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(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo 100-8315 (JP)

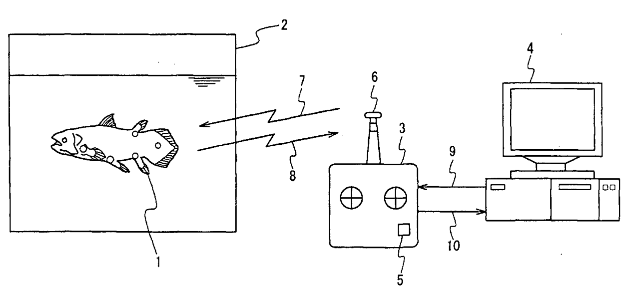
(72) Inventors:
- **YAMAMOTO, Ikuo**
NAGASAKI Res.& Development Center
5-chome Nagasaki-shi, (JP)
- **TERADA, Yuuzi**
KOBE Shipyard & Machinery Works
Hyogo-ku, Kobe Hyogo 652-0854 (JP)

(74) Representative: **HOFFMANN - EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) **FISH-SHAPED UNDERWATER NAVIGATING BODY, CONTROL SYSTEM THEREOF, AND AQUARIUM**

(57) A fish-type underwater navigation body includes a caudal turning section provided for a caudal section of a main unit, a pair of first side turning sections provided in front lower sections of the main unit, and a pair of second side turning sections provided in side lower sections between a center section and the caudal section in the main unit. The fish-type underwater navigation body gets propulsion by turning the caudal turning section. Also, the pair of first side turning sections, the pair of second side turning sections and the caudal turning section function for attitude control of the fish-type underwater navigation body.

Fig. 3



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Description

Technical Field

[0001] The present invention is relates to a fish-type underwater navigation body, a control system of the fish-type underwater navigation body, and an aquarium to exhibit a fish-type underwater navigation body.

Background Art

[0002] A first conventional example of an underwater navigation body is known in Japan Laid Open Patent Application (JP-A-Heisei 11-152085), in which a wing is vibrated like the fin of a fish for propulsion and steering. The first conventional example of the underwater navigation body is composed of wing portions 201a and 201b, as shown in Fig. 1. The wing portions 201a and 201b are connected in series. The wing portions 201a and 201b are turned around rotation axes 204 and 205, respectively. The vibration of the wing portions 201a and 201b is controlled in cooperation to each other, and the wing portions 201a and 201b operate flexibly like a caudal fin of the fish as a whole. Thus, the first conventional example of the underwater navigation body acquires propulsion. Also, the vibration of the wing portions 201a and 201b is controlled in the cooperation to each other and the steering is carried out. The first conventional example of the underwater navigation body contains a single tank 207. The up and down control of the underwater navigation body is carried out by water filling and drainage to the tank 207.

[0003] A second conventional example of the underwater navigation body is known in the above-mentioned reference. The second conventional example of the underwater navigation body is composed of a plurality of vibration wings 121 on the both edges of a main unit 222, as shown in Fig. 2. The vibration wings 221 are driven by a first actuator 224 to rotate around a vertical axis 225. In addition, the vibration wings 221 are driven by a second actuator 223 to turn around an axis 226. Thus, an angle is adjusted. In the second conventional example of the underwater navigation body, the propulsion and steering are carried out by the plurality of vibration wings 221. Either of the vibration wings 221 contributes both of the propulsion and the steering.

[0004] One of the application fields of such an underwater navigation body includes a fish robot (artificial fish). A lot of people expect new amusement facilities for their leisure. Such a fish robot has a high entertainment and a high needs as the new amusement facilities.

[0005] However, the amusement facilities in which the plurality of fish robots swim while imitating ecology in actual undersea do not exist conventionally, and the amusement facilities can be expected in collection of many visitors. Especially, the visitor collecting is effected in the amusement facilities where an ancient fish which does not exist like coelacanth swims.

Disclosure of Invention

[0006] Therefore, an object of the present invention is to provide a fish-type underwater navigation body like a fish robot imitating a fish having a plurality of fins such as pectoral fins, pelvic fins and a caudal fin.

[0007] Another object of the present invention is to provide a fish-type underwater navigation body like a fish robot which is stable in the attitude while swimming to generate propulsion.

[0008] Another object of the present invention is to provide a fish-type underwater navigation body like a fish robot which can be controlled externally.

[0009] Another object of the present invention is to provide a fish-type underwater navigation body control system which controls a fish-type underwater navigation body like a fish robot externally.

[0010] Another object of the present invention is to realize an aquarium in which a fish-type underwater navigation body like a fish robot swims, and which is an amusement facilities having a high visitor collecting effect.

[0011] In a first aspect of the present invention, a fish-type underwater navigation body includes a caudal turning section provided for a caudal section of a main unit, a pair of first side turning sections provided in front lower sections of the main unit, and a pair of second side turning sections provided in side lower sections between a center section and the caudal section in the main unit.

[0012] Here, the fish-type underwater navigation body generates propulsion by turning the caudal turning section. Also, the pair of first side turning sections, the pair of second side turning sections and the caudal turning section function for attitude control of the fish-type underwater navigation body.

[0013] Also, the fish-type underwater navigation body may further include a dorsal turning section provided for an upper section between the center section and the caudal section in the main unit and functions for attitude control of the fish-type underwater navigation body. Also, the fish-type underwater navigation body may further include another caudal turning section provided in the lower section between the center section and the caudal section in the main unit and functions for attitude control of the fish-type underwater navigation body.

[0014] Also, the caudal turning section of the fish-type underwater navigation body may include a first caudal turning section, and a second caudal turning section connected with the first caudal turning section. The first caudal turning section turns in response to a turning operation of the second caudal turning section so as to realize an operation similar to a fish. It is desirable that the turning frequency of the caudal turning section is determined based on a speed of the fish-type underwater navigation body and a width of the fish-type underwater navigation body in a direction perpendicular to a direction of movement of the fish-type underwater navigation body.

[0015] Also, the fish-type underwater navigation body may further include a flotage tank section, and movement of the fish-type underwater navigation body upwardly and downwardly is controlled based on a quantity of water in the flotage tank section. For smooth flotage and sinking operation, it is desirable that the flotage tank section includes a front flotage tank section and a rear flotage tank section. Also, for valance in the left and right directions, it is desirable that the rear flotage tank section includes a pair of flotage tank sections.

[0016] Also, the fish-type underwater navigation body may further include a driving section which drives the caudal turning section, the pair of first side turning sections and the pair of second side turning sections independently, a receiving section which receives a radio wave instruction signal propagated in underwater, and a control section which controls the driving section based on the radio wave instruction signal. In this way, it is possible to control the fish-type underwater navigation body. At the time, it is desirable that a frequency of the radio wave instruction signal is equal to or less than 100 MHz, in consideration of the attenuation of the radio wave instruction signal. Also, it is desirable that the fish-type underwater navigation body further includes a transmitting section which replies a content of the radio wave instruction signal when the radio wave instruction signal is received. Thus, it is possible to determine whether the instruction reached right.

[0017] In another aspect of the present invention, a fish-type underwater navigation body control system includes the above fish-type underwater navigation body, and a control unit which transmits a radio wave instruction signal to the fish-type underwater navigation body through underwater. The fish-type underwater navigation body further includes a driving section which drives the pair of first side turning sections, the a pair of second side turning sections and the caudal turning section independently, a receiving section which receives the radio wave instruction signal propagated in the underwater, and a drive control unit which controls the driving section based on the radio wave instruction signal.

[0018] In this case, it is desirable that the frequency of the radio wave instruction signal is equal to or less than 100 MHz.

[0019] Also, the control unit may further include an operation unit, and a transmitting section which outputs the radio wave instruction signal in the underwater based on an operation of the operation unit.

[0020] Also, the fish-type underwater navigation body may include a supersonic transmission section. In this case, the fish-type underwater navigation body control system further includes a position detecting section which detects the position of the fish-type underwater navigation body based on supersonic signals outputted from the supersonic transmission sections of the plurality of fish-type underwater navigation bodies. The control unit outputs the radio wave instruction signal to one of the plurality of fish-type underwater navigation bodies for avoidance of collision with another of the plurality of fish-type underwater navigation bodies based on the position detected by the position detecting section.

[0021] Also, when the plurality of the fish-type underwater navigation bodies swim, movement of one of the plurality of fish-type underwater navigation bodies is desirably determined based on the radio wave instruction signal generated based on the position detected by the position detecting section, for prevention of collision.

[0022] In another aspect of the present invention, an aquarium includes a water tank and at least one of the fish-type underwater navigation bodies. The fish-type underwater navigation body swims in the water tank.

[0023] Here, an outward appearance of the main unit of the fish-type underwater navigation body imitates coelacanth.

[0024] Also, a plurality of the fish-type underwater navigation body swim in the water tank, and each of the plurality of fish-type underwater navigation bodies move along closed loops, respectively. Also, each of the plurality of fish-type underwater navigation bodies sinks and floats periodically in a gravity direction.

[0025] Also, the aquarium may further include a control unit which transmits a radio wave instruction signal to the fish-type underwater navigation body through underwater. The fish-type underwater navigation body includes a driving section which drives the pair of first side turning sections, the pair of second side turning sections and the caudal turning section independently; a receiving section which receives the radio wave instruction signal propagated in the underwater; and a drive control unit which controls the driving section based on the radio wave instruction signal. The control unit further includes an operation section; and a transmitting section which outputs the radio wave instruction signal into the underwater based on an operation of the operation section.

