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TOWED ARRAY DEPLOYMENT SYSTEM FOR UNMANNED SURFACE VEHICLES

STATEMENT OF GOVERNMENT INTEREST

[0001] The invention described herein may be manufactured and used by or for the Government of the United States of America for Governmental purposes without the payment of any royalties thereon or therefor.

CROSS REFERENCE TO OTHER PATENT APPLICATIONS

[0002] None.

BACKGROUND OF INVENTION

1) Field of the Invention

[0003] The present invention is directed to a method and system for the deployment and retrieval of linear arrays off of Unmanned Surface Vehicles (USVs).

2) Description of Prior Art

[0004] Sonar systems are used to determine the direction of propagating underwater signals and hence the location of the source of these signals. Sonar systems utilize arrangements or arrays of sources and receivers to detect arriving signals and to determine the direction from which these signals originated.

For example, appropriate time delays applied to the receivers serve to steer the array and to calculate the direction of arrival of the incoming signals.

[0005] Some such systems are known generally as towed arrays and are towed behind surface ships, submarines and Unmanned Undersea Vehicles (UUVs). Unmanned Surface Vehicles (USVs) are currently being developed to perform a variety of missions including deploying and retrieving linear acoustic arrays. USVs are relatively small craft with lengths ranging from approximately 7 to 11 meters.

[0006] Handling systems on USVs must fit within tight space and conform to weight limits. Current USV handling systems for towed systems (including linear arrays) store the towed array on the deck of the USV and utilize a mechanical over-boarding system to deploy the towed array. The over-boarding system includes a winch located on deck to handle the cable and some type of over-boarding mechanism to get the array in and out of the water. The mechanism also includes some type of traction winch or mechanism to pull the array off the winch drum and into the water for deployment.

[0007] Since the towed array is similar to a flexible rope that is constructed to be pulled, the towed array cannot be very easily pushed. Therefore, an ideal method of deploying a flexible array is to have the array pulled off the craft and

into the water. Once a sufficient length of the array is in the water, the hydrodynamic drag of the array towed through the water, combined with the array and cable weight, will pull the remaining array and cable off the winch.

SUMMARY OF THE INVENTION

[0008] The present invention is directed to the use of a submerged tube that is flushed with the fluid in which a watercraft is located (e.g., seawater). The fluid is propelled or forced through the tube, drawing the towed array through the interior of the tube and out an end of the tube.

[0009] The tube is attached to the small surface watercraft below the waterline in order that the tube, including the ends of the tube disposed adjacent the stern of the watercraft are submerged. One of these ends houses the aft portion of the towed array.

[0010] In one embodiment, the fluid is propelled through an open valve and the interior of the tube using the forward motion of the watercraft. The propelled fluid creates a pressure difference inside the tube between the valve and exit hole. The pressure difference forces water through the tube and the drag of water moving over the array will force the array to exit out the tube and begin deployment.

[0011] In another embodiment, a pump is used to propel the fluid though the interior of the tube. This embodiment is suitable for slow speed deployment (i.e., when the watercraft is traveling at a relatively slow speed or is stationary).

[0012] In accordance with one exemplary embodiment, the present invention is directed to a system that is used for towed array deployment. This system includes a small surface watercraft capable of defining a waterline along the hull of the watercraft. A tube is attached to the watercraft below this waterline. The tube includes two open ends and a fluid injection system disposed between the two open ends in order to introduce fluid into an interior of the tube.

[0013] A winch is attached to the watercraft preferably on the deck of the watercraft. The winch is disposed adjacent a first one of the two open ends of the tube. A tow cable and towed array are stored on the winch and extend from the winch through the first open end and at least partially through the interior of the tube. This arrangement facilitates deployment of the towed array by the fluid introduced into the interior by the fluid injection system to deploy from the winch, along the interior of the tube and out a second one of the two open ends.

[0014] A preferred shape of the tube is non-rectilinear so that both of the open ends of the tube are disposed adjacent a

stern of the watercraft. In another embodiment, both of the open ends are disposed aft of the fluid injection system.

[0015] In yet another embodiment, the fluid injection system includes a pump having an intake in communication with a fluid and a discharge line in communication with the interior of the tube - adjacent the first end of the tube.

