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(54) **Title**: MARINE PREDATOR REPELLENT APPARATUS AND SYSTEM

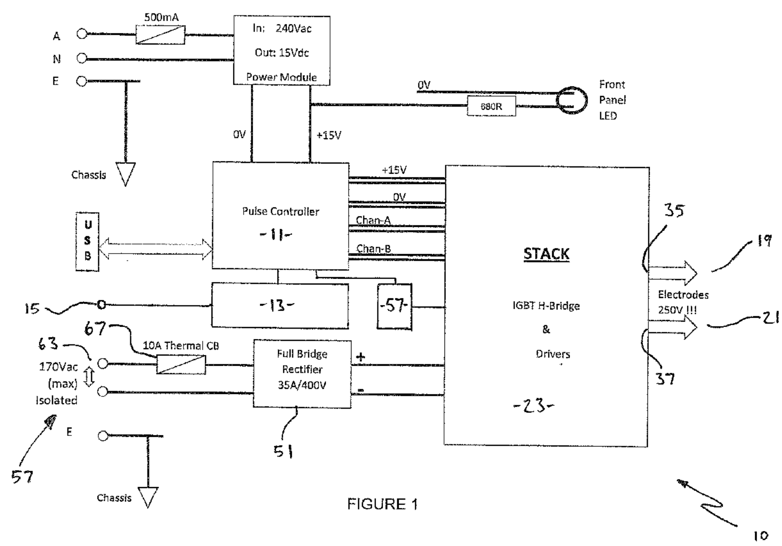

FIGURE 1

(57) **Abstract**: An apparatus (10) for repelling sharks or seals, has a pulse generating circuit (11) arranged to selectively connect to an output switching circuit (23) to control it to switch a power supply (51) having a direct current voltage of from (80) volts and including capacitance with stored charge capacity of at least 8,000 μF, to deliver pulses to at least two electrodes (19, 20). The pulses may be unipolar or bipolar, each unipolar pulse having a pulse width of from 50 μS to 1000 μS, at said direct current voltage less any voltage drop inherent in said output switching circuit. The apparatus (10) can be connected to arrays of electrodes and associated sensors to protect fish pens from predation and swimming beaches from sharks.

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Title: Marine Predator Repellent Apparatus and System

Technical Field

[0001] This invention relates to a system and apparatus to repel marine predators. In particular the invention provides a system and apparatus to repel would-be marine predators, in particular sharks and seals, from the vicinity of in-situ marine fish farms, and from recreational beaches.

Background Art

[0002] The following discussion of the background art is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was part of the common general knowledge as at the priority date of the application.

[0003] In-situ marine fish farms using marine cages (fish pens) that are located in a marine environment, usually in a sheltered cove or bay, have become a common mariculture technique for raising fish for human consumption. Popular species farmed in this manner include Atlantic salmon, ocean trout, Asian seabass and barramundi.

[0004] A problem arises with predation of stock, in particular by seals that invade the marine cages.

[0005] Similarly, some species of shark, notably great white sharks and tiger sharks, represent a threat to people swimming in bathing beaches, and to surfers.

Summary of Invention

[0006] The invention seeks to provide a system and apparatus for repelling marine predators, particularly sharks or seals, from a boundary of a predetermined volume of sea water.

[0007] Throughout the specification unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0008] In accordance with one aspect of the present invention there is provided an apparatus for repelling marine predators including sharks and/or seals, said apparatus having a pulse generating circuit arranged to selectively connect to an output switching circuit to control said output switching circuit, said output switching circuit being provided to switch a power supply having a direct current voltage of from 80 volts and including capacitance with stored charge capacity of at least 8,000 μF, said apparatus and said output switching circuit being connectable to output to at least two electrodes, said output switching circuit being selectively controlled by said pulse generating circuit to generate a train of pulses, said train of pulses including a unipolar pulse having a pulse width of from 50 μS to 1000μS, at said direct current voltage less any voltage drop inherent in said output switching circuit.

[0009] Preferably said train of pulses has a period of from 0.1 seconds to ten seconds.

[0010] Preferably said output switching circuit incorporates insulated gate transistor technology.

[0011] Preferably said output switching circuit incorporates insulated gate bipolar transistor technology.

[0012] Preferably said output switching circuit is an H-bridge switching circuit.

[0013] Preferably said train of pulses includes a bipolar pulse train having said unipolar pulse, followed by a further opposite going unipolar pulse having a pulse width of from 50 μS to 1000μS. The inventor has found that the combination of the further opposite going unipolar pulse following the initial unipolar pulse, spaced by a period of no pulse before the cycle repeats, appears to provide an unexpected deterrent effect to approaching sharks and seals, as compared with an arrangement where the unipolar pulse and the further opposite going unipolar pulse and the unipolar pulse of the following pulse are evenly spaced. As the time between the unipolar pulse and the further opposite going unipolar pulse shortens, this deterrent effect has been found to increase. The following paragraphs attempt to qualify the time periods concerned.

[0014] Preferably said further opposite going unipolar pulse commences within a time of up to ten times the pulse width of said unipolar pulse.

[0015] Preferably said further opposite going unipolar pulse commences within a time of up to five times the pulse width of said unipolar pulse.

[0016] Preferably said further opposite going unipolar pulse commences within a time of up to four times the pulse width of said unipolar pulse.

[0017] Preferably said further opposite going unipolar pulse commences within a time of up to three times the pulse width of said unipolar pulse.

[0018] Preferably said further opposite going unipolar pulse commences within a time of up to two times the pulse width of said unipolar pulse.

[0019] Preferably said further opposite going unipolar pulse commences within a time of up to the same time as the pulse width of said unipolar pulse.

[0020] Preferably the timing of the bipolar pulse train and the period of the train of pulses is such that the unipolar pulse and the further opposite going unipolar pulse occur more or less together, separated by a period of no pulse occurrence, to enable the capacitance to regain stored charge (to recharge).

[0021] Preferably said train of pulses includes a bipolar pulse train having said unipolar pulse, immediately followed by a further opposite going unipolar pulse having a pulse width of from 50 μS to 1000μS. By "immediately followed" it is meant that there can be a gap between commencement of the opposite going unipolar pulse following the first unipolar pulse, in order to prevent simultaneous on-state of all power devices in the H-bridge, which as a person skilled in the art will understand, would short out the power supply and destroy the output switching circuit.

[0022] Preferably said unipolar pulse has a pulse width of from 100 μS.

[0023] Preferably said unipolar pulse has a pulse width of from 200 μS.

[0024] Preferably said unipolar pulse has a pulse width of up to 800 μS.

[0025] Preferably said unipolar pulse has a pulse width of up to 600 μS.

[0026] Preferably said unipolar pulse has a pulse width of about 400 μS.

[0027] Preferably said further unipolar pulse has a pulse width of from 100 μS.

[0028] Preferably said further unipolar pulse has a pulse width of from 200 μS.

[0029] Preferably said further unipolar pulse has a pulse width of up to 800 μS.

[0030] Preferably said further unipolar pulse has a pulse width of up to 600 μS.

[0031] Preferably said further unipolar pulse has a pulse width of about 400 μS.

[0032] Preferably said direct current voltage has a voltage level of from 80 volts to 170 volts.

[0033] Alternatively, for an application where repelling marine predators is proving more difficult, said direct current voltage may have a voltage level of from 80 volts to 250 volts.

[0034] Preferably the electrode voltage differential is from 40 volts to 160 volts DC, for any unipolar pulse. The exact voltage level will depend on water temperature and salinity.

[0035] Alternatively, in an application where repelling marine predators is proving more difficult, the electrode voltage differential may range from 40 volts to 250 volts DC, for any unipolar pulse.

[0036] Preferably said power supply includes stored charge capacity of at least 9,000 μF.

[0037] Preferably said power supply includes stored charge capacity of at least 12,000 μF.

[0038] Preferably said power supply includes stored charge capacity of at least 14,000 μF.

[0039] Preferably said power supply includes stored charge capacity of at least 16,000 μF.

[0040] Preferably said power supply includes stored charge capacity of at least 18,000 μF.

[0041] Preferably said apparatus includes an over-riding control circuit to over-ride operation of said pulse generating circuit, and switch said output switching circuit to supply continuous direct current voltage less any voltage drop inherent in said output switching circuit.

[0042] Preferably said apparatus includes a user operable switch to selectively connect said pulse generating circuit to said output switching circuit to control said output switching circuit to produce said train of pulses.

[0043] Alternatively or additionally, preferably said apparatus includes a timer operable switch to selectively connect said pulse generating circuit to said output switching circuit to control said output switching circuit to produce said train of pulses. In this manner, where the apparatus is used in a situation where predation could occur at certain times of the day and not normally others, such as around dawn and dusk, the timer operable switch would take care of switching the apparatus on, without user intervention.

[0044] Preferably said apparatus includes at least one input to connect a sensing device, and said pulse generating circuit is arranged to selectively connect to said output switching circuit to control said output switching circuit in response to said sensing device detecting the presence of a potential marine predator. A sensing device would, in use, be co-located with electrodes, so the electrodes proximal to the sensing device would be actuated in response to the sensing device detecting the presence of a potential marine predator.

[0045] The sensing device may be selected from one or more of a sensing device which may use electrolocation sensing to sense electric fields emitted by approaching predators, sonar, or if turbidity does not preclude it, visual imaging. Where electrolocation sensing is employed, this must be multiplexed to avoid picking up the electric field produced by the electrodes, to exclude interference from the electric field produced by the electrodes themselves. Sonar sensing devices have proved in testing conducted by the inventor, to be most effective in sensing the approach of potential predators such as sharks and seals.

[0046] Preferably the sensing device comprises at least one real-time sonar imaging sensor associated with processing circuitry to detect the approach of objects in the water.

[0047] Preferably said sensing device and associated processing circuitry outputs a signal proportional to the proximity and extent of potential marine predators that are detected, and said pulse generating circuit is arranged to control said pulse generating circuit and said output switching circuit to vary parameters selected from the pulse width, the period of the train of pulses, and selecting between unipolar and bipolar pulses, in order to increase the intensity of the electric field to increase the repellent efficacy in response to increased proximity and extent of potential marine predators.

[0048] In accordance with a second aspect of the present invention there is provided a system in the form of an installation for repelling marine predators including sharks and/or seals, said system comprising an apparatus having a pulse generating circuit arranged to selectively connect to an output switching circuit to control said output switching circuit, said output switching circuit being provided to switch a power supply having a direct current voltage of from 80 volts and including stored charge capacity of at least 8,000 μF, said apparatus and said output switching circuit being connected to output to at least two electrodes, said output switching circuit being selectively controlled by said pulse generating circuit to generate a train of pulses, said train of pulses including a unipolar pulse having a pulse width of from 50 μS to 1000μS, at said direct current voltage less any voltage drop inherent in said output switching circuit.

[0049] Preferably said train of pulses has a period of from 0.1 seconds to ten seconds.

[0050] Preferably said output switching circuit incorporates insulated gate transistor technology.

[0051] Preferably said output switching circuit incorporates insulated gate bipolar transistor technology.

[0052] Preferably said output switching circuit is an H-bridge switching circuit.

[0053] Preferably said train of pulses includes a bipolar pulse train having said unipolar pulse, followed by a further opposite going unipolar pulse having a pulse width of from 50 μS to 1000μS. The inventor has found that the combination of the further opposite going unipolar pulse following the initial unipolar pulse, spaced by a period of not pulse before the cycle repeats, appears to provide an unexpected deterrent effect to approaching sharks and seals, as compared with an arrangement where the unipolar pulse and the further opposite going unipolar pulse and the unipolar pulse of the following pulse are evenly spaced. As the time between the unipolar pulse and the further opposite going unipolar pulse shortens, this deterrent effect has been found to increase. The following paragraphs attempt to qualify the time periods concerned.

[0054] Preferably said further opposite going unipolar pulse commences within a time of up to ten times the pulse width of said unipolar pulse.

[0055] Preferably said further opposite going unipolar pulse commences within a time of up to five times the pulse width of said unipolar pulse.

[0056] Preferably said further opposite going unipolar pulse commences within a time of up to four times the pulse width of said unipolar pulse.

