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(72) Inventor(s):
**Glyn Philip Cotton**
**Christopher Booker**
**Dan Sean Jones**

(73) Proprietor(s):
**WATR Limited**
**11 Swallowtail Close, Attleborough, Norfolk, NR17 2RW, United Kingdom**

(74) Agent and/or Address for Service:
**ip21 Limited**
**Central Formalities Department, Suite 2, The Old Dairy, Elm Farm Business Park, Wymondham, Norwich, Norfolk, NR18 0SW, United Kingdom**

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14 12 20

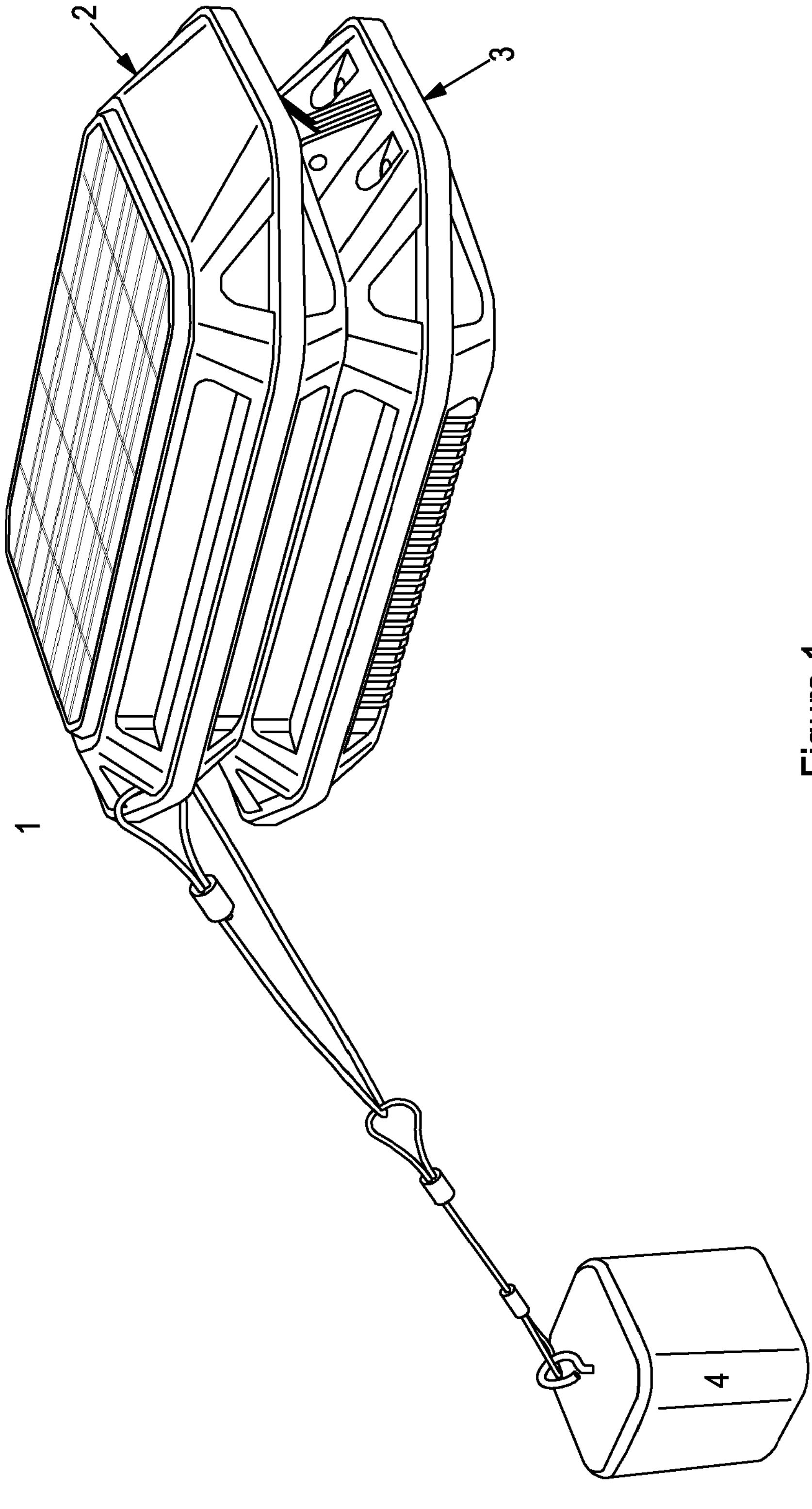


Figure 1

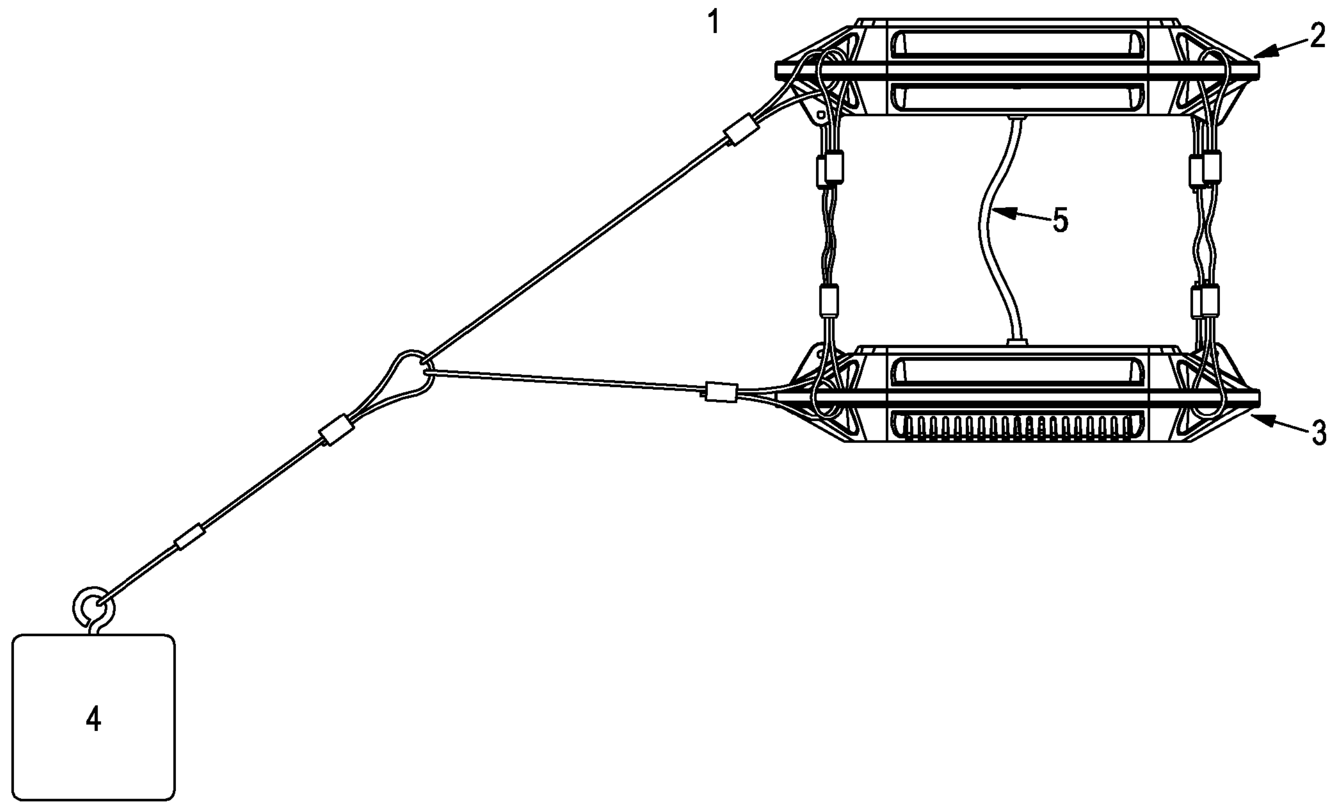


Figure 2

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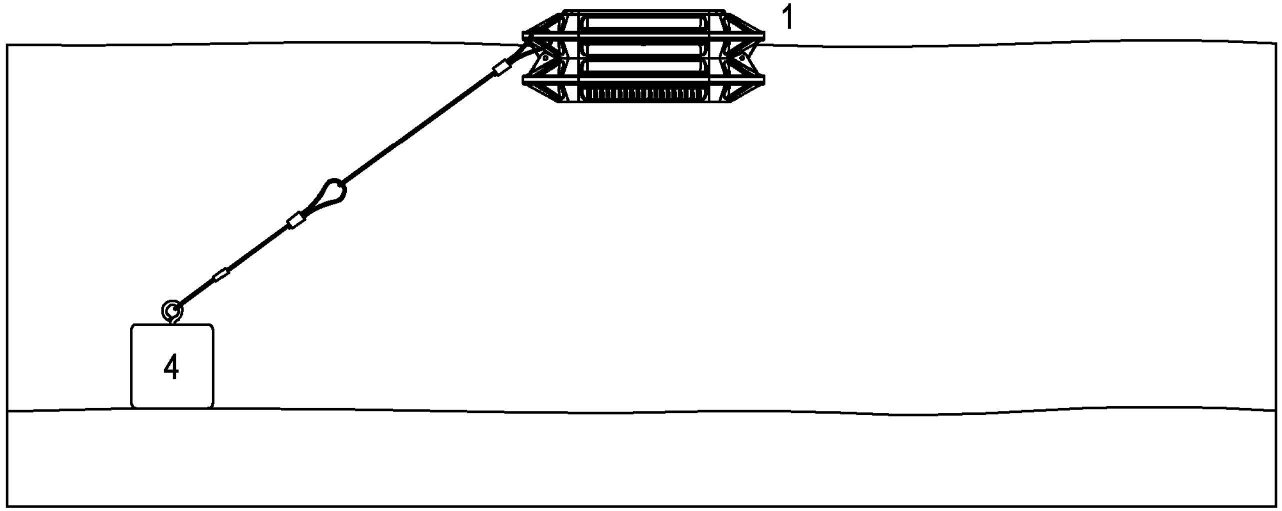



Figure 3(A)

