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(54) **Title:** WAVE GENERATING APPARATUS

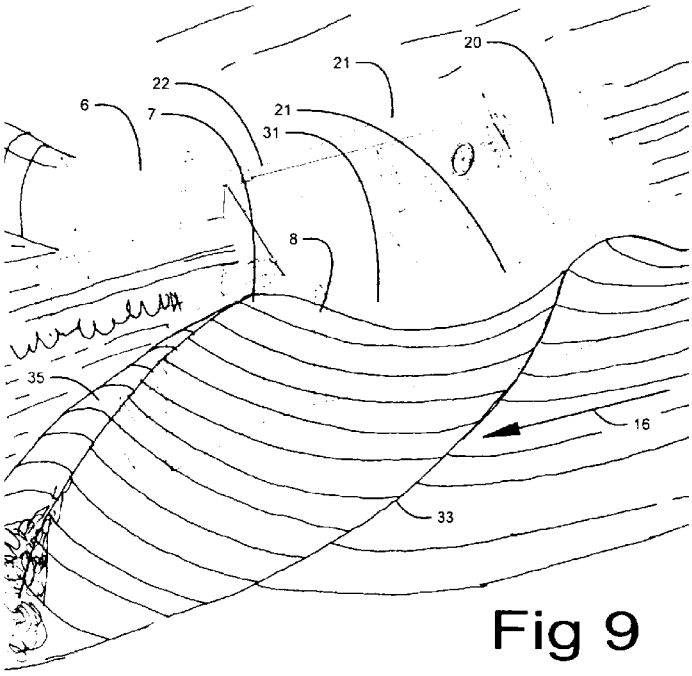

Fig 9

(57) **Abstract:** The invention relates to a wave generating apparatus including: a bow structure for generating a bow wave in the form of a surface gravity wave with a following trough and crest, whereby orbital flow results in the water dropping into the trough and rising toward the crest; and a blade with a substantially vertical face positioned to apply a substantially compressive force to the water rising out of the trough in order to transform the surface gravity wave into a plunging wave. The invention also relates to a boat and a method of generating waves.

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WAVE GENERATING APPARATUS

Related Applications

This application claims priority from Australian Provisional Patent Application No. 2016901474 and Australian Patent No. 2016203389, the contents of which are incorporated by reference.

Field of the Invention

This invention relates to a wave generating apparatus.

Background of the Invention

US Patent No. 6,047,657 discloses a wave making device which is either towed behind a boat or fixed to a transom of the boat. The device includes divergent blades that have a downwardly angled leading edge which presents a plough shaped profile. The profile is concaved around a horizontal axis and progressively curves up to a top edge and then curls over in a forward direction at remote ends of the blades. The plough shaped profile generates a substantially shear force on the water as the device is pulled by the boat in order to force water up and across the curved profile to generate a wave form from the remote ends of the blades. The shear force used to lift the water onto the plough shaped profile also generates downward pressure on the device which can result in substantial downward load on the boat. The waves produced by the device are shaped sheets of water and are not plunging waves that are ideal for surfing.

Object of the Invention

The invention seeks to produce plunging waves using a different means of generating waves.

Summary of the Invention

In accordance with the present invention, there is provided a wave generating apparatus including: a bow structure for generating a bow wave in the form of a surface gravity wave with a following trough and crest, whereby orbital flow results in the water dropping into the trough and rising toward the crest; and a blade with a substantially vertical face

positioned to apply a substantially compressive force to the water rising out of the trough in order to transform the surface gravity wave into a plunging wave.

In one embodiment, the blade has a substantially vertical leading portion parallel to a flow path which tangentially curves around a substantially vertical axis into the substantially vertical face which projects laterally into the flow path.

In one embodiment, the substantially vertical face is planar and angled substantially parallel to the trough at design speed.

In one embodiment, the blade is mounted to a device towed behind the bow structure.

In one embodiment, the device includes a port and starboard blade, for transforming surface gravity waves into plunging waves either side of the device.

In one embodiment, the apparatus includes a hull section that extends between the bow structure and the blade, wherein the leading portion of the blade is coplanar and parallel to the hull section immediately upstream of the blade.

In one embodiment, the hull section has a recessed waterline which curves inward relative to the flow path so as to enhance the trough upstream of the blade.

In one embodiment, the recessed waterline enhances downward orbital flow towards the trough in order to further prime the water rising onto the blade.

In one embodiment, the blade is integrally formed with the hull section.

In one embodiment, the apparatus includes a boat, where the bow structure forms a bow of the boat, the hull section forms part of a hull of the boat and the blade is positioned downstream of the hull section.

In one embodiment, the boat includes port and starboard blades to transform the surface

gravity waves into plunging waves either side of the boat.

In one embodiment, the apparatus forms part of a device that is pulled through the water by a land based mechanism.

In one embodiment the land based mechanism may include controlled water depth and or proximal to a wall or bank of a pool or body of water that may further enhance the effect of the apparatus as it moves through the water.

In one embodiment, part or all of the blade is articulated to allow adjustment to the draft, angle, shape and/or position of the blade.

In one embodiment, the blade produces substantially no downward load as a result of applying compressive force to the water in order to generate the plunging wave.

In another aspect, there is provided a method of generating a plunging wave using the wave generating apparatus, including forming a bow wave from the bow wave structure in order to form a surface gravity wave with a following trough and crest, whereby orbital flow results in the water dropping into the trough and rising toward the crest; and applying a compressive force to the water rising out of the trough in order to transform the surface gravity wave into a plunging wave.

In another aspect, there is provided a boat with a substantially vertical blade that projects outward into a flow path of water traveling past the boat, wherein the boat has a hull which includes a curved profile such that a bow wave trough along a waterline of the hull is enhanced to thereby further prime the water flow to rise downstream of said trough and upstream relative to the blade, and wherein a leading portion of the blade transitions from the curved hull profile to tangentially curve towards a trailing edge of the blade to redirect the primed water flow as it rises from said trough into a crest, and wherein the blade is substantially vertical in order to receive the rising water flow as the boat moves through the water.

In one embodiment, the blade is substantially vertical in order to generate substantially no downward load on the boat as the boat moves through the water.

In one embodiment, the boat further includes a spoiler positioned on an inboard side of the blade to divert water flow at a rear of the blade away from the trailing edge in order to allow for clean separation of the water propelled off the trailing edge of the blade.

In one embodiment, the blade is fitted or retro-fitted directly to the boat.

In one embodiment, part or all of the blade is articulated to allow adjustment to the draft, angle, shape and/or position of the blade.

In one embodiment, the blade is retractable.

In one embodiment, the boat includes port and starboard blades, wherein each blade forms a vertically oriented and outwardly flared hydrofoil either side of the boat.

Brief Description of the Drawings

The invention is described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Figure 1 is a side perspective view of a boat fitted with a wave generating apparatus;

Figure 2 is a rear perspective view of the boat;

Figure 3 is a top view of the boat;

Figure 4 is a perspective view of modified blades of another apparatus;

Figure 5 shows the apparatus generating waves;

Figure 6 is a perspective view of the boat generating waves;

Figure 7 is an enlarged view of the modified blades generating waves;

Figure 8 is a front perspective view of another boat with a wave generating apparatus;

Figure 9 is an enlarged view of the boat, illustrating the wave generation and curved hull profile;

Figure 10 is a front perspective view of the boat;

Figure 11 is a diagrammatic representation of wave resistance along a hull profile of the present invention;

Figure 12 is a diagrammatic representation of a boat hull and the apparatus generating a surface gravity wave;

Figure 13 is a diagrammatic representation of the boat hull and the apparatus transforming the surface gravity wave to a plunging wave;

Figure 14 is a perspective view of the apparatus being pulled by a land based mechanism/installation.

Detailed Description of the Invention

Figures 1 to 3 show a remote controlled boat 1 with a cabin 2 supported on dual hulls 3. A rudder 4 extends down from the cabin 2 and a propeller 5 projects rearward between the hulls 3.

The boat 1 is fitted with a wave generating apparatus 6, that includes port and starboard bow structures 30 and blades 7.

Each blade 7 has a leading portion 8 coplanar and parallel to a hull section 31 immediately upstream of the blade 7. The leading portion 8 smoothly transitions around a substantially vertical axis into a downstream lateral wing 9 which has a vertical aspect that tangentially

curves away from the hull 3.

