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A Photo-reactor bag for growing algae, and a method thereof ✓1

Technical field

The present invention relates to a photo-reactor bag for growing algea, and a method thereof. More specifically, the invention relates to a photoreactor bag having a semi-permeable membrane that permits select substances to pass into and out of the bag whilst preventing algae contained in the photo-reactor bag ✓1 from leaving the photo-reactor bag.

Background

It is known that algae can be grown industrially in order to produce biofuels and other useful products. One known way of growing algae is to use a photo-reactor bag 10, such as the example shown in Fig. 1. The photo-reactor bag 10 is has an upper surface 12 and a lower surface 14, which are formed of an impermeable plastic material that define a space in which a mixture M of algae, water and nutrients can be contained. The upper surface 12 of the bag is transparent such that the algae within the bag 10 is exposed to natural light. The photo-reactor bag 10 further comprises air-filled ribs 16 along each side, which allows the photoreactor bag 10 to remain afloat in water (as shown in Fig. 2). Although the mixture is sealed within the bag, it is in thermal contact with the water on which it floats,

In use (see Fig. 3), the photo-reactor bag 10 is placed onto a body of water, and inlet 20 an outlet 22 pumps are connected to the bag 10 to allow the mixture in the bag 10 to be continually pumped to an external fluid processing system 24 that adds nutrients and extracts algae in the form of a sludge that can be further processed to produce biofuel.

However, the inventors have observed that such a pumping system is energy intensive, which can make it prohibitively expensive to produce biofuel in this way. ✓1

The present invention has been devised to address this problem.

Summary

At its broadest, the present invention relates to a photo-reactor bag having at least one semi-permeable membrane.

According to a first aspect of the present invention, there is provided a photo-reactor bag for growing algae according to [claim 1]. By providing a photo-reactor bag with a semi-permeable membrane, the need for an expensive pumping system is removed, as select substances can pass through the permeable membrane between the bag portion and a body of liquid in which the photoreactor bag is contained automatically whilst keeping the algae contained in the bag. In this way, the bag can self-regulate rather than relying on external pumps. ✓1

For avoidance of doubt, the body of liquid can be a body of water, or a body of wastewater (i.e., a body of water containing nutrients such as ntirates).

Preferably, the upper surface and the lower surface are stitched together at their peripheries to form the space in which the algae is contained.

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In some embodiments, there is provided [claim 2]. By forming the semi-permeable membrane out of a forward osmosis membrane that is configured to allow liquid to pass therethrough, but prevent either nutrients or algae from passing through, nutrients can be prevented from entering into the body of water, and thus the environmental impact of the bag on the area is minimised. ✓½

In some embodiments, there is provided [claim 3]. By providing an inlet, waste water (a mixture of sewage and rainwater) can be provided to the bag. In this way, nutrients can be supplied to algae contained in the bag, and also means that waste water does not have to be pumped directly into the sea. ✓½

In some embodiments, there is provided [claim 4]. By forming the forward osmosis membrane from patches surrounded by regions of polyurethan material, the photo-reactor bag can be made more robust and durable, and so can be used for longer. ✓½

In some embodiments, there is provided [claim 5]. By providing reinforcement straps, the photo-reactor bag can be made even stronger, and therefore even more durable. ✓½

In some embodiments, there is provided [claim 6]. By forming the semi-permeable membrane out of a nutrient permeable membrane, the photo-reactor bag can be placed into bodies of waste water to remove the nutrients from it, which will be absorbed through the membrane and used to grow the algae. Therefore, the photo-reactor bag can be used to clean and treat bodies of water. ✓½

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In some embodiments, there is provided [claim 7]. By forming the membrane from a nitrate permeable membrane, one of the most common nutrients in waste-water can be more effectively targeted and removed.

In some embodiments, there is provided [claim 8]. By increasing the size of the nutrient permeable membrane, there is a larger surface area through which nutrients can pass. Therefore, the algae can be grown more quickly, and more nutrients can be taken out of surrounding wastewater. ✓½

In some embodiments, there is provided [claim 9]. By providing a buoyancy means on the photo-reactor bag, the phot-reactor can be kept afloat on a body of water even when it would not naturally float, and the photo-reactor bag can thereby be prevented from sinking to the seabed and becoming damaged. ✓½

In some embodiments, there is provided [claim 10]. The provision of air filled rims as the buoyancy means provides a cheap and effective way of keeping the photo-reactor bag afloat. Moreover, the provision of two air-filled rims means that the photoreactor bag is less likely to tip over in liquid such that the permeable membrane on the bottom surface is no longer in contact with the liquid. ✓½

In some embodiments, there is provided [claim 11]. By providing foam floats, a greater degree of buoyancy can be achieved, allowing either small air-filled ribs to be used or no air-filled ribs at all. ✓½

