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Attorney Docket No. 79355

BOTTOM ACTIVATED RETRACTABLE CONTROL SURFACE FOR AN UNMANNED UNDERSEA VEHICLE

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT (1) DANIEL W. FRENCH, and (2) JOHN J. VAILLANCOURT, citizens of the United States of America, employees of the United States Government, and (3) THOMAS W. HEDLY, JR., citizen of the United States of America, residents (1) Portsmouth, County of Newport, State of Rhode Island (2) Tiverton, County of Newport, State of Rhode Island, and (3) Portsmouth, County of Newport, State of Rhode Island have invented certain new and useful improvements entitled as set forth above of which the following is a specification:

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1	Attorney Docket No. 79355	
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3	BOTTOM ACTIVATED RETRACTABLE CONTROL	
4	SURFACE FOR AN UNMANNED UNDERSEA VEHICLE	
5		
6	STATEMENT OF GOVERNMENT INTEREST	•
7	The invention described herein may be manufactured and	·
8	used by or for the Government of the United States of America	
9	for governmental purposes without the payment of any royalties	
10	thereon or therefor.	
11		
12	CROSS REFERENCE TO OTHER PATENT APPLICATIONS	
13	Not applicable.	
14		
15	BACKGROUND OF THE INVENTION	
16	(1) Field of the Invention	-
17	This invention generally relates to a bottom activated	÷
18	retractable control surface for unmanned undersea vehicles.	
19	More particularly, the invention relates to a bottom activated	
20	retractable control surface for unmanned undersea vehicles	
21	which is automatically retractable without user intervention.	
22	(2) Description of the Prior Art	
23	The current art for control fins on an unmanned undersea	
24	vehicle is not in question. However, the manner of retracting	
25	and deploying these control fins has not been addressed in the	
26	manner of the present invention. At the present time, if an	
27	unmanned undersea vehicle needs to rest on the bottom of the	

ocean, a standard control fin mounted on the underside of the
 vehicle can be seriously damaged due to this maneuver and its
 resulting contact on the ocean floor.

Thus, a problem exists in the art whereby damage occurs
to the fins of the underwater vehicle during bottom maneuvers.
The invention allows the lower quadrant fin(s) to retract as
the unmanned underwater vehicle settles on the ocean bottom.
Also when the vehicle is on the surface, the invention gives
the capability of controlling surface maneuvering.

10 The following patents, for example, disclose various
11 types of fins or rudders for underwater vehicles, but do not
12 disclose automatically retractable fins as occurs in the
13 present invention.

14	U.S.	Patent	No.	1,246,475	to	Schneider;	; .
15	U.S.	Patent	No.	3,093,105	to	Rebikoff;	
16	U.S.	Patent	No.	3,752,105	to	Hackett;	
17	U.S.	Patent	No.	3,805,540	to	Crabille;	
18	U.S.	Patent	No.	3,902,441	to	Scholle; a	and
19	U.S.	Patent	No.	5,235,926	to	Jones.	

20 Specifically, the patent to Schneider discloses a 21 submerging rudder for submarines. In particular, the device 22 therein is for the purpose of causing submerging rudders of 23 submarines to disappear or to be retracted during the periods 24 in which they are not required to operate, and thus 25 diminishing as far as possible the resistance offered by them 26 to the progress of the vessel or partly into the interior of 27 the hull. According to this invention the rudders which are

1 capable of being retracted into a recess in the interior of 2 the hull of the vessel, are rendered capable of pivoting, that 3 is to say, of operating by rotation, after their protrusion 4 from the said recess. For this purpose the rudder blade is 5 mounted on a rudder shank which can be kept permanently 6 retracted, and on which the rudder blade is adapted to slide 7 for the purposes of being protruded and retracted. The rotation of the rudder shank carries around with it the 8 9 sliding rudder blade and thus allows of rotating the latter 10 for steering purposes as desired as soon as it has been moved 11 out into its position of complete protrusion. Although the 12 rudder retracts into the submarine, it does not automatically 13 operate during an impact of the rudder against an obstacle. 14 Instead, the rudder is manually retracted.