Brief Description of Drawings

[0026]

Fig. 1 is a diagram showing an underwater navigation body of a first conventional example;

Fig. 2 is a diagram showing another underwater navigation body of a second conventional example;

Fig. 3 is a diagram showing an underwater navigation body like a fish robot and a control system according to a first embodiment of the present invention;

Figs. 4A and 4B are diagrams showing the outward appearance of the underwater navigation body in the first embodiment;

Figs. 5A and 5B are diagrams showing the internal structure of the underwater navigation body in the first embodiment;

Fig. 6 is a diagram showing the control system of the underwater navigation body in the first embodiment;

Fig. 7 is a diagram showing an aquarium which exhibits the underwater navigation body, according to a second embodiment of the present invention;

Fig. 8 is a diagram showing the control system of the underwater navigation body in the second embodiment;

Fig. 9 is a diagram showing the outward appearance of the underwater navigation body in the second embodiment;

Figs. 10A and 10B are diagrams showing an operation of the underwater navigation body in the second embodiment;

Fig. 11 is a diagram showing an operation of the underwater navigation body in the second embodiment; and

Fig. 12 is a diagram showing an operation of the underwater navigation body in the second embodiment.

Best Mode for Carrying Out the Invention

[0027] Hereinafter, an underwater navigation body like a fish robot of the present invention will be described in detail with reference to the attached drawings.

[0028] Fig. 3 shows a fish robot and a control system according to the first embodiment of the present invention. A fish robot 1 in a water tank 2 is controlled by a manual control system 3 or an automatic control system 4. By which of the manual control system 3 and the automatic control system 4 the fish robot 1 is controlled is switched by a switch 5 provided for the manual control system 3.

[0029] An antenna 6 is provided for the manual control system 3 to transmit control radio wave 7 to the fish robot 1. The control radio wave 7 propagates through water in the water tank 2 and reaches the fish robot 1. The fish robot 1 operates in response to the control radio wave 7. Also, the fish robot 1 sends echo radio wave 8. The echo radio wave 8 contains data transmitted by the control radio wave 7, and is used to check whether the control radio wave 7 is normally transmitted. The antenna 6 receives the echo radio wave 8.

[0030] Fig. 4A and 4B show the structure of the fish robot 1. The fish robot 1 imitates the form of a coelacanth. The fish robot 1 has many fins, as coelacanth having many fins.

[0031] Fig. 4A is a plan view of the outward appearance of the fish robot 1, and Fig. 4B is a side view of the outward appearance of the fish robot 1. The fish robot 1 is composed of a fish robot main unit 11. Two pectoral fins 12_1 and 12_2, two pelvic fins 13_1 and 13_2, a first dorsal fin 14, a second dorsal fin 15, a first caudal fin 16 are connected with the fish robot main unit 11. A second caudal fin 17 is connected with a caudal portion of the fish robot main unit 11. A caudal fin 18 is connected with the second caudal fin 17. Each of the pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the first dorsal fin 14, the second dorsal fin 15, the first caudal fin 16, the second caudal fin 17 and the caudal fin 18 is formed of a metal plate covered by a soft plastic film.

[0032] Fig. 5A is a plan view showing the internal structure of the fish robot 1. As shown in Fig. 5A, the pectoral fins 12_1 and 12_2 are turnably connected with rotation axes 19_1 and 19_2, respectively. The pectoral fin 12_1 is driven by a motor 20_1 to vibrate (or turn) around the rotation axis 19_1 as shown by the arrow 21_1. The pectoral fin 12_2 is driven by a motor 20_2 to vibrate around the rotation axis 19_2, as shown by the arrow 21_2.

[0033] Similarly, the pelvic fins 13_1 and 13_2 are also turnably connected with rotation axes (not illustrated), respectively. The pelvic fins 13_1 and 13_2 are driven by motors 20_3 and 20_4 shown in Fig. 5B, respectively. The pelvic fins 13_1 and 13_2 are vibrated as shown by the arrows 22_1 and 22_2 in Fig. 5A, respectively.

[0034] Moreover, the second dorsal fin 15 and the first caudal fin 16 are turnably connected with rotation axes (not shown), respectively, in the same way. The second dorsal fin 15 and the first caudal fin 16 are driven by motors 20_5 and 20_6 shown in Fig. 5B, as shown by the arrows 23 and 24, respectively.

[0035] The first dorsal fin 14 is fixed. The first dorsal fin 14 makes the posture of the fish robot 1 stable.

[0036] The second caudal fin 17 contains a vibration fin 17_1 and a vibration fin 17_2. One end of the vibration fin 17_1 is turnably connected with a rotation axis 25, as shown in Fig. 5A. The vibration fin 17_1 is driven by a motor 20_7 to vibrate around rotation axis 25 as shown by the arrow 26. The other end of the vibration fin 17_1 is connected with a rotation axis 27. One end of the vibration wing 17_2 is turnably connected with the rotation axis 27. The vibration fin 17_2 vibrates around the rotation axis 27 as shown by the arrow 26.

[0037] The phase of the vibration of the vibration fin 17_1 and the phase of the vibration of the vibration fin 17_2 are shifted from each other and the vibration fin 17_2 operates in response to the operation of the vibration fin 17_1. That is, the vibration fin 17_1 and the vibration fin 17_2 vibrate flexibly just like actual coelacanth.

[0038] The frequency f of the vibration by the vibration fin 17_1 and the vibration fin 17_2 is expressed by the following equation:

$$f = S \cdot (U/D)$$

where D is the width D of the fish robot main unit 11 (see Fig. 2A), U is the speed of the fish robot 1, and S is a constant. The constant S is set based on the movement and shape of an actual fish. By determining the frequency f in this way, the second caudal fin 17 vibrates just like genuine fish.

[0039] As shown in Fig. 5B, the caudal fin 18 is connected with the second caudal fin 17. The caudal fin 18 turns around the rotation axis (not shown). The caudal fin 18 vibrates around the rotation axis (not shown) as shown by the arrow 26.

[0040] The propulsion of the fish robot 1 is substantially generated only by the second caudal fin 17. The above-mentioned pectoral fins 12_1 and 12_2, pelvic fin 13_1 and 13_2, second dorsal fin 15, first caudal fin 16 and caudal fin 18 do not generate the propulsion of the fish robot 1 substantially. On the other hand, the posture of the fish robot 1 is controlled by all of the pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the second dorsal fins 15, the first caudal fins 16, the second caudal fin 17 and the caudal fins 18. In this way, the behavior of the fish robot when the propulsion is generated and the posture is controlled is same as the actual coelacanth, resulting in the improvement of reality of the fish robot 1.

[0041] Here, each of the pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the second dorsal fin 15, and the first caudal fin 16, and the caudal fin 18 vibrates around only one rotation axis, and the number of degrees of freedom is single. The pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the second dorsal fin 15, the first caudal fin 16 and the caudal fin 18 are driven by the motors, respectively. The pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the second dorsal fin 15, the first caudal fin 16 and the caudal fin 18 which are used only for the control of the posture of the fish robot 1 do not have to do always a complicated movement. Therefore, the number of degrees of freedom in each of the pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the second dorsal fin 15, the first caudal fin 16 and the caudal fin 18 is made single and a driving mechanical section can be made small in size.

[0042] Moreover; the fish robot 1 contains pumps 28_1 and 28_2 and tanks 29_1 and 29_2 as shown in Fig. 5B. The tank 29_1 is situated on the head of the fish robot 1. The tank 29_2 contains two portions which are located to sandwich the above-mentioned motors 20_3 to 20_8.

[0043] The pumps 28_1 and 28_2 injects and drains water into and from the tanks 29_1 and 29_2. A position of the fish robot 1 in a gravity direction is controlled based on the quantity of water inside the tanks. The fish robot 1 sinks and floats into and from the gravity direction by injecting and draining water into and from the tanks 29_1 and 29_2. Thus, the posture of the fish robot 1 is controlled. In this way, the provision of the plurality of the tanks 29_1 and 29_2 facilitates the control of the posture of the fish robot 1.

[0044] Moreover, the fish robot 1 contains a battery cell 31 as a power section (Fig. 5B). The battery cell 31 supplies the whole fish robot 1 with the power supply voltage.

[0045] Fig. 6 shows the control system for instructing the operation of the fish robot 1. Referring to Fig. 6, the fish robot 1 further contains a transmitting and receiving section 30. The transmitting and receiving section 30 receives the control radio wave 7 for instructing the operation of the fish robot 1. The control radio wave 7 contains a control process quantity of each of the motors 20_1 to 20_8 and the pumps 28_1 and 28_2. The motors 20_1 to 20_8 and the pumps 28_1 and 28_2 operate based on the control radio wave 7. That is, the frequency, phase and amplitude of the vibration of each of the above-mentioned pectoral fins 12_1 and 12_2, pelvic fins 13_1 and 13_2, second dorsal fin 15, first caudal fin 16, second caudal fin 17 and caudal fin 18 are controlled based on the control radio wave 7.

[0046] The frequency, phase and amplitude of vibration of the pectoral fins 12_1 and 12_2, pelvic fins 13_1 and 13_2, second dorsal fin 15, first caudal fin 16, first vibration fin 17_1 and second vibration fin 17_2 of the second caudal fin 17, and caudal fin 18 are determined for the fish robot 1 to move in a desired direction at a desired speed. "Propulsion System with Flexible/Rigid Oscillating Fin", (IEEE Journal of Oceanic Engineering vol. 20, No. 1, (1995), pp. 23-30) or a neural network described in Japanese Patent No. 3117310 may be used for the determination. As a result, the pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the second dorsal fin 15, the first caudal fin 16, the second caudal fin 17 and the caudal fin 18 are controlled by the control system 5, and move flexibly just as the fins of actual coelacanth. Such a movement delights the person who sees the fish robot 1.

[0047] In this way, the fish robot 1 is possible to move without being connected with a cable. Because the fish robot 1 can move without being connected with the cable, the reality of the fish robot 1 is improved.