Each blade 7 forms an outwardly flared hydrofoil with an elevated face 10 that curves over into a scooped upper portion 11 and a trailing edge 19 shaped such that water is propelled off the trailing edge in a lateral direction.

The apparatus 6 also includes a spoiler 12 to control water flow on an inboard side of the blade 7 and restrict unfavourable water flow behind the blades that might otherwise cause drag or downward load on the apparatus.

Figure 4 illustrates another boat 13 fitted with modified blades 14 that have a different shape to the blades 7 of Figures 1 to 3. The blades 14 have separately mounted upper portions 15. The blades 14 also have a trailing edge 19, as described above.

Figures 5 and 6 show the apparatus 6 in operation. The boat 1 is driven through water by the propeller 5 to generate a flow path 16 that runs parallel to the hulls 3. The wings 9 project into the flow path 16 to apply a substantially compressive force to water rising up from the trough which causes the water to be redirected up and across the elevated face 10 of the blade 7 to thereby transform the surface gravity wave 33 into a plunging wave 17. The blade has a trailing edge 19 shaped such that water is propelled off the trailing edge, in a direction laterally of the flow path 16. The spoiler 12 acts to divert flow behind a rear of the blade away from the trailing edge 19 in order to reduce drag or downward load and allow for clean separation of the water propelled off the trailing edge 19 of the blade 7 while the scooped upper portion 11 can assist in helping produce a clean overturning shape to the wave as it passes behind the boat 1.

The apparatus 6 thereby generates waves by using a compressive force and the natural orbital energy of a surface gravity wave to lift and push water upward and outward, instead of requiring a plough like device to displace water upwardly.

Figure 7 shows the waveform produced from the trailing edge 19 of the modified blades 14 described with reference to Figure 4. As can be seen, the wave form 18 is generally taller

and the overturning occurs later.

The shape and/or angle of the upper portions 15 can be adjusted, as required, in order to generate different overturning or breaking characteristics. It is also envisaged that the shape of the blade itself could be modified to change the wave form, as needed.

For the purpose of illustrating the principles of the apparatus 6, the invention has been demonstrated only in relation to use on remote controlled boats 1, 13, with the blades 7, 14 being fixed in place. However, it is envisaged a more advanced application of the invention is to have the blades mounted relative to the boat hulls via a mounting apparatus that would allow for articulation of the blades and allow adjustment with respect to draft, angle and/or position, and possibly allow the blades to function as rudders to aid steering of the boat and/or be retracted entirely.

Figures 8 to 10 illustrate another boat 20 fitted with an apparatus 6, where like parts are denoted by like reference numerals. The boat 20 has matching port and starboard curved hull profiles 21 formed in the hull sections 31 upstream of the blades 7. The leading portion 8 of each blade 7 transitions smoothly from the curved profile 21, in a direction downstream of the profile 21. The profile 21 is shaped with a recessed waterline, which curves inward relative to the flow path, to generate or enhance a trough in the flow path upstream of the blade 7, which further primes the water prior to the water being redirected up onto the blade 7, which enhances or primes the water flow favourably as it rises up toward the crest 35, at the time it hits the blades 7.

The curved hull profile 21 is also tapered toward a bow 23 of the hulls 3 in order to minimise the bow wave and the resultant white water the bow wave produces. This may be beneficial as it is more desirable to have a clean "green wall" wave generated by the apparatus 6 instead of having the wave chopped up by turbulent white water.

It should be appreciated from the above that each blade 7 has substantially no horizontally inclined aspect which might otherwise cause the wing 9 to dive. If the wing had a horizontally inclined aspect, the blade 7 would tend to plough under the water and generate

a downward load on the blade 7, which could be problematic for lighter boats and water craft given the stern of the boat would be pulled down. In heavier boats, driver vision may be obscured as a result of the bow lifting in response to the stern being driven down into the water. If the bow were to lift this also reduces the bow wave produced by the bow structure 30, which, in turn reduces the priming effect on the flow path. With substantially no horizontally inclined aspect, the blade 7 is able to generate plunging waves simply by being driven through the water with sufficient power, regardless of the displacement weight of the boat, by using the natural orbital flow of water rising upward toward a crest of a surface gravity wave produced by the bow structure 30 of the apparatus 6.

It should also be appreciated that any horizontal aspect on the inboard side of the wing 9 and/or the blade 7 could exacerbate the downward load described above on the apparatus and be further problematic however the spoilers may be used to prevent this problem.

The apparatus has been described as having two blades 7 in line with the respective hull 3. However, the blades 7 can be in spaced relation beside or behind one or more hulls 3 and still generate a suitable wave form or be used behind or either side of a single hull boat. Also, it is possible for the apparatus to have only a single blade and/or to be part of a structure that is towed through the water such as from a land-based installation instead of being mounted to the boat 1.

The principles of the wave generation used in the present invention are further described with reference to Figures 11 to 14.

Fig 11 shows a half breadth hull 3, with a curved hull profile 21, simplified into a wedge shape, to illustrate the wave resistance produced by the different points as the hull 3 moves through water at design speed. Points 1 and 2 encompass the bow structure 30 which includes the bow 23 and a fore shoulder 54 which indicates a forward beam 36 of the boat. Point 3 represents an aft shoulder 37 which is a point of transition where the hull 3 begins to curve back toward a centreline 38 of the hull 3. Point 4 indicates a reduced beam width 39 of the recessed waterline, where the hull section 31 transitions to the leading portion 8 of the blade 7.

The wave resistance introduced by each of the points along the hull 3 are also illustrated. The resultant wave produced will be a superposition sum of all the different wave systems 40, 41, 42, 43 at any given point along the hull 3. It should be noted that the superposition of the wave systems 40, 41, 42, 43 all provide an upward or high pressure force at the blade leading portion 8. The blade 7 projects into the flow path at Point 4 to provide a compressive force to the water. This effectively reduces the wavelength of the bow wave 40 which causes the crest of the wave to plunge.

Fig 12 shows a top view of the wave generating apparatus 6 in the context of the angle 44 of the face of the blade 7 relative to the direction of the bow wave 40 generated by the bow structure 30. The blade 7, at design speed, is substantially parallel to the wave crest 46 so that the blade 7 provides a compressive force to the wave 33 as the boat moves through the water. The wave length 45 of the surface gravity wave 33 shown here represents where the divergent wave crest 46 may develop in the absence of the blade 7. The shortened wavelength 47 represents the force of the blade 7 advancing the wave crest.

In other words, the blade 7 is substantially vertical, and an obtuse angle relative to the flow path, in order to act with a horizontal force against the surface gravity wave 33. The blade 7 is also substantially parallel to the divergent wave half angle 49 in order to act with a force perpendicular to the divergent wave crest 46. The horizontal and perpendicular forces, are both in the same direction as (axially aligned with) the wave energy path 50. Hence the force is substantially a compressive force with substantially no downward load on the hull 3 or apparatus 6, as compared to the prior art plough shaped blade.

The leading section 8 of the blade 7 also has a concaved aspect that transitions tangentially around a substantially vertical axis 51 and laterally into the flow path 16, as opposed to the prior art plough shaped blade.

Fig 13 shows a sectional view perpendicular to the wave crest 46 with a simplified wedge shaped hull 3 shown in perspective view only to illustrate it's relationship to the wave 33. This shows that not only are the wave systems interfering constructively as water rises downstream of the trough 52 to increase the amplitude at the blade 7, but also the crucial

effect that the blade 7 has in shortening the wave-length 47 and causing the wave to vortex and plunge.

The lateral angle (half angle) 44 of the blade 7 is substantially parallel to the wave trough 52 (divergent wave half angle 49), at design speed, in order to apply a force substantially perpendicular to the surface gravity wave crest 46, or a force in the same direction as the energy path 50 of the surface gravity wave 33.

With sufficient speed, the bow-wave-trough 52 will reach the midpoint 53 between the bow structure 30 and the blade 7. At this point the succeeding wave crest 46 will interfere constructively with the additional upward and high pressure wave system produced by the blade 7, resulting in a combined wave amplitude, when a multi wave system is generated. This wave system is surf-able and suitable for beginners.

As speed is increased, the bow wave-length increases and moves the bow wave trough 52 closer to the blade 7. Simultaneously, the blade 7 advances the development of the succeeding wave crest 46, thereby shortening the wave-length 47 causing the surface gravity 33 wave to rotate further and start to plunge. At this point, the multi wave system is transformed into a plunging wave 48. This wave system is more suitable for advanced surfers.

