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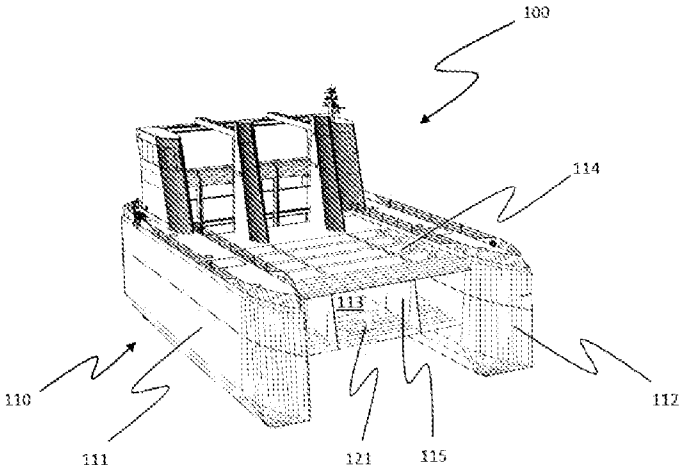
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(73)	Proprietor	ORCAS AS, Ruglandveien 13, 1358 JAR, Norge
(72)	Inventor	Arne Hygen Tørnkvist, Ruglandveien 13, 1358 JAR, Norge
(74)	Agent or Attorney	ONSAGERS AS, Postboks 1813, Vika, 0123 OSLO, Norge

(54)	Title	**A marine vessel and a method for removing debris particles from a water column**
(56)	References Cited:	GB 1503459 A, CN 108468317 A, US 2013146519 A1, JP S55119294 U, JP H0310983 A, CN 108202845 A
(57)	Abstract	

It is disclosed a marine vessel and methods suitable for removing buoyant debris particles from a water column in an autonomous manner. The vessel comprises a hull construction; a longitudinal stabilization passage constrained in space by the structure of the hull construction and a debris collecting device for collecting debris containing water. The vessel may also comprise a haulage system enabling automatic or semi-automatic emptying of the debris collection device into a larger debris storage container.



Title: A marine vessel and a method for removing debris particles from a water column

Technical Field

The present invention relates generally to a marine cleanup vessel, in particular a marine vessel for removing buoyant debris, such as plastic, from a water column.

Background

The global annual plastic consumption has exceeded 320 mill tons, wherein between 4 and 12 million tons end up in the ocean. Plastic is generally a durable material which is resistant to natural biodegradation processes. Consequently, it does not readily break down in the marine environment. In order to protect marine life from the harm caused by plastic pollution, solutions for marine cleanup must be developed and initiated.

US 5,456,197 discloses a barge-like vessel for removing buoyant debris comprising a front mounted collection basin. The vessel also includes a haulage system comprising a track so that the collecting basket may be lifted from the skimming or collection position and moved rearwardly to dump contents into a hold in the vessel. The deeper the collecting basin is submerged, the more debris it will collect. However, the deeper the collecting basin is submerged, the more drag force it will cause.

Further haulage systems for the same purpose are disclosed by JPH 0310983 A, JPS 5174392 A, JPS 55119294 U, wherein winches, wire ropes and roller guides are incorporated.

JPS 5259490 A discloses a ship developed for collecting oil spill from the water surface into an oil spill tank, where seawater and oil is separated. To improv the water surface conditions during the collection process, the ship provides shelter from wind by means of a passage formed in the hull. CN 202147827 U disclose the same principle, but where the passage is formed between the two hulls of a catamaran and connected bottom and top plates.

JPS 5332587 A disclose a ship developed for separating oil spill from sea water. Between the hulls of a catamaran, a series of parallel inclined plates are arranged to erase the entering waves. The calmed water surface facilitates the subsequent oil/water separation. The series of plates contribute to lift oil in the water column.

SE 341668 disclose a vessel developed for separating oil spill from seawater. Between the hulls of a catamaran, a submerged separation table is horizontally

arranged. The water depth of the separation table is adjusted in such a way that it separates an oil containing water layer from a water column. The oil containing layer is lead on the topside of the separation table into a collecting chamber from which oil is pumped into storage tanks onboard the vessel.

GB 1503459 A discloses a boat for collecting floating material comprising twin hulls with a collecting cage located in the channel between them and one or more water jet units between the hulls adjacent the bows for guiding and moving the material into and through the channel and into the cage. The jet unit comprises a cylinder with a plurality of jet nozzles and a drive for angularly adjusting the cylinder about its axis for altering the direction of the water jets. Pumps draw water from the channel and supply it to units via control valves for adjusting the supply rate. A solid or mesh guide plate is provided in the channel. The cage is moved by a hoist.

CN 108468317 A discloses a river trash removal equipment, in particular to river trash rapid removal equipment for municipal administration. The river trash removal equipment aims at achieving the technical effects of removing trash conveniently and being multifunctional and highly efficient. In order to achieve the technical effects, the river trash removal equipment comprises a boat body and a fixing frame is fixedly arranged on the front side of the boat body, and the fixing frame is provided with a collection net. The river trash removal equipment can carry out filtration in the trash collection process and can salvage solid matter conveniently.

US 2013146519 A discloses a collecting device (1) for pollution on a water surface (9), the collecting device (1) including tight side walls (11), a tight end wall (12), a top portion (13), floating means (2), an inlet portion (15) and an aft collecting portion (17), and the collecting device (1) further including a channel portion (16) between the inlet portion (15) and the collecting portion (17), and the bottom portion of the collecting device being capable of through-put.

CH 108202845 A discloses a robot for automatically cleaning up garbage on the water surface and an automatic cleaning method for the garbage on the water surface. The robot comprises a catamaran, a pan-tilt rotationally arranged on the upper portion of the catamaran, a camera device mounted on the pan-tilt, a power device arranged below the catamaran and used for driving the catamaran to move and steer, a power supply mounted in the pan-tilt and used for supplying power for the robot, and a circuit module mounted in the pan-tilt and electrically connected with the pan-tilt, the camera device, the power device and the power supply. The robot provides an automatic cleaning method of the garbage on the water surface, and manual intervention is not needed. Automatic identification of the surrounding garbage can be achieved, and the efficiency of garbage salvaging is improved.

It is an object of the invention to mitigate at least some of the shortcomings of the prior art, and to obtain further advantages.

Further, the invention has the objective of providing a marine cleanup vessel which can operate autonomously.

Summary of the Invention

Said objectives are fully or partially achieved by a vessel and the methods according to the independent claims. Preferred embodiments are set forth in the dependent claims.

According to a first aspect, the invention relates to a marine vessel for removing debris particles from a water column, in particular buoyant debris particles. The vessel comprises a hull construction having a bow portion and an aft portion arranged along a direction of travel.

The hull construction comprises a first longitudinal hull part, a second longitudinal hull part arranged in parallel to the direction of travel of the first longitudinal hull part and a base interconnecting the first and second longitudinal hull parts.

The first and second longitudinal hull parts are, when not ballasted or evenly ballasted, oriented parallel to the water surface when submerged in a body of water and the base extends in the direction of travel along at least a part of the length of the first and second longitudinal hull parts.

The hull construction further comprises a longitudinal stabilization passage constrained in space by at least the first longitudinal hull part, the second longitudinal hull parts and the base where the base is located below the longitudinal stabilization passage.

The longitudinal stabilization passage further comprises a water column inlet and a water column outlet, wherein the water column outlet is closer to the aft portion of the hull construction than the water column inlet.

The vessel also comprises a debris collecting device (DCD) arranged at or near the water column outlet for collecting debris containing water. The term ‘near’ signifies a deviation from the exact location that would still serve the purpose of the debris collecting device, that is, collecting debris containing water after having been sufficiently stabilized during the movements through the longitudinal stabilization passage in order to ensure an effective collection of debris.

The invention relates to a vessel of the above-described type and which further comprises openable blocking or sealing means / device arranged at or near the DCD for hindering flow of water through the water column outlet and a water drainage / opening located in or near a downstream end of the base, i.e. the end of the two longitudinal ends of the base along the direction of travel situated closest to the water column outlet. The geometrical size of the water drainage / opening is adapted to at least partly receive the DCD there within. The vessel further comprises ballasting means / device for adjustment of the trim of the hull construction relative to the water surface of the body of water into which the vessel is submerged. A specific example of ballasting means is fluid-communicating ballast tanks arranged within the longitudinal hull parts. Thus, a vessel is obtained whose cleanup operation is neither affected by the water surface conditions nor the turbulence below the water surface. Furthermore, the cleanup operations may be performed without significant movements of the vessel. This is considered an advantage, in particular in waters with a high density of debris / debris particles.

It is also described that the longitudinal stabilization passage is configured such that the average upwards velocity of debris particles in the water column having entered the water column inlet increases relatively to the initial average upwards velocity of the debris particles immediately upstream of the water column inlet. The reason for the increase may largely be credited to the constrained environment of the water column in the longitudinal stabilization passage set up by the longitudinal hull parts and the base. The average upwards velocity signifies herein the mean upwards velocity of a debris particle averaged during a specific time interval, for example a time interval of 1 second, 2 seconds, 3 seconds or 5 seconds. The size of the relative increase of the debris upwards velocity within the water column compared to debris upwards velocity upstream of the water column inlet will differ depending on the size and nature of the debris particles and how turbulent the water is upstream of the water column inlet.

Example A: In the situation where the water upstream of the water column inlet is completely calm, then the stabilization passage will give very little effect since the water column is already stabilized before it enters the stabilization passage. The buoyant debris upwards velocity would therefore already be close to the “terminal rise velocity” which means the maximum upwards velocity the debris particle has in a complete stabilized water column.

Example B: In the situation where the prevailing wave and/or wind upstream of the water column inlet is according to state three on the Beaufort Scale, and the stabilization passage stabilizes the water column similar to state one on the Beaufort Scale, then the debris particles will approach their individual “terminal rise velocity” during their journey through the stabilization passage. The increase in mean upwards velocity may for

example be 20% or higher compared to mean upwards velocity upstream the water column inlet. The exact gain is depending on the size, type and nature of the debris.

In an embodiment he DCD may comprise filtering means / filtering device for separating at least a portion of the debris from the debris containing water, thus allowing water to escape from the hull construction. The filtering device may be integrated or replaceable, for example a mesh filter with a specific mesh size adapted for filtering debris down to a minimum size.

The base may have a longitudinal shape where its longitudinal and transversal direction is oriented parallel and perpendicular to the longitudinal direction of the hull parts, respectively.

In an embodiment the hull construction may further comprise at least a vertical plate connected to the base. The vertical plate(s) is/are configured to divide the longitudinal stabilization passage in the direction perpendicular to the direction of travel into at least two longitudinal stabilization passage sections.

Note that the term 'vertical plate' signifies herein a plate having a vertical component. In one specific example the horizontal component may be absent or insignificant. The vertical plate may extend a part along the longitudinal length of the hull construction, such as at least 40 % of the length, more preferably at least 60 % of the length, for example 80 %.

The marine vessel may further comprise an elongated object such as one or more stainless metal rods arranged upstream of, or at, the water column inlet in order to avoid that large buoyant objects enter the longitudinal stabilisation passage and thereby affect the efficiency of the clean-up operation and/or damage the DCD.

Moreover, the marine vessel may comprise a debris compression system in order to reduce the volume of extracted debris particles and thereby increase the storage capacity. Such a debris compression system is considered known in the art and is therefore not described in further details herein.

In an embodiment the invention also relates to a vessel of any of the above-described types further comprising mooring means / device and guiding means / device such as booms attachable to or near the bow portions of the hull construction. The guiding means is configured and arranged relative to the hull construction to allow guiding of a flow of water towards and into the water column inlet.

By deploying a vessel as described above in for example rivers and/or at river mouths, debris particles can be extracted before reaching the ocean. With use of appropriate guiding devices such as booms, debris particles running down the river can be effectively gathered and collected. This is advantageous since debris particles reaching the ocean from rivers has the potential of spreading over a very large area. Subsequent collection of debris particles would then be much more difficult and time consuming.

In an embodiment, in order to temporary store the collected debris particles, the vessel of any of the above-described types may further comprise a debris storage container having a detachable arrangement to the hull construction, most preferably at or near the aft portion of the vessel. The debris storage volume of the debris storage container is typically larger than the debris storage volume of the debris collecting device, for example more than 5 times larger. To avoid unintentional spill from the debris storage container at sea, it may comprise an openable closure which remains closed in between the emptying process of the DCD. The openable closure may for example be a curtain roll that is operated by motors. The motors may be activated by sensors to ensure opening and closing just before and just after emptying of debris particles from the DCD, respectively.

In an embodiment the vessel of the above mentioned type may also comprise a haulage system comprising a winch, a handling device such as a handling arm pivotably connected to the debris collecting device, a wire connected at a first end to the winch and at a second end to the handling arm, and a rail system extending from the water column outlet and/or the water drainage to a region/location above the debris storage container. The wire may be running through one ore more sheaves arranged on one or more overhead trolleys. The rail system should enable movement restriction of the DCD along the direction of the rail system only. The rail system preferably comprises a continuous rail.

The particular configuration of the DCD may be switched between an embodiment of the first aspect using filtering means such as a mesh filter, hereinafter also called a 'Trawling Mode', and the second aspect using openable blocking means and a water drainage, hereinafter also called a "Heavy Duty Mode", by use of the haulage system and without the need of human intervention.

For example, DCD may comprise a fixing means / device such as a ring or a hook in order to allow a pivotable connection with a handling device such as a handling arm or handling fork, which handling device is further pivotably connected to the end of the wire situated opposite of the winch. The DCD may further comprise a rail guide configured to establish a moveable coupling with the rail system, for example a protrusion being slidable within the tracks of the rail system. The arrangement of the

fixing means and the rail guide on the DCD is such that, when the wire is pulled in by the winch, the DCD will be guided by the rail system while performing a rotation. The direction of the rotation may be from an initial position where the opening of the DCD is facing in an upstream direction to a position where the opening is facing in an upward direction relative to the base when going from the Trawling Mode to the Heavy Duty Mode. The DCD is afterwards placed within the water drainage.

Likewise, when going from the Heavy Duty Mode to the Trawling Mode, the direction of rotation may be from an initial position where the opening of the DCD is facing upwards relative to the base to a position where the opening is facing upstream relative to the water flow.

The debris collecting device (DCD) may be designed as a cuboid with four edges and eight corners, wherein the debris fixing means / device is arranged at or near one or more of the cuboid's external edges and the rail guide is arranged at or near one or more of the cuboid extern edges other than the edge(s) with the debris fixing means / device, for example at one of the adjacent edges.

When the haulage system is used for emptying the debris collecting device for debris particles, the debris containing DCD may be guided by the rail system until it is emptied into the debris storage container by use of the haulage system. Correct placement of the fixing means and the rail guide ensures that the initial rotation and vertical movement from the base / water drainage takes place without significant spilling of its content.

The emptying of the debris particles contained in the DCD may take place by enforcing a subsequent rotation of the DCD after the initial vertical movement to a degree where the opening of the DCD is facing at least partly downward, preferably fully downward. Such a subsequent rotation may be ensured by the combined use of the hauling system and a bent section of the rail system arranged at and/or above the debris storage container. Additional positioning of the DCD relative to the debris storage container may be obtained by horizontal displacement of an overhead trolley with one or more sheaves constituting part of the haulage system.

The DCD may comprise a penetrable filtering means / filtering device for separating at least a portion of the debris from the debris containing water, thus allowing water to escape from the hull construction while collecting the debris particles into the DCD. The filtering device may be integrated or replaceable, for example a mesh filter with a specific mesh size adapted for filtering debris particles down to a minimum particle size.

The described embodiment concerning the haulage system of the debris collecting device enables the vessel to handle the collected debris in an automated manner, making it well suited for autonomous operation.