[0048] Moreover, the transmitting and receiving section 30 sends data of the control process quantity of each of the motors 20_1 to 20_8 and the pumps 28_1 and 28_2 transmitted with the control radio wave 7, as echo radio wave 8. The control radio wave 7 to be propagated in underwater has a possibility to erroneously transfer the control process quantity. The echo radio wave 8 is used to confirm whether the control process quantity to each of the motors 20_1 to 20_8, and the pumps 28_1 and 28_2 is right transmitted.

[0049] As mentioned above, the operation of the fish robot 1 is controlled by either of the manual control system 3 and the automatic control system 4. By which of the manual control system 3 and automatic control system 4, the fish robot 1 is controlled is switched by the switch 5.

[0050] The manual control system 3 is used for the person who operates the fish robot 1 to instruct the operation of the fish robot 1. When the manual control system 3 is selected by the switch 5, the control process quantity of each of the pumps 28_1 and 28_2 and the motors 20_1 to 20_8 contained in the fish robot 1 is determined in accordance with the operation of the manual control system 3 by the operation person. The control process quantity is transmitted to the fish robot 1 with the control radio wave 7.

[0051] When the automatic control system 4 is selected by the switch 5, the automatic control system 4 controls the fish robot 1 in accordance with algorithm defined by the software loaded thereinto. The automatic control system 4 determines the control process quantity of each of the pumps 28_1 and 28_2 and the motors 20_1 to 20_8 contained in the fish robot 1. The control process quantity is transferred to the manual control system 3 by a control signal 9 and then is transmitted to the fish robot 1 with the control radio wave 7 from the manual control system 3.

[0052] The control radio wave 7 is a FM wave which is generated by carrying out frequency modulation (FM) to an electric signal with the amplitude proportional to the control process quantity. Because the control radio wave 7 is the FM wave, it is difficult for the control process quantity to be erroneously transmitted, even if the control radio wave 7 is attenuated with water.

[0053] The control radio wave 7 is received by the transmitting and receiving section 30. The transmitting and receiving section 30 transfers the control process quantities of the pumps 28_1 and 28_2 and the motors 20_1 to 20_8 transmitted by the control radio wave 7 to the pumps 28_1 and 28_2 and the motors 20_1 to 20_8, respectively. However, only the pumps 28_1 and 28_2, and the motors 20_1, 20_1, 20_7, and 20_8 are illustrated in Fig. 6. The pumps 28_1 and 28_2 inject and drain water into and from the tanks 29_1 and 29_2 in accordance with the transferred control process quantities. The motors 20_1 to 20_8 set displacement quantities in accordance with the transferred control process quantities. The motors 20_1 to 20_8 vibrate the pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the first dorsal fin 14, the second dorsal fin 15, the first caudal fin 16, the first vibration fin 17_1 and the second the vibration fin 17_2 of the second caudal fin 17, respectively. In this way, the fish robot 1 is controlled by the manual control system 3 or the automatic control system 4.

[0054] Moreover, the transmitting and receiving section 30 transmits the control process quantity transmitted by the control radio wave 7 to the manual control system 3 with the echo radio wave 8. The manual control system 3 transfers the control process quantity transmitted by the echo radio wave 8 to the automatic control system 4 as an echo signal 10. The automatic control system 4 determines based on the echo signal 10, whether the control process quantity is transmitted right. Based on the determination, the automatic control system 4 sets a control process quantity of each of the pumps 28_1 and 28_2 and the motors 20_1 to 20_8 to be transmitted to the fish robot 1.

[0055] It should be noted that in this embodiment, a supersonic transmitter may be used instead of the antenna 6. In this case, instead of the control radio wave 7 for controlling the fish robot 1, a supersonic signal is used. However, it is desirable to control the fish robot 1 using the control radio wave 7 like this embodiment, from the viewpoint of the high-speed signal processing in the fish robot 1.

[0056] It is generally thought that it is difficult to transmit a signal through the underwater using the radio wave because the attenuation of the radio wave in the underwater is large. For this reason, when the signal is transmitted through the underwater, a supersonic signal is often used. However, it is actually possible to transmit a signal through the underwater with the radio wave. This is because the attenuation of the radio wave in the underwater is about 10 dB/m when the frequency is 100Mz. Therefore, the distance between two points is within 10 m, the communication between the two points is sufficiently possible using the radio wave. It should be noted that it is desirable that the control radio wave 7 is equal to or less than 100 MHz because the attenuation of the radio wave in the underwater becomes high as the frequency is increased.

[0057] The present invention provides the fish robot realistically imitating fish which has a plurality of fins and a fin for the caudal portion.

[0058] Also, according to the present invention, the underwater navigation body of the fish robot type imitating the fish which has a plurality of fins can be made more compact.

[0059] Next, the second embodiment of the present invention will be described. In the second embodiment, an aquarium is provided in which the fish robots or fish robots similar to the above-mentioned fish robot swim in the water tank.

[0060] Fig. 7 shows the structure of the aquarium. The aquarium has a water tank 102 in which water has been filled and a plurality of fish robots 1 are swimming in the water tank 102.

[0061] It is desirable that the fish robot 1 imitates the form of fish like abyssal fish which it is difficult to acquire, ancient fish like coelacanth, or fish which it is impossible to acquire because it had become extinct, from the viewpoint of increase of amusement. In this embodiment, the fish robot 1 imitates the form of the coelacanth.

[0062] Fig. 8 shows a control system of the fish robot in the second embodiment. The aquarium further contains a supersonic sensor 103, an operation unit 104, a control unit 105 and a radio wave transmitting unit 106. The supersonic sensor 103 is used to detect the position of the fish robot 1. A joystick 104a and a switch (not shown) are provided for the operation unit 104. A visitor who visits the aquarium can instruct how the fish robot 1 swim by operating the joystick 104a. The switch 4b designates whether the fish robot 1 is controlled based on the operation of the joystick 104a or in accordance with the algorithm which is described in the software loaded into the control unit 105, like the first embodiment.

[0063] The control unit 105 controls the fish robot 1 in accordance with the operation of the joystick 104a or the algorithm which is described in the loaded software based on the state of the switch 4b. The control unit 105 generates a signal for controlling the fish robot 1. The radio wave transmitting unit 106 sends the signal to the fish robot 1 with radio wave.

[0064] The fish robot 1 generates a supersonic signal a. The supersonic signal a is used for the detection of the position of the fish robot 1. The supersonic sensor 103 receives and converts the supersonic signal a propagated in the underwater into an electric signal b. The electric signal b is transferred to the control unit 5.

[0065] On the other hand, the operation unit 104 transmits to the control unit 105 an operation signal c1 to indicate the content of the operation accomplished by the joystick 104a. Also, the operation unit 104 outputs to the control unit 105 a specification signal c2 for specifying that the fish robot 1 should be controlled in accordance with which of the detected movement of the fish robot 1 and the operation of the joystick 104a, based on the state of the switch 4b.

[0066] The control unit 105 contains a position detecting section 105_1 and a control section 105_2. The position detecting section 105_1 detects the position of the fish robot 1 based on the electric signal b. The position of the fish robot 1 is notified to the control unit 105_2 by a position signal d.

[0067] The control section 105_2 determines the movement of the fish robot 1. When it is designated based on the switch that the fish robot 1 is controlled in accordance with the operation of the joystick 104a, the control section 105_2 determines the movement of the fish robot 1 based on the content of the operation of the joystick 104a. When it is designated based on the switch that the fish robot 1 is controlled in accordance with the algorithm which is described in the software loaded into the control unit 105, the control section 105_2 determines the movement of the fish robot 1 while the control unit 105 refers to the position of the fish robot 1 in accordance with the algorithm. The control section 105_2 generates and outputs a control signal e for instructing the movement of the fish robot 1 to the radio wave transmitting unit 106. The radio wave transmitting unit 106 converts the control signal e into a control radio wave f and sends it to the fish robot 1.

[0068] Next, the structure of the fish robot 1 will be described. Fig. 9A is a plan view of the outward appearance of the fish robot 1. Fig. 9B is a side view of the outward appearance of the fish robot 1. The fish robot 1 contains a fish robot main unit 11. Two pectoral fins 12_1 and 12_2, two pelvic fins 13_1 and 13_2, the first dorsal fin 14, the second dorsal fin 15, the first caudal fin 16, the second caudal fin 17 are connected with the fish robot main unit 11. The caudal fin 18 is connected with the second caudal fin 17. The pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the first dorsal fin 14, the second dorsal fin 15, the first caudal fin 16, the second caudal fin 17 and the caudal fin 18 are formed of plastic material with elasticity.

[0069] The internal structure of the fish robot 1 in the second embodiment is same as in the first embodiment shown in Figs. 5A and 5B. The different point between the first and second embodiments is in that the fish robot 1 contains the supersonic transmitting units 31. The supersonic transmitting unit 31 sends the above-mentioned supersonic signal a. The supersonic signal a is used for the detection of the position of the fish robot 1, as described above.

[0070] Next, the movement of the fish robot 1 will be described with reference to Fig. 10A and 10B. When it is designated based on the switch that the fish robot 1 is controlled in accordance with the algorithm which is described to the software loaded into the control unit 105, an instruction is given for the fish robot 1 to swim along a closed loop 41, as shown in Fig. 10A. That is, the instruction is given to the fish robot 1 to vibrate the first vibration fin 17_1 and the second vibration fins 17_2 of the second caudal fin 17, such that the fish robot 1 swims to have a predetermined angle θ from the centerline 11a of the fish robot main unit 11, as shown in Fig. 10B. When the first vibration fin 17_1 and the second vibration fin 17_2 are vibrated to have the predetermined angle θ with respect to the centerline 11a, the fish robot 1 goes around along the closed loop 41.

