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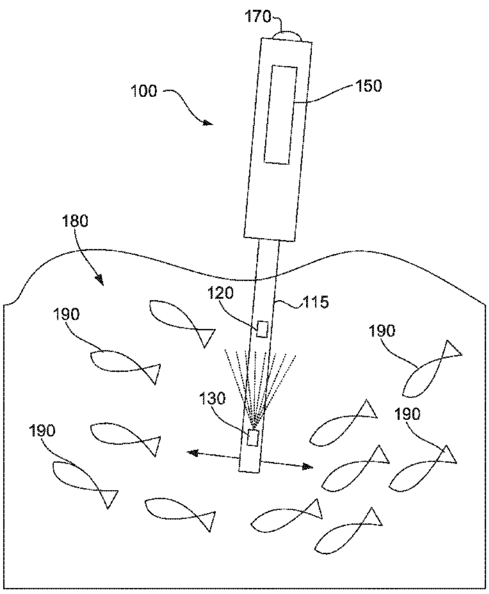

FIG. 2A

(57) Abstract: A device for sensing well-being of fish includes a rod, a first prong and a second prong extending from the rod, an opto-detector, a circuit and a transmitter. The opto- detector includes at least one light emitting diode (LED) and at least one photo detector aligned with a line of sight of the at least one light LED. The LED is mounted on the first prong and the photodiode is mounted on the second prong. A distance between the at least one LED and its corresponding photo-detector is defined so that fish can swim therebetween. The circuit detects interception of the line of site and counts a number of times that the line of sight is intercepted. The transmitter reports output from the circuit.

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SENSOR FOR FISH WELFARE

RELATED APPLICATION/S

This application claims the benefit of priority under 35 USC §119(e) of U.S. Provisional Patent Application No. 62/126,630 filed March 1, 2015, the contents of which are incorporated herein by reference in their entirety.

FIELD AND BACKGROUND OF THE INVENTION

The present invention, in some embodiments thereof, relates to a fish welfare detector and, more particularly, but not exclusively, to detector suitable for detecting fish welfare in an industrially scale fish farming.

Guidelines for monitoring the welfare of livestock are known. The "Five Freedoms" is a code is typically used as a basis for monitoring welfare of livestock such as of cattle, pigs, poultry and the like but not for fish. The "Five Freedoms" outlines five aspects of animal welfare under human control and includes freedom from hunger and thirst, freedom from discomfort, freedom from pain, injury or disease, freedom to express (most) normal behavior and freedom from fear and distress. These regulations are not fully applicable for fish livestock. Known regulations related to fish farming are typically focused on the post-harvest processes and include regulations for slaughtering before packaging or best practices for transferring live fish to processing plants or markets.

SUMMARY OF THE INVENTION

According to an aspect of some exemplary embodiments of the present invention, there is provided a device and method for monitoring welfare of fish livestock and detecting early signs of stress developing in the culture system. The system and method is non-invasive to the fish, does not disturb fish behavior or farm routine and does not require handling the fish. Rather the system and method detects reaction of fish to an object positioned in a swimming path of the fish and is based on an observation that healthy fish enjoying good welfare are known to be efficient in avoiding or escaping physical obstacles in the water and typically react very quickly to any object in the water that obstructs their path. According to some exemplary embodiments, the device and method is toward identifying apathy or a slow response to an object in the water and relating that detection to stress developing within the culture system.

According to aspects of some exemplary embodiments, there is provided a device comprising: a rod; a first prong and a second prong extending from the rod; an opto-detector comprising: at least one light emitting diode (LED); and at least one photo detector aligned with a line of sight of the at least one light LED, wherein the at least one LED is mounted on the first prong and the at least one photo detector is mounted on the second prong; wherein a distance between the at least one LED and its corresponding photo-detector is defined so that fish can swim therebetween, a circuit configured to detect interception of the line of site and to counting a number of times that the line of sight is intercepted; and a transmitter configured to report output from the circuit.

Optionally, the opto-detector includes a pair of LEDs and a corresponding pair of photo-detectors.

Optionally, the device is adapted for being immerged in water.

Optionally, the distance between the at least one LED and its corresponding photo-detector is between 2-30 cm.

Optionally, the device includes an alert unit for alerting a farmer based on the output indicating poor welfare of the fish.

Optionally, the alert unit provides an audile or visual alert.

Optionally, the device includes a handle configured for manipulation by a user.

Optionally, the handle includes a display configured to display the output.

Optionally, the device is configured to be integrated with a feeding station, wherein the feeding station comprises a feeder and a control unit and wherein the circuit is integrated with the control unit of the feeder.

Optionally, the control unit is configured to activate the device.

Optionally, the device includes an actuator configured to actuate movement of the rod.

Optionally, the output is an estimated stress level of fish cultivated in a culture system.

Optionally, the device includes a plurality of opto-detectors.

According to aspects of some exemplary embodiments, there is provided a method comprising: immersing a device in a tank including fish, wherein the device comprises: at least one light emitting diode (LED); and at least one photo detector aligned with a line of sight of the at least one light LED, wherein a distance between the at least one LED and its corresponding photo-detector is defined so that fish can swim therebetween; detecting the number of times that fish swim intercept the line of sight; and determining a wellness of the fish cultured in the tank based the number detected.

Optionally, the method includes moving the device in the tank over a defined path.

Optionally, the method includes providing an alert in response to the number exceeding a defined threshold.

Optionally, the method includes activating the device in synchronization with activation of a feeder configured for feeding the fish.

Optionally, the method includes terminating a feeding session based on detecting at least a threshold number of times that fish intercepted the line of sight.

Optionally, the distance between the at least one LED and its corresponding photo-detector is between 2-30 cm.

Optionally, the method includes reporting a level of fish wellness to a remote computing device based on the output.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings and images in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

FIG. 1 is a simplified schematic drawing of a detector in accordance with some disclosed embodiments;

FIGS. 2A and 2B are simplified schematic drawing of a detector operating in a tank with fish enjoying good welfare and in a tank with fish experience stress respectively in accordance with some disclosed embodiments;

FIG. 3 is a simplified flow chart of an exemplary method for detecting well being of fish in accordance with some disclosed embodiments;

FIGs. 4A-B are schematic side and top views respectively of a detector integrated with a feeding station of a fish farm and operated in an environment with fish enjoying good welfare in accordance with some disclosed embodiments;

FIGs. 5A-B are schematic side and top views respectively of a detector integrated with a feeding station of a fish farm and operated in an environment with fish experiencing poor welfare in accordance with some disclosed embodiments;

FIG. 6 is a simplified block diagram of an exemplary detector integrated with a feeding station in accordance with some disclosed embodiments;

FIG. 7 is a simplified flow chart of an exemplary method for monitoring well being of fish with an automated system in accordance with some disclosed embodiments; and

FIGS. 8A and 8B are images of a prototype for a detector in accordance with some disclosed embodiments.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention, in some embodiments thereof, relates to a fish welfare detector and, more particularly, but not exclusively, to detector suitable for detecting fish welfare in an industrially scale fish farming.

Animal welfare regulations for raising fish are not available to fish farmers. This may be due to the lack of studies available that are suitable for commercial culture conditions. Many available studies for detecting fish welfare are limited to laboratory conditions that are not easily translated to commercial culture conditions. Stress experienced within an industrial culture system may be due to a number of unfavorable conditions or combination of conditions that may not always be predictable or apparent to the farmer. For example, unexpected changes in any one or more of oxygen level in the water, water temperature, pollutants, density of the fish population may occur, and more may lead to stress in the culture system. A welfare detector may be useful for alerting a farmer at an early stage to any unfavorable condition that may be develop in the culture system. Based on the alert, the farmer may take measures to improve the welfare of the fish.

According to some exemplary embodiments, there is provided a fish welfare detector configured to detect response of fish to an object obstructing its current swimming path. According to some exemplary embodiments, the detector includes a proximity sensor that is configured to count occurrences of fish reaching proximity to the detector. Optionally, the proximity sensor is an optical sensor including an LED and photodiode. Alternatively, the optical sensor may use a light source other than an LED or a camera instead of a photodiode. In some exemplary embodiments, the detector includes a pair of prongs that are separated by a distance large enough to accommodate a fish swimming between the prongs. Typically, the LED is mounted on one of the prongs and the photodiode is mounted on other with a line of sight therebetween. Optionally, an array of LEDs is mounted on one of the prongs and an array of photodiodes is mounted on the other with an array of lines of sights, e.g. four LED/photodiode pairs. Proximity of fish to the prongs or passage of fish between the prongs may be detected by the proximity sensor. Typically, number of times proximity is detected is inversely related to the well being of the fish. Optionally, counting is in response to at least one line of sight being intercepted, e.g. when more than one LED/photodiode pair is used. Healthy fish enjoying good welfare will typically react quickly to the appearance of the detector obstructing their swimming path and redirect their movement to avoid contact or proximity to the detector. Fish that are in a condition of stress or poor welfare may respond more slowly or may exhibit apathy to the appearance of the detector.