[0057] Preferably said further opposite going unipolar pulse commences within a time of up to three times the pulse width of said unipolar pulse.

[0058] Preferably said further opposite going unipolar pulse commences within a time of up to two times the pulse width of said unipolar pulse.

[0059] Preferably said further opposite going unipolar pulse commences within a time of up to the same time as the pulse width of said unipolar pulse.

[0060] Preferably said train of pulses includes a bipolar pulse train having said unipolar pulse, immediately followed by a further opposite going unipolar pulse having a pulse width of from 50 μS to 1000μS. By "immediately followed" it is meant that there can be a gap between commencement of the opposite going unipolar pulse following the first unipolar pulse, in order to prevent simultaneous on-state of all power devices in the H-bridge, which as a person skilled in the art will understand, would short out the power supply and destroy the output switching circuit.

[0061] Preferably said unipolar pulse has a pulse width of from 100 μS.

[0062] Preferably said unipolar pulse has a pulse width of from 200 μS.

[0063] Preferably said unipolar pulse has a pulse width of up to 800 μS.

[0064] Preferably said unipolar pulse has a pulse width of up to 600 μS.

[0065] Preferably said unipolar pulse has a pulse width of about 400 μS.

[0066] Preferably said further unipolar pulse has a pulse width of from 100 μS.

[0067] Preferably said further unipolar pulse has a pulse width of from 200 μS.

[0068] Preferably said further unipolar pulse has a pulse width of up to 800 μS.

[0069] Preferably said further unipolar pulse has a pulse width of up to 600 μS.

[0070] Preferably said further unipolar pulse has a pulse width of about 400 μS.

[0071] Preferably said direct current voltage has a voltage level of from 80 volts to 170 volts.

[0072] Preferably said power supply includes stored charge capacity of at least 9,000 μF.

[0073] Preferably said power supply includes stored charge capacity of at least 12,000 μF.

[0074] Preferably said power supply includes stored charge capacity of at least 14,000 μF.

[0075] Preferably said power supply includes stored charge capacity of at least 16,000 μF.

[0076] Preferably said power supply includes stored charge capacity of at least 18,000 μF.

[0077] Preferably said system includes at least one sensing device physically co-located with said electrodes, and said pulse generating circuit is arranged to selectively connect to said output switching circuit to control said output switching circuit in response to said sensing device detecting the presence of a potential marine predator.

[0078] The sensing device may be selected from one or more of a sensing device which may use electrolocation sensing to sense electric fields emitted by approaching predators, sonar, or if turbidity does not preclude it, visual imaging. Where electrolocation sensing is employed, this must be multiplexed to avoid picking up the electric field produced by the electrodes, to exclude interference from the electric field produced by the electrodes themselves. Sonar sensing devices have proved in testing conducted by the inventor, to be most effective in sensing the approach of potential predators such as sharks and seals.

[0079] Preferably the sensing device comprises at least one real-time sonar imaging sensor associated with processing circuitry to detect the approach of objects in the water.

[0080] Preferably said sensing device and associated processing circuitry outputs a signal proportional to the proximity and extent of potential marine predators that are detected, and said pulse generating circuit is arranged to control said pulse generating circuit and said output switching circuit to vary parameters selected from the pulse width, the period of the train of pulses, and selecting between unipolar and bipolar pulses, in order to increase the intensity of the electric field to increase the repellent efficacy in response to increased proximity and extent of potential marine predators.

[0081] Preferably said apparatus includes an over-riding control circuit too over-ride operation of said pulse generating circuit, and switch said output switching circuit to supply continuous direct current voltage less any voltage drop inherent in said output switching circuit.

[0082] Preferably said apparatus includes a user operable switch to selectively connect said pulse generating circuit to said output switching circuit to control said output switching circuit to produce said train of pulses.

[0083] Alternatively or additionally, preferably said apparatus includes a timer operable switch to selectively connect said pulse generating circuit to said output switching circuit to control said output switching circuit to produce said train of pulses. In this manner, where the apparatus is used in a situation where predation could occur at certain times of the day and not normally others, such as around dawn and dusk, the timer operable switch would take care of switching the apparatus on, without user intervention.

[0084] Preferably said electrodes comprise an array of electrodes.

[0085] Preferably said electrodes comprise a planar array of electrodes. The electrodes are in a planar array in the sense that they are located on a planar surface or notional planar surface, which may possess curvature, such as a curved side of a net enclosure containing fish in a fish farm pen, and also the bottom of such an enclosure which can have a conical configuration or curvature due to sagging of the net structure. In effect, in this arrangement, the electrodes are placed against a barrier, past which the predators should not pass. The electrodes are not arranged in a manner that a predator might attempt to swim between individual electrodes of opposite polarity. The aim is to repel the predators as they approach the electrode array, and that the predators should not reach the plane in which the array is placed.

[0086] Preferably the electrodes provide a point source to dissipate electric pulses into the water in which they are immersed. In order to provide a point source, the electrodes can comprise a plate member having a regular shape such as an equilateral or near equilateral triangle, a square, or other regular or close to regular polygon, or a circle, or an elongated polygon or ellipse having a length no greater than twice its width.

[0087] The array of electrodes may comprise individual electrodes located adjacent electrodes of alternate polarity, for example output A, output B, output A, output B, and so on, so that the array is arranged in the following manner:

A	B	A	B	A	B	A	B	A	B	A	B
B	A	B	A	B	A	B	A	B	A	B	A
A	B	A	B	A	B	A	B	A	B	A	B,

and so on.

[0088] Since the electrodes may be alternately anode then cathode when operated with a bipolar pulse train, they are strictly speaking neither cathode nor anode; hence the letter A and B designates the output of the H-bridge that the electrode is connected to.

[0089] The array of electrodes may comprise individual electrodes located adjacent electrodes of the same polarity and arranged in lines, in order to produce an electric field in the water having a banded configuration; for example:

A	A	A	A	A	A	A	A	A	A	A	A
B	B	B	B	B	B	B	B	B	B	B	B
A	A	A	A	A	A	A	A	A	A	A	A

and so on.

[0090] The lines may be arranged vertically, also producing an electric field in the water having a banded configuration; for example:

A	B	A	B	A	B	A	B	A	B	A	B
A	B	A	B	A	B	A	B	A	B	A	B
A	B	A	B	A	B	A	B	A	B	A	B

and so on.

[0091] Also in accordance with the invention, there is provided a system in the form of an installation for repelling marine predators including sharks and/or seals, said system comprising an apparatus as hereinbefore described, said output switching circuit being connected to output to at least two electrodes, to deliver said train of pulses to said at least two electrodes at said direct current voltage less any voltage drop inherent in said output switching circuit.

[0092] Preferably said electrodes comprise an array of electrodes.

[0093] Preferably the electrodes provide a point source to dissipate electric pulses into water in which they are immersed, the electrodes each comprising a plate member.

[0094] Preferably the array of electrodes comprises individual electrodes located adjacent electrodes of alternate polarity.

[0095] Also in accordance with the invention there is provided a system in the form of an installation for repelling marine predators including sharks and/or seals, said system comprising a plurality of apparatus as hereinbefore described, each said apparatus being connected to an associated array of electrodes, to deliver said train of pulses to said associated array of electrodes at said direct current voltage less any voltage drop inherent in said output switching circuit, said arrays of electrodes being co-located and positioned in sectors to form an enclosure, and connected said sensing devices being co-located with their associated array of electrodes.

[0096] Preferably the electrodes in each said array of electrodes provide a point source to dissipate electric pulses into water in which they are immersed, the electrodes each comprising a plate member.

[0097] Preferably each said array of electrodes comprises individual electrodes located adjacent electrodes of alternate polarity.

[0098] Preferably there are a plurality of arrays of electrodes and said system is divided into a plurality of sectors, each with an associated said output circuit and a said motion sensing device.

[0099] Alternatively said system comprises a plurality of said apparatus each connected to an array of electrodes and a said motion sensing device, each said array of electrodes forming a sector. A number of sectors will make up separate zones of protection. The purpose of having multiple sectors is to limit power dissipation to only those sectors where a shark or seal is detected, so that only the sector where a shark or seal is detected will be activated, and possibly an adjacent sector.

[00100] Thus, also in accordance with the invention, there is provided a system in the form of an installation for repelling marine predators including sharks and/or seals, said system comprising an apparatus as herein before described being further characterised by having multiple said output switching circuits, each said output switching circuit having an associated said at least one input, where said pulse generating circuit is arranged to selectively connect to a said output switching circuit to control said output, in response to said associated at least one input receiving a signal from a connected said sensing device; each said output switching circuit being connected to output to an associated array of electrodes, to deliver said train of pulses to said associated array of electrodes at said direct current voltage less any voltage drop inherent in said output switching circuit, said arrays of electrodes being co-located and positioned in sectors to form an enclosure, and connected said sensing devices being co-located with their associated array of electrodes.

[00101] Preferably the electrodes in said array of electrodes provide a point source to dissipate electric pulses into water in which they are immersed, the electrodes each comprising a plate member.

[00102] Preferably each said array of electrodes comprises individual electrodes located adjacent electrodes of alternate polarity.

Brief Description of Drawings

[00103] Two preferred embodiments will now be described in the following description, made with reference to the drawings, in which:

Figure 1 is a block diagram of a circuit for an apparatus for use with both embodiments;

Figure 2 is a block diagram of details of the power supply and output switching circuit, showing the power supply connections, for use with both embodiments;

Figure 3 is a circuit schematic of details of the power supply and output switching circuit for use with both embodiments;

Figure 4 is a block diagram of details of the entire system electronics for use with both embodiments;

Figure 5 is a plan view of an electrode for use in the system of the embodiments;

Figure 6 is an edge view of the electrode of figure 5;

Figure 7 is a plan view of the electrode of figure 5, showing detail of the connection to wiring;

Figure 8 is an edge view of the electrode of figure 7;

Figure 9 is a plan view from above of the system of the first embodiment being an installation for a fish pen for repelling seals;

Figure 10 is a side plan view of the system of the first embodiment;

Figure 11 is a bottom plan view of the system of the first embodiment being an installation for a fish pen for repelling seals;

Figure 12 is a top plan view showing the fish pen and the sonar coverage of the motion sensing;

Figure 13 side view showing part of the sonar arrangement and coverage for the fish pen of figure 12;

Figure 14 is a plan view from above of the system of the second embodiment being an installation for a swimming beach for repelling sharks;

Figure 15 is a side plan view looking across the installation of figure 14;

Figure 16 is a side plan view looking from the ocean toward the beach of the installation of figures 14 and 15; and

Figure 17 is a schematic overview of the system of the first embodiment.

Description of Embodiments

[00104] Referring to figure 1, the shark and seal repelling module 10 of the invention has at its heart a control circuit 11 having a PIC 30 F 2012 microcontroller which is programmed to provide functionality as described below. Other microcontrollers may be utilised in the implementation of the invention, but the one chosen and described provides the required functionality in a cost effective manner.

[00105] The control circuit 11 is connected to a sonar interface circuit 13 which in turn has an input 15 for receiving the output from a plurality of sonar

transceivers 17 which are proximally associated with electrodes 19, 21. The electrodes 19, 21 are arranged in an array which is configured in accordance with the application requirements, as will be explained later. The controller 11 generates signals in response to output from the sonar interface circuit 13. These signals are output (Chan A, Chan B) to a switching circuit 23 in the form of an IGBT 25, 27, 29, 31 (insulated gate bipolar transistor) H-bridge circuit 33, which is controlled by these signals to deliver a variety of pulses to electrode outputs 35, 37, to connect respectively to electrodes 19, 21. The switching circuit 23 comprises a stack of four such H-bridge circuits 33 connected in parallel to spread the load, so that the switching circuit 23 can handle the high current being switched. For brevity, only a single H-bridge circuit is illustrated in figure 3. Depending on the number of electrodes in each array, the number of H-bridge circuits 33 in each stack may need to be varied.