[0071] At this time, as shown in Fig. 11, the fish robot 1 sinks and floats periodically. Through the periodically sinking and floating movement of the fish robot 1, the movement of the fish robot 1 gets to be nearer the movement of the actual fish and the reality increases. The sinking and floating movement of the fish robot is achieved by injecting and draining water into and from the tanks 29_1 and 29_2 by the pumps 28_1 and 28_2.

[0072] It should be noted that when the distance Δl between the fish robots 1 becomes smaller than a predetermined distance L, the fish robots 1 move to avoid crash. The distance Δl is detected based on the positions of the fish robots 1 which are detected by the position detecting section 5_1. As shown in Fig. 12, it is supposed that the distance Δl between the fish robot 1_1 and the fish robot 1_2 becomes smaller than the predetermined distance L. In this case, the angles $\theta 1$ and $\theta 2$ different each other are set to the fish robots 1_1 and the fish robots 1_2, respectively. The first vibration fin 17_1 and the second vibration fin 17_2 of the fish robot 1_1 are controlled to vibrate taking as a vibration center the angle $\theta 1$ from centerline 11a of the fish robot main unit 11, and the first vibration fin 17_1 and the second vibration fin 17_2 of the fish robot 1_2 are controlled to vibrate taking as a vibration center the angle $\theta 2$ from centerline 11a of the fish robot main unit 1_1. Thus, the fish robot 1_1 and the fish robot 1_2 move in different directions and crash of the fish robots can be avoided. Moreover, such a movement delights the visitor which sees the fish robots 1.

[0073] On the other hand, when it is specified that the fish robot 1 is controlled in accordance with the operation of the joystick 104a by the switch, as mentioned above, the fish robot 1 moves in response to the operation of the joystick 104a. When the direction in which the fish robot 1 should move is set by the joystick 104a, the control unit 105 controls the changes of the pectoral fins 12_1 and 12_2, the pelvic fins 13_1 and 13_2, the second dorsal fin 15, the first caudal fin 16, the second caudal fin 17 and the caudal fin 18 for the fish robot 1 to move in the specified direction. Thus, the fish robot 1 moves in the specified direction in accordance with the operation of the joystick of 104a. The operation person who operates the joystick 104a can enjoy that the fish robot 1 moves in accordance with the operation of the joystick 104a.

[0074] In this way, the movement of the fish robot 1 delights the person seeing it. The entertainment of the aquarium in this embodiment is high and the visitor collecting effect can look forward to it.

[0075] It should be noted that in this embodiment, a supersonic transmitting unit may be used instead of the radio wave transmitting unit 106. In this case, instead of the control radio wave f for controlling the fish robot 1, a supersonic signal is used. However, it is desirable to control the fish robots 1 using the control radio wave f like this embodiment from the viewpoint of a quick signal processing inside the fish robot 1. It is considered generally that it is difficult to transmit a signal in the underwater with the radio wave, because the attenuation percentage of the radio wave in the underwater is large. Therefore, when a signal is transmitted in the underwater, a supersonic signal is often used. However, it is actually possible to transmit a signal in the radio wave to be propagated in underwater. The reason is that the attenuation percentage of the radio wave in the underwater is about 10 dB/m when the frequency is 100Mz. This means that the communication between two in the radio wave is sufficiently possible, if the distance between the two is within 10 m. Therefore, the control of the fish robot 1 is carried out while using the control radio wave f and the quick signal processing inside the fish robot 1 is attempted.

[0076] It is desirable that the control radio wave f is generated by FM-modulating the control signal e. It is difficult for the control radio wave f as an FM wave to undergo attenuation influence.

[0077] The amusement facilities where the high visitor collection effect is expected can be provided in the present invention.

Claims

1. A fish-type underwater navigation body comprising:

> a caudal turning section provided for a caudal section of a main unit;
> a pair of first side turning sections provided in front lower sections of said main unit; and
> a pair of second side turning sections provided in side lower sections between a center section and the caudal section in said main unit.

2. The fish-type underwater navigation body according to claim 1, wherein propulsion is generated by turning said caudal turning section.

3. The fish-type underwater navigation body according to claim 1 or 2, wherein said pair of first side turning sections, said pair of second side turning sections and said caudal turning section function for attitude control of said fish-type underwater navigation body.

4. The fish-type underwater navigation body according to any of claims 1 to 3, further comprising:

> a dorsal turning section provided for an upper section between the center section and the caudal section in said main unit and functioning for attitude control of said fish-type underwater navigation body.

5. The fish-type underwater navigation body according to any of claims 1 to 4, further comprising:

> another caudal turning section provided in a lower section between the center section and the caudal section in said main unit and functioning for attitude control of said fish-type underwater navigation body.

6. The fish-type underwater navigation body according to any of claims 1 to 6, wherein said caudal turning section comprises:

> a first caudal turning section; and
> a second caudal turning section connected with said first caudal turning section, and
> said first caudal turning section turns in response to a turning operation of said second caudal turning section.

7. The fish-type underwater navigation body according to claim 6, wherein a turning frequency of said caudal turning section is determined based on a speed of said fish-type underwater navigation body and a width of said fish-type underwater navigation body in a direction perpendicular to a direction of movement of said fish-type underwater navigation body.

8. The fish-type underwater navigation body according to any of claims 1 to 7, further comprising:

> a flotage tank section, and

wherein movement of said fish-type underwater navigation body upwardly and downwardly is controlled based on a quantity of water in said flotage tank section.

9. The fish-type underwater navigation body according to claim 8, wherein said flotage tank section comprises:

a front flotage tank section and a pair of rear flotage tank sections.

10. The fish-type underwater navigation body according to any of claims 1 to 9, further comprising:

a driving section which drives said caudal turning section, said pair of first side turning sections and said pair of second side turning sections independently;
a receiving section which receives a radio wave instruction signal propagated in underwater; and
a control section which controls said driving section based on said radio wave instruction signal.

11. The fish-type underwater navigation body according to claim 10, wherein a frequency of said radio wave instruction signal is equal to or less than 100 MHz.

12. The fish-type underwater navigation body according to claim 10 or 11, further comprising:

a transmitting section which replies a content of said radio wave instruction signal when said radio wave instruction signal is received.

13. A fish-type underwater navigation body control system comprising:

said fish-type underwater navigation body according to any of claims 1 to 12; and
a control unit which transmits a radio wave instruction signal to said fish-type underwater navigation body through underwater,

wherein said fish-type underwater navigation body further comprises:

a driving section which drives said pair of first side turning section, said pair of second side turning sections and said caudal turning section independently;
a receiving section which receives said radio wave instruction signal propagated in the underwater; and
a drive control unit which controls said driving section based on said radio wave instruction signal.

14. The fish-type underwater navigation body control system according to claim 13, wherein a frequency of said radio wave instruction signal is equal to or less than 100 MHz.

15. The fish-type underwater navigation body control system according to claim 13 or 14, wherein said control unit comprises:

an operation unit; and
a transmitting unit which outputs said radio wave instruction signal in the underwater based on an operation of said operation unit.

16. The fish-type underwater navigation body control system according to any of claims 13 to 15, wherein said fish-type underwater navigation body comprises:

a supersonic transmitting section,
said fish-type underwater navigation body control system further comprises:

a position detecting section which detects a position of each of a plurality of said fish-type underwater navigation bodies based on supersonic signals outputted from said supersonic transmitting sections of said plurality of fish-type underwater navigation bodies, and
said control unit outputs said radio wave instruction signal to one of said plurality of fish-type underwater navigation bodies for avoidance of collision with another of said plurality of fish-type underwater navigation bodies based on the positions detected by said position detecting section.

17. The fish-type underwater navigation body control system according to any of claim 13 to 16, wherein said plurality of the fish-type underwater navigation bodies swim, and

movement of one of said plurality of fish-type underwater navigation bodies is determined based on said radio wave instruction signal generated based on the positions detected by said position detecting section.

18. An aquarium comprising:

a water tank; and
at least one of said fish-type underwater navigation bodies according to any of claims 1 to 12, and

wherein said fish-type underwater navigation body swims in said water tank.

19. The aquarium according to claim 18, wherein an outward appearance of said main unit of said fish-type underwater navigation body imitates coelacanth.

20. The aquarium according to claim 18 or 19, wherein a plurality of said fish-type underwater navigation bodies swim in said water tank, and

each of said plurality of fish-type underwater navigation bodies moves along a closed loop.

21. The aquarium according to any of claims 18 to 20, wherein each of said plurality of fish-type underwater navigation bodies sinks and floats periodically in a gravity direction.

22. The aquarium according to any of claims 18 to 21, further comprising:

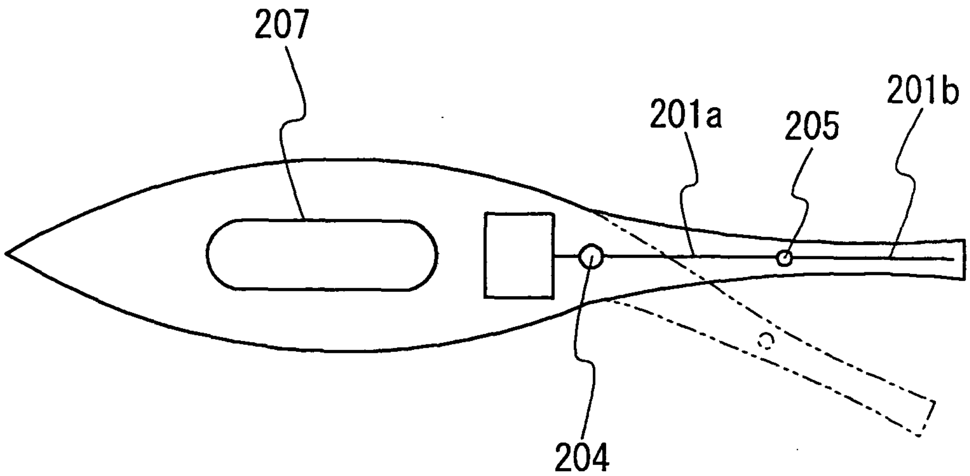
a control unit which transmits a radio wave instruction signal to said fish-type underwater navigation body through underwater, and said fish-type underwater navigation body comprises:

a driving section which drives said pair of first side turning sections, said pair of second side turning sections and said caudal turning section independently;
a receiving section which receives said radio wave instruction signal propagated in the underwater; and
a drive control unit which controls said driving section based on said radio wave instruction signal.