[0016] In still another embodiment, the fluid injection system includes at least one valve. This valve, when in an open position, permits passage of fluid into the interior of the tube. Preferably, the valve is disposed adjacent the bow of the watercraft.

[0017] In still another embodiment, the tube has a U-shape and is positioned with the ends of the U-shape corresponding to the open ends of the tube and disposed adjacent a stern of the watercraft. In this embodiment, the fluid injection system is a valve that permits passage of a fluid into the interior of the tube. This valve is disposed along a curved bottom of the U-shape and adjacent a bow of the watercraft.

[0018] The present invention is also directed to a method for deploying a towed array from a small surface watercraft. In accordance with this method, fluid is introduced into an interior of a tube disposed on a surface watercraft below the waterline of the watercraft. A portion of a towed array is disposed in the interior of the tube. The introduced fluid is

used to draw the towed array through the interior of the tube and out one of two open ends of the tube that is disposed adjacent a stern of the watercraft.

[0019] In one embodiment, in order to introduce the fluid, a valve attached to the tube is opened to permit passage of the fluid into the interior. The motion of the watercraft is used to propel the fluid through the valve and along the interior of the tube. In an alternative embodiment, the fluid is introduced into the tube using a pump attached to the tube to propel the fluid into and along the interior of the tube.

[0020] In still another embodiment, the towed array is stored on a winch disposed on the watercraft. The towed array is fed from the winch through another of the two open ends of the tube and into the interior. Drawing the towed array through the interior of the tube deploys the towed array from the winch.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] A more complete understanding of the invention and many of the attendant advantages thereto will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein like reference numerals and symbols designate identical or corresponding parts throughout the several views and wherein:

[0022] **FIG. 1** is a schematic representation of an embodiment of a towed array deployment system in accordance with the present invention;

[0023] **FIG. 2** is a schematic representation of another embodiment of the towed array deployment system; and

[0024] **FIG. 3** is a schematic representation of yet another embodiment of the towed array deployment system.

DETAILED DESCRIPTION OF THE INVENTION

[0025] Referring initially to **FIG. 1**, an exemplary embodiment of a towed array deployment system **100** in accordance with the present invention is illustrated. The towed array deployment system includes a small surface watercraft **102** having a stern **118** and a bow **120**. Suitable small surface watercraft include, but are not limited to Unmanned Surface Vehicles (USVs), manned vessels and semi-submersibles.

[0026] In general, the watercraft has an overall length **106** of less than 12 meters and preferably in the range of 7 meters to 11 meters. As used herein, the overall length of the watercraft, in feet or meters, is measured from the foremost part of the bow to the aftermost part of the stern, including any fixed projections extending beyond the bow and stern.

[0027] The watercraft **102**, when either at rest or moving through the water includes a waterline **104** (representative of

the fluid in which the watercraft floats). The towed array deployment system also includes an external tube **116** attached to the watercraft **102** below the waterline **104**. A through hull access tube portion **151** can also be provided that passes through the hull of the watercraft **102** so that an end **306** of the tube is located on the deck **150** of the watercraft.

[0028] The tube **116** is a hollow tube having an interior that is sized to accommodate passage of a deployed towed array. Suitable materials for the tube are compatible with the environment and could include metals, composites and plastics. In the embodiment as illustrated, the length of the tube **116** ranges from approximately 0 meters to 20 meters, excluding any through-hull access tube portion **151**. The tube **116** can be a separate structure that is mounted or fixed to the hull of the watercraft **102**. Alternatively, the tube **116** can be integrated into the structure of the hull.

[0029] Referring now to **FIG. 2** and **FIG. 3**, the tube **116** includes two open ends **202**. Although the tube can be straight, preferably the tube has a non-rectilinear shape. This non-rectilinear shape facilitates both of the open ends of the tube **116** being located adjacent the stern **118** of the watercraft **102**. Therefore, the towed array **110** is deployed behind the watercraft **102** with the deployment aided by the motion of the watercraft. In addition, one open end **306** can be used to insert the towed

array **110** into the interior of the tube **116**, and the other open end **308** can be used to deploy the towed array. The top of the u-shape corresponds to the ends **202** of the tube **116**. The bottom or rounded portion of the u-shape **152** is located adjacent to or around the bow **120** of the watercraft **102**.

