Final Diploma

Patent Examination Board

FD2 Drafting of Specifications

Thursday 19 October 2023

10:00 to 14:25 UK British Summer Time (GMT + 1 hour)

Examination time: 4 hours 25 minutes plus 10 minutes upload time

The 4 hours 25 minutes is allocated as follows:

10 minutes – Downloading and printing the question paper;
4 hours – Answering the questions;
15 minutes – Three screen breaks of 5 minutes each.

At 14.25 you MUST immediately stop answering the questions. You then have **10 minutes** in which to upload your Answer document to the PEBX system.

You MUST upload your Answer document to the PEBX system by 14.35. After 14.35 you will not be able to upload it and your examination will be void.

INSTRUCTIONS TO CANDIDATES

1. The whole assessment task is to be attempted.
2. The marks to be awarded are given at the end of the assessment task.
3. The total number of marks available for this paper is 100.
4. You must use the Answer document for your answers.
5. Do not attempt to change the font style, font size, font colour, line spacing or any other pre-set formatting.
6. Start each part of your answer on a new page. Press the control key and the enter key simultaneously to begin a new page.
7. Do not state your name anywhere in the answers.
8. This question paper consists of **15 sheets**, including this sheet, and comprises:
   Assessment task (1 sheet)
   Client letter (3 sheets)
   Doc A – Client drawings (5 sheets)
   A spare set of Doc A – Client drawings for you to annotate and include in your answer if you wish (5 sheets).

AT THE END OF THE EXAMINATION

9. Save your Answer document and any hand-annotated drawings to your hard drive. Then follow the instructions for uploading your document onto the PEBX system.

Assessment Task

Your client sends you the correspondence listed on the Instructions to Candidates sheet regarding a new idea.

Your task is to prepare a complete patent specification that is ready for filing at the UK Intellectual Property Office. The specification should be drafted with a view to obtaining a UK patent.

Note the following:

a) You should assume that the client's description of the prior art in the field is complete.

b) You should not make use of any other prior art or special knowledge that you may have of the subject matter concerned.

c) You should also assume that the client's description of the device and its operation is accurate, i.e. that the device works as described.

Allocation of marks

Introduction and Description: 40 marks
Claims: 55 marks
Abstract: 5 marks
Total: 100 marks

There are many different types of algae that grow naturally in water (e.g. in rivers and lakes), as well as in damp soil and on the surfaces of rocks and trees. Algae need light, water and nutrients to grow, but when the conditions are right, they can grow very quickly and form large colonies, sometimes even covering the entire surface of lakes. Some types of algae can also be processed to produce biofuels and other useful products, which is why my company has been wanting to grow algae on an industrial scale for many years.

It's known that algae can be produced industrially using a so-called 'bioreactor' that artificially replicates the optimum conditions needed for algae growth. In recent years, flexible plastic photo-reactor bags have started to be used instead of the more traditional concrete bioreactor tanks. As shown in my attached drawing, such a photo-reactor bag contains a mixture of algae, water and nutrients, and has inflatable ribs running along its length so that it floats on the surface of a body of water, such as a lake. The upper surface of the bag must be transparent enough to visible light so that algae within the bag are exposed to natural light. Although the mixture is sealed within the bag, it is in thermal contact with the water on which it floats, thereby regulating the temperature of the mixture within the bag. Inlet and outlet pipes connected to the bag allow the mixture to be continually pumped to an external fluid processing system that adds nutrients and extracts algae in the form of a sludge that can be further processed to produce biofuel. However, the fluid pumping and external processing system is energy intensive, and we've found this makes it prohibitively expensive for use in industrial biofuel production.

Anyway, enough about what's already known. I've recently had an idea about how the commercial growth of algae could be improved, and my initial results are looking very promising. I'm giving a presentation about my idea at a conference tomorrow, so I'd like you to file a UK patent application for me, please.

My idea arose when I was reading about how wastewater from sewage treatment plants is often pumped into the sea. Such wastewater typically includes partially treated sewage mixed with fresh water (e.g. rainwater). Instead of allowing the wastewater to flow straight into the sea, my idea is to divert a flow of such wastewater into a modified photo-reactor bag floating in the sea. Algae within the bag can then use the supply of nutrients provided by the wastewater. Before I forget, I should also mention that wastewater has been used previously in known bioreactors to provide the nutrients required for algae growth.

As shown in the attached drawings, I've modified a photo-reactor bag so that the water present in the wastewater can leave the bag, but the algae and nutrients are retained within the bag. I've done this by taking a known photo-reactor bag and replacing regions of impermeable plastic on the bottom of the bag with multiple patches of material that provide a so-called 'forward osmosis membrane' (an 'FO membrane' for short). I had no problem buying the sheets of FO membrane material from a commercial supplier because they are a known type of semi-permeable membrane already used for various other purposes. In use, the FO membrane allows water to pass from the fresh water (i.e. of the wastewater) within the bag to the (saltier) sea water outside the bag. It would also work with seawater inside the bag if the bag was floating on brine; the water outside the bag just needs to be saltier than the water inside the bag. Importantly, it is only water and not any of the algae or nutrients in the wastewater that will pass out of the bag through the FO membrane and into the sea.

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In use, a flow of wastewater enters an inlet at one end of the bag, for example via a flexible pipe connected to a sub-sea sewage outfall pipe. The flow of wastewater into the bag and the loss of water from the bag through the FO membrane means that the nutrients in the wastewater are retained and concentrated within the bag for consumption by the algae. The temperature of the bag's contents is regulated by the sea water, the wave motion agitates the mixture, and the algae is exposed to natural daylight passing through the transparent upper surface of the bag. No pumps or external fluid processing systems are needed, which minimises energy consumption. There is also the added environmental benefit that only water is discharged into the sea, and not any of the nutrients present in the wastewater.