23. The aquarium according to claim 22, wherein the control unit comprises:

an operation section; and
a transmitting section which outputs said radio wave instruction signal into the underwater based on an operation of the operation section.

Fig. 1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201a
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201b
204

Fig. 2

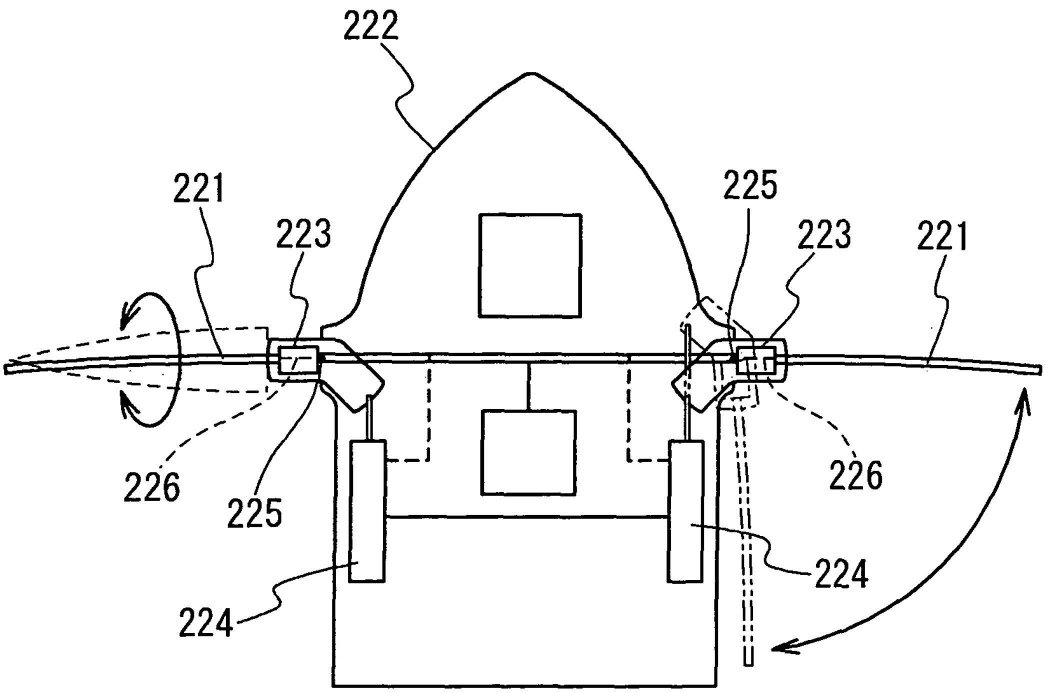
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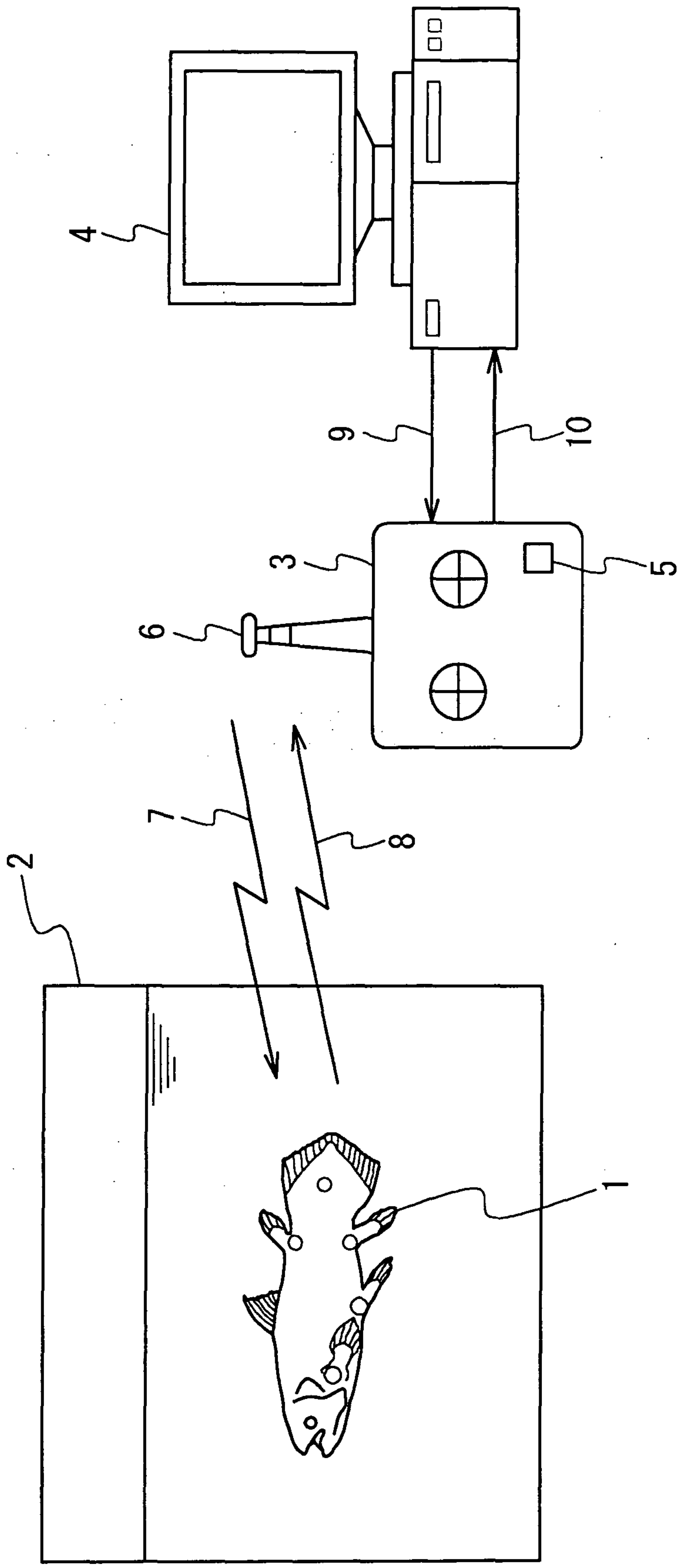
Fig. 3