The blade 7 of the present invention is both a wave generator and a wave transformer. The vortex (or orbital) energy that causes the wave to crest and plunge is provided by the surface gravity wave physics. No horizontally concaved or multidirectional plough shaped profile is required, as per the prior art.

The divergent wave angle, shape of the bow wave, recessed waterline and blade configuration can all be modified to suit varying wave production criteria, as may be required.

The relative position of blade downstream of Point 2 is determined by the desired surfing speed range. For example, if a faster surfing speed is to be achieved, a greater distance is

required between the bow structure and the blade.

It should be appreciated the width of the hull section 31 at Point 4 in Figure 11 is shown to be narrower than Point 2. However, the beam width of the hull at Point 4 can be equal to that at Point 2 while still allowing the blade 7 to transform the surface gravity wave into a plunging wave. Also, although only one blade is illustrated in Figure 11 and 13, a second blade such as shown in Figure 1 to 10 can be used so that port and starboard side plunging waves are produced.

Fig 14 shows the apparatus 6 being pulled through the water by a land based installation/mechanism 60. In this case the mechanism 60 is mounted on the land 61 beneath the water and is proximal to one or more river banks 62. In this embodiment the blade 7 of the apparatus would transform the surface gravity wave 33 downstream and the river bank 62 would transform an additional wave 64 on the river bank 62 upstream of the bow wave 40.

In this embodiment 4 plunging waves may be produced at the same time. Two from each of the port and starboard blades 7 and another two waves on each port and starboard river banks 62.

Claims

1. A wave generating apparatus including:

a bow structure for generating a bow wave in the form of a surface gravity wave with a following trough and crest, whereby orbital flow results in the water dropping into the trough and rising toward the crest; and

a blade with a substantially vertical face positioned to apply a substantially compressive force to the water rising out of the trough in order to transform the surface gravity wave into a plunging wave as the apparatus is moved through a body of water.

2. The wave generating apparatus of claim 1, wherein the blade has a substantially vertical leading portion parallel to a flow path which tangentially curves around a substantially vertical axis into the substantially vertical face which projects laterally into the flow path.

3. The wave generating apparatus of claim 2, wherein the substantially vertical face is planar and angled substantially parallel to the bow wave.

4. The wave generating apparatus of any one of claims 1 to 3, wherein the blade is mounted to a device towed behind the bow structure.

5. The wave generating apparatus of any one of claims 2 to 4, wherein the device includes a port and starboard blade, for generating plunging waves either side of the device.

6. The wave generating apparatus of any one of claims 2 to 5, including a hull section that extends between the bow structure and the blade, wherein the leading portion of the blade is coplanar and parallel to the hull section immediately upstream of the blade.

7. The wave generating apparatus of claim 6, wherein the hull section has a recessed waterline which curves inward relative to the flow path so as to enhance the trough upstream of the blade.

8. The wave generating apparatus of claim 7, wherein the recessed waterline enhances downward orbital flow towards the trough in order to further prime the water rising upstream of the blade.

9. The wave generating apparatus of any one of claims 6 to 8, wherein the blade is integrally formed with the hull section.

10. The wave generating apparatus of any one of claims 4 to 9, including a boat, where the bow structure forms a bow of the boat, the hull section forms part of a hull of the boat and the blade is positioned downstream of the hull section.

11. The wave generating apparatus of claim 10, wherein the boat includes port and starboard blades to generate plunging waves either side of the boat.

12. The wave generating apparatus of any one of claims 6 to 11, forming part of a device that is pulled through the water by a land based mechanism.

13. The wave generating apparatus of any one of claims 1 to 12, wherein part or all of the blade is articulated to allow adjustment to the draft, angle, shape and/or position of the blade.

14. The wave generating apparatus of any one of claims 1 to 13, wherein the blade produces substantially no downward load as a result of applying compressive force to the water in order to generate the plunging wave.

15. A method of generating a plunging wave using the wave generating apparatus of claim 1, including forming a bow wave from the bow wave structure in order to form a surface gravity wave with a following trough and crest, whereby orbital flow results in the water dropping into the trough and rising toward the crest; and applying a compressive force to the water rising out of the trough in order to transform the surface gravity wave into a plunging wave.

16. A boat with a substantially vertical blade that projects outward into a flow path of water travelling past the boat, wherein the boat has a hull which includes a curved profile such that a bow wave trough along a waterline of the hull is enhanced to thereby prime the water flow to rise downstream of said trough and upstream relative to the blade, and wherein a leading portion of the blade transitions from the curved hull profile to tangentially curve towards a trailing edge of the blade to redirect the primed water flow as it rises from said trough into a crest, and wherein the blade is substantially vertical in order to receive the rising water flow as the boat moves through the water.

17. The boat of claim 16, wherein the blade is substantially vertical in order to generate substantially no downward load on the boat as the boat moves through the water.

18. The boat of claim 16 or 17, further including a spoiler positioned on an inboard side of the blade to divert water flow at a rear of the blade away from the trailing edge in order to allow for clean separation of the water propelled off the trailing edge of the blade.

19. The boat of any one of claims 16 to 18, wherein the blade is fitted or retro-fitted directly to the boat.

20. The boat of any one of claims 16 to 19, wherein part or all of the blade is articulated to allow adjustment to the draft, angle, shape and/or position of the blade.

21. The boat of any one of claims 16 to 20, wherein the blade is retractable.

22. The boat of any one of claims 16 to 21, including port and starboard blades, wherein each blade forms a vertically oriented and outwardly flared hydrofoil either side of the boat.

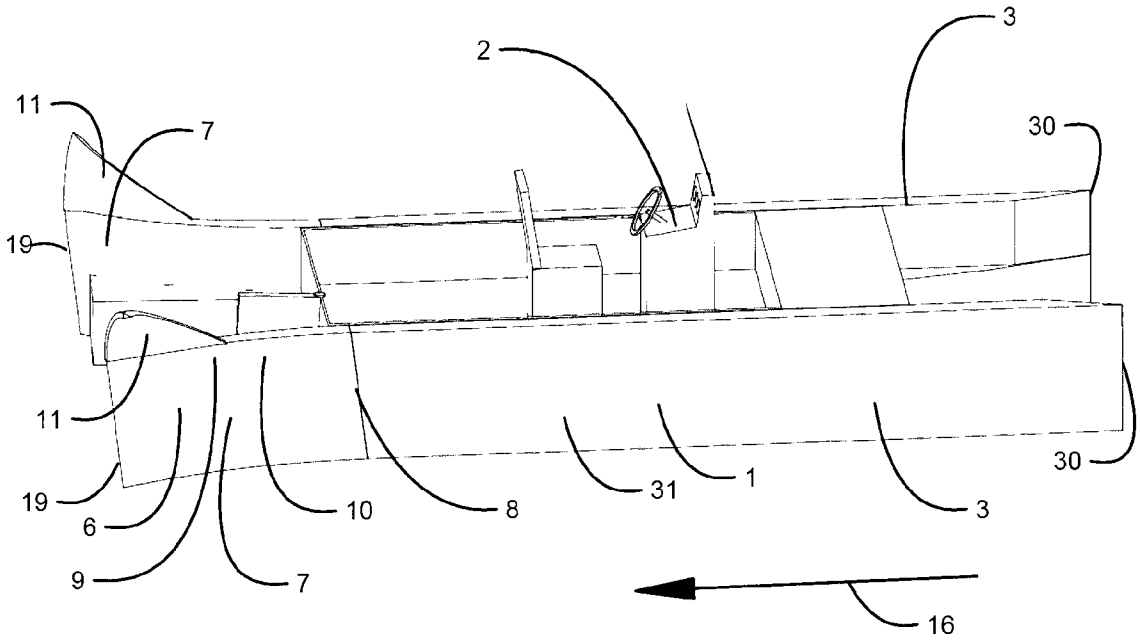
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Fig 1