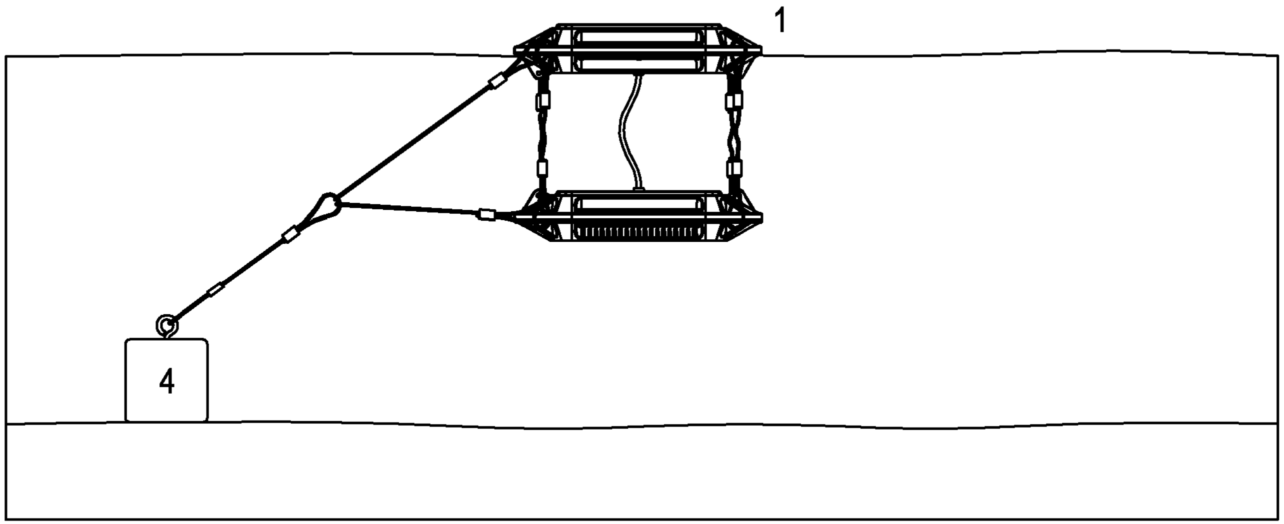



Figure 3(B)

14 12 20

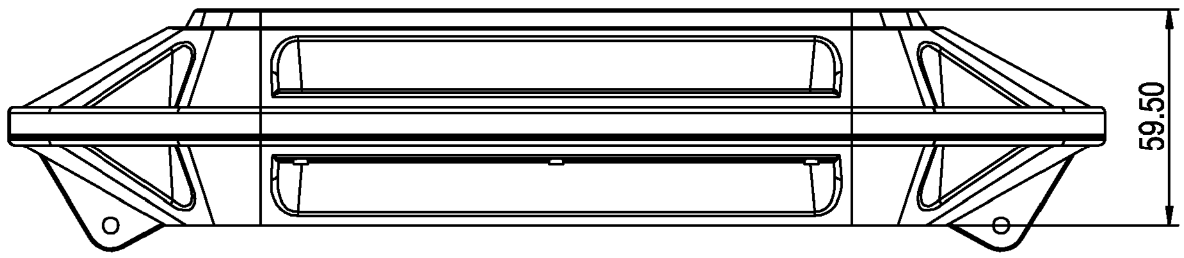



Figure 4(A)

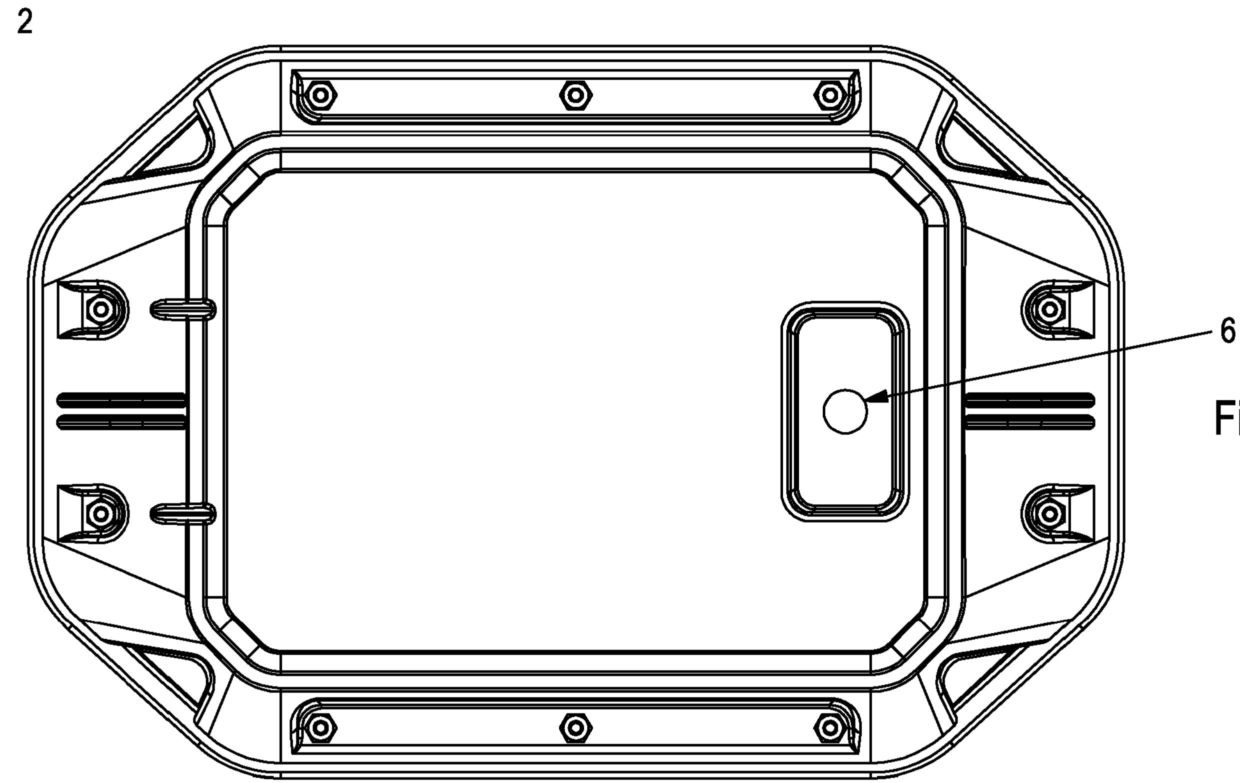



Figure 4(B)

14 12 20

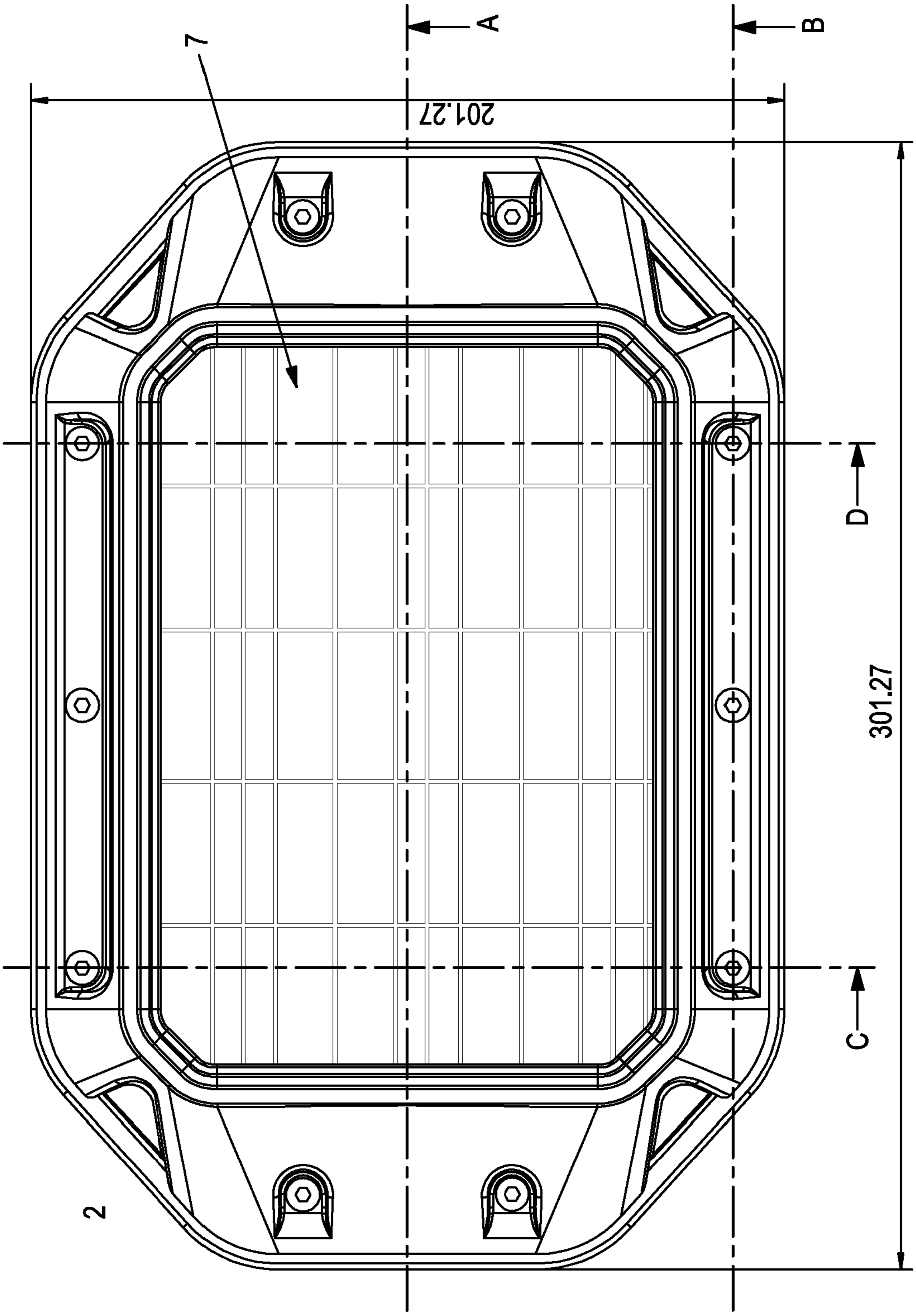



Figure 4(C)