According to some exemplary embodiments, the detector is positioned near a feeder where fish typically congregate to feed. In some exemplary embodiments, the detector is mounted on a movable arm that is actuated by a motor. Optionally, actuation of the arm and activation of the detector is coordinated with feeding times. Optionally, the detector is mounted on an arm with a vibrator. Optionally, the detector is held stationary in a water stream. According to some exemplary embodiments, an alert is transmitted to a farmer in response to the detector detecting deterioration in the well being of the fish based on output from the detector. Optionally, a feeding session is automatically terminated in response to detecting the deterioration. In other exemplary embodiments, the detector is a handheld device and may be manipulated and actuated by the farmer.

Reference is now made to FIG. 1 showing a simplified schematic drawing of a detector in accordance with some disclosed embodiments. According to some exemplary embodiments, a detector 100 includes a rod 115 with a pair of prongs 110. A light source 130, e.g. a light emitting diode (LED) is assembled on one of the prongs 110 and a photodiode 120 is assembled on the other prong 110 so that a line of sight is established between beam of light 135 emitted from LED 130 and photodiode 120. Optionally, LED 130 and photodiode 120 are assembled at or near a distal end 111 of prongs 110. Rod 115, prongs 110, LED 130 and photodiode 120 are adapted to be immersed in water. Typically, tethered electrical connection is established with wires 116 extending through rod 115 and prongs 110 that are typically hollowed. Typically, electrical components that are immersed in the water are hermetically sealed. Optionally, for safety, voltage for operating LED 130 and photodiode 120 does not exceed 24 V. Other electrical components for operating detector 100 may be included in handle 140 that is not immersed in the water or in a control box remote from the handle so that there is no electric current in the water.

In some exemplary embodiments, handle 140 includes a circuit 160 for processing output from photodiode 120 and controlling detector 100, an LCD display 150 for displaying output and messages to a farmer, an operating switch 170 for switching operation of detector 100 ON/OFF and a power supply 165. Alternatively, circuit 160, LCD display 150 and operating switch 170 may be included in a control box remote from the handle and connected to the handle by tethered connection. Elements of detector 100 may be standard off the shelf products that operate at relatively low voltage. Power supply 165 is typically a battery. Display 150 may be selected to provide clear visibility under sun light and in high moisture environments near a fish pond or tank.

According to some exemplary embodiments, a distance between prongs 110 or distance between LED 130 and photodiode 120 is defined based on dimensions of the fish and optionally ranging between 2-30 cm. Other factors that may be considered when defining distance between LED 130 and photodiode 120 may include for example, transparency of the water, sensitivity of the photodiode and intensity of beam 135. Typically, LED 130 and photodiode 120 are selected to handle varied water transparency, e.g. green water, brown water and also reduced visibility due to turbidity.

In some exemplary embodiments, beam 135 emitted by LED 130 is a pulse emitted at a predefined repetition rate and photodiode 120 samples output in synchronization with pulses emitted by LED 130. Optionally, detector 100 includes a plurality of LEDs 130 and/or photodiodes 120. Optionally, detector 100 includes additional prongs with LED(s) 130 and photodiode(s) 120.

When a fish approaches prongs 110 and/or swims between prongs 110, a line of sight between photodiode 120 and LED is intercepted. According to some exemplary embodiments, circuit 160 detects and counts occurrences of interception of beam 135. Optionally, circuit 160 may also track a rate of such occurrences. Output from circuit 160 may be displayed on display 150.

Reference is now made to FIGS. 2A and 2B showing simplified schematic drawing of a detector operating in a tank with fish enjoying good welfare and in a tank with fish experience stress respectively in accordance with some disclosed embodiments. According to some exemplary embodiments, detector 100 is operated manually by a farmer activating detector 100 with button 170, immersing rod 115 into a tank 180 with fish 190 and moving rod 115 around in the water. During activation, detector 100, tracks occurrences of obstructions to a line of sight between LED 130 and photodiode 120. According to embodiments of the present disclosure, healthy fish enjoying good welfare will typically divert their swimming path to avoid detector 100 and will not be close enough to moving rod 115 to intercept beam 135 (FIG. 2A). Therefore in a non-stressed culture environment, detector 100 may record little to no occurrences of interception. However, when a well being of fish 190 is diminished, fish 190 may be slower to react or apathetic to rod 115 moving in tank 180 and may collide with rod 115 or intercept line of sight between LED 130 and photodiode 120 as shown in FIG. 2B. When the well being of fish 190 is diminished, detector 100 will typically detect more occurrences or more frequent occurrences of obstructions to a line of sight between LED 130 and photodiode 120. Optionally, the number of occurrences of obstruction or the rate of such occurrences may be related to a stress-level of the culture environment, e.g. of fish 190 in tank 180.

Reference is now made to FIG. 3 showing a simplified flow chart of an exemplary method for detecting well being of fish in accordance with some disclosed embodiments. Typically, when detector 100 is activated (block 305), detector 100 count events of beam interception over defined time period (block 310). The number of events counted over the defined period may be checked against a threshold (block 320). When the number of events exceeds the threshold, an alert may be provided to a farmer to indicate that fish 190 in the culture environment 180 are experiencing stress, e.g. the well being of the fish is diminishing (block 340). The alert may be a message on display 150, an audio signal or both. Optionally, a level of stress is scaled based on the number of events recorded and the scale is reported to the farmer (block 350). Optionally, when the number of events detected is below the threshold, detector 100 may confirm the well being of the fish (block 330). In some exemplary embodiments, detector 100 is operated manually by a farmer holding handle 140 and immersing rod 115 in tank 180. Optionally, the well being of fish 190 may be checked once or twice a day to ensure that favorable conditions are met. Optionally, duration of the sensing is between 20 seconds and a few minutes, e.g. 30 seconds. Optionally, in response to receiving an alert from detector 100, a farmer may examine the conditions in the tank or culture system 180. Optionally, temperature, oxygen level and purity of the water may be checked in response to receiving an alert. Typically, detector 100 may provide early detection of stress so that an unfavorable condition may be remedied without any significant loss or damage to the fish. Typically, detector provides a warning prior to other parameters such as oxygen indicating unfavorable conditions.

Reference is now made to FIG. 4 showing a schematic side and top view respectively of a detector integrated with a feeding station of a fish farm and operated in an environment with fish enjoying good welfare in accordance with some disclosed embodiments. According to some exemplary embodiments, a detector 200 for detecting well being of fish 190 in culture system 185 may be automated and integrated with a feeding station 400. In some exemplary embodiments, detector 200 is immersed in water body 185 while being supported by a structure 420 in feeding station 400 via a rod 210. Typically, detector 200 is similar to detector 100 described herein above and operates in a similar manner. Detector 200 may include a LED 130 and a photodiode 120 with a line of sight therebetween. Typically, LED 130 and a photodiode 120 are assembled on a pair of prongs 110 extending from a rod 115 as discussed in reference to detector 100 and FIGS. 1 and 2. According to some exemplary embodiments, circuitry associated with detector 200 is integrated with a control unit 450 of feeding station 400. In some exemplary embodiments, control unit 450 is integrated with a wireless communication unit that transmits and receives input from a remote device 460. Optionally, remote device 460 may be a mobile telephone or a personal computer that may be remote from feeding station 400.

In some exemplary embodiments, feeding station 400 floats on a body of water 185 with a platform 410 including floats 430. A feeder 410 above water, supplies food 195 to fish 190 via a hole or opening 415 in platform 420. Typically, operation of feeder 410 is controlled by control unit 450 to supply food at defined periods of time and for a defined duration per feeding. Optionally, feeder 410 may also receive input and communicate with remote device 460 via control unit 450.

According to some exemplary embodiments, detector 200 is activated in synchronization with feeder 410 so that detector 200 can operate while fish 190 congregate in the vicinity of feeder 410 to feed. In some exemplary embodiments, detector 200 includes one or more actuators 510, 520 for moving detector 200 in culture system 185. Optionally, a motor 510 may rotate detector 200 about column 210. Optionally, a linear actuator 520 may move detector 200 in a back and forth liner direction. Alternatively, detector 200 may be stationary with respect to feeding station 400, e.g. may move together with feeding station 400. In some exemplary embodiments, detector 200 may be integrated with a vibrating element, e.g. a piezo electric element that attracts attention of fish by vibrating.

As described herein above, healthy fish enjoying good welfare will typically respond efficiently to the presence of detector 200 and successfully steer away from detector 200 as shown in FIG. 4A and 4B. Therefore, detector 200 will record little or no occurrences of obstruction in the line of sight between photodiode 120 and LED 130.