One point to note is that the photo-reactor bag I've shown in the drawings must be buoyant enough so that it floats on the sea, otherwise it would sink to the sea floor where it would inevitably be damaged (e.g. rocks could puncture or tear the bag so wastewater and algae would leak out). To provide the required buoyancy, the photo-reactor bag itself includes a pair of air-filled ribs that extend along its length. Although these air-filled ribs have the same basic design as those found on known photo-reactor bags, they do have about a 20–30% larger volume to provide the extra buoyancy that I've found is needed to ensure the bag stays afloat, even when there are rough seas.

The bag includes a sealable fluid port that can be connected to a flexible hose to allow the accumulated sludge to be periodically pumped out (e.g. into a visiting barge). I've also stitched a loop into the seams of the photo-reactor bag so it can be attached by ropes to one or more buoys (buoys being floats that are anchored to the seabed) to secure the photo-reactor bag to the seabed and stop it drifting off with the tide. Such buoys also help the bag to be seen, for example so it can be grabbed to allow attachment of the flexible hose for the pumping out procedure.

I should mention that I'm still experimenting to find the best way to provide the required bag buoyancy, but it would also be possible for the photo-reactor bag to have multiple foam floats attached to it (e.g. using more loops stitched into the seams). These floats may provide additional buoyancy, which allows the use of smaller ribs, or they could even be used instead of the air-filled ribs. The amount of buoyancy could also be adjusted to allow the bag to float just below (e.g. by 5–10cm) the surface of the sea. This would allow patches of a transparent FO membrane to be included on the top surface of the bag, which, for example, would allow the surface area of the FO membrane to be increased for a given size bag.

It's obviously ideal to prevent wastewater from entering the sea in the first place, but certain regions of the sea are already uninhabitable for most marine life due to the build-up of large amounts of nutrients (typically nitrates) following the extensive release of wastewater. So, I've also devised a modified version of my photo-reactor bag that can be used to help clean up such regions. This is done using a photo-reactor bag like the one I've described above, but in which a nutrient permeable membrane (e.g. a nitrate permeable membrane) is used instead of the FO membrane. The nutrient permeable membrane allows nutrients (e.g. nitrates) to pass from the sea water outside the bag (where they are present in high concentrations) to the fresh water retained inside the bag (where the nutrient concentration is lower), whilst retaining the algae inside the bag and preventing water from entering or leaving the bag. The nutrient permeable membrane is thus another example of a semi-permeable membrane (i.e. a membrane that is selectively permeable so that only certain, selected, substances can pass

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through it) that allows the exchange of substances between the inside of the photo-reactor bag and the sea. In use, the algae will consume the nutrients, thereby lowering the nutrient concentration in the bag, which in turn means more nutrients will enter the photo-reactor bag through the nutrient permeable membrane. There will thus be a net inflow of nutrients into the bag for consumption by the algae, thereby extracting unwanted nutrients from the sea. The photo-reactor bag can be left floating in the sea, with the algae sludge being pumped out periodically.

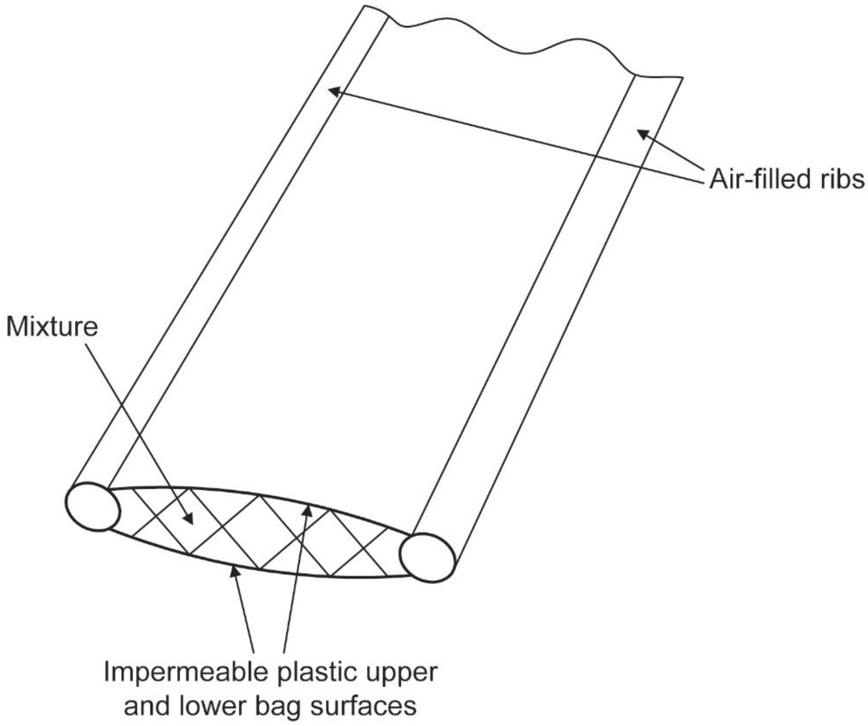
As for the shape and size of my photo-reactor bags, we're still working out the best configuration, but we've found they should ideally be thinner than they are wide to prevent twisting or inversion of the bag when in the sea. The thickness of the bag should also be chosen so that daylight entering the transparent upper surface will penetrate through the entire depth of the mixture. For our preferred algae, this limits the bag thickness to around thirty centimetres. Our initial bags will also be about fifty metres long and two metres wide, but we plan to tailor the exact dimensions on a case-by-case basis.