14 12 20

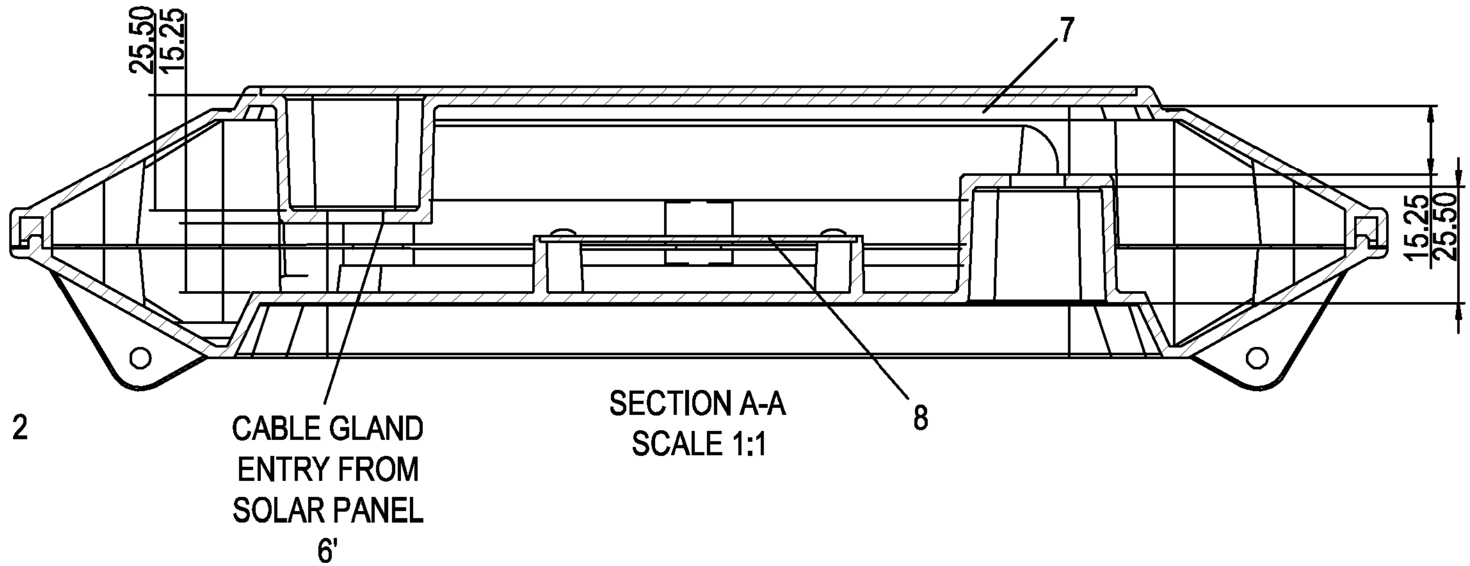



Figure 4(D)

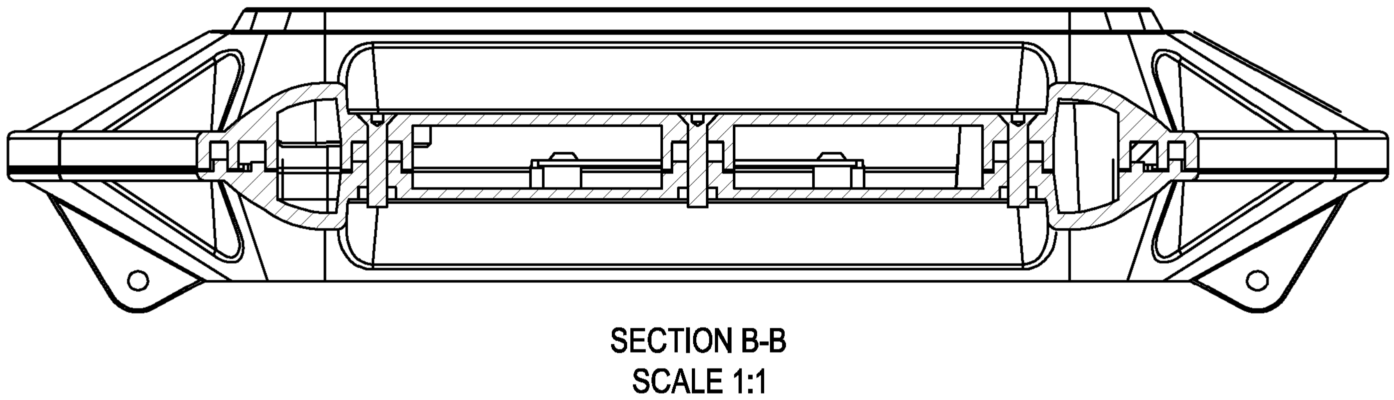
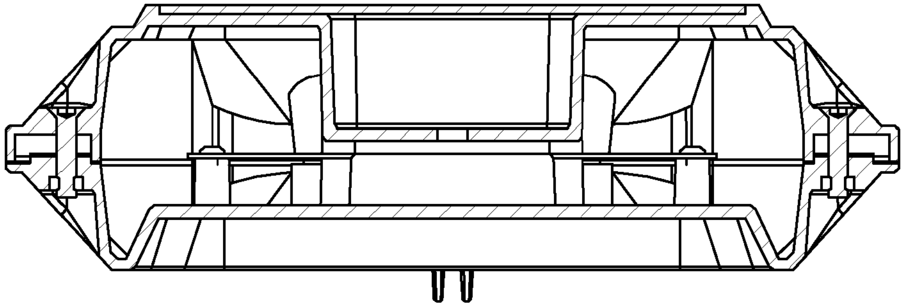
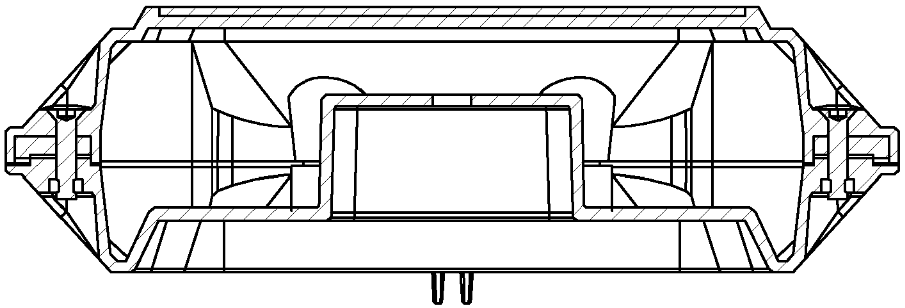



Figure 4(E)



SECTION C-C
SCALE 1:1

Figure 4(F)



SECTION D-D
SCALE 1:1

Figure 4(G)