[0030] The towed array deployment system **100** also includes a fluid injection system disposed between the two open ends to introduce fluid into an interior of the tube **116**. The fluid injection system is preferably located below the waterline **104**.

[0031] In one embodiment as illustrated in **FIG. 2**, the fluid injection system includes at least one valve **204**. Suitable valves include, but are not limited to gate valves and ball valves, pneumatic valves, control valves, check valves and solenoid valves and combinations thereof. The valve **204** is attached to or disposed on the tube **116**, and, when in an open position, permits passage of the fluid (in direction "A") into the interior of the tube. The motion of the watercraft **102** (in direction "B") is used to propel the fluid through the valve **204** and into and through the interior of the tube **116** to one of the open ends of the tube. This motion carries the towed array **110** out of the open end **308** of the tube **116**. In order to facilitate entry of the fluid through the valve **204**, the valve is located adjacent the bow **120** of the watercraft **202**. Preferably, the valve **204** is not located at the forward most position of the

tube **116**, but is located along the length of the tube back slightly from the bow **120** of the watercraft **102** toward the end of the tube through which the towed array **110** is deployed. This alignment encourages the injected fluid to flow through the interior of the tube **116** in the desired direction.

[0032] In one embodiment as illustrated in **FIG. 3**, the fluid injection system includes a pump **302**, preferably disposed below the waterline **104** of the watercraft **102**. Suitable pumps are known and available to those ordinarily skilled in the art. As would be understood by one of ordinary skill in the art, the pump **302** includes an intake and a discharge. In accordance with the present invention, the intake is in communication with a fluid and the discharge line is in communication with the interior of the tube **116**.

[0033] In another embodiment, the discharge line of the pump **302** is in fluid communication with the interior of the tube **116** adjacent a first end **306** of the tube. Therefore, the pump **302** propels fluid substantially along the length of the tube **116**.

[0034] In one embodiment, a valve **304** is provided between the discharge line of the pump **302** and the interior of the tube **116**. Although illustrated as either a valve or a pump, the fluid injection system could include both the valve **304** and the pump **302** to handle deployment of the towed array **110**.

[0035] The towed array deployment system **100** also includes a winch **108** attached to the watercraft **102**. Although the winch **108** could also be located below the waterline **104**, preferably, the winch is located on the deck **150** of the watercraft. Suitable winches are known to those skilled in the art and are commercially-available.

[0036] The winch **108** is disposed adjacent the first one **306** of the two open ends of the tube **116**. In one embodiment, the first end is located on the through-hull portion **151** of the tube. In addition to the winch **108**, one or more pulleys or sheaves may be necessary to help guide the towed array and towed array cable **112** between the winch and the open end of the tube.

[0037] Before deployment, the towed array **110** is stored on the winch **108** and extends from the winch through the first open end and at least partially through the interior of the tube **116**. A tow cable can also be provided between the end of the towed array **110** and the winch **108**. The electronics for the towed array **110** are routed through the towed array and tow cable and through the winch into the signal processing system aboard the watercraft **102**, as is currently understood by one skilled in the art.

[0038] The towed array **110** is deployed from the winch **108**, along the interior of the tube **116** and out a second one **308** of the two open ends. The fluid introduced to the interior by the

fluid injection system is used to draw the towed array **110** through the interior of the tube **116**. Therefore, in a stored position, a suitable length of the towed array **110** is disposed between the fluid injection system and the second end of the tube. After deployment is complete, the winch **108** is used to retrieve the towed array **110** and to return the towed system to a stowed position.

[0039] In using a towed array deployment system **100** to deploy the towed array **110** from the watercraft **102**, fluid is introduced into the interior of the tube **116** that is disposed on the watercraft below the waterline **104**. A portion of a towed array **110** is positioned in the interior of the tube between the fluid injection point and the discharge end of the tube. The fluid introduced into the interior of the tube **116** draws the towed array through the interior of the tube and out through one of two open ends of the tube that is disposed adjacent a stern **118** of the watercraft **102**. In one embodiment, a valve **204** attached to the tube to permit passage of the fluid into the interior is opened, and the motion of the watercraft **102** is used to propel the fluid through the valve and along the interior of the tube. Alternatively, a pump **302** attached to the tube **116** is used to propel the fluid into and along the interior of the tube.

