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(71) Applicant: FOSTER-MILLER, INC. [US/US]; 350 Second Avenue, Waltham, MA 02451 (US).

(72) Inventors: WIESMAN, Richard; 21 High Rock Road, Wayland, MA 01778 (US). STEINGART, Robert; 10 Suffolk Road, Wellesley, MA 02481 (US). HAGGERTY, Matthew; 21 Court Street, Dedham, MA 02026 (US). PRZYBYLOWICZ, Timothy; 13 Garrison Street, Boston,

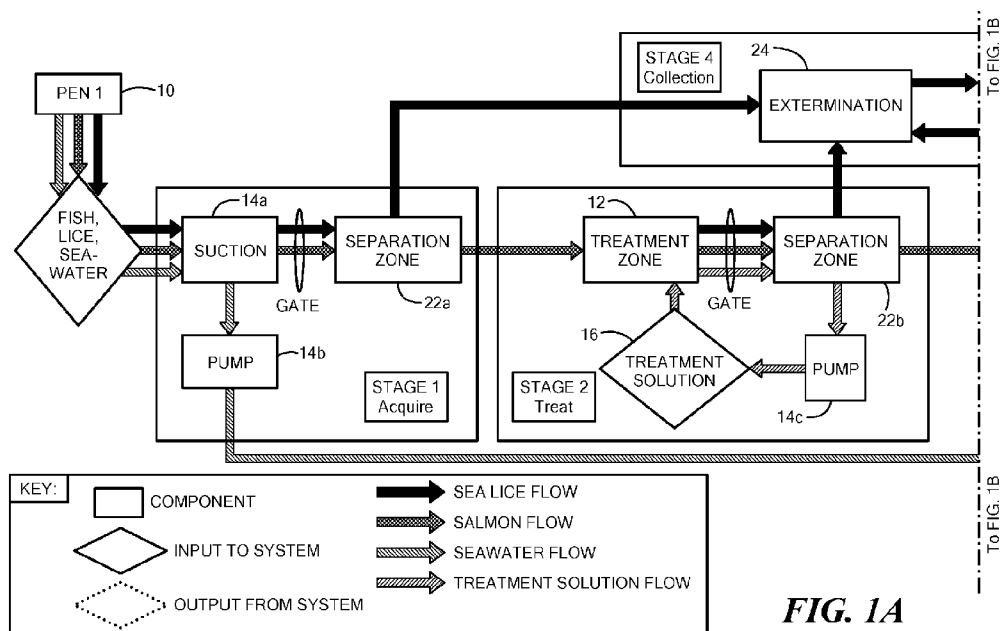
MA 02116 (US). FINSTADSVEEN, Kare; 100 Nevin Road, South Weymouth, MA 02190 (US).

(74) Agent: TESKA, Kirk et al.; Landiorio Teska & Coleman, LLP, 255 Bear Hill Road, Waltham, MA 02451 (US).

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(54) Title: SYSTEM AND METHOD FOR TREATING FISH

**FIG. 1A**

(57) Abstract: A system and method for removing parasites from fish. Individual fish pass in a conduit and a plurality of arms are associated with the conduit circumferentially spaced with respect to each other. A treatment head unit for each arm for dislodging parasites from the fish. The arms are adjusted for closely spacing the head unit with respect to the fish.

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SYSTEM AND METHOD FOR TREATING FISH RELATED APPLICATIONS

This application claims benefit of and priority to U.S. Patent Application Serial No. 15/954,887 filed April 17, 2018, under §§119, 120, 363, 365, and 37 C.F.R. §1.55 and §1.78, and that application and this application also claim benefit of and priority U.S. Provisional Application Serial No. 62/486,598 filed April 18, 2017 under 35 U.S.C. §§119, 120, 363, 365, and 37 C.F.R. §1.55 and §1.78, and each of U.S. Patent Application Serial No. 15/954,887 and U.S. Provisional Application No. 62/486,598 are incorporated herein by this reference.

FIELD OF THE INVENTION

This subject invention relates to methods and systems for treating fish (e.g., salmon) to rid them of parasites. (e.g., sea lice).

BACKGROUND OF THE INVENTION

Fish farming is a large business but the damage caused by parasites cost fish farmers huge sums of money each year. Chemical treatments (see, e.g., U.S. 2013/0095126, incorporated herein by reference) may be ineffective and/or costly, may damage or kill the fish, and/or may pollute the water and/or damage other organisms. Certain pesticides, drugs, vaccines, and the like may result in genetically resistant sea lice.

Warm water and/or fresh water treatments may be ineffective, expensive, and often require long treatment times. Moreover, if the sea lice become resistant to fresh

water, then wild saltwater fish migrating in fresh water can be put at risk.

Some mechanical treatments have been proposed. For example, WO 98/24314, incorporated by reference herein, proposes using water jets to remove sea lice from salmon. But, the water jets are fixed in place. Since the salmon are not stationary, and are not a constant size, large fish may be damaged by the water jets and, for smaller fish, the jet pressure may not be great enough to effectively remove the sea lice. Moreover, the water from the spray nozzles has to travel through water before reaching the surface of the fish body lowering the effectiveness of the water jet. And, the water jets are in a single fixed configuration with fixed angles.

BRIEF SUMMARY OF THE INVENTION

In one preferred method and system, fish (e.g., salmon) are treated in two zones in a cost effective and expedient manner to more effectively remove parasites (e.g., sea lice) from the fish. The throughput of the preferred system results in many fish being treated in a short amount of time. Parts of the process may include a batch treatment or the system may be configured for a continuous process. In the first treatment zone (which may be optional), the fish are subject to a treatment that kills and/or weakens the parasites. This may include chemical treatments, for example, some sort of osmotic de-regulation that may be used in the first zone for killing, paralyzing, and/or weakening the parasites. Optionally, or in addition, the pH level of the sea water in the first treatment zone may be adjusted up or down, or both, to speed and increase the effectiveness of the treatment. Other substances such as hydrogen peroxide may be used. Other treatments

may include varying temperature, salinity, dissolved gases, light exposure, or any other methods including sound, pressure, ultrasound, electrostatic, electromagnetic, laser, and/or plasma exposure that may kill or weaken the parasites. The parasites may be killed or weakened by the treatment(s) in the first treatment zone. Some parasites may be weakened or temporarily paralyzed but still attached to the fish. Other parasites may be released from the fish in the first treatment zone.

In the second treatment zone, physical treatments, (e.g., fish agitation, water jets sprayed through air at the fish) remove parasites from the fish. The removed parasites and their eggs (if any) may be collected by the system, killed (if still alive) and may be used as food (e.g., food for the fish that were previously treated), or for other purposes. The dead parasites may also be collected and simply discharged back into the ocean. This also applies to the parasite's egg-strings and loose eggs. Preferably, the fish are not stressed or harmed, the environment is not harmed, and the method and system are cost effective. 90-100% of the parasites may be removed from the fish using the systems described herein.

Featured is a system for removing parasites from fish comprising a conduit through which individual fish pass, a plurality of arms associated with the conduit circumferentially spaced with respect to each other, a treatment head unit for each arm for dislodging parasites from the fish, and means for adjusting the arms for closely spacing the head unit with respect to the fish.

In some versions, the head unit includes at least one nozzle connected to a fluid source. The fluid source may be temperature controlled. In some designs, the nozzle is

connected to a particulate source. Also, the head unit may include a vacuum head.

Preferably, the nozzle is set at a predetermined angle with respect to the surface of the fish and the system further includes means for maintaining said predetermined angle. In one design, the head unit includes a shoe pivotably attached to the arm and the nozzle is affixed to the shoe. The arm may include a ball pivotably received in a socket attached to the shoe. The shoe may include spaced fingers and the nozzle is positioned between the spaced fingers. The system may further include means for adjusting the nozzle. In one design, the means for adjusting oscillates the nozzle and/or changes the angle of the nozzle about one or more axes.

The system may further include a sensor subsystem configured to recognize features on the fish. The nozzle can be adjusted depending on a sensed fish feature.

The nozzle may be a ball nozzle received in a socket in the head unit and the means for adjusting includes one or more drivers associated with the head unit socket engaging the ball nozzle. In some designs, the arm constitutes a bar linkage pivotably attached to, or in proximity to, the conduit. A spring associated with a bar linkage biases it away from the conduit.

In some versions, the conduit includes a flexible chute circumferentially expandable to accommodate different sized fish. The arms may extend from a ring disposed about the chute and extend and retract based on the size of the fish in the chute.

The system may further include a treatment zone upstream of the conduit where fish are pretreated to kill parasites, paralyze the parasites, weaken the parasites, and/or weaken the attachments of any parasites on the fish.

Also featured is a method of treating fish. Fish travel from a pen to a first treatment zone where the fish are pretreated to kill any parasites on the fish, to weaken any parasites on the fish, and/or to weaken the grip of any parasites on the fish. The fish are singulated and/or oriented for travel through an inclined or vertical conduit of a second treatment zone. At the second treatment zone, at least one treatment head is maintained at a near constant effective distance with respect to the fish body surface to dislodge parasites from said fish. After treatment the fish are discharged.

The fish in the first treatment zone may proceed therethrough in a batch or continuous process. Maintaining the treatment head position may include using one or more pivoting arms with a treatment head mounted thereto. Maintaining the treatment head may include using one or more extendible and retractable arms with a treatment head mounted thereto. The conduit may include a flexible chute.

The fish may move continuously through the first treatment zone while being pretreated. The treatment head may produce a fluid spray directed at the fish. The fluid spray may be temperature controlled. The fluid spray may is preferably maintained at a predetermined angle relative to the surface of the fish. The fluid spray may oscillate. The fluid spray may adjust between different spray angles relative to the surface of the fish. The fluid spray angle may adjust depending on a fish feature being treated. The method may further include killing said dislodged parasites.

The subject invention, however, in other embodiments, need not achieve all these objectives and the claims hereof should not be limited to structures or methods capable of achieving all of these objectives.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Other objects, features and advantages will occur to those skilled in the art from the following description of a preferred embodiment and the accompanying drawings, in which:

Figs. 1A and 1B are a block diagram showing an example of the primary components associated with a system for and method of treating fish where the first treatment zone is a batch subsystem;

Fig. 2 is a schematic view showing an example of a treatment system in accordance with the block diagram of Figs. 1A and 1B;

Fig. 3 is block diagram showing the primary components associated with an example of a system for and method of treating fish where the first treatment zone is continuous;

Fig. 4 is a schematic view showing an example of a system in accordance with the block diagram of Fig. 3;

Fig. 5 is a schematic view showing an example of a mechanism for treating fish in the first treatment zone;

Fig. 6 is a schematic view showing another mechanism for treating fish in the first treatment zone;

Fig. 7 is a schematic view showing another example of first and second treatment zones;

Figs. 8A-8C are schematic views showing examples of spray heads mounted on

pivoting arms in the second treatment zone keeping the spray head nozzles at a constant or near constant close distance and/or at a near constant, predefined angles with respect to the surface of the fish as it proceeds through the second treatment zone;

Fig. 9 is a schematic view showing an example of a spray head extending from a shoe member;

Figs. 10A-10C are schematic views showing a fish traveling through an example of the second treatment zone where the spray heads are mounted to four bar linkages;

Fig. 11 is a schematic view showing fish directed through a radially expandable chute and spray heads arranged on extendible and retractable pistons mounted to a ring disposed about the expandable chute;

Figs. 12-14 are schematic views of spray nozzles attached to a radially expandable chute;

Fig. 15 is a view showing how the spray nozzles maintain a constant jet angle to the surface of the fish and a constant water jet force along the surface of the fish;

Fig. 16 includes views of another fish treatment system;

Fig. 17 is a schematic side view showing another example of a fluid spray head pivotably mounted to a pivoting arm;

Fig. 18 is a schematic view showing the head unit of Fig. 17;

Figs. 19-21 show examples of a nozzle unit pivotably attached to the end of an arm and driven to rotate about 3 different axes to adjust the spray angle relative to the fish surface;

Fig. 22 is a schematic view showing an example of a head unit with a fluid nozzle

that is actively oscillated and/or varied in angle with respect to the surface of the fish;

Fig. 23 is a schematic view showing a socket unit shown in Fig. 22 and including omni-wheel drivers;

Figs. 24-26 are schematic views showing nozzles producing curved fan jet sprays arranged in stages; and

Fig. 27 is a schematic view showing another head unit including a vacuum head and a steam head.

DETAILED DESCRIPTION OF THE INVENTION

Aside from the preferred embodiment or embodiments disclosed below, this invention is capable of other embodiments and of being practiced or being carried out in various ways. Thus, it is to be understood that the invention is not limited in its application to the details of construction and the arrangements of components set forth in the following description or illustrated in the drawings. If only one embodiment is described herein, the claims hereof are not to be limited to that embodiment. Moreover, the claims hereof are not to be read restrictively unless there is clear and convincing evidence manifesting a certain exclusion, restriction, or disclaimer.

Fig. 1 shows an example of a system for removing parasites from fish kept in pen 10 (which may be in the ocean). The system may, for example, be located on a vessel such as a barge or well boat. See US 2016/0244130, incorporated by reference herein.

Fish in pen 10 are transported in sea water to the first treatment zone 12. Various mechanisms can be used to transport fish in sea water, which may include: vacuum

pumps, conveyors, or Archimedes' screws. See WO 2014/129908 and also WO 2014/184776 both incorporated by reference herein.

In first treatment zone 12, the fish may be treated with a substance (e.g., a solution) introduced into the treatment zone 12 as shown at 16. An exemplary dwell time may be 2-30 (e.g., 5) minutes. Preferred is an osmotic deregulator which weakens, paralyzes, and/or kills sea lice on the fish. Examples include Brine (CaCO_3), iodine, potassium iodide, and lactic acid (e.g. four parts per thousand). Other possible treatments include known chemicals and compounds. Adjusting other variables, such as dissolved gases, salinity, and temperature, in conjunction with an osmotic deregulator or other treatment substance may decrease treatment time and improve effectiveness. The pH level of the water in treatment zone 12 may be adjusted to decrease treatment time and improve effectiveness. See, U.S. 8,759,073 incorporated by reference herein. For example, sodium hydroxide may be used to raise the pH of the sea water while maintaining a safe level of pH and exposure time for the fish to approximately 10.0. Hydrochloric acid may be used to lower the pH of the sea water to approximately 4.0 while maintaining a safe level of pH and exposure time for the fish. Again, the dwell time, in one example, may be between two and thirty (e.g., five) minutes. If needed, the water output from treatment zone 12 may be treated again to bring it back to a nominal pH level (e.g., 8.3). Ozone may also be used in treatment zone 12. See, for example, WO 2014/129908 and WO 2013/066191 (both incorporated herein by this reference). The water temperature in the first treatment zone may be controlled to improve the effectiveness of the treatment and to improve the general health of the fish during

treatment.

In treatment zone 12, some or all of the parasites will be killed or at least weakened. One or more of the above described treatments as well as others may be used in treatment zone 12. The parasites may be weakened to the point they are not as strongly attached to the fish. Some parasites may be removed from the fish.