[00106] The switching circuit 23 switches 240 volts DC from supply rails 39 and 41 controlled by outputs Chan A Chan B connecting to the H-bridge circuits 33, the polarity of the electrode output depending on whether Chan A or Chan B is switched. Power for the supply rails is provided by four 4,700 μF 450 volt electrolytic capacitors 43, 45, 47, 49 which are fed via a full wave bridge rectifier circuit 51 comprising four 400v 35 amp diodes. The full wave bridge rectifier circuit 51 electrolytic capacitors 43, 45, 47, 49 and H-bridge circuit are all located in a housing 53 which incorporates a bleed resistor connected in series with a microswitch which co-operates with a door 55 of the housing, so that on opening the door 55, microswitch which is normally open, closes, allowing the bleed resistor to discharge any stored charge in the electrolytic capacitors 43, 45, 47, 49. This feature minimises the risk of electric shock to personnel working on the installed system.

[00107] Other features incorporated with the pulse controller include a monitoring circuit 57 to monitor aspects of the switching circuit 23 include heatsink temperature monitoring, IGBT device monitoring to determine if any individual IGBT device fails, and switching circuit output voltage and current monitoring to determine if these parameters get out of the expected tolerance range. These monitored parameters are stored and transmitted using a GPRS Telemetry Data Logger 59, so that any out of specification instances can be recorded, including time and date of occurrence, and transmitted to a base station 61, so that service personnel may attend to any fault condition. The GPRS Telemetry Data Logger 59 and associated circuitry sends information regarding

system performance and other diagnostic messages to the base station 61. In addition, remote command messages to power up or down, and to perform system diagnostics, can be sent from the base station 61 to the GPRS Telemetry Data Logger 59.

[00108] The full wave bridge rectifier circuit 51 is provided AC input 63 power of 170 VAC which is derived from an inverter circuit powered by storage batteries, all located in a cabinet. Solar panels and a wind turbine can be used in a marine application for protecting a fish pen, and mains grid electricity 71 connected via a variac 73 and isolating transformer 75 or simply a step-down transformer can be used for protecting a swimming beach. A 10 amp thermal contact breaker 67 is provided in line from the AC input 63.

[00109] The control circuit 11 provides output (Chan A, Chan B) to drive the H-bridge circuit 33 in four modes, being off mode, DC mode, unipolar pulse mode, and bi polar pulse mode.

[00110] In off mode, the pulse generator drives the H-bridge circuit 33 so that all legs of the bridge are "OFF". (ie no signal to either outputs Chan A Chan B).

[00111] In DC mode the pulse generator will drive the IGBT stack so that two opposing legs of the H-bridge are "ON" continuously.

[00112] In unipolar pulse mode, the pulse generator will drive the IGBT Stack so that two opposing legs of the H-bridge are periodically pulsing. The other two legs are always "OFF".

[00113] The control circuit is capable of generating a pulse width between 200us and 1000us in incremental steps of 1us, and capable of generating a pulse period of between 10s and 0.1s in incremental steps of 0.1s. This corresponds to frequencies between 0.1Hz and 10Hz in increments of 0.1Hz.

[00114] In bipolar pulse mode, the pulse generator drives the H-bridge so that each of the opposing legs of the bridge are sequentially and periodically pulsing.

[00115] The control circuit 11 is capable of generating a pulse width between 200us and 1000us in incremental steps of 1us, with a positive going pulse immediately followed by a negative going pulse of the same pulse width, or vice versa.

[00116] The control circuit 11 is capable of generating a pulse period of between 10s and 0.1s in incremental steps of 0.1s. This corresponds to frequencies between 0.1Hz and 10Hz in increments of 0.1Hz.

[00117] The electrode voltage for all the above pulsing modes can be varied between 40 Volts DC and 160 Volts DC, and can be preselected depending on water temperature and salinity.

[00118] The sonar input 15 receives signals from a plurality of real-time multi-beam imaging sonar units 81. These are Gemini 720i sonar units produced by Tritech International Limited of the United Kingdom. These sonar units 81 have a 120° field of view with a vertical beam width of 20°. A sufficient number of these sonar units are provided to ensure coverage in front of the area (volume of water) to be protected by the array of electrodes 19, 21. The sonar units can reliably detect the presence of seals and sharks at 50 metres.

[00119] The Gemini 720i has a high operating frequency of 720 kHz and produces high clarity images in real-time. The sonar interface circuit identifies the presence of large self-propelled continuous profile objects in the water and distinguishes them from large shoals of discrete fish, and objects that are in the water and moving with the tide. In simple trials, the sonar interface circuit produces a true/false binary output which is used to actuate the electrode array proximal to the sonar unit 81. The signal fed to the electrodes is bipolar, with the pulse width and frequency preset based on observations of the reactions of approaching predators. If the predators show signs of becoming accustomed to the pulses, the pulse width and/or frequency may be adjusted to achieve the required repellent effect.

[00120] However, in an alternative arrangement, the sonar interface circuit 13 processes the output data from the sonar units 81 to produce a signal proportional to the extent and proximity of detected seals or sharks, which is fed to the or a control circuit 11. The control circuit 11 controls the delivery of pulses to the switching circuit 23 so that the switching circuit 23 begins delivering high current pulses to the array of electrodes 19, 21 on detecting any seals or sharks, and delivers high current pulses to the array of electrodes 19, 21 in proportion to the extent and proximity of detected seals or sharks. The control circuit adjusts the pulse delivery (their width and frequency) and whether unipolar or bipolar, in a manner so as to increase their intensity as the signal proportional to the extent and proximity of detected seals or sharks increases, and to decrease their

intensity as the signal proportional to the extent and proximity of detected seals or sharks decreases. At rest, i.e. with no predators detected by the sonar units 81, the control circuit 11 operates to ensure no delivery of any electric field or pulses from the switching circuit 23 to the array of electrodes, so that power consumption is minimised. This also avoids the potential problem of attracting sharks to the electric field.

[00121] In order to avoid the inherent animal behaviour in the long term to get used to the electrical fields which could result in the apparent eventual failure of the system to repel them successfully, the microcontroller in the control circuit 11 can be programmed to vary the output voltage value during certain frequencies. This results in an uneven train of pulses that will prevent familiarization by the animal.

[00122] In use, an entire installation to detect and repel sharks and seals will comprise a modular arrangement formed by a plurality of shark and seal repelling modules 10, as described above. Each module 10 has its own array of electrodes 19 and 21, and associated with one or more sonar units 81 to cause activation of the array of electrodes 19 and 21 in response to detected predators. The modules 10 may be configured to activate adjacent modules 10, depending on whether the configuration of the installation requires this. Alternatively the number of sectors covered by sonars 81 and connected sonar interface units 13, and the number of zones covered by modules 10 and associated arrays of electrodes 19, 21 may be unequal, in which case the output of any sonar interface unit 13 may be connected to more than one control circuit 11.

[00123] Turning to figures 5 to 8, details of an electrode 83 are shown, together with the electrode connector 85. Each electrode 83 comprises a 300 mm diameter disk 86 of titanium metal, having a thickness of 2 mm. Each electrode 83 has at its centre a titanium nut 87 with an internally threaded aperture 89 at the centre thereof, welded to the disk 86.

[00124] The electrode connector 85 has a plastic body 93 with a titanium bolt 95 epoxied inside. The titanium bolt 95 is electrically connected by an electrical cable 97, 99 extending from each end of the plastic body 93, the cables 97 and 99 also being embedded in the epoxy, to prevent ingress of water which would cause corrosion and eventual failure of the connection. The cables 97 and 99 each connect to a further plastic body (not shown) spaced 2 metres away, so that adjacent electrode connectors 85 are spaced 2 m apart. These connectors 85 will

form a string of electrodes which are electrically connected to form either electrode 19 or 21 connected to output 35 or 37 respectively.

[00125] The titanium bolt 95 screws into the titanium nut 87 to secure the electrode 83 to the electrode connector 85. The electrode 83 has two apertures 101 at 90° radial spacing from the central titanium stud 87. These apertures are used to secure the electrodes 83 to each other and/or to a fish pen, to relieve the strain on the electrical cables 97, 99.

[00126] Referring to figures 9 to 13, an installation 103 of the shark and seal repelling modules 10 is illustrated. The installation 103 is fitted to a fish pen 105. The fish pen has a diameter of 53 metres, and comprises an upper floating platform 107 of annular configuration. Suspended from the outer periphery 109 of the floating platform 107 is an tubular predator net 111 which extends downward to a depth of 15.6m in this installation, and then is closed by a conical net base 113 which extends to a further depth of 6.4 m at its centre 115. Contained within the predator net 111 and spaced away from the predator net 111, is an inner net (not illustrated) which contains fish stock being raised in the fish pen. There are five shark and seal repelling modules 10a, 10b, 10c, 10d, and 10e with associated cabinets 117a, 117b, 117c, 117d, and 117e each containing rechargeable batteries, and with an associated wind turbine 119a 119b, 119c, 119d, and 119e. The wind turbines charge their associated batteries to supply power to their associated modules 10a, 10b, 10c, 10d, and 10e.

[00127] There are five zones 121, 123, 125, 127 and 129 of electrode arrays, four zones of arrays being located in four zones 121, 123, 125, 127 around the circumferential side of the predator net 111, and one array zone 129 located in the base 113 of the net 111. The electrode arrays form a virtual enclosure around a protected area (volume) within the net 111. The electrodes 19, 21 of the four zones 121, 123, 125, 127 of arrays are connected in horizontal lines of alternating polarity spaced nominally six metres apart, as can be seen in figure 10. Each line comprises a plurality of titanium disks 86 electrically connected together, and roped together through an aperture 101 with nylon cord. Each electrode is also secured to the predator net using nylon cord through an aperture 101. The array zone 129 of the conical net base 113 comprises concentrically spaced lines of electrodes 19 and 21 of alternating polarity. These are secured to each other and the predator net 111 using nylon cord, in the same fashion as the electrode lines on the annular net wall.

[00128] Module 10a is connected to the array of electrodes located along the circumferential tubular surface of the predator net 111 extending downward between the lines indicated at 131 and 133 (zone 121). Module 10b is connected to the array of electrodes located along the circumferential surface of the predator net 111 extending downward between the lines indicated at 133 and 135 (zone 123). Module 10c is connected to the array of electrodes located along the circumferential surface of the predator net 111 extending downward between the lines indicated at 135 and 137 (zone 125). Module 10d is connected to the array of electrodes located along the circumferential surface of the predator net 111 extending downward between the lines indicated at 137 and 131 (zone 127). Module 10e is connected to the array of electrodes located on the conical base 113 (zone 129).

[00129] There are five sets 141, 142, 143, 144, and 145 of two sonar units 81 one sonar unit of each set being located close to the surface and the other sonar unit of each set being located vertically below the first, near the junction of the tubular side of the predator net and the conical base 113. The five sets 141, 142, 143, 144, and 145 of sonar units are spaced equally around the periphery of the fish pen 105, spaced about 72° apart from each other. The interconnection between sonar units 81 and the modules 10a, 10b, 10c, 10d, and 10e is as follows.

[00130] Sonar units comprising set 141 will actuate modules 10a, 10b and 10e to cause electrodes in zones 121, 123 and under the base 113 at zone 129, to be pulsed. Sonar units comprising set 142 will actuate modules 10b, 10c and 10e to cause electrodes in zones 123, 125 and under the base 113 at zone 129, to be pulsed. Sonar units comprising set 143 and set 144 will actuate modules 10c, 10d and 10e to cause electrodes in zones 125, 127 and under the base 113 at zone 129, to be pulsed. Sonar units comprising set 145 will actuate modules 10a, 10d and 10e to cause electrodes in zones 121, 127 and under the base 113 at zone 129, to be pulsed.

[00131] In practice there will be a number of control circuits 11 each associated with its switching circuit 23. However, rather than a number of sonar interface circuits being provided, the sonar interface circuit 13 function may be provided by a single computer or processor which receives input from all of the sonar units 81, and processes the signals from the sonar units 81 to actuate the appropriate control circuit 11. Reference is made to figure 17 which provides a schematic overview of the arrangement.

[00132] Figure 12 shows a plan view of the horizontal coverage 151, 152, 153, 154, and 155 of each of the sets 141, 142, 143, 144, and 145 of sonar units 81. Referring to figure 13, a side view through set 141 of sonar heads 81 showing the vertical sweep height 157 of the upper sonar head 81 and the vertical sweep height 159 of the lower sonar head 81. As can be seen the vertical sweep height 159 of the lower sonar head 81 extends to the sea floor 161 in the present installation. If the depth of the sea is too great at the site of the fish pen 105, it would be necessary to install further sonar modules to view the volume of water beneath the fish pen 105.