14 12 20

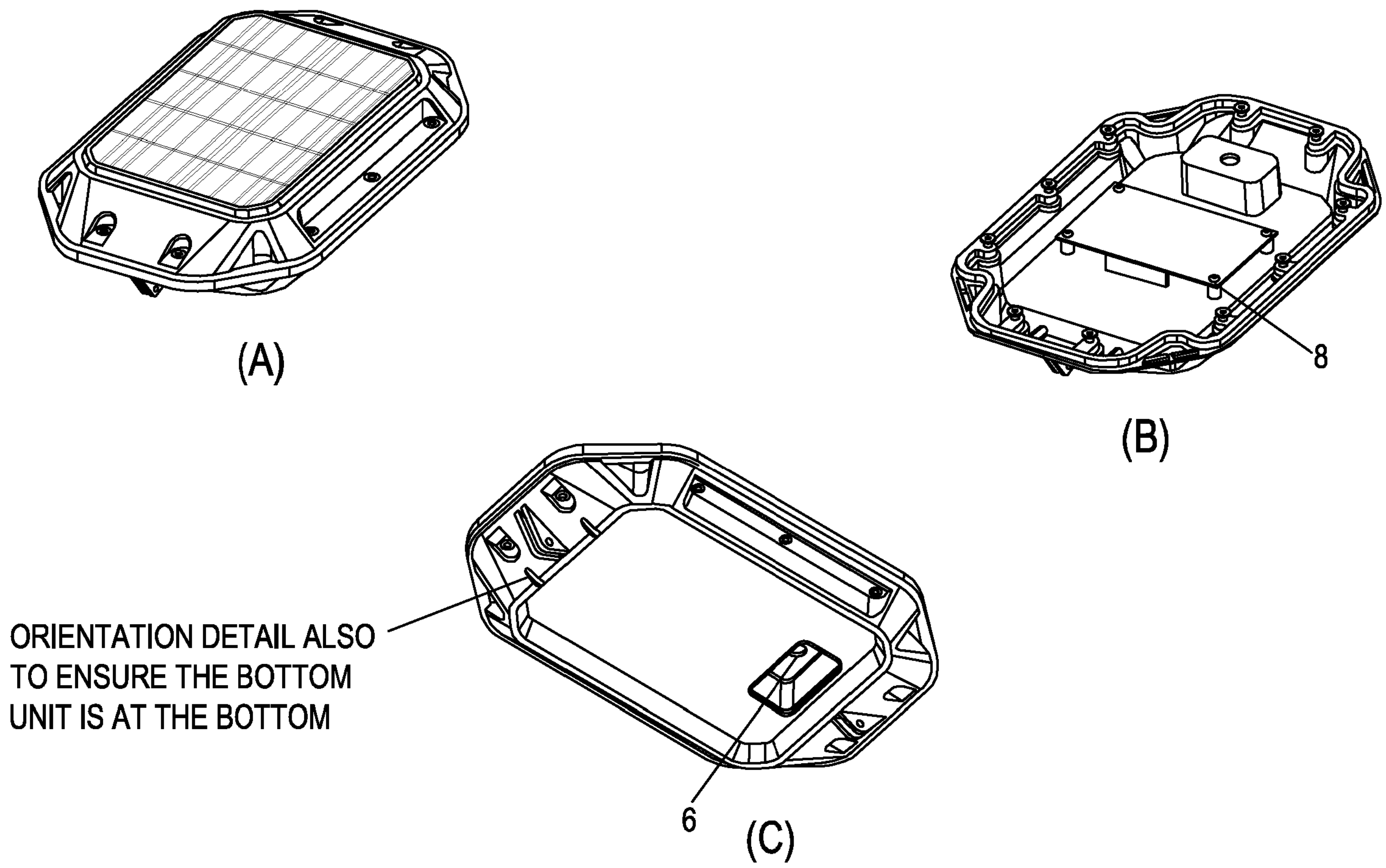



Figure 5

14 12 20

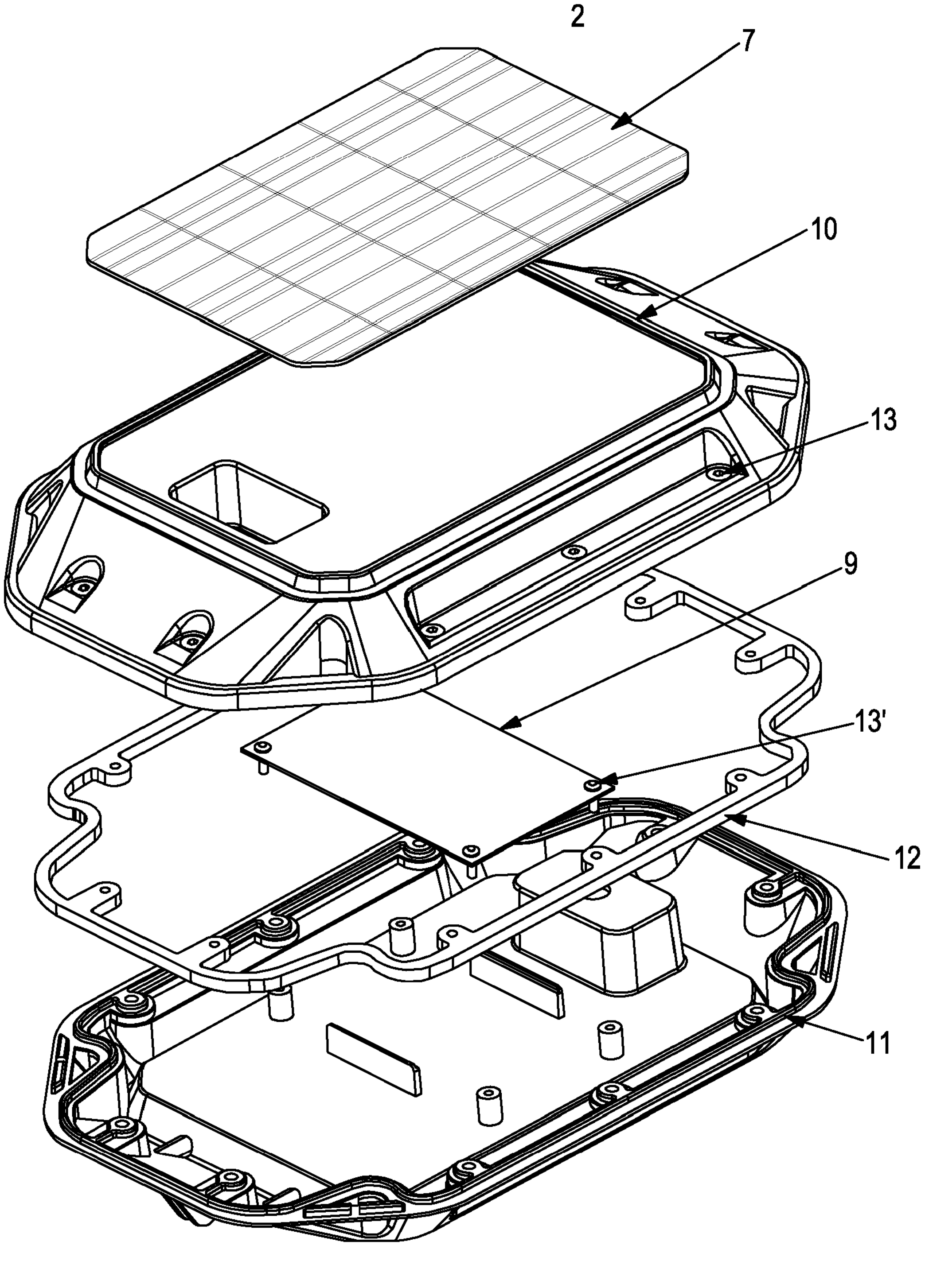



Figure 6

14 12 20

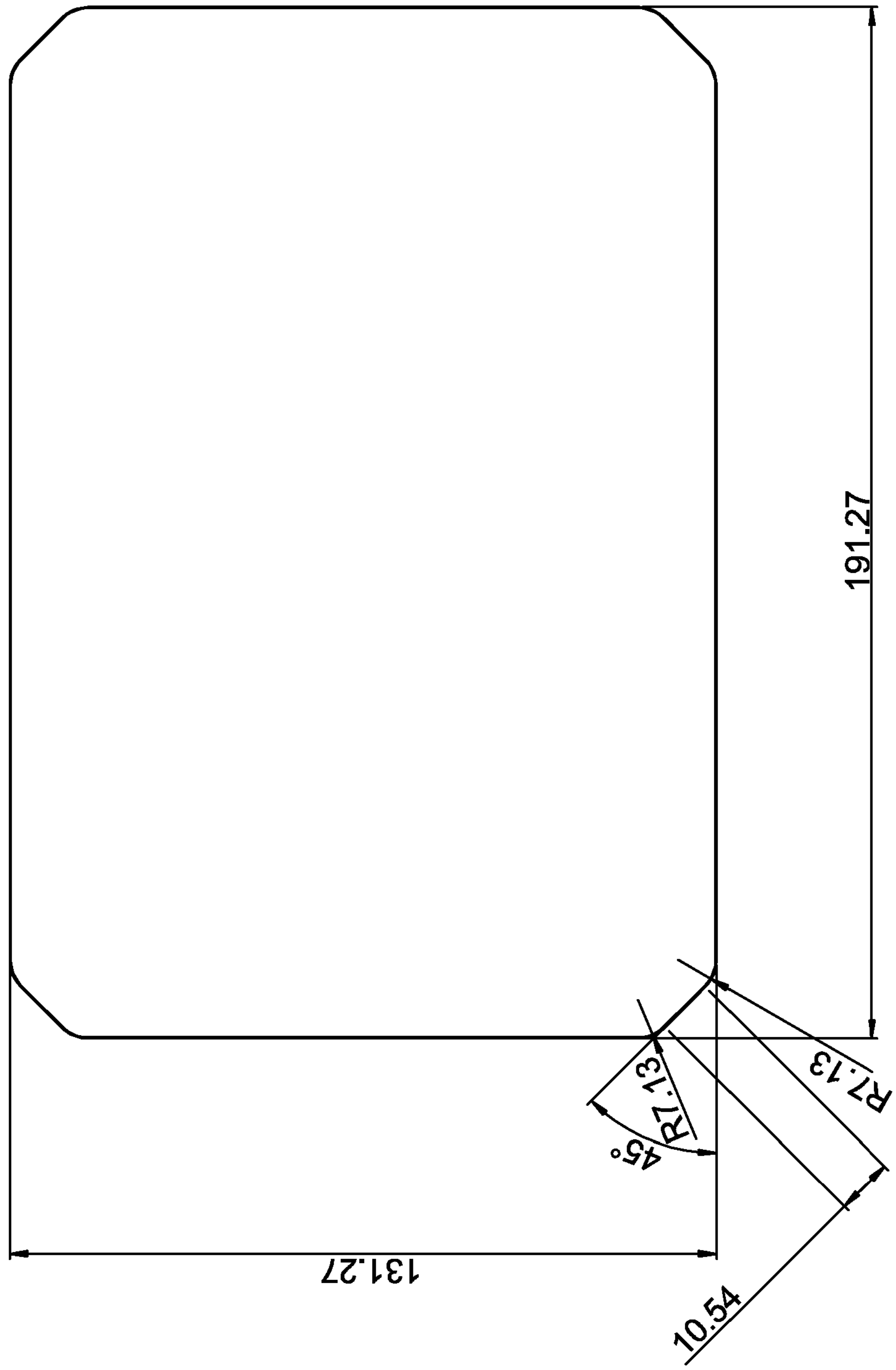



Figure 7

14 12 20

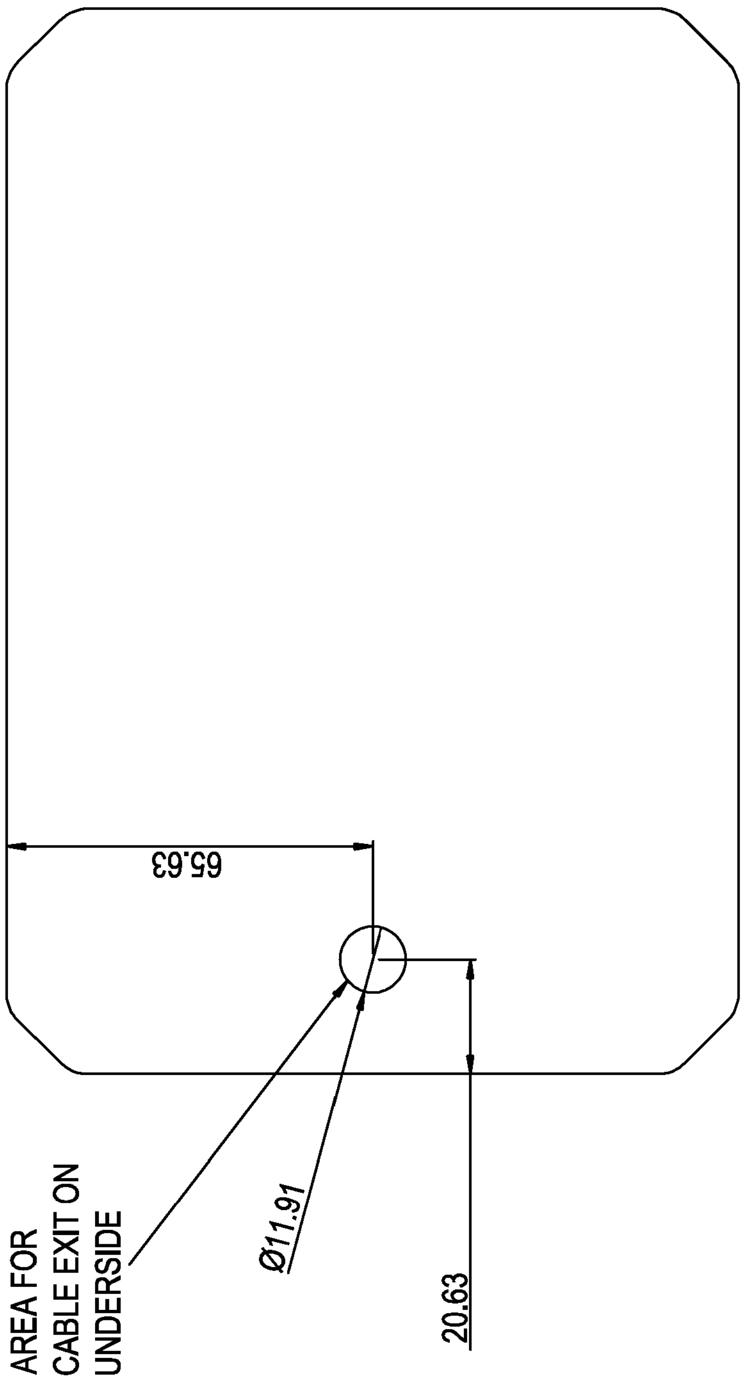



Figure 8

14 12 20

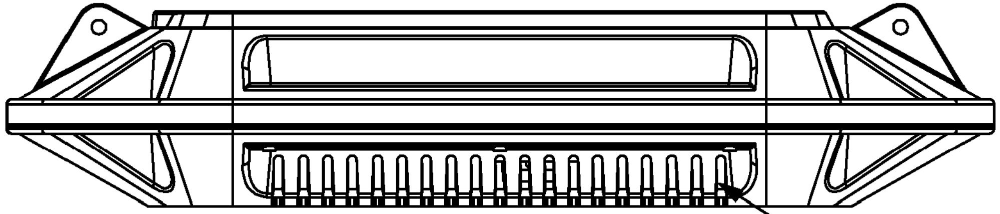



Figure 9(A)