The fish are then preferably transferred to second treatment zone 18 where a physical treatment is preferred to remove parasites from the fish. Treated fish with reduced parasites are then returned to a pen. The fish may optionally be sedated for the treatment in the first and/or second zone.

The system may further include separation zones 22a, 22b, and 22c where lice (and/or their eggs) in the sea water and/or another solution present in the system are collected and exterminated at station 24. UV radiation may be used. Other extermination means may be used. The dead sea lice may be transported to storage vessel 26 for use as fish food, for example. The separation zones may include, for example, grates, filters, and the like through which water and any sea lice (and/or their eggs) pass but fish are directed to a different path. These separation zones ensure the parasites do not reattach themselves to the fish and ensure that any eggs do not mature into parasites. There may be a singulation and/or orientation mechanism 28 upstream of treatment zone 18 so only a single fish at a time, oriented head first, enters treatment zone 18. Singulation and/or orientation may also be performed manually with a mechanism to present the fish to human operators for this purpose. Sea water may be sprayed on the fish in treatment zone 18 via pump 14b. Pump 14c may be used to pump sea water at separation zone 22b

to mix with the treatment solution at 16 which is pumped into treatment zone 12. Any removed sea lice and egg strings in the system due to spraying of the fish, scraping of the fish, and/or due to movement of the fish, or treatment of any kind of the fish, may be removed from the system in separation zone 22c where water and removed sea lice are directed to extermination zone 24. In some examples, the fish are not swimming in the sea water in second treatment zone 18.

Fig. 2 shows an example where a series of gates 30a and 30b are used. Fish are brought into optional separation zone 22a via conduit 40 with gate 30a open and gate 30b closed until a predetermined amount of fish are present in chamber 32a of treatment zone 12 in sea water. Weighing or some other process may be used to determine when a sufficient number of fish are present in chamber 32a.

A treatment solution or compound such as shown at 16 is then pumped into chamber 32a to treat the fish for a predetermined dwell time after which gate 30b is opened and, the fish may be singulated and oriented at station 28 to travel within one or more conduits, 42a, 42b, 42c of treatment zone 18. The fish, after mechanical treatment in treatment zone 18 then pass through separation zone 22c and back into a pen.

A continuous flow system is shown in Fig. 3. Continuous flow may be beneficial as the fish may be treated faster enabling a higher throughput through the system. Continuous flow may also have the advantage of exposing each fish more precisely to the treatment desired for the precise amount of time. Here, in treatment zone 12, the fish are treated while they are singulated or at least in smaller groups and moving in water. Fig. 4 also shows an example where treatment zone 12 is a continuous flow process as opposed

to a batch process. Still, the fish spend a predetermined time in treatment zone 12 via, for example, a serpentine conduit 50. Alternatively, a motorized Archimedes screw 60, Fig. 5, inside conduit 62 may be used. In another version shown in Fig. 6, coiled conduit 64 is fixed to motorized shaft 66 for treating fish 67 for a predetermined dwell time in the first treatment zone 12. In still another version, the pocket feeder mechanism of U.S. 2005/0158430, incorporated by reference herein, may be used. Thus, the fish may be moved along in water through first treatment zone while being treated using one or more of the mechanisms described above (or a similar mechanism).

Also, whenever the fish must be transported from one location to another in the overall system, the subsystems shown in Figs. 5 - 7 or the pocket feeder mechanism of U.S. 200/0158430 may be used. Other subsystems may be used as well.

Fig. 7 shows an example of a system where a motorized vertical conveyor 70 is used to bring fish 67 in sea water up to separation zone 22a where the sea water is removed from the system at separation zone 22 through filter 72. Lice in the sea water may be further filtered out, killed, and collected as noted above.

Optionally, a treatment substance as shown at 16 is introduced into the sea water in vertical conveyor 70 to treat the fish and kill or at least weaken the sea lice or other parasites as the fish move upwards in the conveyor. The pH of the sea water may be raised or lowered, a chemical or biological agent may be used, the water may be warmed or cooled, and/or an osmotic treatment may be used. Other treatments may be used as well. Thus, in this example, the device which moves the fish into the system is also the first treatment zone.

Then, the fish, now in air, travel in downwardly inclined conduit 42 and are subject to mechanical treatment in treatment zone 18. Preferably, the treatment zone 18 constitutes a continuous treatment subsystem. In one preferred embodiment, a series of circumferentially oriented treatment heads (e.g., spray heads) 80 are used. For example, there may three sets of spray heads with four or eight spray heads in each set. If four spray heads are used, they may be oriented 90° apart and if eight spray heads are used they may be oriented 45° apart. The spray heads function to dislodge the parasites from the fish. In separation zone 22b, there is a grate or filter as shown at 73 for removing from conduit 42 any fluid ejected by the spray heads. Again, any sea lice (and/or eggs) in this fluid may be filtered out, collected, and/or destroyed. The conduit may be inclined to provide the optimal velocity and efficacy e.g., between 5 and 90° with respect to horizontal. Killing the eggs in the system can prevent lice from these eggs from returning which could create further problems.

Featured in some embodiments are treatment heads which are urged close to the fish 67 no matter their size. Also, the spray heads may be configured to always spray a fluid, (e.g., water or gas) at a constant angle relative to the fish outer surface. A treatment substance may also be added to the fluid supplied to the spray heads.

In systems with fixed spray heads, small fish may not receive enough of a pressurized spray to dislodge sea lice and a large fish may receive a pressurized spray at too high a pressure and/or velocity, and/or momentum which damages the fish scales, eyes, fins, or the like. This problem is addressed in the subject invention.

Also, any given fish body is small in diameter at the head, then larger in the

middle, and then smaller again at the tail. Fixed in place spray heads do not account for this change in fish geometry. This problem too is addressed in the subject invention as discussed below. Finally, prior systems sprayed fluid towards the fish while the fish were in water. The water generally diminishes the effectiveness of the fluid jet spray by diminishing the jet velocity and/or impact pressure, and/or momentum. This problem too is addressed in the subject invention since the fish preferably travel in conduit 42 in air or other medium. In prior systems, if the fish in water passed too close to a given fixed jet spray head then the fish could be harmed including any damage to the eyes or other sensitive areas.

Fig. 8A shows an example where spray head 80 is mounted to the distal end of arm member 90 pivotably attached inside downwardly inclined conduit 42. Fluid is supplied to spray head 80 via hose 92. Arm 90 is biased away from conduit 42 via compression spring 94. Spray head 80 may be further fitted with a shoe 96 which may pivot relative to arm 90 and which is biased via a spring 98 to an orientation parallel with the longitudinal axis of the conduit. As shown in Fig. 9, spray head 80 may rise above shoe 96 and includes a nozzle 98. The nozzle 98 may be configured for delivering a fan spray of fluid. The fan spray could be curved in shape conforming to the fish body. In some embodiments, the nozzle and/or the spray head may pivot with respect to the arm it is mounted to. The spray head may then oscillate (e.g., between angles of 0 to 90° or less). Shoe 96 may include rear upwardly sloping end 97 and spaced forward fingers 99a and 99b each including an upwardly sloping ski tip portion as shown.

In Fig. 8A, the spray from a nozzle (see nozzle 98, Fig. 9) is shown to be

tangential to the surface of the fish. In other embodiments, the spray may be at an angle relative to this tangent (e.g., 0-90°). The nozzle may also deliver a spray angled appropriately to clean underneath and/or behind fins, gills, and the like. The lateral orientation of the nozzles may be +/- 90° along the front to back of the fish.

Shoe 96 may be made of or include a slippery top surface (e.g., Delrin or Teflon or similar type material) so as not to harm the fish. The shoe may also function to scrape parasites off the fish body. As shown in Figs. 8A-8C the arms pivot so at all times the spray head is kept very close to the fish body no matter its size and, for a given fish, close to its small head, larger body, and smaller tail as the fish passes through the system. The spray head nozzle, in all cases, is also kept aligned to spray fluid at a selected optimized angle between 0 and 90 degrees rearward along the fish body to more effectively dislodge parasites and eggs from the fish while not harming scales, gills, and fins.

In this way, the jet spray is more effective: the cleaning spray is in air, the spray nozzle is kept a near constant distance from the fish no matter its size or what portion of orientation anywhere along the circumference of the conduit the fish is being treated, and the jet spray remains at a near constant angle relative to the fish body. With the cleaning sprays in air, little energy is lost from the spray as it moves through air to the lice and fish surface. Alternatively, if the fish and spray jets are in water, as long as the spray nozzle is kept a near constant distance from the fish and a near constant angle relative to the fish body, the spray pressure may be adjusted to remain effective.

In Figs. 10A-10C, the spray heads 80 are attached to four bar linkages 100. Preferably, the spray heads are attached to top bar 102 thereof. Top bar 102 is then

attached via pivots 104 and 106 to bars 108 and 110 which are pivotably attached via pivots 112 and 114 to the conduit 42 wall (the fourth "bar").

By using a four bar or other linkage, the spray head nozzle is kept at a constant distance from the fish body and at a constant angle relative to the longitudinal axis of the conduit. The linkage keeps the spray head at a constant angle with respect to the pipe wall as the linkage and the spray head follows the outer surface of the fish moving by. With pivoting shoes on the outer bar, the head will follow the fish surface and keep the jet spray angle constant with respect to the fish surface while bar 102 stays parallel to the pipe wall. Compression spring 116 between arms 108 and 110 may be used to bias the four bar linkage away from the conduit (e.g., at a 90° angle relative to the longitudinal axis of the conduit wall).

In some examples, opposing spray heads may be 1-2 inches apart from each other (when the arm is 90° to the conduit), the spray heads may be disposed a near constant distance of 1-2 inches from the fish body, may provide a fluid spray at a pressure, for example, of 25-200 PSI and at a flow rate, for example, of 0.5-1 GPM to effectively remove parasites. Closer distances of the nozzle to the fish may be possible (e.g., 1-2 mm). Fan shaped sprays or other shapes may be used to optimize treatment coverage on the surface of the fish regardless of the shape and size of the fish. Different sets of nozzles may be in stages of the process to give maximum efficiency. The fan nozzles may overlap as needed for the biggest fish (bigger circle) and thus the longest circumference and distance between the nozzles. In one example, the final cleaning of the fish to remove salmon lice and eggs may be done by "curtain" nozzles. Flat shaped

jets or jets that are made out of a slit in the circumference of the tube that face inwardly may be used, to make the pressure variation less dependent on the distance from the head of the jet.

There are other means for adjusting the arms depending on the size of the fish and the conduit and for closely spacing the spray head nozzles with respect to the fish. For example, Fig. 11 shows singulated and oriented fish in a vertical or angled conduit which here is in the form of a flexible conforming transversely or circumferentially or radially expandable chute 42' (e.g., a net, mesh, or the like). See, for example, U.S. Patent No. 4,705,141, incorporated by reference herein.

The material of the chute may assist in scraping sea lice or other organisms off the surface of the fish in the second treatment zone 18. The material of the chute, however, should be configured to allow the water jet to reach the surface of the fish body. In this example, there is a ring 120 disposed about the chute and the spray heads 80 (in this example 8 spray heads) are mounted on piston arms 122 extending inwardly from the ring 120. Ring 120 may form a distributor for the fluid delivered to it via hose 92 and thus is configured to deliver the fluid to the individual spray heads via their respective arms. This radially expandable chute may also act as a speed controller, so the fish is constantly treated equally over its length passing the nozzles at a controlled speed.

The piston arms may extend and retract based on the size of fish 27 in the chute and the area being treated (e.g., head, body, tail) to keep the spray nozzles of the spray head at a constant or near constant close distance to the surface of fish 27. Preferably, the spray nozzles of the spray heads are oriented to spray rearwardly along the body of fish

27 to effectively remove parasites and to prevent damage to the scales of fish 27. The piston arms may be actuated. The spray heads may also rotate as shown by arrow 81 (e.g., up and down) to vary the spray angle. Conforming fan sprays may be used.

One or more sensors 130 may be used to sense the distance of the body of fish 27 from the ring 120 (or, alternatively, a nozzle). The output of the sensor(s) may be fed to a processor (not shown) which then drives the actuators of the piston arms accordingly to keep the spray heads at a desired distance to the fish body. The sensor subsystem could be based on capacitance, for example, with the exterior of chute 42' including markers which can be sensed by the sensor(s). Other sensor subsystems may be used. In other examples, the nozzles are attached to the material of the chute or sleeve. See Figs. 12-14.

The ring/piston arrangement shown in Fig. 11 may be used, in addition, in conjunction with conduits 42a, 42b, and 42c, Fig. 2, as well provided there are orifices in the conduits for the spray heads and piston arms. In some examples, the second treatment zone includes only one conduit. In other examples, the second treatment zone includes multiple conduits. The nozzles may be used in multiple stages, multiple angles, and/or orientations. Also sensors may be employed to target single salmon lice or more dense populations to make the process more cost effective. This process could also contribute to counting and/ or to verify the quality of the cleaning process in a cost effective way. Also possible is a closed-loop control system with real-time monitoring of key parameters to ensure consistent quality e.g. salinity, temperature, O₂, CO₂, number of fish processed, and the like, the amount of sea lice removed per period of time and the like. Data could be gathered and analyzed over time to provide optimal treatments

amongst the individual treatment centers or groups of treatment centers.

The result in any embodiment is a more effective treatment method and system which is cost-effective and which is ecologically sound.

Fig. 15 shows how the nozzles are configured to maintain a constant jet angle to the surface of the fish and how the nozzles maintain a constant water jet force along the surface of the fish (e.g., adjusting the nozzles so they are kept at a constant or near constant distance from the fish).

Fig. 16 shows an embodiment where two drive belt assemblies urge fish from a treatment tank to another location. The belts may be mesh like in construction so nozzles spray a fluid from inside one or both belt assemblies.

Preferred are means for maintaining a head unit close to, at a constant or near constant distance from, the surface of the fish irrespective of the size of the fish, the portion of the fish being treated, the position of the fish in the conduit, and the like. In Figs. 7-14 the head unit includes at least one nozzle. The nozzle may spray a fluid, for example, liquid or a gas to dislodge lice from the fish. The liquid may be sea water, fresh water, or a chemical or other treatment liquid. The liquid (e.g., water) may be heated or cooled. The nozzles may be configured for delivering a fan spray. The fan spray may have an arc shape configured to conform to the surface of the fish. One or more nozzles may spray a gas such as air (heated if necessary), CO₂, liquid nitrogen, cold air, and the like. Thus, the fluid spray may be temperature controlled. A steam spray may be used.

One or more nozzles may be configured for droplet impingement. One or more nozzles may be configured for particle impingement (e.g., CO₂, ice particles, or the like).

In some designs, the angle of the nozzle relative to the surface of the fish is fixed and yet remains at a constant or nearly constant angle with respect to the surface of the fish.