In an embodiment the vessel can be powered by solar energy by use of solar panels. Alternatively, or in addition, the vessel can be powered by hydrogen or any liquified fuel such as LPG (liquified petroleum gas), LNG (liquified natural gas) or diesel, or any compressed gas such as CNG (compressed natural gas). Any combination of said powering means may also be envisaged. Use of solar panels are considered particularly beneficial for autonomous vessels since such use will significantly reduce, or even completely eliminate, the need of recharging / refueling.

According to a second aspect, the invention relates to a method for removing debris particles, in particular buoyant debris particles, from a water column using a marine vessel submersed in a body of water.

The vessel of the second aspect comprises a hull construction having a bow portion and an aft portion arranged along a direction of travel, comprising a first longitudinal hull part, a second longitudinal hull part arranged in parallel to the direction of travel of the first longitudinal hull part and a base / floor interconnecting the first and second longitudinal hull parts. The base extends in the direction of travel along at least a part of the length of the first and second longitudinal hull parts. The hull construction further comprises a longitudinal stabilization passage constrained in space by at least the first longitudinal hull part, the second longitudinal hull parts and the base. The base is located below the longitudinal stabilization passage. The longitudinal stabilization passage further comprises a water column inlet and a water column outlet, where water column outlet is closer to the aft portion of the hull construction than the water column inlet, The vessel of the seventh aspect also comprises a debris collecting device (DCD) arranged at or near the water column outlet for collecting debris containing water, openable blocking means / device or sealing means / device arranged at or near the DCD for hindering flow of water through the water column outlet, a water drainage / opening located in or near a downstream end of the base, wherein the geometrical size of the water drainage is adapted to at least partly receive the DCD there within, and ballasting means / device for adjustment of the trim of the hull construction. The ballasting means may for example include fluid-communicating ballast tanks located in the hull parts.

The method comprises the steps of:

- lowering the DCD at least partly into the water drainage / opening;
- allowing water to flow into the stabilization passage through the water column inlet;
- optionally allowing stabilization of the water column during flow of water through the stabilization passage by increasing the average upwards velocity of the debris particles in the water column having entered the water column inlet relative to the initial average upwards velocity of the debris particles immediately upstream of the water column inlet;

- blocking flow of water through the water column outlet by use of the openable blocking means / device, for example by use of watertight lamellae curtains;
- lowering the aft part of the vessel relative to the water surface while optionally elevating the forward (bow) part of the vessel by use of the ballasting means until the base at the vessel's bow portion is raised above the water surface;
- subsequently raising the vessel relative to the water surface by way of the ballasting means while maintaining the bow portion of the base above the waterline; and
- allowing water confined in the stabilization passage to flow through the DCD and to exit through the water drainage / opening, preferably via the filtering means of the DCD.

The advantages of the above described method of the second aspect is the same as the advantages of the vessel according to the first aspect.

Any of the above-mentioned methods may include a debris storage container for detachable arrangement at or near the aft portion of the vessel. The internal debris storage volume of the debris storage container is typically larger than the internal debris storage volume of the DCD.

In an embodiment the vessel may also include a haulage system comprising a winch, a handling device such as a handling arm or fork pivotably connected to the DCD, a wire connected at a first end to the winch and at a second end to the handling device, or alternatively connected directly to the DCD in absent of a handling device, and a rail system of the type described above extending from the water column outlet and/or the water drainage located in or near a downstream end of the base. The DCD and the haulage system may be configured such that the DCD is moveable along the rail system. The rail system preferably comprises a continuous rail. The wire may run through one or more sheaves arranged on one or more overhead trolleys, preferably horizontally displaceable overhead trolley(s).

The method may further comprise the steps of:

- moving the DCD along the rail system by way of the haulage system from a first position at or near the water column outlet and/or the water drainage to a second position above the debris storage container;
- tilting / rotating the DCD to the extent that debris particles are transferred from the DCD to the debris storage container;
- optionally back-flushing the DCD; and
- transporting the debris collecting device along the rail system by us of the haulage system from the second position above the debris storage container back to the first position at or near the water column outlet and/or the water drainage.

The described embodiment of the method enables handling of the collected debris particles in an automated manner, making it well suited for autonomous operation.

The back-flushing of the DCD while hanging above the debris storage device in the emptying position may be performed by exposing the filtering means inside the DCD for compressed fluid such as water in order for objects / particles, still attached to the filter means after performing the emptying procedure of the DCD, to be released and fall into the storage device. The exposure of compressed fluid may be obtained by one or more nozzles directed towards the opening of the debris storage container, for example below the bent section of the rail system, though above in height to the opening of the debris storage container.

Brief Description of Figures

The invention will now be described with reference to the exemplifying embodiments shown in the accompanying drawings, wherein:

Fig. 1a shows a front perspective of the vessel according to the invention;
Fig. 1b shows a front perspective of the vessel of fig. 1a with installed solar panels;
Fig. 2a shows a rear perspective of the vessel of fig. 1a;
Fig. 2b shows a rear perspective of the vessel of fig. 1b;
Fig. 3 shows a top view of the vessel of figs. 1a and 2a;
Fig. 4 shows a vertical cross-section of a vessel according to the invention operating in a first operational mode, where fig. 4A shows an enlarged drawing of the top most part of the rail system;
Figs. 5-8 show vertical cross-sections of a vessel according to the invention operating in a second operational mode, where fig. 5A shows an enlarged drawing of the top most part of the rail system;
Fig. 9 shows a top view of a vessel according to the invention in a third operational mode;
Figs. 10-12 show vertical cross-sections of a vessel according to the invention, illustrating a procedure for emptying debris in a debris storage container of the vessel according to the first operational mode, where figs. 10A-12A show enlarged drawings of the debris collecting device (DCD); and
Figs. 13-16 show vertical cross-sections of a vessel according to the invention, illustrating a procedure for emptying debris in a debris storage container of the vessel according to the second operational mode.

Detailed description

Fig. 1a and Fig. 2a show a front perspective and a back perspective, respectively, of a marine vessel 100 which is suitable for cleanup of polluted waters, e.g. an ocean, a river or a lake. The vessel 100 gathers buoyant debris particles and separates the debris particles from the water before the debris particles are stored and offloaded. A typical example of buoyant debris particles is buoyant plastic. Hereinafter, the term 'debris particle' will be abbreviated 'debris'.

The vessel 100 can be run on hydrogen, liquid fuel, LPG, CNG, LNG, solar panels, etc. or any combination thereof. The debris recovery operation can continue for the duration of the energy reserve. However, the vessel is preferably adapted to operate autonomously. One embodiment is illustrated in Fig. 1b and 2b where the vessel 100 is seen equipped with solar panels 101 configured to collect solar energy for continuous operation in sea. By equipping the vessel 100 with solar panels 101 and batteries, the vessel can be partly or completely self-sufficient with energy. Furthermore, to prolong the duration of the energy reserve the vessel 100 is designed to reduce the energy consumption relative to the amount of debris recovered. In the specific illustrated embodiment, the solar panels 101 are placed horizontally relative to the sea plane.

When operating without a crew, the vessel 100 can be controlled or monitored from a remote location, for example by an onshore control system via satellite communication systems. All operational activities are preferably fully automated without any need for human labor.

The vessel 100 further comprises a debris collecting device (DCD) operably connected to an automatic haulage, storage and offloading system (AHSO-system). Propulsion can be ensured by a traditional propulsion system / propulsion means 103 arranged in the aft portion of the vessel 100.

Buoyant debris collecting system

Figs. 1a, 1b, 2a, 2b and 3 show a catamaran-type hull construction 110, where Fig. 3 shows the vessel 100 from a top view.

However, a skilled person would understand that alternative constructions can be used, such as mono-hulls or other multi-hulls.

The illustrated catamaran 110 comprises two hull parts 111, 112 of the same size which are arranged side by side in parallel. Each hull part 111, 112 extends in the longitudinal direction from an aft portion to a bow portion. The hull parts 111, 112 are connected by a base or floor 113. Additional strength of the hull construction 110 is achieved by means of a strengthening deck 114 interconnecting the hull parts

111,112. The strengthening deck 114 are in the specific embodiment shown arranged above the floor 113.

Note that the relative terms 'below' and 'above' refer herein to the water surface when the vessel 100 is submersed in water.

The floor 113 extends the entire, or substantially the entire, longitudinal length of the two hull parts 111, 112. The floor 113 can alternatively extend beyond the longitudinal length of the two hull parts 111, 112.

With the specific placement of the hull parts 111,112 and the floor 113, a stabilizing passage 120 is formed between the two hull parts 111, 112 and above the floor 113. The stabilizing passage 120 extends the entire length of the overlapping longitudinal length of the two hull parts 111, 112 and is vertically restricted downwards by the floor 113.

The stabilizing passage 120 is preferably divided into a plurality of longitudinal passage sections 125 by use of vertical plate(s) 115 connected between the floor 113 and the strengthening deck 114. The stabilizing passage 120 has a water column inlet 121 in a bow portion and a water column outlet 122 in an aft portion. Hence, with the above configuration the stabilizing passage 120 is suitable for receiving and stabilizing a water column above the floor 113. The height of the received water column depends on the vertical position of the floor 113 relative to the water surface (corresponding to the water depth if the floor 113 is submerged in the water). The vertical position of the floor 113 can be adjusted, for example by way of ballasting means and/or mechanical means. Division into longitudinal passage sections 125 is particularly advantageous when the stabilizing passage 120 is wide, for example more than 50 % of the longitudinal length of the hull parts 111,112, as the divisions into passage sections 125 will have a stabilizing effect on the vessel 100.

Again, with particular reference to fig. 3, the floor 113 has a longitudinal length (from the aft portion to the bow portion) which is longer than the perpendicularly oriented transverse width.

Further, the stabilizing passage 120 has a length from the water column inlet 121 to the water column outlet 122 being long enough to make the passage suitable for stabilizing a water column adequately for buoyant debris to experience a substantial rise within the water column.

In open sea, turbulence caused by waves leads to vertical mixing and distribution of buoyant debris in a water column. The buoyant debris thus move deeper as a function of worsened sea condition. This makes the cleanup more energy consuming as a larger volume of water must be filtered. If the water column is stabilized, i.e.

turbulence is reduced or avoided, the buoyant particles will move towards the surface. The longer the water column is stabilized, the closer to the surface the debris gets. By stabilizing the water column for a sufficient amount of time, the vast majority of the buoyant debris will experience a significant rise towards the surface. This will reduce the required depth of the debris collecting device and thereby the required volume of water to be filtered, and thus reduce the drag force of the vessel which again reduces the amount of energy consumed in removing the same amount of debris.

The vessel 100 is designed to be scaled to different sizes. In one scale of the vessel 100, the floor 113 has a longitudinal length of 40 meters and a width of 30 meters. At a speed of 2 knots [1,0289 m/s] it takes 38,9 seconds from the time a plastic piece enters the water column inlet 121 until it is captured by a debris collecting device (DCD) 130. If the plastic piece has a vertical velocity of 0,02 m/s in a stable water column, then the same plastic piece has moved approximately 0,78 meters closer to the surface when it reaches the DCD 130.

Depending on the density of debris and water conditions the vessel 100 can shift between different modes of operation.

Fig. 4 shows a vertical cross-section of the vessel 100 in a first operational mode, also called 'Trawling Mode" having similarities to a fishing boat trawling for fish, the vessel 100 is in this mode configured to continuously clean up the water that enters the water column inlet 121 during forward movements.

This mode is mostly intended for debris recovery in waters containing a high or medium density of buoyant debris, for example a debris density between 10 kg/km^2 and 5000 kg/km^2.

In a typical operation, the floor 113 is submerged to a suitable water depth and kept substantially levelled by way of ballasting means located for example within the hull parts 111,112. A water column, typically having a height of 3-5 meters, enters the water column inlet 121. The water column heights may however be higher or lower than these typical heights.

As the water column travels through the stabilizing passage 120 it will experience a stabilization causing buoyant debris to rise in the water column as mentioned above. The time it takes for a water column to travel through the stabilizing passage 120 depends on the speed of the water column; a speed that is mainly depending on the speed of the vessel 100. Hence, the propulsion speed of the vessel 100 may thus be adjusted, and thereby also the stabilization time.

The floor 113, especially its bow portion and aft portion, is hydrodynamically shaped to provide as little drag force as possible. Between the aft portion and the

bow portion of the vessel 100, the floor 113 has a straight elongated middle portion. In the embodiment shown in Fig. 4, both the top surface and the bottom surface of the middle portion of the floor 113 is flat. The bottom surface may have alternative shapes, e.g. following the contour of the bottom surface of the hull parts. However, the top surface should preferably be flat in order to ensure a smooth and predictable operation.

The floor 113 may also be provided with apertures / openings to reduce the dampening effect of floor 113 wherever that has a beneficial effect on how the vessel moves when expected wave heights and wave periods increases.

Shelter from wind may be provided by the hull parts 111, 112.

A water column enters the water column inlet 121, travel through the stabilizing passage 120 and exit through the water column outlet 122 without being restricted. In order to recover debris, the only required restriction of the water column in the stabilizing passage 120 is a debris collecting device (DCD) 130 as mentioned above. The DCD 130 has the objective of separating debris from the water. To do so, it must filter the water. Water is thus allowed to pass through the DCD 130, while debris is restrained. Several types of filtering means 131 can be used, e.g. traditional water filters, wire mesh or permeable fabrics. However, for an effective operation the type of filtering means should preferably be such that the DCD 130 causes low drag force and high debris collecting efficiency.

The DCD 130 of Fig. 4 is in the form of a cuboid (basket, box, etc.) that may be submerged to a suitable water depth within the stabilizing passage 120 at or near the water column outlet 122. The desired submerged water depth depends primarily on the distribution of the buoyant debris in the water column.

The DCD 130 may be submerged to a water depth corresponding to the vertical distribution of the debris in the water column in order to optimize the recovery of debris from the water column. An increase of the size of the filtering area of the DCD 130 is proportional with increase in the drag force. Hence, it follows that the drag force caused by the DCD 130 increases as deeper the DCD 130 is submerged. For the DCD 130 to achieve maximum recovery at the lowest possible submerged position, it should preferably be positioned at the location of the stabilizing passage 120 where the debris have been rising in the stabilized water as long as possible. As explained above, the debris upwards velocity may be further enhanced by exposing the water column with bubbles using a compressed gas system.

The exemplified DCD 130 of Fig. 4 includes a rigid box with an upstream DCD opening 135 and a downstream filtering side with filtering means 131 (see e.g. fig. 10). The upstream DCD opening 135 is hence facing towards the water column inlet 121, i.e. upstream, during collection of debris. The DCD 130 has a geometry

adapted to cover the entire width of its associated stabilizing passage 120. Alternatively, if several DCDs 130 are used, each DCD 130 has a geometry independent of the width of each passage section 125. The DCD 130 may include filtering means 131 such as a disposable or reusable filter 131. Alternatively, or in addition, the DCD 130 may be provided with integrated filtering means 131.

It is considered highly advantageous that the above described cleanup process does not harm the maritime life. Because the DCD 130 does not have to be submerged all the way down to the floor 113, there may be a gap between the DCD 130 and the floor 113. This gap allows marine life such as fish to exit the stabilizing passage 120, thereby avoiding being captured within the DCD 130. The filtering means 131 causes a small pressure build-up in the DCD 130, which again creates a water cushion in front of the filtering means side. This water cushion may prevent marine life from getting trapped in the DCD 130, since submerged buoyant debris has an upwards velocity in stabilized water, while marine life has not.

Fig. 5 – 8 show cross-sections of the vessel 100 in different stages of a second operational mode. This mode, also called "Heavy Duty Mode", is intended for debris recovery in waters with a very high amount of buoyant debris, for example a buoyant debris density of more than 1 kg/m^2. Instead of recovering debris from a continuous flow of water due to forward movement of the vessel 100, this mode takes one volume of water at the time.

Fig. 5 shows the initial stage of the second operational mode. The floor 113 displays a water drainage / opening 123 in the aft portion, near the water column outlet 122. The drainage 123 is adapted to receive a debris collecting device (DCD) 130 similar to the DCD 130 described for the first operational mode. However, in the second operational mode, the DCD 130 is rotated compared to the first operational mode, thus having the DCD opening 135 oriented upward relative to the water surface and the floor 113.