Reference is now made to FIG. 5 showing a schematic side and top view respectively of a detector integrated with a feeding station of a fish farm and operated in an environment with fish experiencing poor welfare in accordance with some disclosed embodiments. When fish 190 are not enjoying good welfare, fish 190 may be slower to react or apathetic to rod 115 moving in water 185 and may collide with rod 115 or intercept line of sight between LED 130 and photodiode 120 as shown in FIG. 5. When fist 190 are not feeling well, detector 200 will typically detect more occurrences or more frequent occurrences of obstructions to a line of sight between LED 130 and photodiode 120. Optionally, the number of occurrences of obstruction or the rate of such occurrences may be related to a stress-level of the culture environment 185. According to some exemplary embodiments, output from detector 200 may be processed by control unit 450 and reported to remote device 460.

Reference is now made to FIG. 6 showing a simplified block diagram of an exemplary detector integrated with a feeding station in accordance with some disclosed embodiments. According to some exemplary embodiments, a feeding station 400 includes a feeder 410, a detector 200 configured to detect well being of fish in a culture system and a control unit 450. Detector 200 may include an optical sensor 650 mounted on a structure and optionally one or more actuators, e.g. actuators 510 and 520 for actuating movement of the structure during detection. Optical sensor 650 may include a LED 130 and photodiode 120 that are aligned to share a line of sight between them. Alternatively, optical sensor 650 may include a camera, e.g. a line camera or area camera.

Reference is now made to FIG. 7 showing a simplified flow chart of an exemplary method for monitoring well being of fish with an automated system in accordance with some disclosed embodiments. According to some exemplary embodiments, activation of feeder is detected (block 705) and in response detector 200 is activated together with feeder 410 or at a pre-defined delay after feeder 410 is activated (block 710). Optionally, an actuator for controlling movement of detector 200 is also activated (block 720) and detector 200 is moved in the water in a pre-defined pattern while detector 200 is detecting well being of fish. Typically, detector 200 together with control unit 450 counts the number of times that fish 190 intercept a line of sight between LED 130 and photodiode 120. According to some exemplary embodiments, the number counted is related to a stress level felt by fish 190 in the culture system 185 (block 735). Optionally, the stress level is compared to a pre-defined threshold that indicates poor fish welfare (block 740). If the level exceeds the defined threshold, feeding may be terminated (block 750) and a farmer may be alerted by receiving a report (block 760). Feeding may have adverse effect on fish 190 that are not faring well. Terminating the feeding session may prevent further harm to the well being of the fish. In some exemplary embodiments, output from detector 200 may also be stored and reported at the end of a feeding session.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Various embodiments and aspects of the present invention as delineated hereinabove and as claimed in the claims section below find experimental support in the following example.

EXAMPLES

Reference is now made to the following example, which together with the above descriptions illustrates some embodiments of the disclosure in a non limiting fashion.

<u>SENSOR DESCRIPTION</u>

The sensor prototype shown in FIGS. 8A and 8B was designed and built at the Institute of Agricultural Engineering, A.R.O., Israel. The sensor incorporates two LEDs (Light Emitting Diode) sources and two detectors. An operator holds both the light source and the detector under the water. When a fish passes between a light source 130 and a detector 120 it crosses the light beam and triggers a signal of detection. The signal is transferred to the control unit 600 and recorded with its time stamp.

An electronic counter and LCD display 150 are located in the control box 600. The sensor components include one or more LEDs 130. When a fish crosses the light beam, a signal is triggered. An operator holds the sensor under water in a predefined constant location against the stream or smoothly moves the sensor in a well-defined path, e.g. from one corner of a culture tank to another within 30 sec.

The control box 600 is located above the water, visible to the operator, while the rest of the sensor is submerged, covered with water. An operator holds the sensor under water in a predefined constant location against the stream or smoothly moves the sensor in a well-defined path, e.g. from one corner of a culture tank to another within 10 sec. During the time that the sensor is underwater, the number of fish passing the beam is recorded. The operation concept of this sensor is: lively fish are ‘hard-to-get’– low chance that a fast swimming lively fish, can be touched. In contrast, a ‘phlegmatic’ fish may be touched, or in this case will not run away from the sensor’s light beams.

MATERIALS AND METHODS

Fish and experimental setup

Tilapia fingerlings, weighing 25 g on average, were used. The experiment was replicated three times, with a couple of months’ time interval between replicates. Each replicate was conducted in four 100 L tanks, each filled with 20 L water, placed indoors at the central health lab, Kibbutz Nir David, Israel. Each tank was stocked with 40 fish two days before the measurements were conducted. During these two days the same conditions were maintained in the four tanks: water temperature of 24°C and 90-100% oxygen saturation. The oxygen was supplied by compressed air and controlled through a manual valve. The level of the oxygen was measured by manual device.

On the day of measurements at 9:00, the water temperature, controlled by a central computerized heating system, was lowered to 15°C in two tanks and remained 24°C in the other two tanks. Shortly thereafter, 10 minutes before starting the measurements, air flow was stopped in two tanks – one with 24°C and one with 15°C. The resulting four treatments, combinations of two temperature and two dissolved oxygen levels, are presented in Table 1.

Table 1: Conditions in treatments of the tank experiment

Tank No.	Temp. (^{0}C)	% - oxygen	Condition	Number of replications
1	15	50	Poor welfare	3
2	15	90-100	Suboptimal 1	3
3	24	50	Suboptimal 2	3
4	24	90-100	Good (optimal) welfare	3

At 10:00, after making sure all fish behave normally, the operator dipped the electronic sensor (Fig. 1) into the first tank and activated it. Monitoring was carried out during 30 seconds while the sensor was randomly moved in all directions inside the tank (Fig.1, right). Exactly the same process was then repeated in the other three tanks. The operator did not know which tank belong to which treatment. To ensure accurate sampling, 24 measurement cycles were performed at intervals of a few minutes apart. The measuring order of the four tanks was randomized in each cycle.

Analysis

The average of the 24 measurement cycles in each of the four culture tanks (treatments) was calculated for the three replicates of the experiment, yielding 12 values. These data were subjected to a three-factor analysis of variance which examined the main effects of the two environmental factors (oxygen and temperature) and the effect of the interaction between them, and the differences between the blocks (the three replicates).

RESULTS

The electronic sensor performed well throughout the experiment, with no need for special electronic, software or mechanical adaptations in variety of fish culture tanks.

Analysis of variance revealed significant main effects of both factors, as well as among replications (blocks), but there was no significant interaction between temperature and oxygen level.

The results of analysis of variance presented in Table 2. Significant effects are marked with a star (*). The average number of detections at the four experimental conditions is presented in Table 3, which also show the calculated effects of lowering temperature or oxygen on fish behavior as measured by failure to escape the detector. Both lowering the temperature or the oxygen level significantly increased the average number of fish detected (Table 3). The effect of the difference between the two temperatures was stronger than that of the difference between the two oxygen levels – 6 and 2 more fish detections per 30 seconds, respectively. No significant interaction between the two factors was observed. Lowering the temperature caused increased the number of detections by 5.85 and 6.06 at 100% and 50% oxygen saturation, respectively. Likewise, lowering oxygen saturation increased the number of detections by 2.02 and 2.23 at 24ºC and 15 ºC, respectively.

Accordance with the lack of interaction between the two factors, the difference between the good and poor conditions was 8 detections, which equals the sum of the effects of the two factors (6 and 2 detections, for temperature and oxygen, respectively).

Table 2: Results of analysis of variance

Source	F-Ratio	Prob> F
Replication (block)	20.9886	0.0020*
Temperature	210.0725	<0001*
Oxygen	26.7201	0.0021*
Combined effect	0.0559	0.8209
The entire model: $\mathbf{R^2 = 0.979}$		

Table 3: Average number of fish detections (per 30 seconds) at the four experimental conditions, and calculated main effects of lowering the water temperature or oxygen content

Temperature / Oxygen	24°C	15°C	Effect of lowing water temperature
100%	2.49	8.34	5.85
50%	4.51	10.57	6.06
Effect of lowing water oxygen content	2.02	2.23	**5.95** / **2.12**

Nile tilapia is not the only an exemplary species. The system and method described herein may be applied for many different species of fish. Optionally, the size or dimensions of the detector may be adapted to the size and dimensions of the fish being cultivated. It is noted that temperature and oxygen are not the only stressors in the water. In this exemplary study, low temperature and low oxygen level were assumed to induce stress. Alternatively, cortisol concentration in water or fish blood, may serve as "the gold reference" to quantify stress level in correlation with the sensor output.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

WHAT IS CLAIMED IS:

1. A device comprising:

a rod;

a first prong and a second prong extending from the rod;

an opto-detector comprising:

at least one light emitting diode (LED); and

at least one photo detector aligned with a line of sight of the at least one light LED,

wherein the at least one LED is mounted on the first prong and the at least one photo detector is mounted on the second prong;

wherein a distance between the at least one LED and its corresponding photo-detector is defined so that fish can swim therebetween,

a circuit configured to detect interception of the line of site and to counting a number of times that the line of sight is intercepted; and

a transmitter configured to report output from the circuit.