Fig. 17 shows conduit 42 and arm 90 pivotably mounted thereto. Arm 90 supports head unit 200 which, in this example, includes shoe 96' designed to engage the surface of the fish 67. Shoe 96' is pivotably mounted to the distal end of arm 90 via a spherical joint, for example, ball 202 on the distal end of arm 90 and socket 204 thereabout mounted to shoe 96'. A liner 206 may be provided to reduce friction between the ball and the socket. As better shown in Fig. 18, shoe 96' includes spaced fork members 210a and 210b with nozzle 80 mounted therebetween. In this way, nozzle 80 is able to passively pivot up and down and rotate to keep the nozzle spray at a constant or near constant angle relative to the surface of fish irrespective of the size of the fish, the portion of the fish being treated, the position of the fish in the conduit, and the like. Further included may be a compression spring between arm 90 and conduit wall 42 and a spring/elastic connection 212 between shoe 96' and arm 90 (shown in Fig. 17 in the neutral position). The distance of nozzle 80 from the surface of the fish is kept constant and close to the fish via pivoting arm 90. The result is the surface of the fish passively dictates the position of the jet which will maintain a constant angle with respect to the surface of the fish.

As shown in Figs. 19-21, it may be desirable for the nozzles to oscillate and/or change their angles with respect to the surface of the fish as the fish passes by the nozzles. The nozzles may rotate as shown in Fig. 19 to change the pitch angle of the

spray, vary the yaw angle as shown in Fig. 20, and/or may roll as shown in Fig. 21.

Means may be included to rotate the nozzle about one more axes 220, Fig. 19; 222, Fig. 20; and/or axis 224, Fig. 21. Motors, drivers, and the like may be used.

For example, nozzles may be desired which quickly oscillate between a tangential spray as shown at 226, Fig. 19 and a rearwardly directed angled spray as shown at 228. Motors, drivers, and the like, may be used to provide such oscillations.

In still other designs, the angle of the spray may be adjusted depending on the portion of the fish being treated. For the main body of the fish, a tangential or near tangential spray may be desired. At the head of the fish, a shallow angle, rearwardly directed spray may be desired to protect the eyes and gills of the fish. When the pelvic fin or anal fin are detected, for example, it may be desirable to oscillate or adjust the nozzle along one or both axes 222, Fig. 20, and 224, Fig. 21 to more effectively remove lice behind the pelvic fin or anal fin. Such oscillations may be configured for nozzles aimed at the side and/or bottom of the fish. The same is true for a nozzle aimed at the top of the fish. To more effectively remove lice behind the dorsal fin, oscillations or adjustments of the nozzle angle may be desired about axis 220, Fig. 19; axis 222, Fig. 20; and/or axis 224, Fig. 21.

Figs. 22-23 show one design for a nozzle actively adjusted. Here, head unit 212 is mounted to an arm constituting a bar linkage with members 108 and 110. Head unit 212' includes socket 230 pivotably mounted to the distal end of members 108 and 110. Socket 230 pivotably receives ball nozzle 232 therein. There are means for moving ball nozzle 232 relative to socket 230. For example, socket 230, Fig. 23 may include integrated

drivers 240 and/or 240b shown here as driven omni-wheels which engage the outer surface of the ball nozzle 232 and move it. Driver 240a may change the pitch angle of the spray and driver 240b may change the yaw direction of the spray. Different and/or additional drives may be provided.

The nozzles may oscillate continuously about one or more axes. Alternatively, or in addition, the nozzle spray angle may be adjusted based on the portion of the fish being treated. A sensor 250 is shown in Fig. 22 for detecting features on the fish (e.g., fins, eyes, the tail, the body section, and the like). Distance sensors may be used. An image recognition subsystem may also be used. Other sensing subsystems are possible.

Figs. 24-26 show a system with multiple nozzles, here configured to provide a curved conforming fan spray. Two stages of such nozzles may be used but additional stages are also possible. The nozzles may oscillate and/or the spray angle of the nozzles may be actively or passively adjusted. In other examples, the spray angle remains constant and/or nearly constant. As shown, nozzles 80a, 80b, 80c, and 80d of the first stage are configured to produce a spray having a larger arc than nozzles 80e, 80f, 80g, and 80h of the second stage. Furthermore, the nozzles of the second stage are offset (for example, by 45°) from the nozzles of the first stage for better coverage of the fish body.

Besides nozzles spraying fluid (e.g., treatments and/or temperature controlled fluids or particles), Fig. 27 shows a head unit 200' carrying a vacuum head 250, steam head 252, and flexible hook 254. The steam head preferably weakens lice 256 which is then removed from the fish 67 by suction using the vacuum head which is maintained close to the surface of the fish as discussed above (e.g., via a pivoting arm or a retractable

and extendible arm or the like). Flexible hook unit 254 may further remove lice from the fish body which are sucked away by the vacuum head. Hot air, other gases, liquids, and/or treatments may be used besides steam. In some examples, one or more vacuum heads are used without steam head 252. In other embodiments, the nozzle heads discussed previously are used in conjunction with one or more vacuum heads. Various means have been shown previously which would maintain head unit 200' close to the surface of the fish. Other treatment head units are possible.

Although specific features of the invention are shown in some drawings and not in others, this is for convenience only as each feature may be combined with any or all of the other features in accordance with the invention. The words “including”, “comprising”, “having”, and “with” as used herein are to be interpreted broadly and comprehensively and are not limited to any physical interconnection. Moreover, any embodiments disclosed in the subject application are not to be taken as the only possible embodiments. Other embodiments will occur to those skilled in the art and are within the following claims.

In addition, any amendment presented during the prosecution of the patent application for this patent is not a disclaimer of any claim element presented in the application as filed: those skilled in the art cannot reasonably be expected to draft a claim that would literally encompass all possible equivalents, many equivalents will be unforeseeable at the time of the amendment and are beyond a fair interpretation of what is to be surrendered (if anything), the rationale underlying the amendment may bear no more than a tangential relation to many equivalents, and/or there are many other reasons

the applicant cannot be expected to describe certain insubstantial substitutes for any claim element amended.

What is claimed is:

CLAIMS

1. A system for removing parasites from fish comprising:
a conduit through which individual fish pass;
a plurality of arms associated with the conduit circumferentially spaced with respect to each other;
a treatment head unit for each arm for dislodging parasites from said fish;
and
means for adjusting the arms for closely spacing the head unit with respect to the fish.
2. The system of claim 1 in which the head unit includes at least one nozzle.
3. The system of claim 2 in which said nozzle is connected to a fluid source.
4. The system of claim 3 in which said fluid source is temperature controlled.
5. The system of claim 2 in which the nozzle is connected to a particulate source.
6. The system of claim 1 in which the head unit includes a vacuum head.

7. The system of claim 2 in which the nozzle is set at a predetermined angle with respect to the surface of the fish and the system further includes means for maintaining said predetermined angle.

8. The system of claim 7 in which said head unit includes a shoe pivotably attached to said arm and the nozzle is affixed to the shoe.

9. The system of claim 8 in which the arm includes a ball pivotably received in a socket attached to the shoe.

10. The system of claim 9 in which the shoe includes spaced fingers and the nozzle is positioned between the spaced fingers.

11. The system of claim 2 further including means for adjusting the nozzle.

12. The system of claim 11 in which said means for adjusting oscillates the nozzle.

13. The system of claim 11 in which said means for adjusting changes the angle of the nozzle about one or more axes.

14. The system of claim 13 further including a sensor subsystem configured to

recognize features on the fish.

15. The system of claim 14 in which the nozzle is adjusted depending on a fish feature.

16. The system of claim 11 in which said nozzle is a ball nozzle received in a socket in the head unit and said means for adjusting includes one or more drivers associated with the head unit socket engaging the ball nozzle.

17. The system of claim 1 in which said arm constitutes a bar linkage pivotably attached to, or in proximity to, the conduit.

18. The system of claim 17 further including a spring associated with a bar linkage biasing it away from the conduit.

19. The system of claim 1 in which the conduit includes a flexible chute circumferentially expandable to accommodate different sized fish.

20. The system of claim 19 in which said arms extend from a ring disposed about the chute and extend and retract based on the size of the fish in the chute.

21. The system of claim 1 further including a treatment zone upstream of said

conduit where fish are pretreated to kill parasites, paralyze the parasites, weaken the parasites, and/or weaken the attachments of any parasites on the fish.

22. A method of treating fish, the method comprising:

urging fish from a pen to a first treatment zone where the fish are pretreated to kill any parasites on the fish, to weaken any parasites on the fish, and/or to weaken the grip of any parasites on the fish;

singulating and/or orienting the fish for travel through an inclined or vertical conduit of a second treatment zone; and

at the second treatment zone, maintaining at least one treatment head at a near constant effective distance with respect to the fish body surface to dislodge parasites from said fish; and

discharging the fish.

23. The method of claim 22 in which the fish in the first treatment zone proceed therethrough in a batch or continuous process.

24. The method of claim 22 in which maintaining the treatment head position includes using one or more pivoting arms with a treatment head mounted thereto.

25. The method of claim 22 in which maintaining the treatment head includes using one or more extendible and retractable arms with a treatment head mounted thereto.

26. The method of claim 22 in which said conduit includes a flexible chute.
27. The method of claim 22 in which the fish move continuously through the first treatment zone while being pretreated.
28. The method of claim 22 in which the treatment head produces a fluid spray directed at the fish.
29. The method of claim 28 in which said fluid spray is temperature controlled.
30. The method of claim 28 in which said fluid spray is maintained at a predetermined angle relative to the surface of the fish.
31. The method of claim 28 in which said fluid spray oscillates.
32. The method of 28 in which said fluid spray adjusts between different spray angles relative to the surface of the fish.
33. The method of claim 32 in which the fluid spray angle adjusts depending on a fish feature being treated.