15 Crabille relates generally to boat rudders, and more 16 specifically to an automatic flip-up rudder for use on air-17 boats and other boats wherein the rudder is the sole object 18 which protrudes beneath the hull. The rudder is adapted to 19 yieldably pivot in a vertical plane out of engagement with any 20 obstruction which may be encountered. The rudder is mounted such that it will be automatically returned to an effective 21 22 operating position after passing over the obstruction. 23 Further, it should be understood that Crabille is a spring-24 loaded rudder that can "break away" when striking an object 25 and retract automatically when the object has been cleared. 26 The retraction is exterior to the vehicle due to placement of 27 the rudder at the outset, and any retraction/restoration does

not affect the external volume of the vehicle. Instead, the
 rudder remains within the volume of water and does not alter
 the flowline of the vehicle.

The patent to Rebikoff relates to an arrangement 4 5 applicable to submarine vessels in which there is provided a submarine vessel having a pair of fins (or hydroplane) for 6 7 controlling the descent and ascent and stability of the vessel, wherein each fin is articulated about an axis sub-8 9 stantially perpendicular to the plane of the fin, whereby the 10 fin can fold back partially or wholly against the vessel on 11 striking an obstacle against the action of resilient means which normally hold the fin in its proper position. The fins 12 13 fold back when they strike an obstacle and once the obstacle has been cleared, regain their original position under the 14 action of a restoring spring or equivalent means. When the 15 16 fins are retracted totally or even partially, their action is evidently different from that in their normal position. 17 The 18 fins are always parallel to the direction of movement. The 19 shock causing retraction is therefore always perpendicular to the shaft at which the fin is articulated and there is there-20 21 fore no risk of deformation of this shaft. This patent, however, does not allow the fins to retract fully into the 22 23 body of the vehicle. If bottom operation were desirable, the fins taught by Rebikoff cannot completely recess into the 24 vehicle and damage would likely occur. Also, the fin could 25 still interfere with an obstacle since the surfaces are still 26 "exposed" when retracted. 27

The patent to Hackett discloses a rudder construction for 1 small boats, particularly sail boats, in which the rudder is 2 mounted on its rotatable support arm for pivotal movement on a 3 horizontal axis to prevent damage to the rudder in the event 4 that it strikes an obstruction in the water. A detent means 5 yieldably retains the rudder in its normal vertical position 6 or a horizontal or intermediate position. The tiller may be 7 manipulated to move the rudder to any of a plurality of 8 positions. More specifically, the design relates to a surface 9 craft rudder that will move up into a set number of preset 10 notches in the design. The device does not automatically 11 return into its operating position after object impact and 12 13 instead must be manually returned to an operating position. Further, the notched positions limit the number of positions 14 of the rudder and an infinite number of positions within the 15 16 fully extended and fully retracted range are not obtainable.

Scholle discloses a sailboat having retractable and self-17 ejectable hydraulic controls. A small lightweight sailboat of 18 19 the type readily transported in passenger vehicles such as station wagons and the like is provided with hydraulic 20 controls integrally and movably coupled to the hull of the 21 The hydraulic controls comprise rudder and 22 sail-boat. 23 centerboard assemblages, each of which are pivotally coupled to the hull of the sailboat in a manner enabling them to be 24 retracted and self-ejected when maneuvering the boat through 25 shallow waters or over submerged obstacles. Due to the manner 26 in which these hydraulic control assemblages are pivotally 27

coupled to the hull of the sailboat, they can be fully 1 2 retracted within the sailboat hull and onto the deck of the 3 sailboat and secured in their fully retracted positions for 4 storage when the sailboat is not in use or when preparing the 5 sailboat for overland transport. Retraction and storage of 6 the rudder assemblage is achieved by pivotally mounting the 7 rudder at the stern of the sailboat in a manner which permits the rudder to be rotated onto and laid flat upon the deck. 8 9 Retraction and storage of the centerboard assemblage is 10 achieved by pivotally mounting a centerboard within a 11 removable centerboard trunk in a manner which permits the 12 centerboard to be locked within the centerboard trunk and 13 released therefrom by controls housed within the trunk. Thus, 14 the rudder hinges upward upon obstacle impact but does not 15 return to operating position automatically. Although the 16 centerboard does spring load in the retracted position upon an 17 obstacle impact, manual intervention must be used to put the 18 centerboard back in an operation position when reaching a 19 fully retracted position. Further, the centerboard does not 20 rotate for steering and thus cannot retract in a rotated 21 position.