When making my photo-reactor bags, I found that the material of the FO membrane is much thinner and less robust than the impermeable polyurethane plastic sheets used to form known photo-reactor bags. This means the FO membrane material will tear or split much more easily than a polyurethane plastic sheet or other similar impermeable plastic sheets. To make the photo-reactor bag sufficiently robust for long-term use in the sea, I used multiple patches of FO membrane material surrounded and supported by regions of stronger, thicker polyurethane plastic material. Further robustness was added to the bag by the inclusion of reinforcement strips that run along and across the bag between the FO membrane patches. I purchased the nitrate permeable membrane material from the same supplier as the FO membrane, but whilst it is still not as strong as the impermeable plastic it is much more robust than the FO membrane material, which allows a large, single piece of such material to be used. It therefore looks like I'll need to tailor the amount of reinforcement, depending on the specific semi-permeable membrane material or materials I use for each different type of photo-reactor bag I produce.

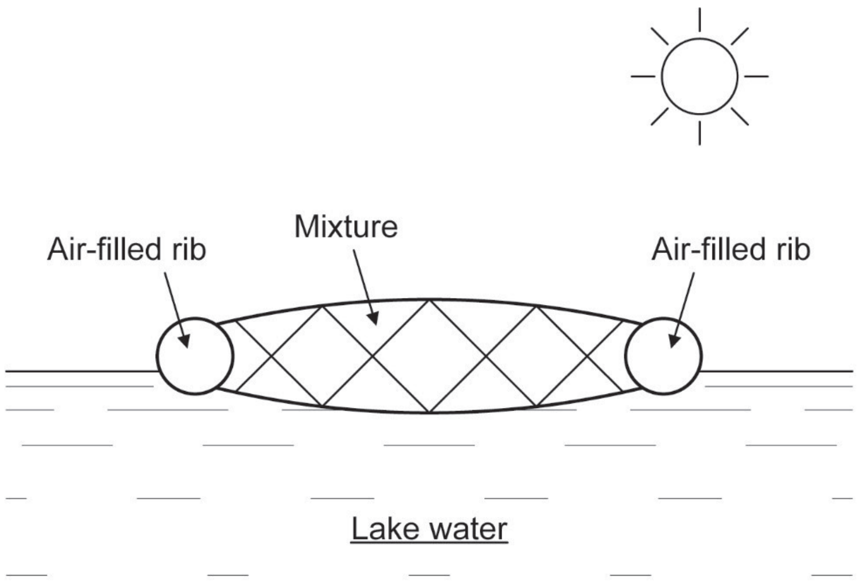
As well as installing the apparatus and growing algae for biofuel, I also plan to sell the apparatus to third parties, such as water treatment companies. Although many types of algae are available from many sources, I will also sell bottles of appropriate freshwater algae with the bags, along with the buoys, ropes, etc. that anchor everything in place in the sea.

I trust this letter provides all the information you need to file a UK patent application, because I'm afraid I won't be available to discuss this until after the conference has ended later this week.