2. The device according to claim 1, wherein the opto-detector includes a pair of LEDs and a corresponding pair of photo-detectors.

3. The device according to claim 1 or claim 2, wherein the device is adapted for being immerged in water.

4. The device according to any one of claims 1-3, wherein the distance between the at least one LED and its corresponding photo-detector is between 2-30 cm.

5. The device according to any one of claims 1-4, comprising an alert unit for alerting a farmer based on the output indicating poor welfare of the fish.

6. The device according to claim 5, wherein the alert unit provides an audile or visual alert.

7. The device according to any one of claims 1-4, comprising a handle configured for manipulation by a user.

8. The device according to claim 7, wherein the handle includes a display configured to display the output.

9. The device according to any one of claims 1-6, wherein the device is configured to be integrated with a feeding station, wherein the feeding station comprises a feeder and a control unit and wherein the circuit is integrated with the control unit of the feeder.

10. The device according to claim 9, wherein the control unit is configured to activate the device.

11. The device according to any one of claims 1-10, comprising an actuator configured to actuate movement of the rod.

12. The device according to any one of claims 1-11, wherein the output is an estimated stress level of fish cultivated in a culture system.

13. The device according to any one of claims 1-11 comprising a plurality of opto-detectors.

14. A method comprising:

immersing a device in a tank including fish, wherein the device comprises:

at least one light emitting diode (LED); and

at least one photo detector aligned with a line of sight of the at least one light LED, wherein a distance between the at least one LED and its corresponding photo-detector is defined so that fish can swim therebetween;

detecting the number of times that fish swim intercept the line of sight; and

determining a wellness of the fish cultured in the tank based the number detected.

15. The method according to claim 14 comprising moving the device in the tank over a defined path.

16. The method according to claim 14 or claim 15 comprising providing an alert in response to the number exceeding a defined threshold.

17. The method according to any one of claims 14-16, comprising activating the device in synchronization with activation of a feeder configured for feeding the fish.

18. The method according to claim 17, comprising terminating a feeding session based on detecting at least a threshold number of times that fish intercepted the line of sight.

19. The method according to any one of claims 14-17, wherein the distance between the at least one LED and its corresponding photo-detector is between 2-30 cm.

20. The method according to any one of claims 14-19, comprising reporting a level of fish wellness to a remote computing device based on the output.