Sealing means or blocking means 124 are provided in the aft portion of the floor 113 to block the water column outlet 122 such that water is hindered to flow there through. The sealing means 124 can be installed and retracted as required. In the illustrated embodiment of Fig. 5, the retractable sealing means 124 is in the form of a lamella-curtain-like wall lowered/ hoisted vertically. One or a plurality of sealing means 124 can be used for the stabilizing passage 120, alternatively each passage section 125, and can be guided and held in place by a suitable rigid structure. Elastomeric seals may be provided in the contact area between the sealing means 124 and the rigid structure.

In the initial step of the second operational mode, as illustrated in Fig. 5, the water column outlet 122 of the stabilizing passage 120 or passage sections 125 are closed

by closing the sealing means 124 and fitting the DCD 130 within the water drainage 123 in the floor 113.

A number of water drainages 123 and debris collecting devices 130 are preferably provided. When the vessel 100 is ballasted in such a way that at least the bow portion of the floor 113 is substantially submerged, a water column is allowed to enter the water column inlet 121. As soon as the stabilizing passage 120 or passage sections 125 are filled with water and a collectable amount of debris, the second stage of the second operational mode can be initiated.

Fig. 6 shows the second stage of the second operational mode. The vessel 100 is given an aft trim by moving ballast water from the bow to the aft, for example from a bow ballast tank to an aft ballast tank, until the bow portion of the floor 113 is above sea level. The water in the stabilizing passage 120 is then isolated from the surrounding water. When the vessel 100 has an aft trim and the bow portion of the floor 113 is above sea level, the stabilizing passage 120 and the sealing means 124 form a basin in which a body of water and its debris 102 (illustrated as filled circles) can be confined.

Fig. 7 shows the third stage of the second operational mode. The vessel 100 is de-ballasted by pumping out water evenly from the ballast tanks, causing the vessel 100 to rise and thereby the captured water to be sucked through the water drainage 123 into which the DCD 130 is arranged. The water thus exits through the filtering means 131 while the debris 102 is collected within the DCD 130. The minimum size of the collected debris 102 in the DCD 130 depends on the type of filtering means used.

Fig. 8 shows the vessel 100 in a stage of the second operational mode wherein all the confined water has been drained and only the debris 102 is left in the DCD 130. The vessel 100 is now ready for a new cycle and may be re-ballasted back to its initial trim.

Fig. 9 shows a top view of the vessel 100 in a third operational mode. This mode, also called “River Mode”, is intended for debris recovery in waters with a natural water current such as a river stream or ocean current. In the third operation mode the vessel 100, similar or equal to the vessel 100 described above, is moored with mooring lines such that the water column inlet 121 is oriented towards the direction of the current. Water will then flow through the stabilizing passage 120 even though the vessel 100 is kept stationary. In this mode propulsion means 103 are redundant or optional, thereby being less energy consuming compared to the first and second mode.

In order to cover a wider area than the area of the stabilizing passage 120, the vessel 100 may comprise one, preferably two, water guiding means such as booms 104.

Each boom 104 is connected to the bow portion of a hull part 111, 112 and extends outwardly away from the vessel 100 forming a debris collecting funnel. In a river or river mouth, such booms 104 can be arranged to cover an extensive part of the river.

Haulage, storage and offloading system

Figs. 10 – 12 show vertical cross-sections of the vessel 100, where the framed drawings on the right shows the DCD in more details. After one or several operational cycles according to any of the above-mentioned operational modes, the DCD 130 starts to fill up. Hence, to allow the DCD 130 to be automatically emptied during operation, the inventive vessel 100 is further equipped with an automated haulage, storage and offloading system, also called AHSO-system. This system renders autonomous operation of the vessel 100 possible.

The AHSO-system described in the following is suitable for all operational modes of the vessel 100.

As mentioned above, the DCD 130 may in one embodiment have a cuboid form. When viewed from the side, and with reference to fig. 10, the perpendicular corner edges of the DCD 130 are shown as bottom left corner edge (BL), bottom right corner edge (BR), top left corner edge (TL) and top right corner edge (TR).

In the embodiment of figs. 10-12, the DCD 130 comprises the following components:

BL: A primary rail guide or wheel assembly 132 running inside a rail system 141. This particular corner edge is the only corner edge that runs inside and along the rail system during the entire emptying cycle, and is located at the corner edge at the side opposite to the DCD opening 135.

BR: A distance piece 134 which has no function in the Trawling Mode (first operational mode), only in heavy duty mode (second operation mode). See figs. 13-16.

TR: A fixing means 133 for rotatable connection to a handling arm 147 and/or a wire 143 constituting part of the AHSO-system. This fixing means 133 ensures that the DCD 130 may be hoisted by a winch 146 connected to the wire 143 in this point and to be rotated to ensure that the loss of content of debris 102 is avoided or minimized during an emptying cycle. Since the AHSO-system is located higher than the DCD 130, the DCD will freely rotate along its vertical movement along the rail system 141, a rotation that in the embodiment shown in figs. 10-12 is used to empty the DCD 130 by turning the DCD opening 135 downward.

TL: A distance piece 134 that together with the wheel in BL keeps the DCD 130 in a vertical position when hoisted upwards. The distance piece 134 is free to move in/out from the reel.

The DCD 130, or each DCD 130, is operably connected to the AHSO-system 140 which may comprise:

- A rail system or rails 141 to which the DCD 130 is pivotably connected via the wheel assembly 132 (similar to a wheel system on a rollercoaster vehicle). The rails 141 may be covered by two or more rubber gaskets to avoid that the rails 141 are clogged by debris. The rails 141 may further extend from a position at the water column outlet 122 and/or in the water drainage 123 of the floor 113 to a location above a debris storage container 105 having a debris storage volume being typically a multiple number of times larger than the storage volume of the debris collecting device 130. The rails 141 may have a vertical portion enabling the DCD 130 to be vertically displaced by the AHSO-system 140 relative to the floor 113. As best seen in figs. 4-5, the top of the vertical portion of the rails 141 includes a bent section 141a, where the first bent after the vertical section leads the DCD 130 into a horizontal part oriented towards the aft direction of the vessel 100. The horizontal part of the bent section 141a ends at a location above or nearly above the debris storage container 105. At its aft end of the horizontal part of the bent section 141a, the rails 141 make a U-turn to flip the box / DCD 130 such that DCD opening 135 at least partly facing towards the open side of the debris storage container 105 (see fig. 12). The rails 141 may be arranged in connection with the rigid structure of the sealing means 124.
- A winch 146, suitable for pulling in and feeding out a wire 143 as described below.
- A flexible handling arm 147, pivotably connected to the DCD 130. The flexible handling arm 147 may be shaped like a fork and connected at two corners along the TR corner edge of the DCD 130. Further, the flexible handling arm 147 may be configured to freely rotate 360 degrees. As mentioned above, the connecting points of the flexible handling arm 147 is located at or near the corner edge of the DCD opening 135, i.e. diagonally opposite to the wheel assembly 132.
- The wire 143, connected at a first end to the flexible handling arm 147 and a second end to the winch 146.
- A sheave 144 arranged on an overhead trolley 145, through which the wire 143 runs. The sheave 144 enables full wire tension and correct wire angle for the entire travel of the DCD 130 along the rails 141.

Fig. 10 shows the DCD 130 being elevated by the AHSO-system. The sheave 144 is moved slightly towards the bow portion of the vessel 100 compared to the operational mode. The DCD 130 is raised above the sea level to allow the inside water to drain.

If the DCD 130 is used in the first operational mode (Trawling Mode) or the third operational mode (River Mode), it will be rotated during the movement upward such that the open side is oriented upward to prevent debris 102 from falling out. The rotation of the DCD 130 may be achieved by the above described pivot connections with the rails 141 and the handling arm 147. When the winch 146 pulls in the wire 143, the DCD 130 will travel along the rails 141 while rotating relative to the rails 141.

If the DCD 130 is used in the second operational mode (Heavy Duty Mode), it will not be rotated as the DCD opening 135 is already upwardly oriented when the emptying cycle commences.

Fig. 11 shows the DCD 130 located at the top of the vertical part of the rail 141. The pivotal connections of the DCD 130 connecting the DCD 130 to the handling arm 147 and the rails 141 ensure that the DCD 130 is tilted in a way which keeps the debris 102 inside the DCD 130. At this point the overhead trolley 145 with the sheave 144 is moved towards the aft portion of the vessel 100 until it reaches a horizontal position approximately above the debris storage container 105.

Fig. 12 shows the DCD 130 in the process of emptying the debris content into the debris storage container 105. When a plurality of DCD 130 are used, they may all share one common debris storage container 105. With the DCD 130 positioned in the U-turn portion of the rails 141, the wire 143 running over the sheave 144 is fed out such that the DCD 130 is tilted with the DCD opening 135 facing at least partly downward. All or a major amount of the collected debris 102 will then leave the DCD 130. Any remaining debris 102 can be removed from the DCD 130 and transferred into the debris storage container 105 by means of a back-flushing device, for example by use of a compressed water system injecting water onto the filtering means 131. The DCD 130 is then returned to a position in the water column outlet 122 or in the water drainage 123 by use of the AHSO-system 140.

When the debris storage container 105 is full, it can be detached from the vessel 100. A suitable storage container lid may be used to close the filled debris storage container 105 prior to detachment.

To detach the debris storage container 105 from the vessel 100, the vessel 100 may be given an aft trim such that the debris storage container 105 reach water level and can float away from the vessel 100. The debris storage container 105 is thus preferably configured to float even when fully loaded with debris 102.

Empty debris storage containers 105 can be made available onboard the vessel 100 and/or be supplied by other vessels / facilities, for example at offshore locations. In this way the vessel 100 can maintain a continuous operation.

A full storage container 105 can be collected or towed to shore by another vessel.

The features of all the devices of this description are also relevant for all the methods of this description, and vice versa.

Figs. 13-16 shows identical or similar emptying procedure as shown and described with reference to figs. 10-12, but during the second operational mode (Heavy Duty Mode). As best seen in fig. 13, the DCD 130 is initially arranged within the water drainage 123 with the DCD opening 135 upward. The activation of the AHOS system 140 by pulling the wire 143 in using the winch 146 causes the DCD 130 to move vertically upwards along the rail system 141 without any rotation (fig. 14) until the wheel assembly 132 reaches the start of the bent section 141a (fig. 15). From there on, the DCD 130 experiences a counterclockwise rotation that with the DCD opening 135 at least partly facing the opening of the debris storage container 105.

In the preceding description, various aspects of the marine vessel according to the invention have been described with reference to the illustrative embodiment. For purposes of explanation, specific numbers, systems and configurations were set forth in order to provide a thorough understanding of the vessel and its workings. However, this description is not intended to be construed in a limiting sense. Various modifications and variations of the illustrative embodiment, as well as other embodiments of the vessel, which are apparent to persons skilled in the art to which the disclosed subject matter pertains, are deemed to lie within the scope of the present invention.

Reference numerals

100 – marine vessel
- 101 – solar panel
- 102 – debris / debris particles
- 103 – propulsion means / propulsion system
- 104 – boom
- 105 – debris storage container

110 – hull construction / catamaran
- 111 – first longitudinal hull part
- 112 – second longitudinal hull part
- 113 – base / floor
- 114 – strengthening deck
- 115 – longitudinal plate
- 116 – roof

120 – passage / stabilizing passage
- 121 – water column inlet
- 122 – water column outlet
- 123 – water drainage
- 124 – blocking means / sealing means / sealing plate / curtain-like wall
- 125 – passage sections

130 – debris collecting device (DCD)
- 131 – filtering means / mesh filter
- 132 – primary rail guide / wheel assembly
- 133 – fixing means / ring / hook
- 134 – distance piece
- 135 – DCD opening

140 – haulage system / automatic haulage, storage and offloading (AHOS) system
- 141 – rail / rail system
  - 141a – bent section
- 143 – wire
- 144 – sheave
- 145 – overhead trolley
- 146 – winch
  - 146a – winch support
- 147 – handling arm / handling fork / handling device

CLAIMS

1. A marine vessel (100) for removing debris particles (102) from a water column, comprising:
   - a hull construction (110) having a bow portion and an aft portion arranged along a direction of travel, comprising:
     - a first longitudinal hull part (111);
     - a second longitudinal hull part (112) arranged in parallel to the direction of travel of the first longitudinal hull part (111);
     - a base (113) interconnecting the first and second longitudinal hull parts (111, 112), wherein the base (113) extends in the direction of travel along at least a part of the length of the first and second longitudinal hull parts (111, 112);
     - a longitudinal stabilization passage (120) constrained in space by at least:
       - the first longitudinal hull part (111),
       - the second longitudinal hull parts (111,112) and
       - the base (113), the base (113) being located below the longitudinal stabilization passage (120),
     - wherein the longitudinal stabilization passage (120) further comprises:
       - a water column inlet (121) and
       - a water column outlet (122), the water column outlet (122) being closer to the aft portion of the hull construction (110) than the water column inlet (121),
   - a debris collecting device (130) arranged at or near the water column outlet (122) for collecting debris containing water;

   c h a r a c t e r i z e d b y

   - openable blocking means (124) arranged at or near the debris collecting device (130) for hindering flow of water through the water column outlet (122);
   - a water drainage (123) located in or near a downstream end of the base (113), wherein the geometrical size of the water drainage (123) is adapted to at least partly receive the debris collecting device (130) there within; and
   - ballasting means for adjustment of the trim and elevation of the hull construction (110) relative to the sea surface.

2. The marine vessel (100) in accordance with claim 1, wherein the debris collecting device (130) comprises filtering means (131) for separating at least a portion of the debris particles (102) from the debris containing water.

3. The marine vessel (100) in accordance with claim 1 or 2, wherein the hull construction (110) further comprises
   - a vertical longitudinal plate (115) connected to the base (113), wherein the vertical longitudinal plate (115) is configured to divide the longitudinal stabilization passage (120) in the direction perpendicular to the direction of travel into at least two longitudinal passage sections (125).

4. The marine vessel (100) according to any preceding claim, further comprising:
   - mooring means; and
   - guiding means (104) attachable to or near the bow portions of the hull construction (110), wherein the guiding means (104) is configured and arranged relative to the hull construction (110) to allow guiding of a flow of water towards and into the water column inlet (121).

5. The marine vessel (100) according to any preceding claim, further comprising:
   - a debris storage container (105) for detachable arrangement at or near the aft portion of the vessel (100), wherein the debris storage volume of the debris storage container (105) is larger than the debris storage volume of the debris collecting device (130).

6. The marine vessel (100) according to claim 5, further comprising
   - a haulage system (140) comprising
     - a winch (146);
     - a handling device (147) pivotably connected to the debris collecting device (130),
     - a wire (143) connected at a first end to the winch (146) and at a second end to the handling device (147), wherein the wire (143) is passed over at least one movable sheave (144); and
   - a rail system (141) extending from at least one of
     - the water column outlet (122) and
     - a water drainage (123) located in or near a downstream end of the base (113),

     to a region above the debris storage container (105),

   wherein the debris collecting device (130) and the haulage system (140) are configured such that the debris collecting device (130) is moveable along the rail system (141).

7. The marine vessel (100) according to any preceding claim, wherein the vessel (100) is powered by solar energy by use of at least one solar panel (101).