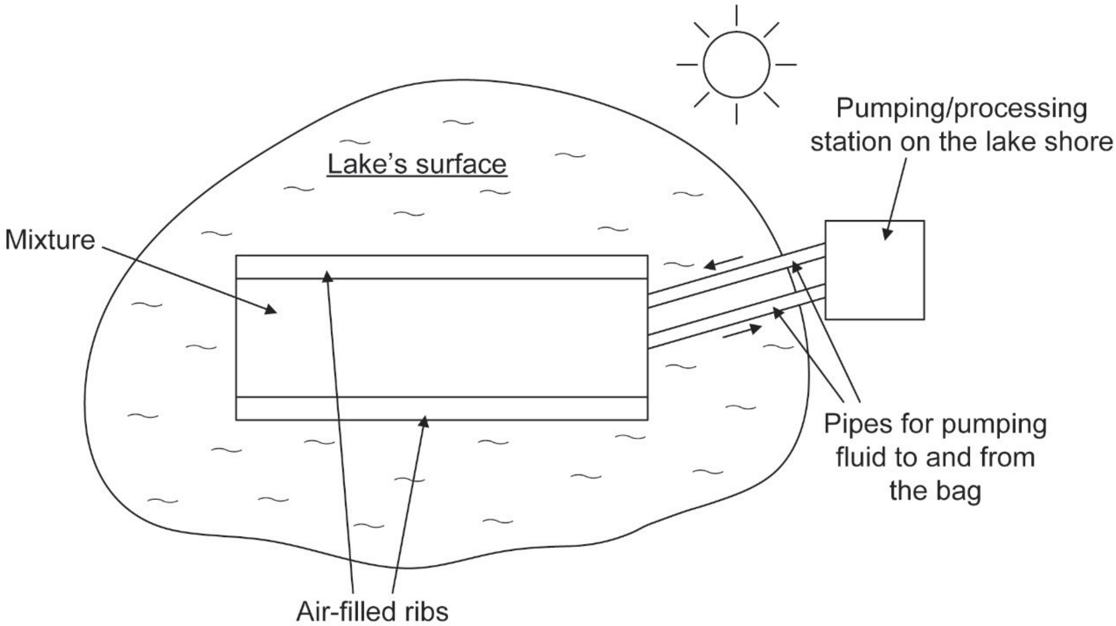
Known photo-reactor bags



a) View of a section of a known photo-reactor bag

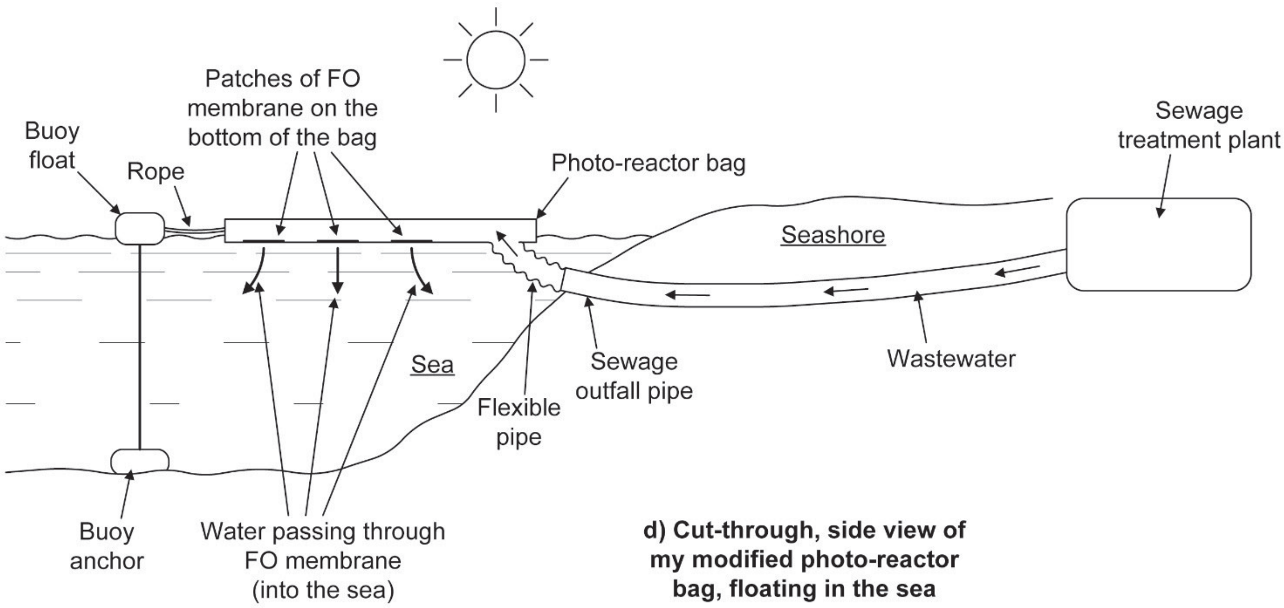


b) Cut-through view of the bag floating on a lake

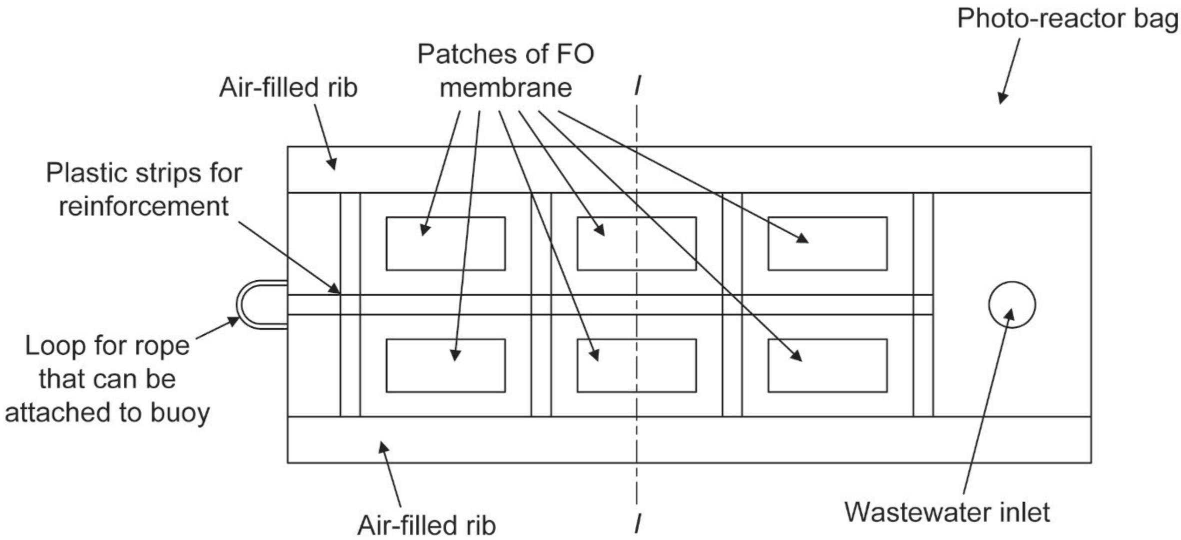


c) View from above of the bag floating on a lake