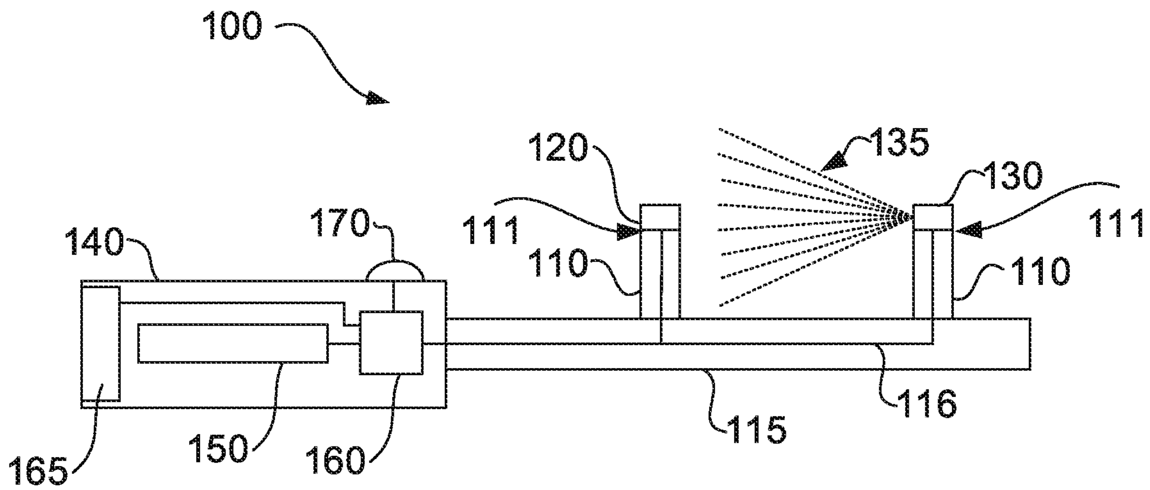

FIG. 1

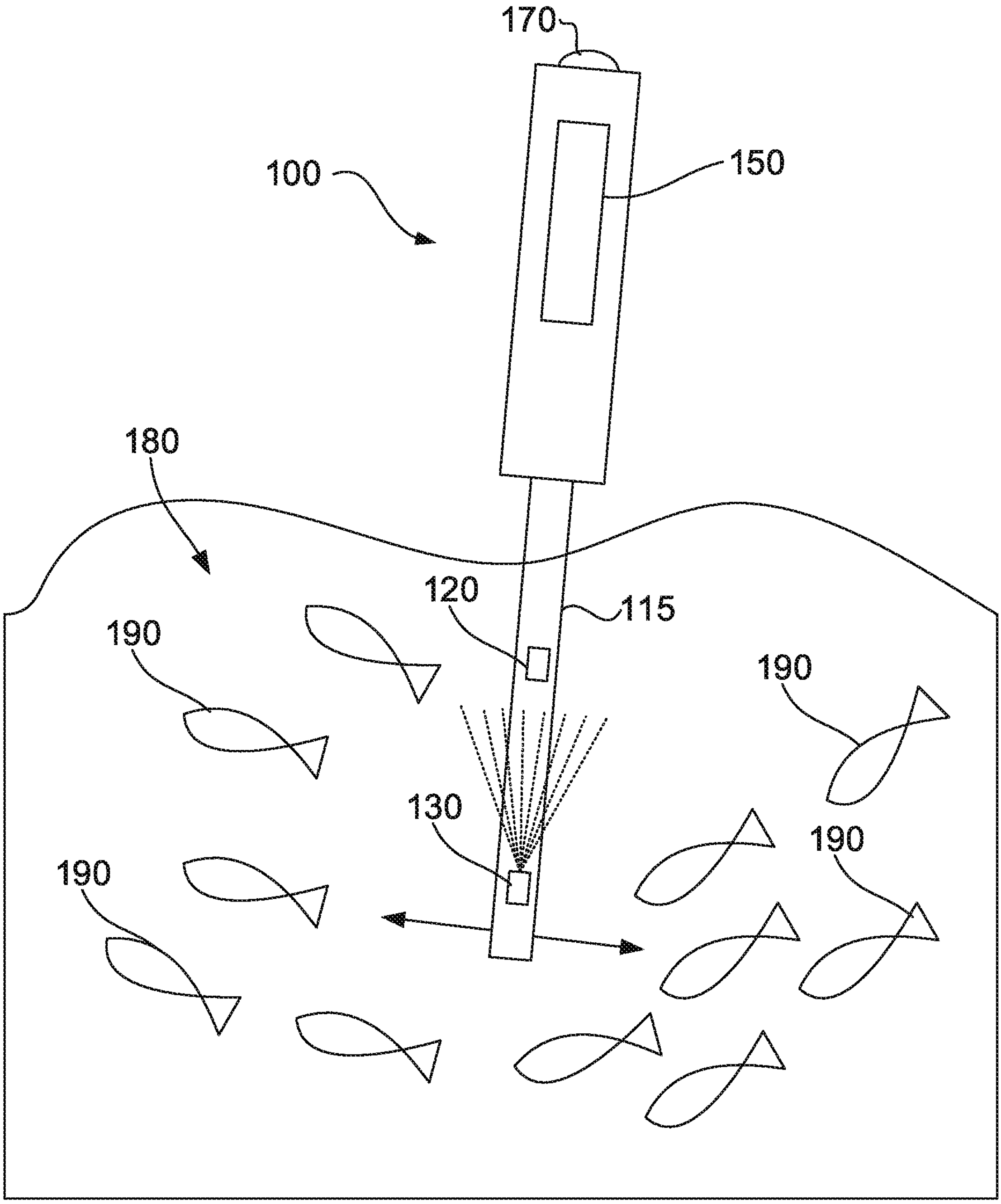

FIG. 2A

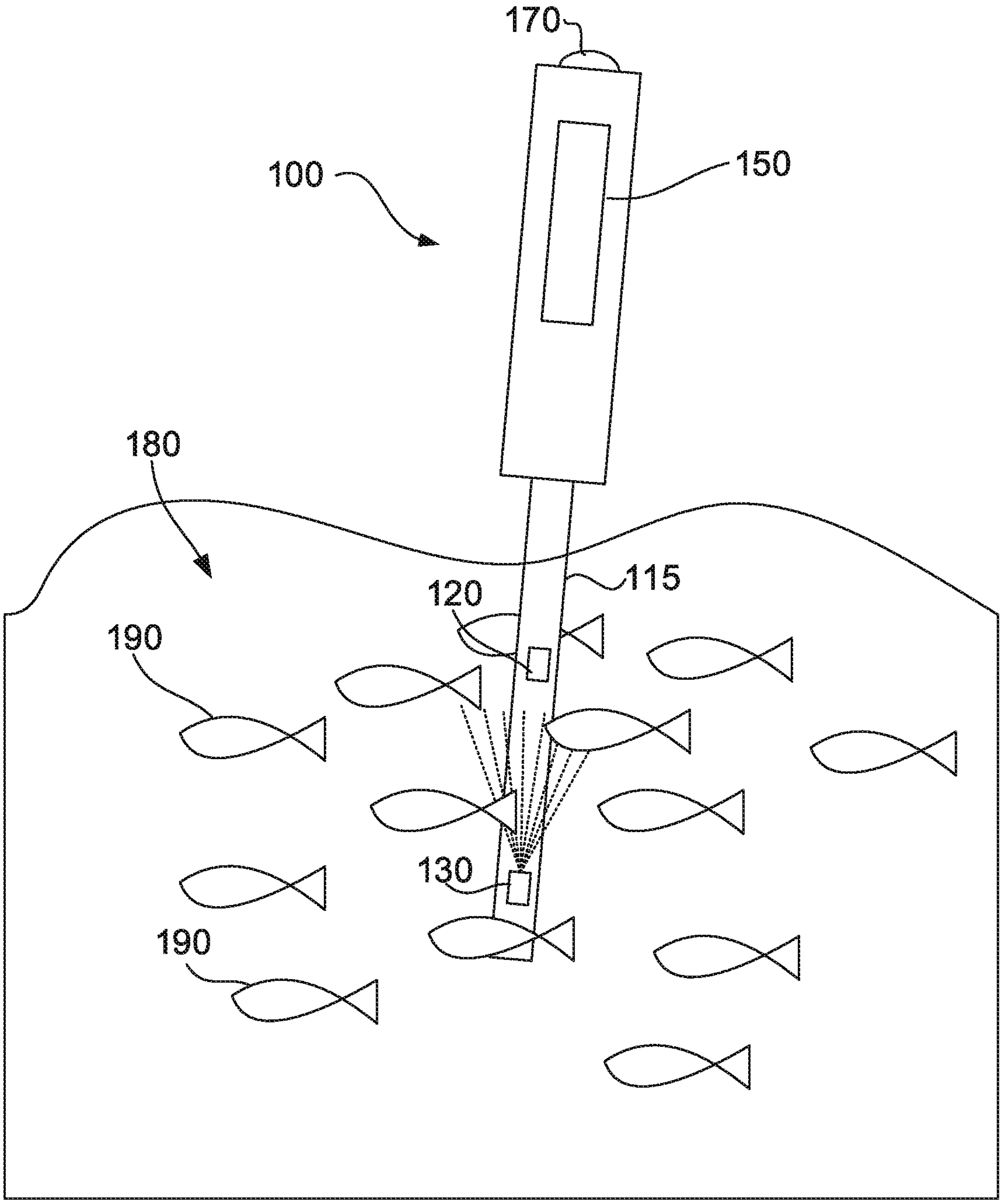

FIG. 2B

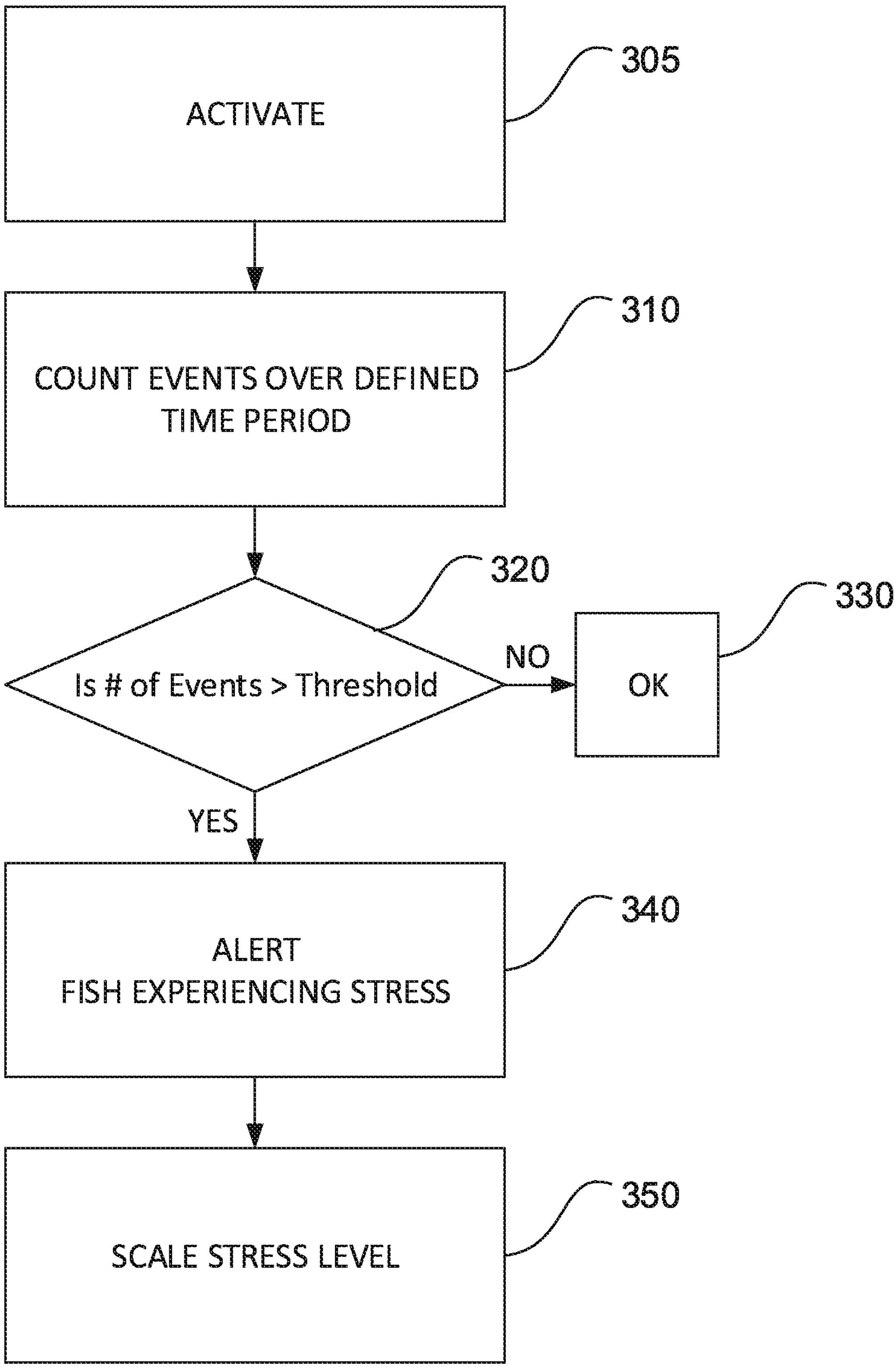
ACTIVATE
305
COUNT EVENTS OVER DEFINED TIME PERIOD
310
Is # of Events > Threshold
320
NO
OK
330
YES
ALERT
FISH EXPERIENCING STRESS
340
SCALE STRESS LEVEL
350