34. The method of claim 22 further including killing said dislodged parasites.

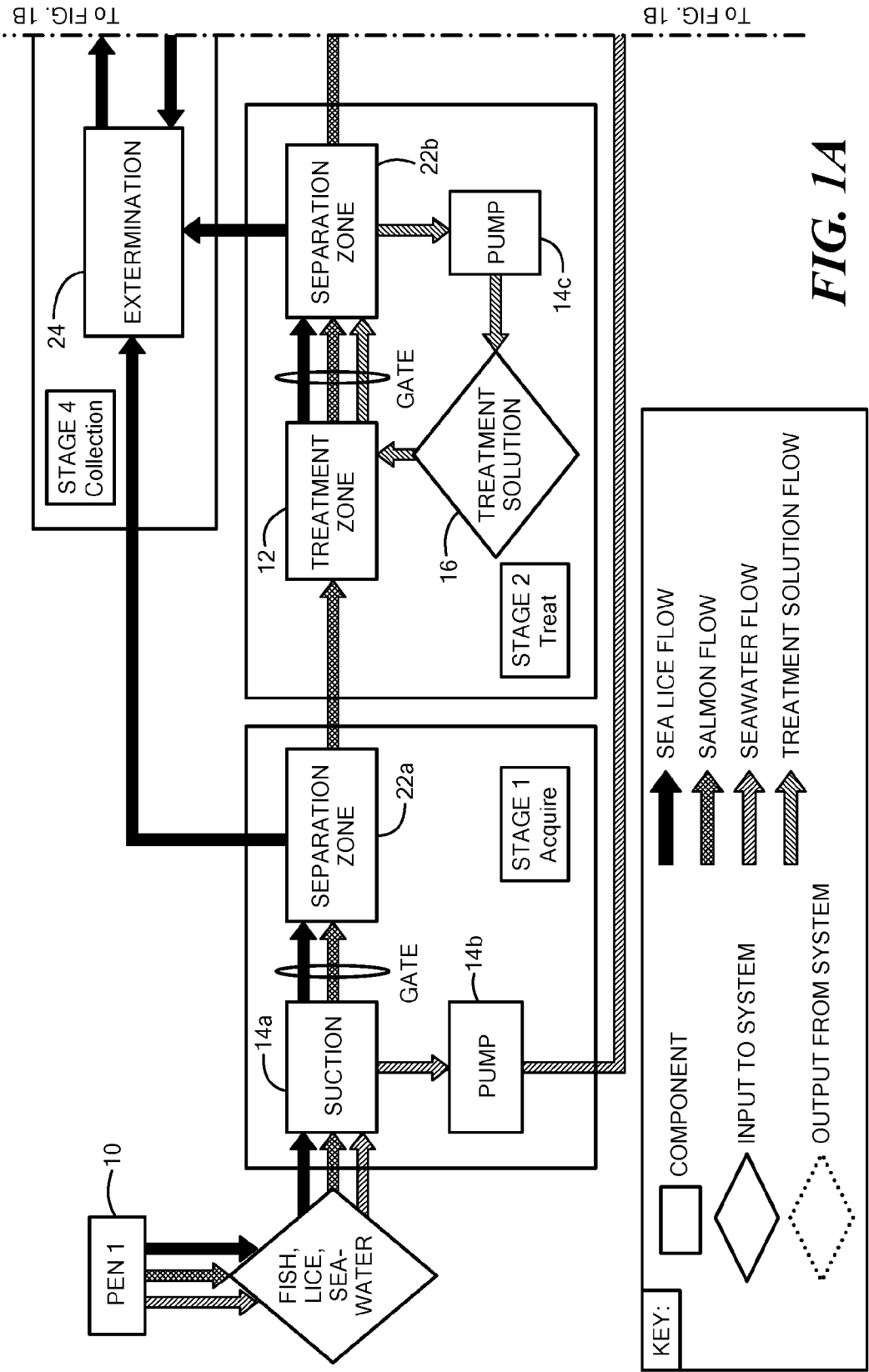


FIG. 1A

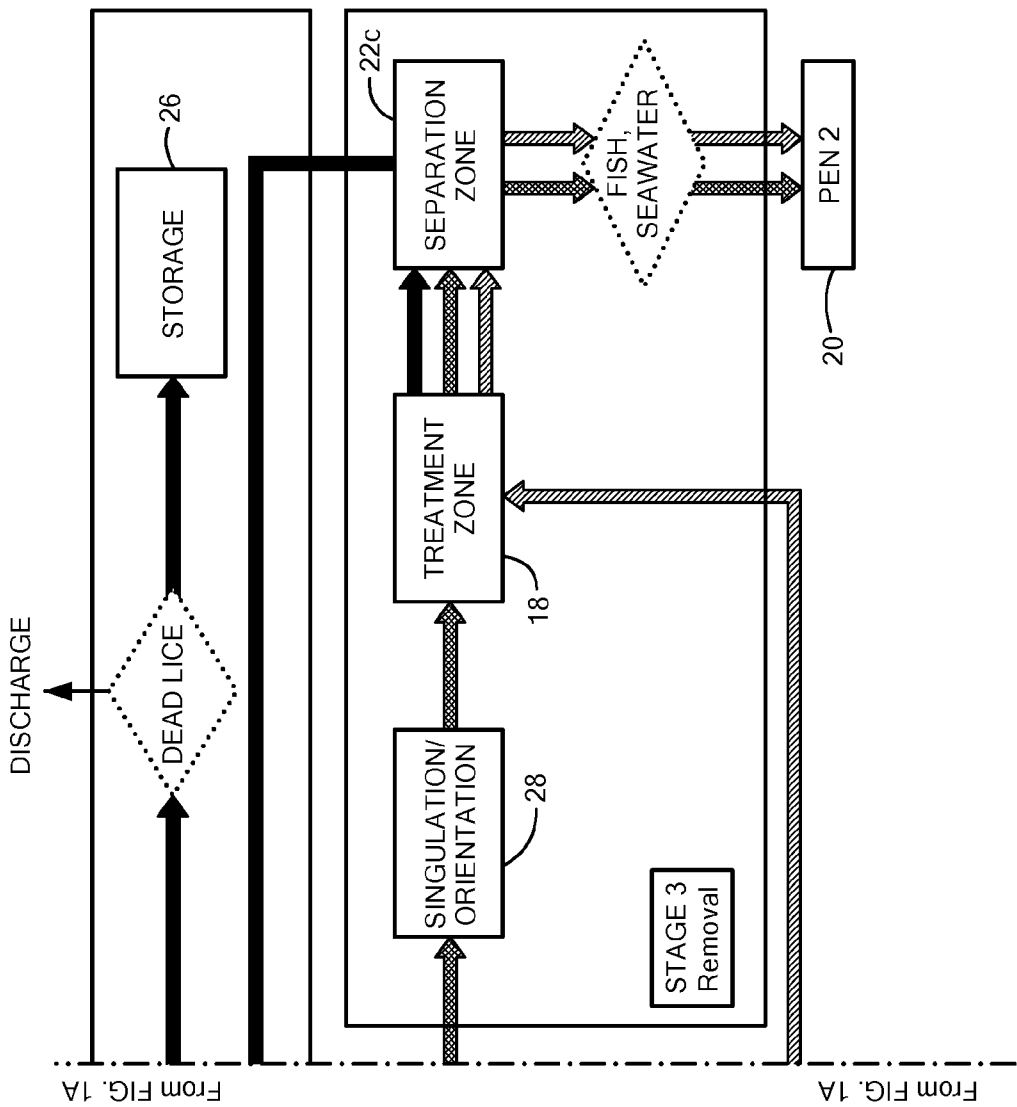
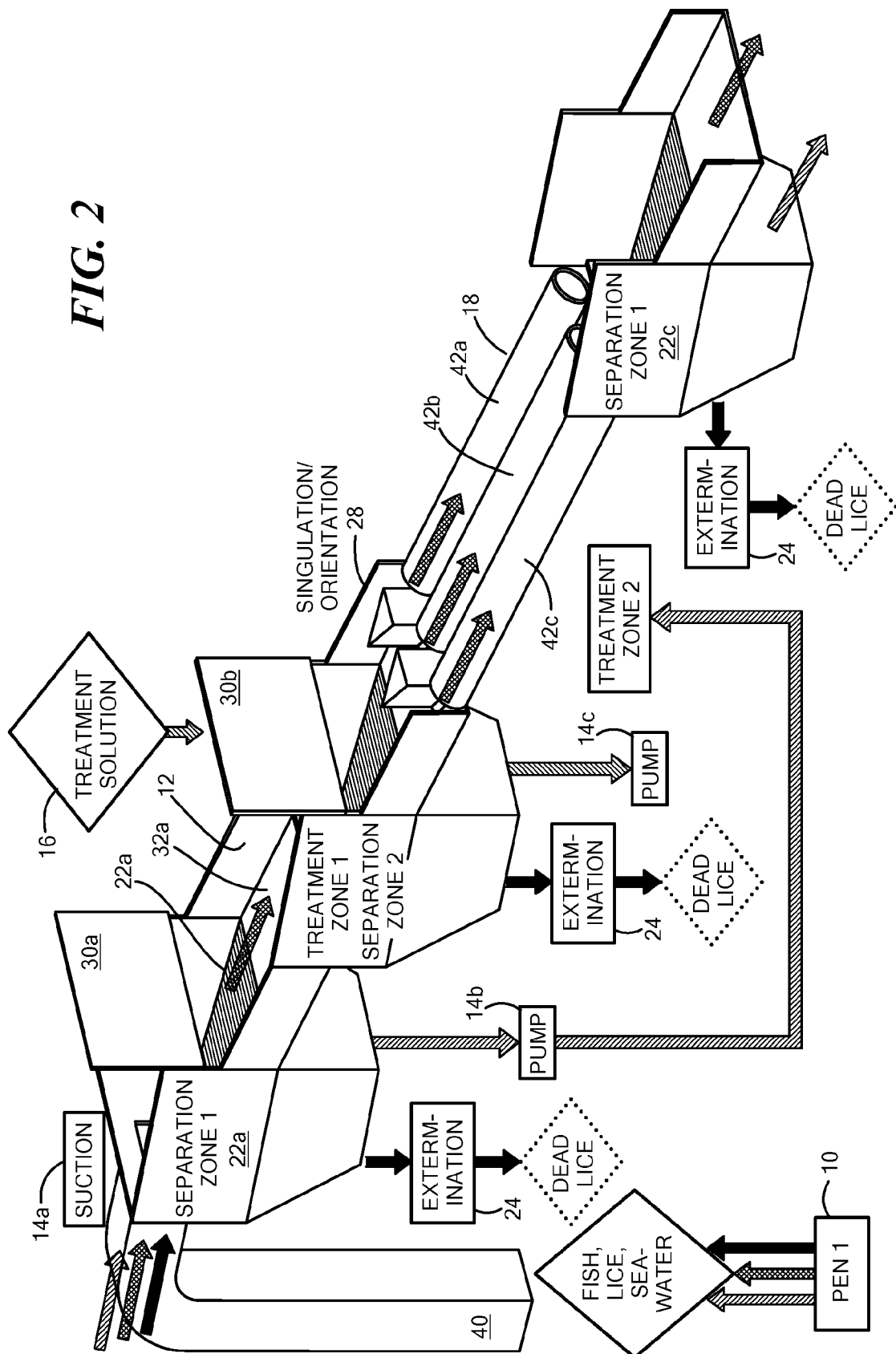


FIG. 1B

FIG. 2



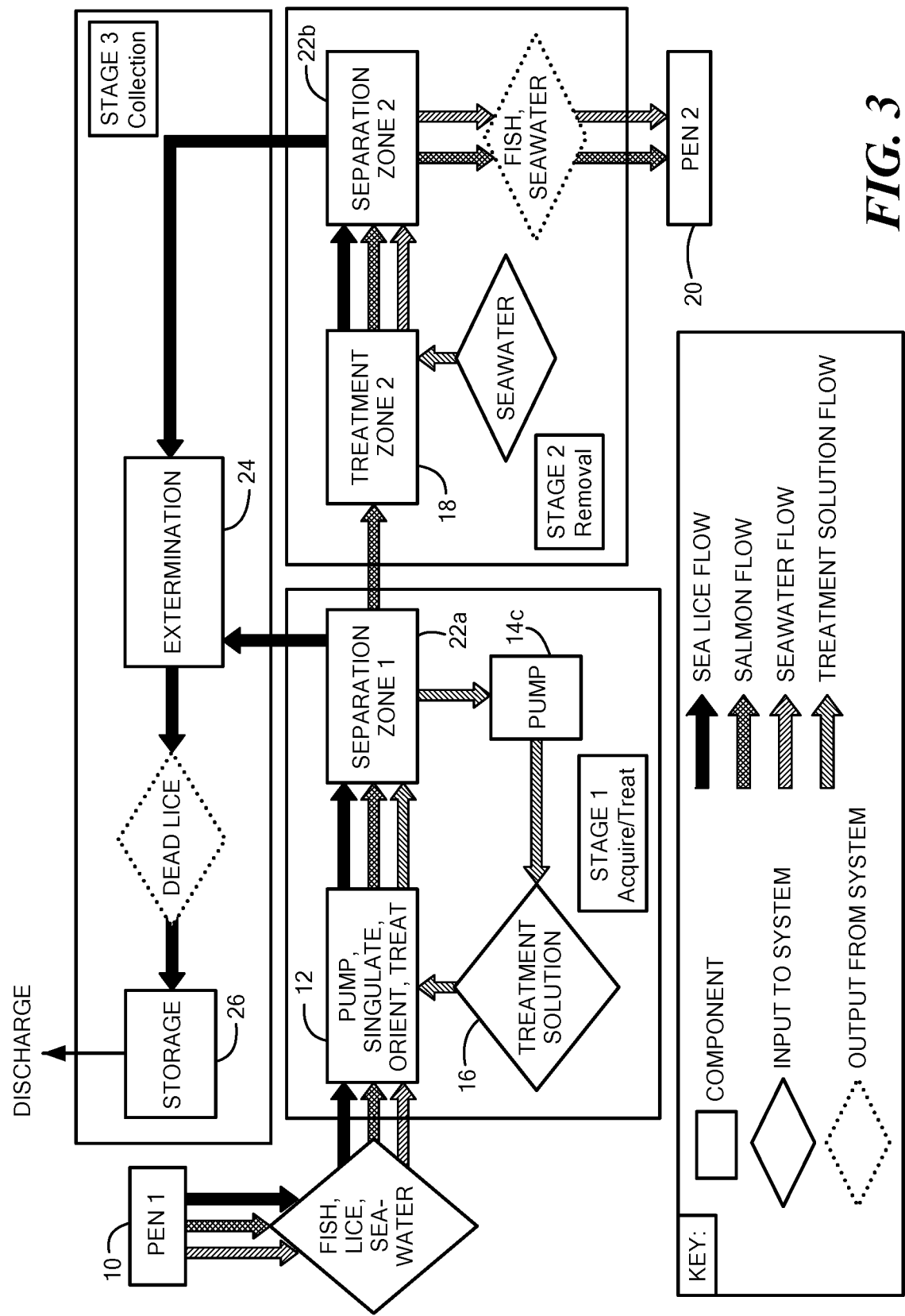
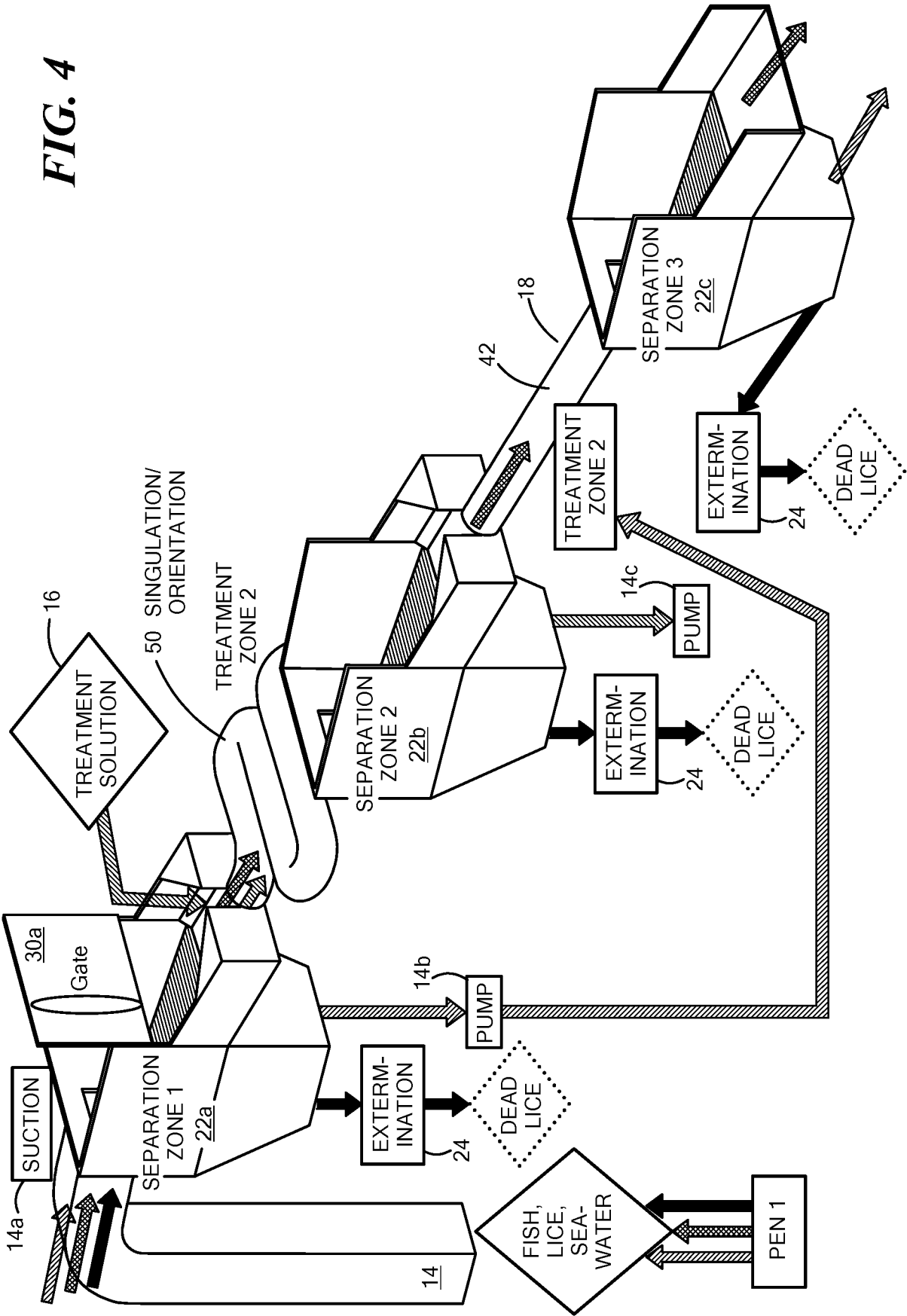


FIG. 3

FIG. 4



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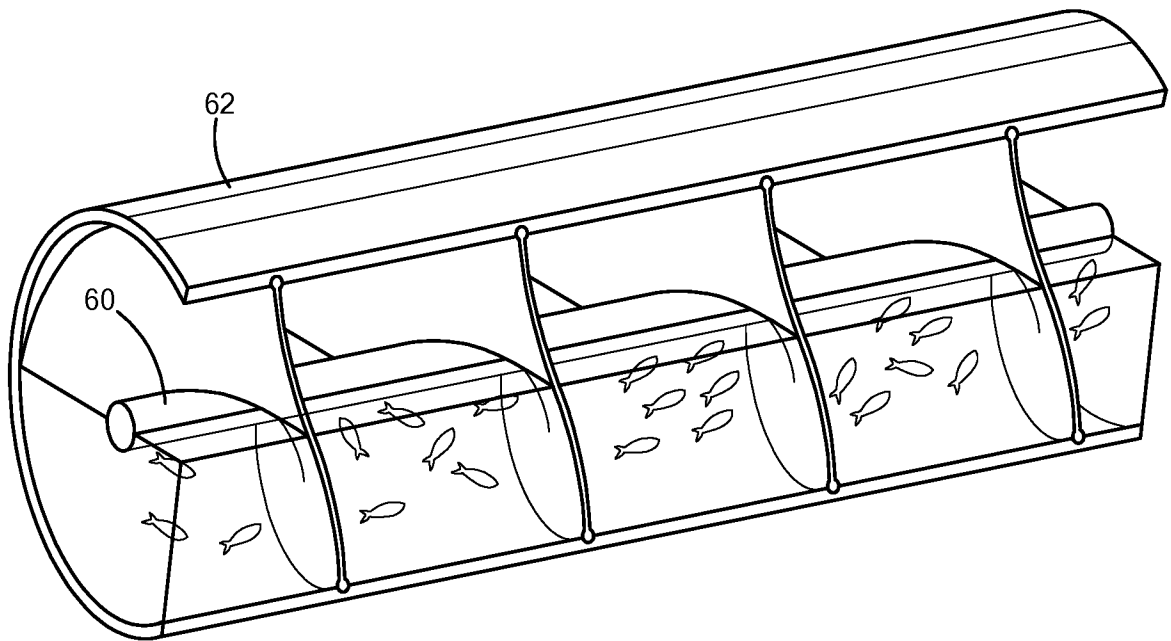


