(12) **APPLICATION**

(19) NO (21) **20171632** (13) **A1**

NORWAY (51) Int Cl.
A01K 61/54 (2017.01)
A01K 80/00 (2006.01)
A01G 33/00 (2006.01)

Norwegian Industrial Property Office

(21)	Application nr	20171632	(86)	Int.application.day and application nr	2016.04.07 PCT/EP2016/057670
(22)	Application day	2017.10.13	(85)	Entry into national phase	2017.10.13
(24)	Date from which the industrial right has effect	2016.04.07	(30)	Priority	2015.04.14, US, 62/146,983
(41)	Available to the public	2017.10.13			

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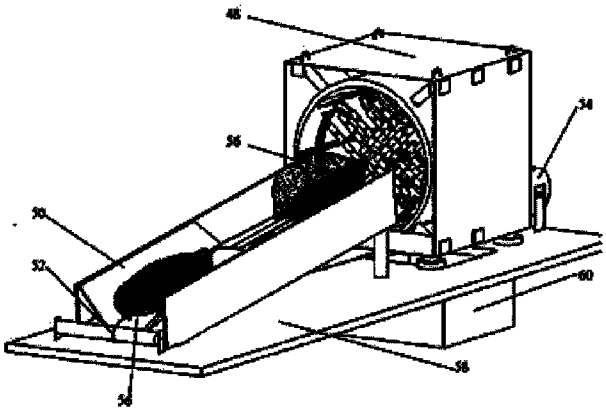
(54) Title **SYSTEM AND APPARATUS FOR CULTIVATING AND HARVESTING AQUATIC BIOMASS**

(57) Abstract

A system and related apparatus for cultivating and harvesting aquatic biomass. The system has three main aspects or elements, including a substrate device having outstretched wings upon which aquatic organisms are attached and allowed to grow in a marine environment, a flotation device for suspending one or more substrate devices, and an automated device for harvesting and collecting the aquatic biomass from the substrate devices, having a number of modular arms that transport the substrate through a cylindrical member, cutting arms that remove biomass from the substrate devices, and washing arms that dislodge the biomass and clean the substrate devices.



System and apparatus for cultivating and harvesting aquatic biomass

Field of the invention

The invention relates to aquaculture, in particular to a system and related apparatus for cultivating and harvesting biomass in a marine environment.

Background

Aquaculture is an important and growing industry. In addition to the farming of various species of fish, other species of aquatic plants and animals are an important resource that can be cultivated in a marine environment.

As used herein, the term “aquatic biomass” refers to marine plants and animals grown and harvested in a controlled environment. Examples of such plants and animals include, but are not limited to: Molluscs, Kelp,Tunicates,Algae,Shell Fish,Mussels, Invertebrate and Microbes. Throughout this application, terms such as “aquatic biomass”, “water”, “marine”, “sea floor” and the like will be described in relation to a salt water, marine environment, however it should be understood that these terms may be interchanged with and equally relate to a fresh water environment or fresh water species of organisms.

Known installations for cultivating in particular plant species have several drawbacks. Known installations include, for example, network of ropes, nets and other similar growth media on which marine plants and animal species such as molluscs and the like

are grown. Known growth media are often quite crude in their implementation, require complicated manual procedures for the cultivating and harvesting of the biomass. In particular, known systems are not scaleable nor modular. A need exists, therefore, for scalable, simpler, more effective and automated system and apparatus for cultivating and harvesting aquatic biomass.

Summary of the Invention

According to one aspect, the invention provides and integrated system for cultivating and harvesting aquatic biomass. The system is comprised of three main aspects or elements. These are:

1. A substrate device upon which aquatic organisms are attached and allowed to grow in a marine environment, hereafter referred to as an Aquatic Biomass Collector ("ABC" for short).
2. A flotation device for suspending one or more ABC, hereafter referred to as an "Aquatic Float Element with detachment device" ("AFE").
3. An automated device for harvesting and collecting the aquatic biomass from the ABC, hereafter referred to as an "Aquatic Biomass Harvester" . ("ABH").

While one aspect of the invention regards the integrated system, the three main elements of the system may be considered individually as aspects of the invention.

The Aquatic Biomass Collector (ABC).

The ABC according to one embodiment comprises one or more vertically arranged central shafts having a substrate material arranged between supporting struts attached at their ends to the central shaft, forming a plurality of "wings" projecting laterally from the central shaft. Any number of wings can project from the shaft. In a preferred embodiment, four wings are arranged perpendicularly. The substrates provide a two sided surface strong enough to support its shape while submerged in water. The substrate may be formed from a number of materials, so long as the material is suited for attached and growth of intended marine species. Examples of such material include solid or perforated plastic sheeting, netting, mesh and other permeable or semi-permeable cloth-like materials. A solid, rigid material could also be employed.

This substrate functions as a growth area below the surface of the water. The elongated shaft has fastening points at both ends so that several ABC can be suspended one above the other by a connecting line, as well as optionally being anchored to the sea floor. In another embodiment, the supporting struts can also be attached together at top and bottom using brackets replacing the elongated shaft, and each bracket has fastening points serving as anchoring points similar to the elongated shaft.

Aquatic Biomass Collector is placed into the aquatic environment so various free-living biological organisms living in the water column are allowed to attach and grow. This can occur naturally,

or alternatively juveniles of the species may be actively pre-attached to the substrate.

The Aquatic Float Element with detachment device (AFE).

The main purpose for use of the "Aquatic Float Element with detachment device" (AFE) is to provide a buoyant support apparatus for suspending the ABC under the surface of the water. The AFE provides a simplified deployment and recovery means for the ABC.

The AFE comprises a buoyant body with a central bore. The buoyant body can have any desired geometric shape, however in a preferred embodiment the buoyant body is cylindrical in shape. A vertical notch extends from the exterior lateral surface of the buoyant body to the central bore, large enough to allow the suspension line for the ABC to pass with sufficient clearing into the central bore. At the top of the buoyant body is an enlarged receiving cavity axially arranged with the central bore. The receiving cavity is arranged to receive a stopper device fixed to the upper part of the suspension line of the ABC. Attachment points are provided at the top and bottom or sides of the buoyant body in order to connect a series of AFE together at a location, as well as to anchor the AFEs to the sea floor.

In use, a number of ABC are connected vertically by a suspension line, with the stopper device fixedly attached to the line near the top of the line. The line is threaded through the notch in the buoyant body. The weight of the ABCs will cause the ABCs to sink until the stopper device rests in the receiving cavity. In order to

harvest, the suspension line is simply raised until the stopper is free of the receiving cavity, the line is removed from the notch, and the connected ABCs taken, for example, onboard a collection vessel.

The buoyant body may be made of any appropriate material that has sufficient buoyancy to support all of the attached ABCs together with the weight of the aquatic biomass at harvest time. Examples include a molded plastic body with a hollow or foam interior, cork, rubber, or a hollow steel or concrete construction and the like, know to one skilled in the art of flotation devices.

Aquatic Biomass Harvester (ABH).

To efficiently harvest the biomass from the ABC after it has been lifted out of the water, the system of the invention provides a harvesting and cleaning device referred to herein as “Aquatic Biomass Harvester” (ABH).

The ABH has a housing in which is arranged an inner structure in the form of an elongated cylindrical shape large enough for the ABC wing units to pass through. ABCs are pulled through the cylinder by connecting the ABC units to a continuous belt or rope that is pulled through the cylinder by a rotating drum or winch mechanism. Arranged on the inner surface of the cylindrical structure are a plurality of longitudinal tracks or rails that serve as attachment points for a number of modular, functional arm members, the arms of which are directed towards the interior of the cylinder. The number of arm members corresponds to the

number of "wings" of the ABC. In this application, the structure of the ABH will be described with reference to an embodiment where the ABCs have four perpendicular substrate wings, however one skilled in the art will recognize that embodiments with a different number of wings is possible, thereby requiring a corresponding number of arm members.

According to one aspect, the arms have two forked pairs of rollers arranged such that pairs of rollers together form longitudinal slots or passages along the length of the cylinder between which a wing of the ABC will be sandwiched as the ABC is pulled through the cylinder.

The arms may be arranged in any desirable order according to the function of the arms. For example four shape-guide arms or four pie-shaped guides may be arranged around the circumference of the entrance to the cylinder to form four slots that press and hold the four wings of the ABC outstretched as it enters the cylinder. Transport arms having forked pairs of arms equipped with rollers may be arranged after the shape-guide arms to facilitate the transport of the ABC units along the length of the cylinder. Arms having a cutting or scraping surface may be arranged after the transport arms, with a cutting device arranged to contact the surface of the wings, and thereby cut or scrape off the biomass as the ABC is pulled through the cylinder past the cutting arms. Arms having nozzles for directing pressurized water may be arranged after the cutting arms, with the nozzles directed towards the surface of the wings in order to wash off any dislodges biomass and clean the wings.

At the bottom of the cylinder is provided an opening through which the dislodged biomass may fall into a container or other collection means. When the ABC units exit the ABH, the ABC units are disconnected from the continuous belt or rope, to be reused later.

According to another aspect, a number of ABH devices may be arranged in series, with each ABH unit having a specialized function determined by the type of arms arranged in the ABH. For example, a first ABH unit may comprise only transport arms, a second ABH unit may comprise only cutting arms, a third ABH unit may comprise only arms with nozzles. Due to the modular nature of the ABH units and the arms, any desirable combination and arrangement of arms is possible.

According to yet another aspect, the ABH is provided with a ramp leading to the entrance of the BH, the ramp having profiles for spreading the wings of the ABC apart as the ABC is pulled into the ABH.

Brief description of the drawings

The invention is described in more detail with reference to the accompanying drawings, wherein:

Figure 1 shows a front elevation view of an Aquatic Biomass Collector according to the invention.

Figure 2 shows a perspective view of the Aquatic Biomass Collector according to the invention from figure 1.

Figure 3 shows an exploded view of an Aquatic Biomass Collector.

Figure 4 shows five examples of the substrate fabric for an Aquatic Biomass Collector.

Figure 5 shows a perspective view of a second embodiment of the Aquatic Biomass Collector.

Figure 6 shows an exploded view of embodiment of Aquatic Biomass Collector from figure 5.

Figure 7 shows an illustration of how several Aquatic Biomass Collectors can be linked together and how they are under an Aquatic Float Element (AFE) exposed in an aquatic environment.

Figure 8 shows a front elevation view of an Aquatic Float Element (AFE) and an Aquatic Biomass Collector hanging below.

Figure 9. shows various views of the various components of an aquatic float element.

Figure 10. shows a perspective view of an aquatic float element in practical use and according to the invention from figure 8 and 9.

Figure 11 and 12 show a front and from behind perspective view of an aquatic biomass harvest (ABH).

Figure 13 shows a perspective view of the housing enclosing the Aquatic Biomass Harvester with the opening underneath.

Figure 14 shows a perspective view of the cylindrical member in the ABH.

Figure 15 shows a perspective view of the cylindrical member mounted in the housing of the Aquatic Biomass Harvester.

Figure 16 shows a perspective view a common arm mounting bracket.

Figure 17 shows a close up perspective view of a common arm mounting bracket engaging a mounting rail.

Figure 18. shows a front perspective view of the biomass harvesting unit.

Figure 19 and 20. shows a perspective and front elevation view of a shape-guide arm.

Figure 21 shows a front elevation view of a shape-guide plate.

Figure 22 shows a perspective view of a transport arm.

Figure 23 shows a perspective view of a cutting or scraping arm.

Figure 24 shows a front elevation view a cutting or scraping arm.

Figure 25. shows a perspective view of a washing arm with nozzles.

Detailed description of the invention

The system of the invention comprises three main elements designed to work together to provide an integrated system for cultivating and harvesting aquatic biomass.

The Aquatic Biomass Collector (ABC) of the invention is shown in figs 1-7. A first embodiment is illustrated in figs 1-3, and a second embodiment is illustrated in figs 5 and 6.

As seen in figs 1-3, a first embodiment of the ABC comprises an elongated vertical shaft 10. A plurality of curved support struts 12 are connected at their ends to the vertical shaft 10 to form a plurality of "wings" 14. The ABC can comprise any number of wings, however a preferred embodiment comprises four wings 14 arranged perpendicularly to each other, as seen in fig 2. A number of horizontal support braces 16 extend from the vertical shaft 10 to support struts 12 to hold the wings outstretched. Arranged at each end of vertical shaft 10 are eye bolts 18. A substrate material 20 is stretched between struts 12 and shaft 10, upon which aquatic organisms will attach and grow. Any material upon which such organisms may attach may be used. Preferable materials include solid, permeable or semi-permeable plastic (polypropylene ,polyethylene, PVC, nylon and similar), mesh, metal (Iron, aluminum, steel, titanium and similar), rubber

(silicone , natural- and synthetic rubber), fibrous materials, wood or cloth like materials. Preferred materials will be environmentally friendly, flexible and semi permeable. Fig 4 illustrated the surface structure of preferred materials, where weaving and permeations provide attachment points for organisms.

Figs 5 and 6 show an alternate embodiment for the ABC. According this aspect of the invention, the ABC comprises a top and bottom bracket 22. Bracket 22 comprises a plurality of angled and vertical attachment tubes 24 and eye ring 26. The number of vertical and angled attachment tubes corresponds to the number of wings. As seen in fig 6, vertical shafts 26 are connected between the top and bottom bracket using the vertical attachment tubes, curved support struts 28 are connected between the angled attachment tubes, with horizontal support braces 30 extending between support struts and vertical shafts. As in the first embodiment, a substrate material 20 is arranged to form wings 14.

As shown in fig 7, a plurality of ABCs may be suspended one above the other by attachment lines 32 underneath the surface of the water 34. The ABCc are suspended by flotation devices 36 referred to as “Aquatic flotation element” (AFE).

The AFE comprises a buoyant body 38 that floats on the water surface. A stopper device 40 is affixed to support line 32. Stopper device 40 may have any geometrical shape, however preferred embodiments include a cylindrical shape or conical shape. As seen in fig 9, the buoyant body 38 has a central bore 41 and a

notch 42 extending from the outer surface of the buoyant body to the central bore. Support line 32 is threaded through notch 42 into central bore 41. At the top surface of buoyant body 38 is a receiving cavity 44. A shown in fig 10, stopper device fits into and is supported in cavity 44 by the combined weight of the ABCs and any biomass growing thereon. A plurality of attachment eyes 46 are arranged on the top and bottom or sides surfaces of buoyant body 38, used to connect adjacent AFE together as well as to anchor the AFEs to the sea floor. In use, the connected ABC are placed into AFEs and aquatic organisms are allowed to attach to the wings naturally. Alternatively, juvenile organisms may be affixed to the wings prior to installation of the ABCs. After a period of growth, the ABC may be retrieved by lifting the stopper device out of the retaining cavity, and the ABC taken for example on board a harvesting vessel.