Jones discloses a pair of pivotally attached fins depending into the water below the hull of the boat. When turning maneuvers are executed, the tendency of the boat to skid sideward is resisted by the downwardly engaged fin panels. When underwater objects or the bottom of a body of water are encountered, the leading edge of the fins strike the

1 objects(s), causing the fins to pivot upward to clear the 2 obstacle(s) and then return automatically to the water to 3 provide an extra measure of boating safety. The fins are not 4 used for steering the vehicle and are simply hinged with no 5 spring loading. The stabilizers re-enter the water due to the 6 drag of two small wings extending normally from the 7 stabilizer. These wings will "grab" the water to pull the 8 stabilizers back down into the water. Spring energy is not 9 used herein and the stabilizers cannot rotate for steering.

In view of the prior art, there exists a need for providing a totally autonomous retraction control for a rudder that retracts out of the flow into the hull of the vehicle allowing bottoming of the vehicle with no damage to the rudder. The device should allow both low-speed control and high-speed maneuvering while allowing obstacle avoidance by permitting the rudder to bend out the way of debris.

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SUMMARY OF THE INVENTION

19 Therefore it is an object of this invention to provide a
20 bottom activated control device in an underwater vehicle.
21 Another object of this invention is to provide a bottom
22 activated control device in an underwater vehicle which
23 retracts fully within the hull of a vehicle.

Still another object of this invention is to provide a
bottom activated control fin in an underwater vehicle in which
the control fin is automatically retracted into the well

portion of the underwater vehicle upon contact of the control
 fin with an outside force other than fluid.

A still further object of the invention is to provide a bottom activated control fin in an underwater vehicle in which the control fin is automatically retractable even if the control fin is rotated with respect to the longitudinal axis of the underwater vehicle.

8 Yet another object of this invention is to provide a
9 bottom activated retractable control fin for an underwater
10 vehicle which is simple to manufacture and easy to use.

11 In accordance with one aspect of this invention, there is 12 provided a bottom activated retractable control device in an 13 underwater vehicle. The device includes a fin member having a 14 front edge, a trailing edge opposite to the front edge, a 15 bottom edge between the front edge and the trailing edge, and 16 an arm portion extending from and coextensive with the leading edge and away from the bottom edge. A pivot housing is 17 18 provided for receiving the arm portion of the fin member, the 19 housing enabling both a vertical pivot of the fin member upon contact of the fin with an object and axial rotation of the 20 21 fin about the arm portion of the fin member. A well is formed 22 in the bottom surface of the underwater vehicle, the well 23 corresponding in depth to a fully retracted position of the 24 fin member and in width to any rotated position of the fin 25 member. A spring member extends through the pivot housing and 26 the arm portion, the spring member normally biasing the fin member away from the vehicle, the fin member automatically 27

retracting into as much as an entirety of the well in response 1 to a force against the control fin. 2 3 BRIEF DESCRIPTION OF THE DRAWINGS 4 5 The various objects, advantages and novel features of this invention will be more fully apparent from a reading of 6 the following detailed description in conjunction with the 7 accompanying drawings in which like reference numerals refer 8 to like parts, and in which: 9 FIG. 1A is a bottom perspective view of a first preferred 10 embodiment of the present invention having retractable control 11 12 fins; FIG. 1B is a side view of the first preferred embodiment 13 14 according to FIG. 1A; FIG. 1C is an end view of the first preferred embodiment 15 16 according to FIG. 1A; FIG. 2 is a side view showing full vertical rotation of a 17 18 single control fin according to the preferred embodiment of 19 the present invention; FIG. 3A is a detailed perspective view of a single 20 control fin according to the preferred embodiment of the 21 present invention; 22 23 FIG. 3B is a detailed perspective view of the pivot housing of the prevention invention; 24 FIG. 4A is a perspective view of a single control fin 25 26 extending from a vehicle well according to the preferred embodiment of the present invention; and 27