FIG. 5

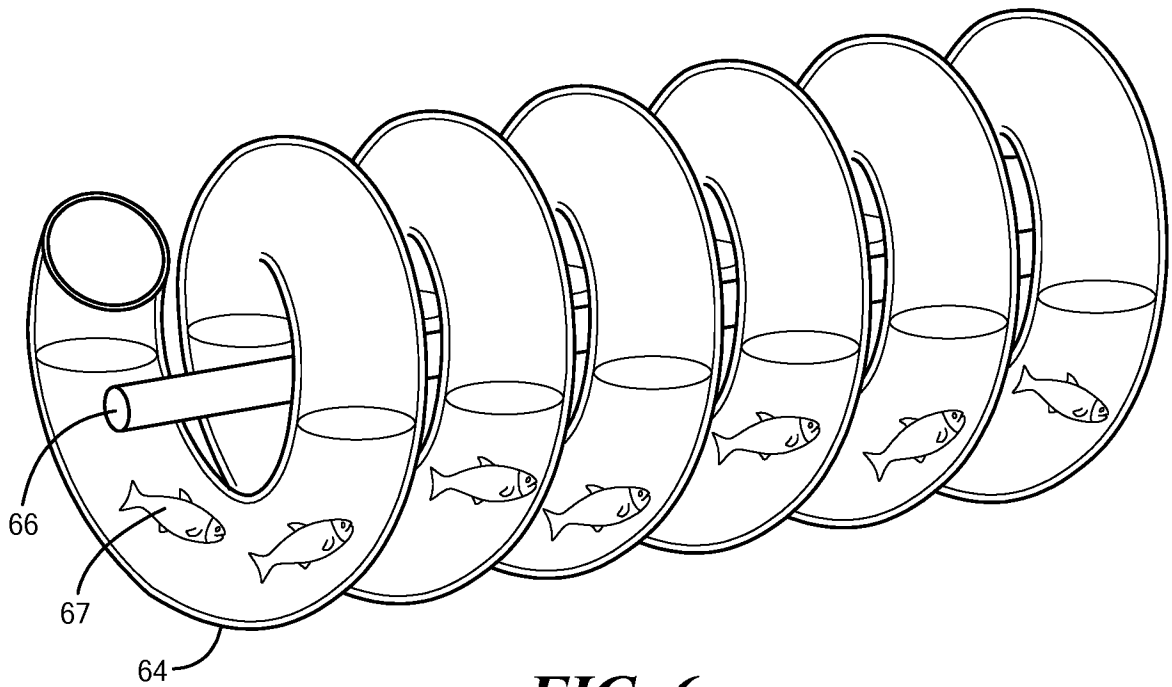


FIG. 6

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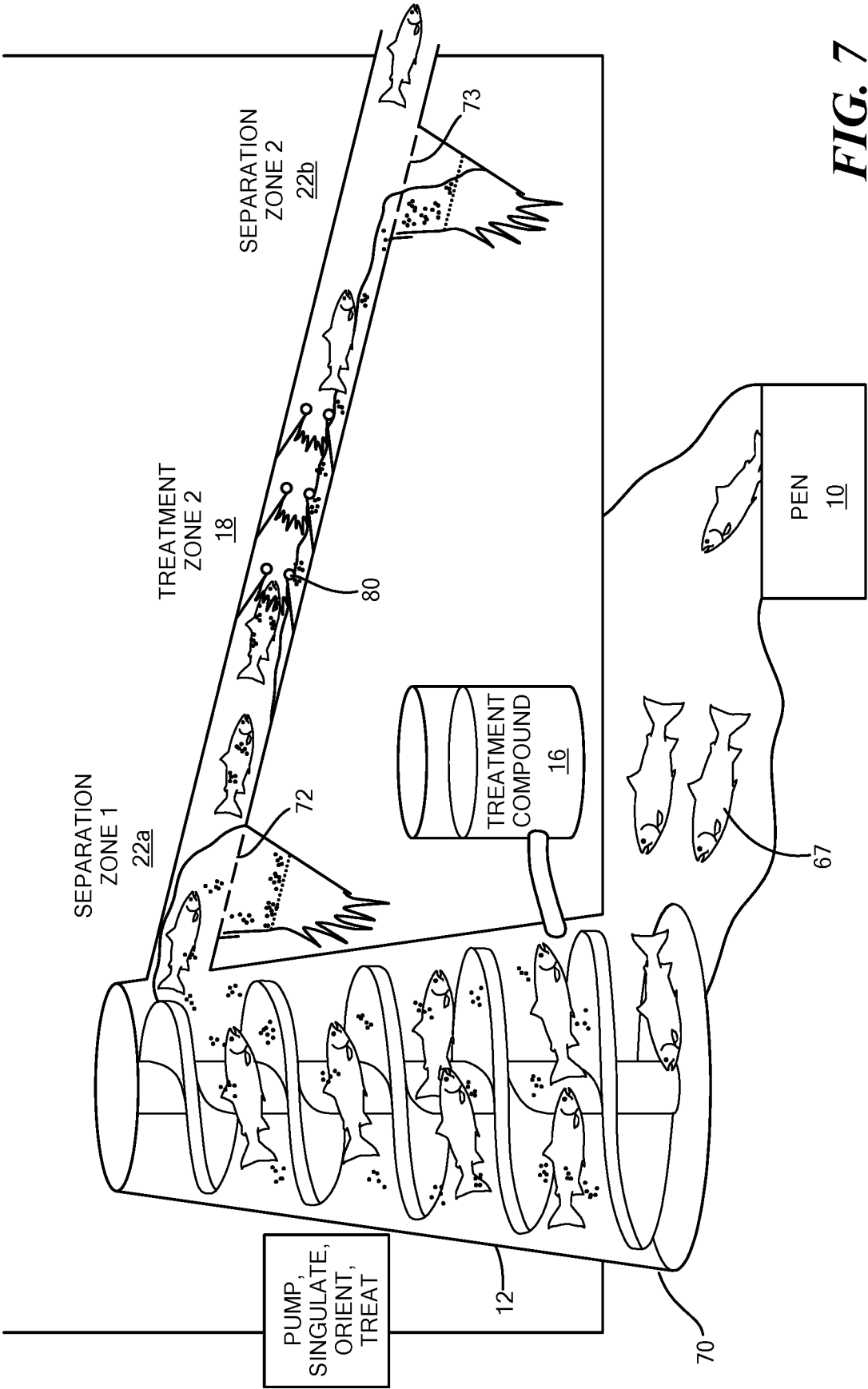


FIG. 7

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FIG. 8A

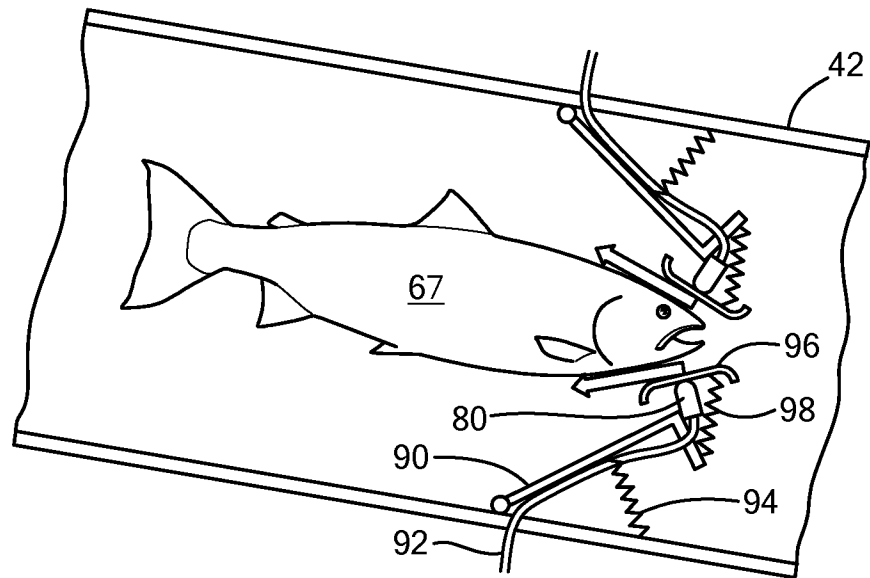


FIG. 8B

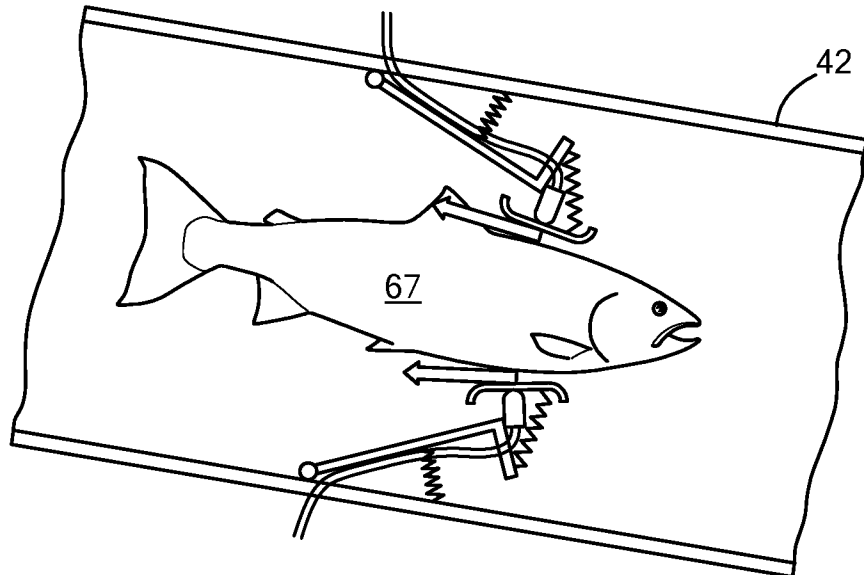
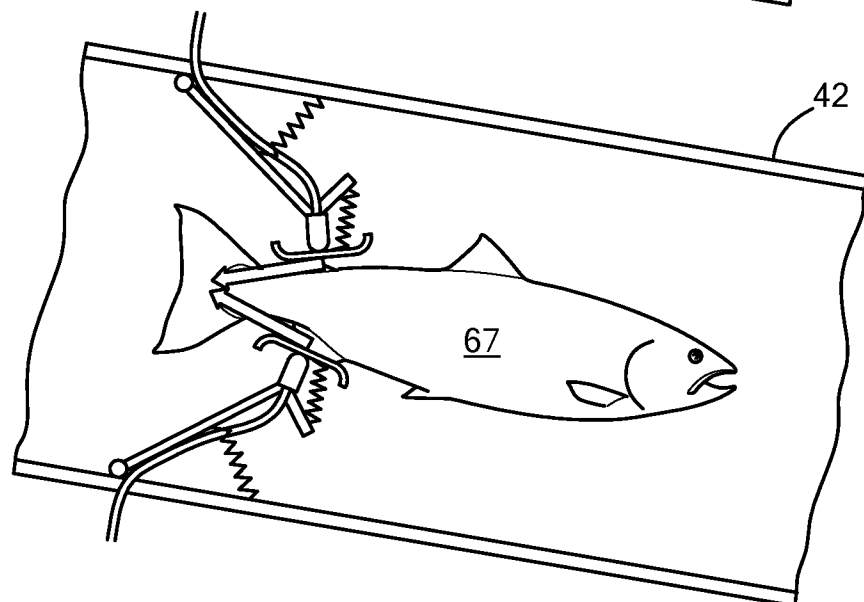
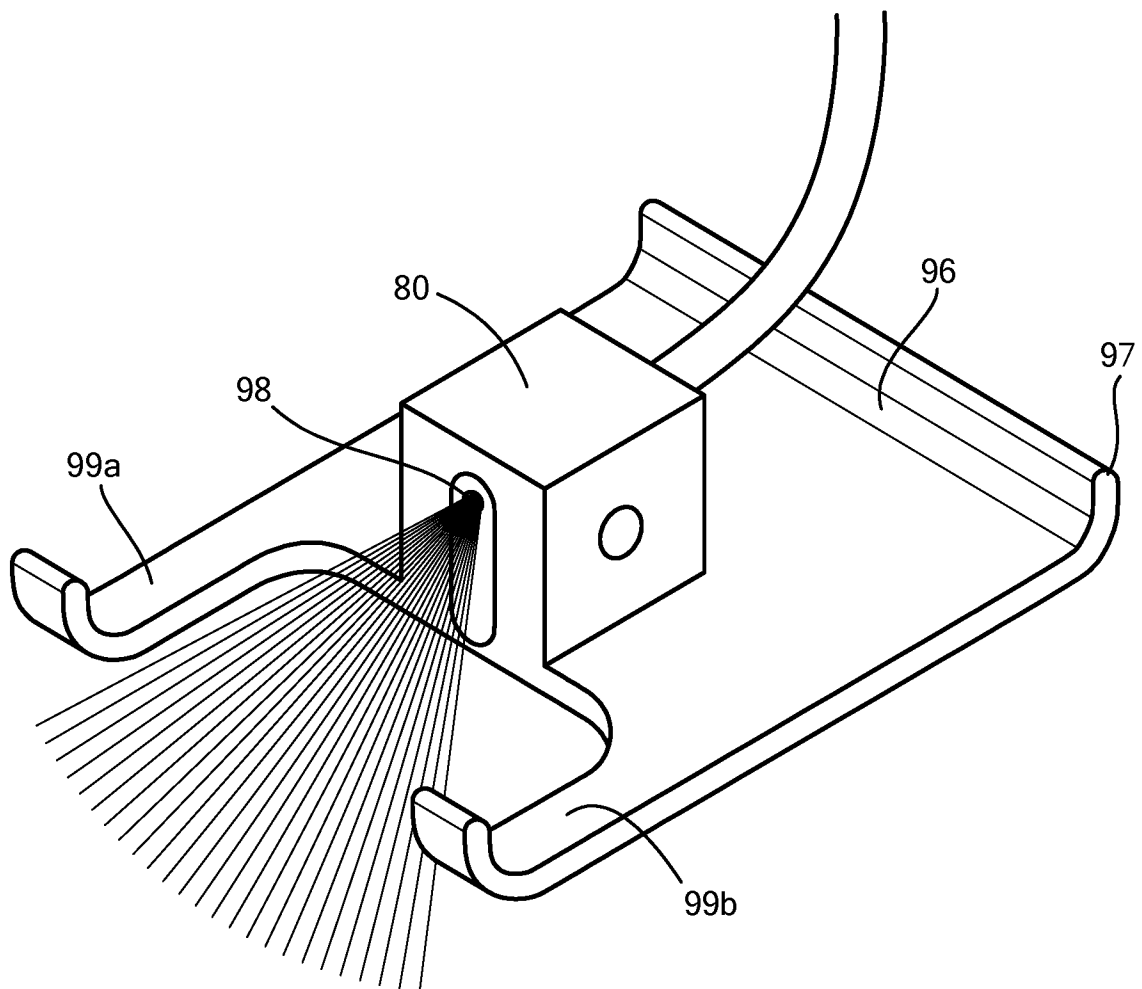