FIG. 3

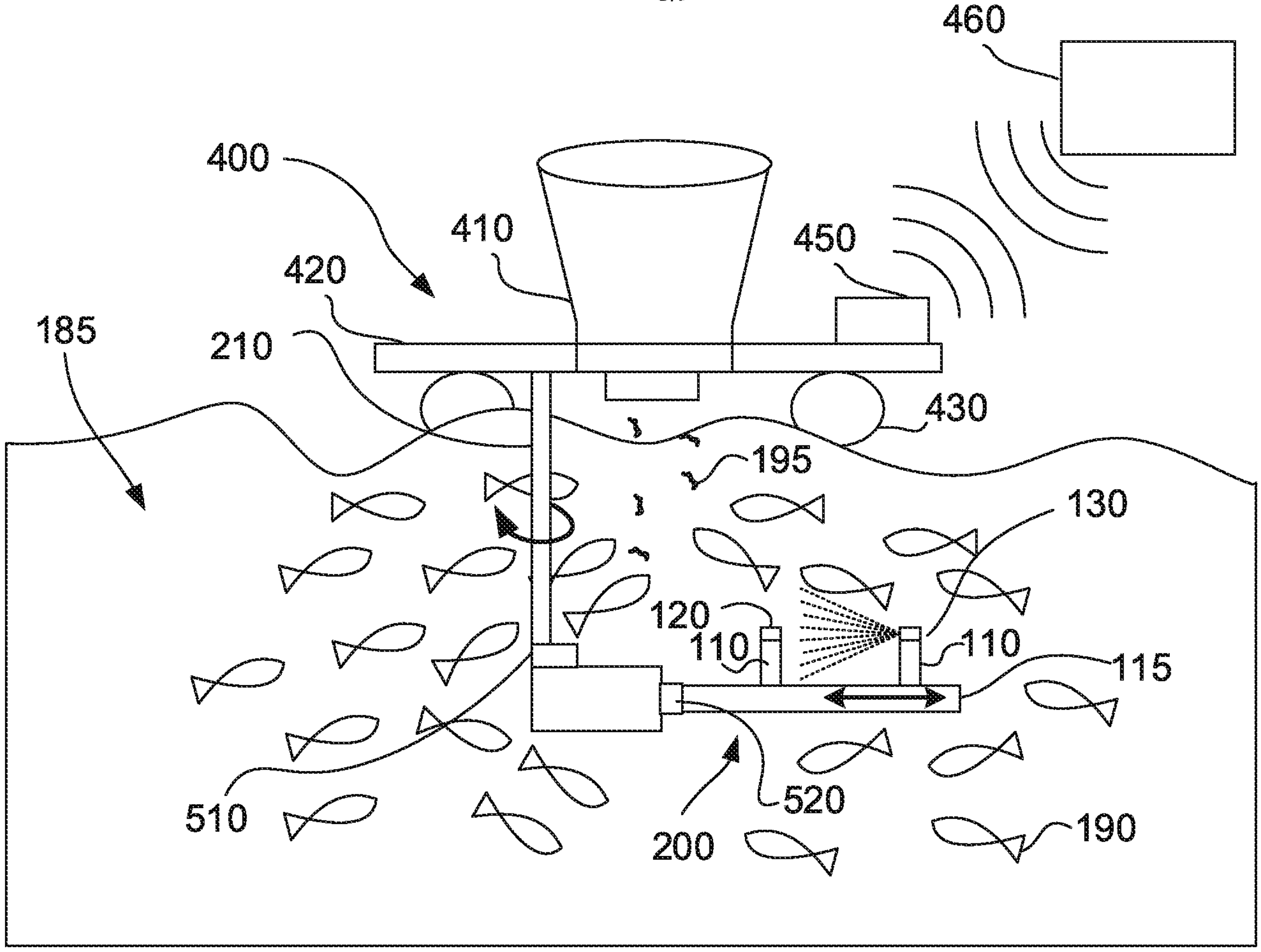
460
400
410
450
420
185
210
430
195
130
120
110
110
115
510
520
200
190

FIG. 4A

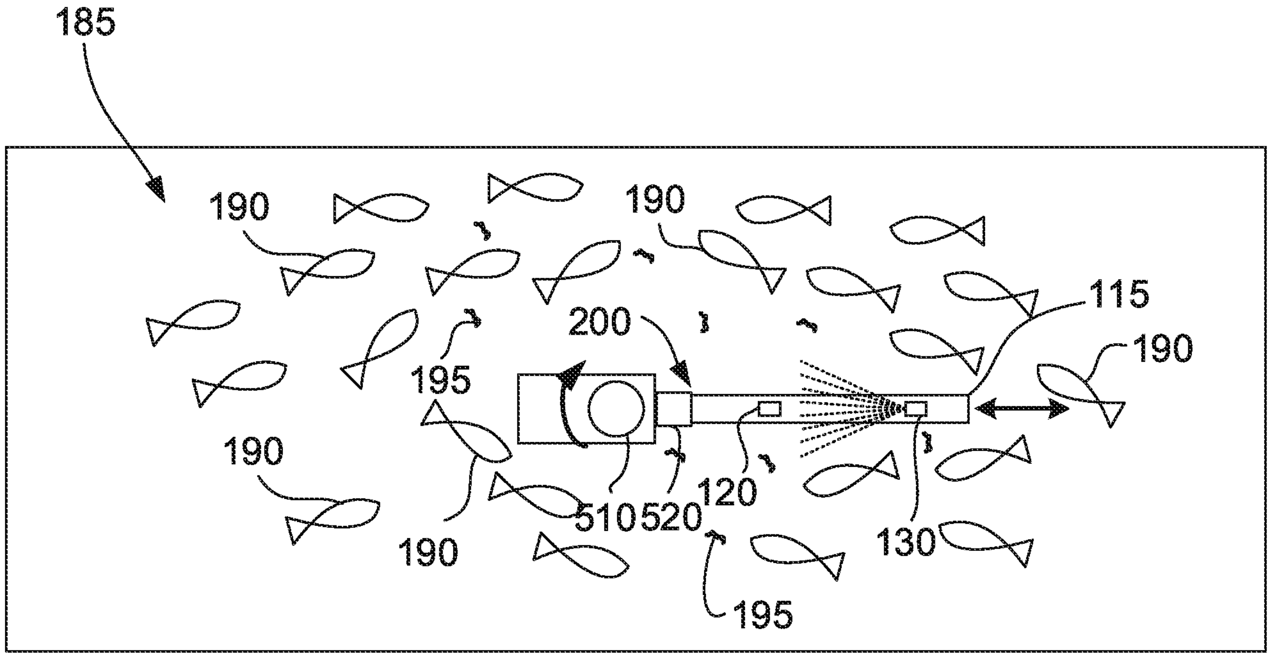
185
190
190
115
200
190
195
190
510
520
120
130
190
195

FIG. 4B

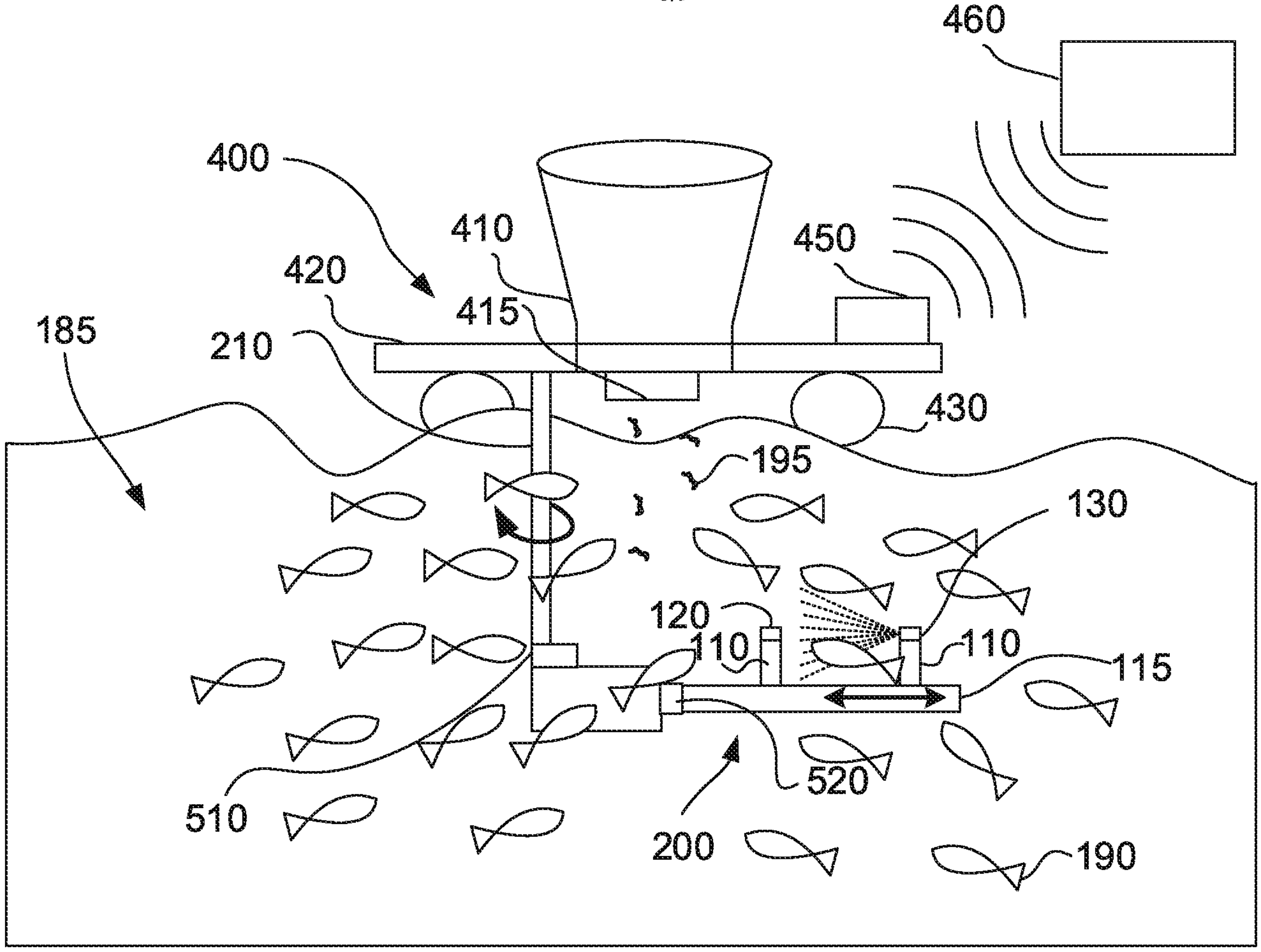
460
400
410
450
420
415
185
210
430
195
130
120
110
110
115
510
520
200
190