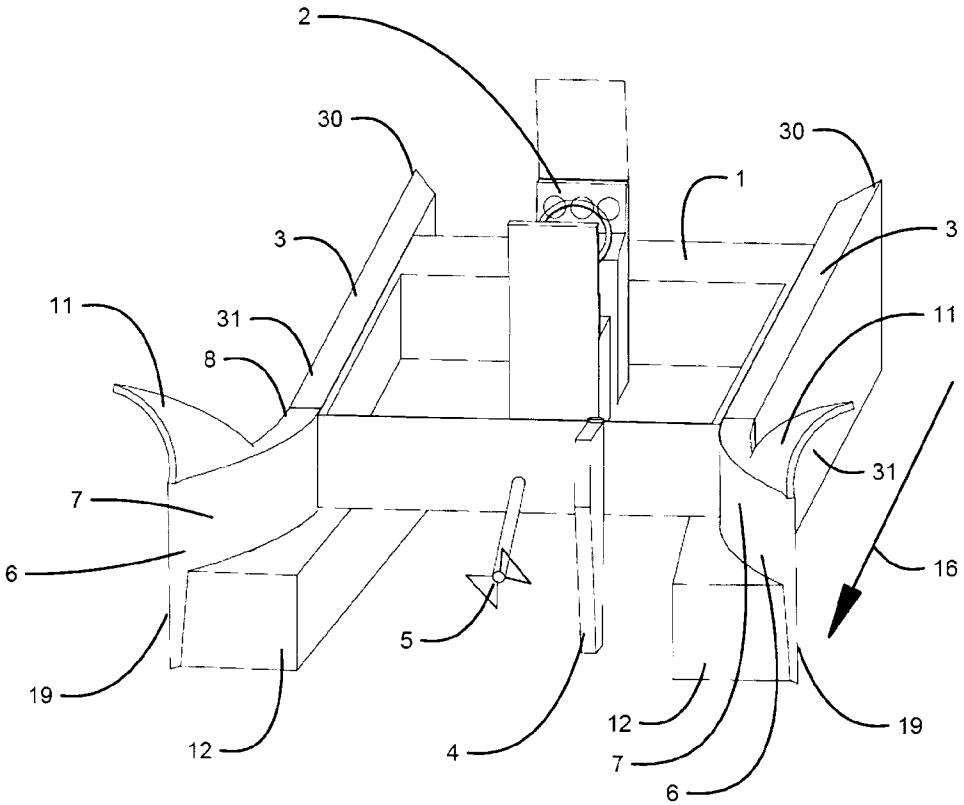
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Fig 2