Upon retrieval, the biomass-laden ABCs are taken to an appropriate site for harvesting/removal of the biomass. The site may be onboard a harvesting vessel, or at an installation on land. The biomass is removed from the ABC by an automated device hereafter referred to as an “Aquatic biomass harvester (ABH), as shown in figs 11-29.

As seen in fig 11, the ABH comprises biomass removal unit 48, with a ramp 50 leading to a front end of the biomass removal unit 48. A continuous belt or rope 52 leads from a far end of the ramp 50, passes through the biomass removal unit to a rear, rotating drum or winch 54, passes back under the construction to the far end of the ramp. Belt or rope 52 thus travels a circuitous,

continuous path through the biomass removal unit. One or more ABC units 56, having been previously detached from their respective suspension lines 32, are connected to continuous belt or rope 52 by clips or the like to be thereafter pulled through the biomass removal unit 48 by drum or winch 54.The ramp 50, biomass removal unit 48 and other components of the ABH may rest upon a platform 58. A biomass collection bin 60, or other collection means, is arranged under the biomass removal unit 48, as shown in figs 11 and 12.

The biomass removal unit 48 comprises a housing 62 as shown in fig 13. The housing is equipped with leveling feet 64. Lifting rings 66 are arranged at the top of housing 62 for transport of the removal unit. Housing 62 has an opening 68 at the bottom.

A cylindrical member 70 shown in fig 14 is arranged in housing 62 as shown in fig 15. Cylindrical member 70 has, arranged on its inner surface, a plurality of rails or tracks 72 extending in the longitudinal direction of the cylinder member. Rails or tracks 72 serve as attachment points for various functional arm members, as described below.

The functional arm members perform various functions in the biomass removal process, and are modular in nature, meaning that the number, type and order of arms that can be attached to tracks 72 is customizable. The arms are based on a common mounting bracket 74, depicted in figure 16. The mounting bracket comprises a forked arm frame 76, extenders 78, and attachment heads 80. In the figures, both attachment heads 80 and tracks 72

are shown as having a square profile, however it should be understood that other geometries are possible. Attachment heads 80 slide into engagement with tracks 72, such that forked arm frames 76 are directed towards the interior of cylindrical member 70, as shown in fig 17.

Fig 18 shown biomass removal unit 48 with a number of functional arms arranged inside. According to one possible configuration, the first arms mounted in the biomass removal unit are of a different basic configuration than the remaining arms. According to this aspect, the first arms are so-called "shape guide arms" The purpose of the shape guide arms is to cause the wings of the ABC, which may have slightly collapsed due to the weight of the biomass, to be spread out into its normal shape. The figures illustrate an embodiment where the ABCs have four perpendicular wings. As seen in figs19 and 20, the shape guide arms 82 comprise attachment heads 80, extenders 78, a frame 84 and arms 86. Arms 86 are equipped with rollers 88. As seen in the frontal view of fig 20, shape guide arms are pie shaped. As shown in Fig 18, four such shape guide arms 82 are arranged about the circumference of cylindrical member 70, and spaced so as to form four slots or passages 90, together forming "X" shape passages through the biomass removal unit. The "X" shape of the slot corresponds to the outstretched wings of the ABC units. An alternative to shape guide arms is shown in fig 21. This alternate arrangement employs a shape guide plate 92, arranged as a angled pie-shape plate. Shape guide plates 92 are arranged forming "X" shaped slots in a similar fashion. Shape guide plates 92 are provided with a screw mechanism 94 connected to a

mounting bracket 96 having mounting heads 80. The screw mechanism may be adjusted to alter the inclined angle of the shape guide plates.

Next in line in the biomass removal unit, after the shape guide arms/plates, are arranged a series of functional arms. In a preferred arrangement, the next arms in line are transport arms 98, shown in fig 22. Transport arms 98 are based on the common forked mounting bracket shown in fig 16. Two pairs of roller arms 100A and 100 B project from the mounting bracket 74. One or more guide rollers 102 is arranged between the two halves of the forked bracket. Four of such transport arms are mounted to tracks 72 about the circumference of the cylindrical member 70. Roller arms 100A and 100B form a slot or passage for the wings of an ABC, where four such transport arms arranged to form an "X" shaped passage through the biomass removal unit, aligned with the "X" shaped passage formed by the shape guide arms. The ABC are thus pulled through the biomass removal unit, with the wings of the ABC following the slots formed by the arms.

In a preferred arrangement, a plurality of cutting or scraping arms 104 are arranged after the transport arms. Cutting arms 104 are likewise based on the common mounting bracket of fig 16, with the addition of cutting devices 106 projecting between roller arms 100A and 100B. Cutting device 106 is an elongated body rotatably mounted on an axle 108. A cutting or scraping edge 110 extends along the length of the cutting device. The cutting device may thereby be rotated such that the cutting or scraping edge is either facing the reverse of the direction of travel of the ABC units

(in order to cut), or facing with the direction of travel in order to scrape. The cutting device is preferably spring loaded to allow a flexible engagement with the surface of ABC wings, so as not to dame the material of the wings. As with the other arms, four such cutting arms are arranged about the circumference of cylindrical member 70, to form an "X" shaped passage. As the ABC units are pulled past the cutting arms, cutting edge 110 will dislodge biomass from the ABC wings.

In a preferred arrangement, the cutting arms are followed by washing arms 112. Again, washing arms 112 are based on the common mounting bracket of fig 16. Is this event, the arms are provided with nozzle arms 114 connected by a hose 116 to a pressurized water supply. Jets 118 direct pressurized water onto the wings of the ABC as the ABC units are pulled past the washing arms.

The dislodged and sprayed biomass is thereby allowed to fall through the opening at the bottom of the biomass removal unit, into the collection bin or other collection means.

While the preceding example was described with an ABC having four wings, it should be understood that if an ABC is provided with a different number of wings, the cylindrical member 70 will be provided with a corresponding number of tracks 72.

Because the system is modular, and order of arranging the arms is possible. According to one aspect, a series of housing could be provided, each having a different set of arms. For example, a first

housing could comprise only transport arms, followed by a housing comprising only cutting arms, followed by a housing comprising only washing arms.

CLAIMS

1. A system for cultivating and harvesting aquatic biomass, comprising,
   a. A substrate device (56) arranged for an aquatic species to attach and grow in a marine environment, the substrate device comprising one or more elongated central shafts (10), a plurality of support struts (16) attached at their ends to the shaft or shafts to define a plurality of laterally extending wings (14), upon which wings are mounted a substrate material (20) upon which the aquatic species may be attached, the device further comprising an attachment member (18) at a top of the central shaft, to which is connected a support line (32) for suspending the substrate below the surface of a body of water (34) , and
   b. A biomass harvesting unit (48), comprising
      i. an elongated cylindrical member (70) having a plurality of longitudinal tracks or rails (72) disposed on the inner surface of the cylindrical member,
      ii. a winch or rotating drum device (54) arranged at a rear end of the cylindrical member, arranged to pull a continuous belt or rope (52) from a front end of the cylindrical member, through the cylindrical member, and back to the front end, said belt or rope having attachment points for connecting the substrate device,
      iii. a plurality of functional arm members comprising a mounting bracket (74) having an attachment head (80), the attachment head arranged to slidingly

engage the tracks or rails disposed on the inner surface of the cylindrical member,

iv. wherein the functional arm members comprise arms (76) that, when mounted to the tracks or rails, are directed towards the interior of the cylindrical member, at least one of which arm members further comprises a cutting device (106) directed towards the interior of the cylindrical member for dislodging biomass from the wings of a substrate device,

v. further wherein a plurality of arms are mounted about the circumference of the cylindrical body, the number of arms around the circumference corresponding to the number of wings of the substrate device, the arms arranged around the circumference such that adjacent arms form slots or passages (90) for receiving the wings of the substrate device,

vi. whereby, a substrate device, attached to the continuous belt or rope, will be pulled through the cylindrical member, such that the wings of the substrate device contact the cutting device of the arms, thereby dislodging the biomass from the substrate device.

2. The system for cultivating and harvesting aquatic biomass according to claim 1, wherein

a. An attachment member is arranged at the bottom of the central shaft of the substrate device,

b. A plurality of substrate devices are suspended one above the other in the marine environment by support lines,

c. A stopper device (40) is fixedly attached to the support line above the uppermost substrate device,

d. A flotation device (36) is arranged to float on the surface of a body of water, the flotation device comprising a buoyant body (38) having a central bore (41), a longitudinal notch (42) leading from an outer surface of the buoyant body to the central bore whereby the support line may be threaded through the notch to the central bore, and a receiving cavity (44) in a top surface of the buoyant body, the cavity having a size corresponding to, and arranged to receive, the stopper device.

3. The system for cultivating and harvesting aquatic biomass according to one of the preceding claims, wherein the substrate device comprising top and bottom brackets (22) having attachment tubes (24) for receiving there-between the ends of elongated shafts and the ends of the support struts.

4. The system for cultivating and harvesting aquatic biomass according to one of the preceding claims, wherein the cylindrical member of the biomass harvesting unit is arranged in a housing (62), and a ramp (50) leads up to the front end of the cylindrical body, the ramp arranged to guide substrate device towards the front end of the cylindrical body.

5. The system for cultivating and harvesting aquatic biomass according to one of the preceding claims, wherein the functional arms that may be mounted to the tracks or rails

are provided as a set of arms having different configurations and functions that may be arranged longitudinally along the tracks or rails, including:

a. Arms (100A, 100B) comprising rollers for transporting the wings of the substrate devices,
b. Arms comprising cutting devices (106),
c. Arms comprising a nozzle device (114) projecting towards the interior of the cylindrical member, the nozzle device comprising jets (118) arranged to direct pressurized water towards the wings of the substrate device.

6. The system for cultivating and harvesting aquatic biomass according to one of the preceding claims, wherein the cylindrical member is provided with an opening (68) at a bottom end, arranged for dislodged biomass to fall through, with a collection bin (60) or other collection means arranged underneath said opening.
7. The system for cultivating and harvesting aquatic biomass according to one of the preceding claims, wherein the functional arm members are forked, with pairs of rollers of the fork defining the slots or passages for the wings of the substrate device.
8. The system for cultivating and harvesting aquatic biomass according to one of the preceding claims, wherein the harvesting unit further comprising a plurality of pie-shaped guide members (82, 92) arranged at the front end of the cylindrical member, the pie-shaped guide arms arranged about the circumference of the cylindrical member such that adjacent arms forms slots for receiving the wings of the

substrate devices as they are pulled into the harvesting unit by the winch or drum.

9. The system for cultivating and harvesting aquatic biomass according to claim 8, wherein the pie-shaped guide members comprise arms with rollers.

10. The system for cultivating and harvesting aquatic biomass according to claim 8, wherein the pie-shaped guide members are plates having an adjustable screw mechanism (94) for adjusting the angle of the plate.

11. A device for harvesting aquatic biomass from a substrate member of the type having central shaft with substrate surfaces arranged as wings projecting laterally from the shaft upon which cultivated biomass is attached, the harvesting device comprising:

a. an elongated cylindrical member having a plurality of longitudinal tracks or rails disposed on the inner surface of the cylindrical member,

b. a winch or rotating drum device arranged at a rear end of the cylindrical member, arranged to pull a continuous belt or rope from a front end of the cylindrical member, through the cylindrical member, and back to the front end, said belt or rope having attachment points for connecting the substrate member,

c. a plurality of functional arm members comprising a mounting bracket having an attachment head, the attachment head arranged to slidingly engage the tracks or rails disposed on the inner surface of the cylindrical member,

d. wherein the functional arm members comprise arms that, when mounted to the tracks or rails, are directed towards the interior of the cylindrical member, at least one of which arm members further comprises a cutting device directed towards the interior of the cylindrical member for dislodging biomass from the wings of a substrate member,

e. further wherein a plurality of arms are mounted about the circumference of the cylindrical body, the number of arms around the circumference corresponding to the number of wings of the substrate member, the arms arranged around the circumference such that adjacent arms form slots or passages for receiving the wings of the substrate member,

f. whereby, a substrate member, attached to the continuous belt or rope, will be pulled through the cylindrical member, such that the wings of the substrate member contact the cutting device of the arms, thereby dislodging the biomass from the substrate member.

12. The device for harvesting aquatic biomass according to claim 11, wherein the cylindrical member of the biomass harvesting device is arranged in a housing, and a ramp leads up to the front end of the cylindrical body, the ramp arranged to guide substrate members towards the front end of the cylindrical body.

13. The device for harvesting aquatic biomass according to claim 12, wherein the functional arms that may be mounted to the tracks or rails are provided as a set of arms having

different configurations and functions that may be arranged longitudinally along the tracks or rails, including:

a. Arms comprising rollers for transporting the wings of the substrate members,

b. Arms comprising cutting devices,

c. Arms comprising a nozzle device projecting towards the interior of the cylindrical member, the nozzle device comprising jets arranged to direct pressurized water towards the wings of the substrate member.

14. The device for harvesting aquatic biomass according to claim 13, wherein the cylindrical member is provided with an opening at a bottom end, arranged for dislodged biomass to fall through, with a collection bin or other collection means arranged underneath said opening.

15. The device for harvesting aquatic biomass according to claim 14, wherein the functional arm members are forked, with pairs of rollers of the fork defining the slots or passages for the wings of the substrate members.

16. The device for harvesting aquatic biomass according to claim 15, wherein the harvesting unit further comprising a plurality of pie-shaped guide members arranged at the front end of the cylindrical member, the pie-shaped guide arms arranged about the circumference of the cylindrical member such that adjacent arms forms slots for receiving the wings of the substrate members as they are pulled into the harvesting unit by the winch or drum.

17. The system for cultivating and harvesting aquatic biomass according to claim 8, wherein the pie-shaped guide members comprise arms with rollers.

18. The system for cultivating and harvesting aquatic biomass according to claim 8, wherein the pie-shaped guide members are plates having an adjustable screw mechanism for adjusting the angle of the plate.