3

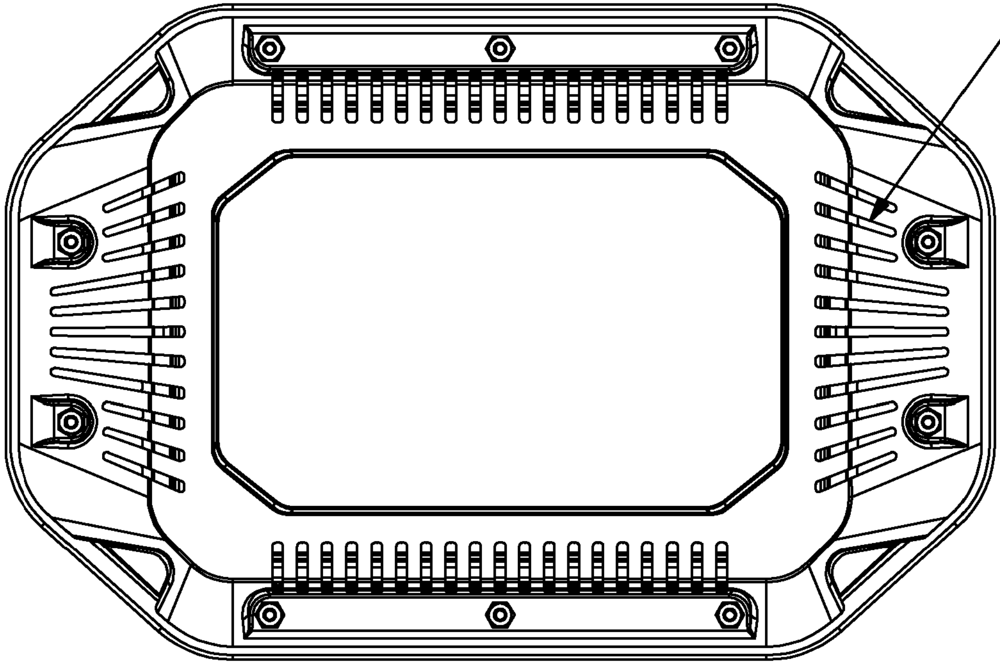


Figure 9(B)

14 12 20



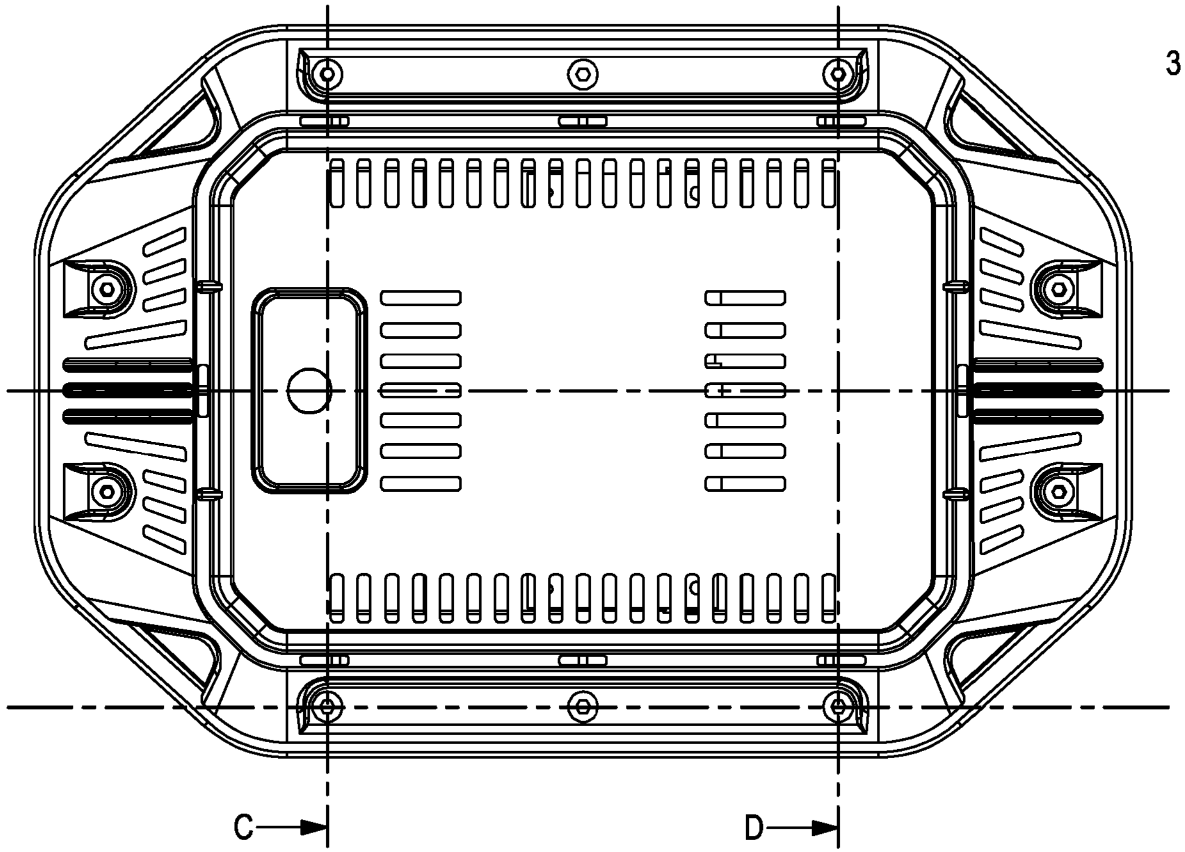



Figure 9(C)

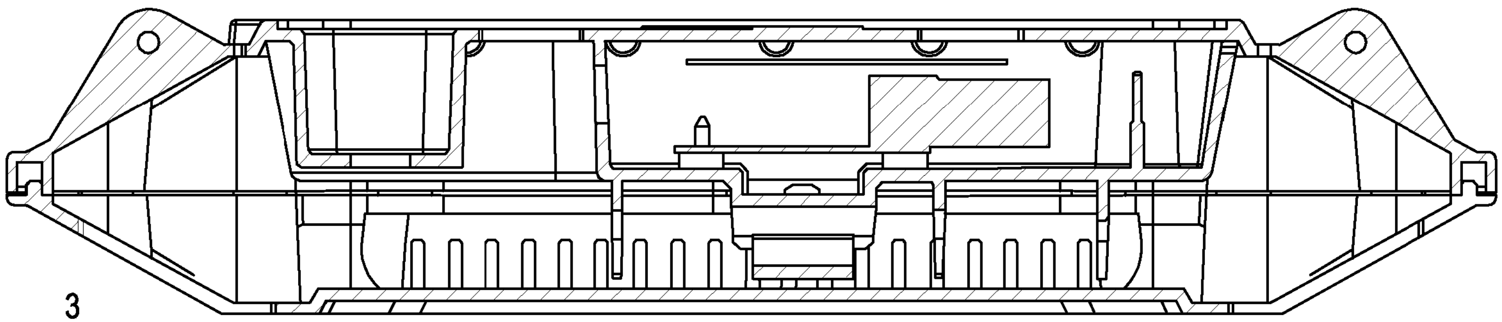



Figure 9(D)

SECTION A-A
SCALE 1:1

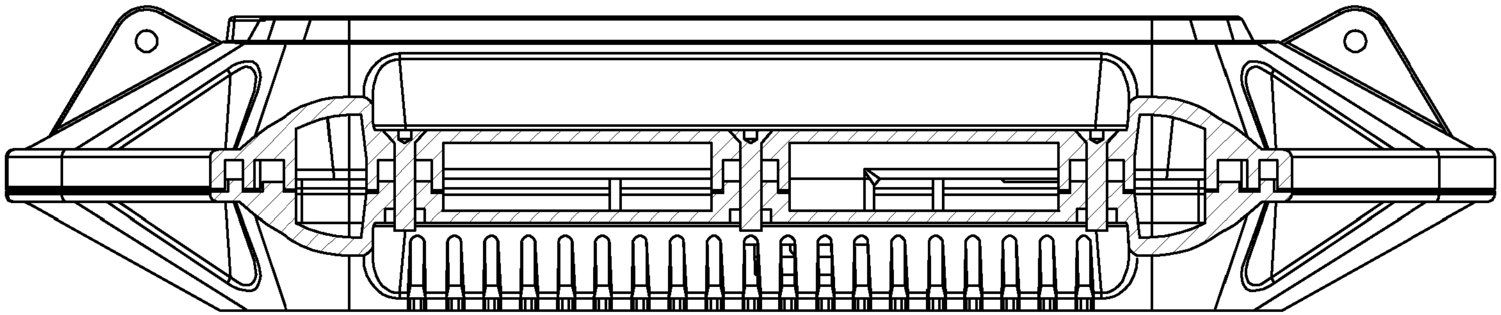


Figure 9(E)

SECTION B-B
SCALE 1:1

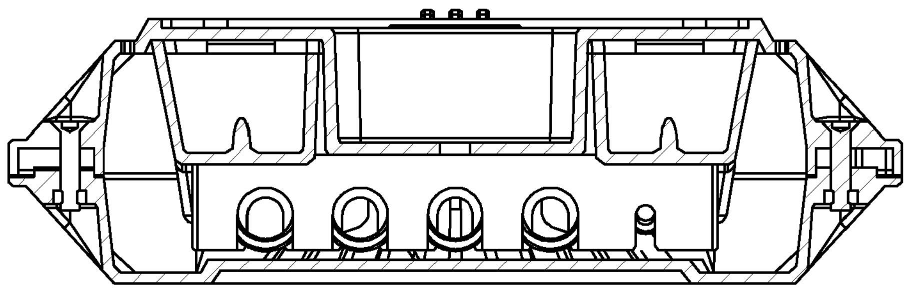


Figure 9(F)

SECTION C-C
SCALE 1:1

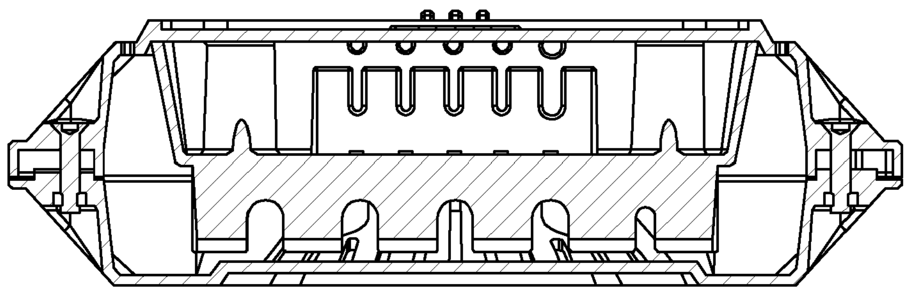


Figure 9(G)