[00133] Referring to figures 14 to 16, an installation of a shark repelling module 10 is shown to protect part of a swimming beach 163. The shark repelling module is as hereinbefore described and is connected to strings of electrodes 19 and 21 of alternating polarity. Each string comprises vertically spaced electrodes 81 of like polarity, electrically connected together by electric cable 97, 99 and mechanically connected together using nylon rope, as hereinbefore described. Each string 19, 21 is located suspended from a half circumferential annular float 165 and secured by anchoring ties 167 into the seabed 161. The strings 19 are all electrically connected to output 35 of IGBT stack in module 10 and the strings 21 are all electrically connected to output 35 of IGBT stack in module 10.

[00134] The electrodes 81 in each string 19 and 21 are located spaced two metres apart and each string 19 is located spaced six metres from each adjacent string 21. Since the installation in this setting does not present the same weight issues and power storage limitations as that in the fish pen installation, the electrodes are not divided into zones, and instead are all powered to pulse, on detecting an incoming predator.

[00135] Sonar units (not shown) are provided at a spacing of 30 metres, requiring a total of four sonar units 81 to monitor the sea beyond the enclosure formed by the float 165 and electrodes.

[00136] The module 10 is powered by rechargeable battery pack 117 connected to a wind generator 119, although in less remote locations may be grid connected via a step down isolation transformer.

[00137] For both applications, the inventor has found that the electrode array needs to generate an electric field in the water of 0.4 volts/metre to 1.2

volts/metre, depending upon the salinity and temperature of the water, in order to turn away sharks and seals from the installation.

[00138] It should be appreciated that the scope of the invention is not limited to the particular embodiment and applications described herein, and that changes may be made without departing from the spirit and scope of the invention.

The Claims Defining the Invention are as Follows

1. An apparatus for repelling marine predators including sharks and/or seals, said apparatus having a pulse generating circuit arranged to selectively connect to an output switching circuit to control said output switching circuit, said output switching circuit being provided to switch a power supply having a direct current voltage of from 80 volts and including capacitance with stored charge capacity of at least 8,000 µF, said apparatus and said output switching circuit being connectable to output to at least two electrodes, said output switching circuit being selectively controlled by said pulse generating circuit to generate a train of pulses, said train of pulses including a unipolar pulse having a pulse width of from 50 µS to 1000µS, at said direct current voltage less any voltage drop inherent in said output switching circuit.

2. An apparatus as claimed in claim 1 wherein said train of pulses has a period of from 0.1 seconds to ten seconds.

3. An apparatus as claimed in claim 1 or 2 wherein said output switching circuit incorporates insulated gate bipolar transistor technology in an H-bridge switching circuit, and said train of pulses includes a bipolar pulse train having said unipolar pulse, followed by a further opposite going unipolar pulse having a pulse width of from 50 µS to 1000µS.

4. An apparatus as claimed in claim 3 wherein said further opposite going unipolar pulse commences within a time of up to ten times the pulse width of said unipolar pulse.

5. An apparatus as claimed in claim 3 wherein said train of pulses includes a bipolar pulse train having said unipolar pulse, immediately followed by a further opposite going unipolar pulse having a pulse width of from 50 µS to 1000µS.

6. An apparatus as claimed in any one of the preceding claims wherein said unipolar pulse has a pulse width of from 100 µS.

7. An apparatus as claimed in claim 6 wherein said unipolar pulse has a pulse width of up to 800 µS.

8. An apparatus as claimed in any one of claims 3 to 7 wherein said further unipolar pulse has a pulse width of from 100 µS.

9. An apparatus as claimed in claim 8 wherein said further unipolar pulse has a pulse width of up to 800 μS.

10. An apparatus as claimed in any one of the preceding claims wherein said direct current voltage has a voltage level of from 80 volts to 250 volts.

11. An apparatus as claimed in any one of the preceding claims wherein said power supply includes stored charge capacity of at least 9,000 μF.

12. An apparatus as claimed in any one of the preceding claims wherein said apparatus includes at least one input to connect a sensing device, and said pulse generating circuit is arranged to selectively connect to said output switching circuit to control said output switching circuit in response to said sensing device detecting the presence of a potential marine predator.

13. An apparatus as claimed in claim 12 wherein said sensing device and associated processing circuitry outputs a signal proportional to the proximity and extent of potential marine predators that are detected, and said pulse generating circuit is arranged to control said pulse generating circuit and said output switching circuit to vary parameters selected from the pulse width, the period of the train of pulses, and selecting between unipolar and bipolar pulses, in order to increase the intensity of the electric field to increase the repellent efficacy in response to increased proximity and extent of potential marine predators.

14. A system in the form of an installation for repelling marine predators including sharks and/or seals, said system comprising an apparatus as claimed in any one of the preceding claims, said output switching circuit being connected to output to at least two electrodes, to deliver said train of pulses to said at least two electrodes at said direct current voltage less any voltage drop inherent in said output switching circuit.

15. A system as claimed in claim 14 wherein said electrodes comprise an array of electrodes.

16. A system as claimed in claim 14 or 15 wherein the electrodes provide a point source to dissipate electric pulses into water in which they are immersed, the electrodes each comprising a plate member.

17. A system as claimed in claim 15 wherein the array of electrodes comprises individual electrodes located adjacent electrodes of alternate polarity.

18. A system in the form of an installation for repelling marine predators including sharks and/or seals, said system comprising a plurality of apparatus as claimed in claim 12 or 13, each said apparatus being connected to an associated array of electrodes, to deliver said train of pulses to said associated array of electrodes at said direct current voltage less any voltage drop inherent in said output switching circuit, said arrays of electrodes being co-located and positioned in sectors to form an enclosure, and connected said sensing devices being co-located with their associated array of electrodes.

19. A system as claimed in claim 18 wherein the electrodes in each said array of electrodes provide a point source to dissipate electric pulses into water in which they are immersed, the electrodes each comprising a plate member.

20. A system as claimed in claim 18 or 19 wherein each said array of electrodes comprises individual electrodes located adjacent electrodes of alternate polarity.

21. A system in the form of an installation for repelling marine predators including sharks and/or seals, said system comprising an apparatus as claimed in claim 12 or 13, said apparatus being further characterised by having multiple said output switching circuits, each said output switching circuit having an associated said at least one input, where said pulse generating circuit is arranged to selectively connect to a said output switching circuit to control said output, in response to said associated at least one input receiving a signal from a connected said sensing device; each said output switching circuit being connected to output to an associated array of electrodes, to deliver said train of pulses to said associated array of electrodes at said direct current voltage less any voltage drop inherent in said output switching circuit, said arrays of electrodes being co-located and positioned in sectors to form an enclosure, and connected said sensing devices being co-located with their associated array of electrodes.

22. A system as claimed in claim 20 wherein the electrodes in said array of electrodes provide a point source to dissipate electric pulses into water in which they are immersed, the electrodes each comprising a plate member.

23. A system as claimed in claim 20 or 21 wherein each said array of electrodes comprises individual electrodes located adjacent electrodes of alternate polarity.

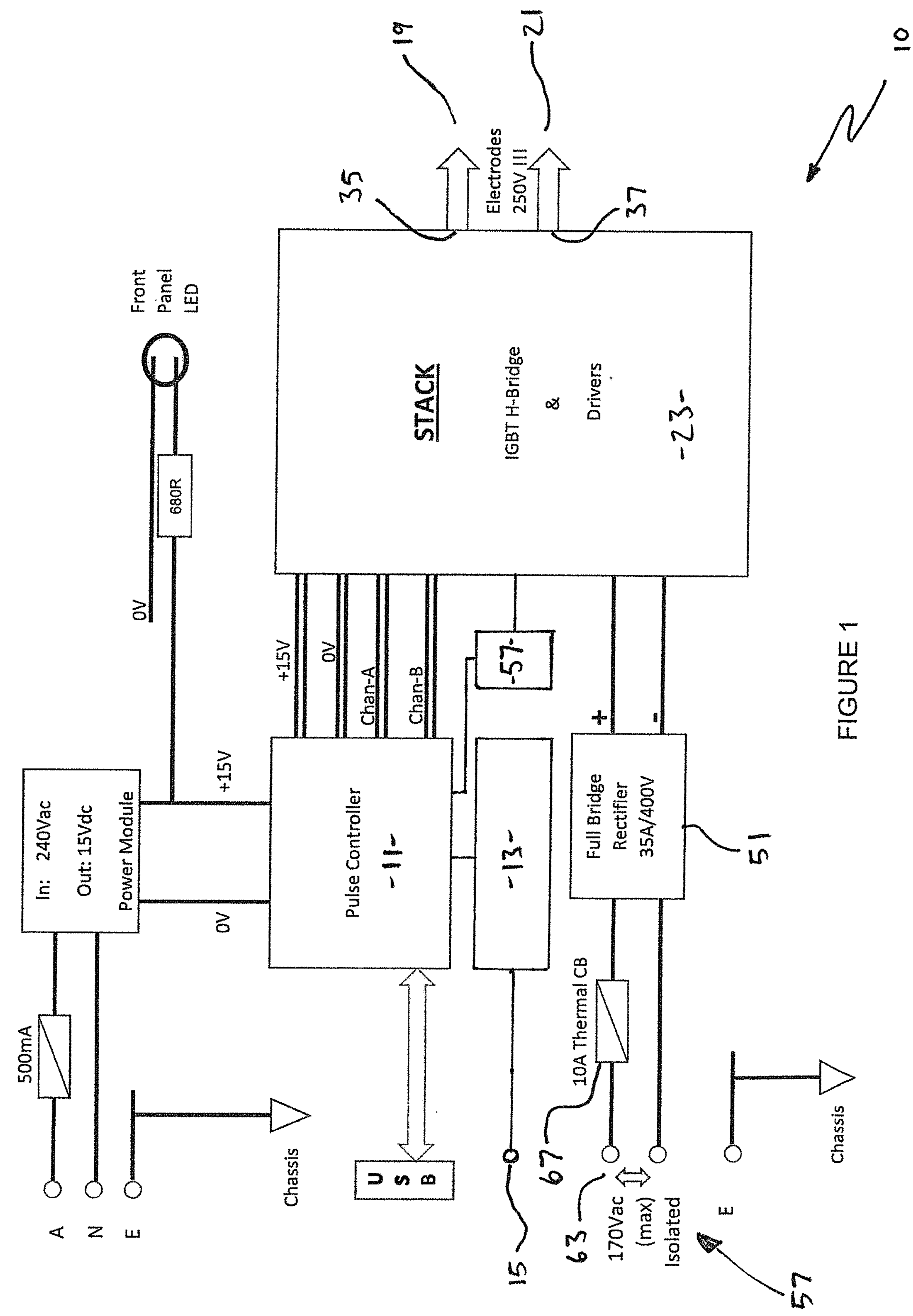

STACK
IGBT H-Bridge
&
Drivers
-23-
Electrodes
250V !!!
Front
Panel
LED
680R
0V
+15V
0V
Chan-A
Chan-B
-57-
In: 240Vac
Out: 15Vdc
Power Module
+15V
0V
Pulse Controller
-11-
-13-
Full Bridge
Rectifier
35A/400V
+
-
500mA
10A Thermal CB
Chassis
Chassis
U
S
B
A
N
E
170Vac
(max)
Isolated
E
10
19
21
35
37
51
15
63
67
57