FIG. 8C



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**FIG. 9**

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FIG. 10A

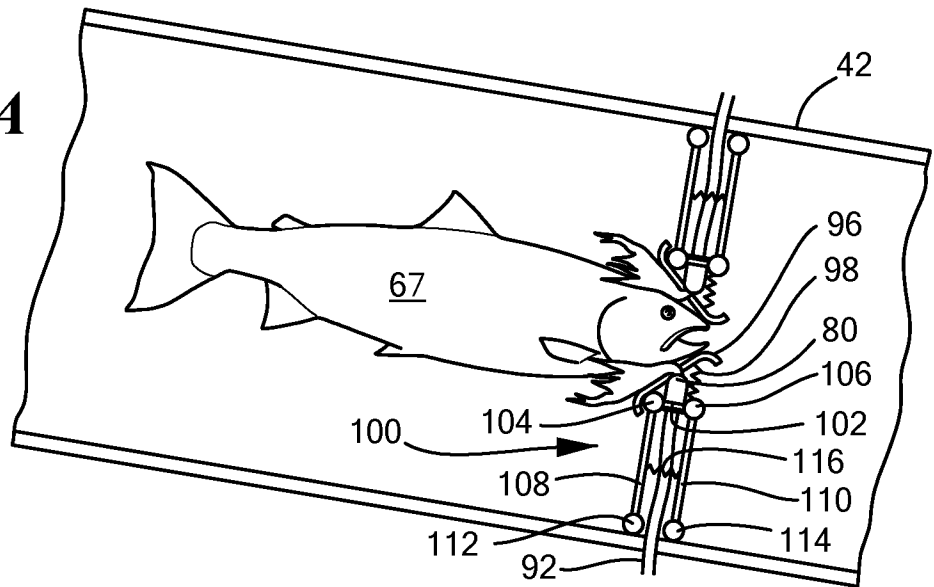


FIG. 10B

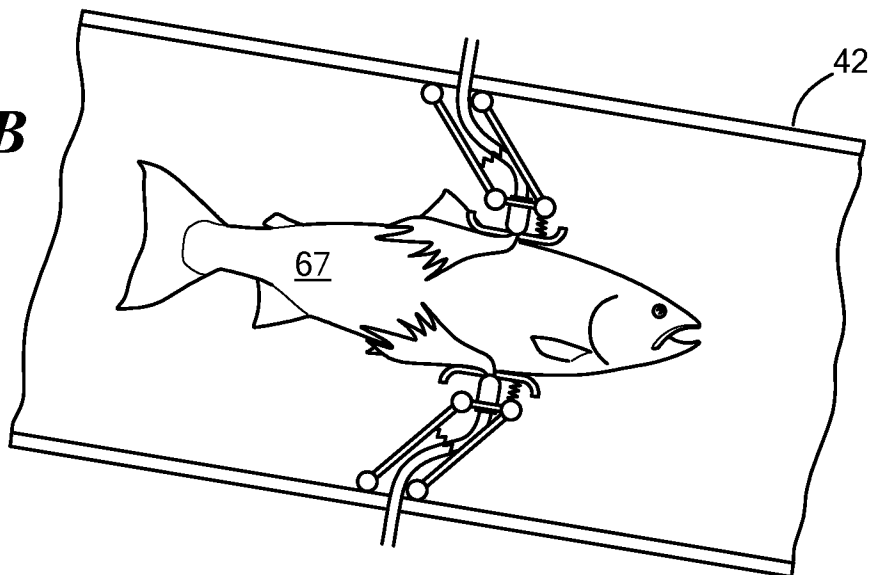
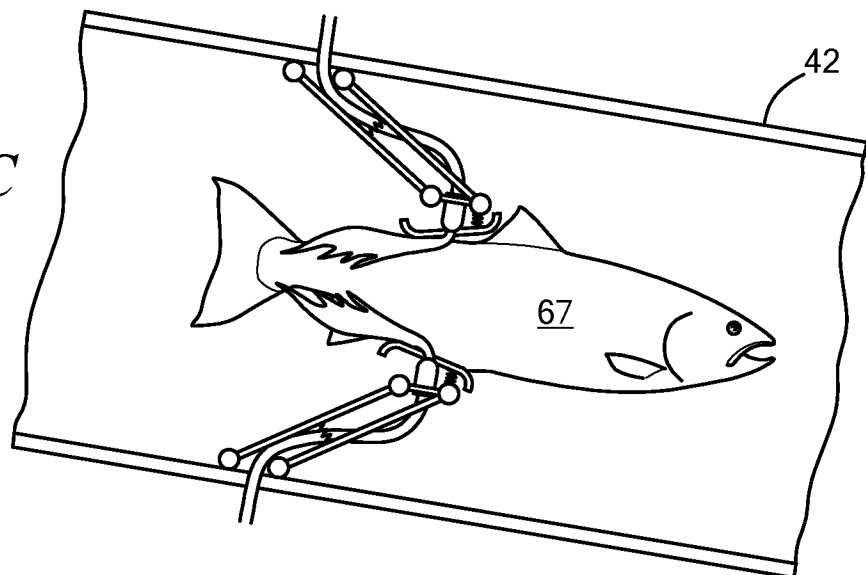


FIG. 10C



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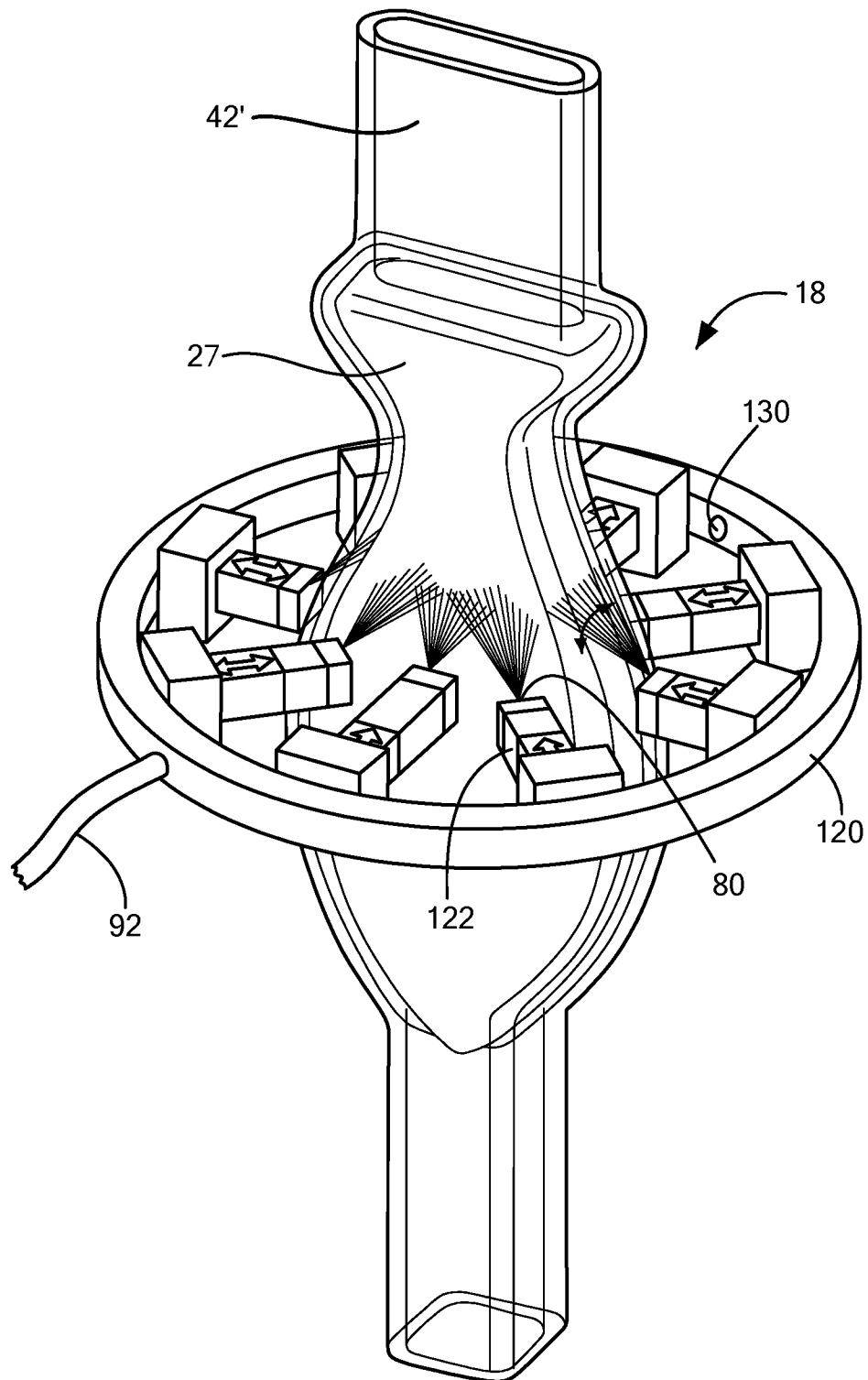


FIG. 11

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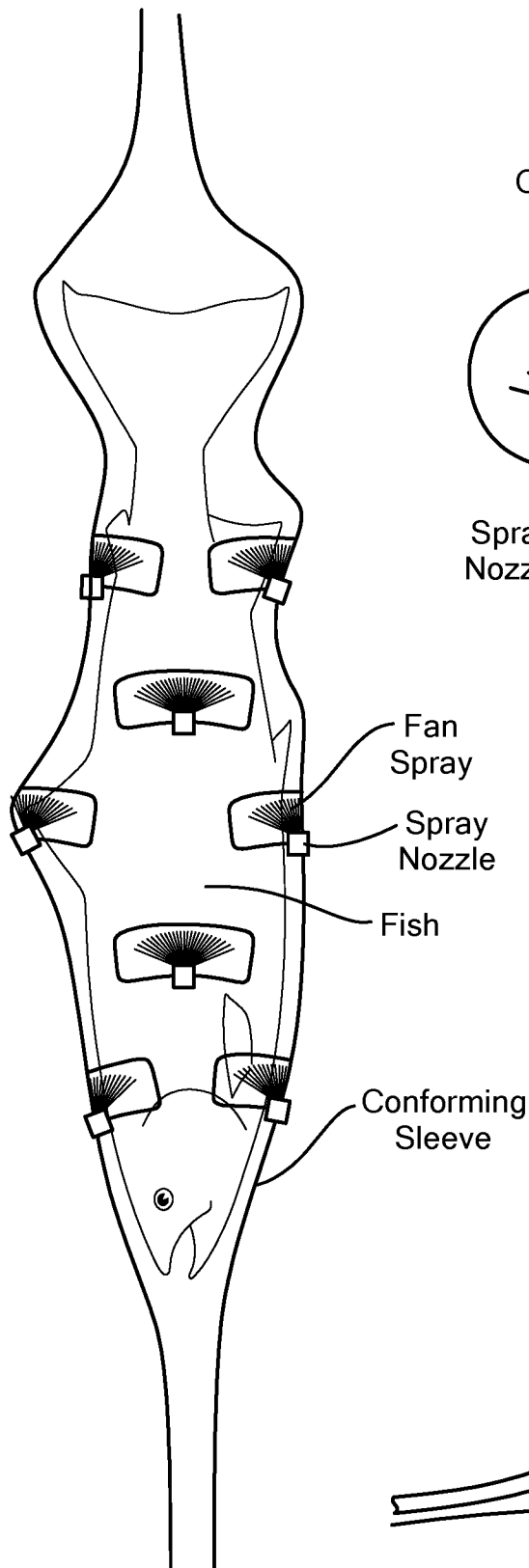