SECTION D-D
SCALE 1:1

14 12 20

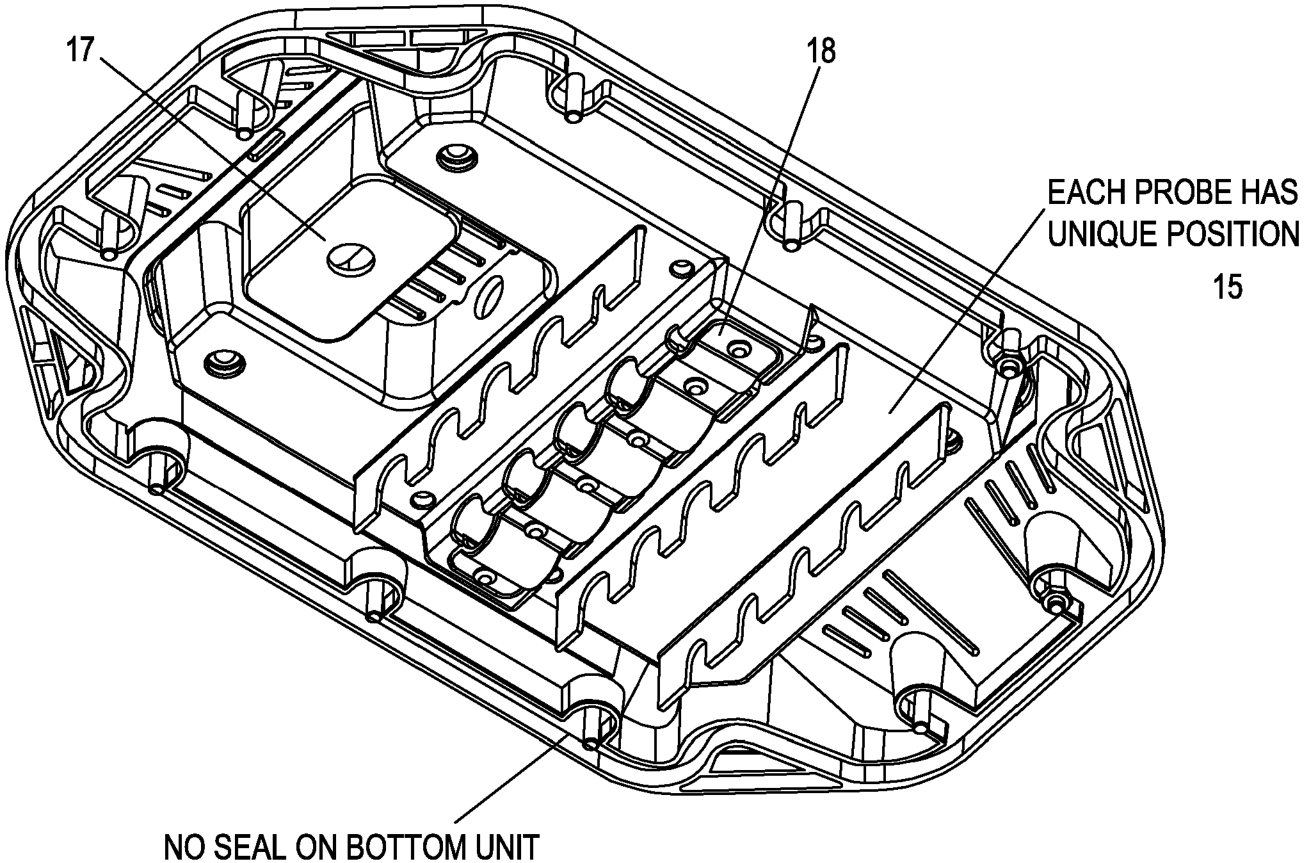



Figure 10

14 12 20

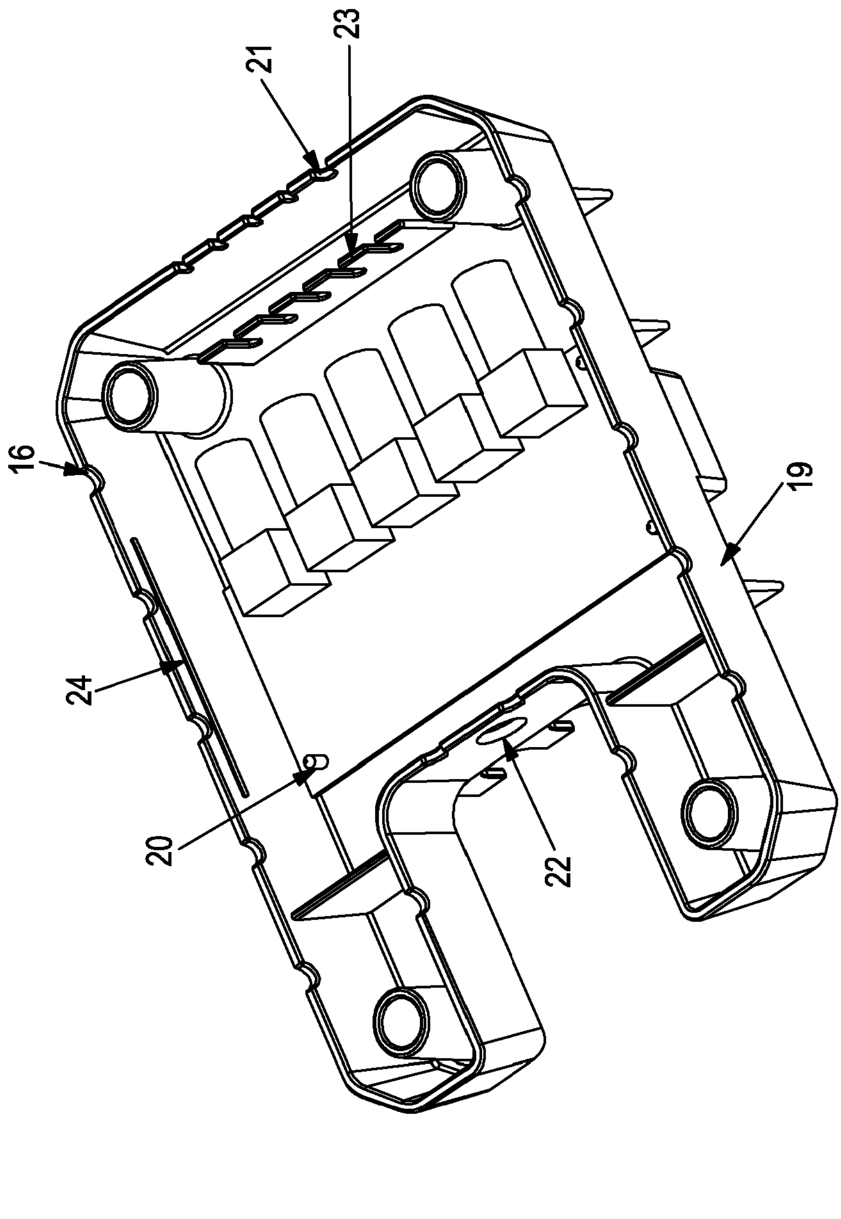



Figure 11

14 12 20

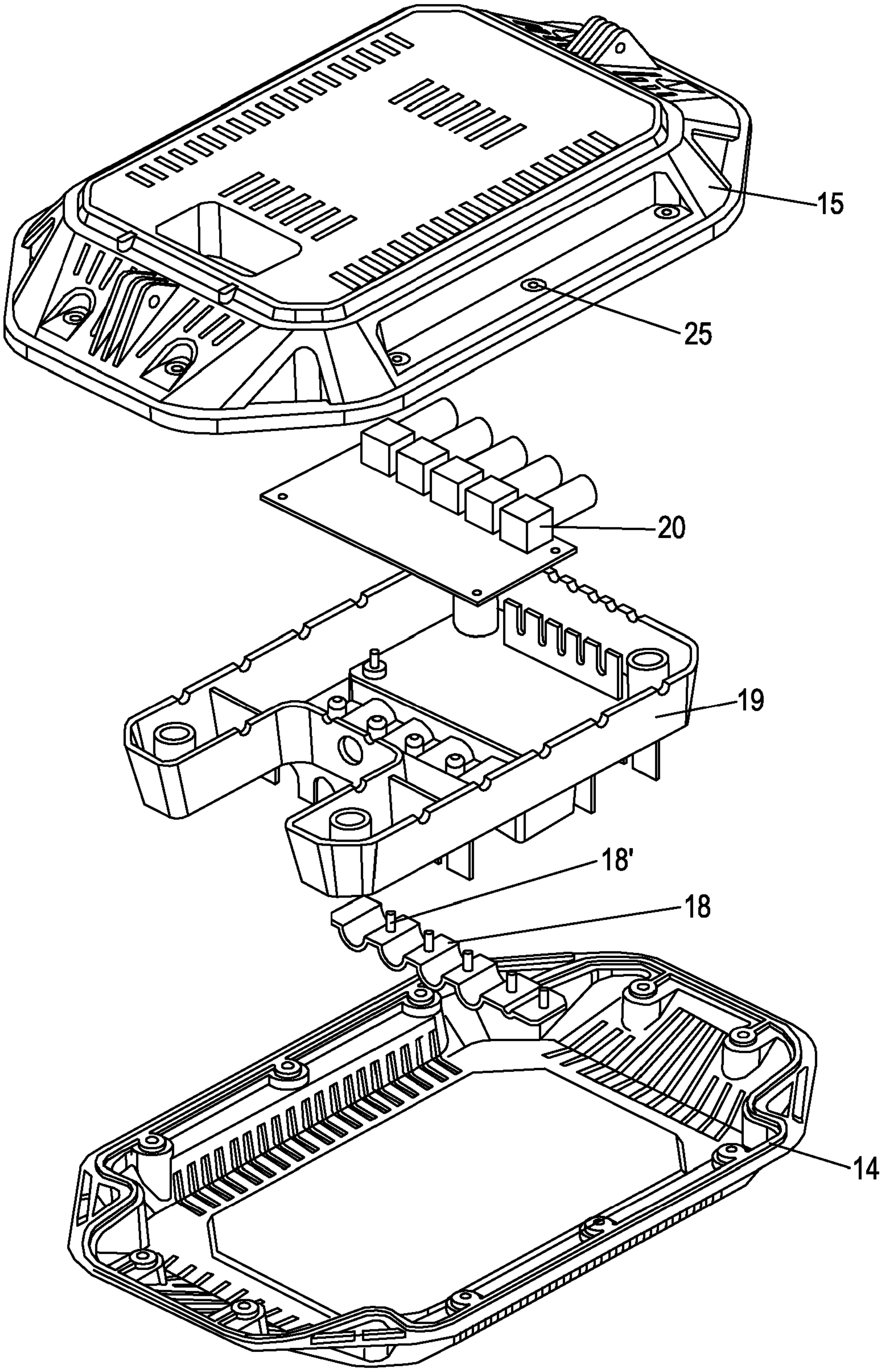



Figure 12

14 12 20

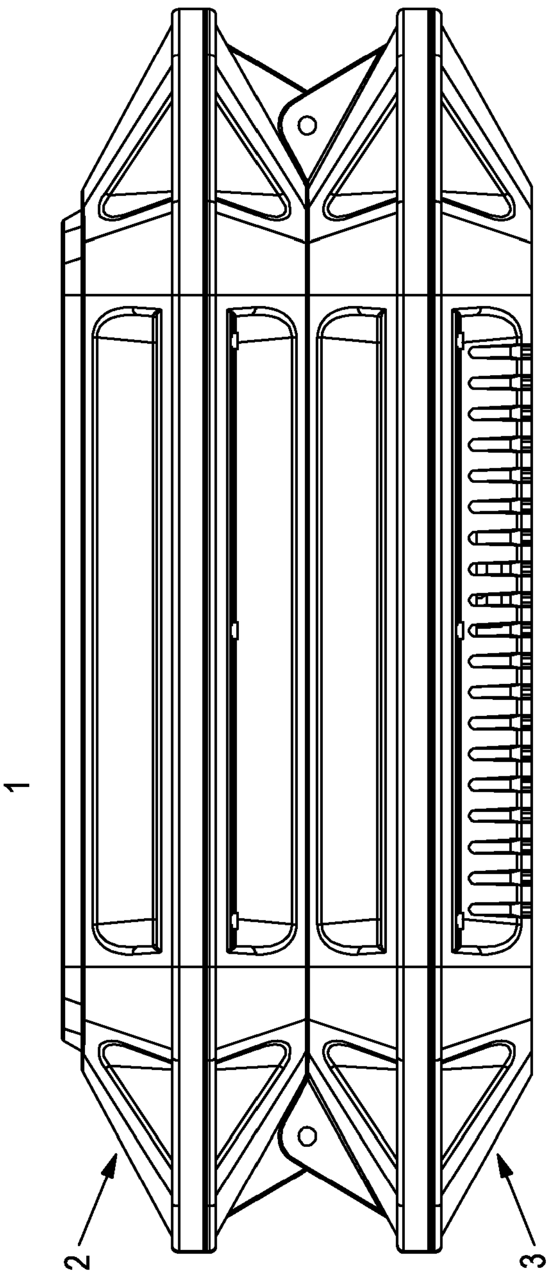
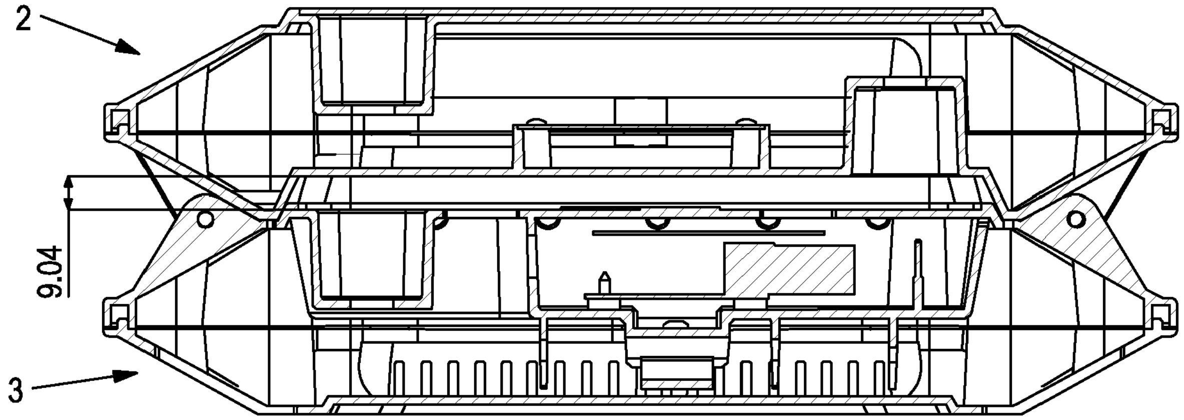


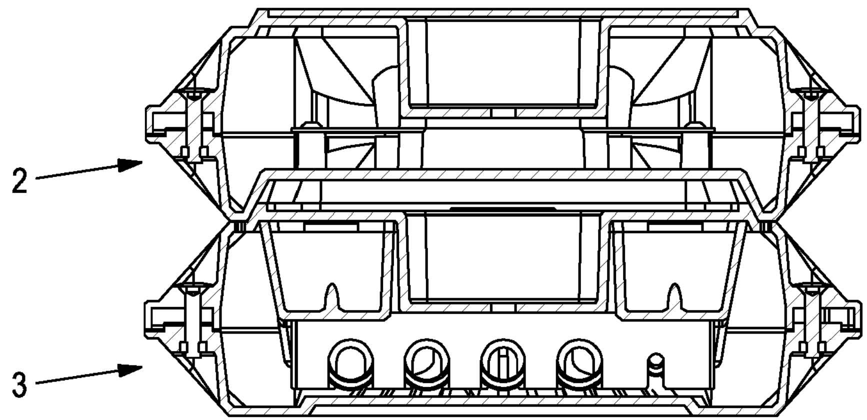

Figure 13(A)

14 12 20




SECTION A-A
SCALE 1:1

Figure 13(B)




SECTION B-B
SCALE 1:1

Figure 13(C)

The following terms are registered trade marks and should be read as such wherever they occur in this document:

LoRa

SigFox

## MONITORING DEVICES AND MONITORING METHODS



### Technical Field

Aspects of the present invention generally relate to water monitors and in particular to systems and methods for monitoring water reliably and continuously, at different depths.

### Background

Water is essential for survival and one of the biggest worldwide issues associated with is poor water quality. For example, manufacturing factories and pesticides used in agriculture are often detrimental to water quality used by utility companies or fish farms. There is a paramount, ongoing, requirement to improve water quality around the globe.

Known monitoring systems are cabled and have complex calibration processes. Accordingly, current monitoring solutions involve expensive lab tests, unreliable equipment and huge costs. Worldwide, it is estimated that manufacturing companies spend over 65 billion USD per year on water monitoring. Usually, water monitoring is implemented too late, when the problem has already occurred, or it is imminent.

It is to these problems, amongst others, that aspects according to the invention attempt to offer solutions. In particular, aspects of the present invention seek to provide accurate and reliable means for monitoring water conditions.

**Summary of the invention**

According to a first independent aspect of the invention, there is provided a water monitoring device according to claim 1.

The variable connecting element is a retractable cable passing through housings of the first and second units, respectively. The water monitoring device can improve water quality by providing an easy, accurate and reliable way of monitoring water conditions at different depths.



Advantageously, the two units and their functions are decoupled. The first unit contains the battery, communications and, preferably, control means. The control means may include a battery control means. The first unit is preferably sealed and enables for example wireless communication with the device. The second unit contains the probes and enables communication with the first unit, e.g. via a cabling between the two communication devices. The second unit allows water to reach the probes, which can monitor water at different depths, whilst the first unit floats at water surface.

For example, the first and second communication devices include may be printed circuit boards (PCBs). In a dependent aspect, the first unit comprises a control device for controlling the variable connecting element. The control device may be part of the first communication device (i.e. master PCB) for example. Advantageously, the second unit may be lowered automatically when a trigger occurs, such as for example, when a parameter data received from the second communication device reaches a certain threshold. Alternatively, the variable connecting element may be controlled by a user (manually).

In a dependent aspect, the first unit comprises a photovoltaic (PV) element. This enables the battery life to be extended and the device to operate for long periods of time. Advantageously, the device does not have to be powered via a cable, increasing its flexibility and reliability.