19. A substrate device for cultivating an aquatic in a marine environment, the substrate device comprising one or more elongated central shafts, a plurality of support struts attached at their ends to the shaft or shafts to define a plurality of laterally extending wings, upon which wings are mounted a substrate material upon which the aquatic species may be attached, the device further comprising an attachment member at a top of the central shaft, to which is connected a support line for suspending the substrate below the surface of a body of water.

20. The substrate device according to claim 19, wherein the substrate device comprises top and bottom brackets having attachment tubes for receiving there-between the ends of elongated shafts and the ends of the support struts.

21. The substrate device according to claim 19 or 20, wherein the substrate material is a flexible, permeable or semi-permeable material.

22. The substrate device according to claim 19, 20 or 21 wherein four wings are arranged perpendicularly to one another.

23. The substrate device according to claim 19, 20, 21 or 22 further comprising a stopper device fixedly attached to the support line above the substrate device, a flotation device arranged to float on the surface of a body of water, the flotation device comprising a buoyant body having a

central bore, a longitudinal notch leading from an outer surface of the buoyant body to the central bore whereby the support line may be threaded through the notch to the central bore, and a receiving cavity in a top surface of the buoyant body, the cavity having a size corresponding to, and arranged to receive, the stopper device.

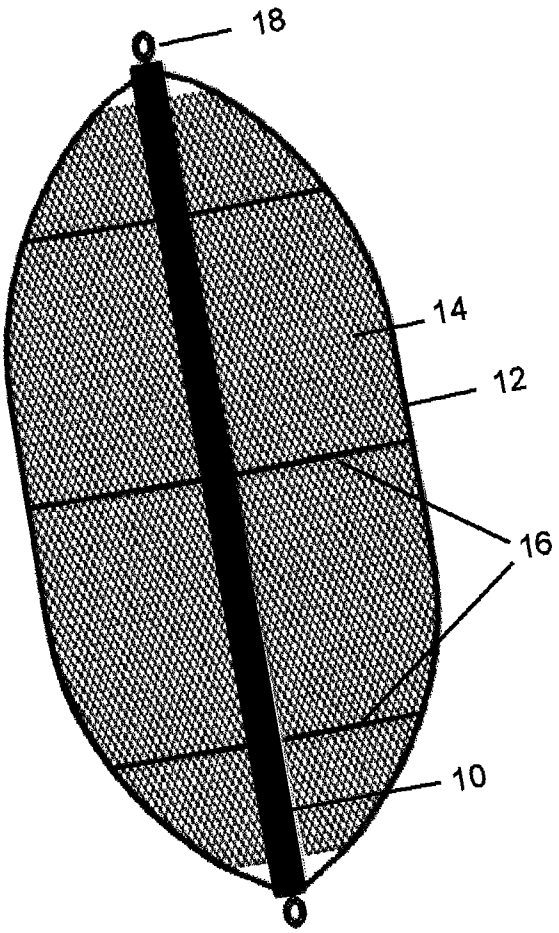


Figure 1.

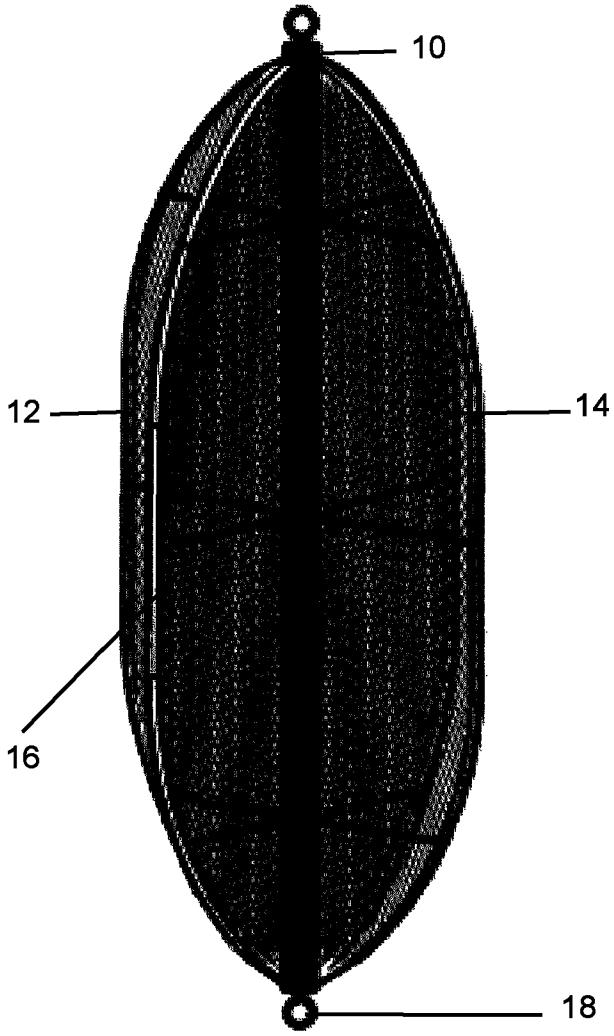
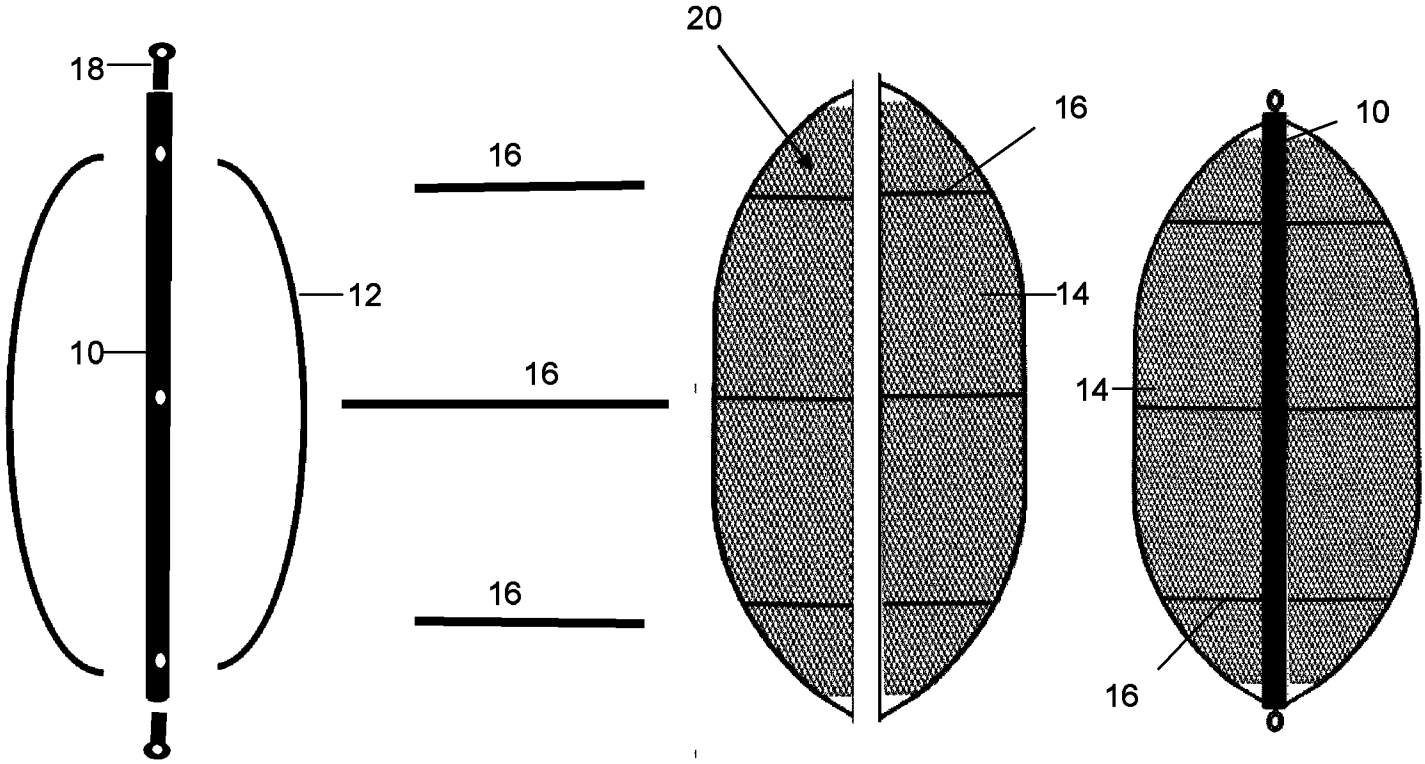


Figure 2.



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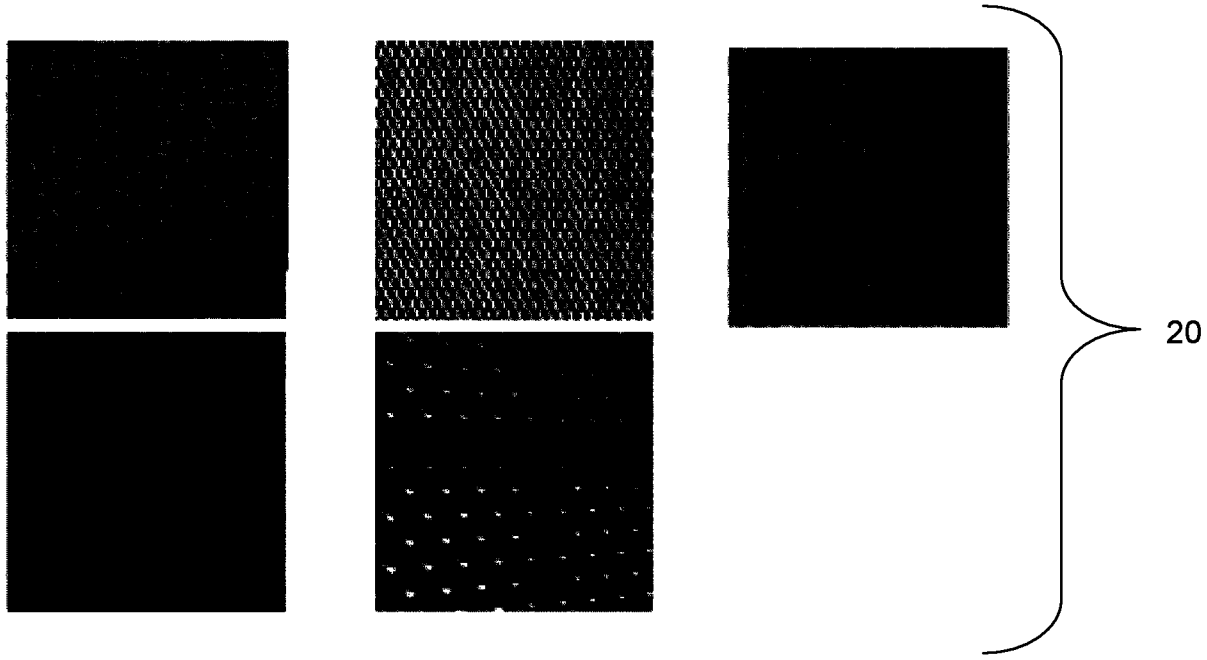

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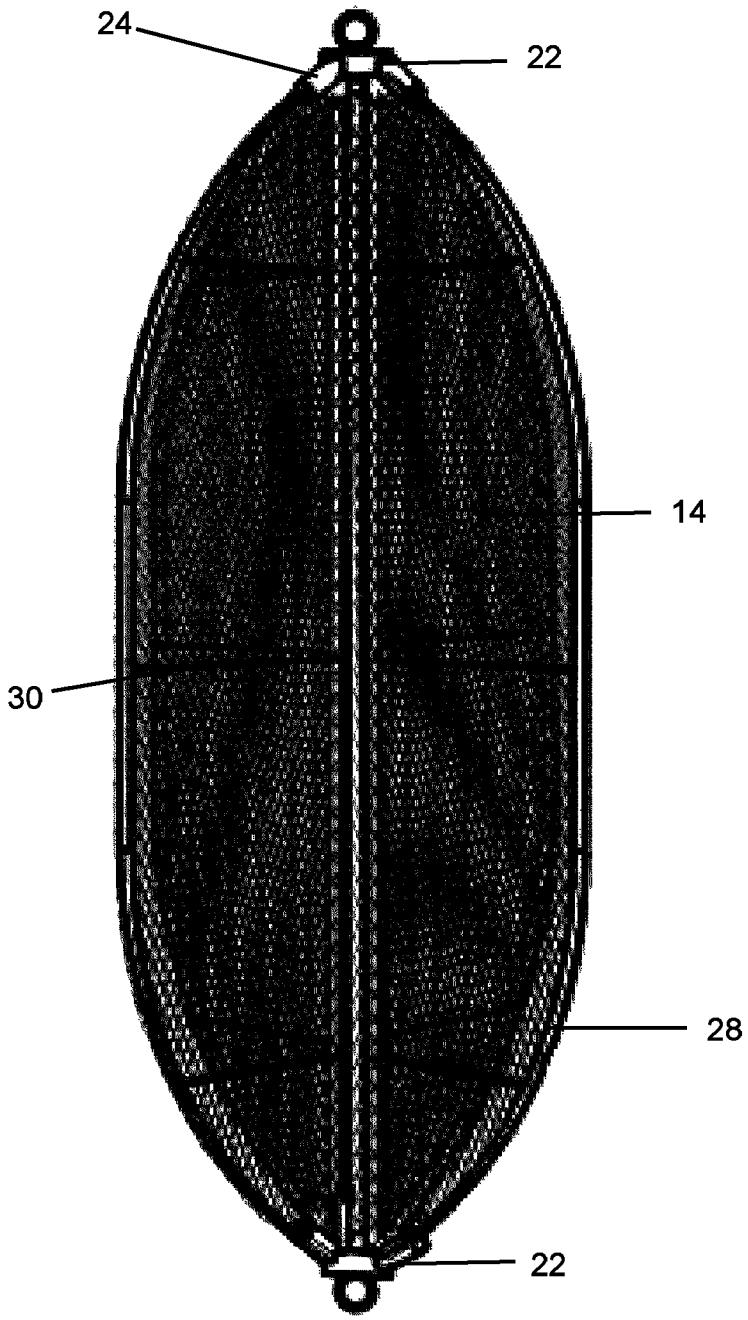