FIG. 5A

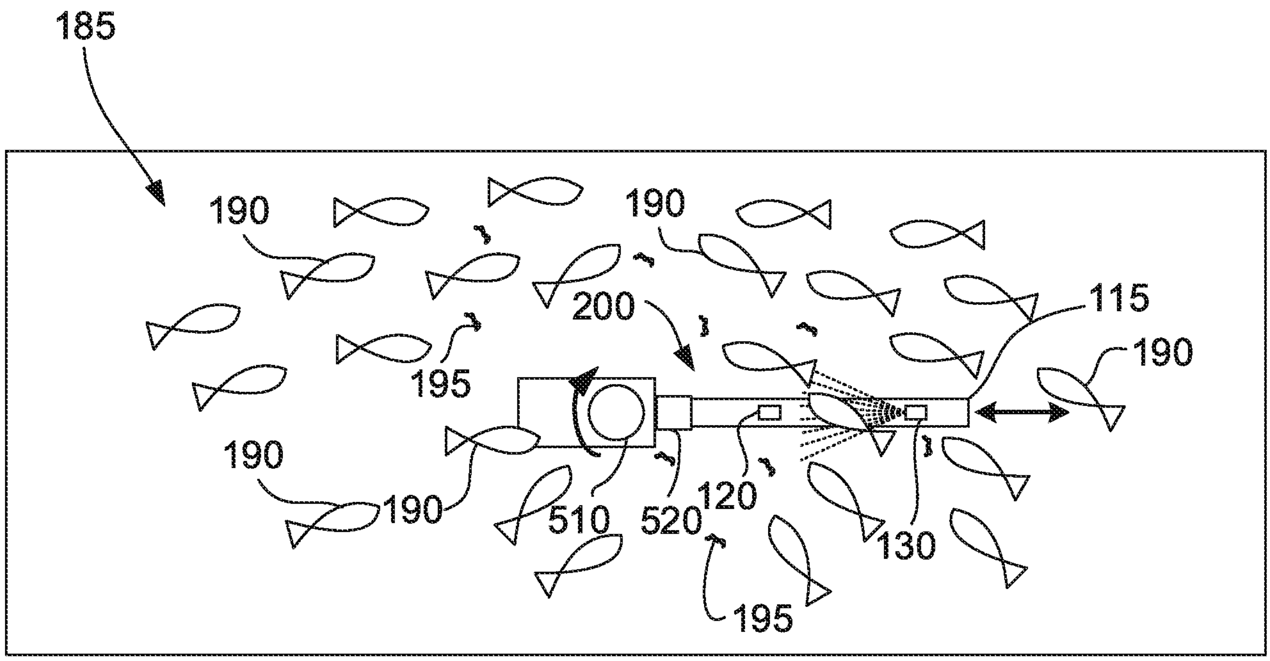
185
190
190
200
115
195
190
190
190
190
510
520
120
130
195

FIG. 5B

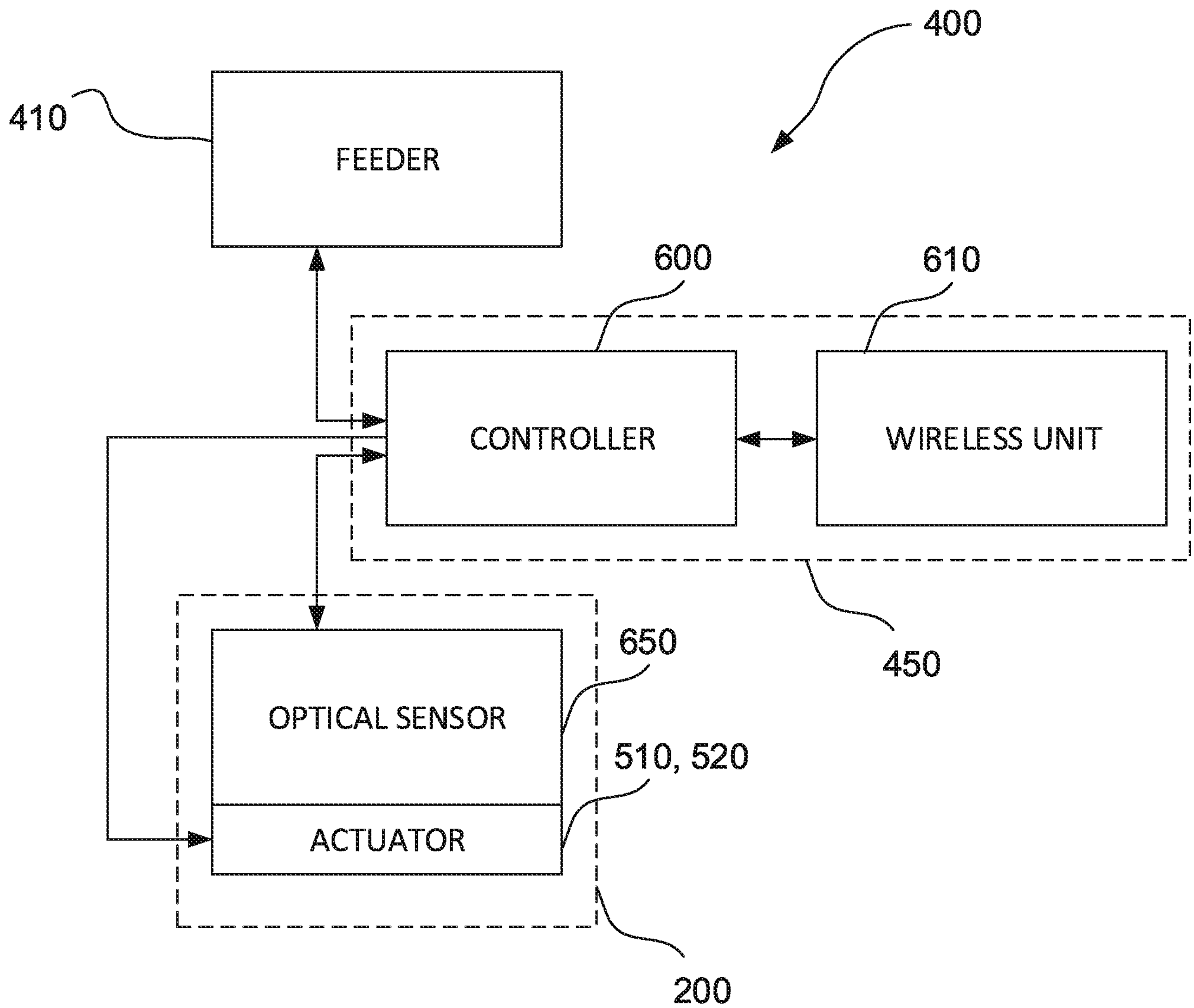
400
410
FEEDER
600
610
CONTROLLER
WIRELESS UNIT
450
650
OPTICAL SENSOR
510, 520
ACTUATOR
200