8. A method for removing debris particles (102) from a water column using a marine vessel (100) submersed in a body of water,
c h a r a c t e r i z e d i n that the vessel (100) comprises:
- a hull construction (110) having a bow portion and an aft portion arranged along a direction of travel, comprising:
    - o a first longitudinal hull part (111);
    - o a second longitudinal hull part (112) arranged in parallel to the direction of travel of the first longitudinal hull part (111);
    - o a base (113) interconnecting the first and second longitudinal hull parts (111, 112), wherein the base (113) extends in the direction of travel along at least a part of the length of the first and second longitudinal hull parts (111, 112);
    - o a longitudinal stabilization passage (120) constrained in space by at least:
        - ▪ the first longitudinal hull part (111),
        - ▪ the second longitudinal hull parts (111,112) and
        - ▪ the base (113), the base (113) being located below the longitudinal stabilization passage (120),
    - o wherein the longitudinal stabilization passage (120) further comprises:
        - ▪ a water column inlet (121) and
        - ▪ a water column outlet (122), the water column outlet (122) being closer to the aft portion of the hull construction (110) than the water column inlet (121), and
- a debris collecting device (130) arranged at or near the water column outlet (122) for collecting debris containing water,
- openable blocking means (124) arranged at or near the debris collecting device (130) for hindering flow of water through the water column outlet (122);
- a water drainage (123) located in or near a downstream end of the base (113), wherein the geometrical size of the water drainage (123) is adapted to at least partly receive the debris collecting device (130) there within; and
- ballasting means for adjustment of the trim of the hull construction (110);

wherein the method comprises the steps of:
- lowering the debris collecting device (130) at least partly into the water drainage (123);
- blocking flow of water through the water column outlet (122) by use of the openable blocking means (124);
- allowing water to flow into the stabilization passage (120) through the water column inlet (121);
- trimming the aft portion of the vessel (100) relative to the water surface, by use of the ballasting means until the base (113) at the vessel's bow portion is raised above the water surface;

- raising the vessel (100) relative to the water surface by way of the ballasting means while maintaining the bow portion of the base (113) above the waterline; and
- allowing water confined in the stabilization passage (120) to flow through the debris collecting device (130) and to exit through the water drainage (123).

9. The method according to claims 8, wherein the vessel (100) further comprises:
- a debris storage container (105) for detachable arrangement at or near the aft portion of the vessel (100), wherein the debris storage volume of the debris storage container (105) is larger than the debris storage volume of the debris collecting device (130);
- a haulage system (140) comprising
    - o a winch (146);
    - o a handling device (147) pivotably connected to the debris collecting device (130),
    - o a wire (143) connected at a first end to the winch (146) and at a second end to the handling device (147);
    - o a sheave (144) onto which the wire (143) is running; and
    - o a rail system (141) extending from at least one of the water column outlet (122) and a water drainage (123) located in or near a downstream end of the base (113),

wherein the debris collecting device (130) and the haulage system (140) are configured such that the debris collecting device (130) is moveable along the rail system (141).

wherein the method further comprises the steps of:
- moving the debris collecting device (130) along the rail system (141) by way of the haulage system (140) from a first position at or near at least one of the water column outlet (122) and the water drainage (123) to a second position above the debris storage container (105);
- tilting the debris collecting device (130) in order to transfer debris particles (102) from the debris collecting device (130) to the debris storage container (105); and
- transporting the debris collecting device (130) along the rail system (141) by use of the haulage system (140) from the second position above the debris storage container (105) back to the first position at or near at least one of the water column outlet (122) and the water drainage (123).

Patentkrav

1. Et havgående fartøy(100) for å fjerne avfallspartikler (102) fra en vannsøyle, omfattende:

- en skrogkonstruksjon (110) som har et baugparti og et akterparti arrangert langs en bevegelsesretning, som omfatter:

o et første langsgående skrogparti (111);

o et andre langsgående skrogparti (112) arrangert parallelt med bevegelsesretningen til det første langsgående skrogpartiet (111);

o en base (113) som forbinder det første og andre langsgående skrogpartiet (111, 112), hvor basen (113) strekker seg i bevegelsesretningen langs minst en del av lengden av det første og andre langsgående skrogpartiet (111, 112);

o en langsgående stabiliseringspassasje (120) begrenset i rommet av minst:

▪ det første langsgående skrogpartiet (111),

▪ det andre langsgående skrogpartiet (111,112) og

▪ basen (113), hvor basen (113) er plassert under den langsgående stabiliseringspassasjen (120),

o hvor den langsgående stabiliseringspassasjen (120) videre omfatter:

▪ et vannsøyleinnløp (121) og

▪ et vannsøyleutløp (122), hvor vannsøyleutløpet (122) er nærmere akterdelen av skrogkonstruksjonen (110) enn vannsøyleinnløpet (121),

- en avfallsoppsamlingsanordning (130) arrangert ved eller nær vannsøyleutløpet (122) for oppsamling av avfallsinneholdende vann;

karakterisert ved

- åpningsbare blokkeringsmidler (124) arrangert ved eller i nærheten av avfallsopplingsanordningen (130) for å hindre strømning av vann gjennom vannsøyleutløpet (122);

- et vannavløp (123) plassert i eller nær en nedstrøms ende av basen (113), hvor den geometriske størrelsen til vannavløpet (123) er tilpasset til minst delvis å motta avfallsoppsamlingsanordningen (130) deri; og

- ballasteringsmidler for justering av trim og heving av skrogkonstruksjonen (110) i forhold til havoverflaten.

2. Det havgående fartøyet (100) ifølge krav 1, karakterisert ved at avfallsopplingsanordningen (130) omfatter filtreringsmidler (131) for å separere minst en del av avfallspartiklene (102) fra det avfallsinneholdende vannet.

3. Det havgående fartøyet (100) ifølge krav 1 eller 2, hvor skrogkonstruksjonen (110) videre omfatter:

- en vertikal langsgående plate (115) forbundet med basen (113), hvor den vertikale langsgående platen (115) er konfigurert til å dele den langsgående stabiliseringspassasjen (120), i retningen vinkelrett på bevegelsesretningen, i minst to langsgående passasjeseksjoner (125).

4. Det havgående fartøyet (100) ifølge hvilket som helst av de foregående kravene, videre omfattende:

- fortøyningsmidler; og

- føringsmidler (104) som kan festes til eller nær baugpartiet av skrogkonstruksjonen (110), hvor føringsmidlene (104) er konfigurert og arrangert i forhold til skrogkonstruksjonen (110) for å tillate føring av en strøm av vann mot og inn i vannsøyleinnløpet (121).

5. Det havgående fartøyet (100) ifølge hvilket som helst av de foregående kravene, videre omfattende:

- en avfallslagringsbeholder (105) for avtagbart arrangement ved eller nær akterpartiet av fartøyet (100), hvor avfallslagringsvolumet til avfallslagringsbeholderen (105) er større enn lagringsvolumet for avfallsoppsamlingsanordningen (130).

6. Det havgående fartøyet (100) ifølge krav 5, videre omfattende

- et trekksystem (140) som omfatter

o en vinsj (146);

o en håndteringsanordning (147) dreibart koblet til avfallsoppsamlingsanordningen (130),

o en vaier (143) koblet i en første ende til vinsjen (146) og ved en andre ende til håndteringsanordningen (147), hvor vaieren (143) føres over minst én bevegelig trinse (144); og

- et skinnesystem (141) som strekker seg fra minst én av

o vannsøyleutløpet (122) og

o et vannavløp (123) plassert i eller nær en nedstrøms ende av basen (113), til et område over avfallsbeholderen (105), hvor avfallsoppsamlingsanordningen (130) og trekksystemet (140) er konfigurert slik at avfallsoppsamlingsanordningen (130) er bevegelig langs skinnesystem (141).

7. Det havgående fartøyet (100) ifølge hvilket som helst av de foregående krav, hvor fartøyet (100) drives av solenergi ved bruk av minst ett solcellepanel (101).

8. Fremgangsmåte for å fjerne avfallspartikler (102) fra en vannsøyle ved å bruke et havgående fartøy (100) nedsenket i en vannmasse,

karakterisert ved at fartøyet (100) omfatter:

- en skrogkonstruksjon (110) som har et baugparti og et akterparti arrangert langs en bevegelsesretning, omfattende:

o et første langsgående skrogparti (111);

o et andre langsgående skrogparti (112) arrangert parallelt med bevegelsesretningen til det første langsgående skrogpartiet (111);

o en base (113) som forbinder det første og andre langsgående skrogpartiet (111, 112), hvor basen (113) strekker seg i bevegelsesretningen langs minst en del av lengden av det første og andre langsgående skrogpartiet (111, 112);

o en langsgående stabiliseringspassasje (120) begrenset i rommet av minst:

▪ det første langsgående skrogpartiet (111),

▪ det andre langsgående skrogpartiet (111,112) og

▪ basen (113), hvor basen (113) er plassert under den langsgående stabiliseringspassasjen (120),

o hvor den langsgående stabiliseringspassasjen (120) videre omfatter:

▪ et vannsøyleinnløp (121) og

▪ et vannsøyleutløp (122), hvor vannsøyleutløpet (122) er nærmere akterdelen av skrogkonstruksjonen (110) enn vannsøyleinnløpet (121), og

- en avfallsoppsamlingsanordning (130) arrangert ved eller nær vannsøyleutløpet (122) for oppsamling av avfall som inneholder vann,

- åpningsbare blokkeringsmidler (124) arrangert ved eller i nærheten av avfallsoppsamlingsanordningen (130) for å hindre strømning av vann gjennom vannsøyleutløpet (122);

- et vannavløp (123) plassert i eller nær en nedstrøms ende av basen (113), hvor den geometriske størrelsen til vannavløpet (123) er tilpasset til minst delvis å motta avfallsoppsamlingsanordningen (130) deri; og

- ballasteringsmidler for justering av trimmingen til skrogkonstruksjonen (110);

hvor fremgangsmåten omfatter trinnene:

- å senke avfallsoppsamlingsanordningen (130) i det minste delvis ned i vannavløpet (123);

- å blokkere vannstrømningen gjennom vannsøyleutløpet (122) ved bruk av de åpningsbare blokkeringsmidlene (124);

- å la vann strømme inn i stabiliseringspassasjen (120) gjennom vannsøyleinnløpet (121);

- å trimme akterpartiet av fartøyet (100) i forhold til vannoverflaten, ved bruk av ballasteringsmidlene inntil basen (113) ved fartøyets baugparti er hevet over vannoverflaten;

- å heve fartøyet (100) i forhold til vannoverflaten ved hjelp av ballasteringsmidlene mens baugpartiet av basen (113) opprettholdes over vannlinjen; og

- å tillate vann innestengt i stabiliseringspassasjen (120) å strømme gjennom avfallsoppsamlingsanordningen (130) og komme ut gjennom vannavløpet (123).

9. Fremgangsmåten ifølge krav 8, hvor fartøyet (100) videre omfatter:

- en avfallslagringsbeholder (105) avtagbart arrangert ved eller nær akterpartiet av fartøyet (100), hvor avfallslagringsvolumet til avfallslagringsbeholderen (105) er større enn lagringsvolumet til avfallsoppsamlingsanordningen (130);

- et trekksystem (140) som omfatter

  o en vinsj (146);

  o en håndteringsenhet (147) dreibart koblet til avfallsoppsamlingsanordningen (130),

  o en vaier (143) koblet i en første ende til vinsjen (146) og i en andre ende til håndteringsanordningen (147);

  o en trinse (144) som vaieren (143) løper på; og

  o et skinnesystem (141) som strekker seg fra minst én av vannsøyleutløpet (122) og et vannavløp (123) plassert i eller nær en nedstrøms ende av basen (113),

hvor avfallsoppsamlingsanordningen (130) og trekksystemet (140) er konfigurert slik at avfallsoppsamlingsanordningen (130) er bevegelig langs skinnesystemet (141),

hvor fremgangsmåten videre omfatter trinnene:

- å flytte avfallsoppsamlingsanordningen (130) langs skinnesystemet (141) ved hjelp av trekksystemet (140) fra en første posisjon ved eller nær minst én av vannsøyleutløpet (122) og vannavløpet (123) til en andre posisjon over avfallslagringsbeholderen (105);

- å vippe avfallsoppsamlingsanordningen (130) for å overføre avfallspartikler (102) fra avfallsoppsamlingsanordningen (130) til avfallslagringsbeholderen (105); og

- å transportere avfallsoppsamlingsanordningen (130) langs skinnesystemet (141) ved bruk av trekksystemet (140) fra den andre posisjonen over avfallslagringsbeholderen (105) tilbake til den første posisjonen ved eller nær minst én av de vannsøyleutløpet (122) og vannavløpet (123).