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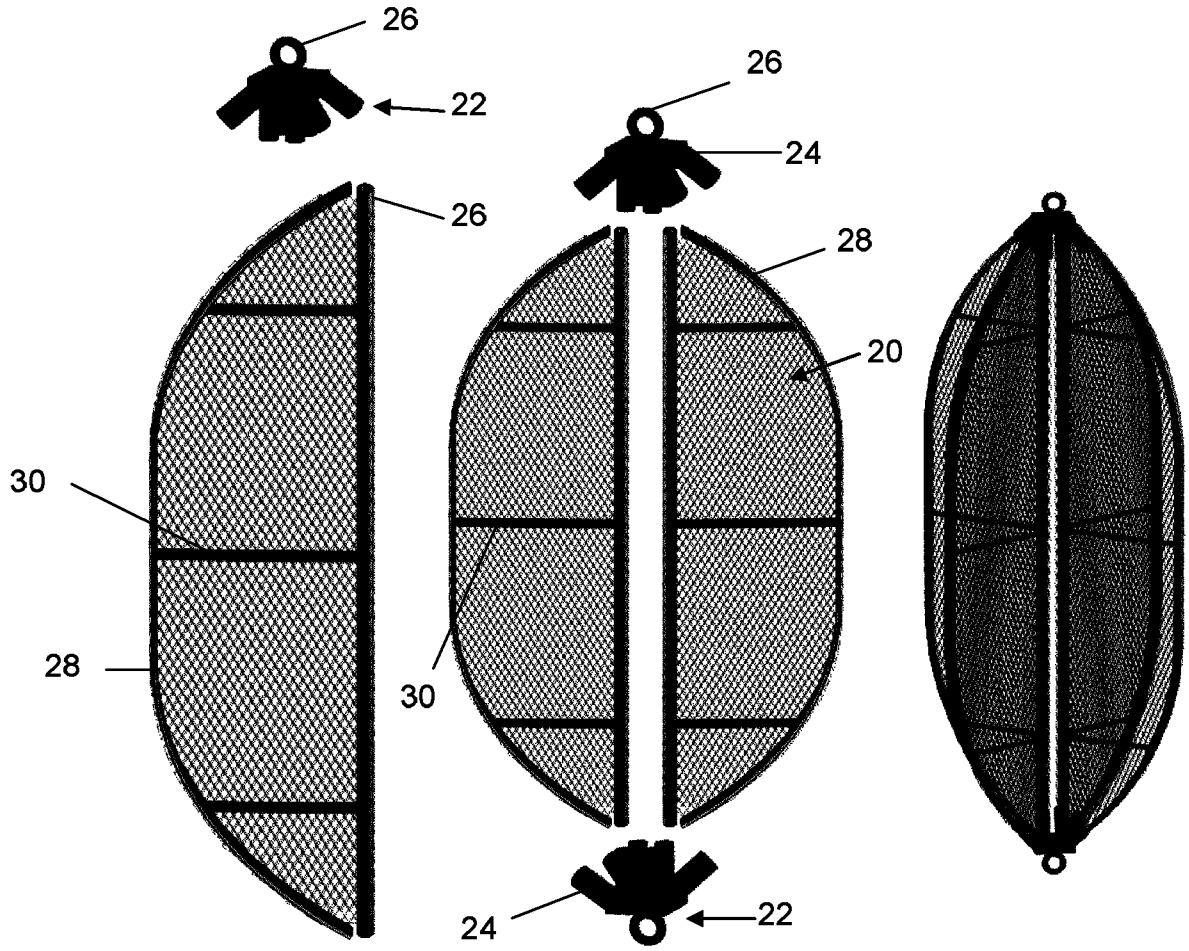

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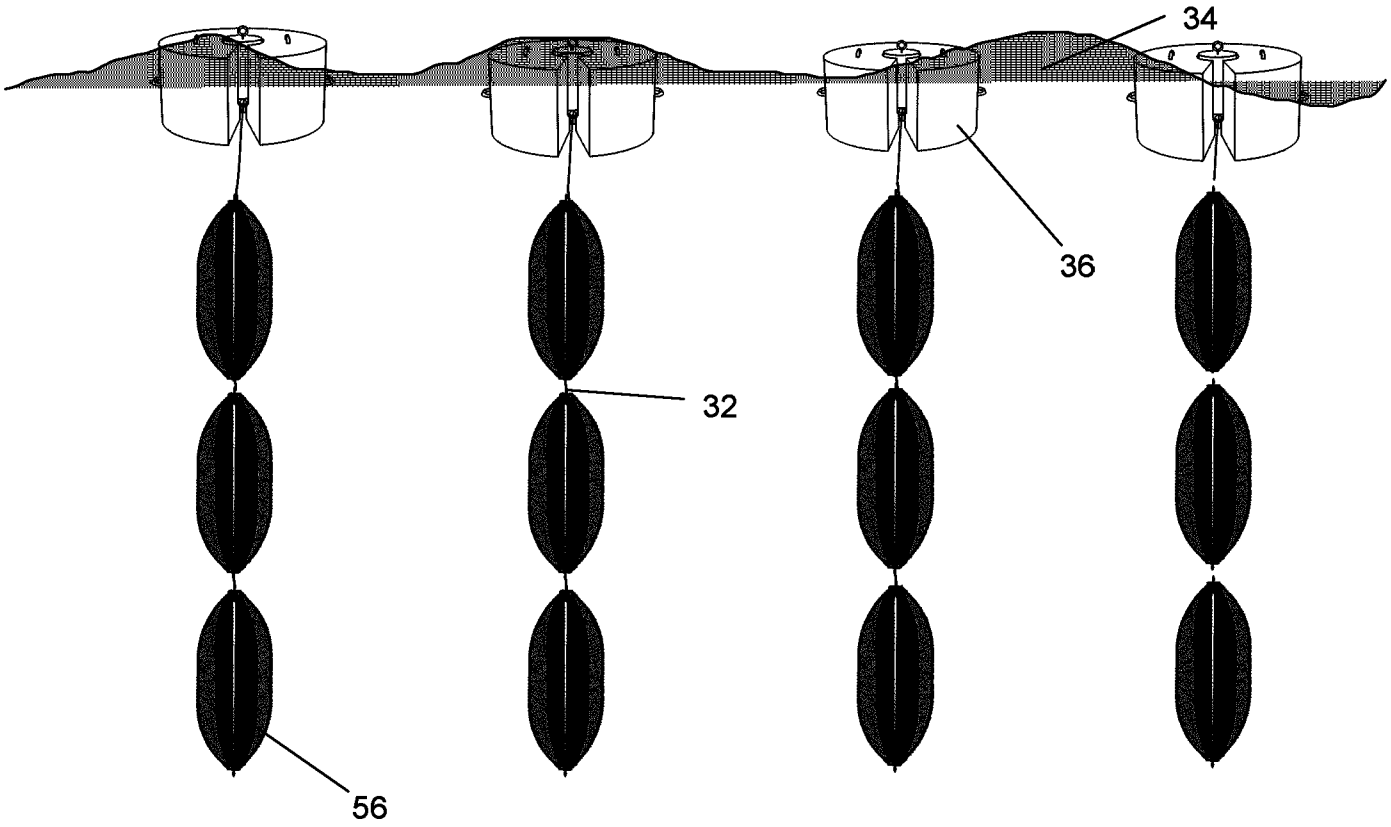

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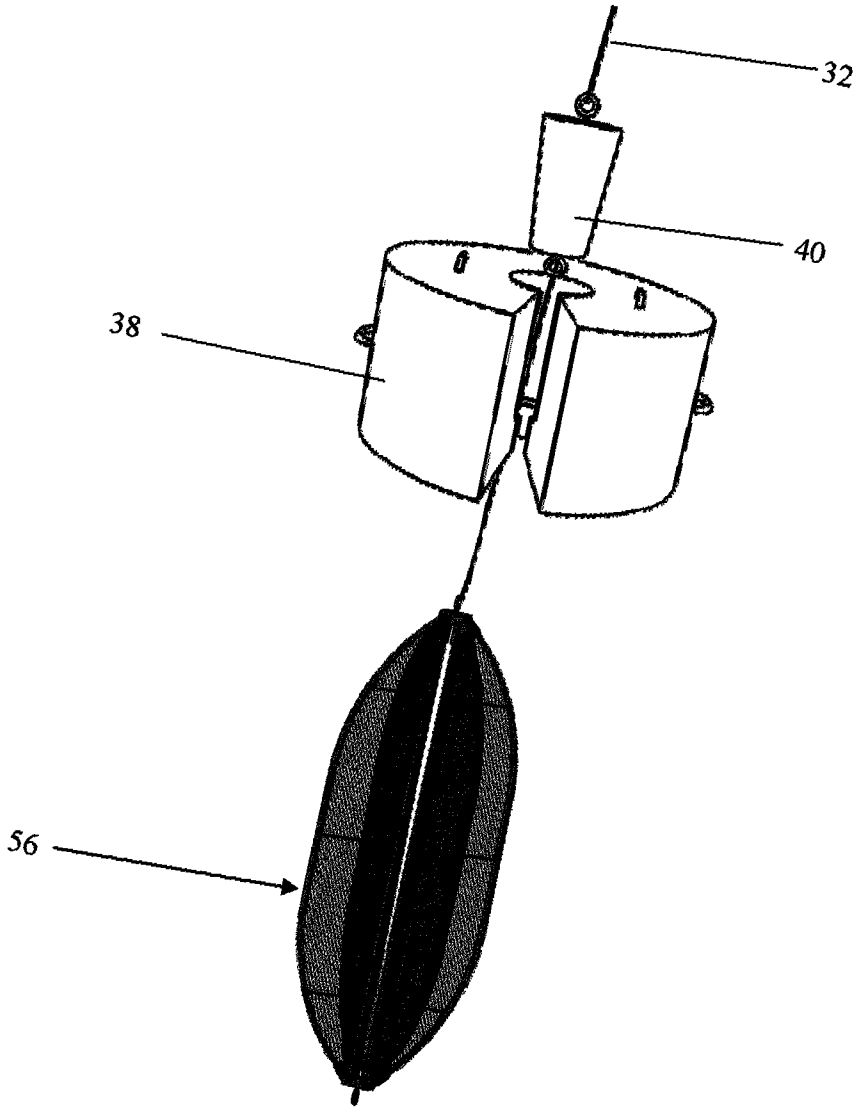

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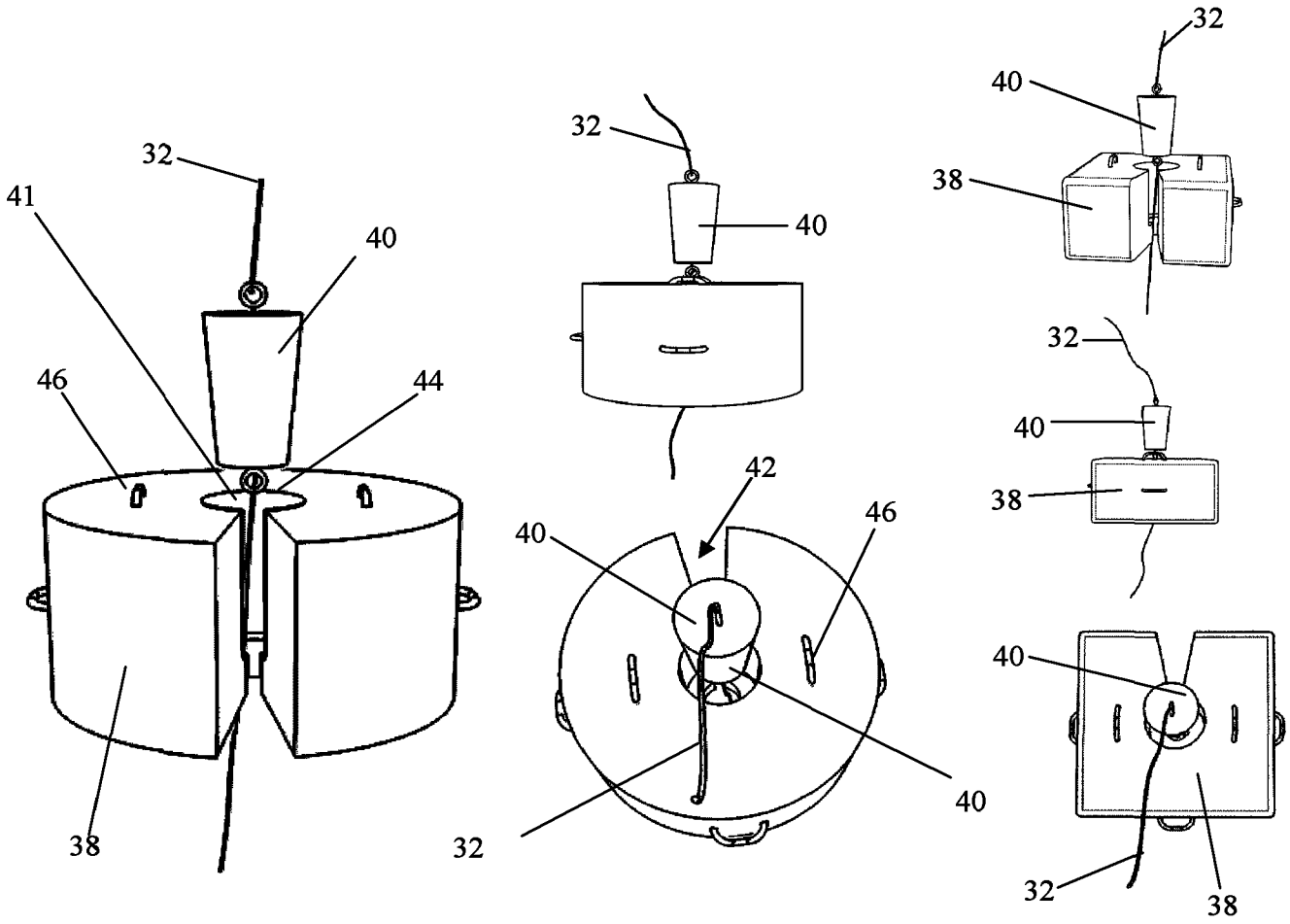