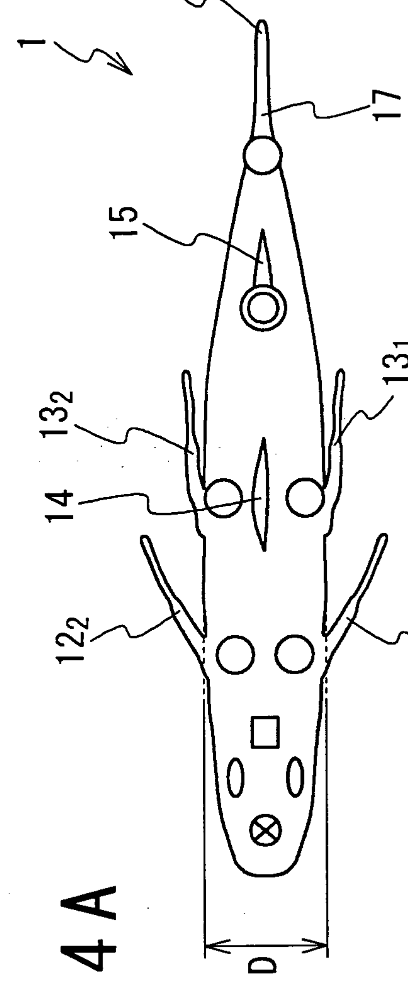


Fig. 4A

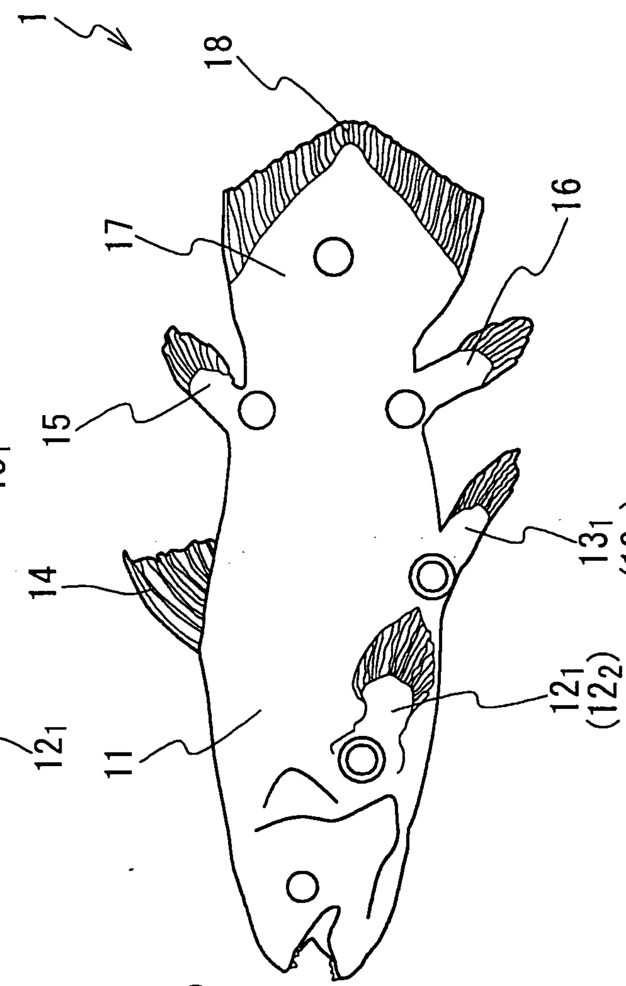
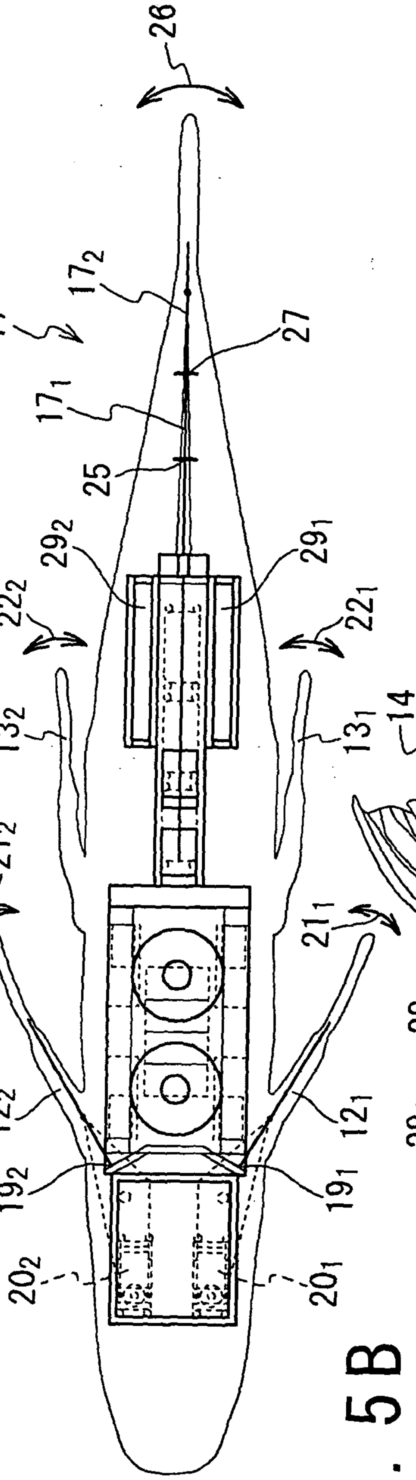


Fig. 4B

Fig. 5A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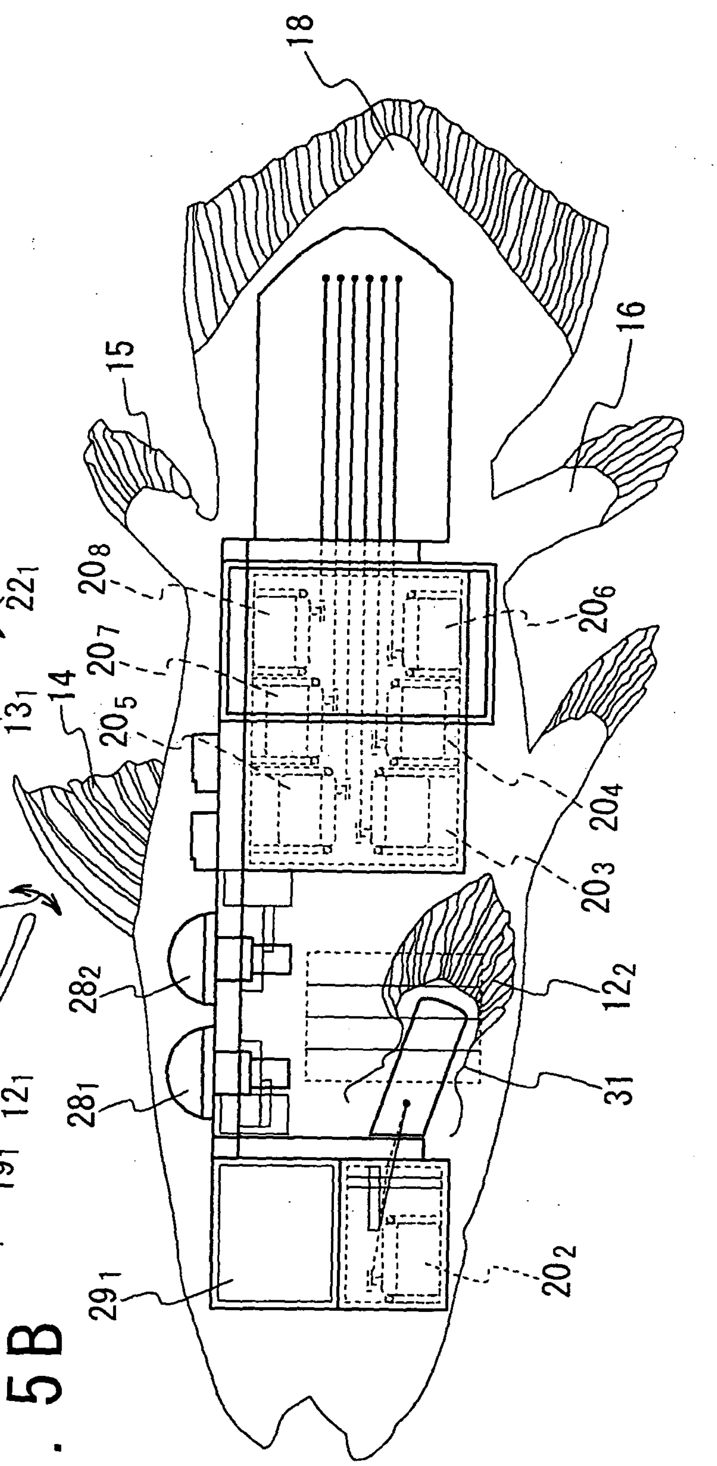
20_1

Fig. 5B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20_5
20_4
20_3
28_2
12_2
31
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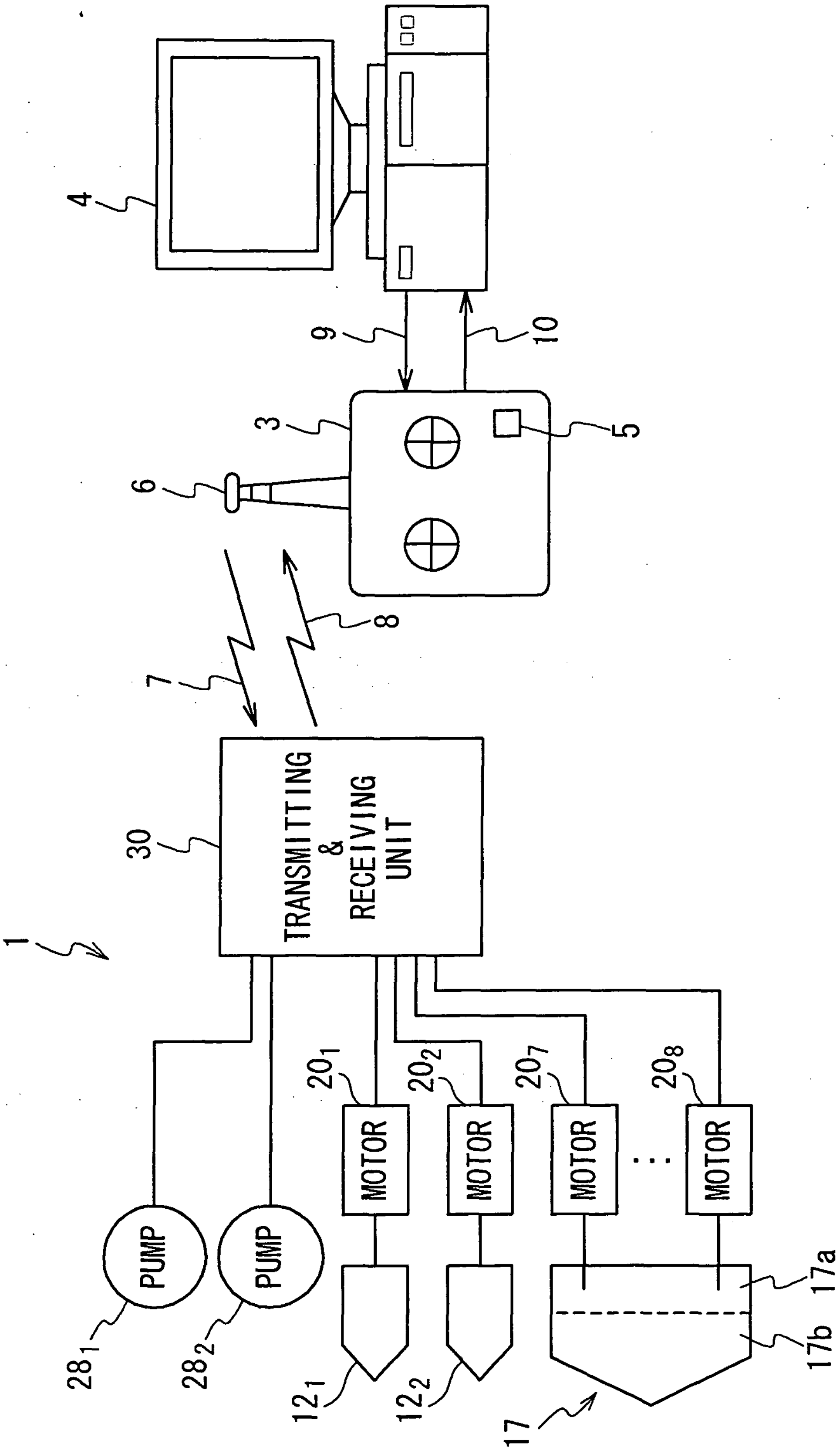
29_1
20_2