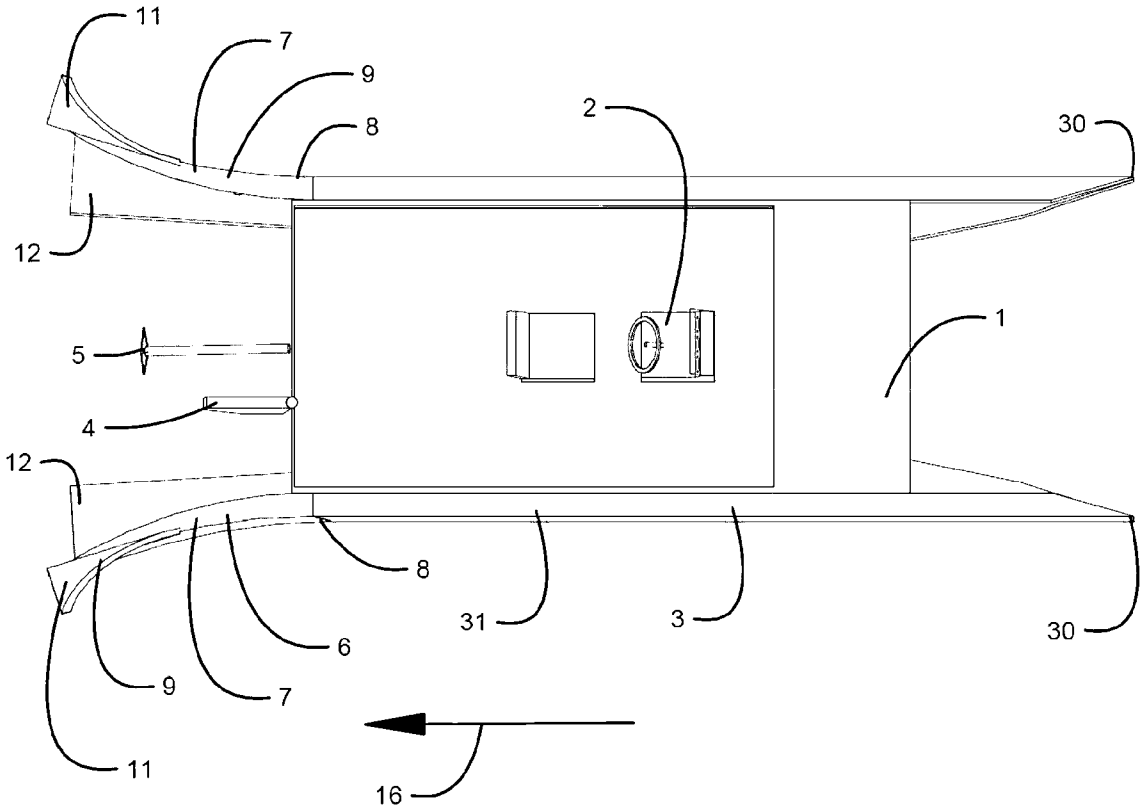


Fig 3

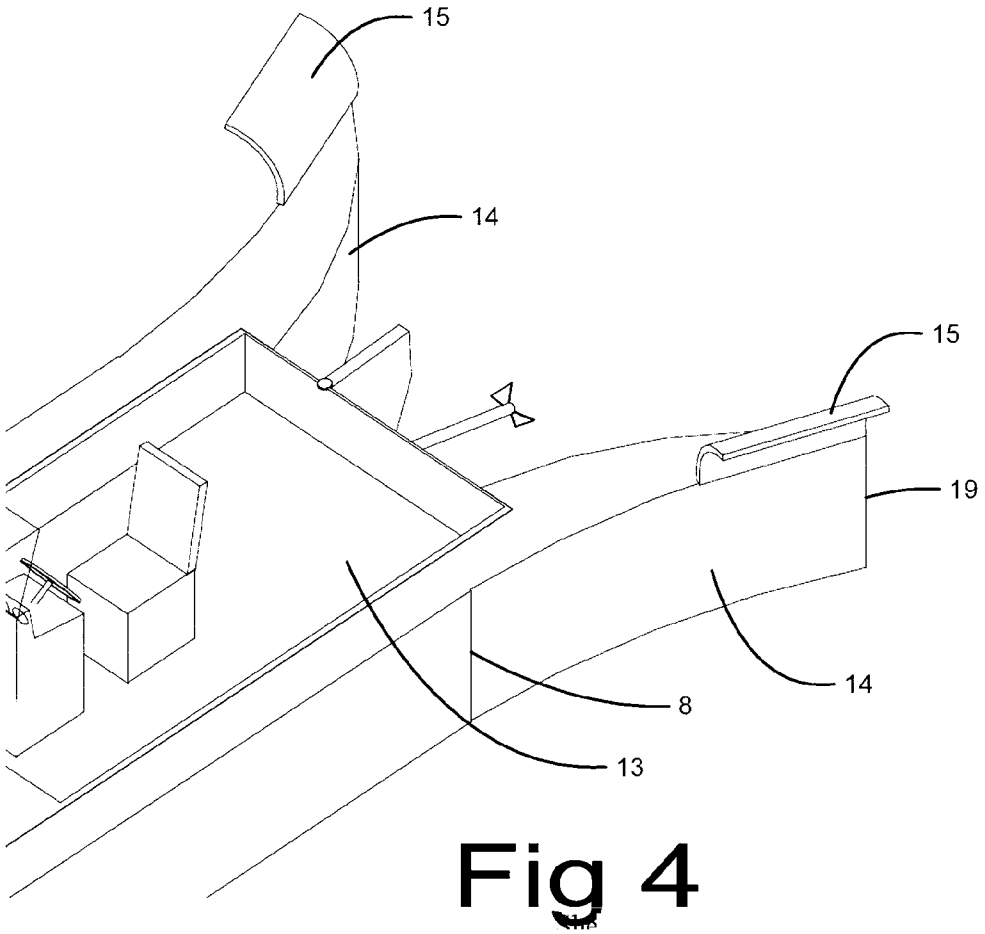


Fig 4

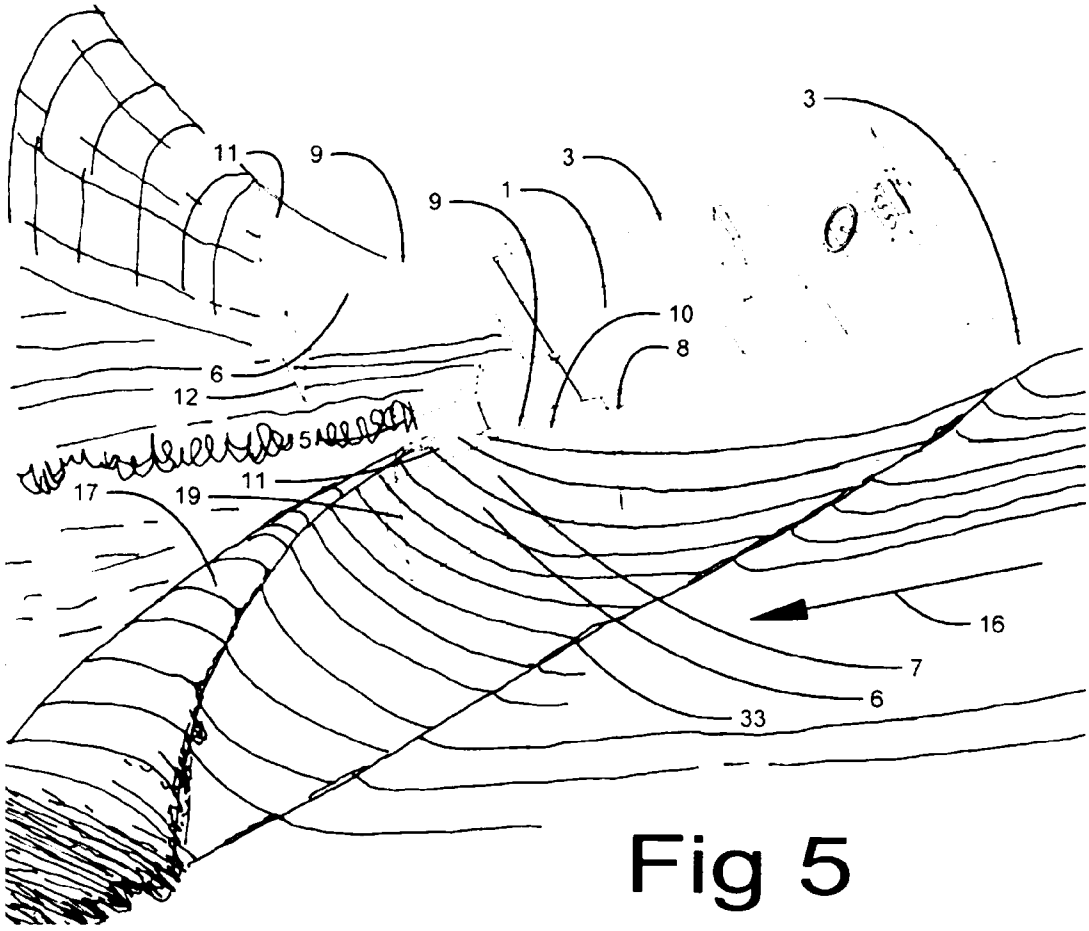
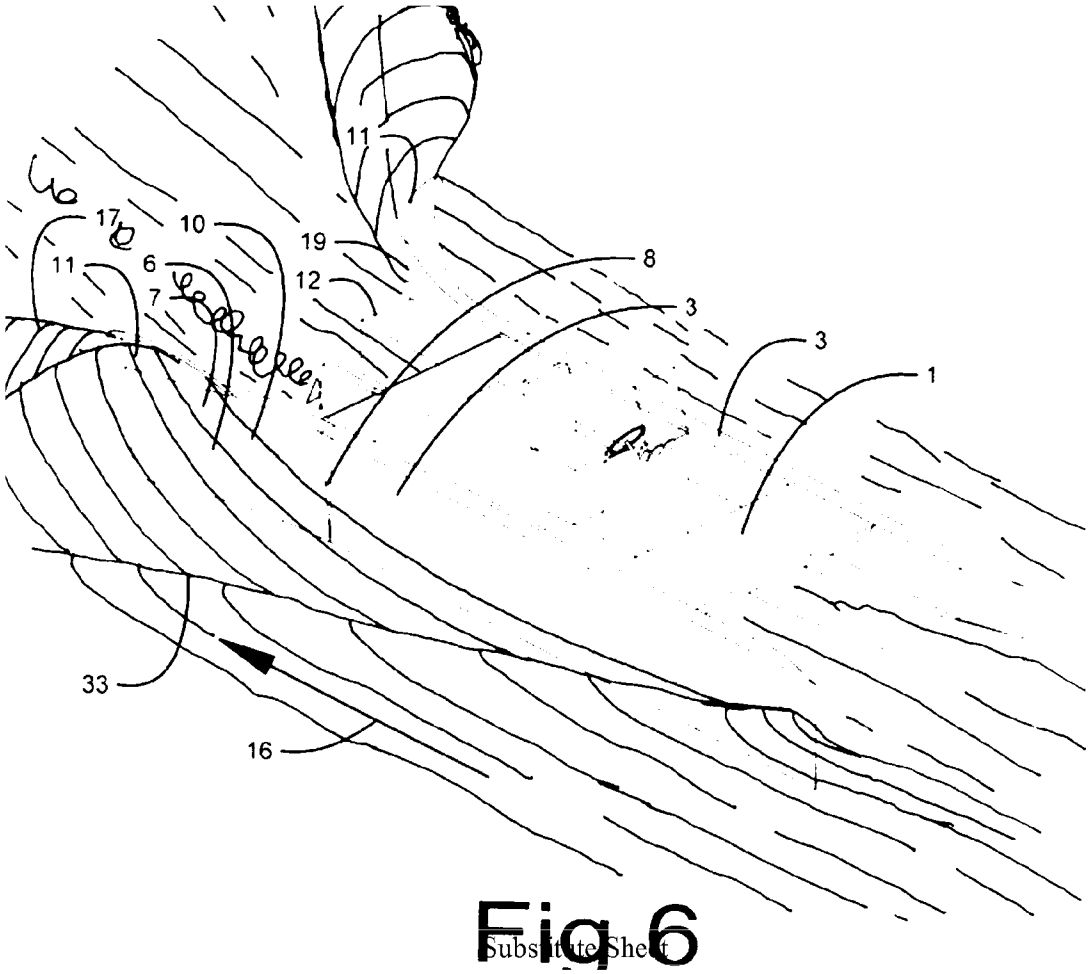