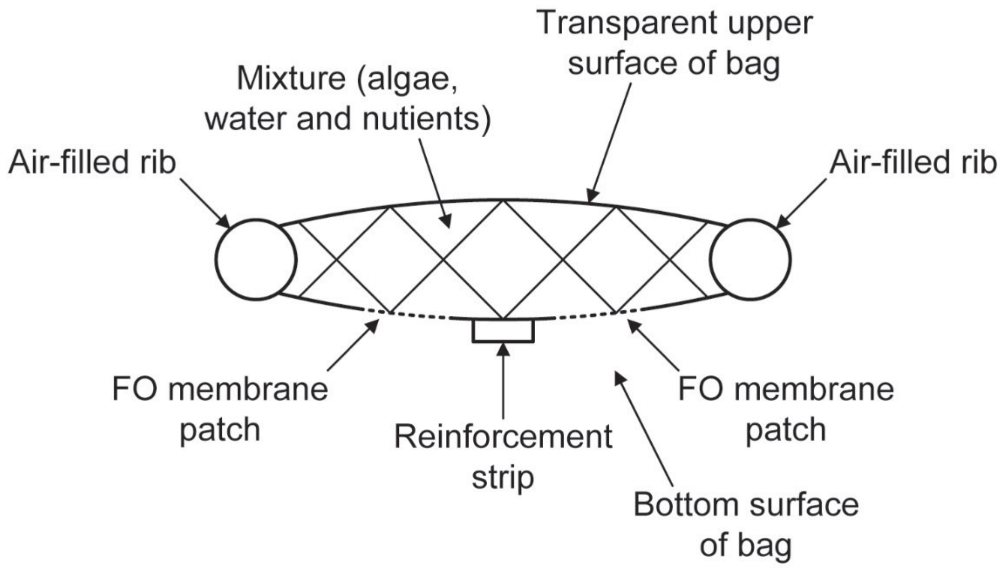
My photo-reactor bag



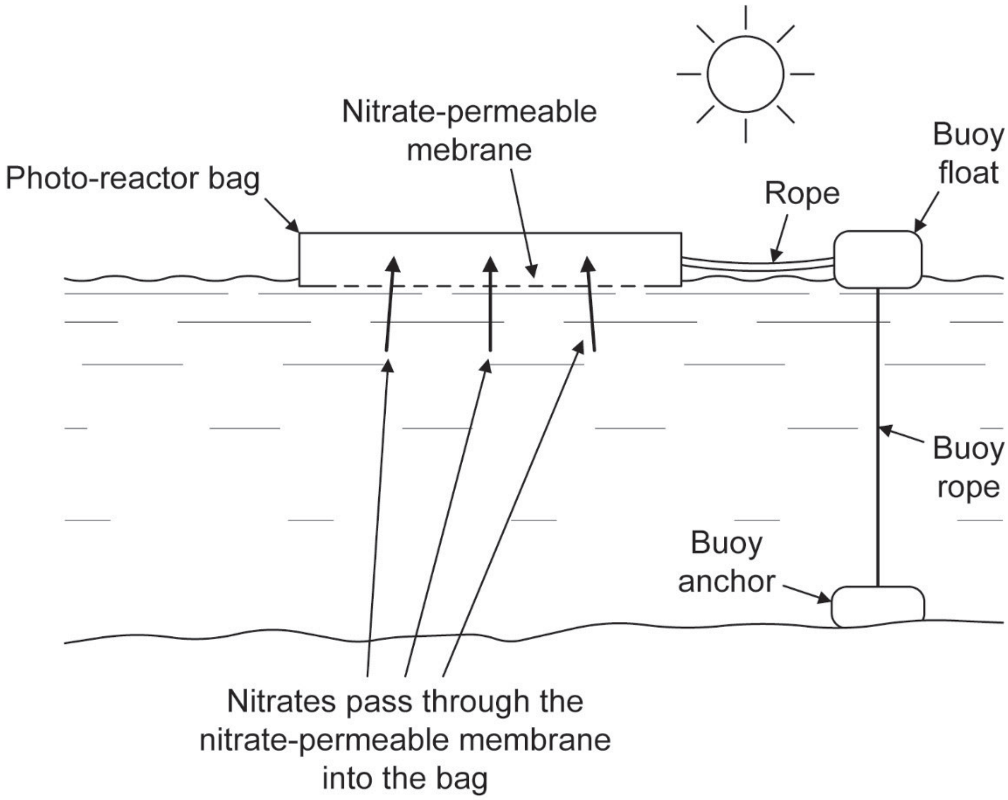
d) Cut-through, side view of my modified photo-reactor bag, floating in the sea



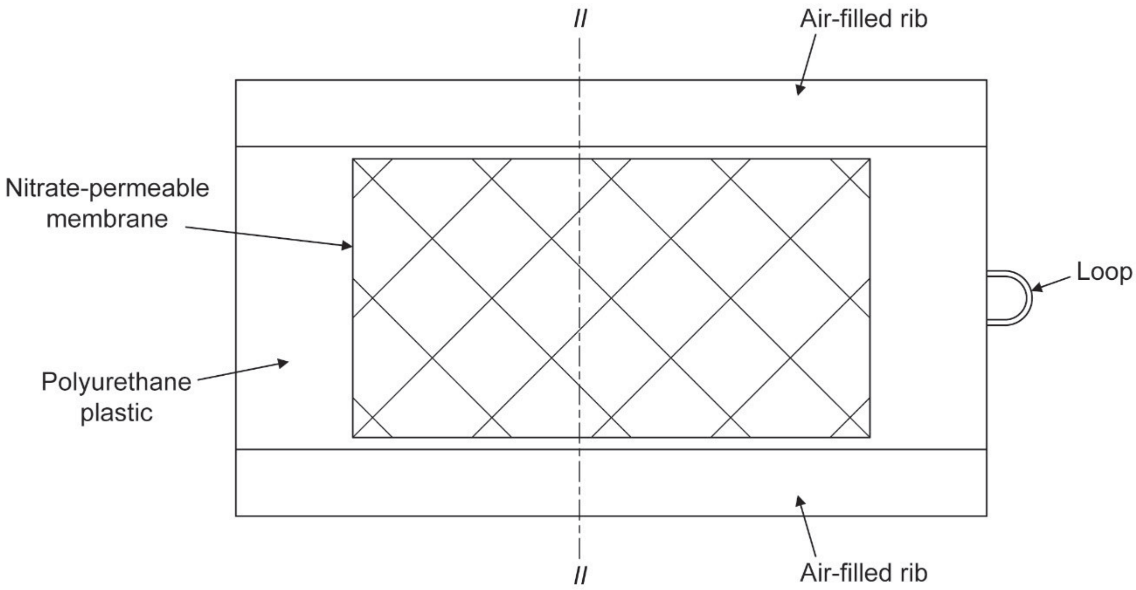
e) View of the bottom of my photo-reactor bag



