; and

a cup affixed to said rearward surface of said blade, said cup extending generally longitudinally along said blade, said cup having one end spaced from said outer edge of said blade, said cup being in spaced relation to said first edge and in spaced relation to said second edge, said cup extending for a distance less than a length of said radius.

18. The reverse cupping apparatus of claim 17, said blade having a greatest thickness in an area between said first edge and said second edge, said cup positioned at said greatest thickness.

19. The reverse cupping apparatus of claim 17, said blade having a width dimension between said first edge and said second edge, said cup positioned at a location approximately 2/3 of said width dimension from said first edge.

20. The reverse cupping apparatus of claim 17, said blade having a curvature, said cup having a curvature corresponding to said curvature of said blade.

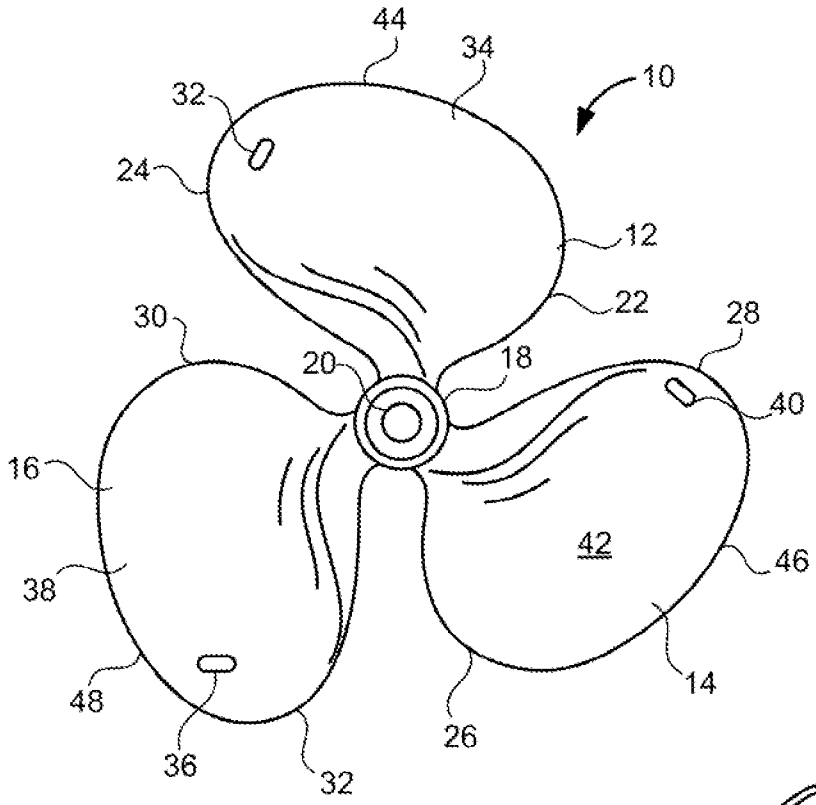
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FIG. 1

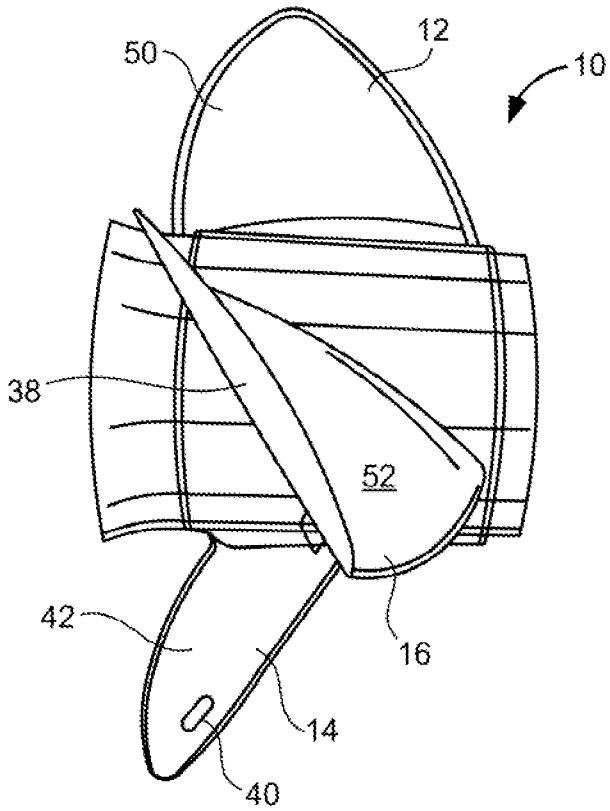
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FIG. 2