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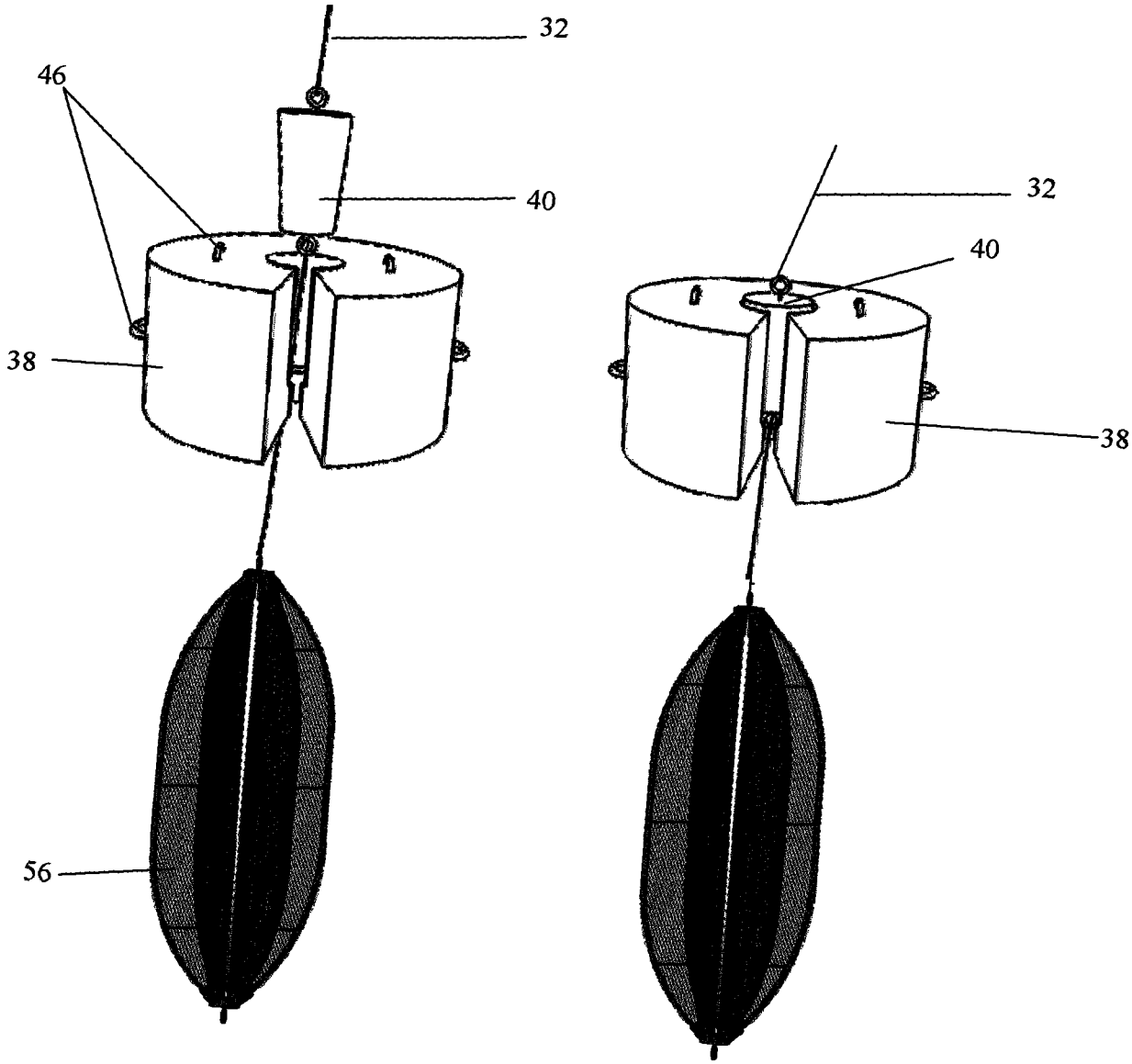

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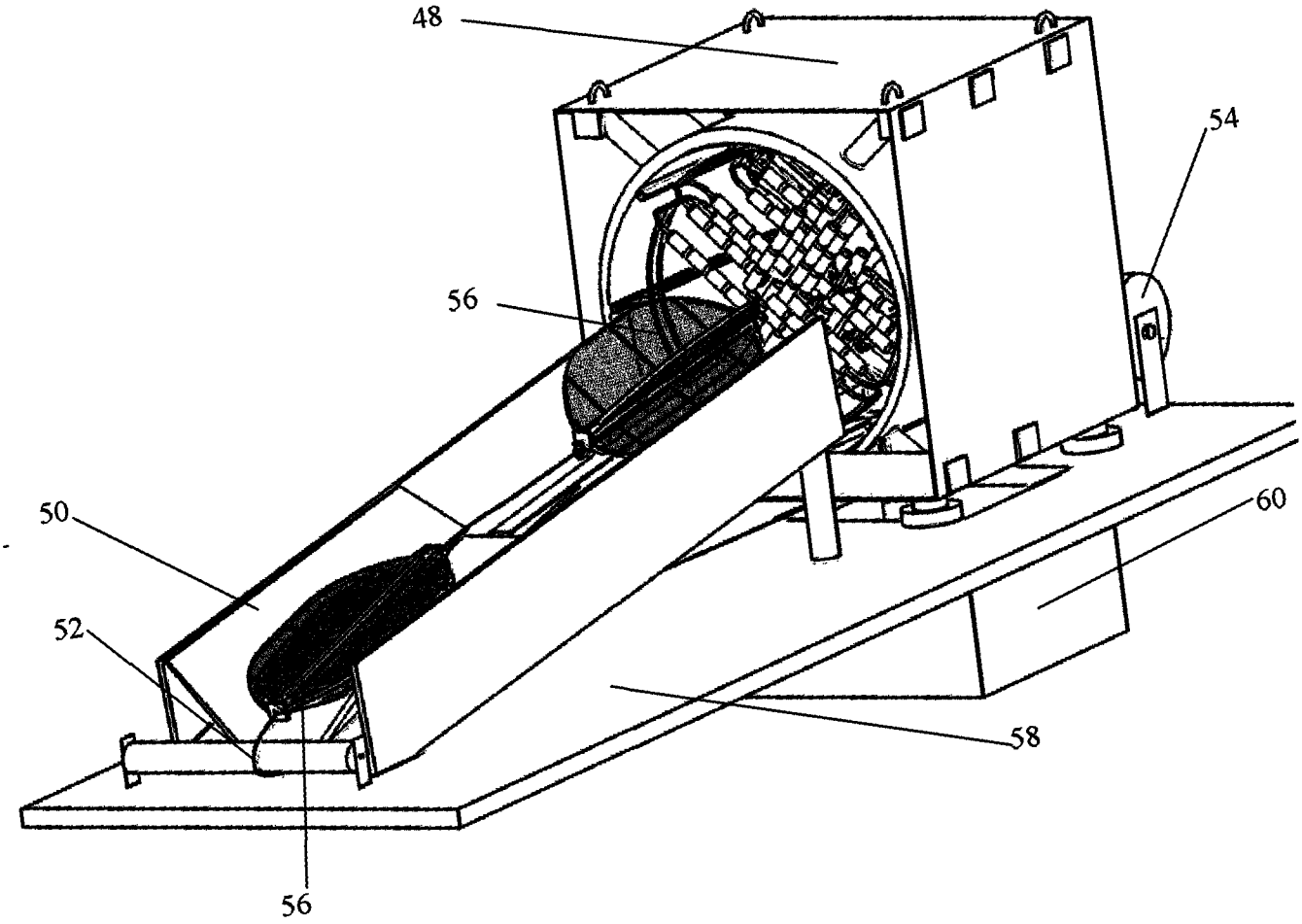

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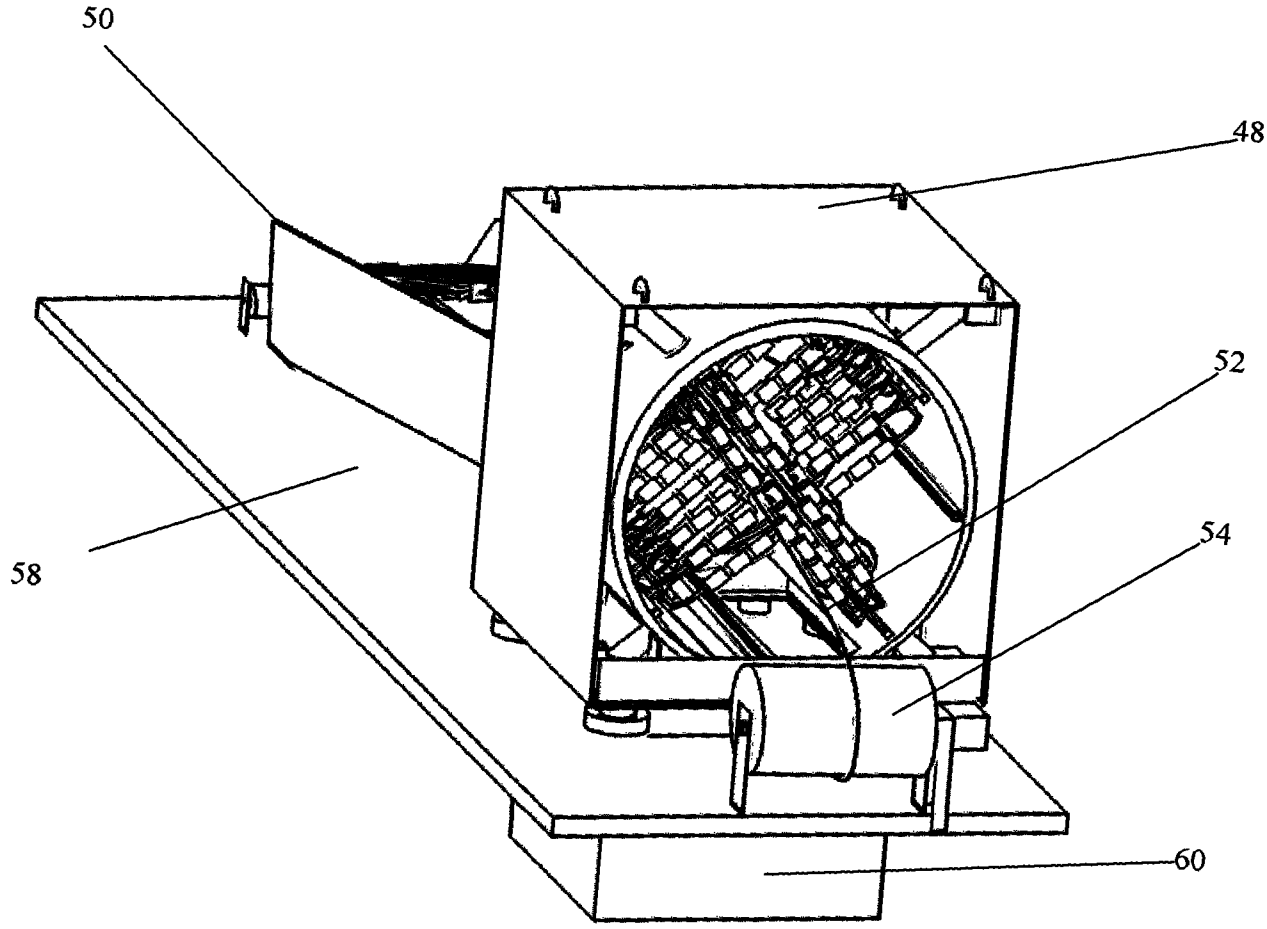

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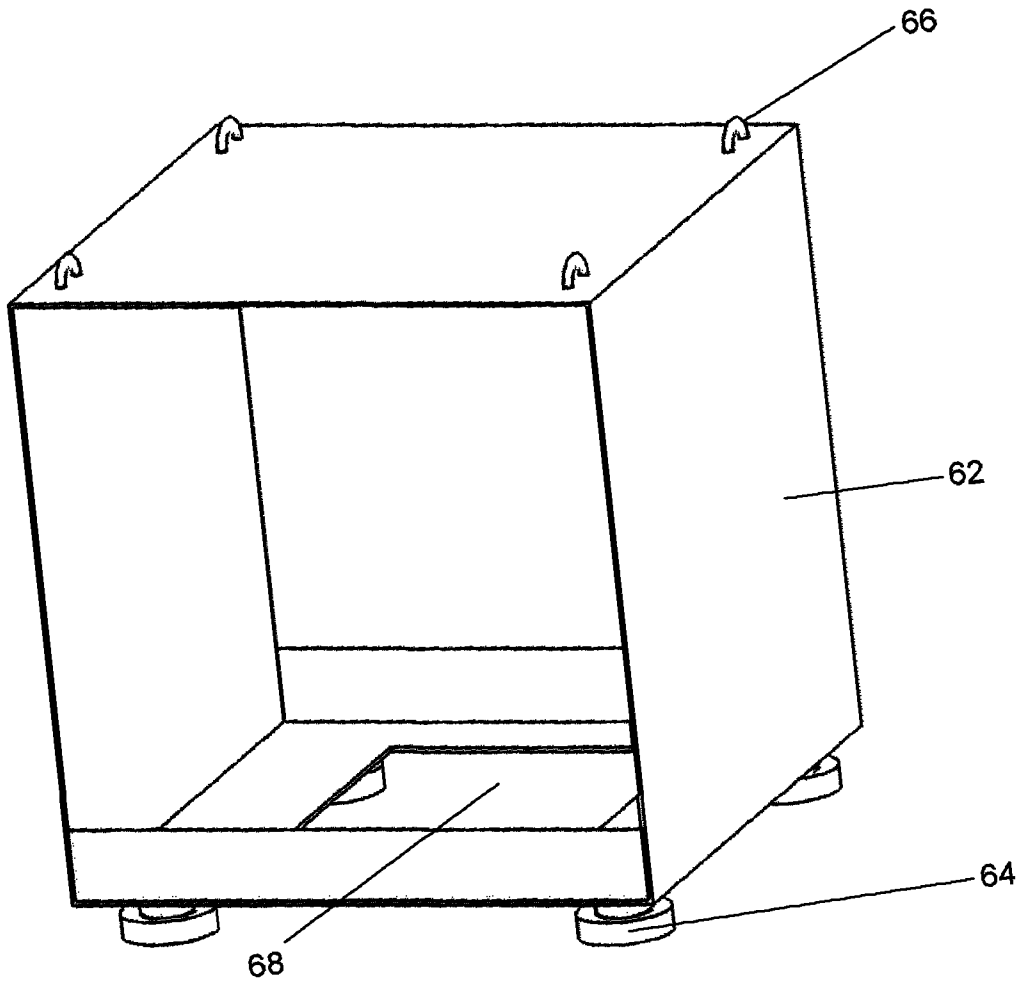