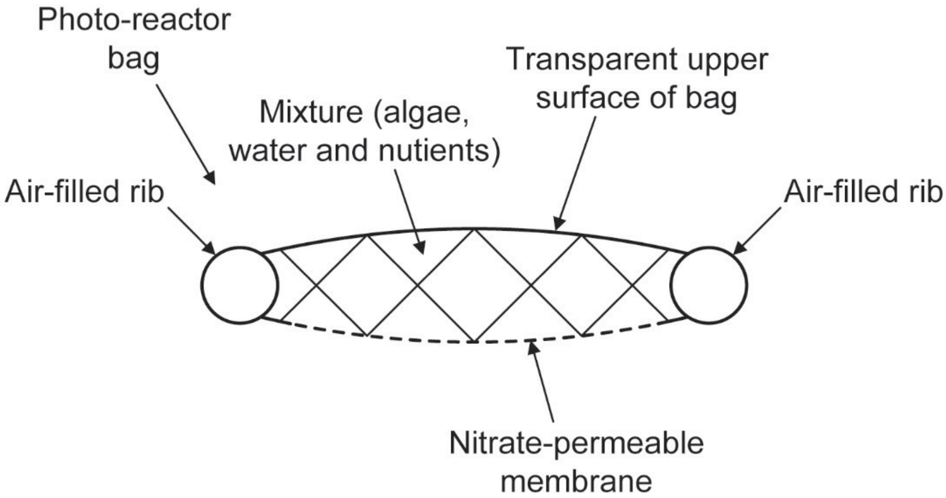
f) Section I-I through the bag



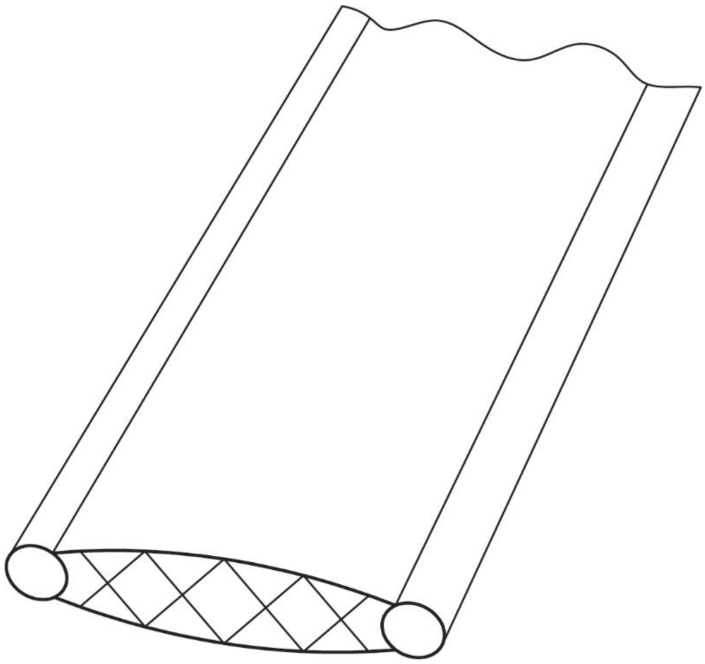
g) Cut-through, side view of my alternative photo-reactor bag, floating in the sea