In a dependent aspect, the second unit comprises a holding element for receiving a plurality of probes. For example, this may be a probe holder strip enabling probe versatility.

According to a second independent aspect of the invention, there is provided a method for monitoring water according to claim 13.



According to a comparative example, there is provided a communication unit for a water monitoring device, the communication unit comprising at least one first communication device for communicating over a plurality of communication protocols, the communication unit configured to communicate data using a first communication protocol from said plurality of protocols, detect when the first communication protocol is no longer available, and switch to communicate data to a second, available, communication protocol.

Advantageously, switching to one of the plurality of communication protocols enables continuous, reliable communication with the water monitoring device under any conditions, anywhere in the world. Preferably, the plurality of communications protocols include LoRa, SigFox, WFi, cellular and RF communication protocols.

According to a further comparative example, there is provided a communication method for water monitoring, the method comprising providing a communication unit comprising at least one first communication device for communicating over a plurality of communication protocols, the communication unit configured to communicate data using a first communication protocol from said plurality of communication protocols, detect when the first communication protocol is no longer available, and switch to communicate data to a second, available, communications protocol.

According to a third independent aspect of the invention, there is provided a water monitoring device according to claim 14.

The waters sensor is for example a thermometer or any other probe for measuring water parameters including chemical properties. For example, the first and second communications devices include ‘master’ and ‘slave’ printed circuit boards (PCBs). The communication and control device enables positioning of the second unit relative to the first unit, for example, to lower it and the sensor at different depths. This also enables the users to initiate immediate action as soon as a problem occurs.



According to a fourth independent aspect of the invention, there is provided a method for monitoring water according to claim 15.

It will be appreciated that the dependent aspects may be used in combination with any of the independent aspects.

**Brief Description of the Drawings**

Aspects of the present invention will now be described, by way of example only, with reference to the accompanying figures, in which:

Figure 1 shows a water monitor according to the invention, in a first use position;
Figure 2 shows the water monitor according to the invention, in a second use position;
Figures 3(A), 3(B) show the water monitor deployed in water in the first and second use positions, respectively;
Figures 4(A) to 4(G) show views of the top unit assembly components;

Figures 5(A) to 5(C) show further views of the top unit assembly components;

Figure 6 shows the top unit being assembled;

Figures 7 and 8 are schematic views of the top unit components, including exemplary dimensions;

Figures 9(A) to 9(G) show views of the bottom unit assembly components;

Figure 10 and Figure 11 show further views of the bottom unit assembly components;

Figure 12 shows the bottom unit being assembled;

Figures 13(A) to 13(C) are schematic views of the water monitor including the top and bottom units.