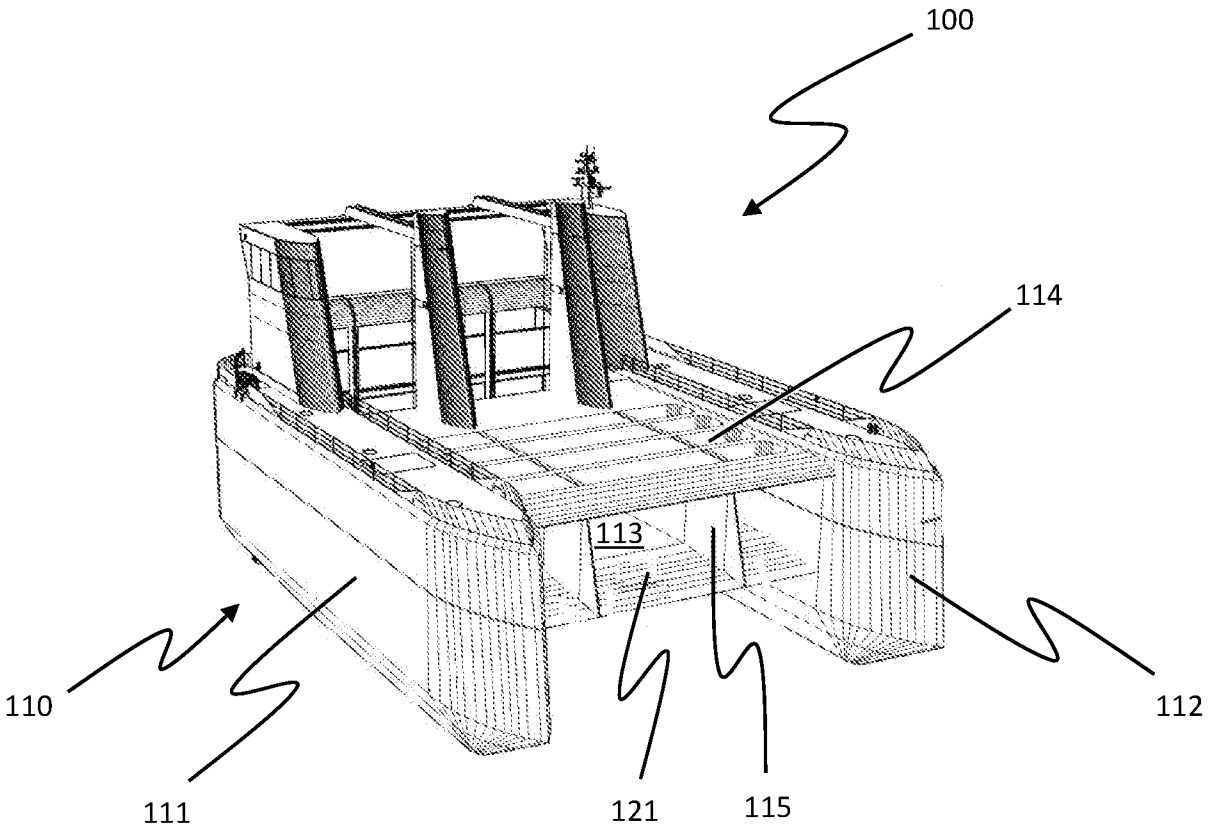


FIG. 1a

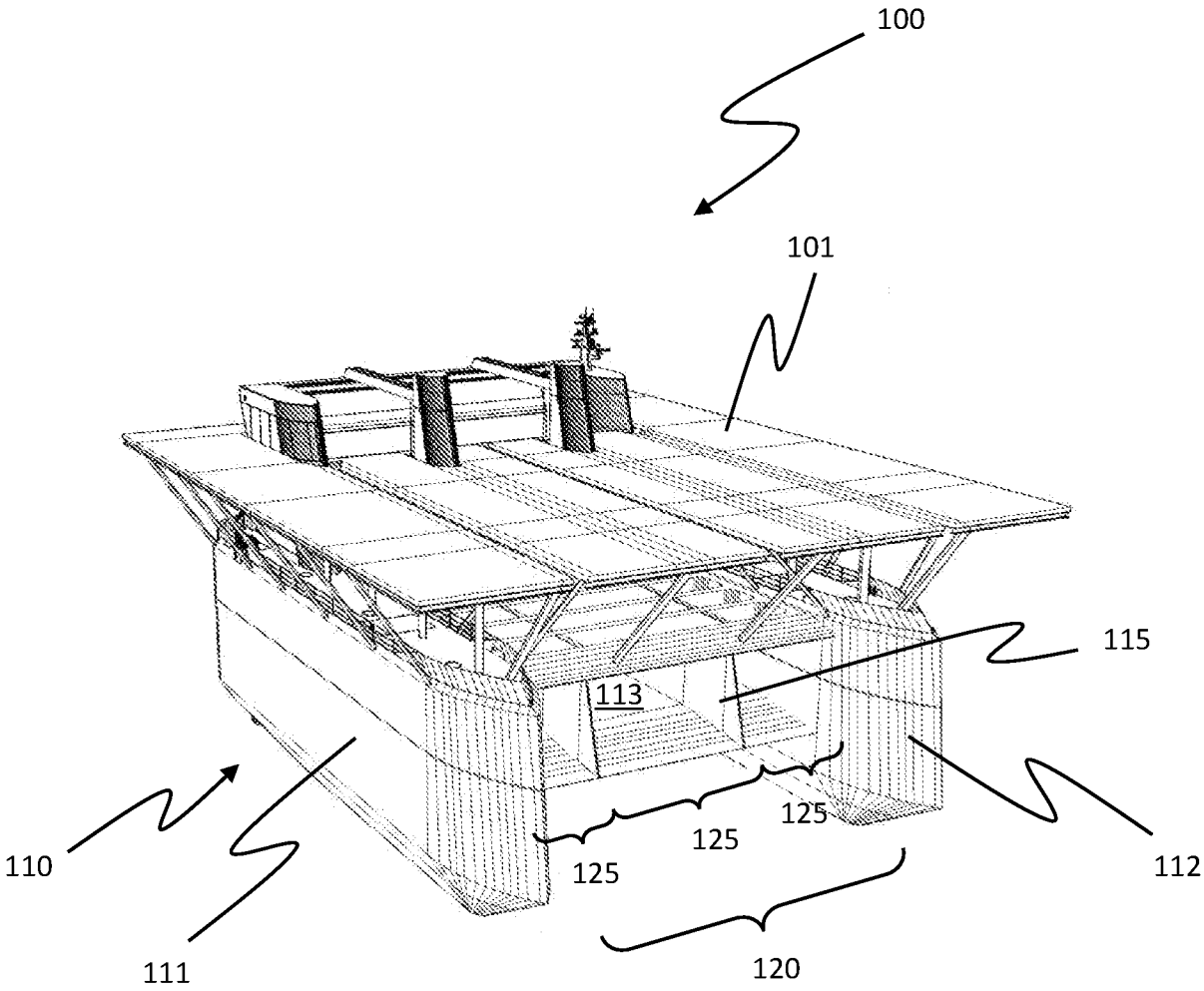


FIG. 1b

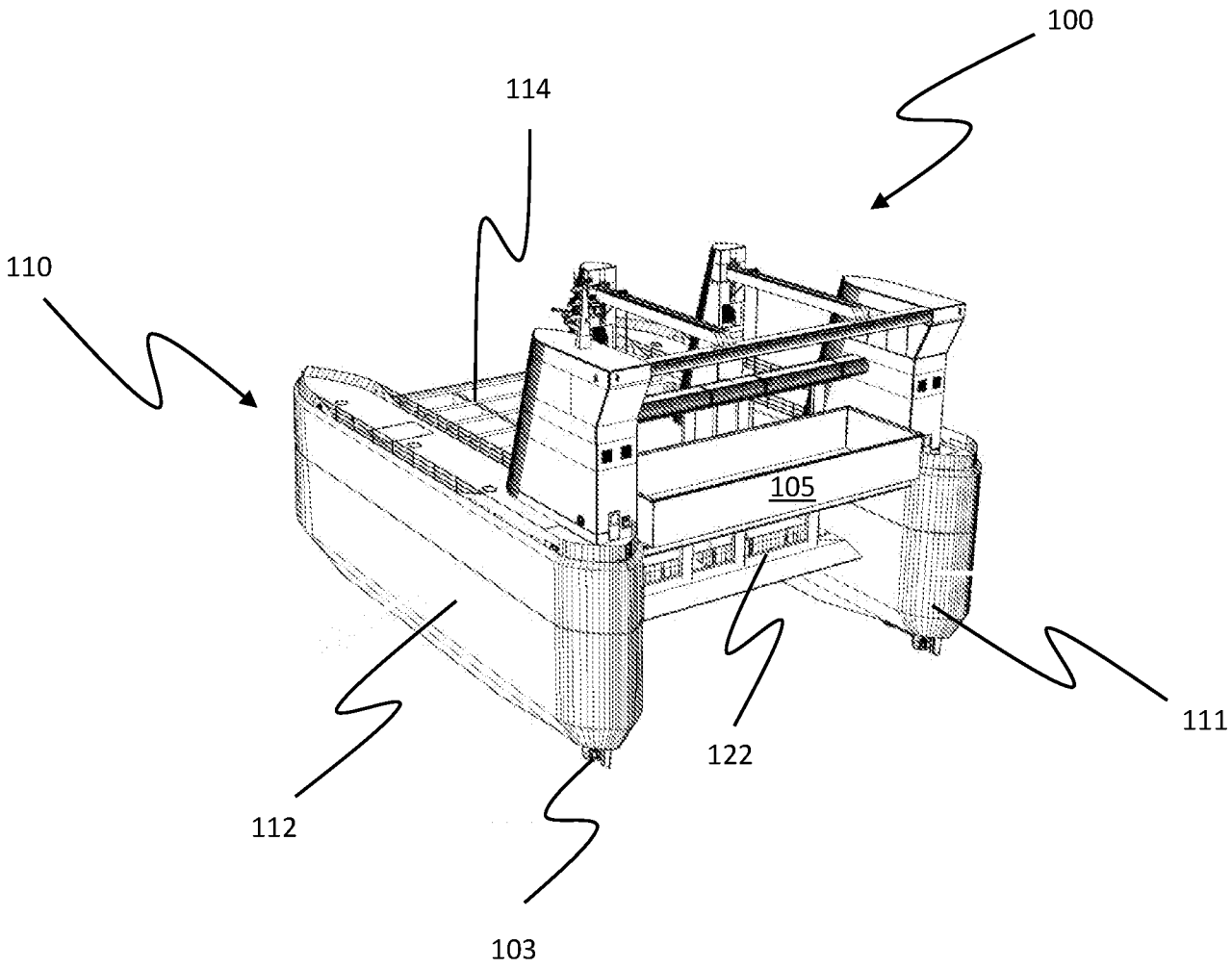


FIG. 2a

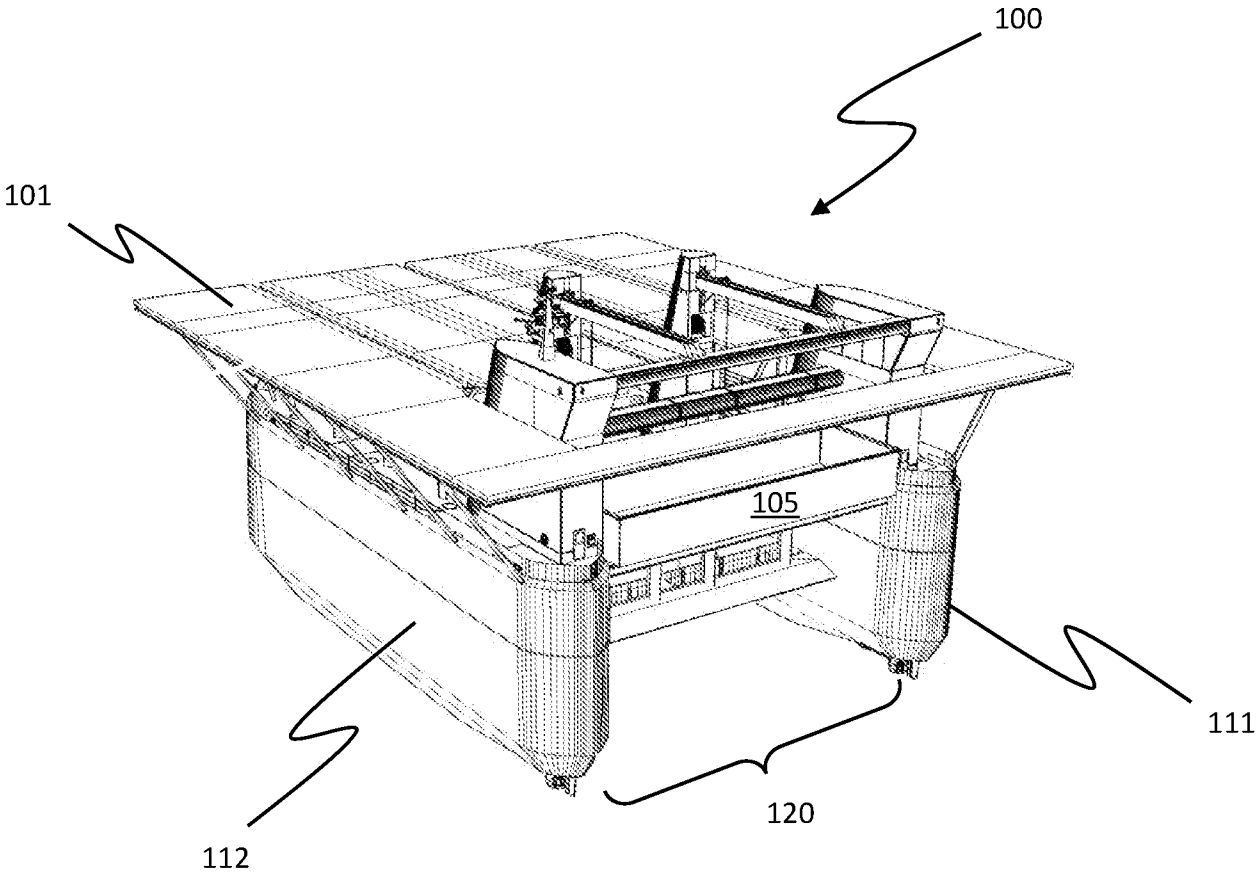


FIG. 2b

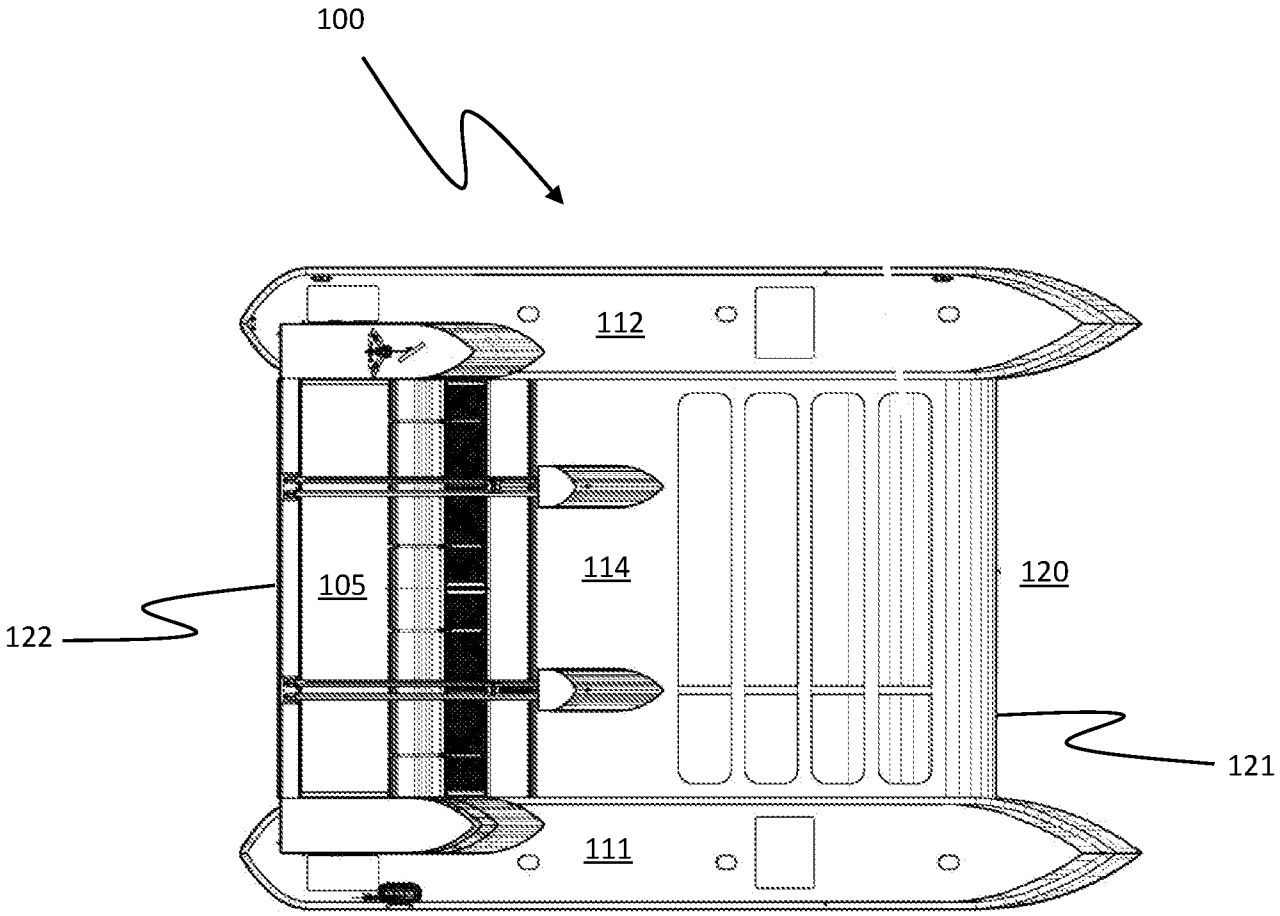


FIG. 3

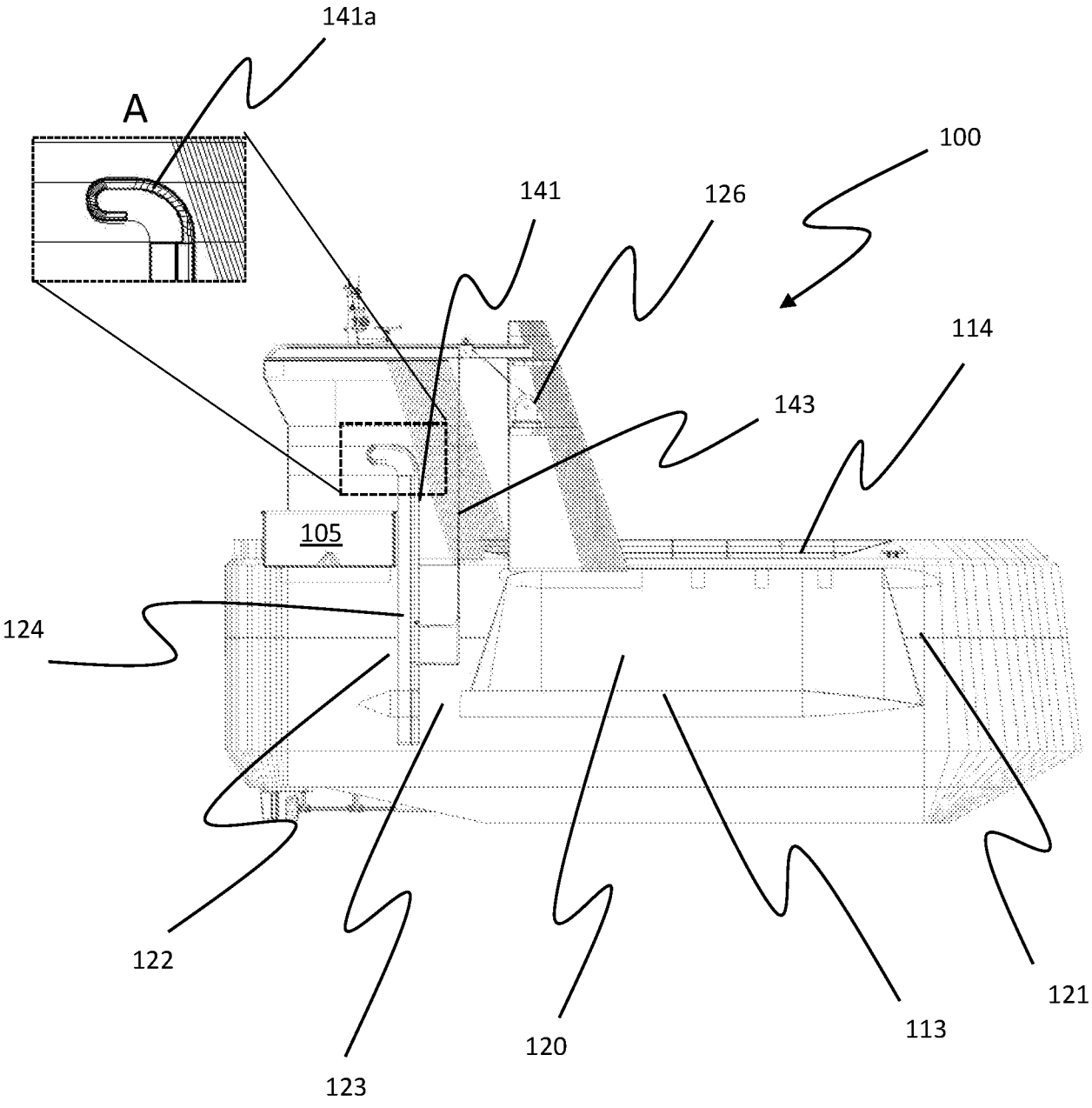


FIG. 4