FIG. 12

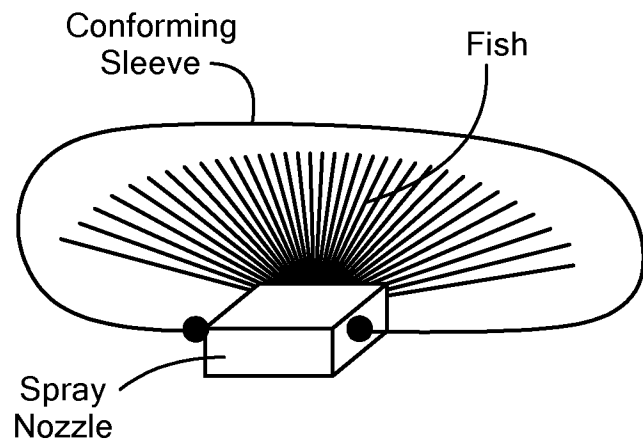


FIG. 13

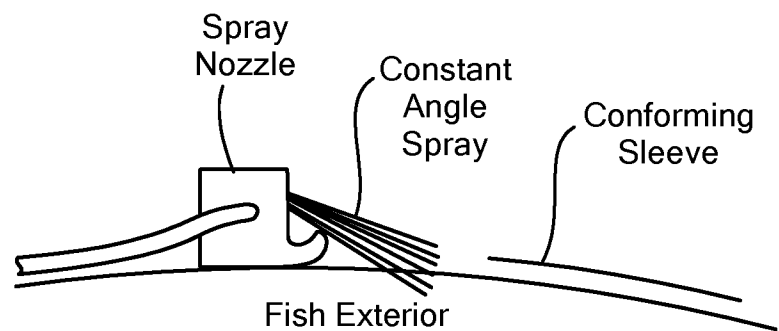


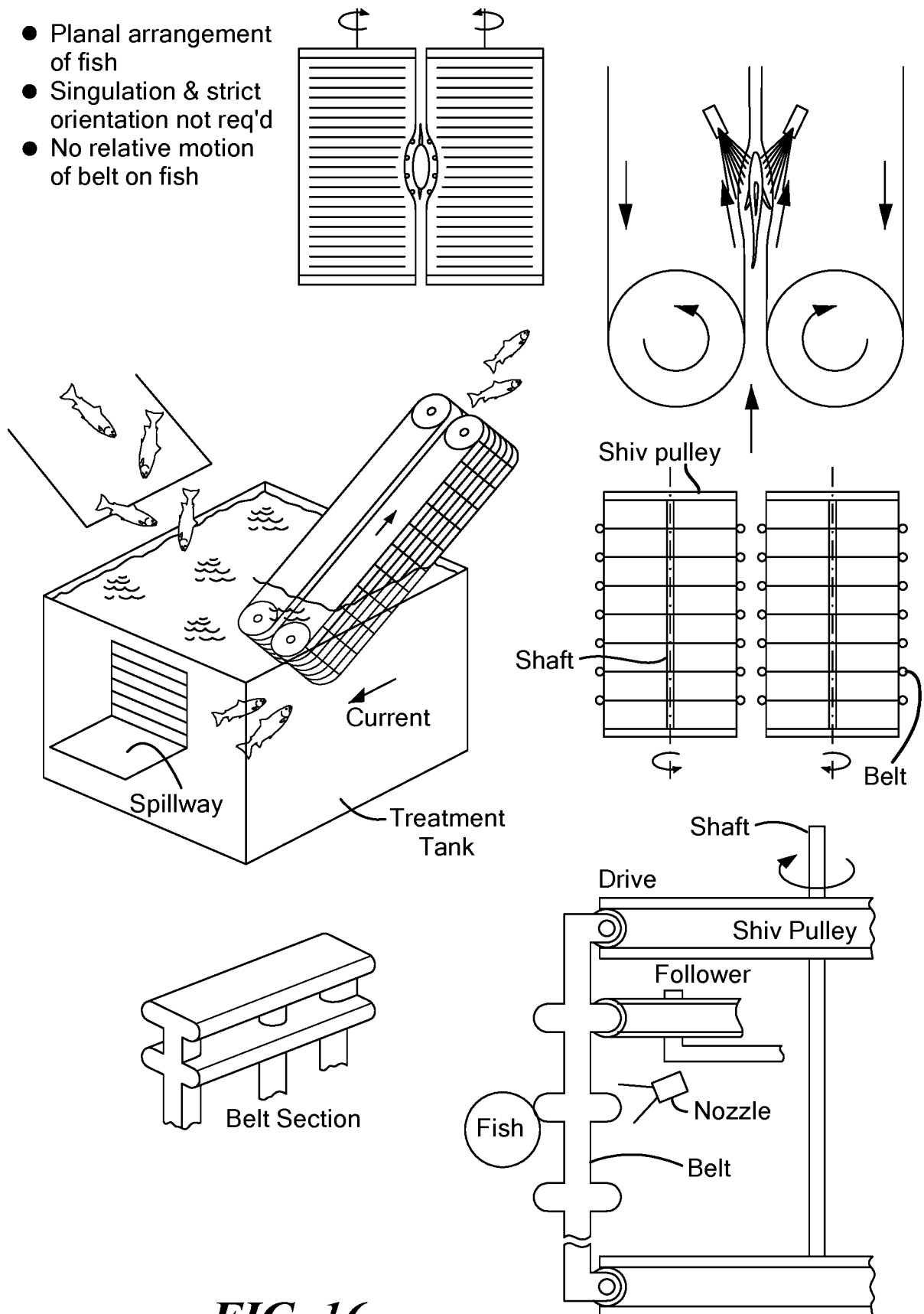
FIG. 14



FIG. 15

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- Planal arrangement of fish
- Singulation & strict orientation not req'd
- No relative motion of belt on fish

**FIG. 16**

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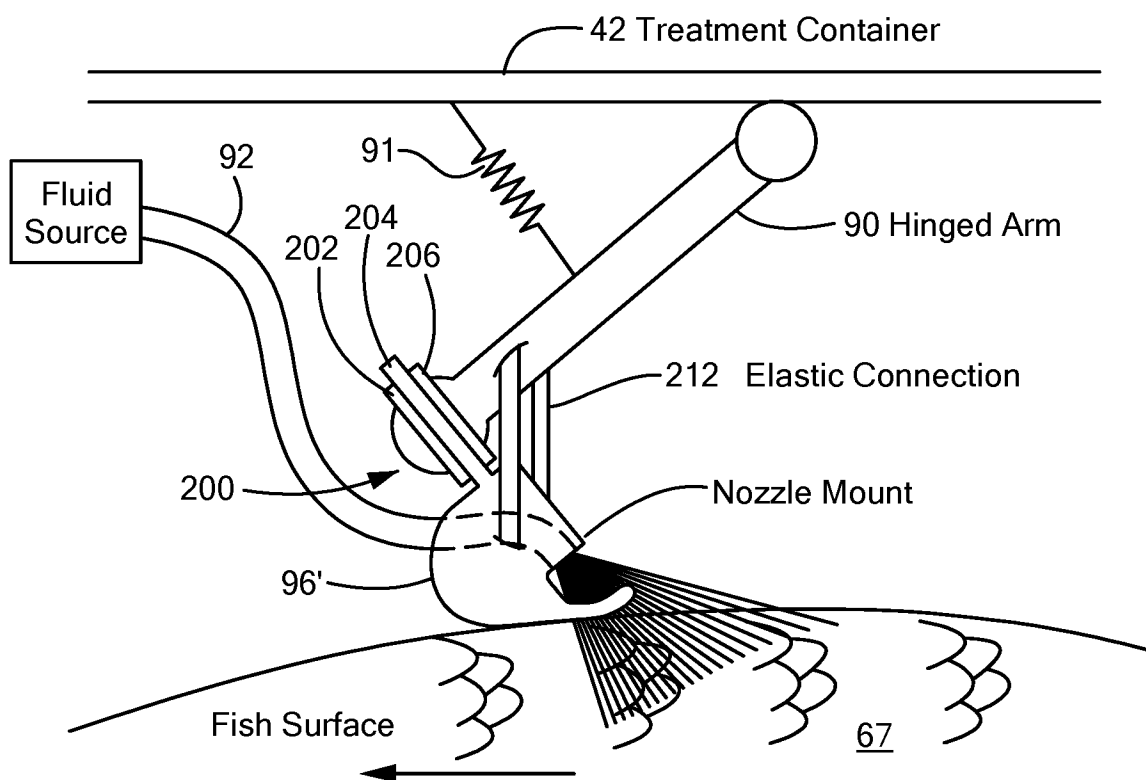


FIG. 17

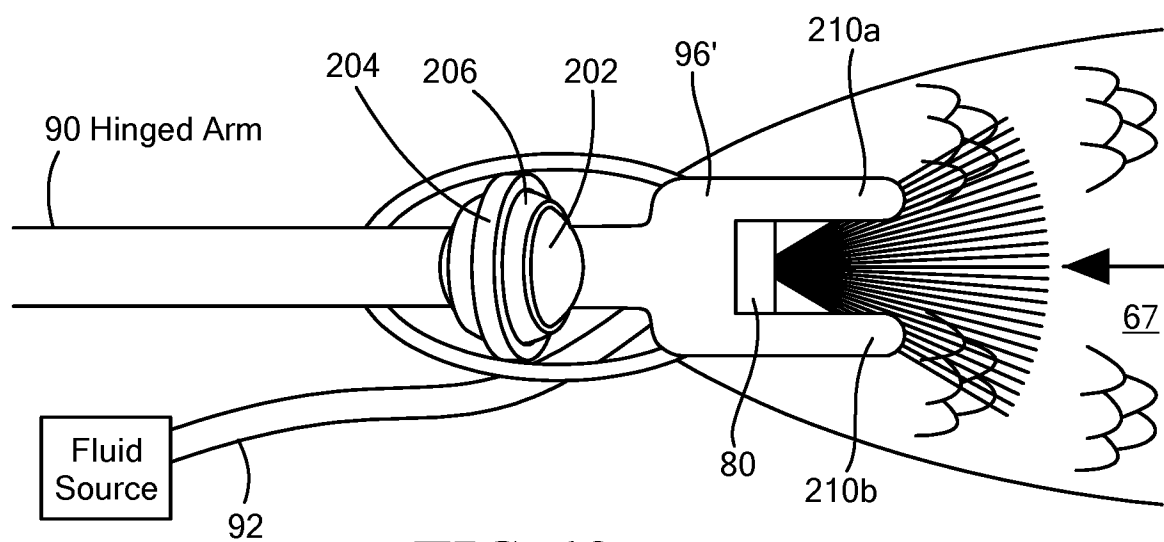
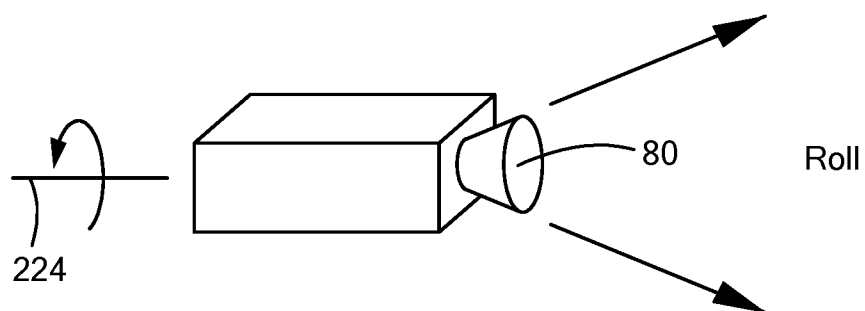
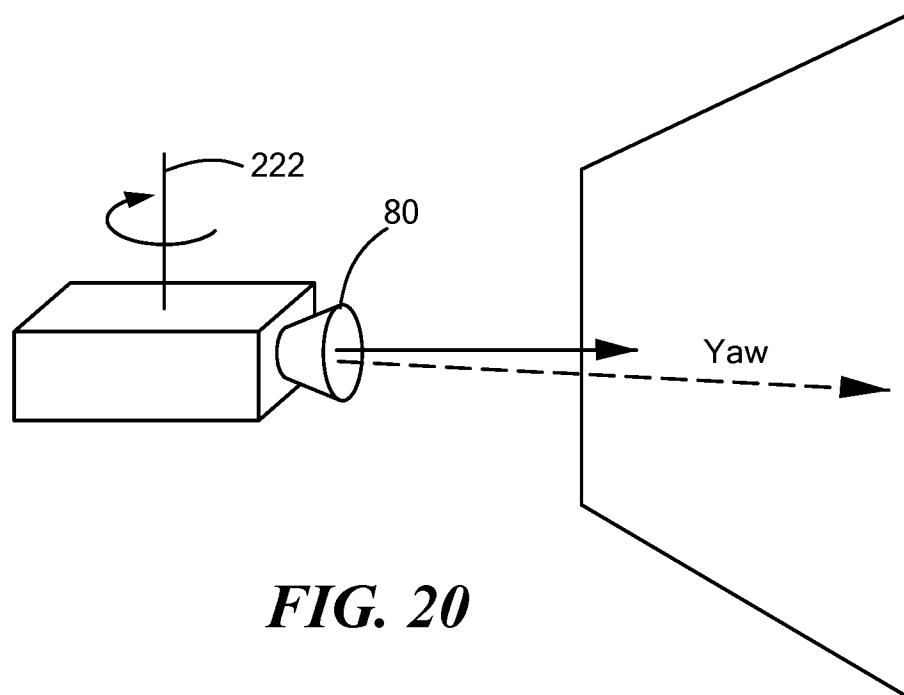
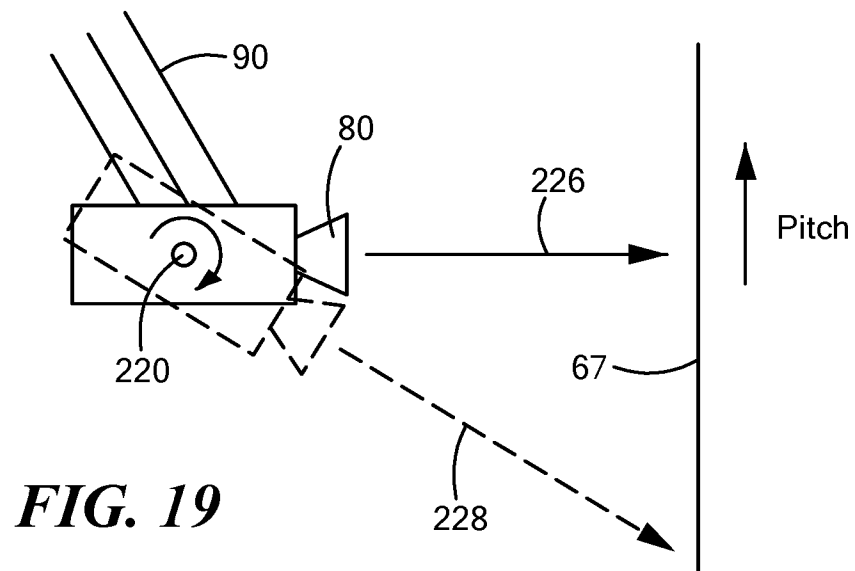


FIG. 18

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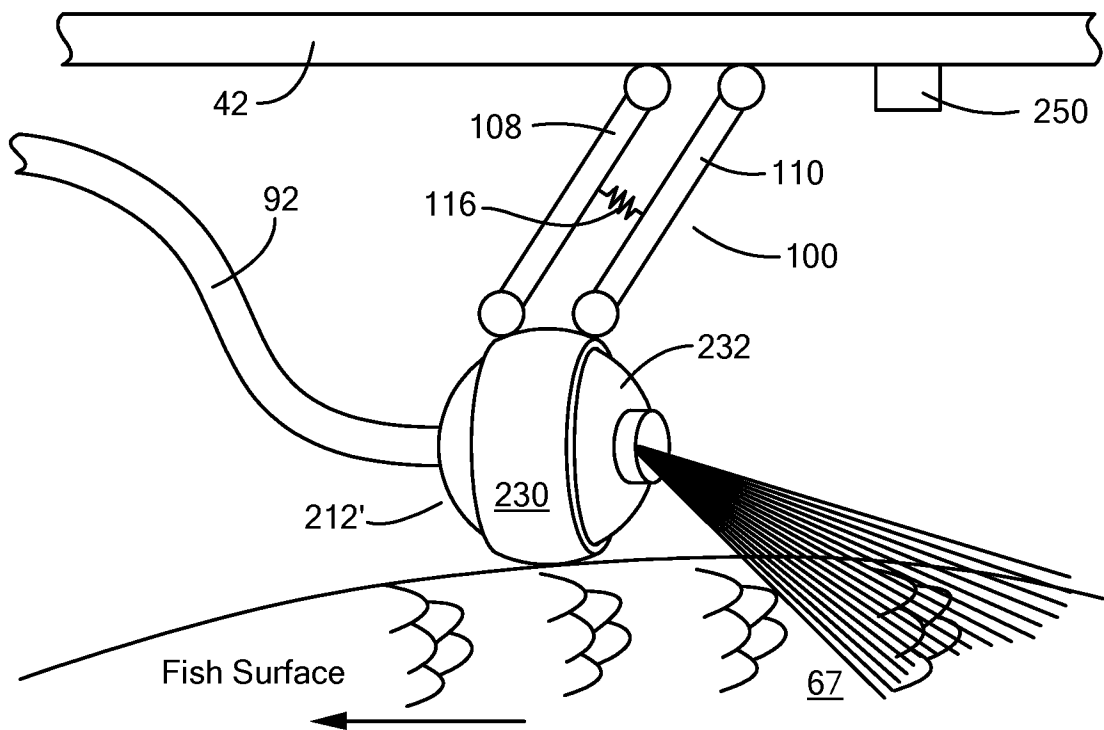