In some embodiments, there is provided [claim 12]. By providing an outlet, algae sludge can easily be removed from the bag, allowing the photo-reactor bag to be used more continuously. ✓½

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In some embodiments, there is provided [claim 13]. This allows the photo-reactor bag to be secured to the seabed (via the buoy), such that the photo-reactor bag is prevented from drifting off with the tide. ✓½

In some embodiments, there is provided [claim 14]. This allows a greater surface area of the photoreactor to be submerged in a liquid, making it easier to ensure that the entire membrane surface is in contact with the liquid. ✓½

In some embodiments, there is provided [claim 15]. This allows the membrane to be increased for a given bag size, meaning that algae can be grown quicker. ✓½

In some embodiments, there is provided [claim 16]. This allows the photo-reactor bag to be prevented from twisting, or for the bag to become inverted such that the lower surface of the bag comes out of the water.

In some embodiments, there is provided [claim 17]. This allows daylight entering through the upper surface to penetrate through the entire depth of the mixture, such that algae growth is promoted throughout the mixture. ✓½

In some embodiments, there is provided [claim 18]. This means that a large amount of algae can be grown simultaneously, making the process more efficient.

In some embodiments, there is provided [claim 19]. This increases the durability of the bag, as it is made more resistant to tearing.

In some embodiments, there is provided [claim 20]. This allows a maximum amount of light to travel through the upper surface, such that algae is grown more quickly.

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According to a second aspect of the present invention, there is provided a method of growing algae using wastewater containing water and nutrients according to [claim 21]. This allows wastewater to be treated before being discharged into the sea, whilst simultaneously allowing a useful biproduct (namely the biofuel created from the algae) to be produced. ✓½

According to a third aspect of the present invention, there is provided a method of growing algae using wastewater containing water and nutrients according to [claim 22]. This allows nutrients already released into the sea to be removed, whilst simultaneously allowing a useful biproduct (namely the biofuel created from the algae) to be produced.

According to a fourth aspect of the present invention, there is provided a kit of parts according to [claim 23].

Brief description of the drawings

The present invention will now be described, by way of example only, with reference to the drawings, in which:

Fig. 1 (prior art) shows a perspective view of a known photo-reactor bag

Fig. 2 (prior art) shows an end view of the photo-reactor bag of Fig. 1 in a body of liquid.

Fig. 3 (prior art) shows a plan view of the photo-reactor bag of Fig. 1 being used to generate biofuel.

Fig. 4 shows a side view of a photo-reactor bag according to a first example of the present invention being used to treat wastewater.

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Fig. 5 shows a plan view of the photo-reactor bag of Fig. 4.

Fig. 6 shows a sectional view of the photo-reactor bag of Fig. 5 along the I-I line.

Fig. 7 shows a side view of the photo-reactor bag of Fig. 4 in a body of water.

Fig. 8 shows a plan view of a photo-reactor according to a second example of the present invention,

Fig. 9 shows an end view of the photo-reactor bag of Fig. 8

In the following, like parts will be given like reference numerals.

Detailed description of the drawings

Fig. 4 shows a photoreactor 100 according to a first example of the present invention being used to treat waste water from a sewage treatment plant 90 before the wastewater is subsequently released into the sea. The photoreactor comprises an upper surface 110 and a lower surface 120, wherein the upper surface 110 and the lower surface 120 are attached together around their peripheries to form a space in between in which a mixture of algae, water and nutrients can be contained. The upper surface 110 is transparent, such that daylight can enter into the photo reactor bag 100 and help to promote growth int the algae contained therein. The lower surface 120 is in contact with water on which the photo-reactor bag 100 floats, and contains a plurality of patches of forward osmosis membrane 122. The forward-osmosis membrane 122 permits liquid to pass between the photo-reactor bag 100 and the body of water in which the photo-reactor bag is located, whilst preventing both the nutrients and the algae contained within the photo-reactive bag 100 from passing into the water.

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The photoreactive bag 100 is further attached to a buoy 80 via a rope 82. The buoy 80, in turn, is attached to the sea bed of the body of water in which the photo-reactor bag is located, such that the photo-reactor bag 100 is prevented from drifting around as a result of tides.

In use, waste water is supplied from the sewage treatment plant 90 to the photo-reactor bag 100 via an inlet tube 130 that connects the two. Said waste water contains both water and nutrients. The algae contained within the photo-reactor bag 100 absorbs the nutrients from the wastewater, causing the algae to grow and leaving just water within the photo-reactor bag 100. The left over water then passes through the forward osmosis membrane patches 122. In this way, the algae can be grown and harvested to generate useful products such as biofuels, whilst the waste water from the sewage treatment plant 90 is effectively treated before being released into the sea.