FIG. 6

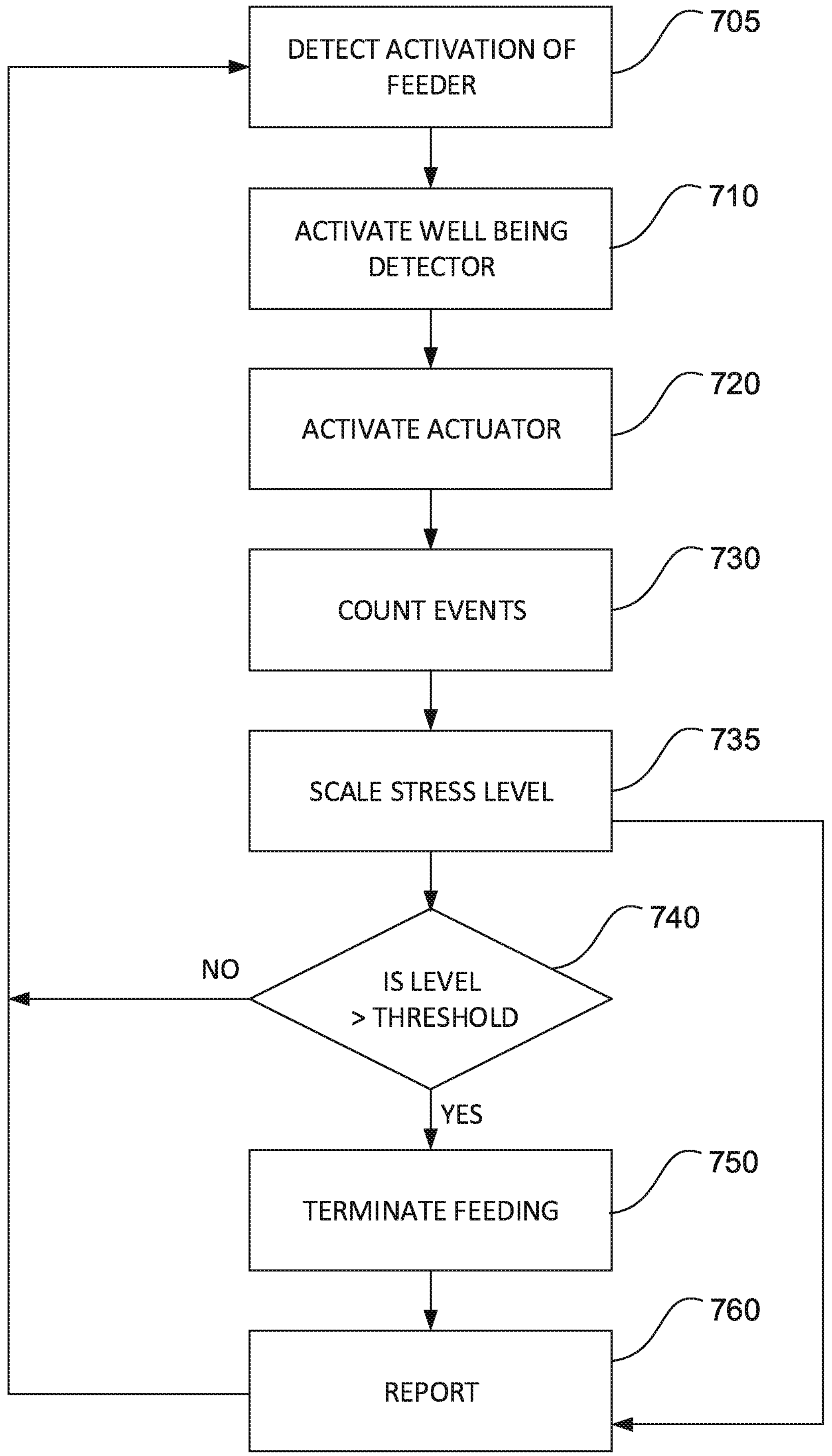
DETECT ACTIVATION OF FEEDER
705
ACTIVATE WELL BEING DETECTOR
710
ACTIVATE ACTUATOR
720
COUNT EVENTS
730
SCALE STRESS LEVEL
735
IS LEVEL > THRESHOLD
740
NO
YES
TERMINATE FEEDING
750
REPORT
760

FIG. 7

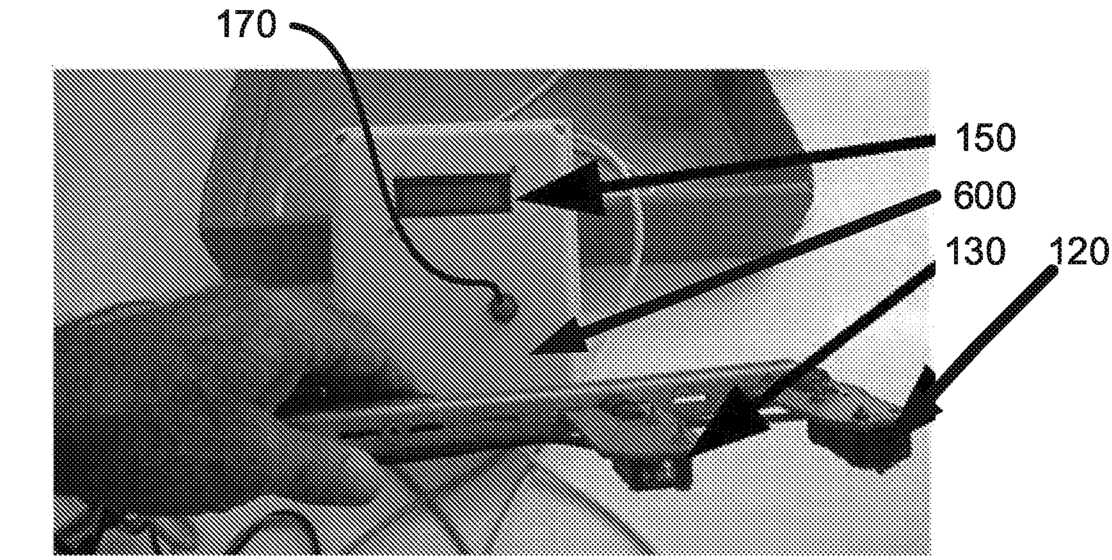

FIG. 8A

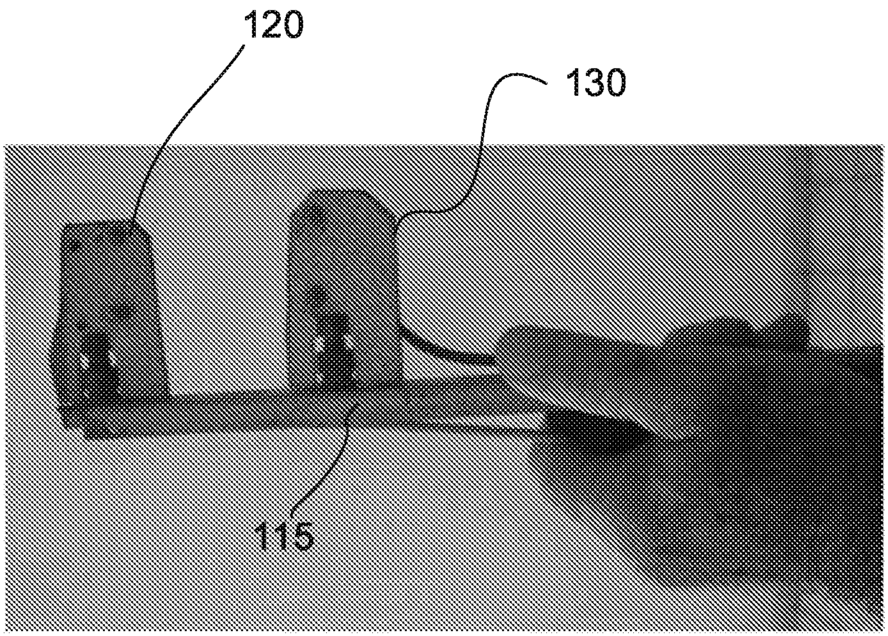

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2016/050233

A. CLASSIFICATION OF SUBJECT MATTER
IPC (2016.01) A01K 61/00

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)
IPC (2016.01) A01K 61/00

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)
Databases consulted: PATENTSCOPE, Esp@cenet, Google Patents, Google Scholar
Search terms used: fish, behavior, movement, light transmitter, photo detector, rod, detection.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9519103 A2 UTHAUG MAGNAR; WIKEN ARENT 20 Jul 1995 (1995/07/20) Entire document	1-4,9-11,13
A	Entire document	5-8,12,14-20
P,X	US 9210917 B1 HEAD CLYDE W 15 Dec 2015 (2015/12/15) Entire document	1-4,9-11,13
A	Entire document	5-8,12,14-20

☐ Further documents are listed in the continuation of Box C. ☒ 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
21 Jun 2016	21 Jun 2016
Name and mailing address of the ISA: Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. 972-2-5651616	Authorized officer Drori Avishag Telephone No. 972-2-5657821

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2016/050233

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
US 9210917 B1	15 Dec 2015	US 9210917 B1	15 Dec 2015
WO 9519103 A2	20 Jul 1995	WO 9519103 A2	20 Jul 1995
		WO 9519103 A3	24 Aug 1995
		AU 1468595 A	01 Aug 1995
		NO 940085 D0	10 Jan 1994
		NO 940085 A	11 Jul 1995
		NO 300477 B1	02 Jun 1997