FIGURE 1

POWER SUPPLY CONNECTIONS

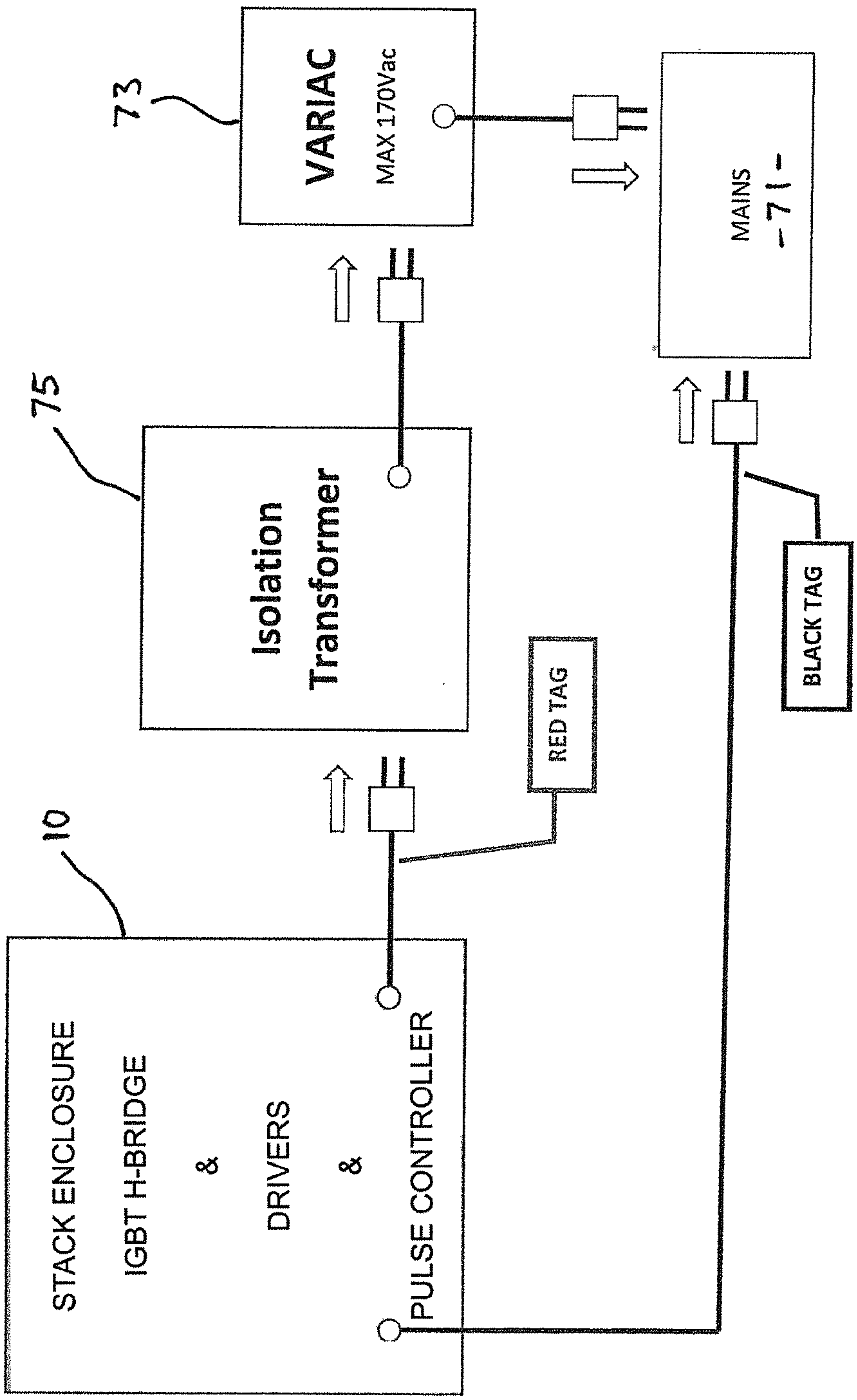


FIGURE 2

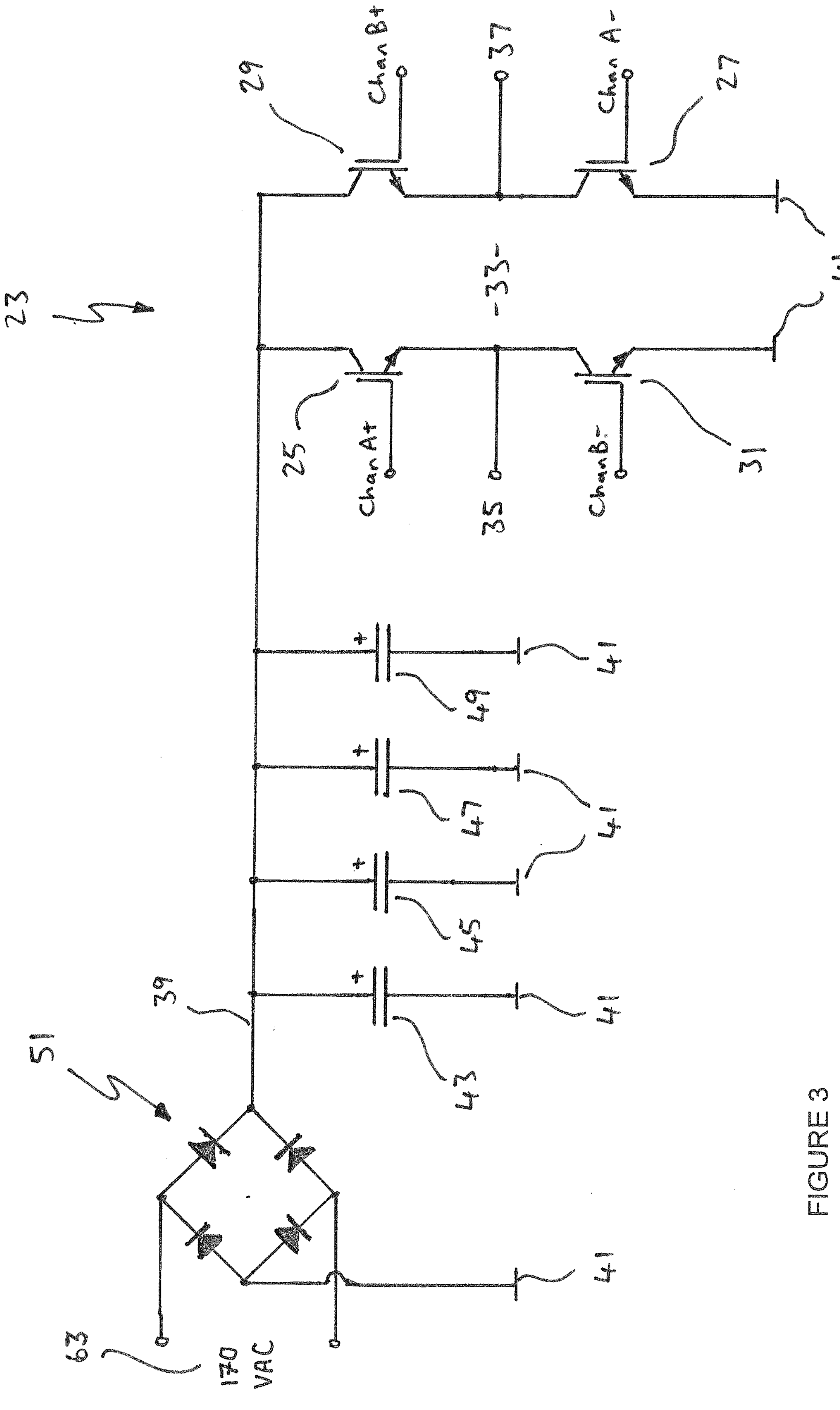
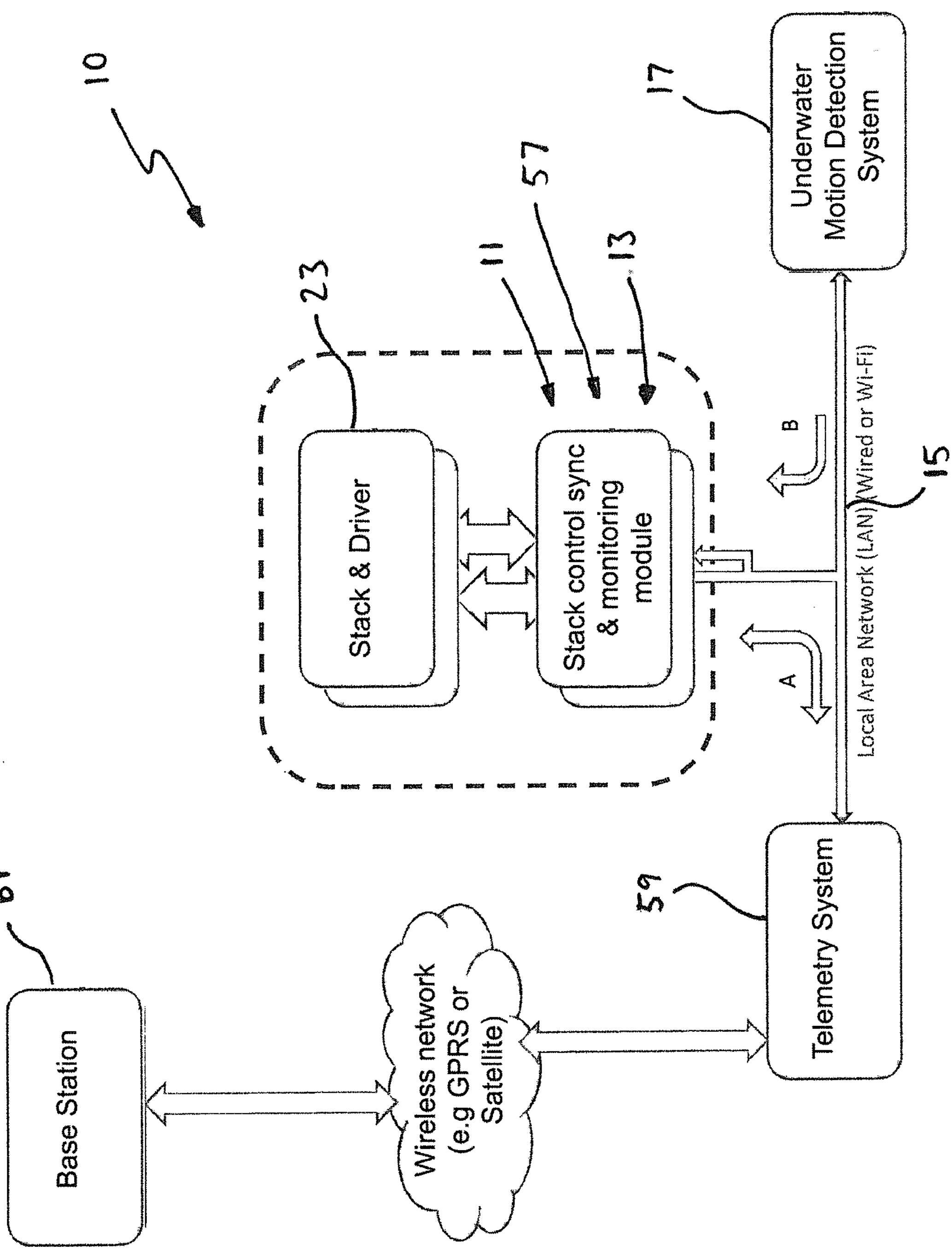

Chan B+
37
Chan A-
29
27
23
-33-
41
25
31
Chan A+
35
Chan B-
49
47
45
43
39
51
63
170 VAC

FIGURE 3

FIGURE 4


10
23
11
57
13
Stack & Driver
Stack control sync & monitoring module
B
A
Local Area Network (LAN) Wired or Wi-Fi)
15
17
Underwater Motion Detection System
Telemetry System
59
Wireless network (e.g GPRS or Satellite)
61
Base Station