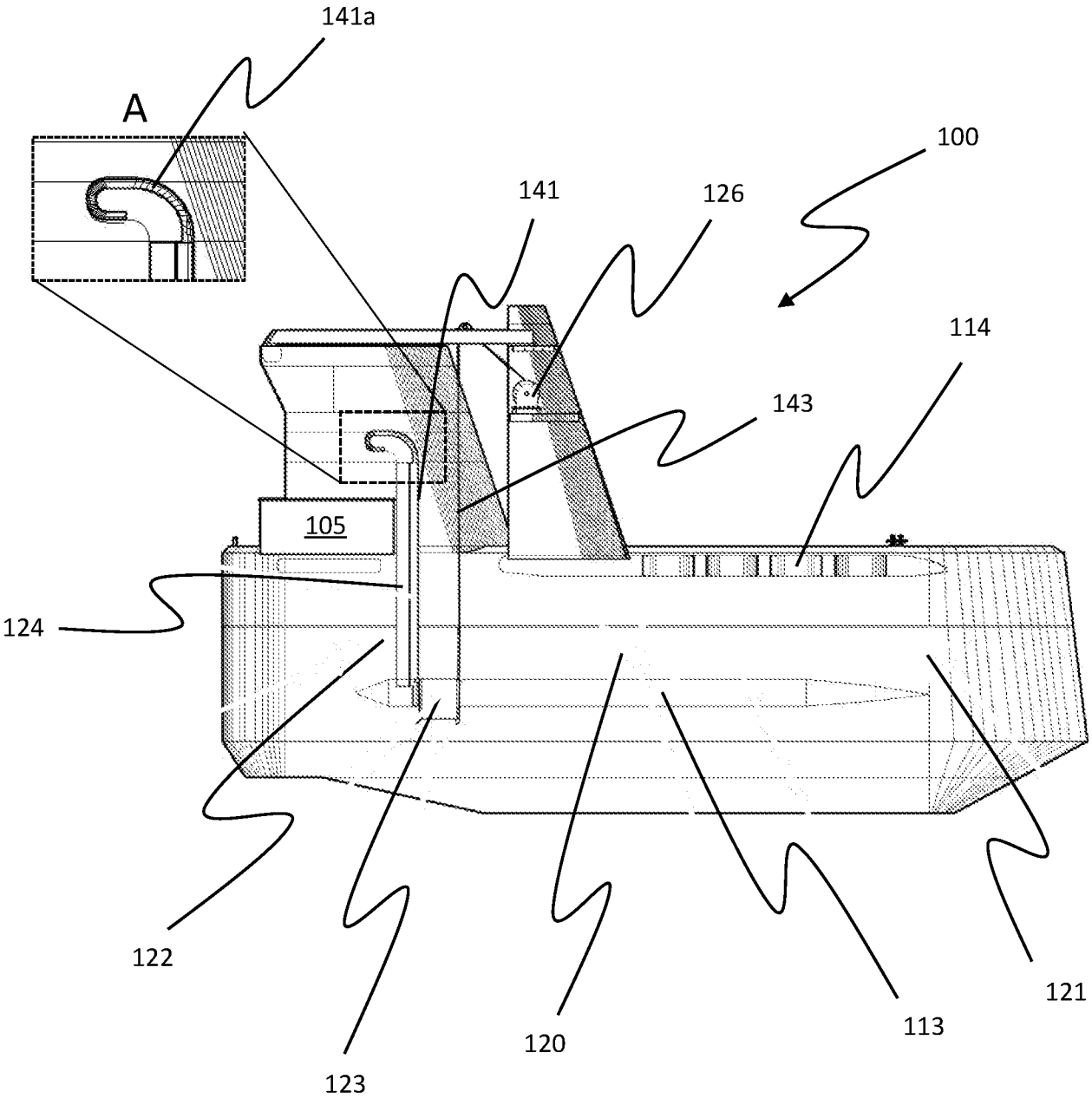


FIG. 5

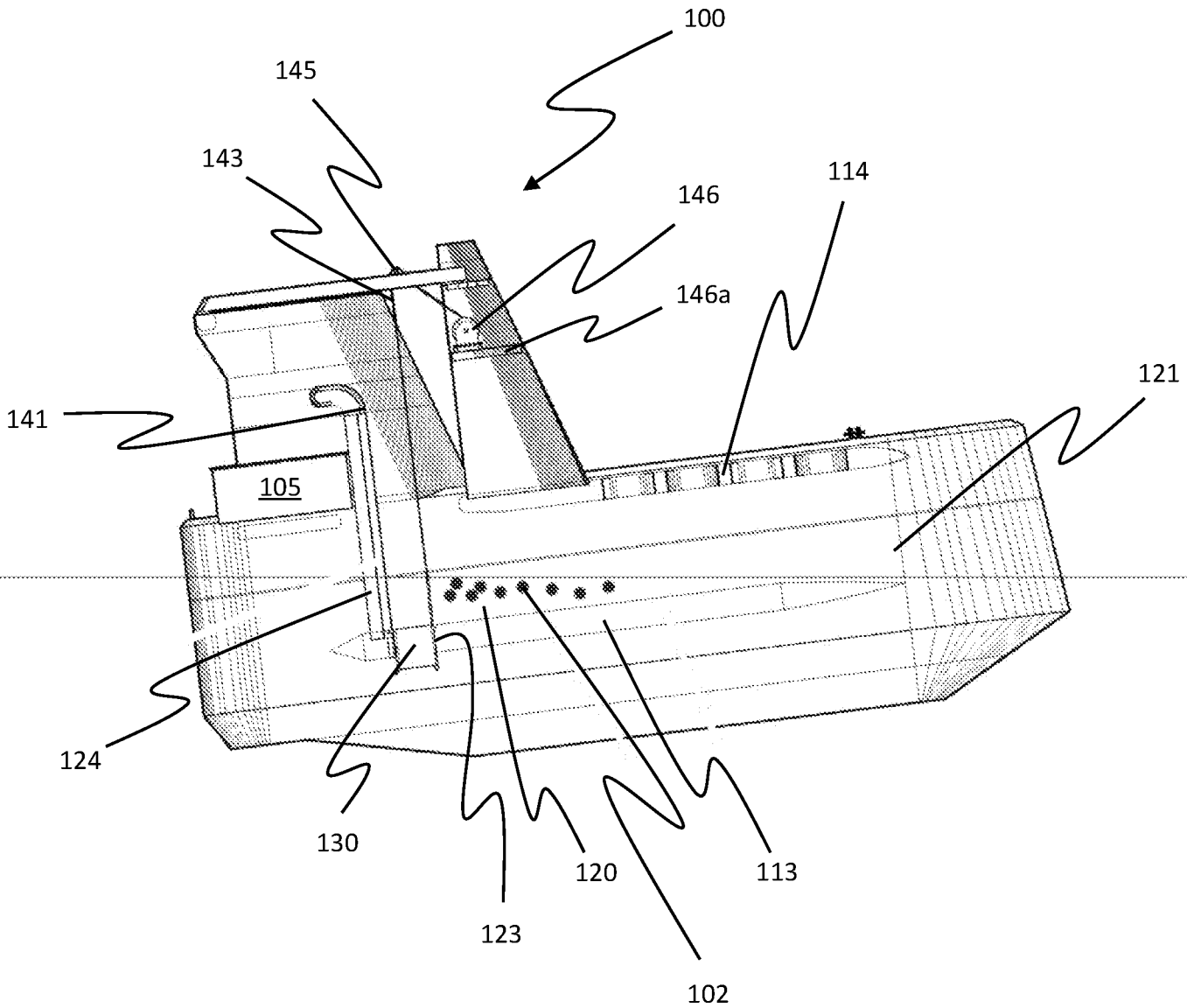


FIG. 6

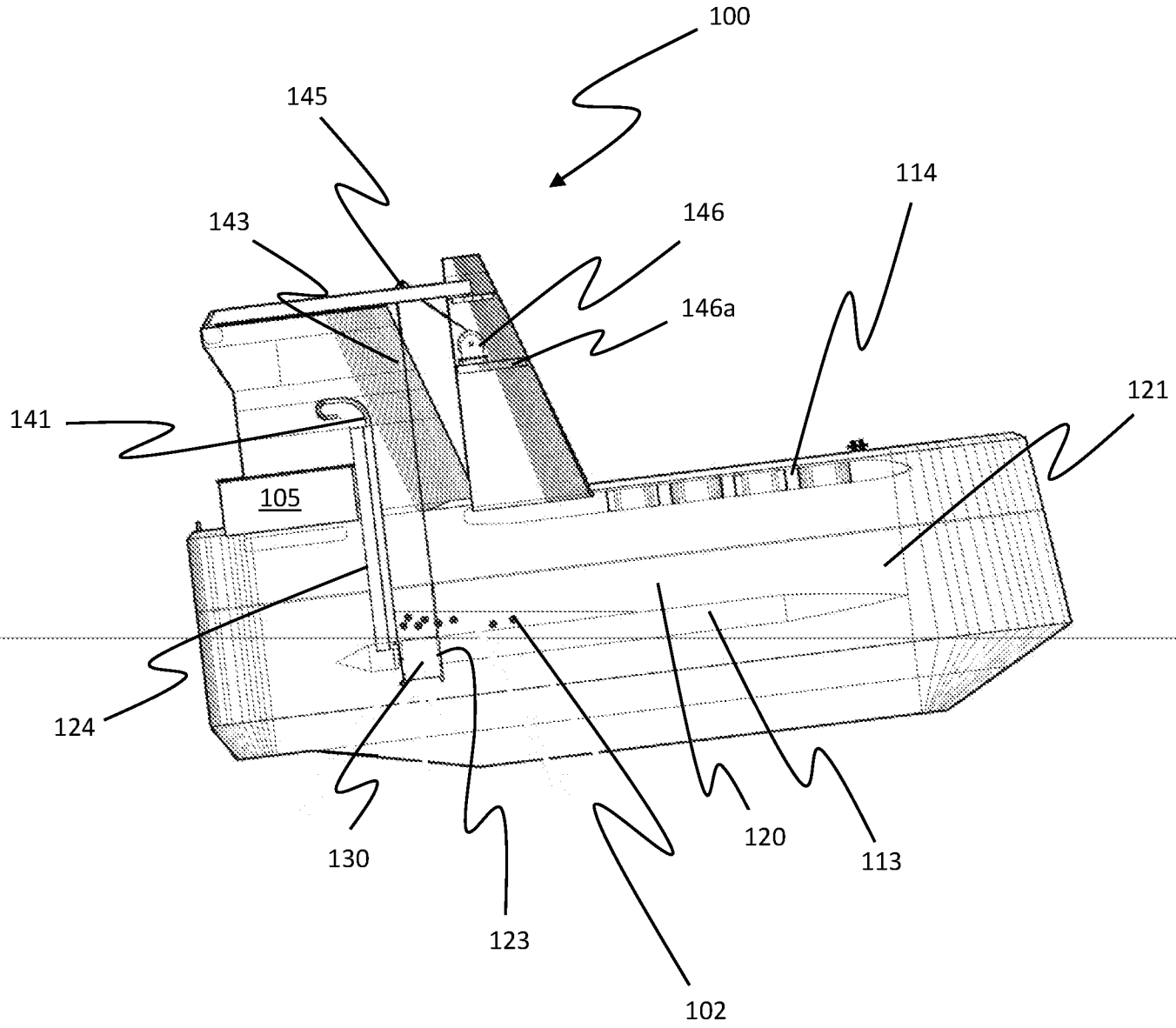


FIG. 7

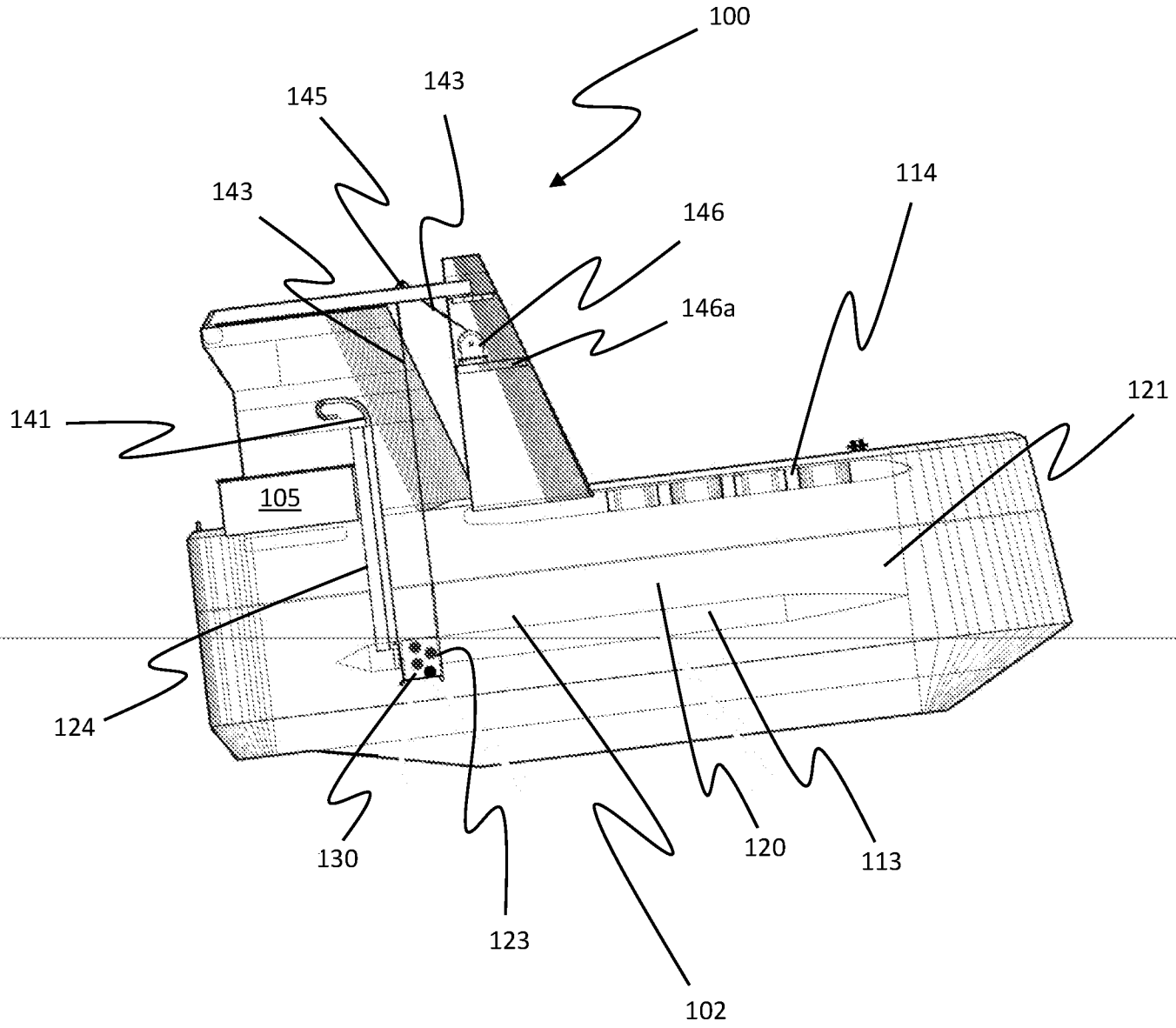


FIG. 8

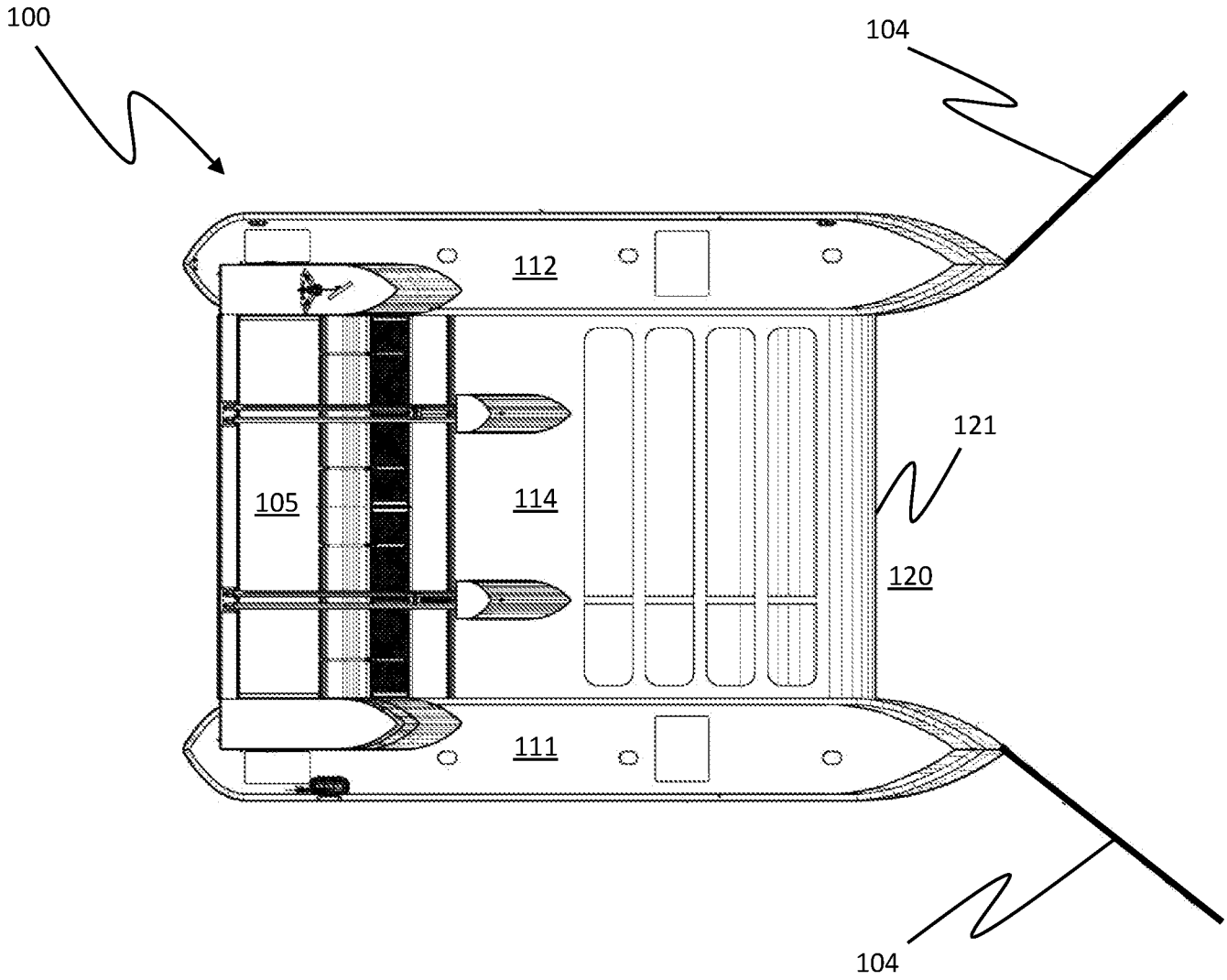


FIG. 9

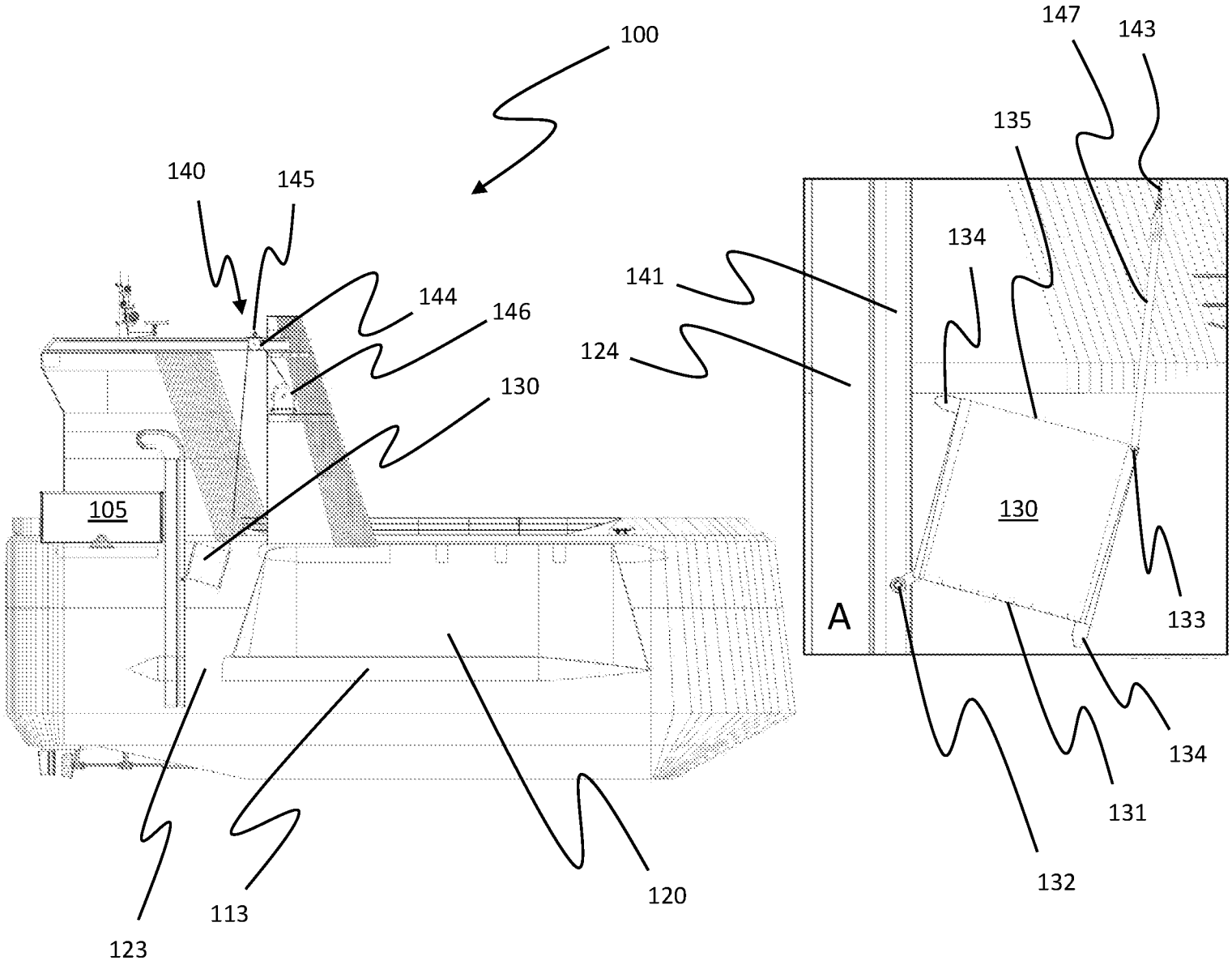

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FIG. 10