The photo-reactor bag of Fig. 4 is shown in more detail in Figs.5 and 6. Specifically, Fig. 5 shows a plan view of the photo-reactor bag 100 of Fig. 4, and Fig. 6 shows a sectional view of the bag 100. As shown, the photo-reactor bag 100 includes the patches of forward osmosis membrane 122 dispersed on the lower surface 120 within a polyurethane plastic layer 124, which helps to prevent tearage in the membrane 122. The photo-reactor bag 100 is further reinforced with reinforcing straps 126 which extend along the polyurethane layer 124 between the patches 122.

The photo-reactor bag 100 further includes two air-filled ribs 140 which extend along opposing sides of the photo-reactor bag 100. These air-filled ribs 140 ensure that the photo-reactor device remains afloat even when it would not

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naturally be buoyant. A loop 150 is also shown at an end of the bag, which can be used to attach the photo-reactor bag 100 to the buoy 80 via the rope 82, and a water inlet 152 for allowing the wastewater from the sewage treatment plant 90 into the photo-reactor bag 100.

Fig. 7 shows a photo-reactor bag 200 according to a second example of the present invention, wherein the photo-reactor bag is again attached to a buoy 80 via a rope to prevent the photo-reactor bag from drifting with the tide.

The bag 200 includes an upper surface 210, that is transparent so that light may enter the mixture contained within the bag 200. Further, the bag 200 includes a lower surface 220 which includes a nutrient permeable membrane 222. This membrane 222 permits nutrients to travel therethrough, but prevents either water or algae in the mixture M from leaving the bag 200. In use, nutrients enter the bag 200 via the nutrient permeable membrane 222 from the nutrient-rich liquid in which the bag 200 is placed, and are thereby absorbed by the algae in the mixture M in order to grow.

Figs. 8 and 9 show more detailed views of the bag 200 shown in Fig. 7. More specifically, fig. 8 shows a plan view of the bag 200, and Fig. 9 shows a sectional view of the bag 200 along the line II-II. The bag includes air-filled ribs 240 and a loop 250 in a similar manner to the example shown in Fig. 5. In contrast to Fig. 6, the bag 200 is shown as including one single large patch of nutrient permeable material 222 through which nutrients can pass. ✓6

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Intro + Descript

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Claims

1. A photo-reactor bag for growing algae, the photo-reactor bag comprising:

a bag portion for containing a mixture of algae, liquid and nutrients, the bag portion including an upper surface through which light can permeate, and a lower surface formed at least in part from a semi permeable membrane;

wherein, in use, the photoreactor bag is configured to be placed in a body of liquid with the lower surface in contact with the body of liquid,

wherein the semi permeable membrane is configured to allow the exchange of select substances between the bag portion and the body of liquid, whilst retaining the algae within the bag portion. ✓10

2. The photo-reactor bag of any previous claim, wherein the semi-permeable membrane is a forward osmosis membrane that is configured to allow liquid to pass therethrough, but prevent either nutrients or algae from passing through. ✓2

3. The photo-reactor bag of claim 2, further comprising an inlet configured to supply the bag portion with nutrients. ✓1

4. The photo-reactor bag of claim 2 or claim 3, wherein the forward osmosis membrane is formed as patches on the bag portion that are surrounded by regions of polyurethane plastic material. ✓½

5. The photo-reactor bag of any one of claims 4, further comprising reinforcement straps that run along and across the bag portion between patches of the forward osmosis membrane. ✓½

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6. The photo-reactor bag of claim 1, wherein the semi-permeable membrane is a nutrient permeable membrane that is configured to allow nutrients to pass therethrough, but prevent either liquid or algae from passing through. ✓2

7. The photo-reactor bag of claim 6, wherein the nutrient permeable membrane is a nitrate permeable membrane. ✓1

8. The photo-reactor bag of claim 6 or claim 7, wherein the nutrient permeable membrane is formed as one or more large patches on the bag portion. ✓½

9. The photo-reactor bag of any previous claim, further comprising a buoyancy means attached to the bag portion for keeping the photo-reactor bag afloat in the body of liquid.

10. The photo-reactor bag of claim 9, wherein the buoyancy means comprises a pair of air-filled ribs that extend along each respective side of the bag. ✓1

11. The photo-reactor bag of claim 9 or claim 10, wherein the buoyancy means comprises one or more foam floats. ✓1

12. The photo-reactor bag of any previous claim, further comprising a sealable fluid port for allowing accumulated algae sludge to be pumped out from the photo-reactor bag via a hose. ✓1

13. The photo-reactor bag of any previous claim, further comprising a loop attached to the bag portion for attaching the photoreactor bag to a buoy. ✓1

14. The phot-reactor bag of any previous claim, wherein the buoyancy means is adjustable such that the bag portion can float up to 10cm below a surface of the body of water. ✓1

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15. The photo-reactor bag of any previous claim, wherein the upper surface of the bag portion includes one or more patches of transparent semi-permeable membrane. ✓1

16. The photo-reactor bag of any previous claim, wherein a thickness of the photo-reactor bag between the upper surface and lower surface is thinner than a width of the photo-reactor bag.