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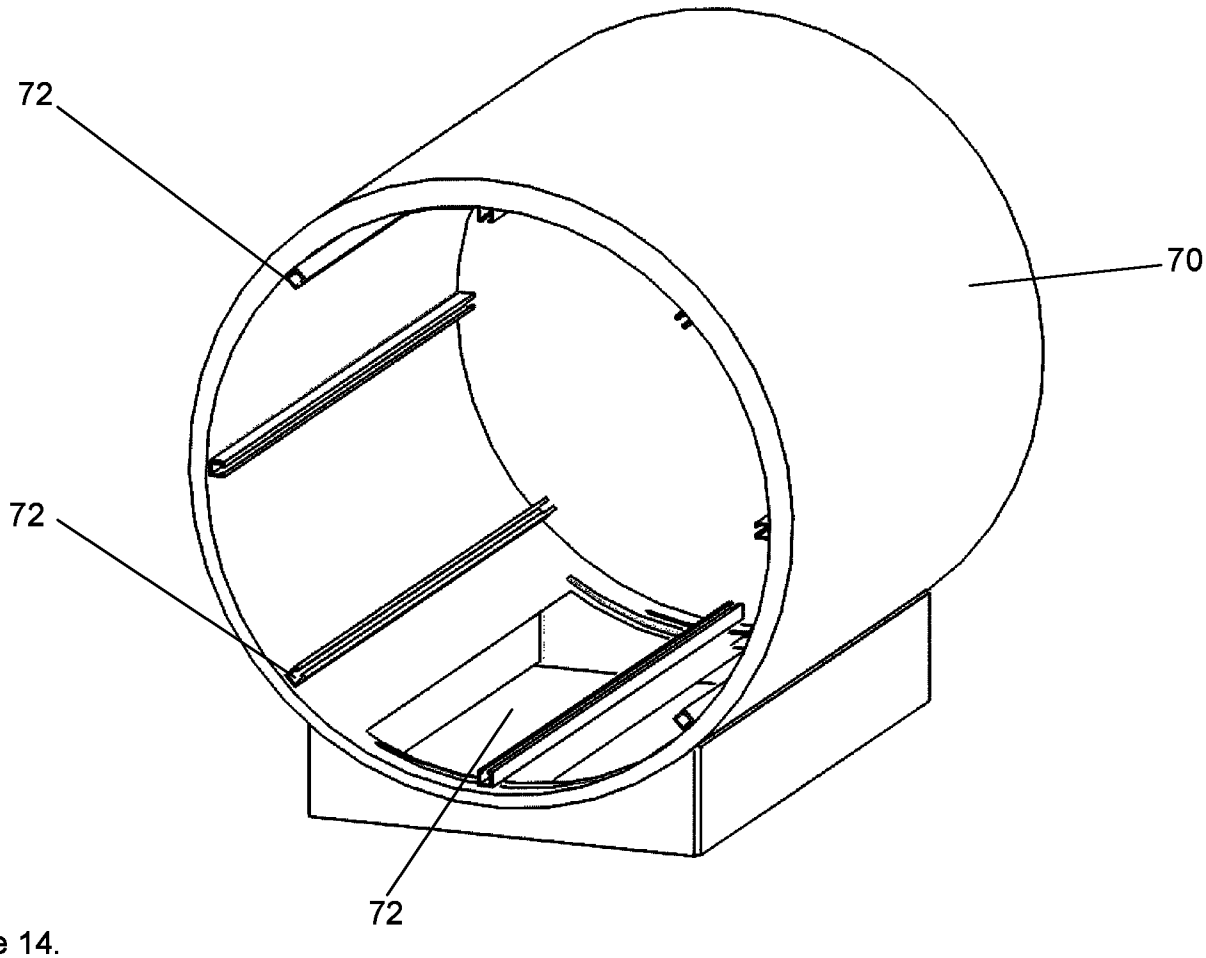

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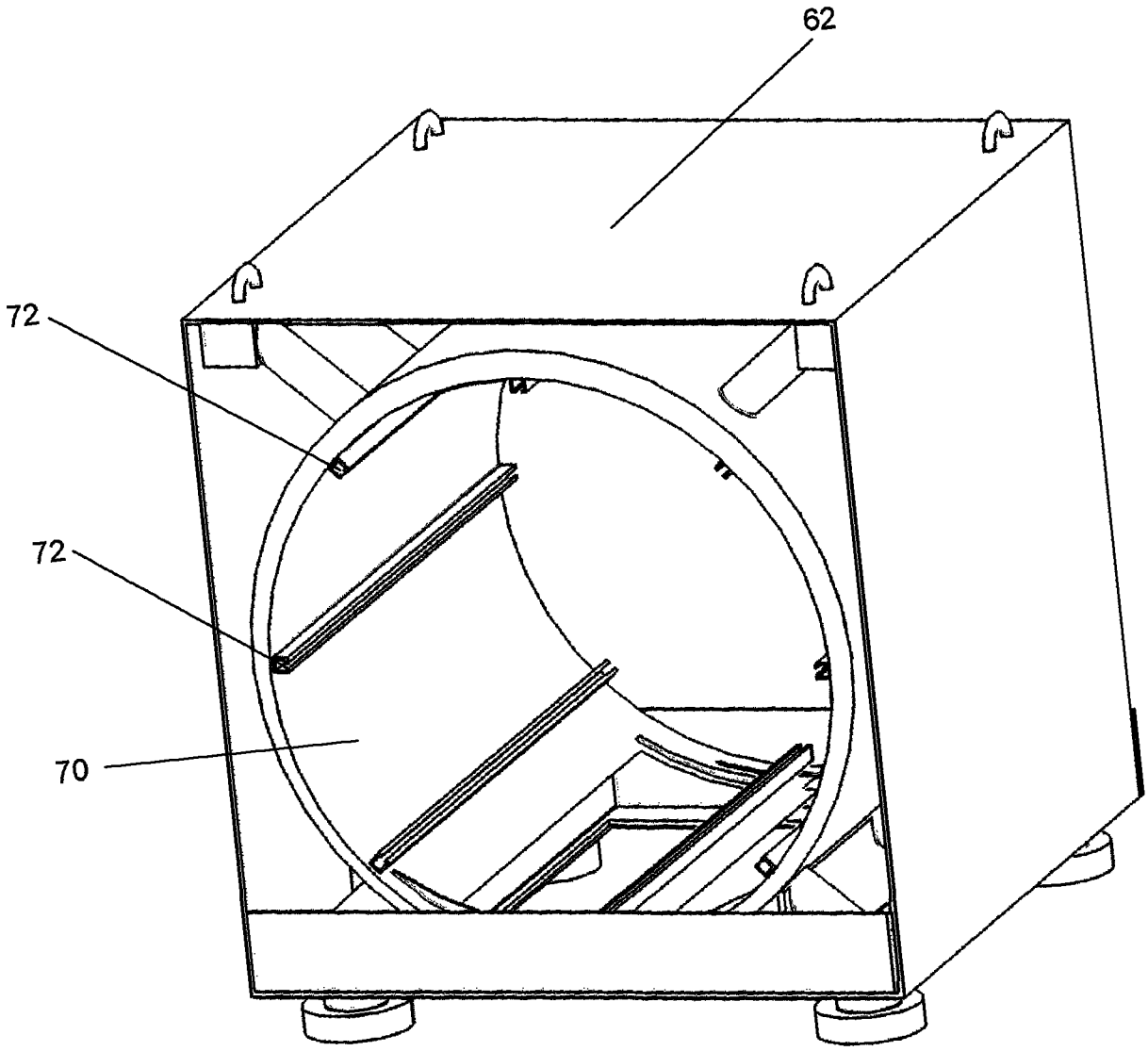

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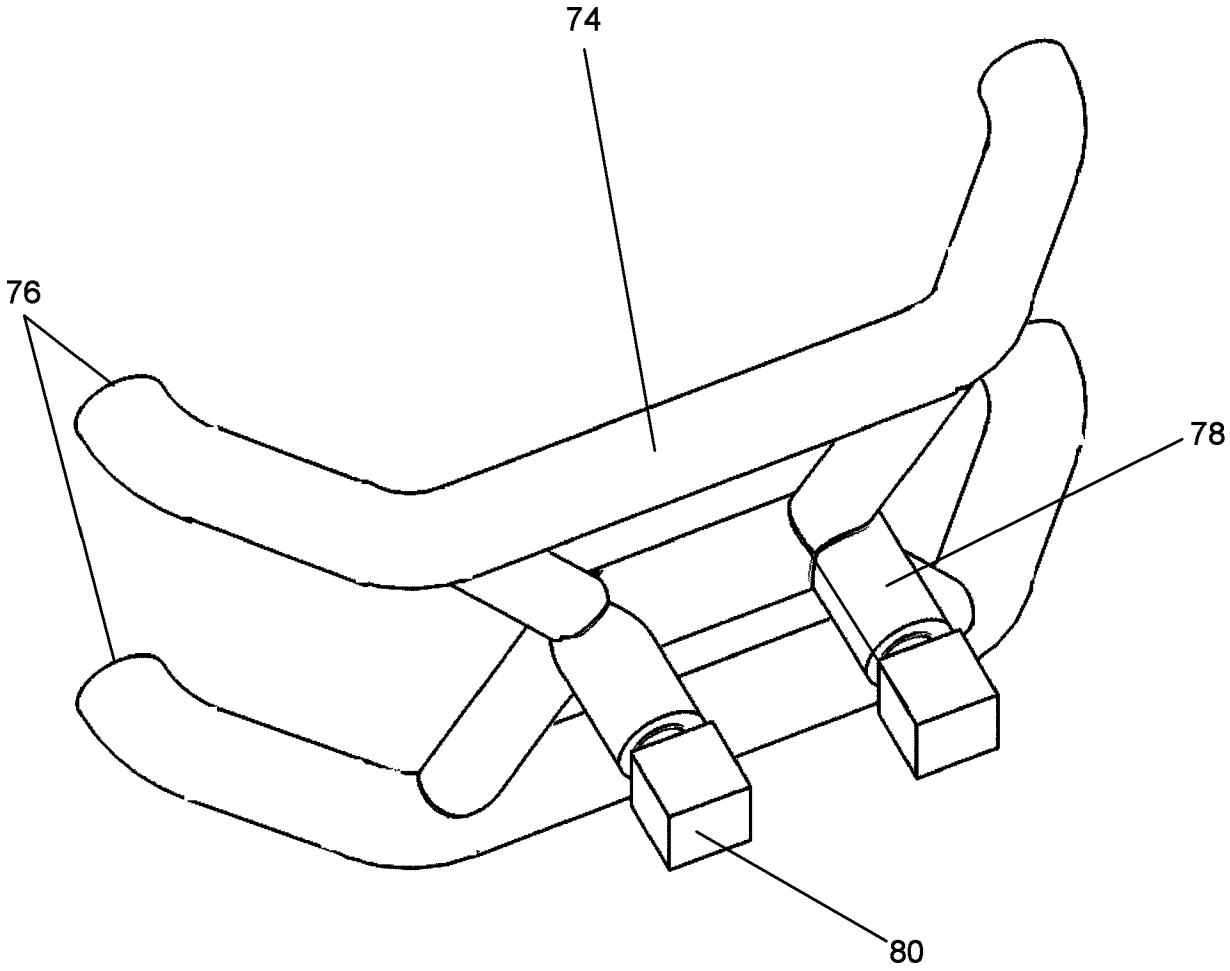

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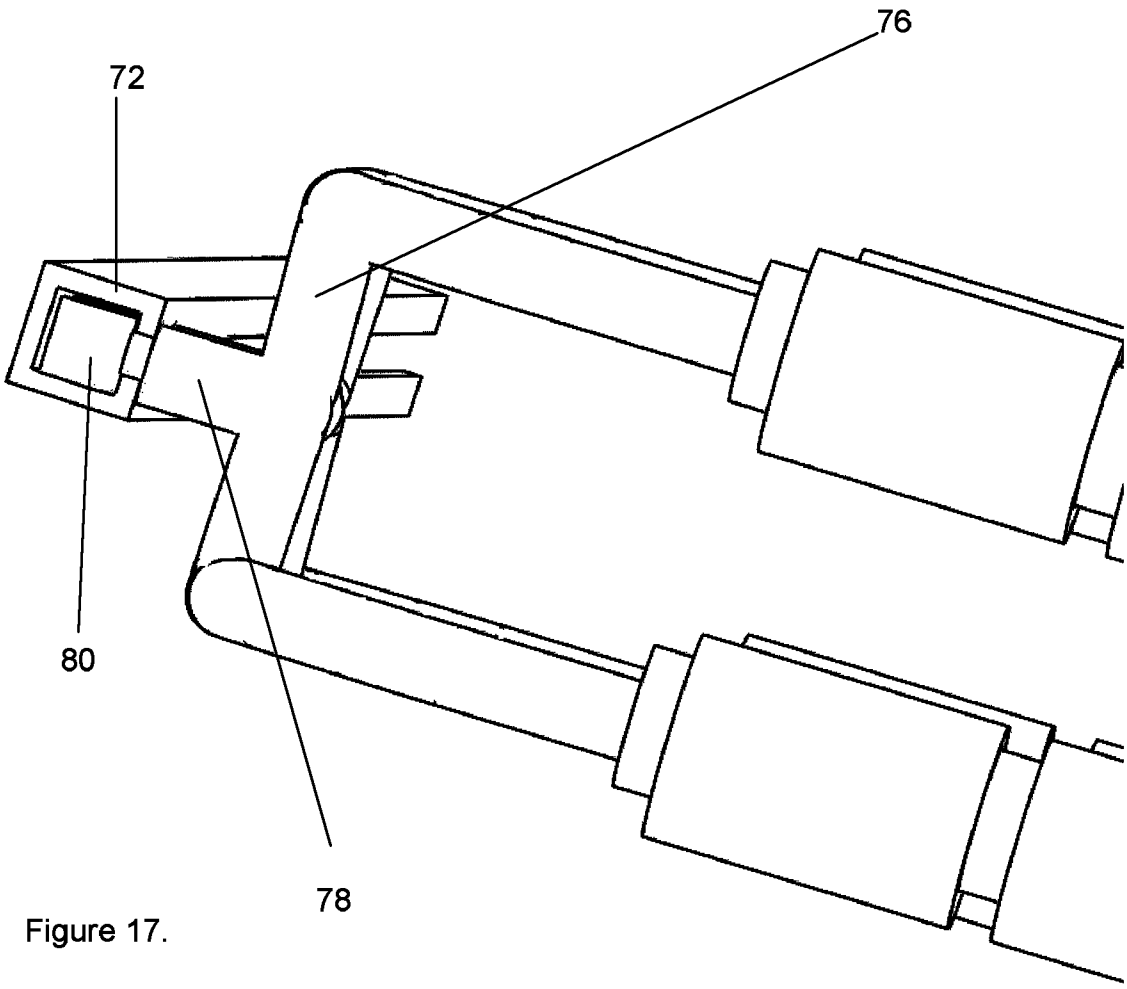