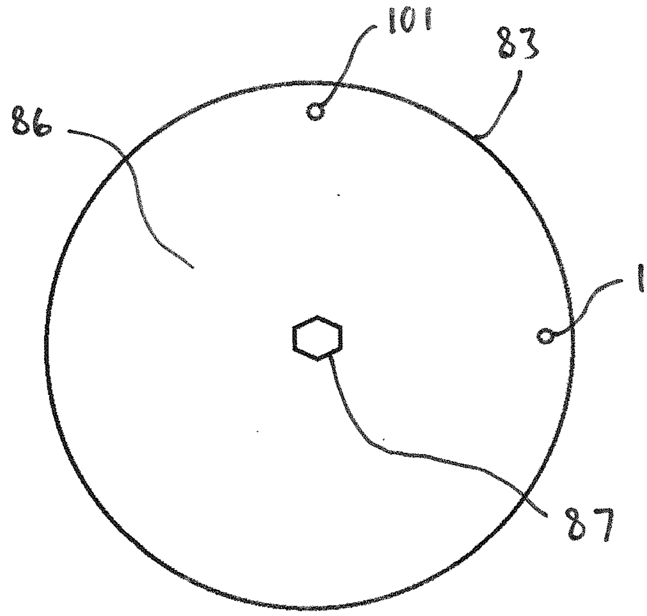


FIGURE 5

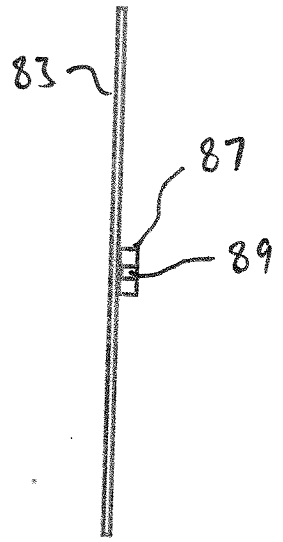


FIGURE 6

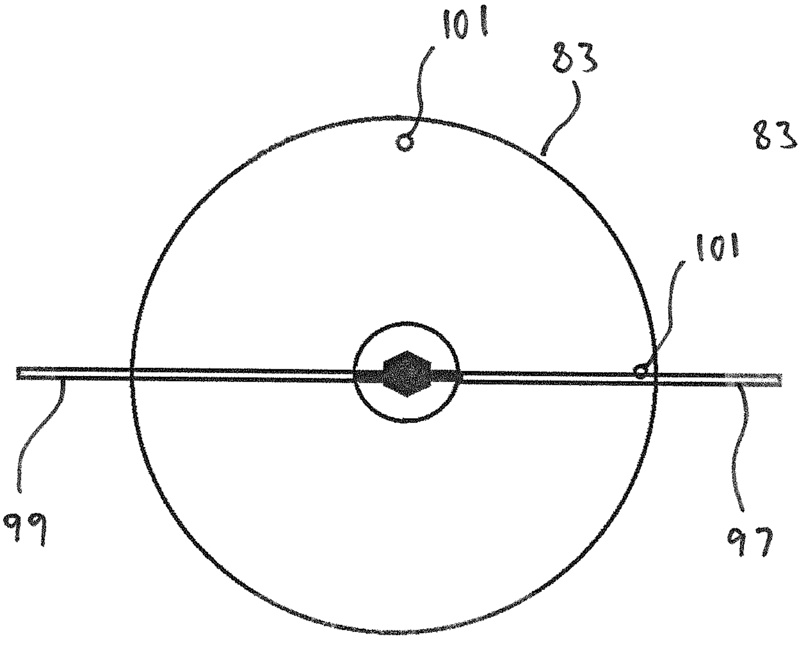


FIGURE 7

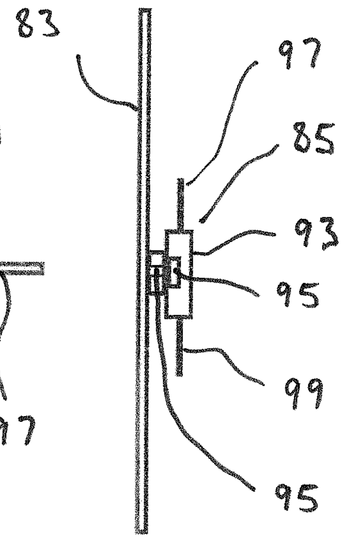


FIGURE 8

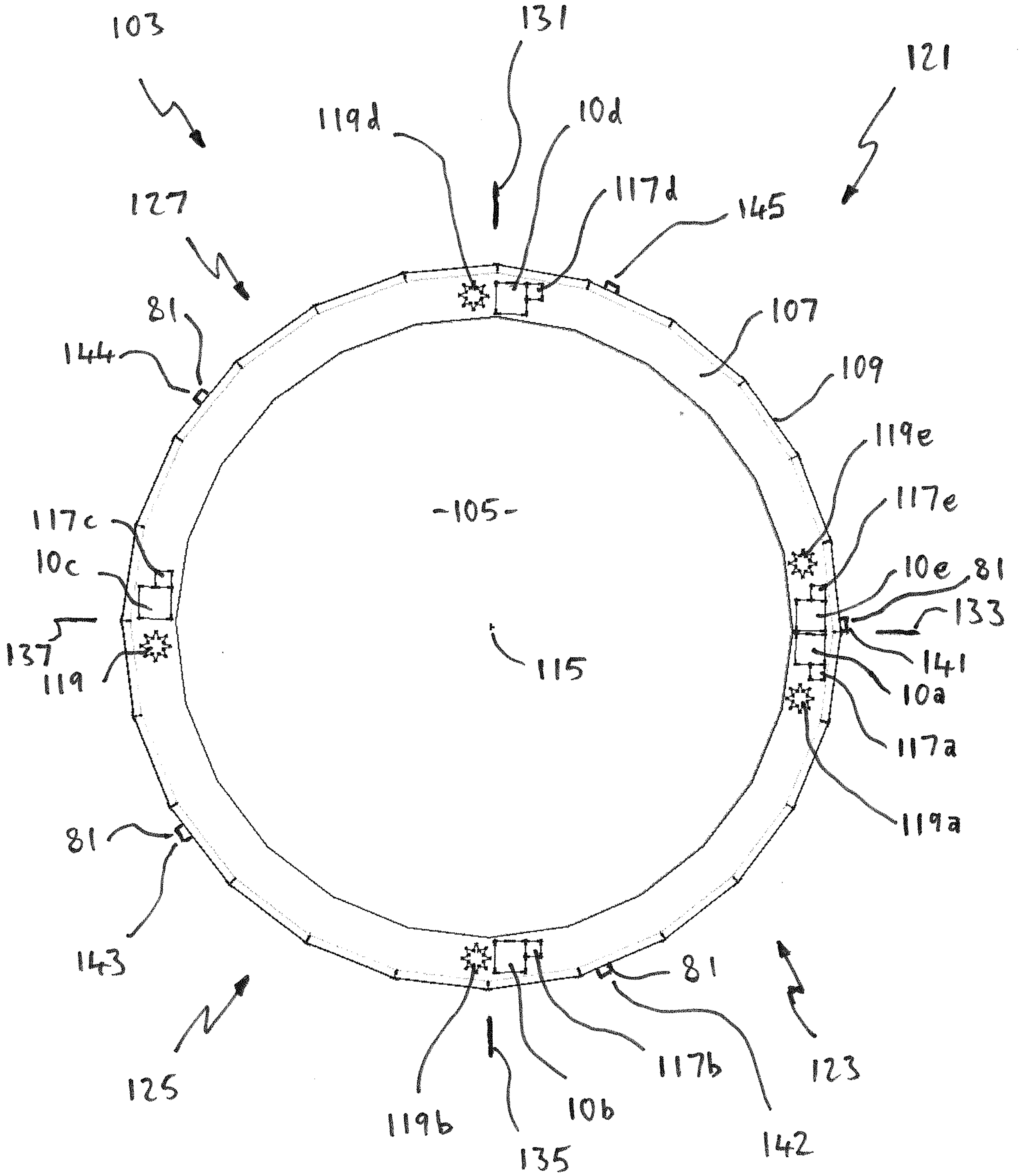

103
131
121
119d
10d
117d
145
127
81
144
107
109
119e
117e
117c
10c
-105-
10e
81
133
137
119
115
141
10a
117a
119a
81
143
81
125
119b
10b
135
117b
142
123

FIGURE 9

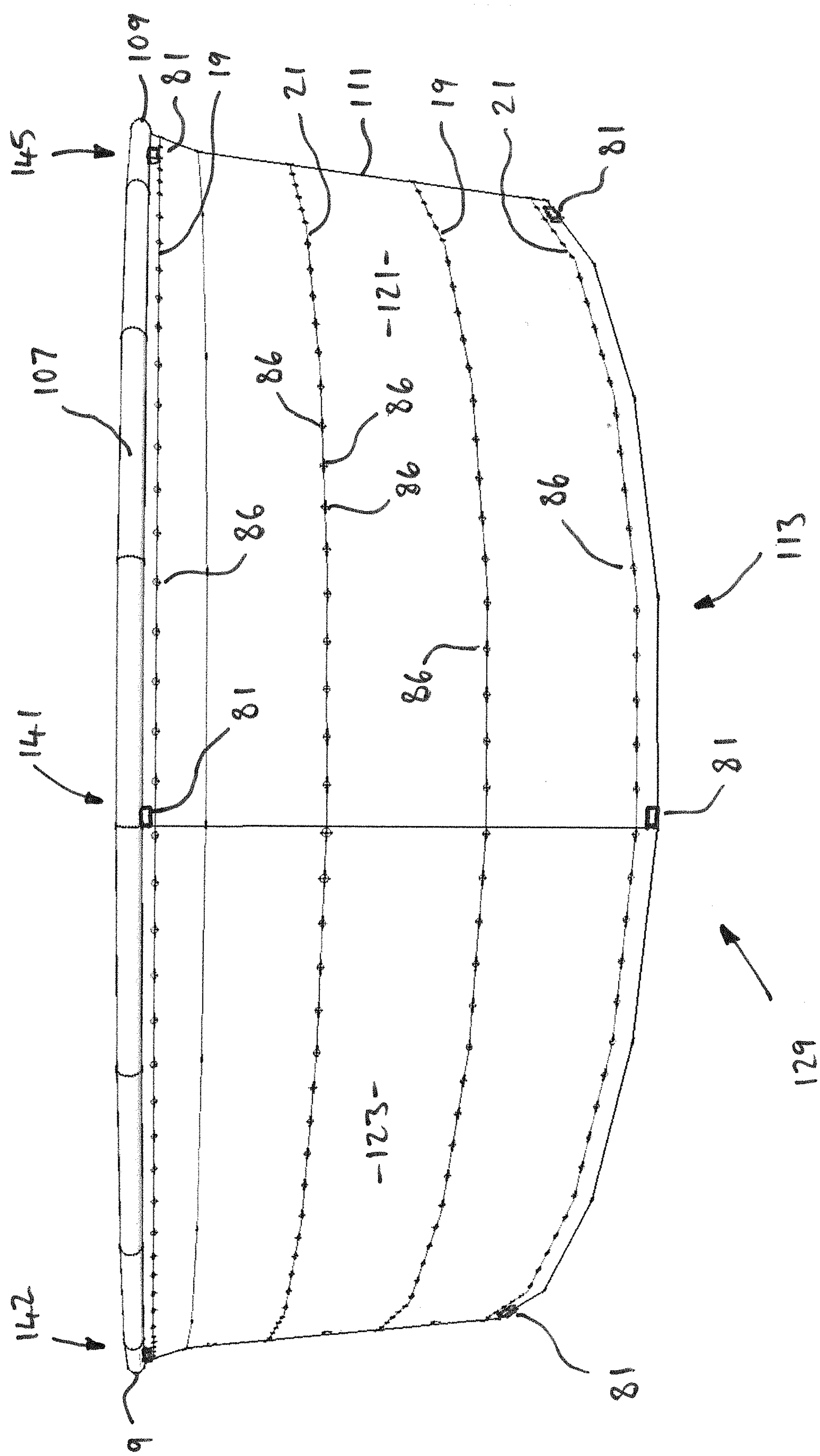

109
81
19
21
111
19
21
81
145
107
-121-
86
86
86
86
86
86
113
141
81
81
-123-
129
142
109
81