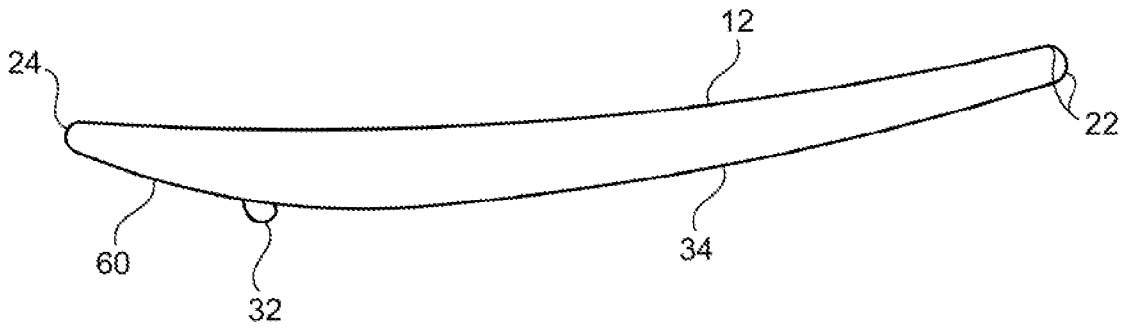

FIG. 3

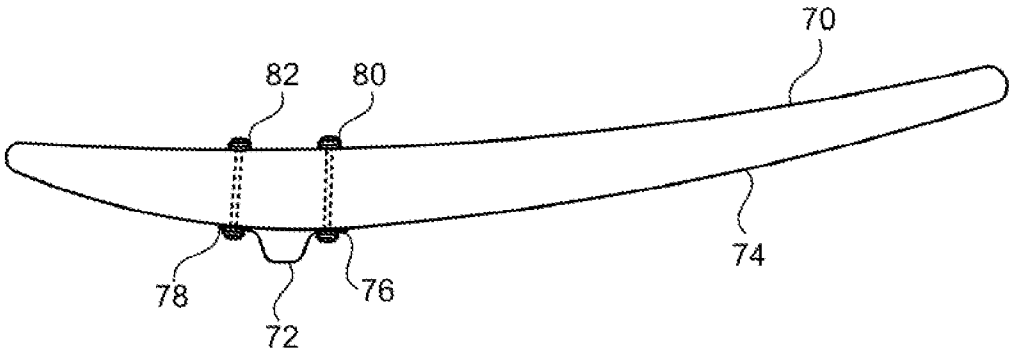

FIG. 4

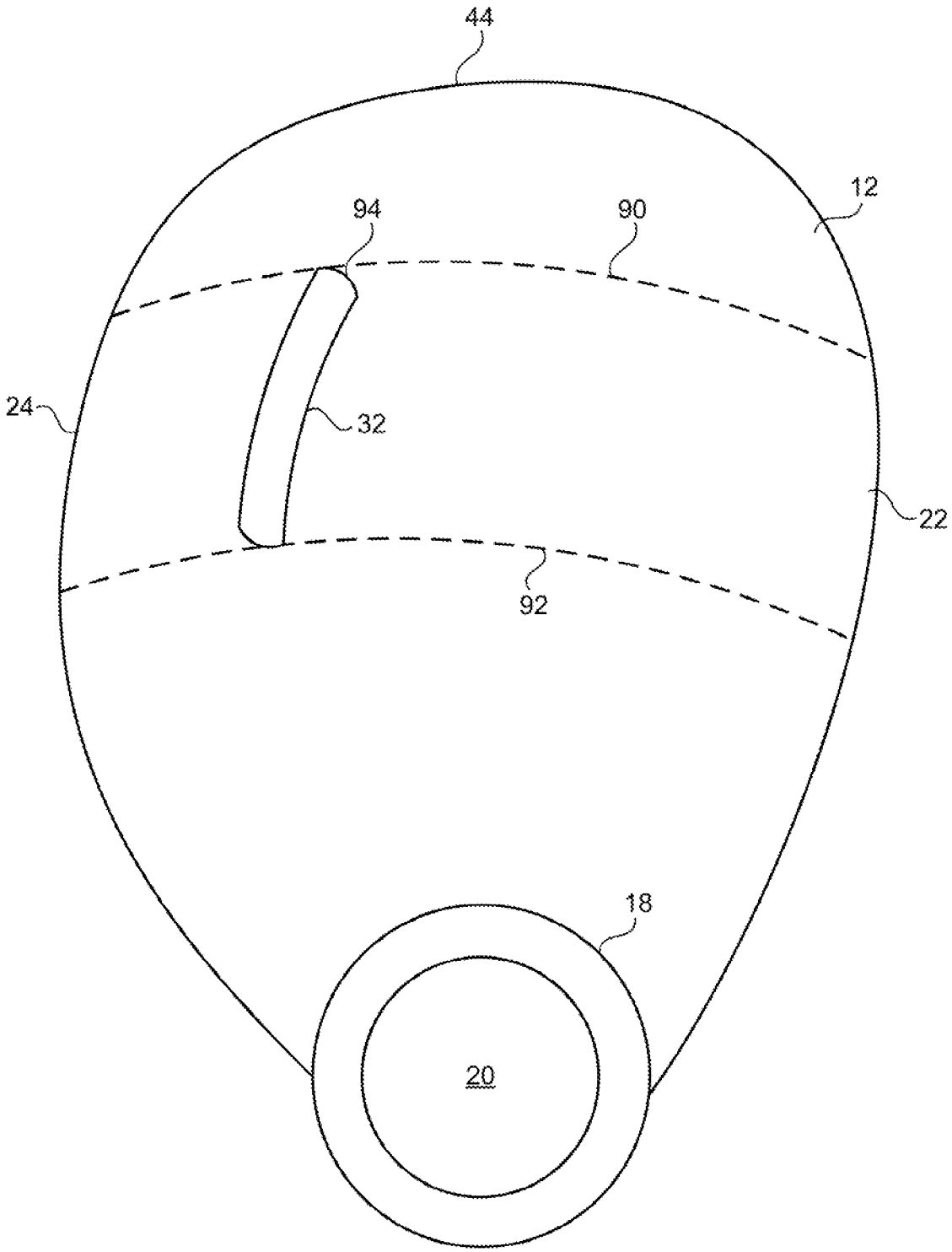

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/57745

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B63H1/26 (2015.01)
CPC - B63H1/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) Classifications: B63H1/26; B64C11/00; F03D1/00, 11/00 (2015.01)
CPC Classifications: B63H1/26; B64C11/00; F03D1/00, 11/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, Other Countries (INPADOC), RU, AT, CH, TH, BR, PH), ProQuest, Google/Google Scholar, IEEE; KEYWORDS: propeller, blade, reverse, thrust, drive, cup, attachment, accessory, thickness

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X – Y	US 2014/0227099 A1 (TWIN DISC, INC) Aug. 14, 2014; figures 1, 4, 5, 8; paragraphs [0013], [0050], [0068]	1, 3-9, 11-17, 19-20 — 1, 2, 9, 10, 17, 18
Y	US 7,637,722 B1 (KOEPSEL et al.) Dec. 29, 2009; figure 1, column 4, lines 50-56, column 6, lines 27-33	1, 2, 9, 10, 17, 18
A	US 8,636,469 B2 (POWERS, C S) Jan. 28, 2014; entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 December 2015 (24.12.2015)	21 JAN 2016
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)