17. The photo-reactor bag of any previous claim, wherein a thickness of the photoreactor bag between the upper surface and lower surface is no more than 30 cm. ✓1

18. The photo-reactor bag of any previous claim, wherein the photo-reactor bag is fifty meters long and two meters wide.

19. The photo-reactor bag of any previous claim, wherein the bag portion is at least partially comprised of impermeable plastic sheets.

20. The photoreactor bag of any previous claim, wherein the upper surface is transparent.

21. A method of growing algae using wastewater containing water and nutrients, comprising steps of:

inputting the wastewater into a photo-reactor bag according to any one of claims 2-5;

growing algae contained in the photo-reactor bag by allowing the algae to feed on the nutrient rich wastewater;

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discharging the nutrient free water into a body of liquid via the semi-permeable membrane.

22. A method of growing algae using wastewater, comprising steps of;

placing a photo-reactor bag according to any one of claims 6-8 into a body of waste water, the photo-reactor bag containing algae and a low nutrient liquid;

allowing nutrients from the waste water to permeate into the bag through the semi-permeable material, wherein it is taken in by the algae in order to grow. ✓½

23. A kit of parts comprising:

a photo-reactor bag according to any one of claims 1-20, and at least one of:

one or more bottles of freshwater algae;

one or more buoys; and/or

one or more ropes for attaching the buoys to the photoreactor bag. ✓2

Claims 27

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Abstract

A Photo-reactor bag for growing algae, and a method thereof

✓½

The present invention relates to a photo-reactor bag 100 200 for growing algae, and a method thereof. More specifically, the bag 100 200, which defines a space in which algae can be grown includes an upper transparent surface 110 210 and a lower surface 120 220 containing one or more permeable surfaces 122 222 which allows select substances into the bag 100 200 whilst preventing the algae in the bag from being removed. This allows wastewater to be treated, whilst also allowing algae to be grown within he bag to produce a useful biofuel product.

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[Fig. 5]

Abstract 3½

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Doc A - Client drawings

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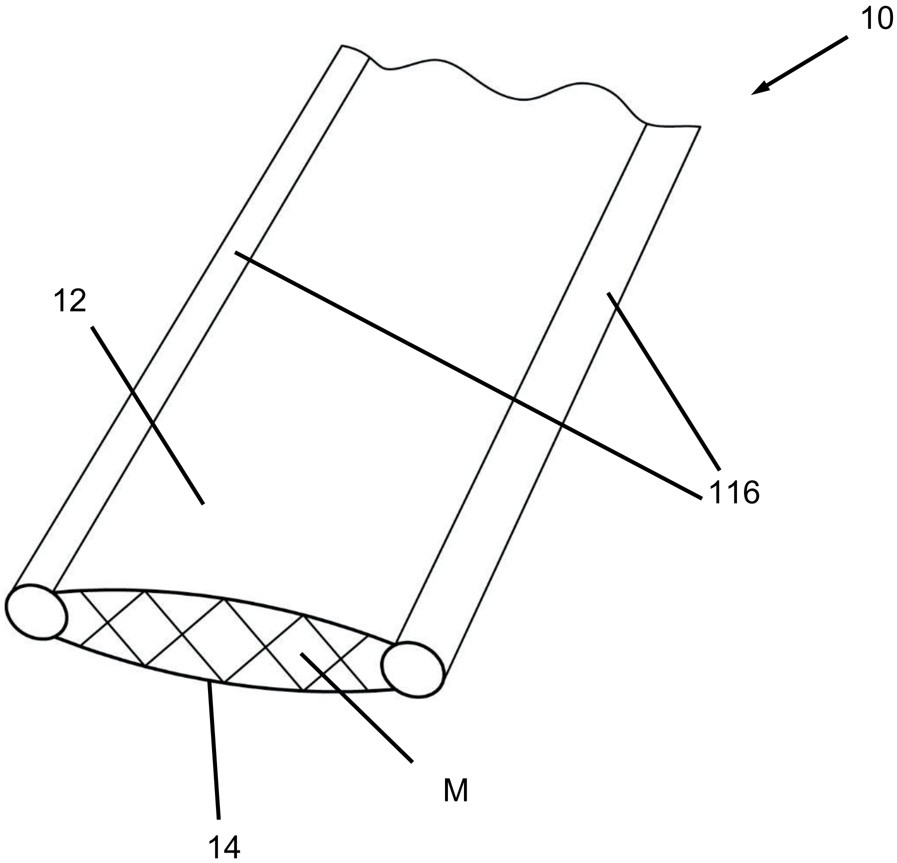