FIGURE 10

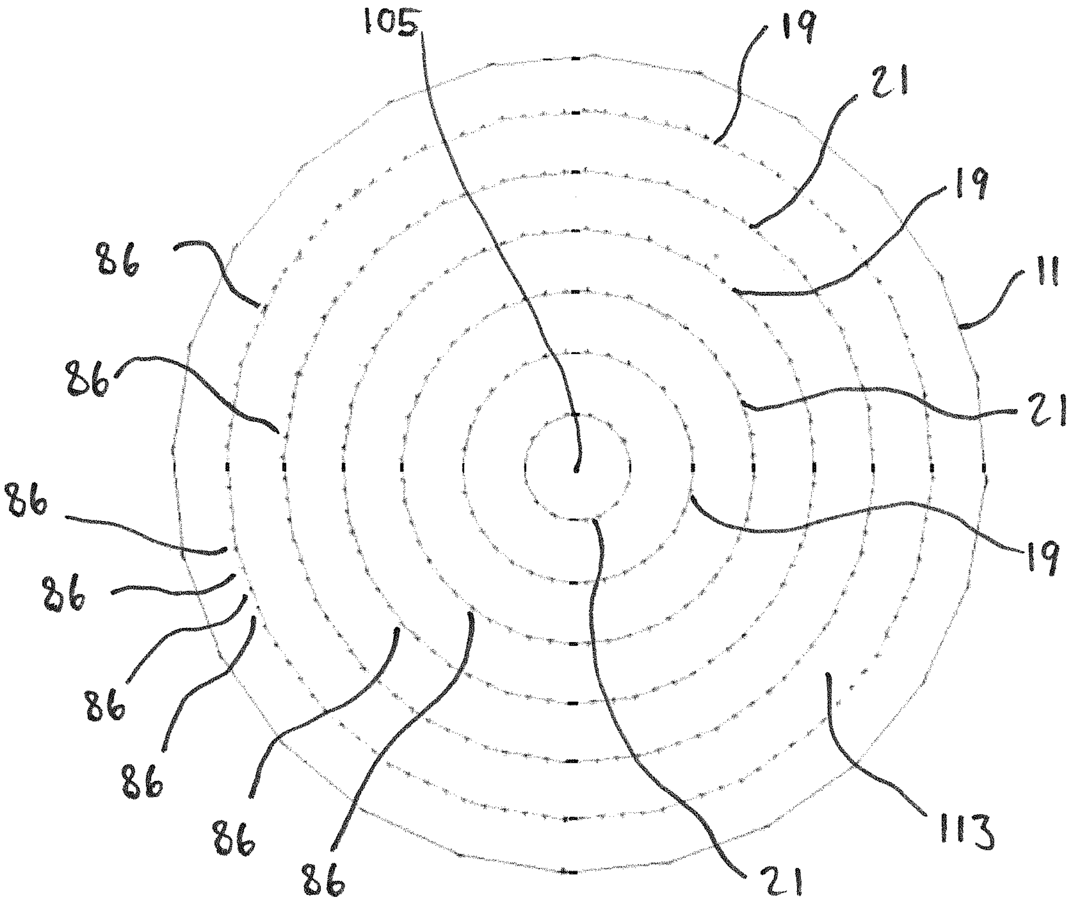


FIGURE 11

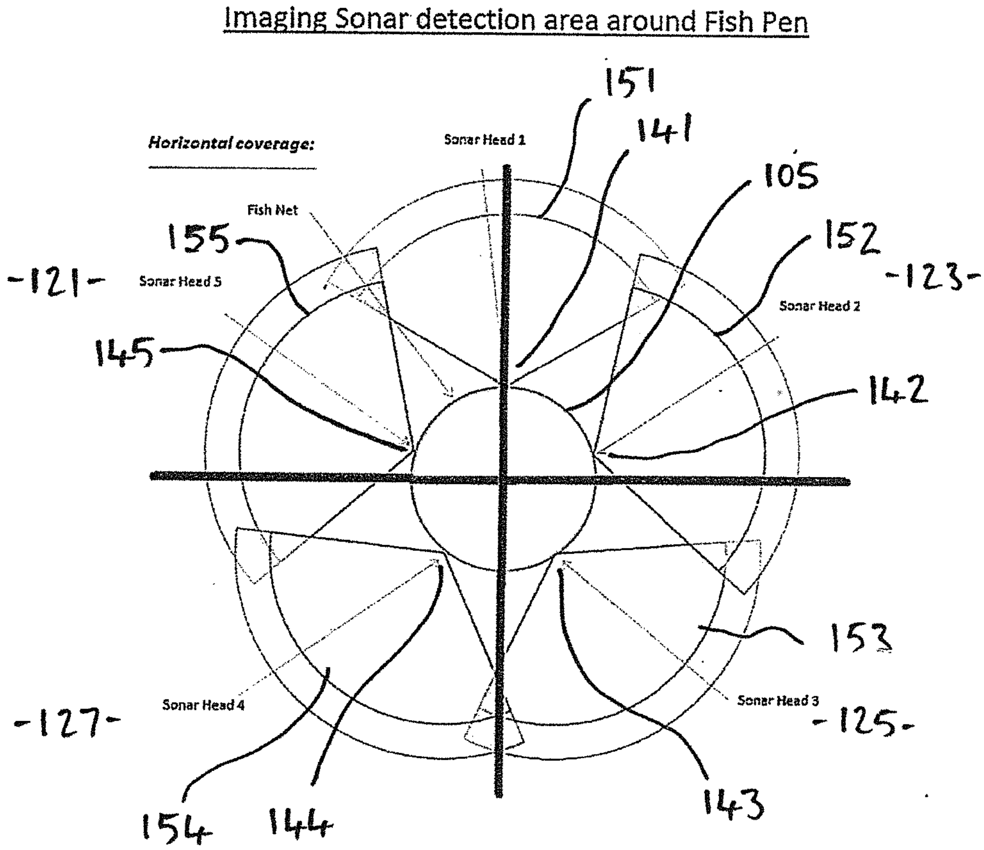


FIGURE 12

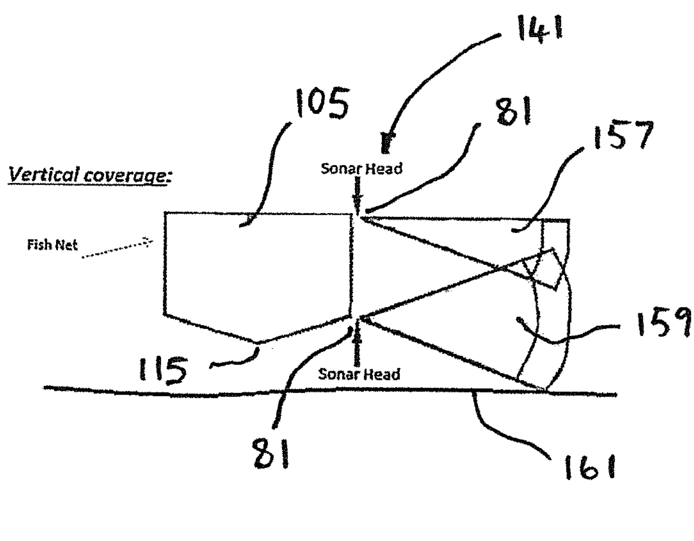


FIGURE 13

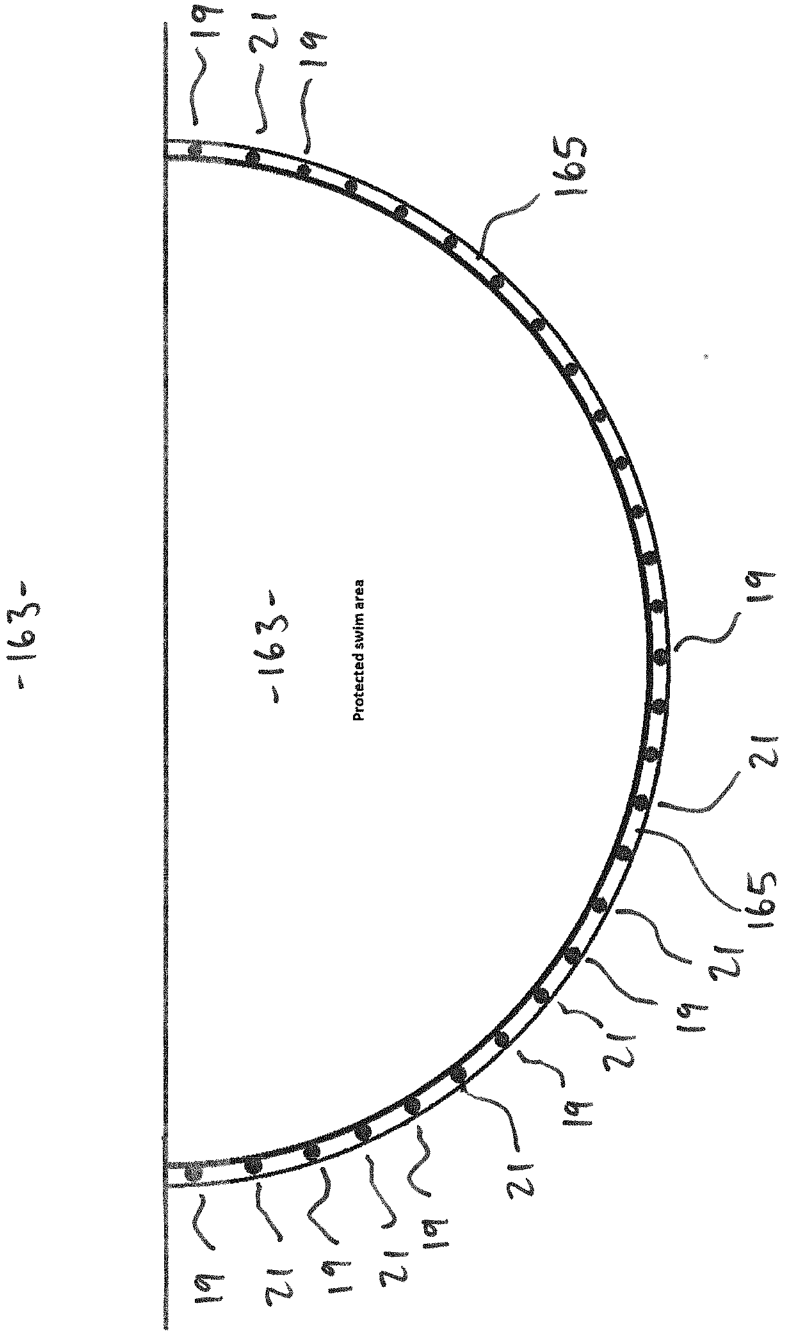


FIGURE 14

Electronic Beach Barrier - Side View

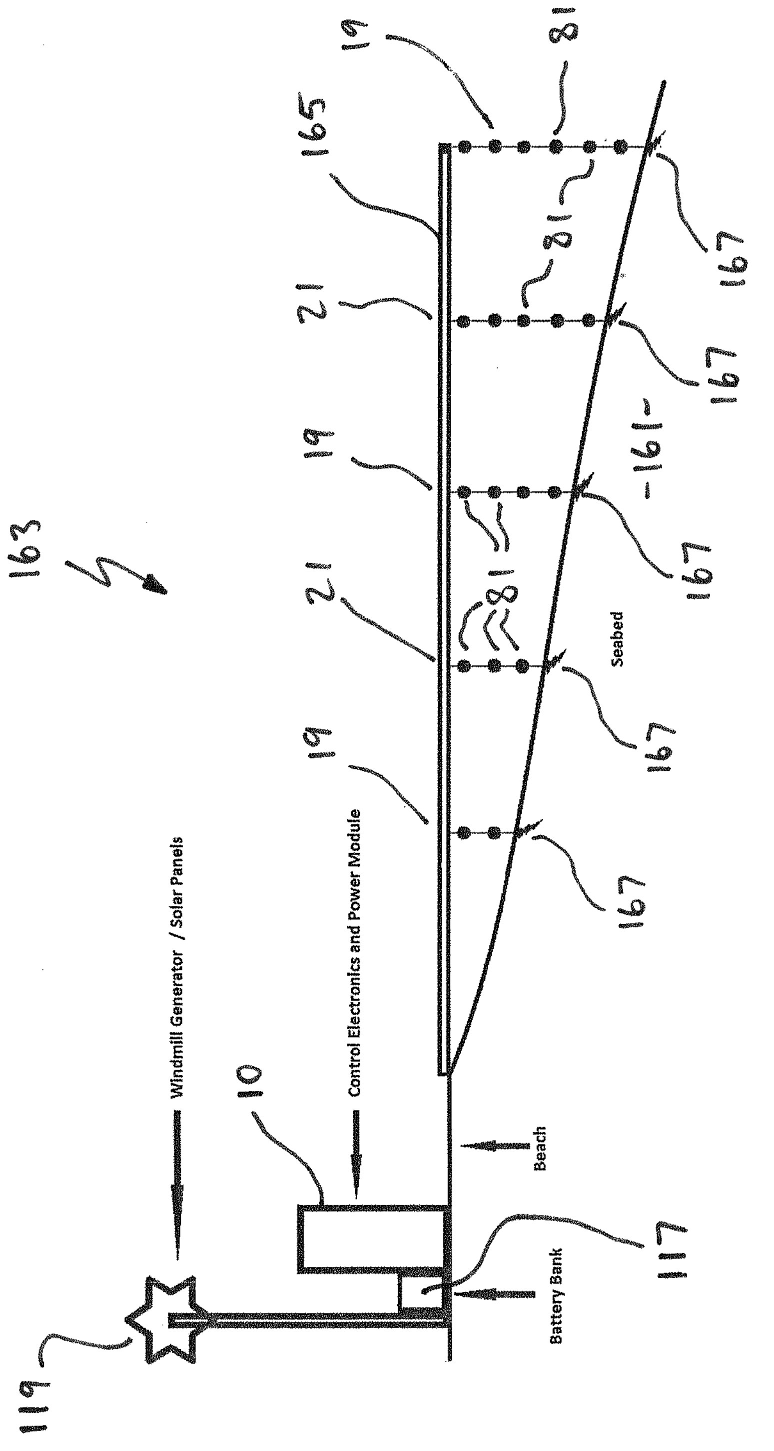


FIGURE 15

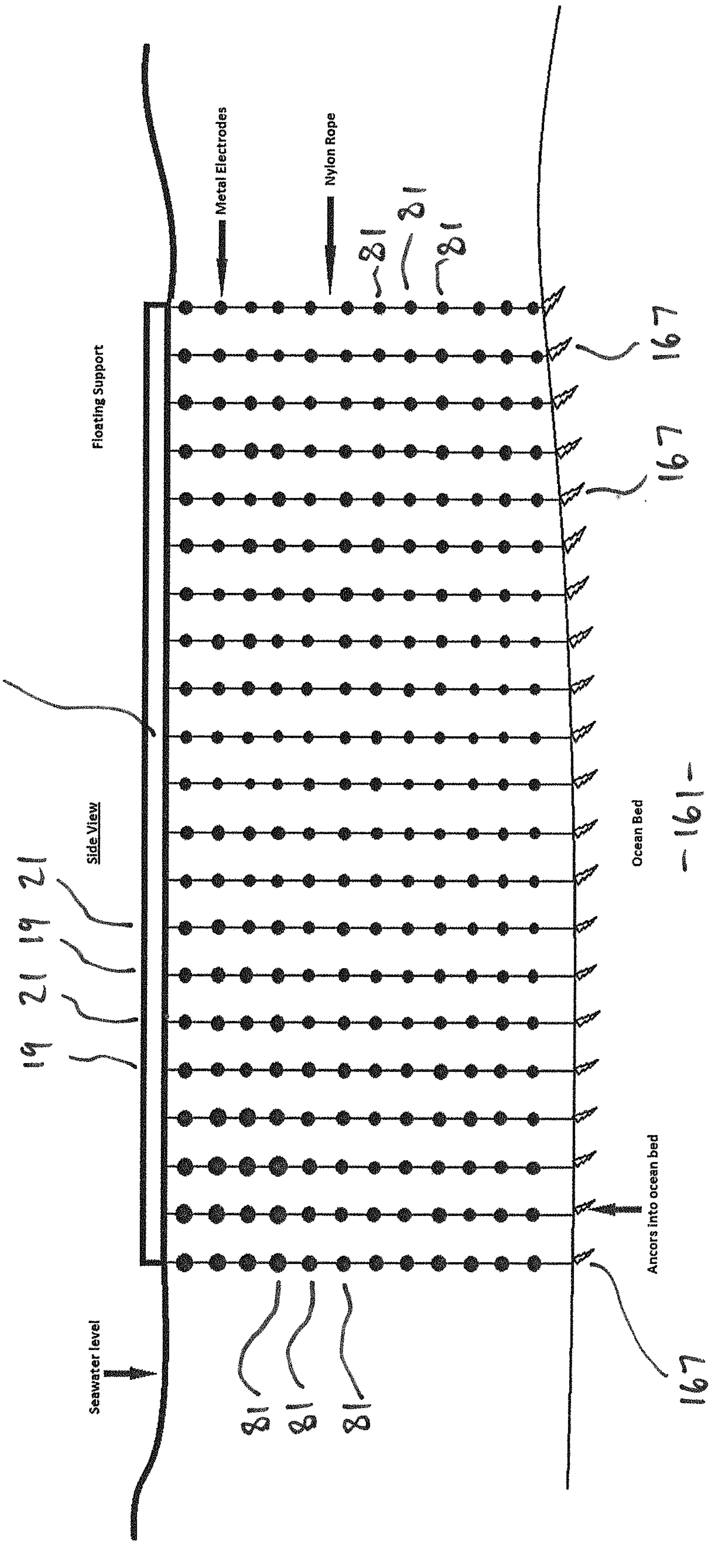

Metal Electrodes
Nylon Rope
Floating Support
Side View
Ocean Bed
Ancors into ocean bed
Seawater level
81
165
19
21
167
161

FIGURE 16

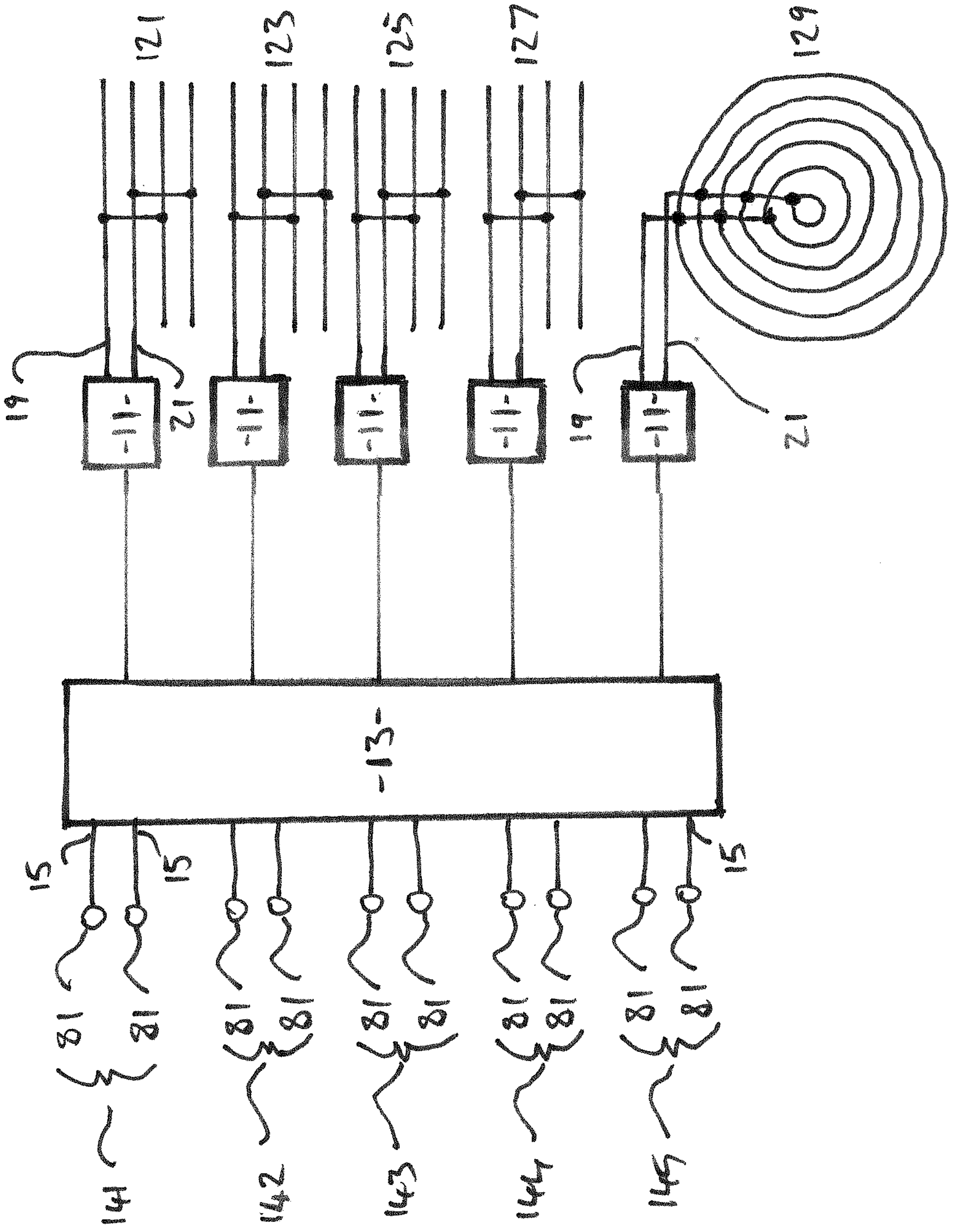


FIGURE 17

INTERNATIONAL SEARCH REPORT	International application No. **PCT/AU2016/050510**

A. CLASSIFICATION OF SUBJECT MATTER

A01M 29/24 (2011.01) A01K 79/02 (2006.01) H05C 1/04 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC and WPIAP: B63C2009/0088, B63C9/05, A01K79/02, A01M29/24/LOW, A01K61/00/LOW, H05C1/00/LOW (IPC and CPC); marine predators, sharks, aquaculture, pulse, capacitance, and similar terms (KEYWORDS).

Google Patents: electrical shark repellent system, and similar terms.

AusPat and Espacenet: applicant and inventor name search.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 August 2016	19 August 2016
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	**Authorised officer** Theodore Prawiradiraja AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262223650

INTERNATIONAL SEARCH REPORT	International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT	**PCT/AU2016/050510**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5566643 A (CHARTER et al.) 22 October 1996 Abstract, Figures 1-22, Column 5 Line 44 to Column 12 Line 40	1-23