[0040] The towed array **110** is stored on a winch **108** disposed on the watercraft **102** and is fed from the winch through another

of the two open ends of the tube opposite the discharge end of the tube and into the interior. Drawing the towed array **110** through the interior of the tube **116** deploys the towed array from the winch **108**.

[0041] An advantage of the towed array deployment system and method of the present invention is the provision of a simple method of deploying a flexible line array from a small surface watercraft without having to stow the entire array on a winch.

[0042] It will be understood that many additional changes in details, materials, steps, and arrangements of parts which have been described herein and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

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TOWED ARRAY DEPLOYMENT SYSTEM FOR UNMANNED SURFACE VEHICLES

ABSTRACT

A towed array deployment system is provided that uses the flow of fluid through the interior of a tube to deploy a towed line array. The system includes a small surface water craft such as an unmanned surface vehicle having a length between seven and eleven meters and a U-shaped tube mounted to the outside of the hull of the watercraft below the waterline. A towed array is fed from a winch aboard the surface craft, through one end of the tube, and the fluid is introduced through into the interior of the tube to force the towed array for deployment through the tube and out a second end of the tube near the stern of the watercraft.

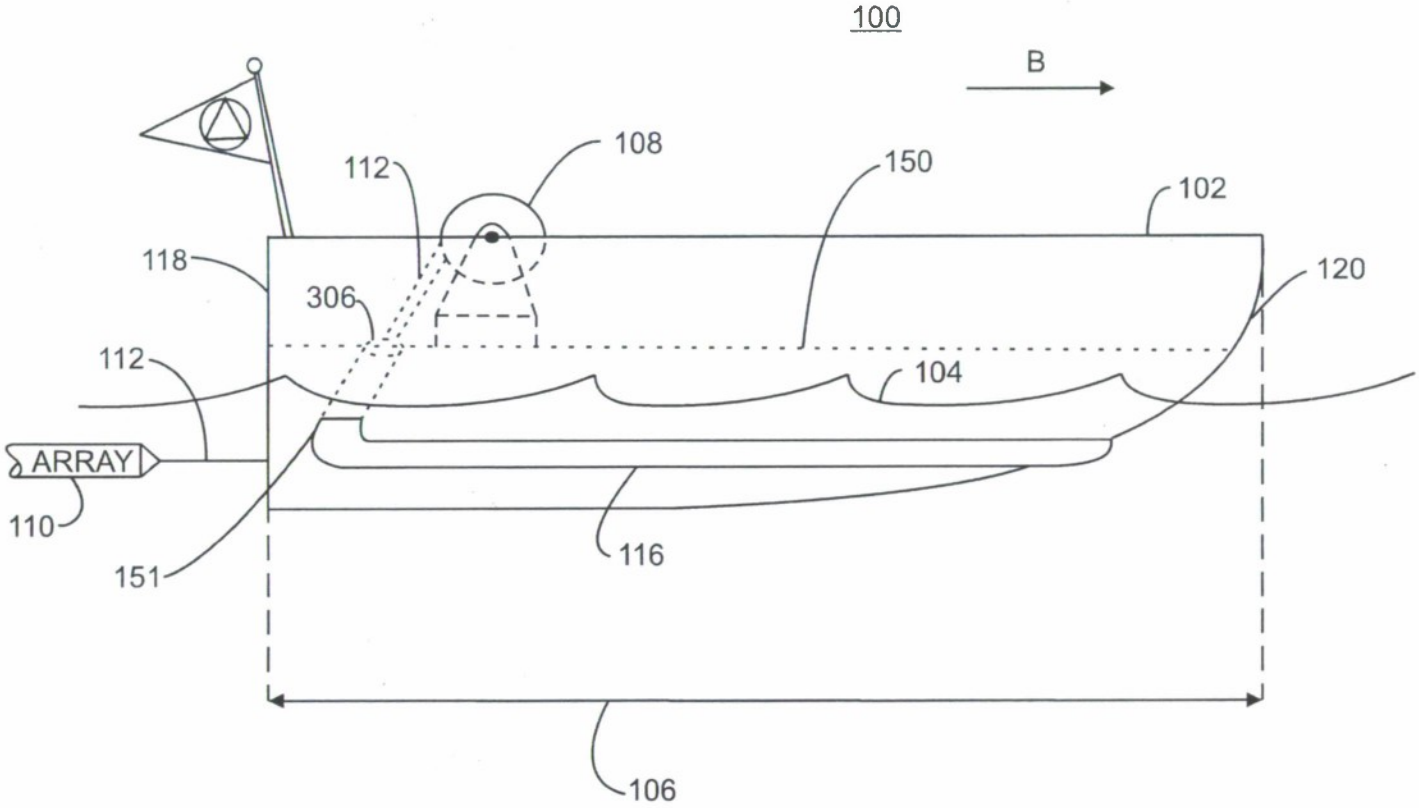
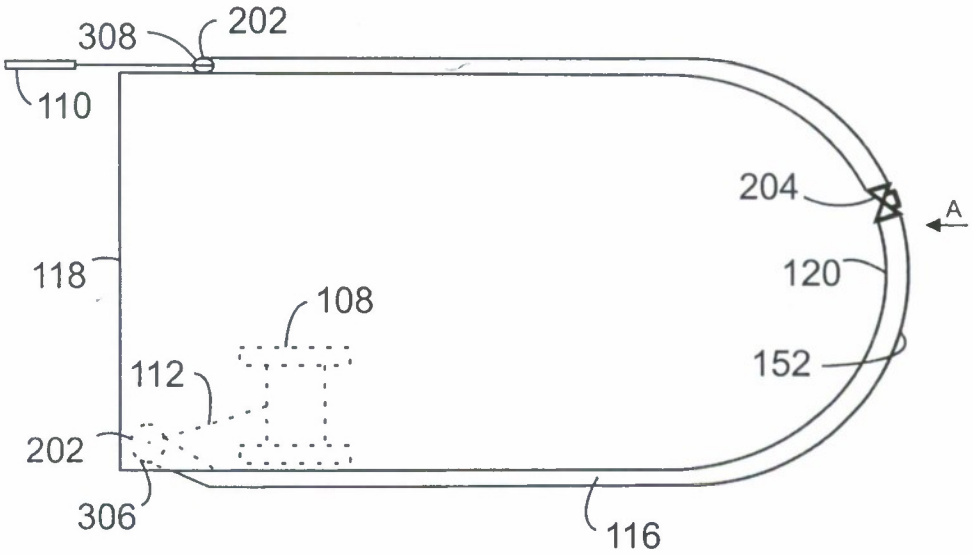