Fig. 6


1
4
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8
30
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&
RECEIVING
UNIT
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MOTOR
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20_2
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17
17a
17b

Fig. 7

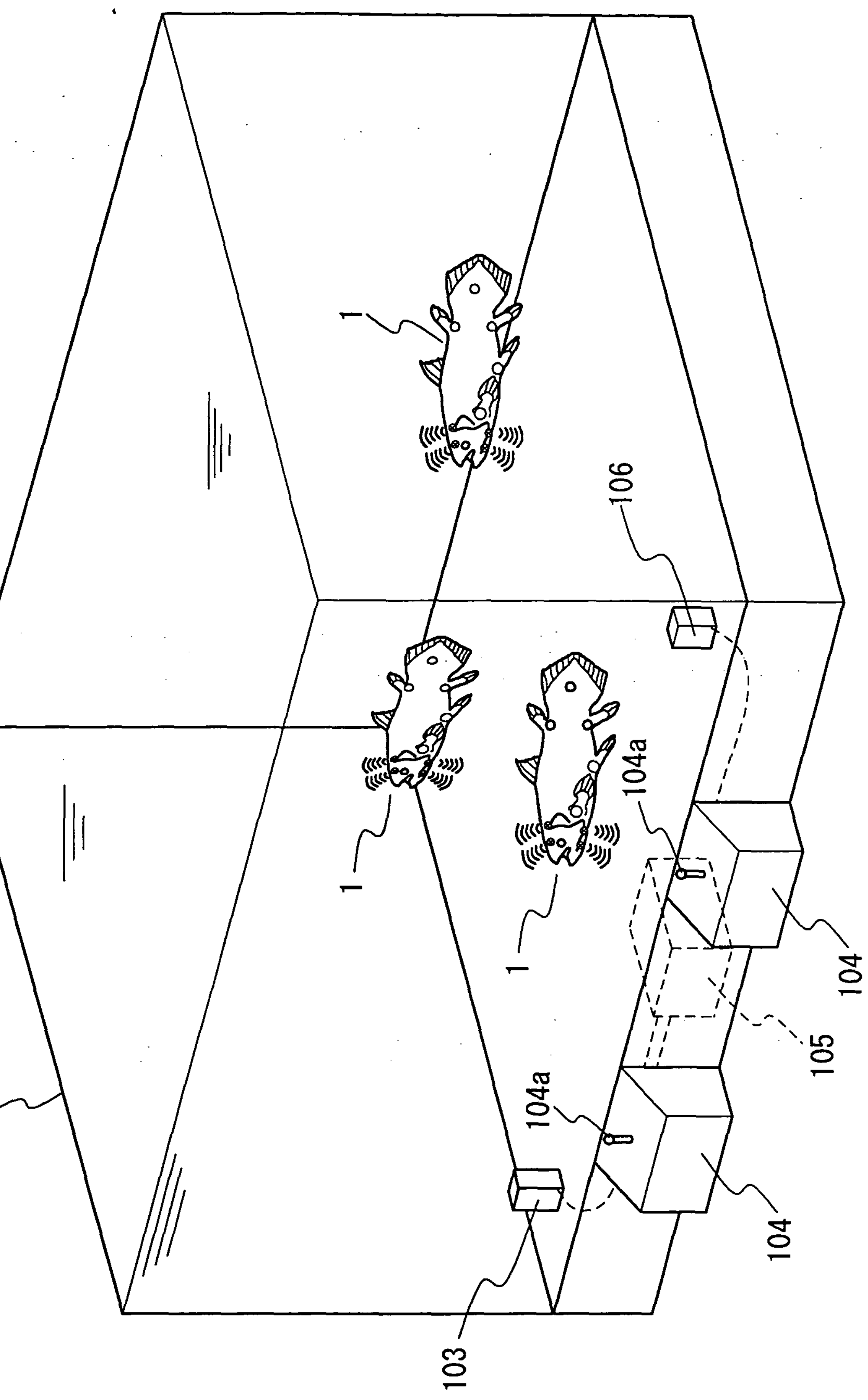
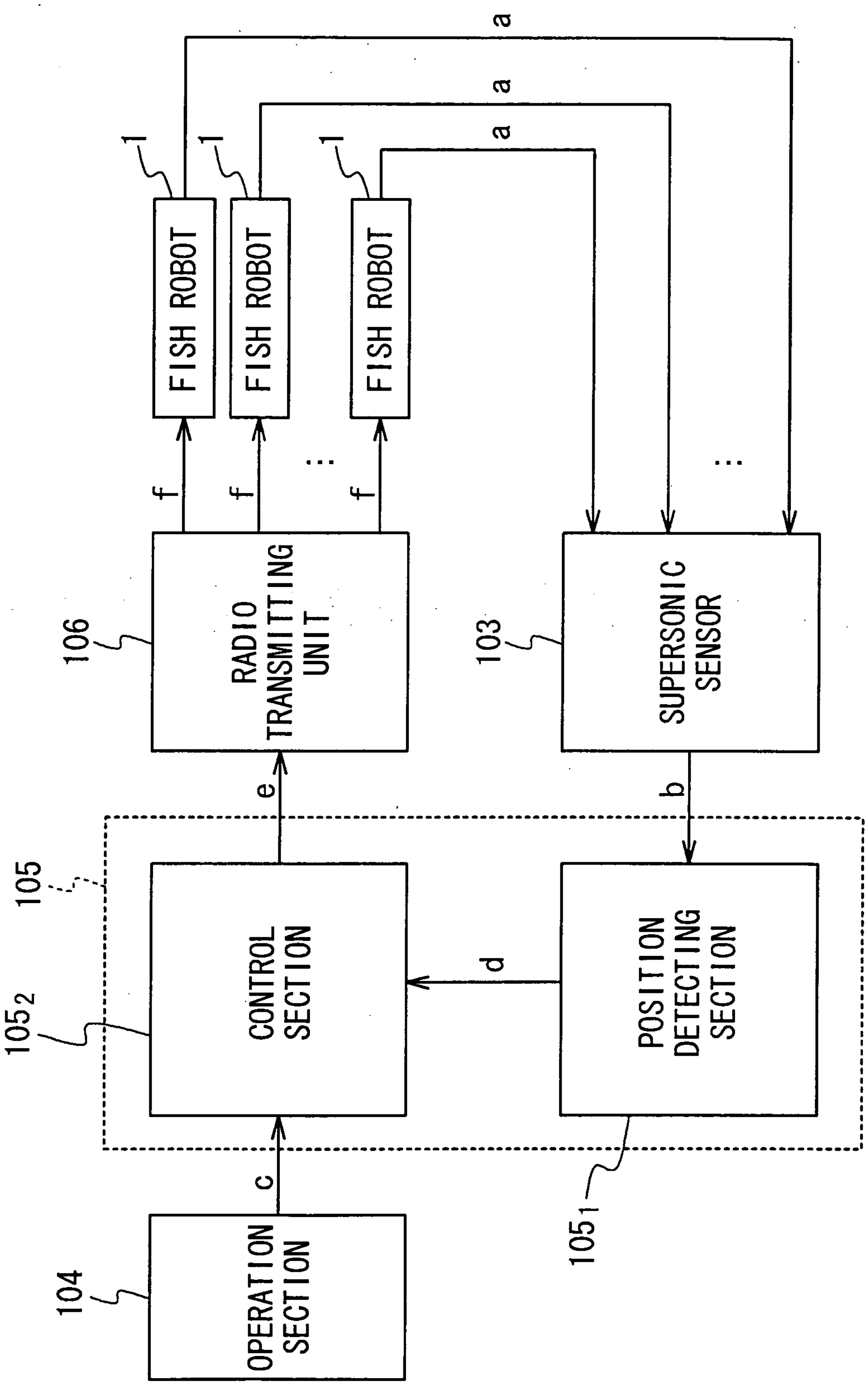


Fig. 8


FISH ROBOT
FISH ROBOT
FISH ROBOT
1
1
1
a
a
a
f
f
f
RADIO TRANSMITTING UNIT
106
SUPERSONIC SENSOR
103
e
b
105
CONTROL SECTION
105_2
d
POSITION DETECTING SECTION
105_1
c
OPERATION SECTION
104