FIG. 22

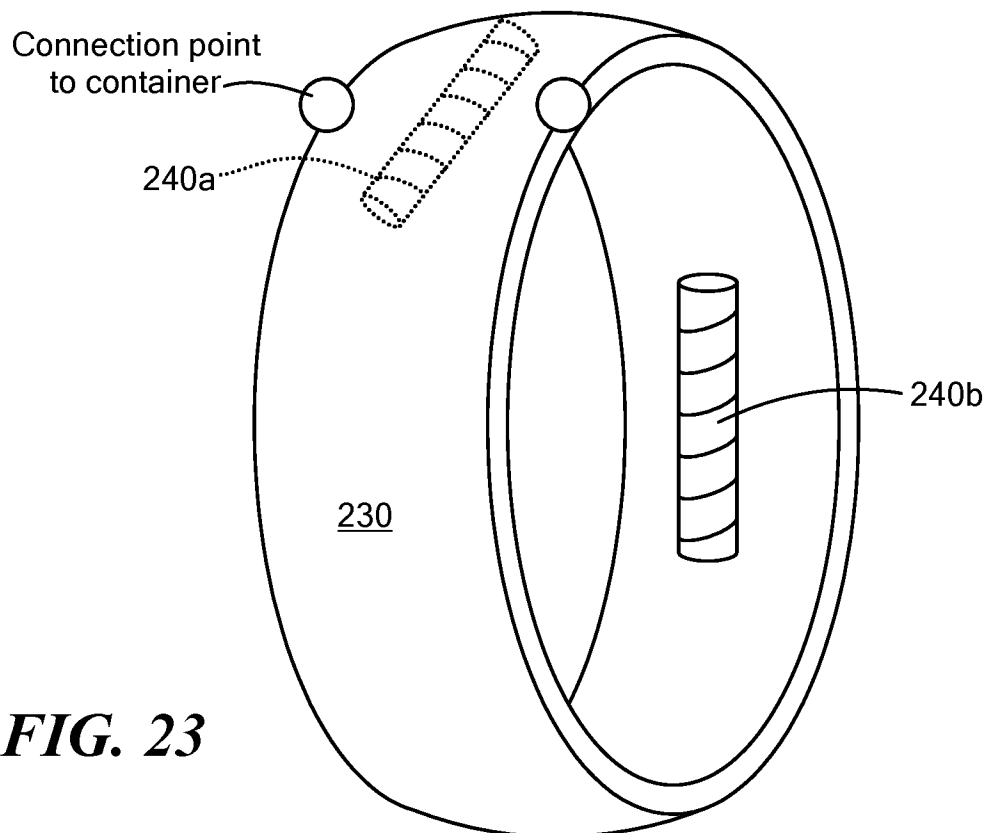


FIG. 23

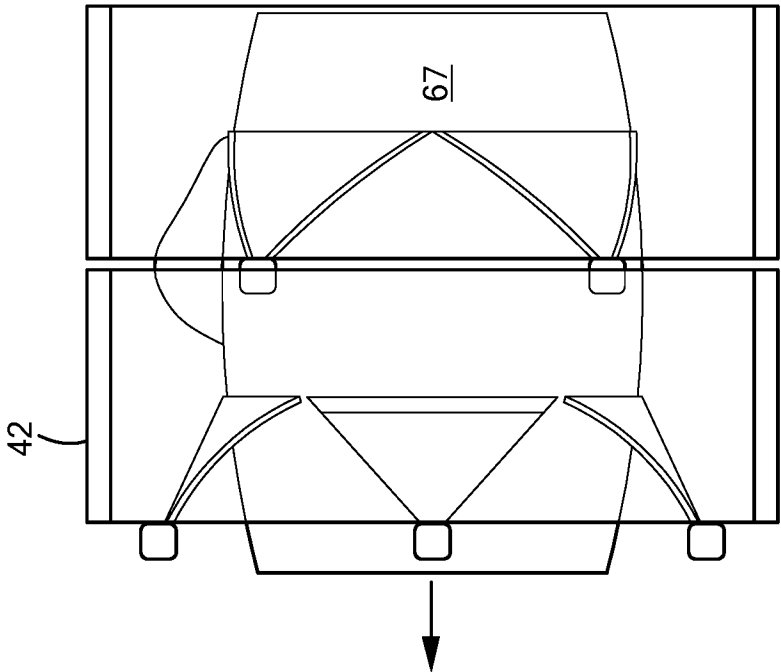


FIG. 25

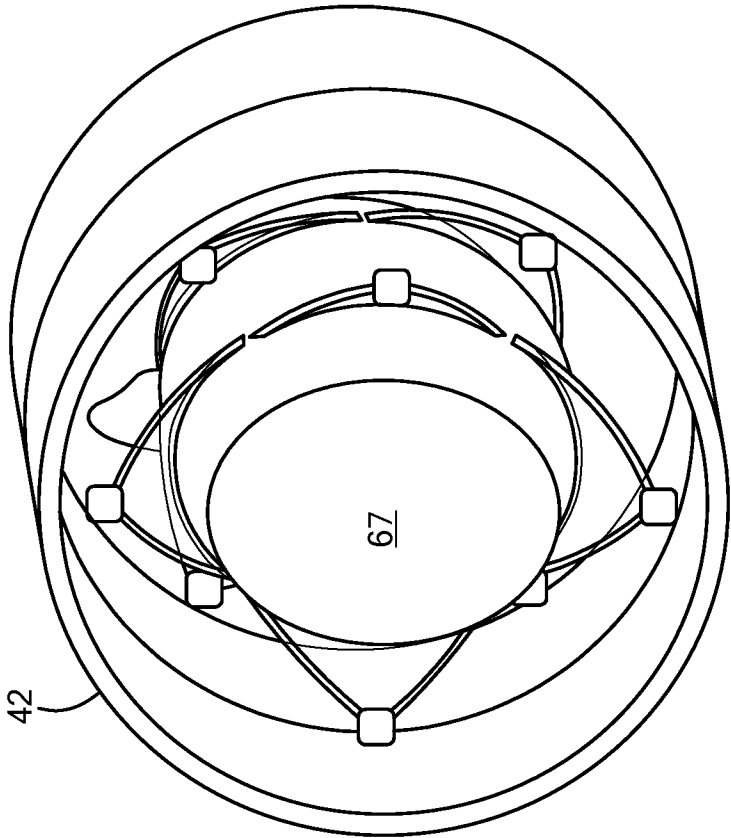


FIG. 24

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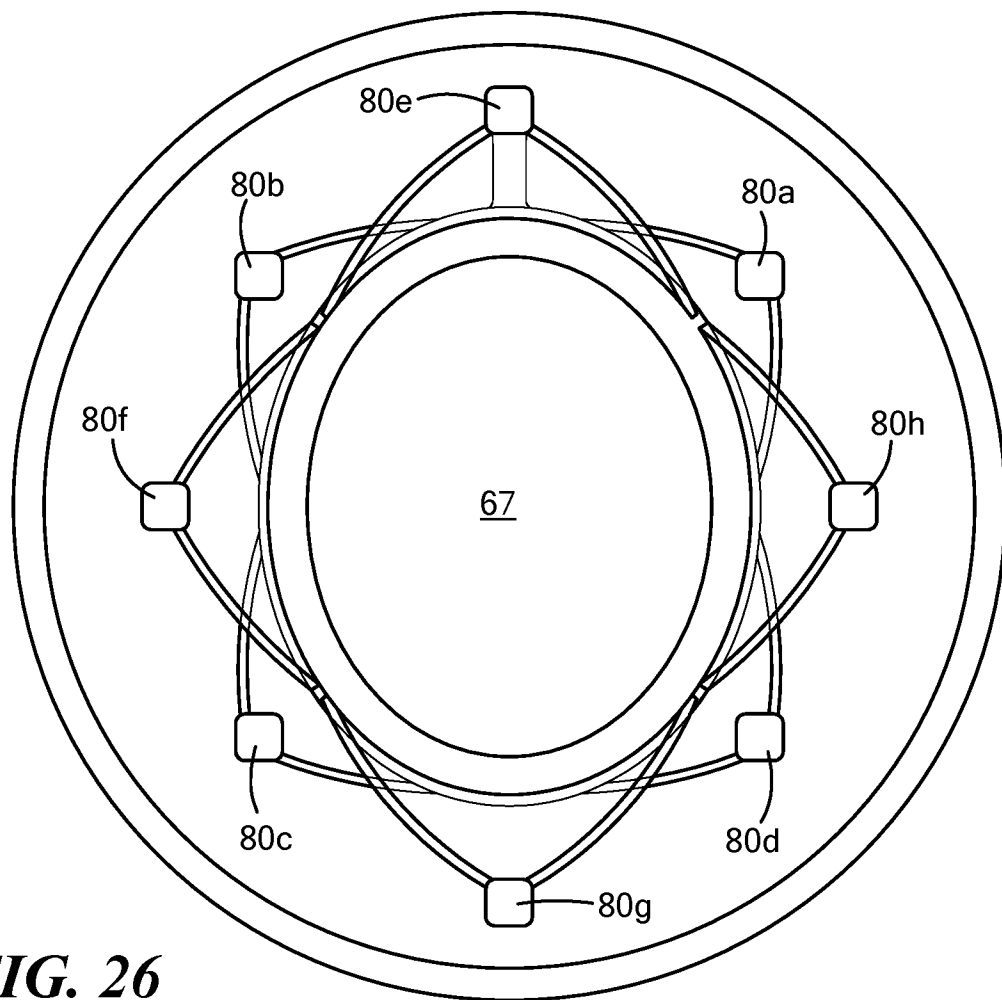


FIG. 26

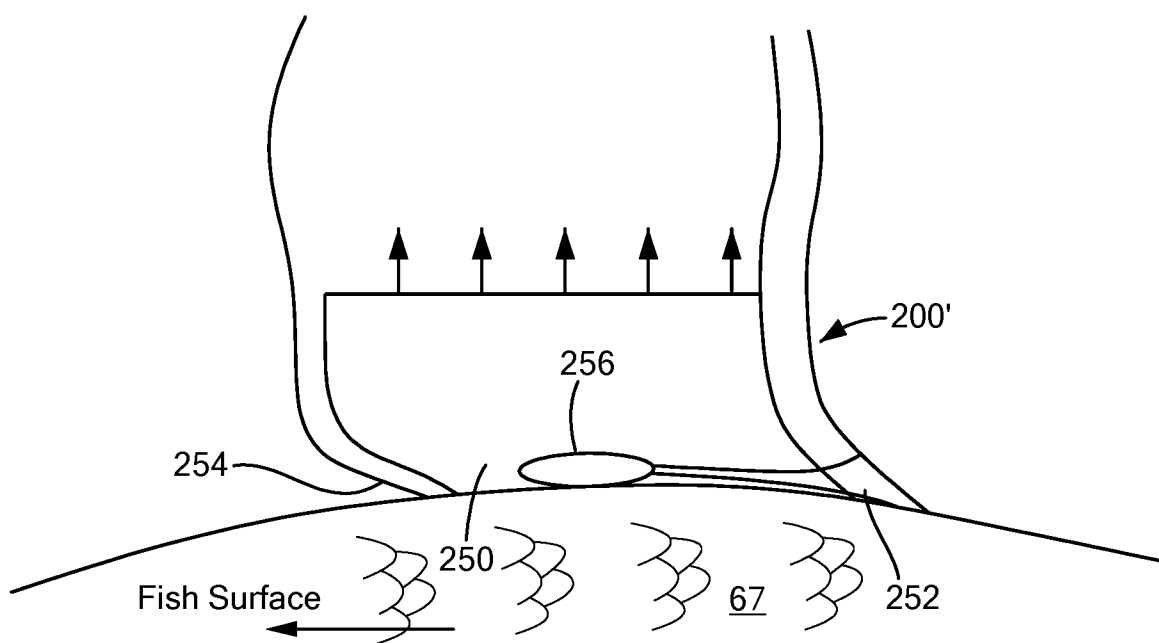


FIG. 27

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US18/27948

A. CLASSIFICATION OF SUBJECT MATTER

IPC - A01K 61/13, 63/04 (2018.01)

CPC - A01K 63/045, 61/13

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)

See Search History document

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

See Search History document

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	WO 2016/189146 A1 (HANSEN, E) December 01, 2016; page 2, lines 3-4; page 7, lines 22-23; page 8, line 33; page 9, lines 1-5, 7-9; page 11, lines 9-14; page 12, lines 5-6; page 13, lines 12-30; claims 1, 14; figure 4	22, 28, 30 ----- 23, 27, 29, 31, 34
Y —	EP 3,114,926 A1 (MARINE HARVEST NORWAY AS) January 11, 2017; abstract; figure 1; paragraphs [0012], [0052], [0062]; claim 6; figure 9	23, 27
Y	WO 2016/168888 A1 (PENROSE, G) October 27, 2016; page 15, lines 13-16	29
Y —	CN 102742542 B DONGYING HAIYUE AQUATIC PRODUCT CULTURE CO LTD) March 20, 2013; paragraph [0024] of English translation	31
Y —	GB 2,271,046 B (THOMASSEN, JM et al.) May 22, 1996; page 2, lines 1-6; page 3, lines 5-8; page 4, lines 26-27	34
A	US 2013/0050465 A1 (BECK, E) February 28, 2013; abstract; figure 2; paragraph [0020]	1-21, 24-25
A —	CA 2,858,878 A1 (GRUPO MARCO SPA) February 13, 2015; page 10, lines 12-15	24-25
A	US 1,461,350 A (FRIEDRICHS, GLA) July 10, 1923; page 1, lines 100-102	26
A	WO 2014/123427 A1 (AKVADESIGN AS) August 14, 2014; page 37, lines 21-23	26
A	WO 2016/133802 A1 (EVOQUA WATER TECHNOLOGIES LLC) August 25, 2016; claims 11-12	32-33



Further documents are listed in the continuation of Box C.



See patent family annex.

•

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“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

15 June 2018 (15.06.2018)

Date of mailing of the international search report

05 JUL 2018

Name and mailing address of the ISA/

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P.O. Box 1450, Alexandria, Virginia 22313-1450

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Authorized officer

Shane Thomas

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US18/27948

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 101507052 B1 (NFRDI) March 30, 2015; page 7 of English translation, ninth paragraph	32-33