FIG. 1


308
202
110
204
A
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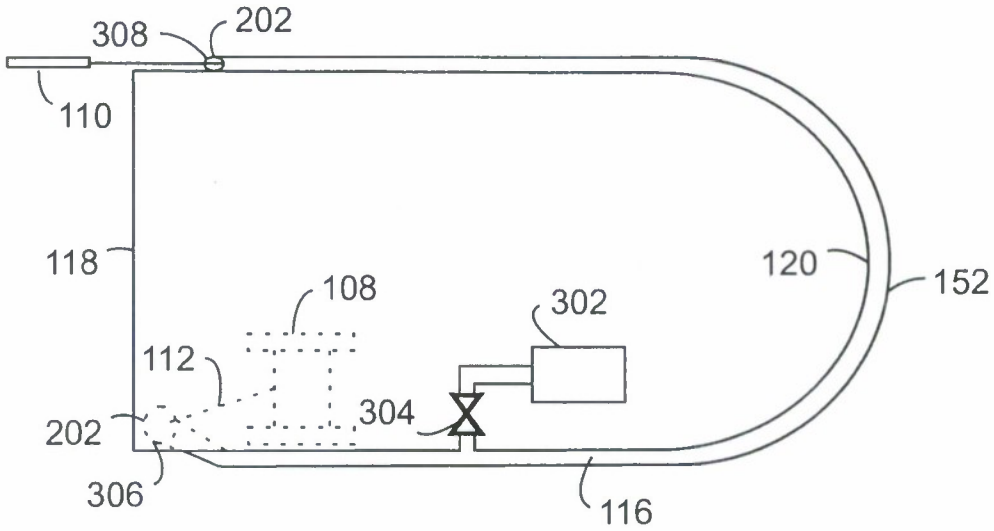
108
152
112
202
306
116

FIG. 2


308
202
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202
306
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FIG. 3