**Detailed Description**



Referring first to Figures 1 and 2, a water monitoring device 1 to be deployed in water has a top unit 2 and a bottom unit 3. In use, the device 1 floats in water and may be anchored to an anchor element 4 by one or more cables connecting either one of the units 1,2, or both, to the anchor element 4. The units 2, 3 may optionally be tethered to each other from their respective corners, as shown in Figure 2. Preferably, the connecting elements (tethers) provided at each of the respective corners are of equal lengths so that they maintain the relative positioning of the units 2 and 3, in use.

As shown in Figure 2, units 2 and 3 are connected by a retractable cable 5 which enables unit 2 to be lowered in water at a desired depth, by selecting the length of the deployed portion of the cable 5. Figures 1 and 3(A) show the device 1 in a first position, with the units 2 and 3 adjacent each other. Figured 2 and 4(B) show the device in a second position, with unit 3 located at a predetermined distance from unit 2, achieved by lengthening the retractable cable 5 to a length equal to the predetermined distance. Unit 3 includes water probes (monitoring instruments) which may thus be advantageously used to sample water measuring water parameters at multiple depths. The bottom unit 3 may be lowered when a threshold is reached, such as for example an algae level reaches a predetermined parameter. It will be appreciated that there may be a plurality of triggers for lowering the bottom unit 3, including manual and automatic triggers.

Figures 4(A) to 4(G) show views of the top unit 2 assembly components. Figure 4(B) includes an aperture 6 (cable gland exit) in the bottom of the top unit 2 for allowing the retractable cable 5 connecting the two units 2,3 to pass through. Figure 4(D) shows a corresponding aperture 6' representing the cable gland entry. On the top surface of the top unit 2, there is provided a solar panel 7 comprising a plurality of photovoltaic (PV) cells, used to extend the life of a battery included inside the top unit 2. Advantageously, the device 1 can stay in the water up to 12 months before being recalibrated.

The top unit 2 comprises a battery and battery controller, main ('master') PCB 9, communication units including antennae and multiple different types of communication units to support various communication methods (protocols): e.g. LoRa, SigFox, WFi, Cellular and RF to enable data transmission from any location around the globe, continuously (24/7). For example, when a communication method is not available, the main PCB 9 selects another communication method.



With reference to Figures 5(A) to (C), the main PCB 9 is affixed (e.g. by screws 13') to the base of the top unit 2. The bottom surface of the top unit 2 may be provided with orientation details (e.g. indentations) to ensure the bottom unit 3 is provided to the bottom of the top unit 2.

Figure 6 illustrates the top unit 2 being assembled, including the solar panel 7, top and bottom case components 10, 11 separated by a silicone seal 12 and affixed at multiple connection points in this example by screws 12. The top and bottom case components 10, 11 may be made by a suitable waterproof material such as plastic. The assembled top unit 2 is thus sealed so that it does not allow for water to damage its electrical components.

In an example, the solar panel 7 is 20 cm x 20 cm although it will be appreciated that its dimensions, as well as the dimensions of the top unit 2 may vary. Figures 7 and 8 respectively indicate examplary dimensions for the top and bottom surfaces of the top unit 2. It will also be appreciated that the shape of the units 2,3 or their various assembly components may vary.

Figures 9(A) to 9(G) show views of the bottom unit 3 assembly components and Figure 12 shows the bottom unit being assembled. The bottom unit 3 has a similar shape and dimensions to the top unit 3, including bottom and top case components 15, 14. The bottom and top case components 15, 14 may be made by a suitable waterproof material such as plastic. It can be seen that the bottom unit 3 has a plurality of cut-outs (apertures) 16 in the bottom for air to escape and water to enter the bottom unit 3 and reach the probes inside it. There is no seal in the bottom unit 3 as the water is allowed to enter the unit 3.



With reference to Figure 10, the bottom case component 15 of the bottom unit 3 has a cable gland entry (aperture) 17 for the retractable cable 5.  A probe holder strip 18 is affixed (e.g. screwed) to the bottom case component 15 for holding the plurality of probes (not shown), each of which has an assigned (e.g. marked) position in the bottom unit 3. The probe strip 18 may have stilt elements 18' as shown in Figure 12.

The probes (monitoring devices) may be off the shelf probes or bespoke, tailored to specific monitoring requirements. They may include for example, dissolved oxygen probes, temperature probes, ORP probes, pH probes, and conductivity probes. At a minimum, it is envisaged to monitor levels of pH, oxygen reduction potential, dissolved oxygen, conductivity, water level, water flow and temperature. Additional 'bolt-on' probes may monitor for example, water salinity/TDS, metals, BOD, ammonia, rhodamine, COD, sulphide, crude/refined oil, turbidity, sulphite, chlorophyll a, blue green algae, nitrates, phenol. The probe holder strip therefore provides a high level of probe versatility.

The bottom unit 3 includes a potting tray 19 as shown in Figures 11 and 12 holding a ‘slave’ PCB 20 for communication to the main PCB 9 of the top unit 2. The probes also connect to the slave PCB. The potting tray 19 has cut outs 21 for cable exits, an aperture 22 representing a cable gland entry (for a cable connecting the master and slave PCBs), and cable grips 23 (for probe cables). The PCB 20 sits on posts (no screws required) as it is potted in the potting tray 19. An elongated aperture (‘fill line’) 24 allows the potting tray 19 to be filled with water.

Figures 13(A) to 13(C) show the water monitoring device 1 fully assembled, in the first position, that is when the bottom unit 3 has not been deployed at a desired depth.



In use, the probes communicate to the slave PCB and the slave PCB 20 communicates with the master PCB 9. The master PCB sends the monitored parameters in real time to a software platform including an API. For example, a user may have a software application on a PC or a mobile device such as a phone or tablet which indicates the monitored parameters.

When removed from water, the top unit 2 may be opened and data can be displayed very quickly (less than 2 minutes) from opening the top unit 2. Advantageously, the bottom unit 3 can be recalibrated, providing for a managed, effectively new device before recalibration.  This is an affordable solution that can be rolled out at any scale to provide instant feedback of issues with water quality as well as historical analytics to track trends in the collected data.

Artificial intelligence (AI) models may be employed and trained on data sets received from the device 1. For example, a free roving unit may enable mobility of the device 1 for multi-location testing, while AI enables the unit to revisit and test problem areas. It will be appreciated that elements of the device 1 may be tailored to solve bespoke problems. For example, the casing components of the bottom and top units 3,2 could each be replaced with a buoy to enable the unit to be robust enough to withstand extreme conditions and test coastal waters.

Although the invention has been described in terms of preferred embodiments as set forth above, it should be understood that these embodiments are illustrative only. For example, aspects of the inventio may potentially be used not just in water but other liquids. Those skilled in the art will be able to make modifications and alternatives in view of the disclosure which are contemplated as falling within the scope of the appended claims. Each feature disclosed or illustrated in the present specification may be incorporated in the invention, whether alone or in any appropriate combination with any other feature disclosed or illustrated herein.

## Claims

1. A water monitoring device comprising first and second units, the first unit for housing at least one first communication device and a battery, the second unit for housing at least one probe for monitoring at least one parameter and a second communication device for communication with the first communication device, wherein the first and second units are connected by a variable connecting element enabling the second unit to be lowered below the first unit, in use, at a plurality of depths, wherein each one of the first and second units has a plurality of corners; the device further comprising tethering means for further connecting the first and second units from their respective corners to restrict a relative movement of the first and second units, in use, wherein the variable connecting element is a retractable cable passing through housings of the first and second units, respectively.
2. A water monitoring device according to claim 1, wherein the first unit comprises a first control means.
3. A water monitoring device according to claim 1 or claim 2, wherein the first control means comprises battery control means.
4. A water monitoring device according to any preceding claim, wherein the first unit is sealed to be waterproof.
5. A water monitoring device according to any preceding claim, wherein the first communication device comprises a wireless communication unit.
6. A water monitoring device according to any preceding claim, wherein the first unit comprises a control device for controlling the variable connecting element.
7. A water monitoring device according to any preceding claim, wherein the first unit comprises a photovoltaic (PV) element.
8. A water monitoring device according to any preceding claim, wherein the second unit comprises a holding element for receiving a plurality of probes.

9. A water monitoring device according to any preceding claim, wherein the first and second units have substantially the same dimensions.
10. A water monitoring device according to any preceding claim, wherein the tethering means comprise first apertures adjacent first unit edges and second apertures adjacent second unit edges.
11. A water monitoring device according to claim 10, wherein the tethering means further comprise tethers of substantially equal lengths for respective attachment to the first and second apertures.
12. A water monitoring device according to claim 11, wherein the tethers comprise looped ends for being received in, respectively said first and second apertures.
13. A method for monitoring water, the method comprising:
providing first and second units, the first unit for housing at least one first communication device and a battery, the second unit for housing at least one probe for monitoring at least one parameter and a second communication device for communication with the first communications device, and
connecting the first and second units by a variable connecting element to lower the second unit below the first unit, in use, at a plurality of water depths, wherein each one of the first and second units has a plurality of corners; and providing tethering means for further connecting the first and second units from their respective corners to restrict a relative movement of the first and second units, in use, wherein the variable connecting element is a retractable cable passing through housings of the first and second units, respectively.
14. A water monitoring device comprising first and second units,
the first unit comprising at least one first communication and control device;
the second unit for housing at least one probe and a second communication device for sending data from the water sensor to the first communications device, wherein the first communication and control

device is configured to control the relative position of the second unit relative to the first unit,

wherein the first and second units are connected by a variable connecting element enabling the second unit to be lowered below the first unit, in use, at a plurality of depths, wherein each one of the first and second units has a plurality of corners; the device further comprising tethering means for further connecting the first and second units from their respective corners to restrict a relative movement of the first and second units, in use, wherein the variable connecting element is a retractable cable passing through housings of the first and second units, respectively.

15. A method for monitoring water, the method comprising providing first and second units,

the first unit comprising at least one first communication and control device;

the second unit for housing at least one probe and a second communication device; and

sending data from the water sensor to the first communications device; and controlling, by the first communication and control device the relative position of the second unit relative to the first unit,

wherein the first and second units are connected by a variable connecting element enabling the second unit to be lowered below the first unit, in use, at a plurality of depths, wherein each one of the first and second units has a plurality of corners; and providing tethering means for further connecting the first and second units from their respective corners to restrict a relative movement of the first and second units, in use, wherein the variable connecting element is a retractable cable passing through housings of the first and second units, respectively.