Fig 5



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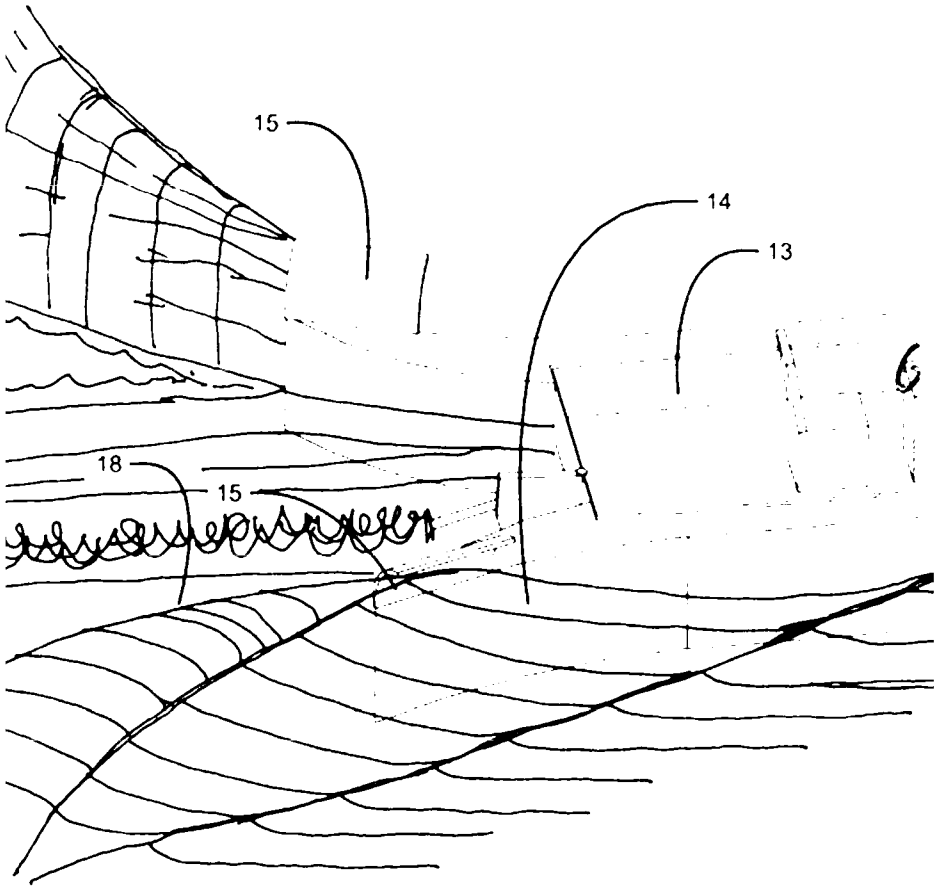
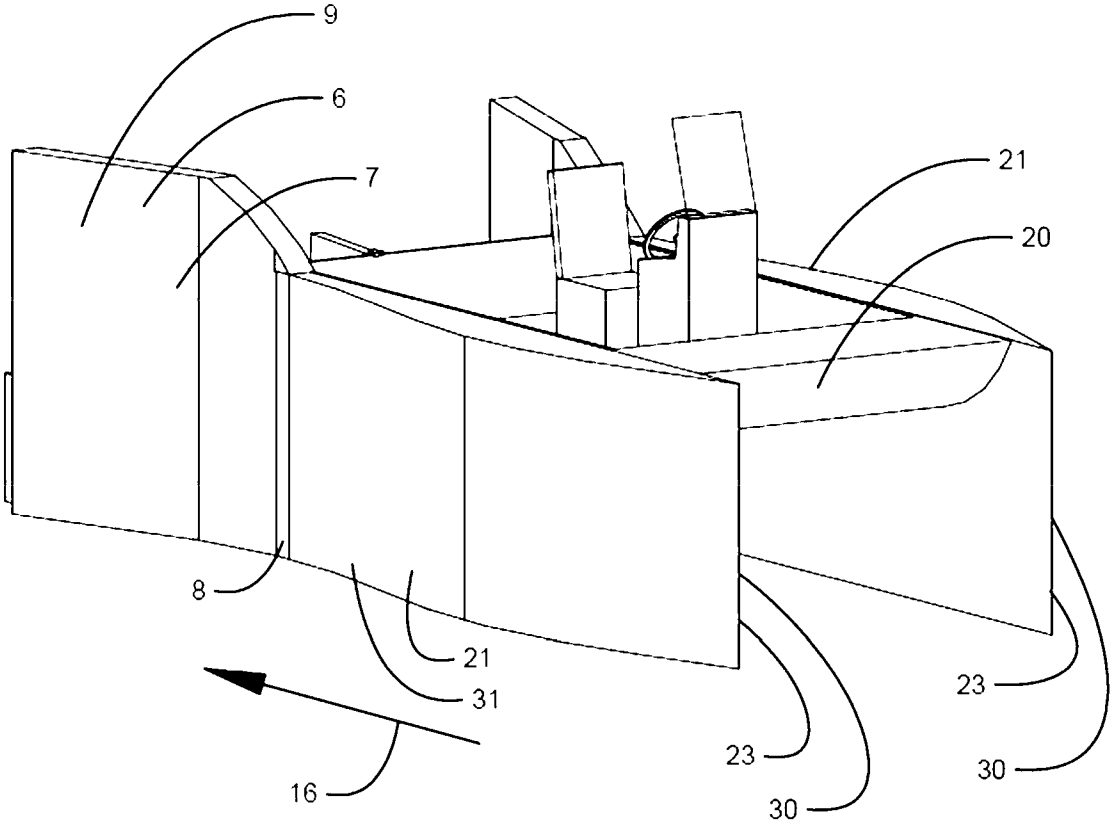


Fig 7



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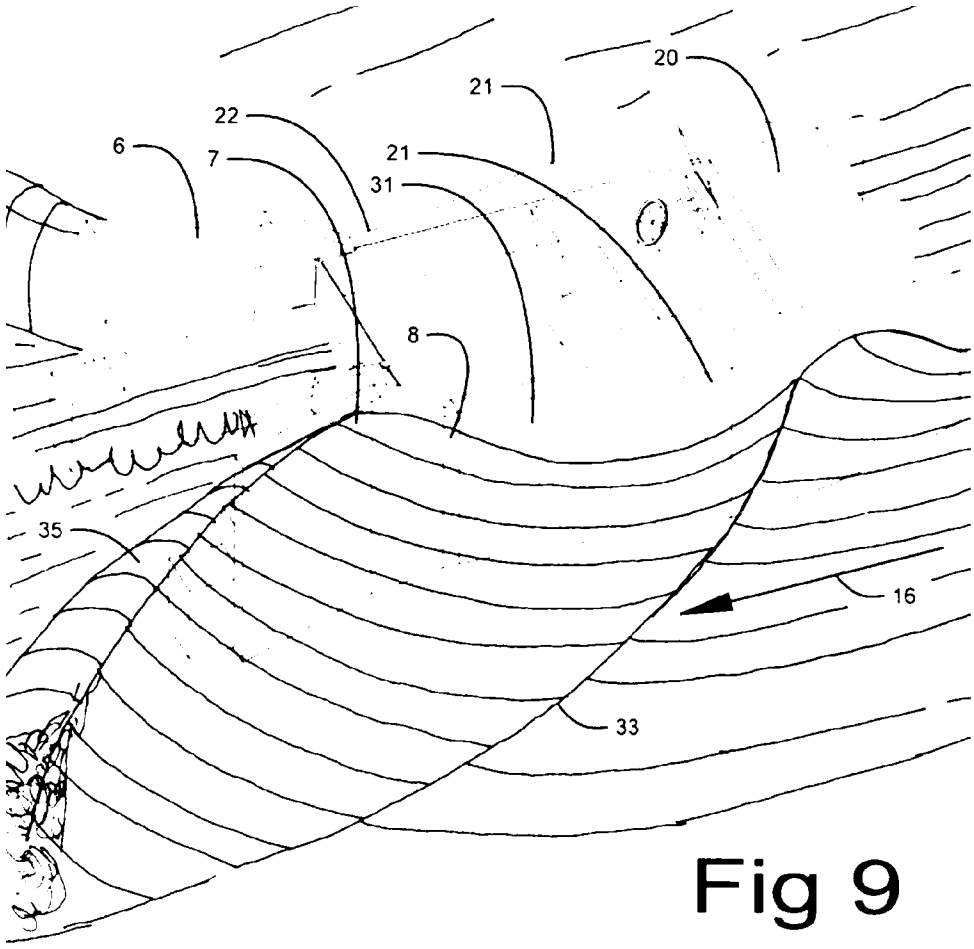