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Fig. 1 (prior art)

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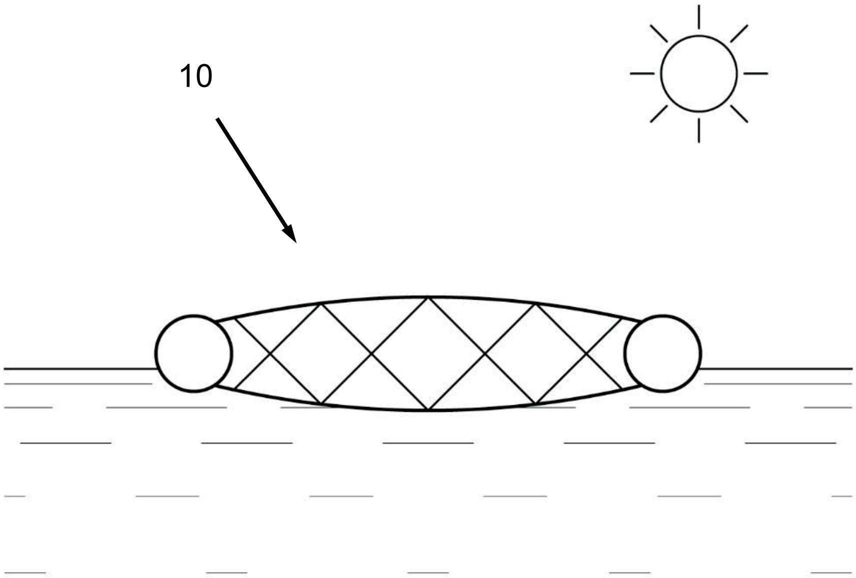

Fig. 2 (prior art)

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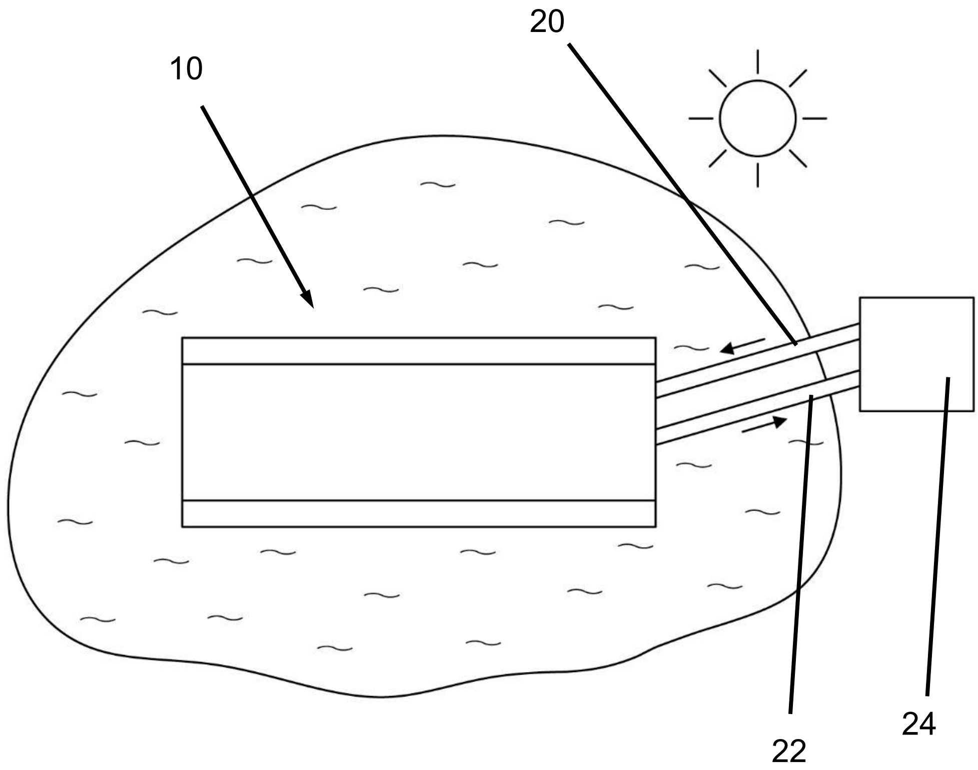

Fig. 3 (prior art)