FIG. 4B is a perspective view of a single control fin 1 retracted into the vehicle well according to the preferred 2 embodiment of the present invention. 3 4 5 DESCRIPTION OF THE PREFERRED EMBODIMENT In general, the present invention is directed to a bottom 6 activated retractable control surface such as a fin 10 for an 7 undersea vehicle 12, in which the bottom mounted control 8 surface 10 automatically retracts into the body of the vehicle 9 10 12. Referring first to FIGS. 1A, 1B, and 1C, there is shown 11 an underwater unmanned vehicle 12 having two separate bottom 12 activated control surfaces/fins 10 mounted thereto. The 13 unmanned underwater vehicle 12 is shown in FIG. 1A from a 14 bottom perspective, in FIG. 1B from the side, and in FIG. 1C 15 from an end thereof. The vehicle 12 includes a bottom surface 16 14, a front end 16, and a rear end 18 opposite that of the 17 front end 16. A well portion 50 is formed in the bottom 18 surface 14 of the vehicle for receiving fins 10 when 19 retracted. 20

It is intended that this vehicle 12 is designed for 21 bottom operations and the potential damage to the lower 22 control surfaces 10 is significantly reduced (or possibly 23 eliminated) with the retractable feature of the control fins 24 A fixed control surface would be damaged during bottom 25 10. It should be understood, however, that the scope 26 operations. of this invention is not intended to be limited by the 27

specific example herein and may be applied to other craft
 which are likely to encounter such resistance.

FIG. 2 illustrates the control fin 10 of the present 3 invention, including a full range of motion thereof. The 4 intent of the graphic is to show the rotational path of the 5 fin 10 from a full-extended position 22 to full-retracted 6 The normal operating position of the control fin 7 position 24. 10 is the extended position 22. The rotation to the retracted 8 position 24 is initiated by contact of the fin 10 with an 9 object or a bottom surface of a body of water and associated 10 11 with forward and/or vertical motion of the vehicle 12 settling 12 on the bottom.

FIG. 3A illustrates additional details of the retractable 13 control surface/fin 10. The control fin 10 includes a leading 14 edge 34, a trailing edge 36, an upper surface 38, and a bottom 15 In the preferred embodiment, each of the upper surface 40. 16 surface and the bottom surface are substantially parallel to 17 18 each other. It can be seen from the figures that the fin 10 in fact resembles an airplane fin due the steering and 19 maneuvering capability thereof. In addition, a projection arm 20 42 extends from the leading edge 34 of the fin 10 at the upper 21 surface 38 thereof. A pivot pin 43 is positioned in the 22 projection arm 42 perpendicular to the plane of fin 10. 23

24 Referring now to FIG. 3B, the control fin 10 is mounted
25 to a pivot housing 30 by means of the pivot pin 43 of the
26 control fin 10. The pivot housing 30 and pivot pin 43 are
27 mechanically linked to a torsional spring 32. More

1 specifically, the pivot housing 30 is substantially block 2 shaped and includes a longitudinal hole 44 formed therethrough 3 and a slotted portion 46 at a lower central part thereof. 4 Projection arm 42 extends into slot 46. The slot 46 is 5 defined by depending legs 48 as shown. At the outer sides of 6 the depending legs 48, the pivot pin 43 is rotatably mounted 7 such that the pivot pin 43 extends through the depending legs 8 48. In a preferred embodiment, torsional springs 32 are 9 joined between pivot pin 43 and housing 30 on each side of 10 housing 30.

11 The spring 32 is pre-loaded with the control fin 10 in 12 the extended 22 or down position shown. Rotation of the 13 control fin 10 is initiated by forward and/or upward contact 14 of the control fin 10 with an object such as the bottom of the 15 ocean. This contact is mainly due to the vehicle 12 gliding 16 or hovering down to rest on the bottom. The fin 10 is 17 normally biased in the extended position 22.

18 An actuator (not shown) rotates a control shaft 26 and 19 hence the pivot housing 30 about a vertical axis of the pivot 20 housing 30. The control shaft 26 thus controls rotation of 21 the fin 10 about the control shaft rotation axis. This 22 rotation is controlled by the vehicle. Steering control of 23 the fin 10 is not the intended feature of the present 24 invention and will not be explained further herein. Still 25 further, it should be understood that the "vertical" rotation 26 of the control fin 10 is the result of contact with an 27 external object. It is possible to vertically rotate the

control fin 10 while it is in any point of rotation about the vertical axis of the control shaft 26. This is a substantially advantageous feature and one which has not been previously known in the art.