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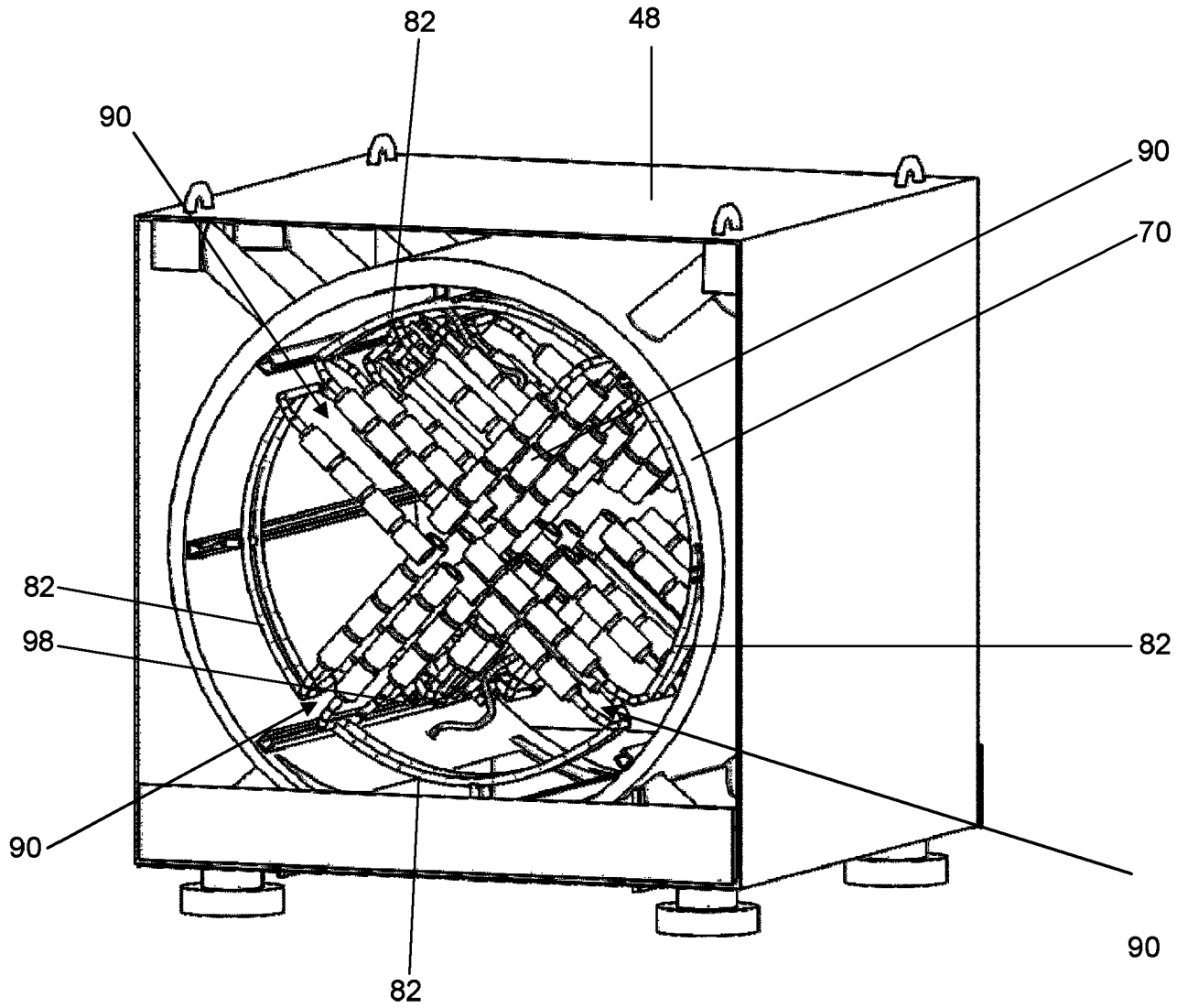

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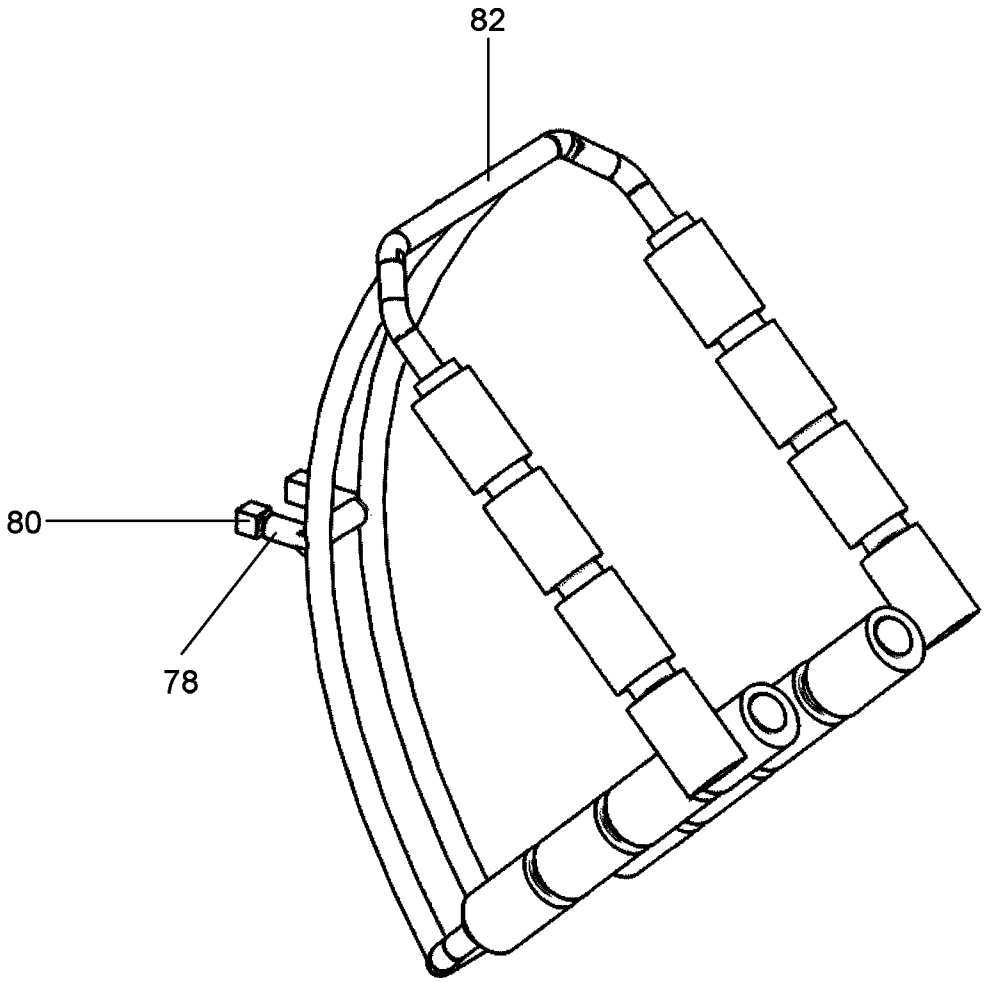

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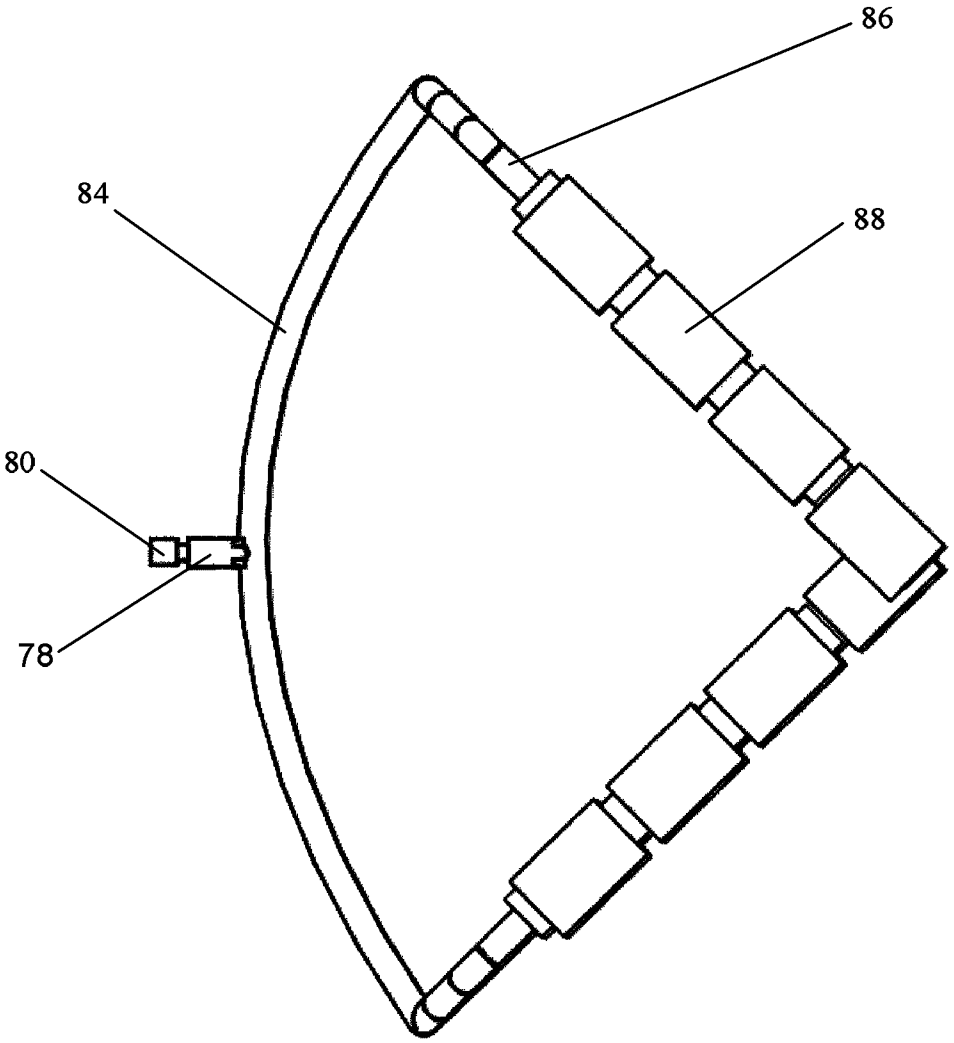
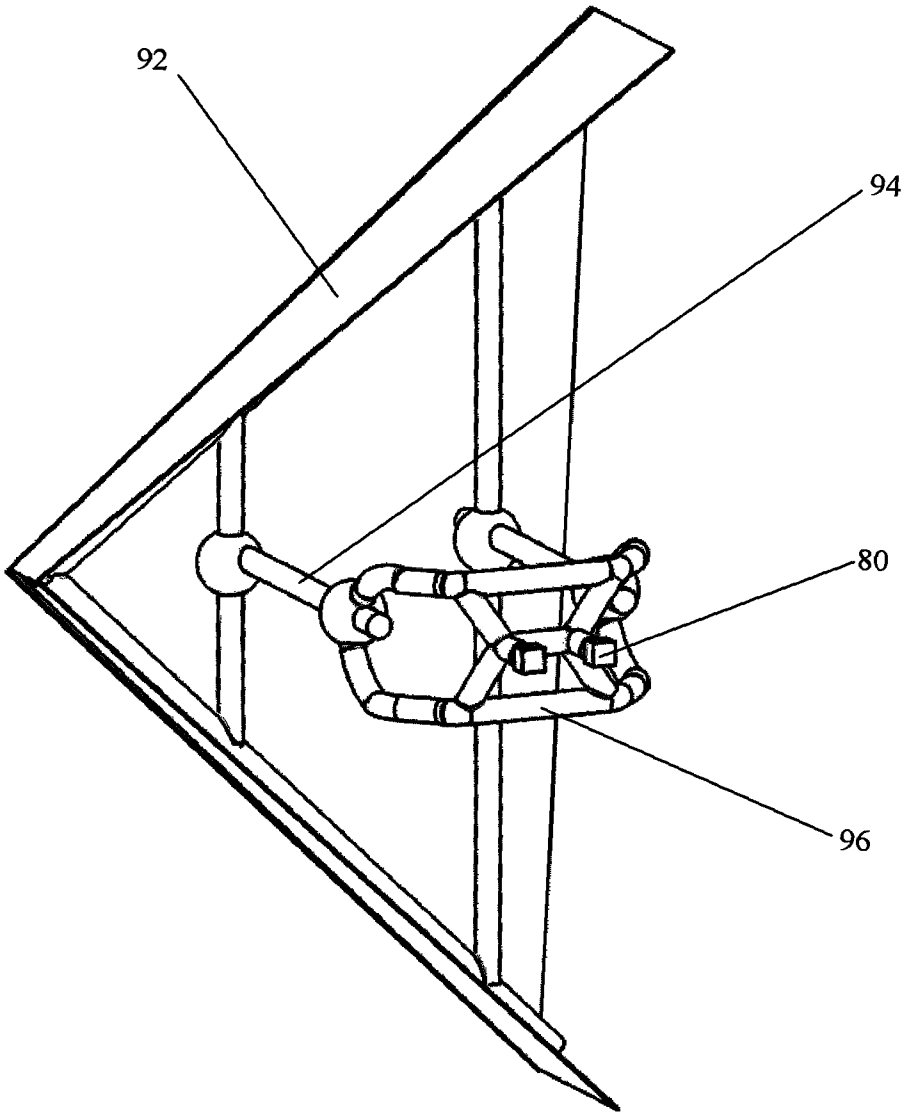