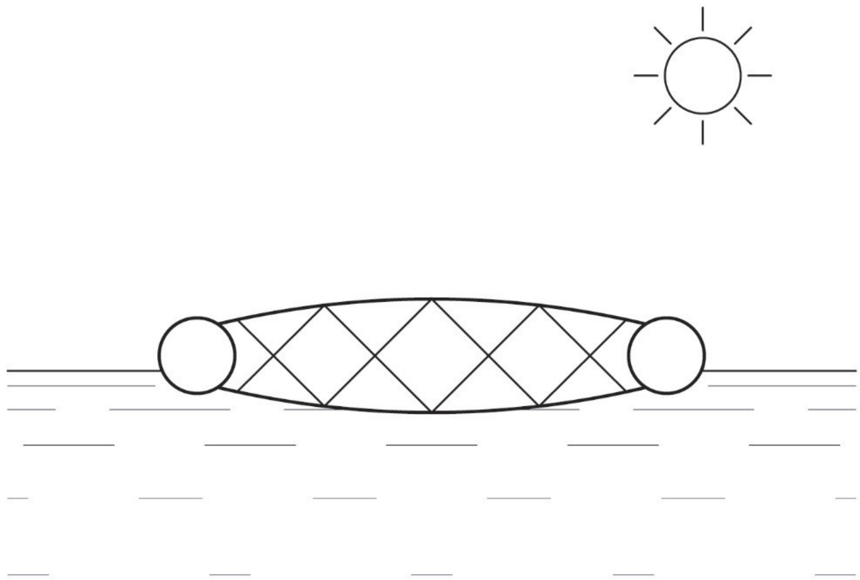


h) View of the bottom of my alternative photo-reactor bag



i) Section II-II through the bag





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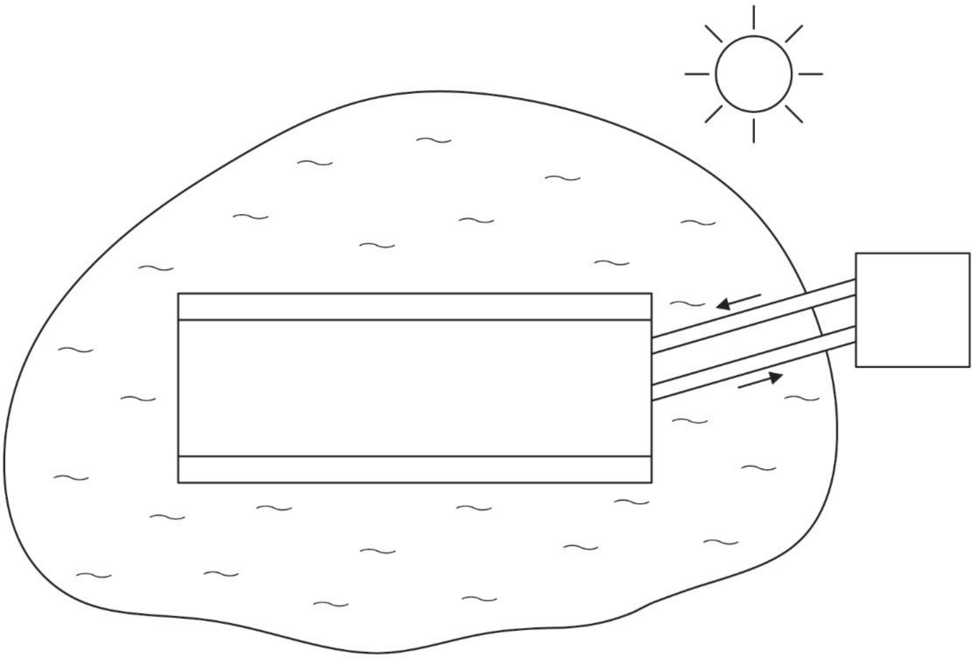

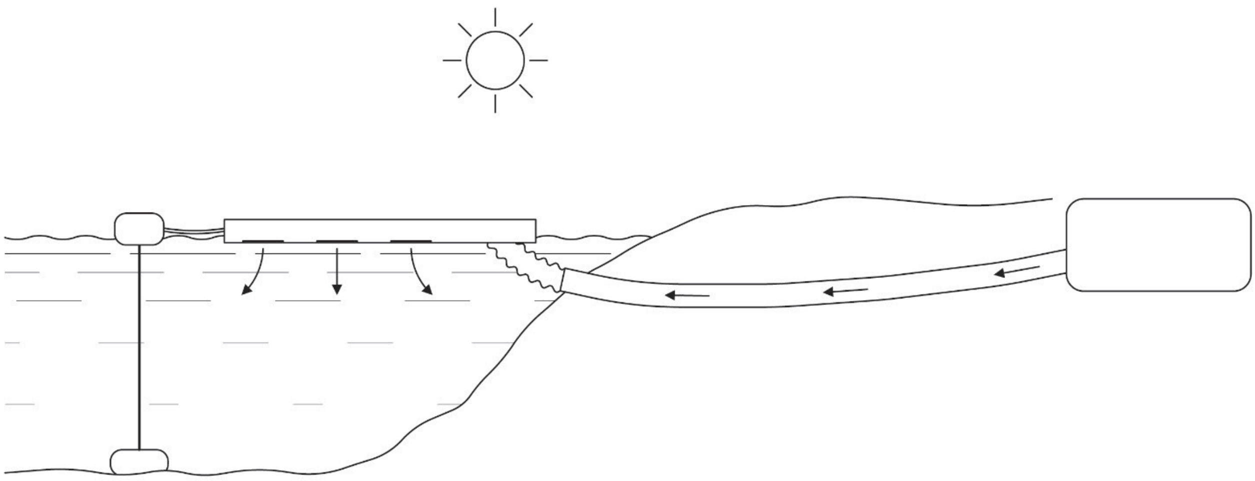

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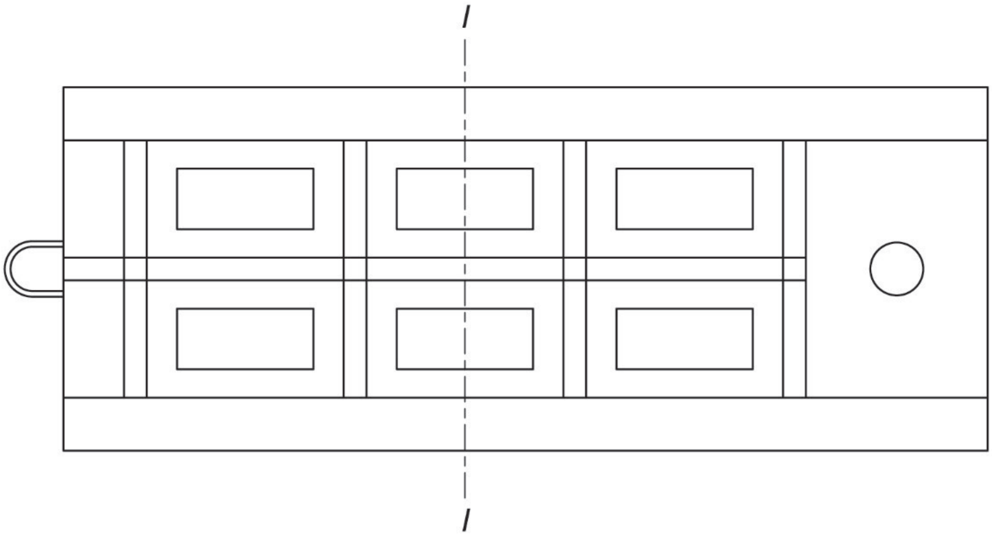
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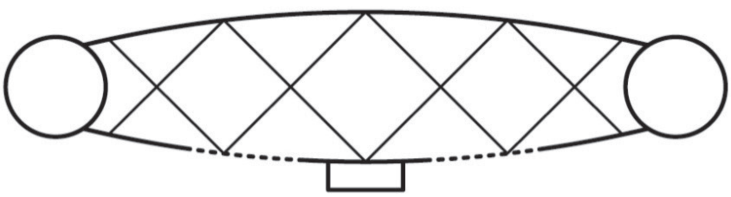