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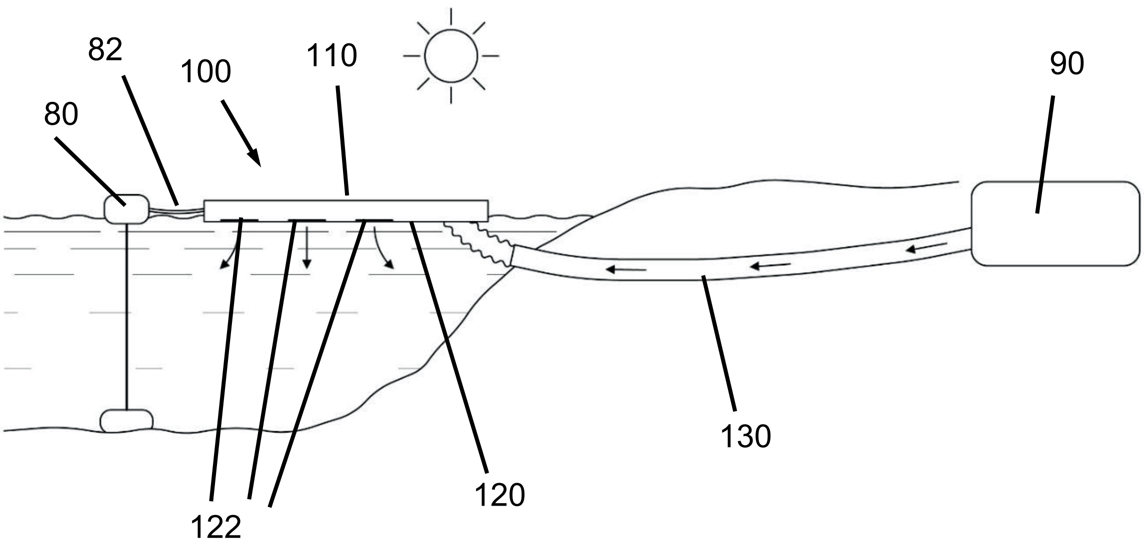

Fig. 4

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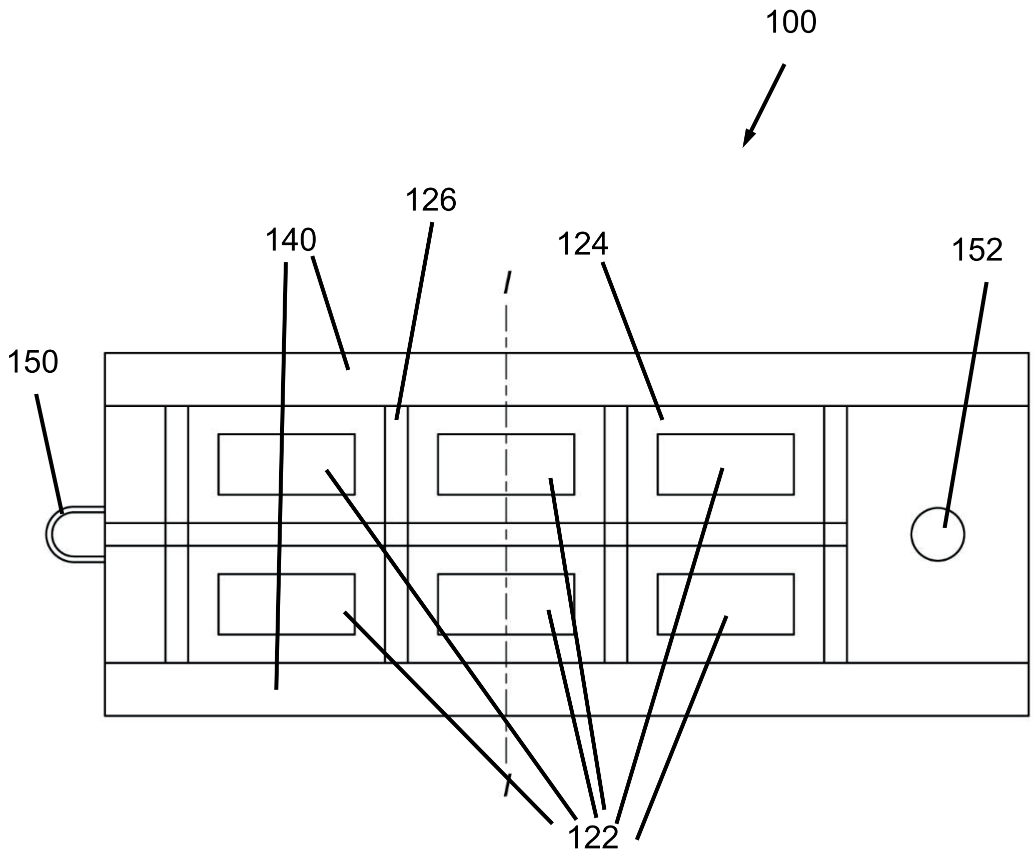