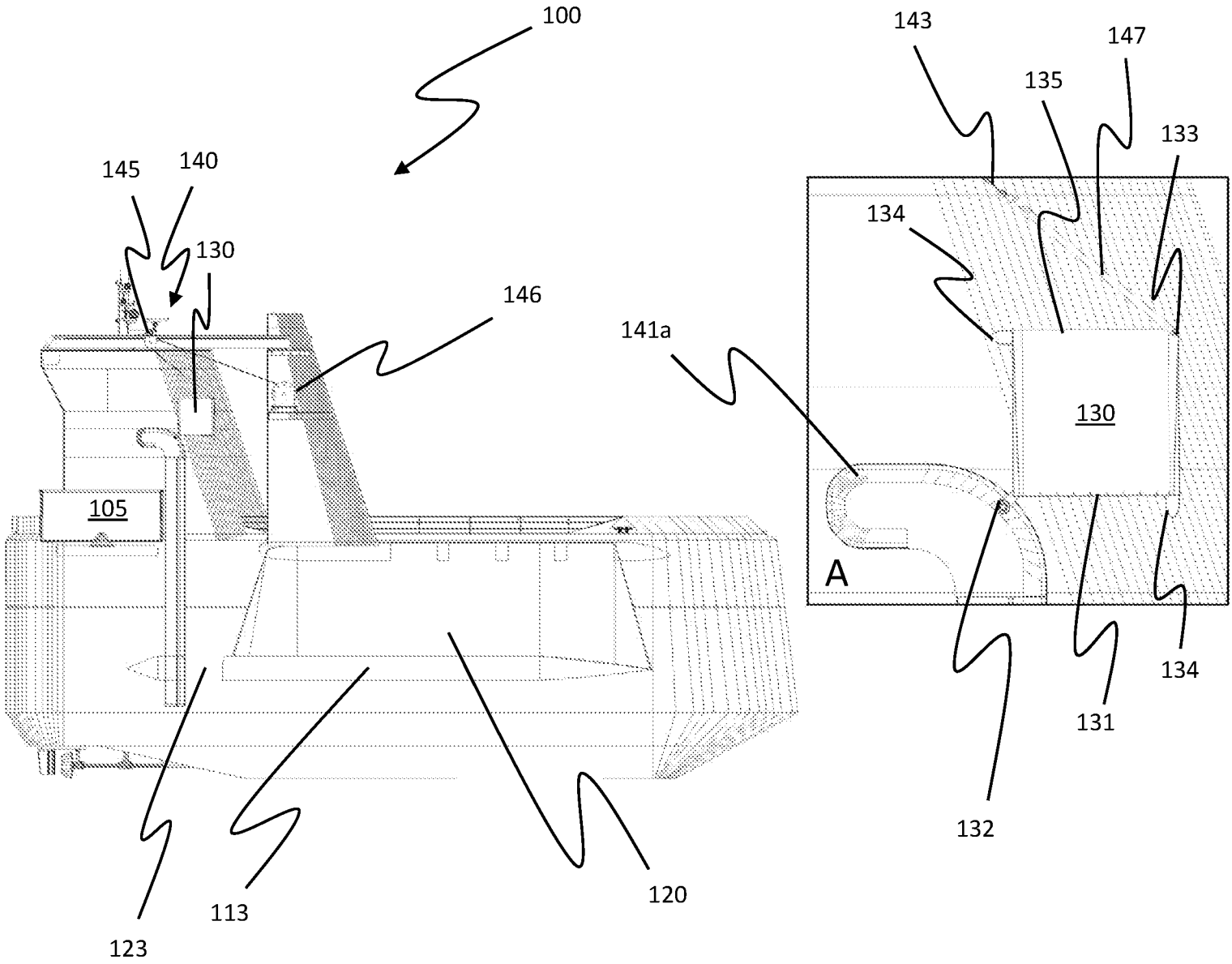

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FIG. 11

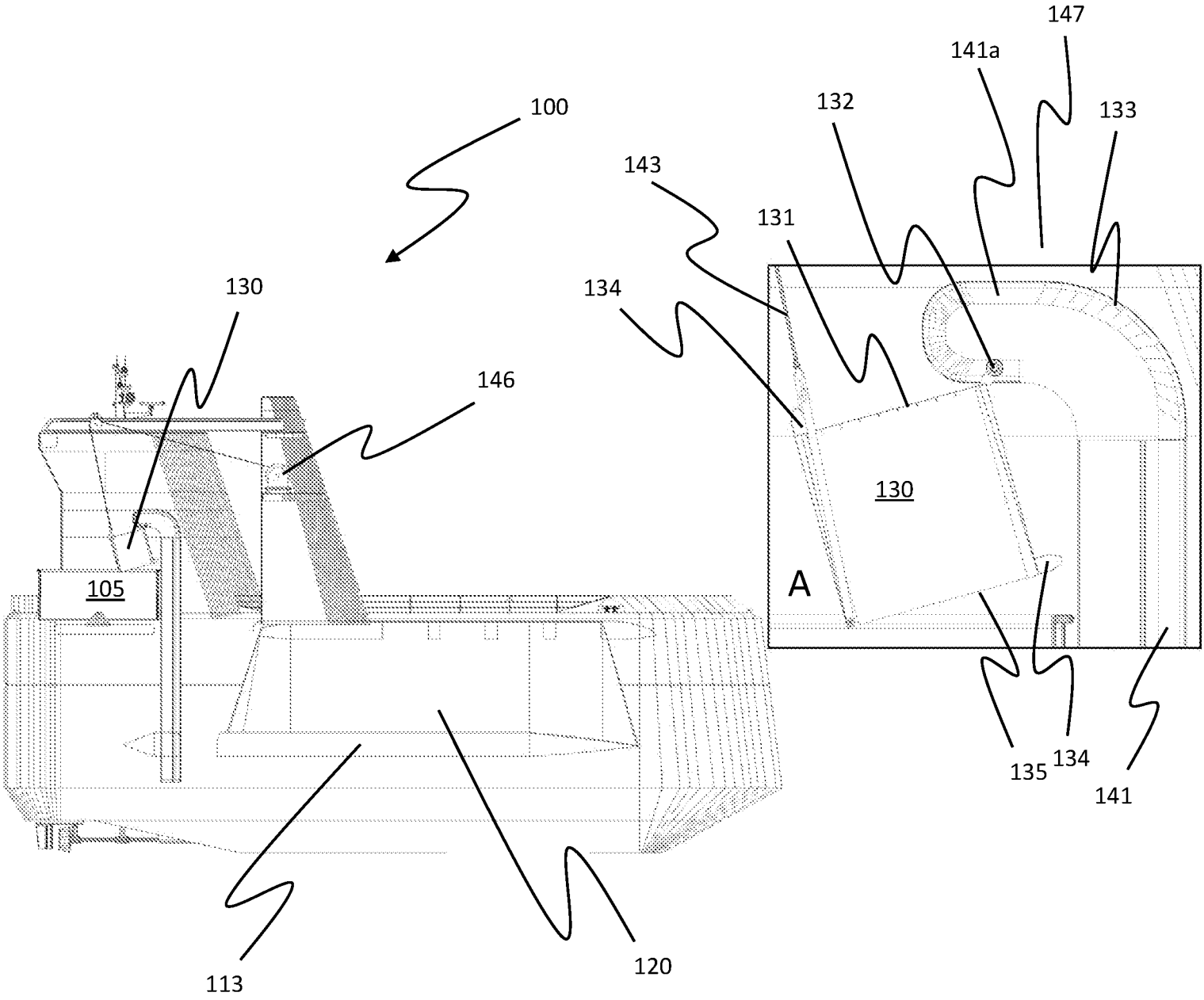

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FIG. 12

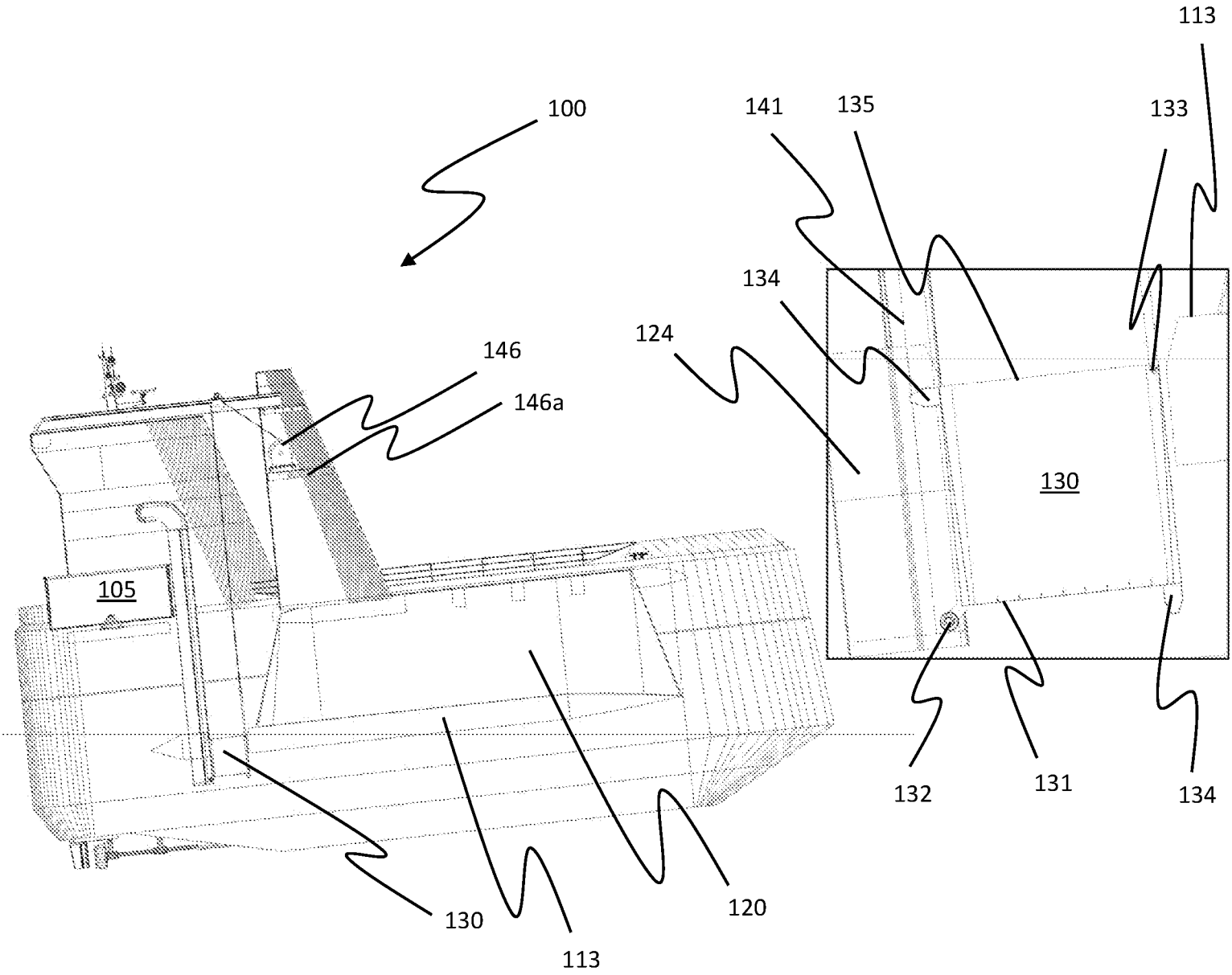

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FIG. 13