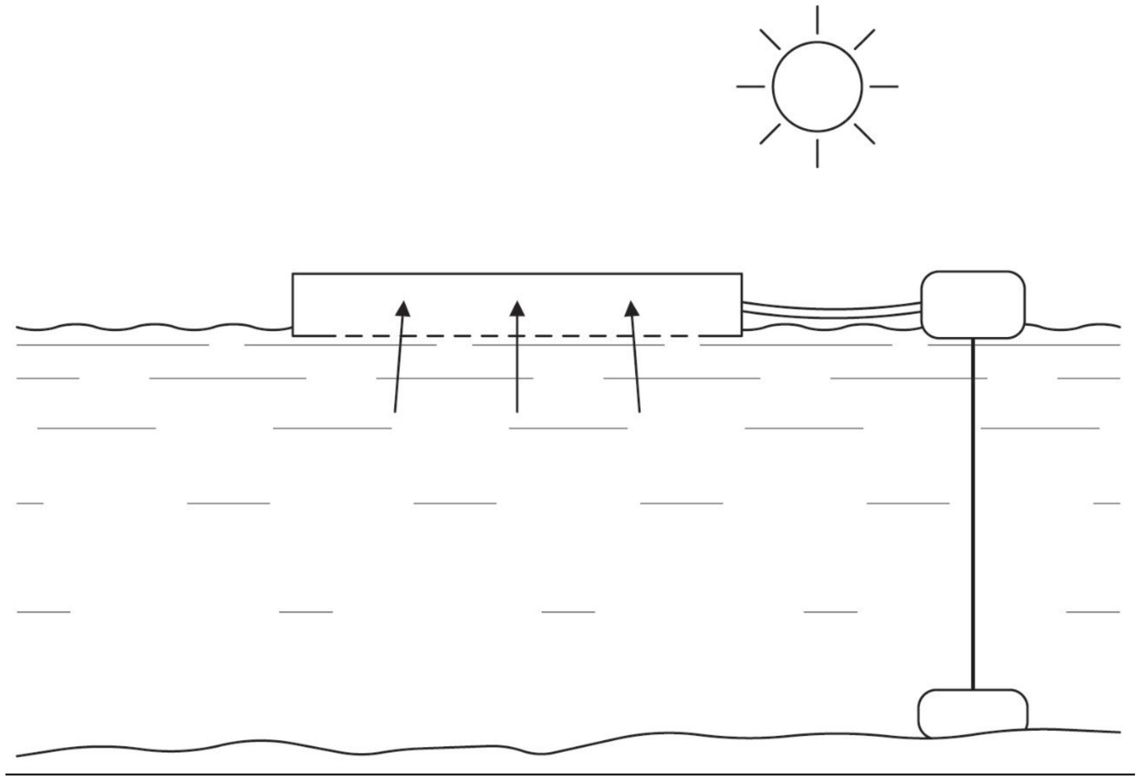

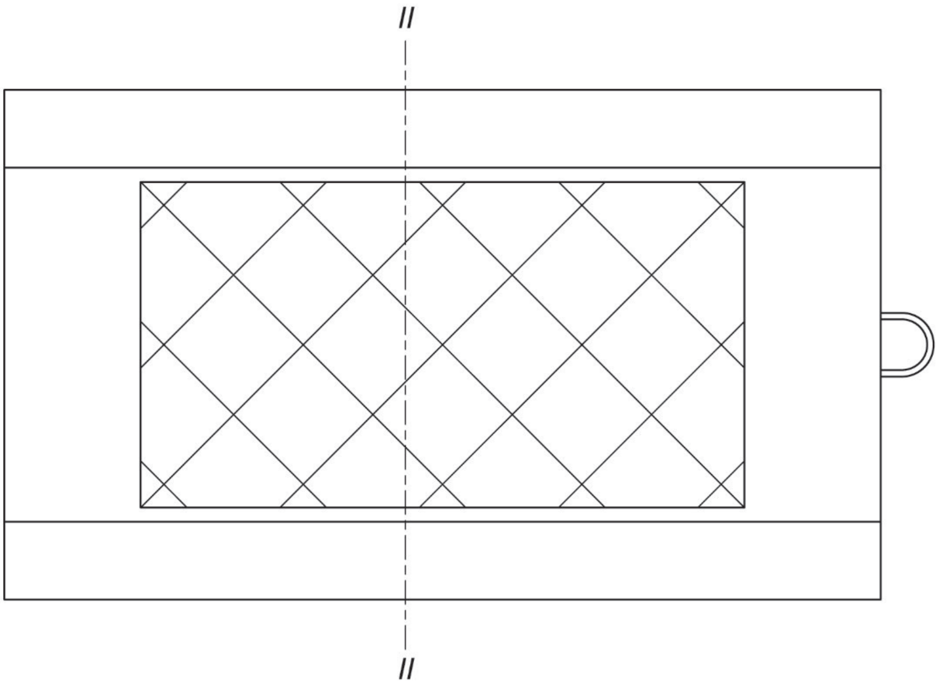

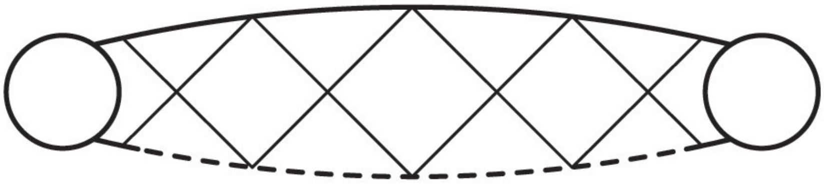

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