Figure 20



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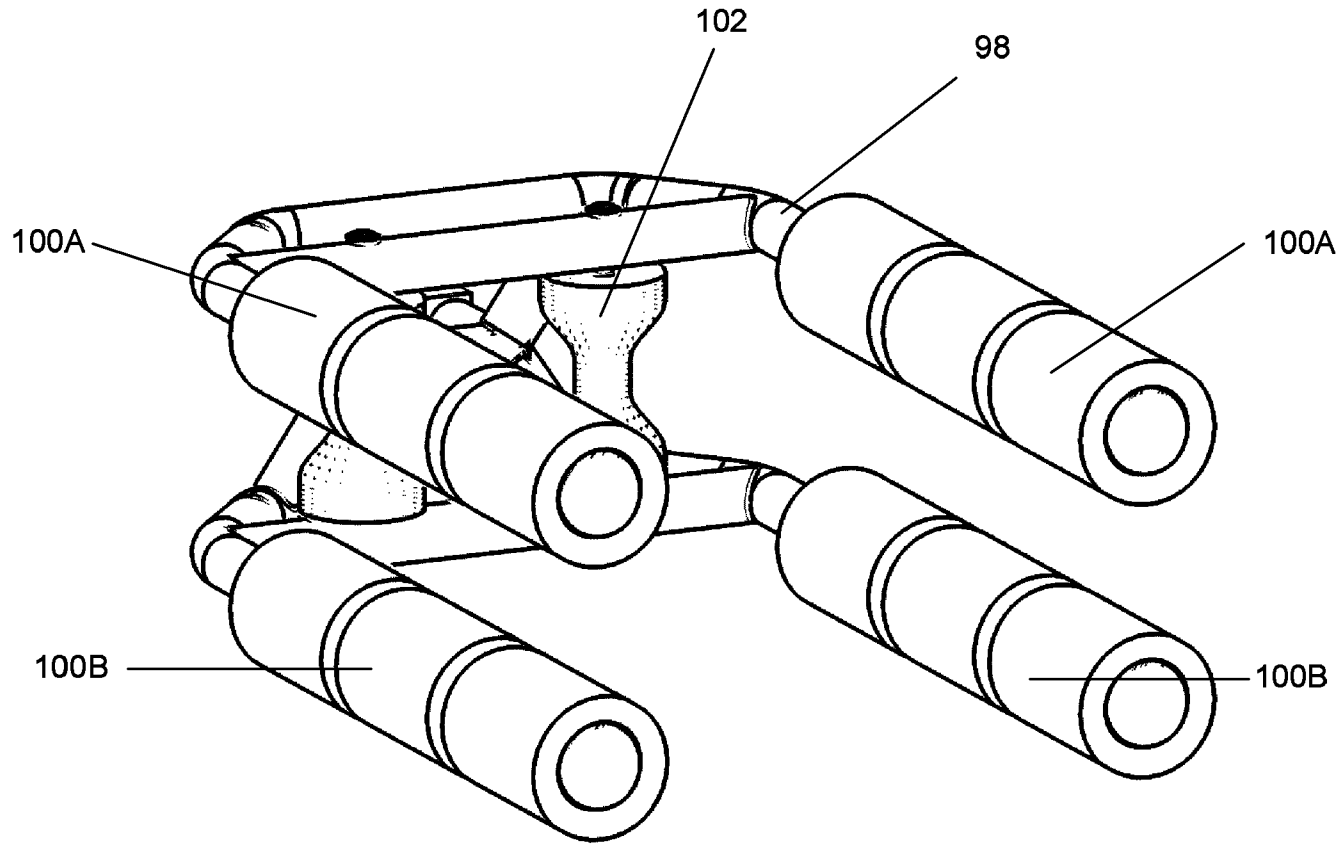

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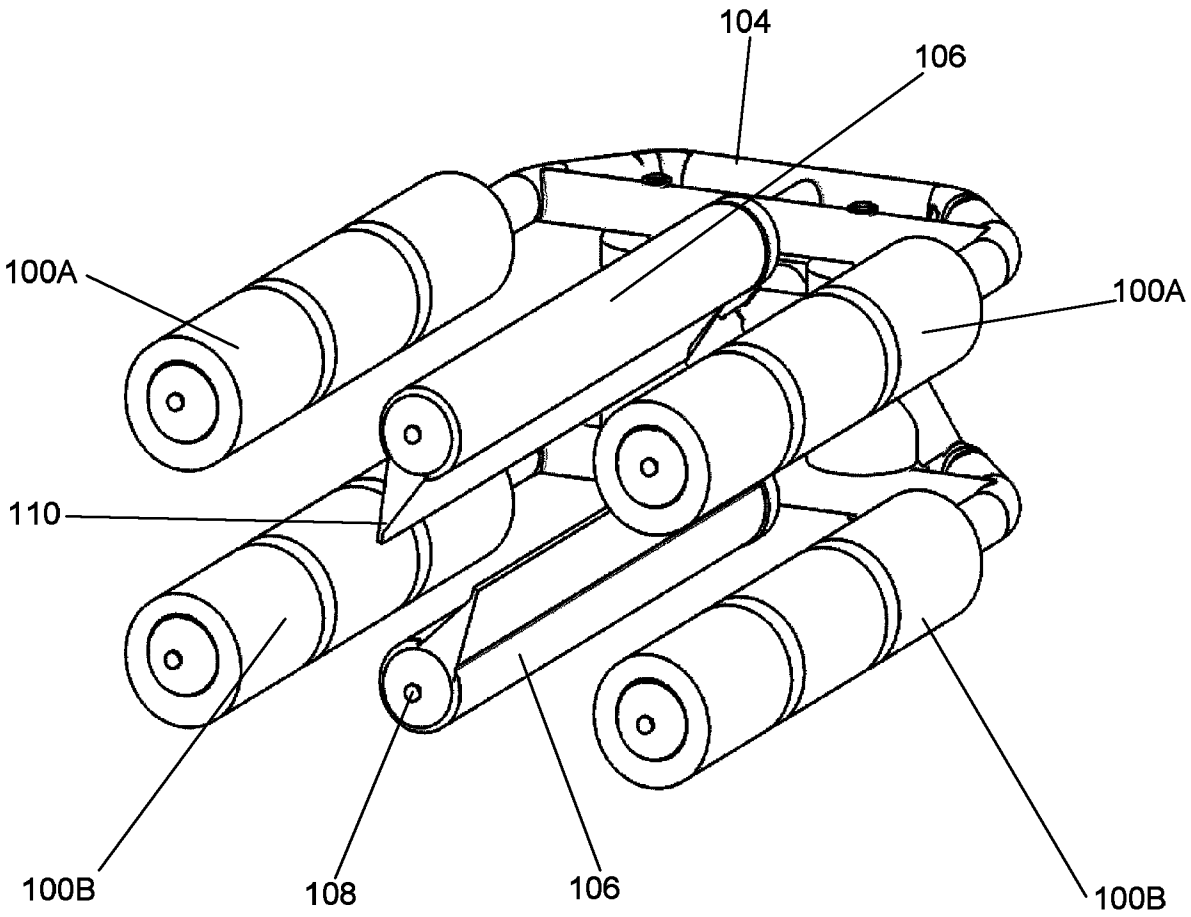

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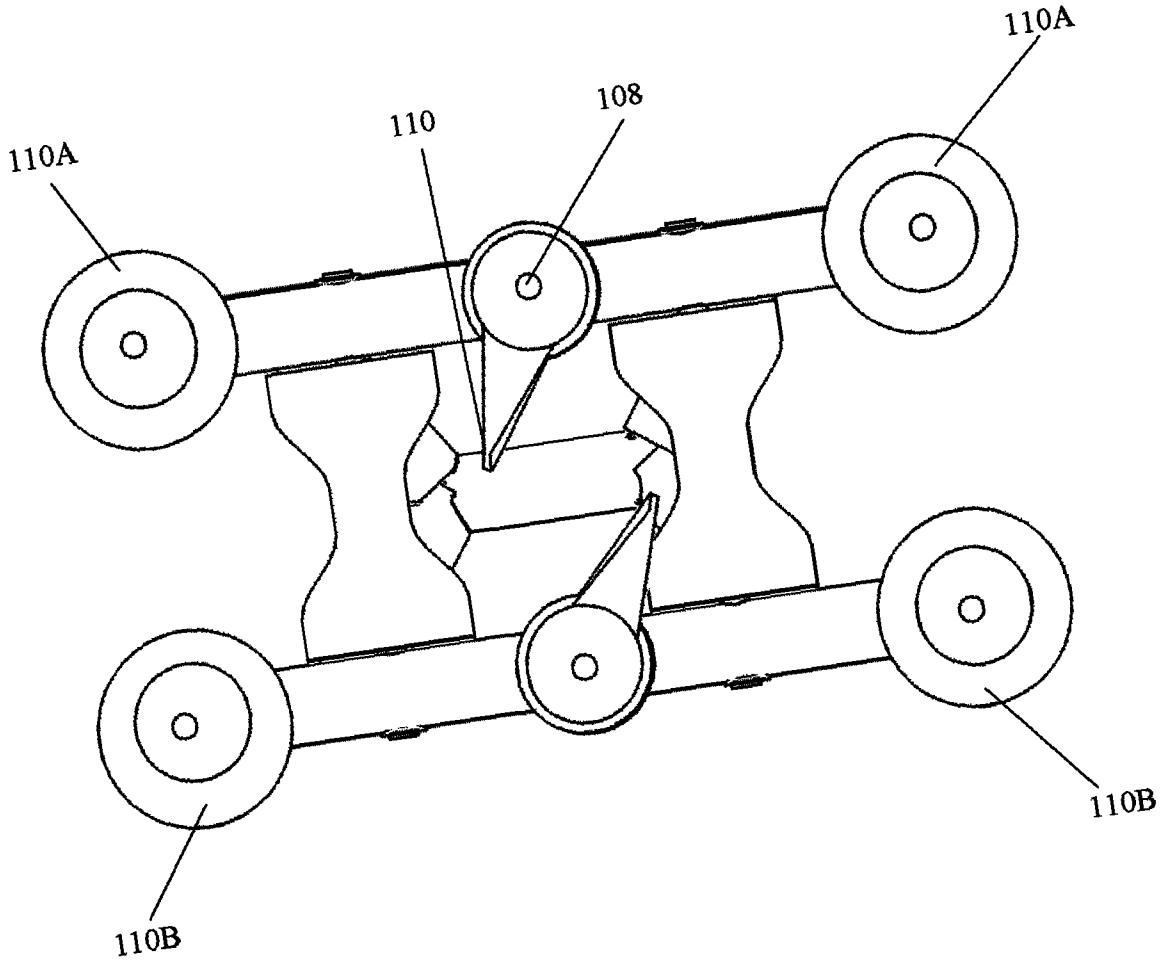

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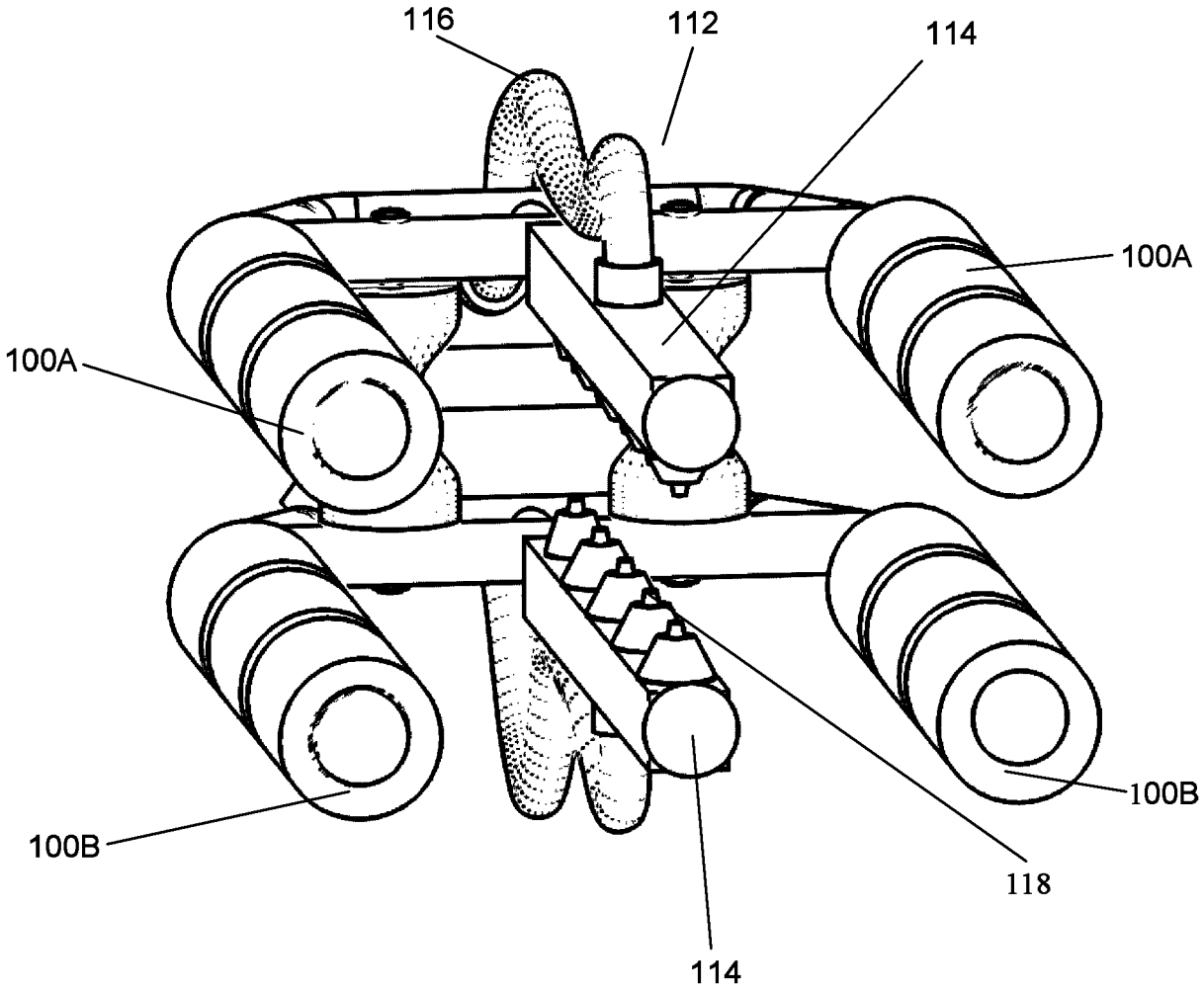

Figure 25.