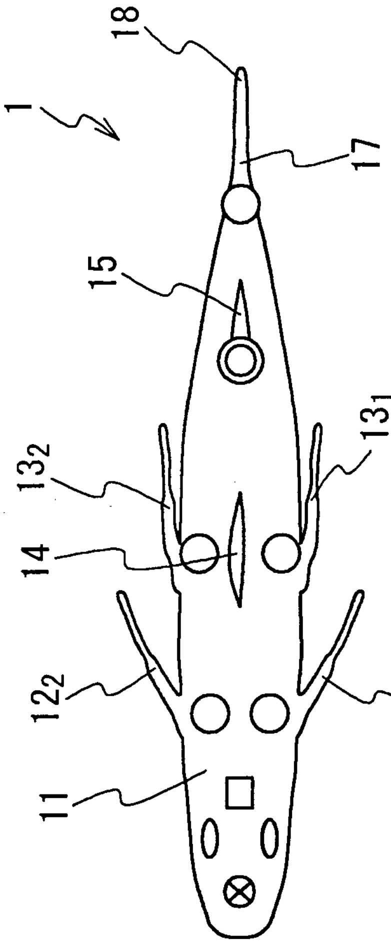

1
18
17
15
13_2
13_1
14
12_2
12_1
11

Fig. 9A

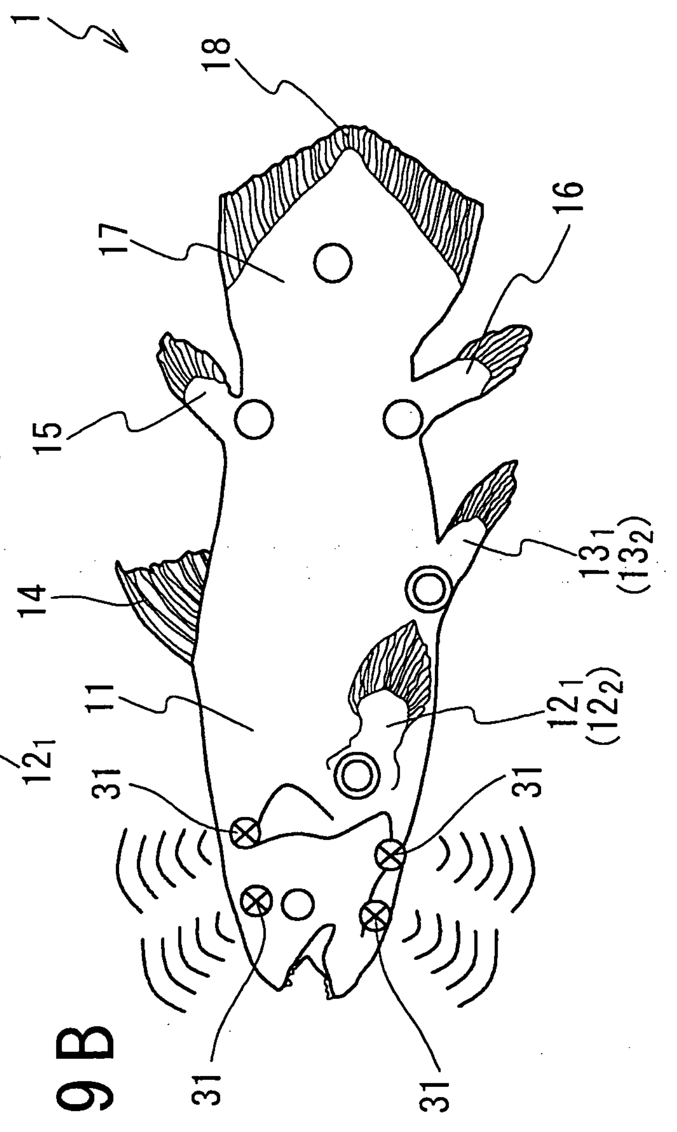

1
18
17
16
15
14
13_1 (13_2)
11
12_1 (12_2)
31
31
31
31

Fig. 9B

Fig. 10A

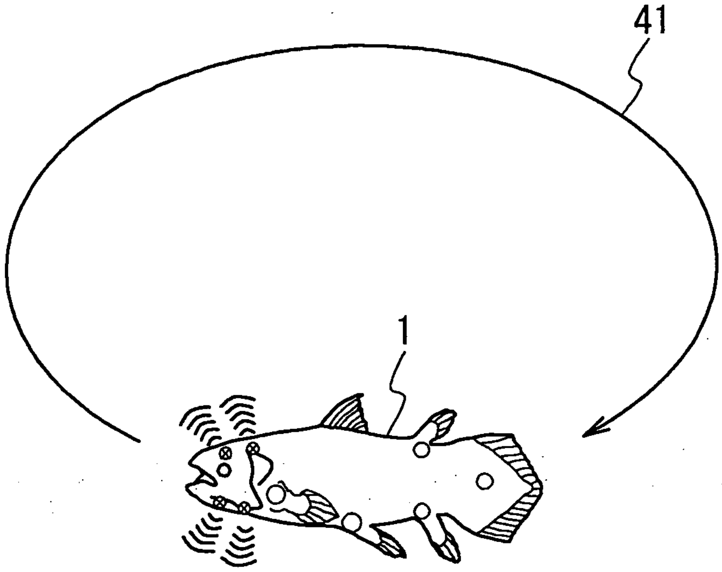


Fig. 10B

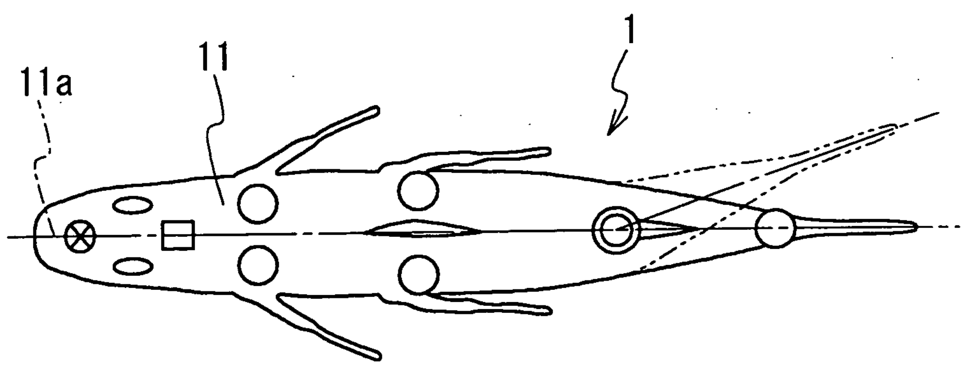


Fig. 11

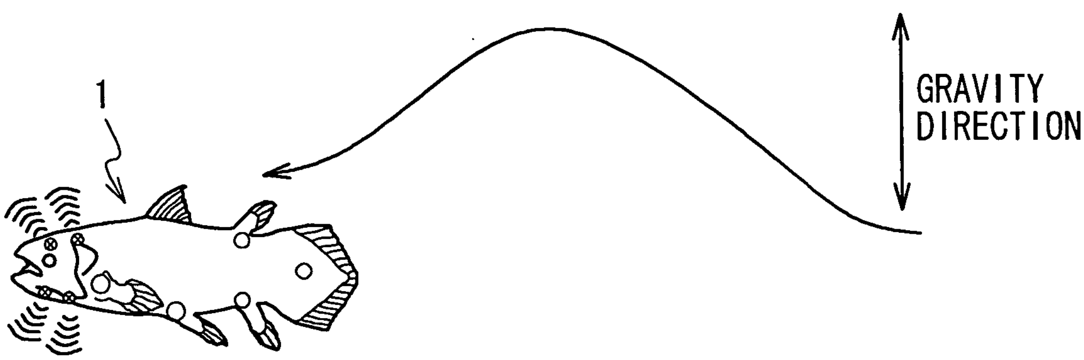
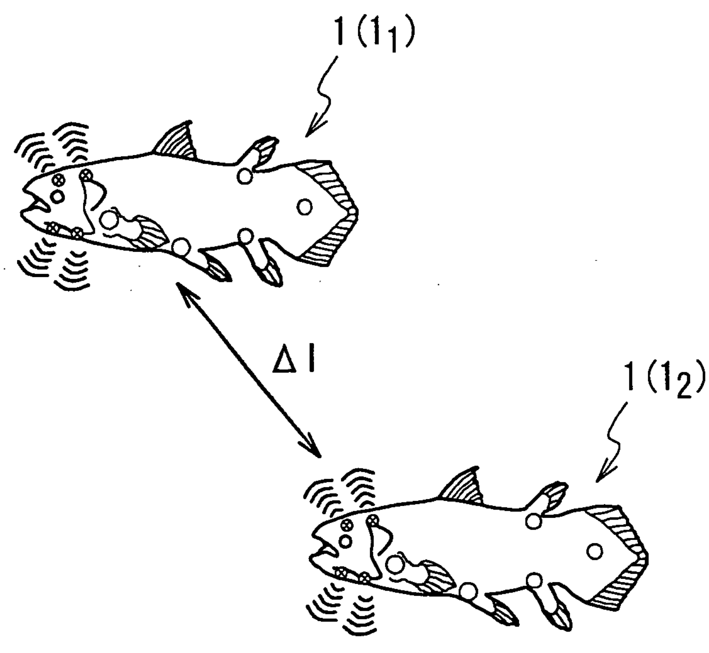


Fig. 12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/04306

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 A63H23/10, B63H1/36

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)
Int.Cl^7 A63H23/10, 30/02, B63H1/36

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

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	"Sakana Robot Shihan Hatsugoki o Seisaku Kaishi", [online], 25 December, 2000 (25.12.00), Mitsubishi Juko News No.3893, [retrieval date 11 July, 2002 (11.07.02)], Internet<URL:http://www.mhi.co.jp/news/sec1/001225.html>	1-5,18-21 6-17,22,23
Y	EP 0903288 A2 (Mitsubishi Heavy Industries, Ltd.), 24 March, 1999 (24.03.99), Full text; all drawings & US 6089178 A & JP 11-152085 A	6-9
Y	JP 61-200090 A (Akihiro OKUYAMA), 04 September, 1986 (04.09.86), Page 3, lower left column, lines 4 to 11; Figs. 1 to 4 (Family: none)	9

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

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"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
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"&" document member of the same patent family

Date of the actual completion of the international search 12 July, 2002 (12.07.02)	Date of mailing of the international search report 30 July, 2002 (30.07.02)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/04306

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 20607/1990 (Laid-open No. 112251/1991) (Mitsubishi Heavy Industries, Ltd.), 18 November, 1991 (18.11.91), Page 6, line 14 to page 7, line 20; Fig. 2 (Family: none)	10-15,22,23
Y	US 2002/0036953 A1 (Kanji ISOMICHI), 28 March, 2002 (28.03.02), Full text; all drawings & JP 2002-55154 A	11,14,16,17
Y	JP 9-188250 A (The Nippon Signal Co., Ltd.), 22 July, 1997 (22.07.97), Par. Nos. [0002] to [0003]; all drawings (Family: none)	16,17

Form PCT/ISA/210 (continuation of second sheet) (July 1998)