Fig 9

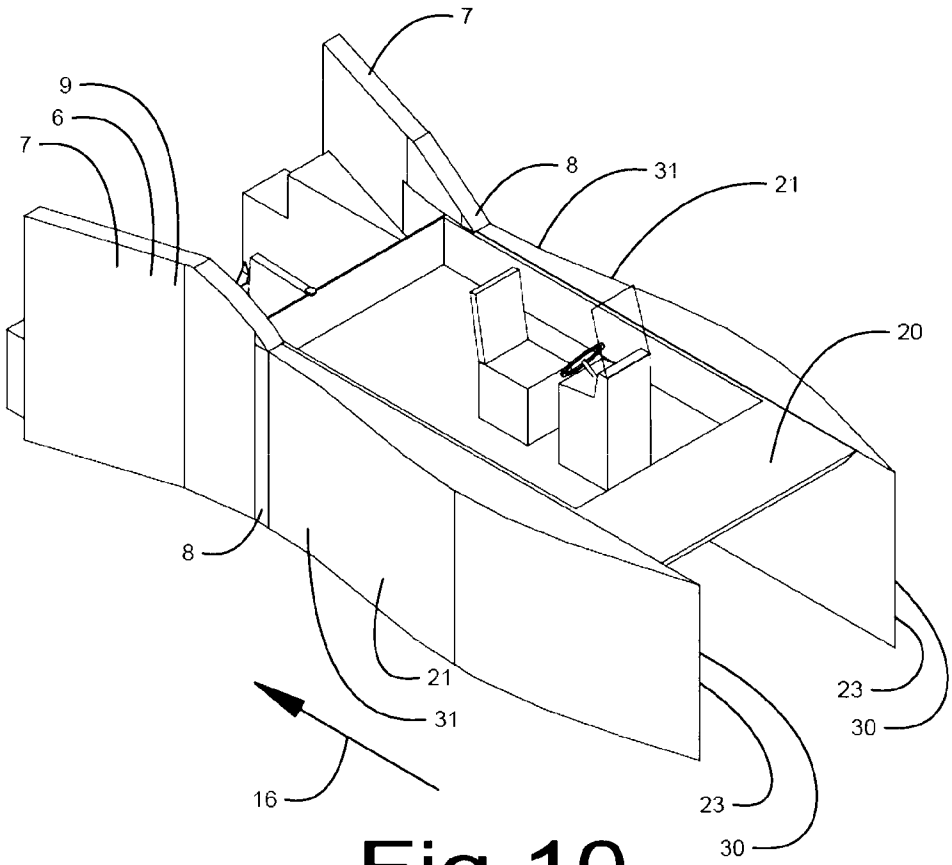

Fig 10

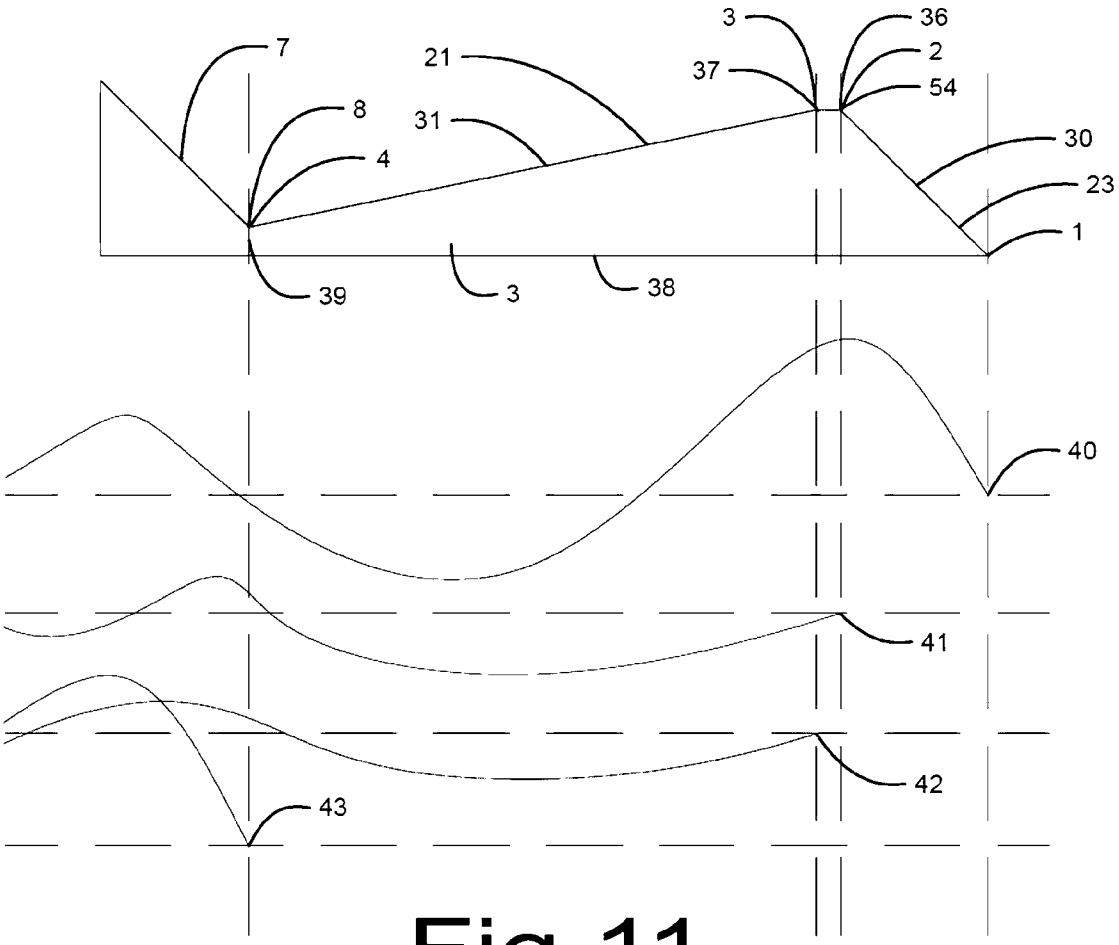
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Fig 11

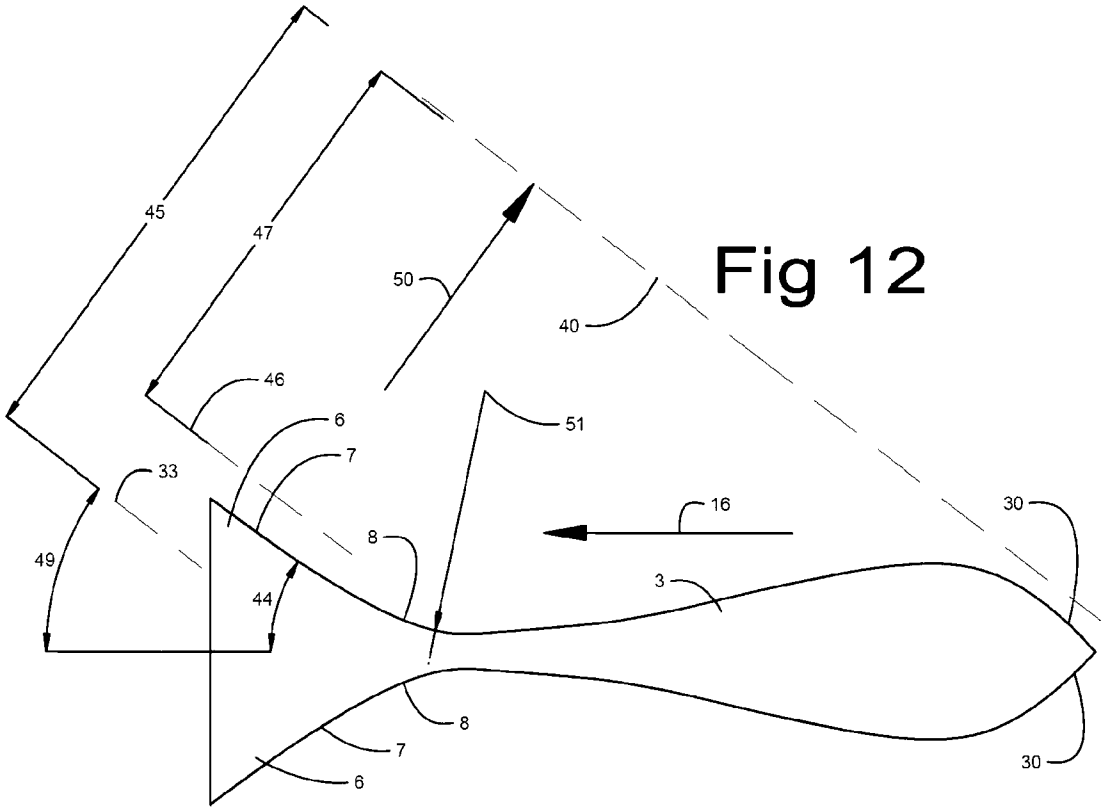
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Fig 12