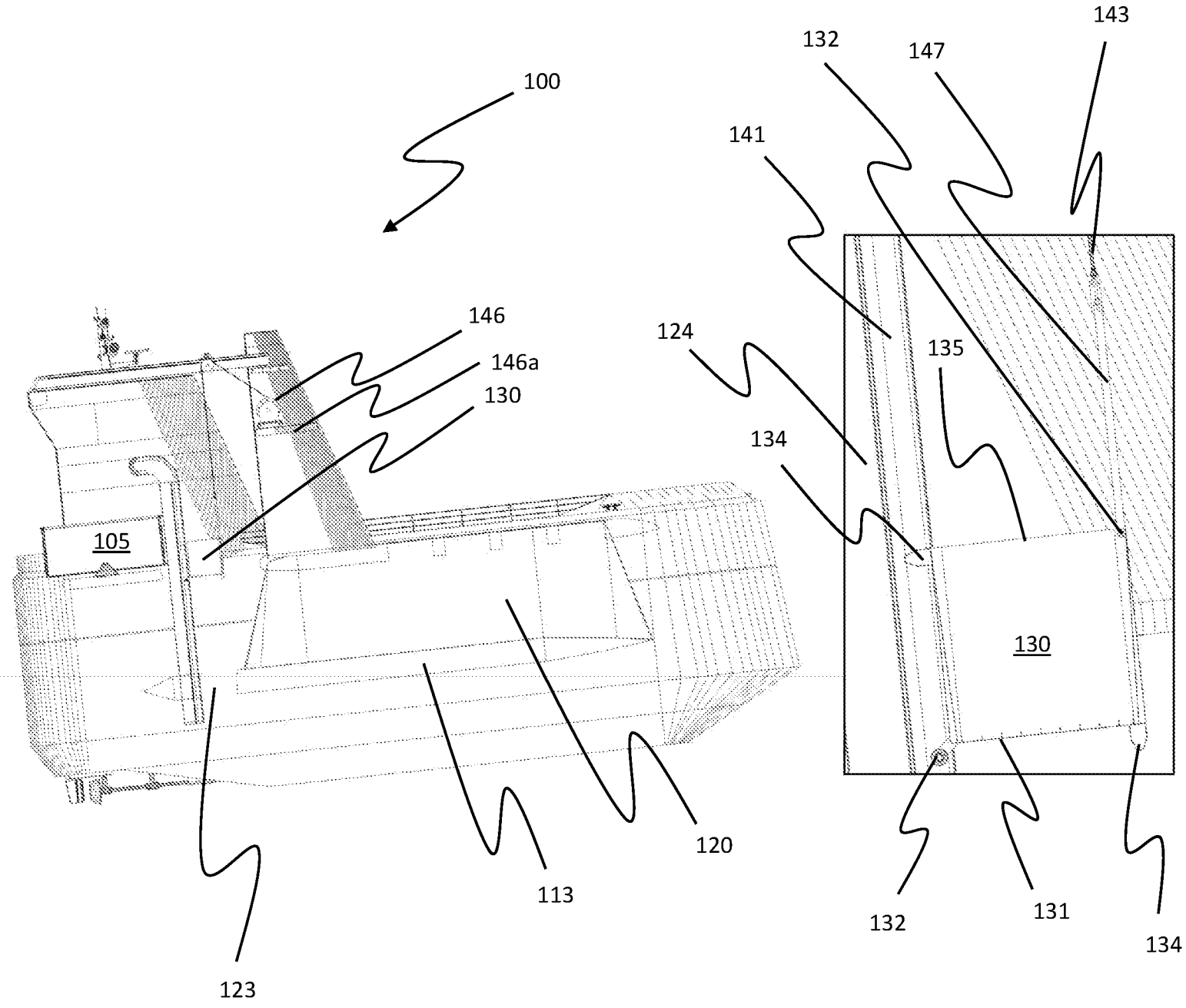

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FIG. 14

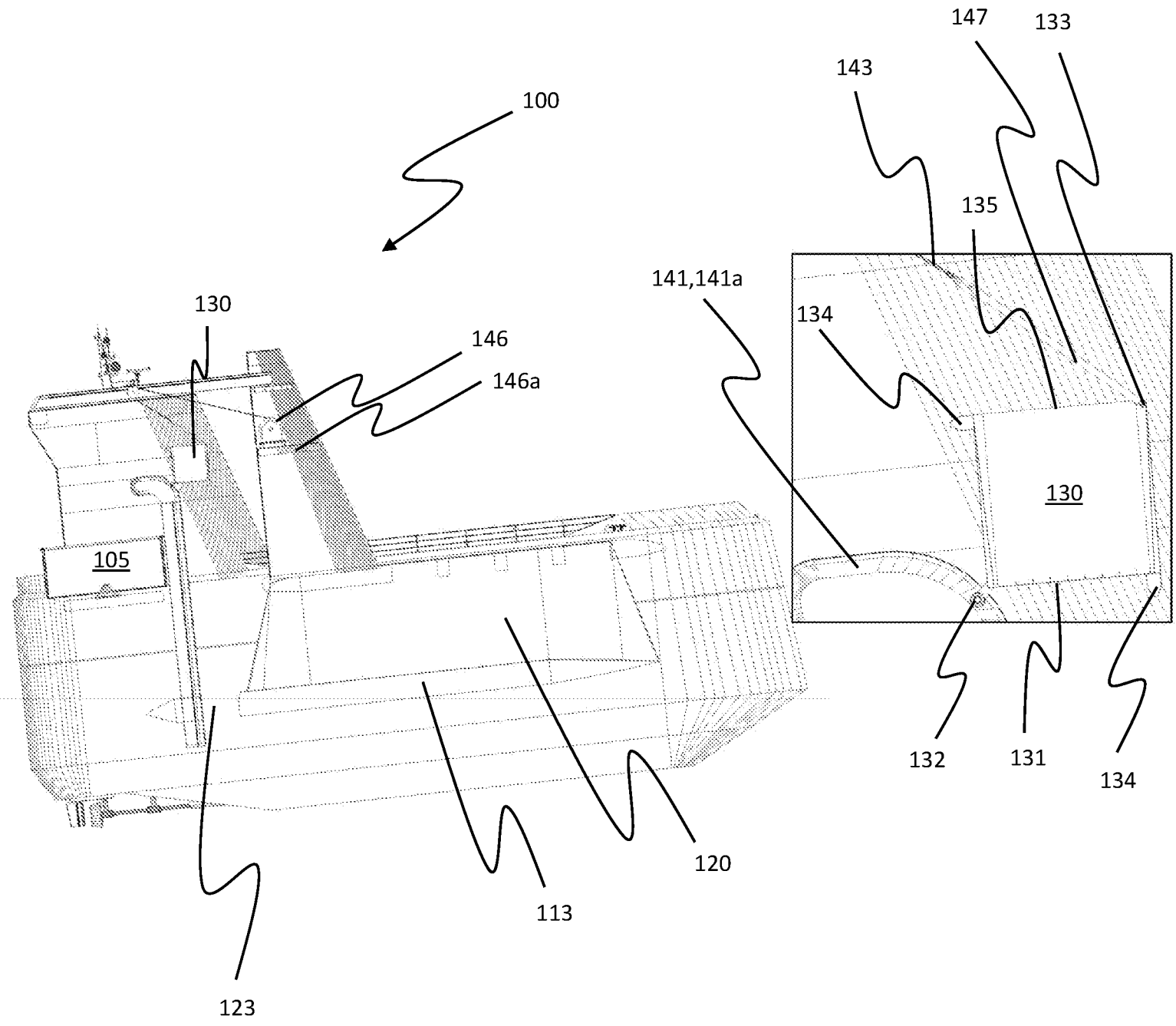

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FIG. 15

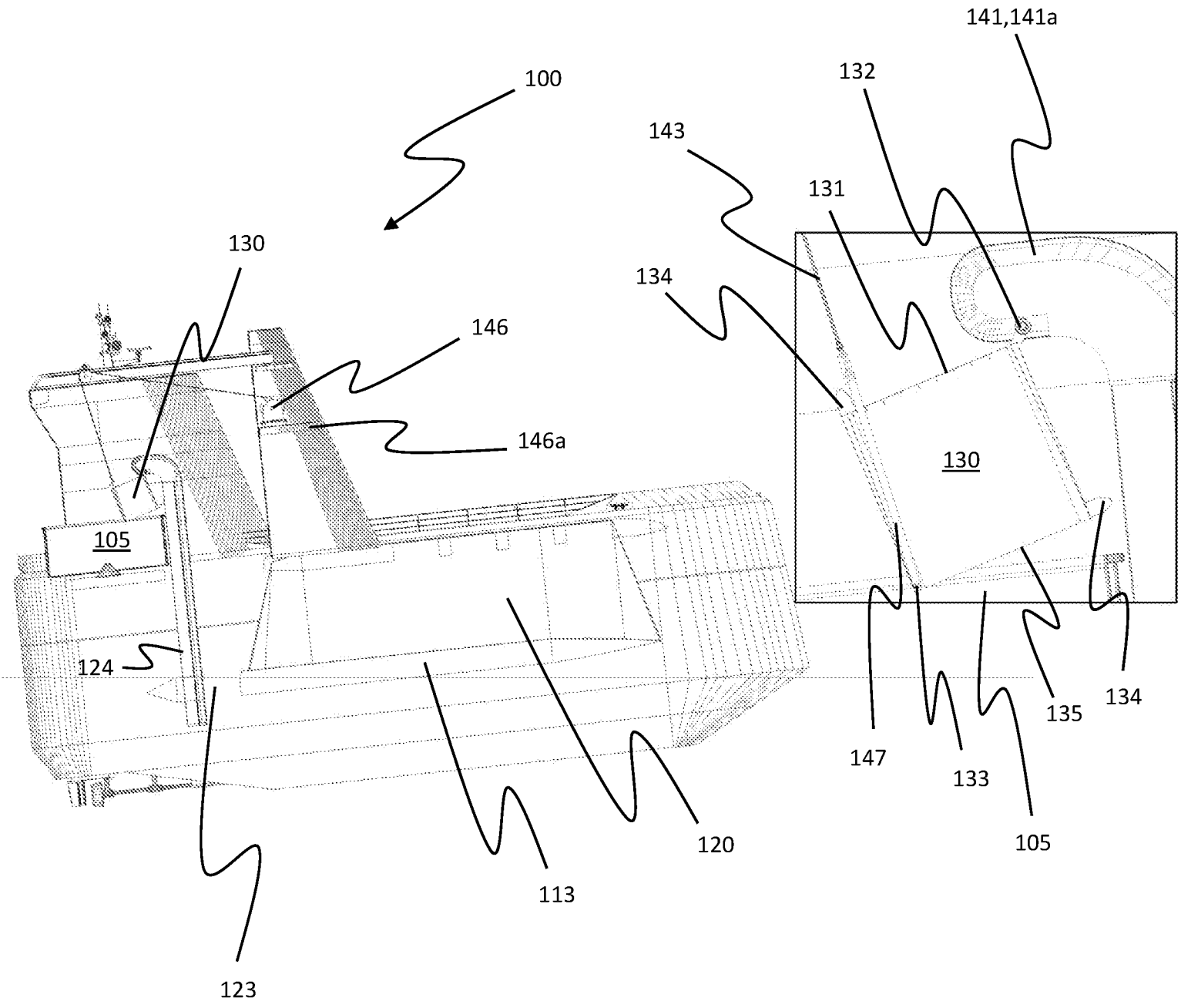

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FIG. 16