5 FIG. 4 illustrates the retraction of the control fin 10 6 in combination with the well portion 50 of the vehicle 12. The control fin 10 is illustrated in both its extended 22 and 7 8 retracted 24 position. As described with reference to FIG. 9 1B, the retraction well 50 is a recessed pocket in the bottom 10 surface 14 of the vehicle 12. The lower portion of the well 11 50 is flush with the bottom surface 14 of the vehicle 12. The 12 control fin 10 is capable of being completely retracted into 13 the well 50 and protected from damage from the bottom and 14 weight of the vehicle 10. Likewise, retraction of the fin 10 15 may be at any of a plurality of retracted degrees depending 16 upon the amount of contact with the fin and a distance away 17 from the object contacted.

18 The retraction well 50 is shaped in an angular form, 19 which matches the angular sweep of the control fin 10 as 20 rotated by the pivot housing 30 and the control shaft 26. Once again, this feature allows the control fin 10 to retract 21 22 into or extend from the well 50 at any angle of fin operation. The control fin 10 does not have to be parallel with the 23 24 vehicle axis (straight) for it to operate or for it to extend 25 from or retract into the well 50.

26 Thus, the present invention also allows an unmanned
27 underwater vehicle 12 to have surface capability. The

inventive control fins 10 on the bottom of the vehicle 12 give
 the vehicle rudder control while on the surface of the water.
 By allowing the control fins 10 to retract, the bottom
 maneuver can take place without damaging the fins 10.

5 It will be understood that the torsional spring 32 may be 6 reduced in pre-loaded torque to allow the fin 10 to retract at certain higher speeds of the vehicle 12. Accordingly, the 7 8 faster the vehicle 12 travels, the more the fin 10 can 9 retract, due to drag on the fin(s). The slower the vehicle 12 10 travels, then the more the fin 10 will extend due to reduced 11 drag. This alternative is an added bonus, because research 12 has shown that controllability at low speeds is more difficult 13 and the extra extension of fin 10 will provide additional 14 control. The higher speed operations will benefit in 15 efficiency by having the fins 10 retracted and thereby causing 16 less drag on the vehicle 12.

Further, the size of the invention may be changed to
accommodate the task and all parts can be enlarged or
miniaturized. Spring tension may also be changed to
accommodate the task at hand.

Accordingly, it is anticipated that the invention herein
will have far reaching applications other than those of
underwater vehicles.

This invention has been disclosed in terms of certain embodiments. It will be apparent that many modifications can be made to the disclosed apparatus without departing from the invention. Therefore, it is the intent of the appended claims

to cover all such variations and modifications as come within
 the true spirit and scope of this invention.

1 Attorney Docket No. 79355 2 3 BOTTOM ACTIVATED RETRACTABLE CONTROL SURFACE FOR AN UNMANNED UNDERSEA VEHICLE 4 5 ABSTRACT OF THE DISCLOSURE 6 7 A bottom activated retractable control device includes a fin member having a front edge, a trailing edge opposite to 8 the front edge, a bottom edge between the front edge and the 9 10 trailing edge, and an arm portion extending from and 11 coextensive with the leading edge and away from the bottom 12 The arm portion includes a pivot pin extending in a edge. 13 perpendicular direction from each side of the arm portion. А 14 pivot housing having an aperture is provided for receiving the pivot pin of the arm portion, the housing enabling both a 15 16 vertical pivot of the fin member upon contact of the fin with 17 an object and axial rotation of the fin about the arm portion 18 A well is formed in the bottom surface of of the fin member. 19 an underwater vehicle corresponds in depth to a fully 20 retracted position of the fin member and in width to any 21 rotated position of the fin member. A spring member is joined 22 between the pivot housing and the pivot pin, the spring member 23 normally biasing the fin member away from the vehicle, the fin 24 member pivoting into as much as an entirety of the well in 25 response to a force against the control fin.





FIG. 2









FIG. 3A



FIG. 3B