Fig. 5

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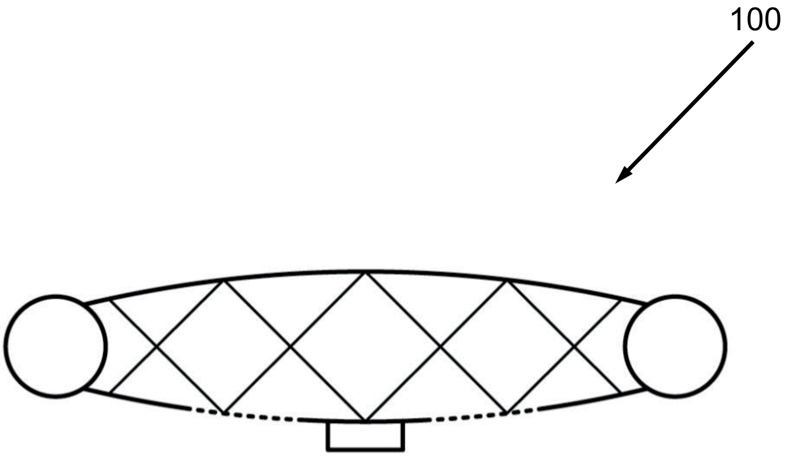

Fig. 6

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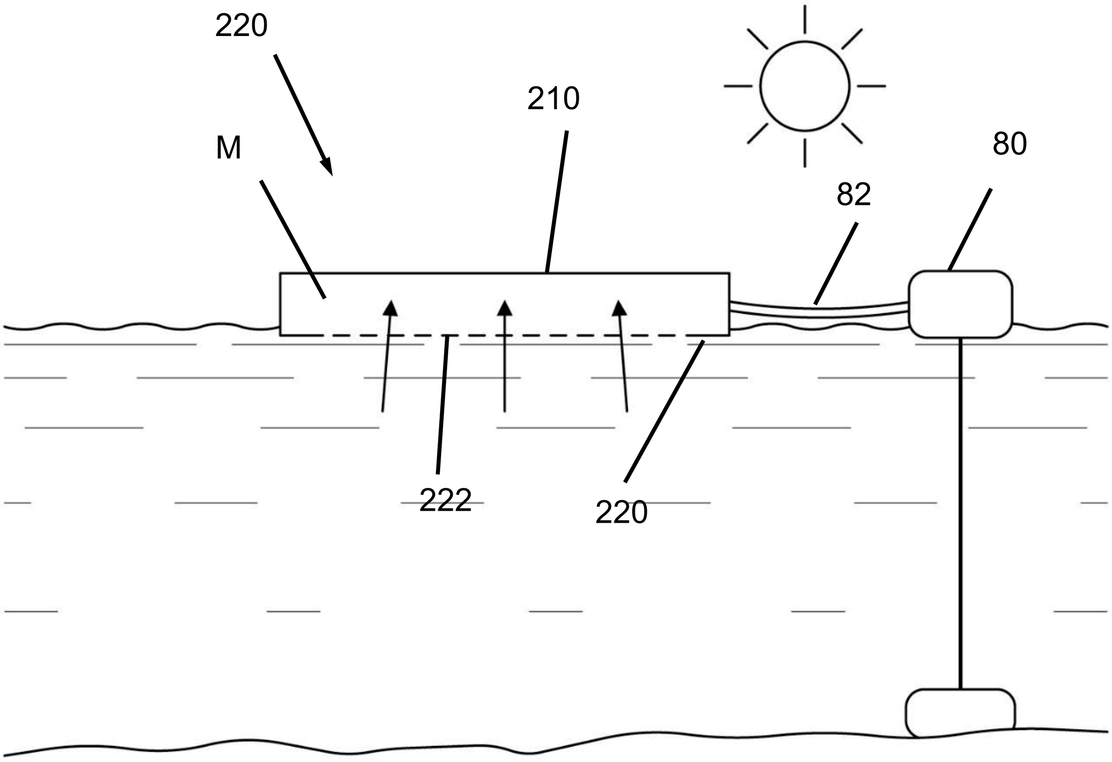