X	US 5327854 A (SMITH et al.) 12 July 1994 Abstract, Figures 1-7, Column 2 Line 29 to Column 6 Line 62	1-23
X	GB 2505992 A (ACE AQUATEC LIMITED) 19 March 2014 Abstract, Figures 1-16, Page 18 Line 1 to Page 42 Line 2	1-23
X	US 2010/0071631 A1 (VINANO, JR. et al.) 25 March 2010 Abstract, Figures 1-3, Paragraphs [0023]-[0043]	1-23
X	US 2011/0174235 A1 (VINANO et al.) 21 July 2011 Abstract, Figures 1-11, Paragraphs [0042]-[0091]	1-23
X	US 2011/0290190 A1 (BECKER) 01 December 2011 Abstract, Figures 1-7, Paragraphs [0050]-[0122]	1-23
X	US 2012/0031343 A1 (DELUZE) 09 February 2012 Abstract, Figures 1-3, Paragraphs [0120]-[0141]	1-23
A	WO 2014/190385 A1 (SEACHANGE TECHNOLOGY HOLDINGS PTY LTD) 04 December 2014 Abstract, Figures 1-29, Paragraphs [0075]-[00122]	1-23
A	US 3683280 A (HOLT) 08 August 1972 Abstract, Figures 1-2, Column 4 Line 9 to Column 7 Line 11	1-23
A	US 4211980 A (STOWELL) 08 July 1980 Abstract, Figures 1-6, Column 3 Line 6 to Column 6 Line 66	1-23
A	US 4580525 A (MARZLUF) 08 April 1986 Abstract, Figures 1-6, Column 2 Line 34 to Column 3 Line 51	1-23
A	US 4593648 A (MARZLUF) 10 June 1986 Abstract, Figure 1, Column 2 Line 38 to Column 3 Line 5	1-23

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2016/050510**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 5566643 A	22 October 1996	US 5566643 A	22 Oct 1996
		AU 669806 B2	20 Jun 1996
		AU 6592894 A	12 Jan 1995
		BR 9402543 A	07 Feb 1995
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Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

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This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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