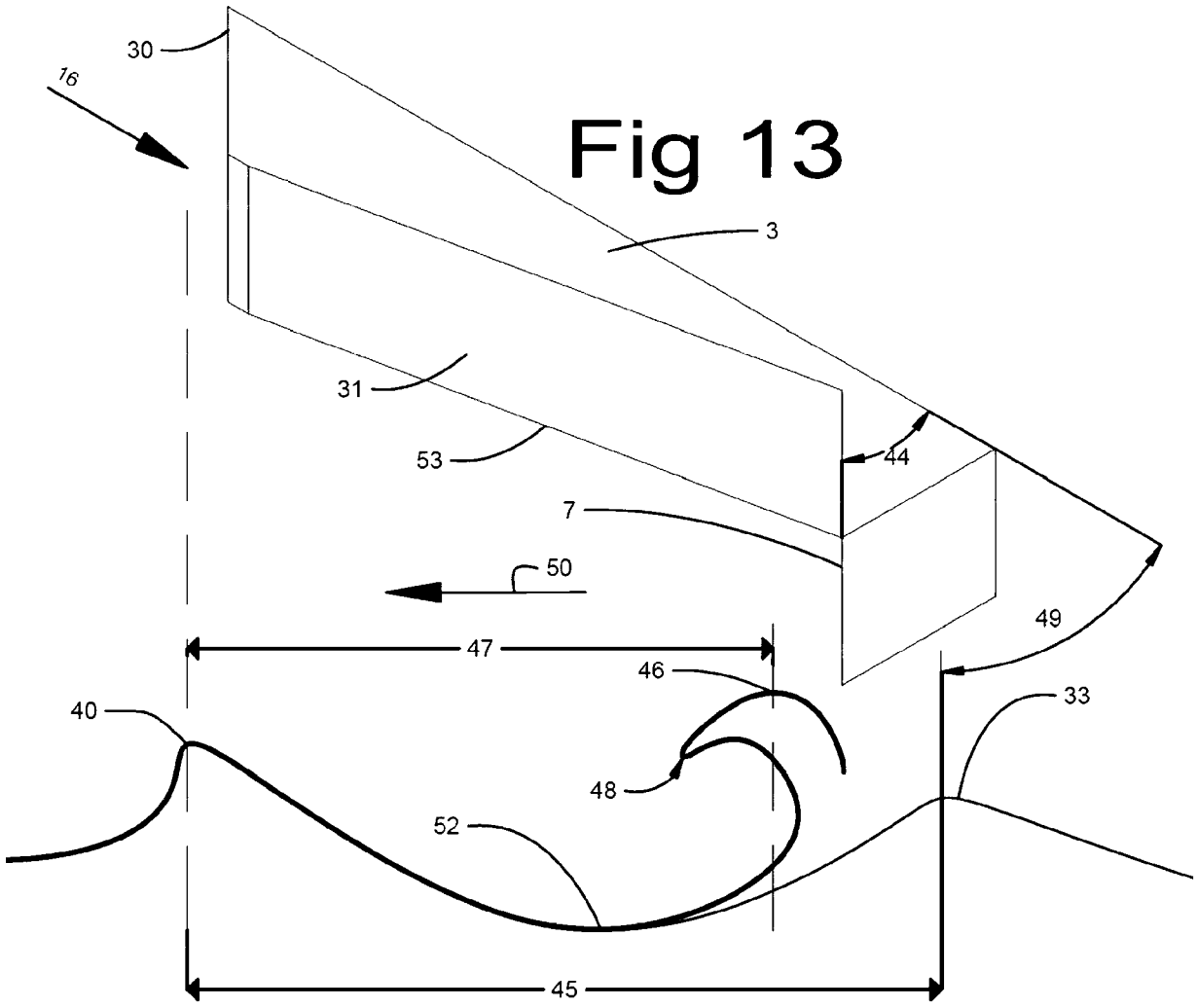

Fig 13

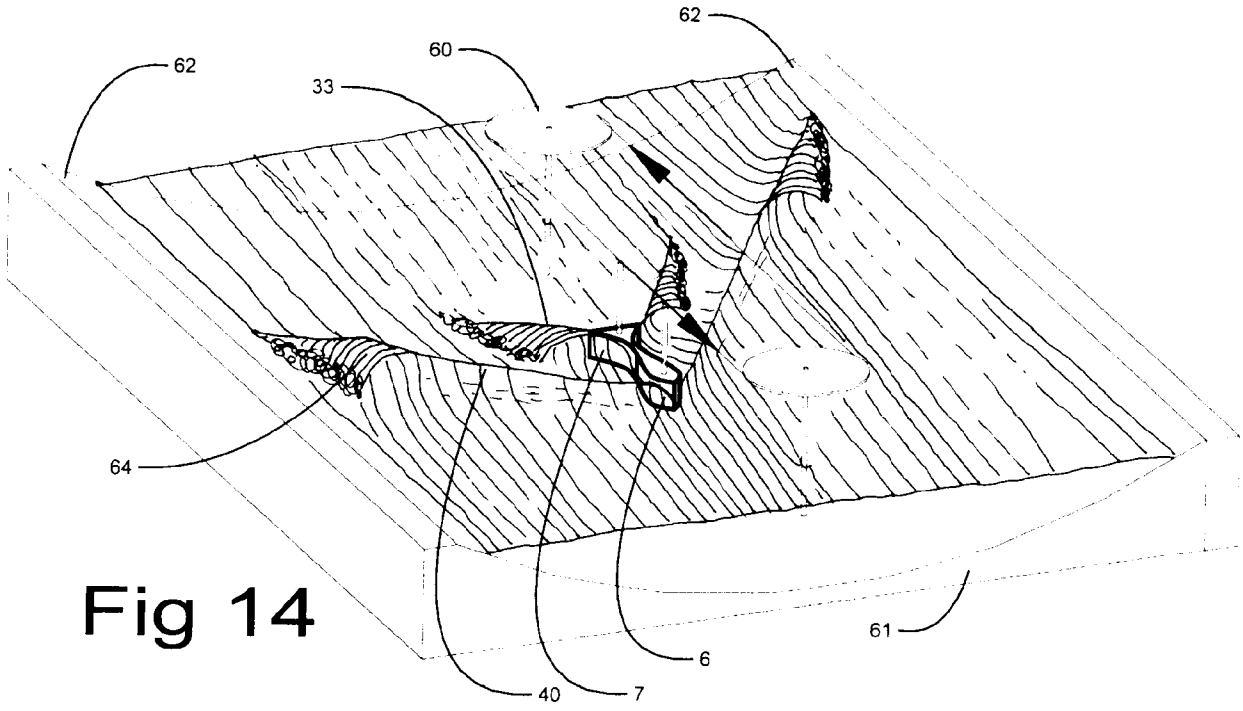

Fig 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2017/050358

A. CLASSIFICATION OF SUBJECT MATTER

B63B 35/85 (2006.01) A63B 69/00 (2006.01)

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)

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)

Databases: EPODOC, WPIAP, TXPEA, TXPEB, TXPEC, TXPEE, TXPEF, TXPEH, TXPEI, TXPEP, TXPES, TXPEPEA, TXPUSEOA, TXPUSE1A, TXPUSEA, TXPUSEB, TXPWOEA, Espacenet.

Keywords: Produce, generate, making, create, manipulate, wave, surf, wake, vertical, axial, perpendicular, upright, face, ramp, foil, spoiler, wing, blade, trough, diffuser and similar terms.

IPC/CPC: B63B2035/855, A63B69/0093, B63B35/85, E04H4/0006, A63G3 1/007.

Applicant(s)/Inventor(s) name searched in Espacenet, AusPat and internal databases provided by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] 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 ɒ 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
10 July 201 7	10 July 2017
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Clive Gaskin AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262256108

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7252047 B1 (BAUCOM, JR) 07 August 2007 Figures 1 - 9 and the corresponding text in the description.	1 - 5, 10, 11, 13, 15, 16, 18 - 22
X	US 6105527 A (LOCHTEFELD ET AL.) 22 August 2000 Figures 1 - 25 and the corresponding text in the description.	1 - 3, 5 - 11, 14 - 19, 22
X A	US 6047657 A (COX) 11 April 2000 Figures 1 - 5 and the corresponding text in the description.	1, 4, 5, 10, 11, 13, 15 18
X	US 2014/0026799 A1 (ANTHONY KALIL) 30 January 2014 Figures 1 - 14 and the corresponding text in the description.	1, 5, 6, 10, 11, 13 - 15
X	US 2013/0228 115 **A1** (MALIBU BOATS, LLC) 05 September 2013 Figures 1 - 29 and the corresponding text in the description.	1, 5 - 8, 10, 11, 13 - 15
X	US 2013/0199433 A1 (THOMAS J. LOCHTEFELD) 08 August 2013 Figures 1 - 32 and the corresponding text in the description.	1 - 9, 12, 14, 15
A	US 59 11190 A (LOCHTEFELD ET AL.) 15 June 1999	
A	US 2003/01 19592 **A1** (LOCHTEFELD ET AL.) 26 June 2003	

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INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2017/050358**

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		US 63 19137 B1	20 Nov 2001
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		WO 2013116683 A1	08 Aug 2013

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		AU 668713 B2	16 May 1996
		AU 6212896 A	31 Oct 1996
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		AU 6156096 A	30 Dec 1996
		AU 714278 B2	23 Dec 1999
		AU 3665093 A	03 Sep 1993
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		AU 6262996 A	24 Dec 1996
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INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2017/050358**

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Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
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End of Annex

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