Fig. 7

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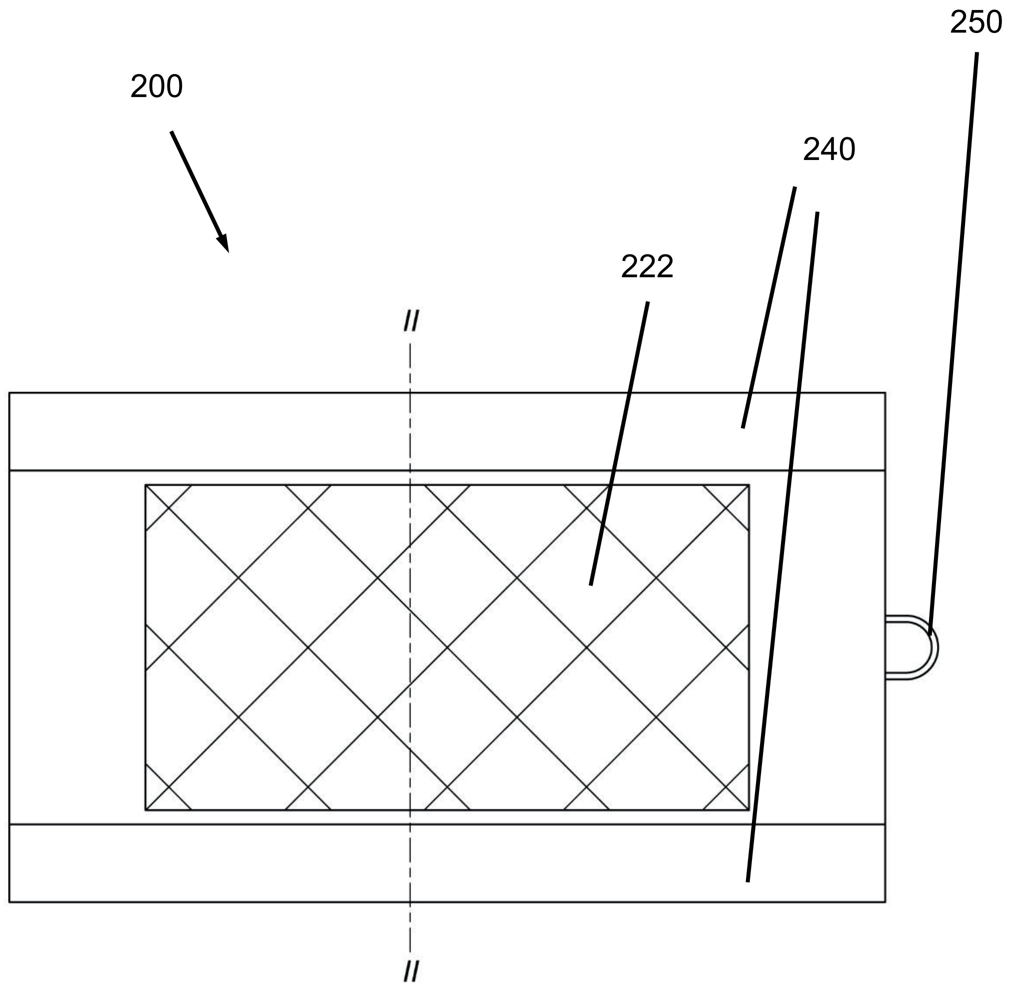

Fig. 8

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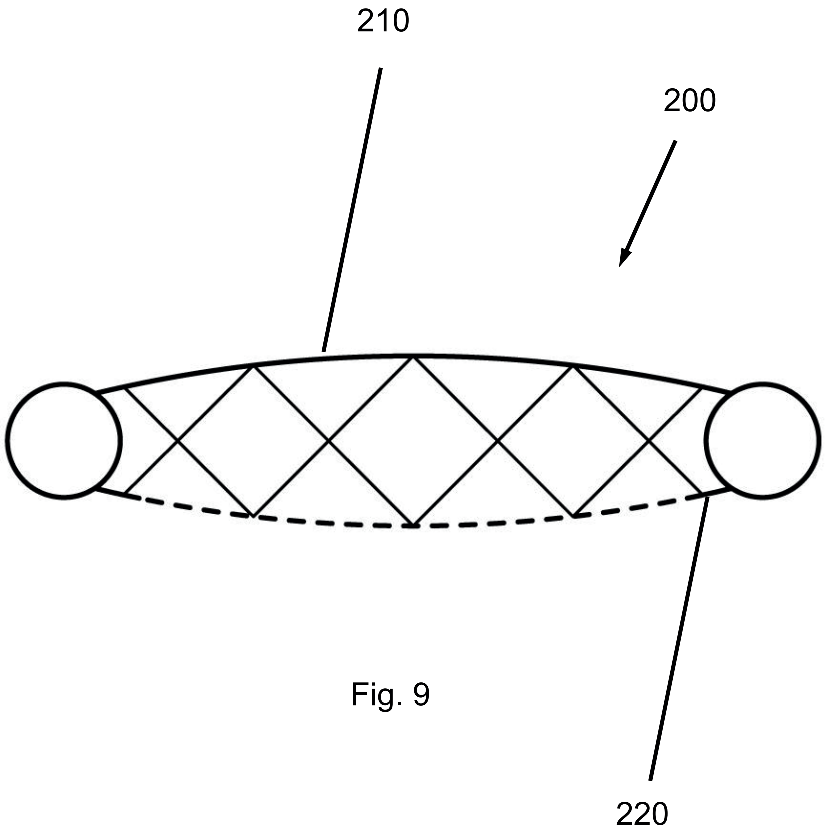

Fig. 9

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